Department
of Energy &
Climate Change

# DRIVERS OF GROWTH AND COST CHANGES IN EUROPEAN RENEWABLE HEAT TECHNOLOGIES

Report by Eunomia to the Department of Energy and Climate Change

January 2016

*Report for Fraser Allan, Department of Energy and Climate Change*

*Prepared by Sam Taylor, Simon Hann, Chloe Bines, Sarah Ettlinger of Eunomia*



URN [15D/519]



Any enquiries regarding this publication should be sent to us at rhi@decc.gsi.gov.uk.

# Executive Summary

This report aims to build upon a previous report completed in early 2014 by Eunomia on behalf of DECC entitled 'European Experience of Renewable Heat Deployment'. The previous report aimed to provide information on the long-term deployment patterns of some of the key RHTs and, describe the relevant policies in some of the more developed markets in other European countries.[1]

Provision of any explanation for the reasons for the deployment of RHTs was outside the scope of the previous study. This report, therefore, aims to provide an analysis of the drivers of growth and costs in selected European markets. The main aims of this study are to:

- Provide an explanation of how growth in RHTs has changed over time within the selected countries, including a discussion of the drivers and barriers;
- Identify data related to the changes in costs of RHTs over time in Germany and discuss how these changes have influenced growth;[2]
- Provide an indication of future scenarios of deployment of RHTs in the UK from 2014-2020; and
- Conduct a literature review on the data available on biomass boiler efficiencies in Europe.

The main method of data gathering for this report has been by interviews with national experts and a review of relevant literature. It should be noted that by their very nature, views expressed by individuals are only a personal interpretation of the trends observed in each of the markets. Thus we recommend a degree of caution is exercised by all readers in interpreting the results.

## Key Drivers and Barriers in Comparison Countries

The key drivers and barriers for each of the comparison countries can be summarised as follows:

1. **Oil and gas prices:**
   The second oil crisis in the late 1970s provided a key kick start to many RHTs, whilst taxation of fossil fuels is also significant in Austria and Denmark. At the same time, however, in the Netherlands, relatively cheap natural gas has acted as a disincentive for RHTs;

2. **Environmental movement:**
   The growth of the 'green' movement in the 1970s and early 1980s in all comparison countries led to high public acceptance and enthusiasm for RHTs. In Austria (and to a lesser extent, Denmark), this also led to a 'do-it-yourself' culture for domestic scale plant and an entrepreneurial spirit, which stimulated the domestic supply chain; and

[1] These included Austria, Denmark, France, Germany, The Netherlands, Norway, Sweden and Switzerland.

[2] Germany was chosen as a 'pilot' country for gathering and analysis of cost data, with analysis of further countries potentially to be undertaken at a later date

3. **Poor quality installations:**
   In most comparison countries, but particularly in Austria, as a very early adopter of many RHTs, the industry suffered from poor technology performance. In response, significant effort was made to introduce quality standards and training to build trust and confidence in RHTs;

4. **Availability of biomass feedstock:**
   Austria, Denmark and Germany are endowed with a high percentage of forestry cover and therefore have easy access to biomass supplies. This is in contrast to the Netherlands, which relies upon imported fuels (via Rotterdam, widely regarded as the EU's main biomass hub);

5. **Financial support from Government:**
   State funding programmes have been the key driver for deployment of RHTs across all comparison countries, but particularly in Germany, in which the MAP was relatively stable until 2010. In contrast, policy in the Netherlands has been far more inconsistent, which has impacted upon public and investor confidence and thus hindered deployment;

6. **Competition from other renewable heat technologies:**
   In all of the comparison countries, there has been competition between the RHTS. This has often been influenced to a large degree by the amount of financial support available from Government, which has in some cases had unintended consequences by 'skewing' the market significantly in favour of a particular technology;

7. **Competition from Solar PV:**
   Due to frequent public misunderstanding of the difference between solar PV and solar thermal, alongside an 'either-or' mentality at a time of limited funds, many households and businesses have opted for solar PV, which has been driven by high levels of government support. To a lesser extent, this has also had an impact on other non-solar RHTs;

8. **Government support for district heating:**
   In both Austria and Germany, but particularly in Denmark, additional levels of support for the development of new district heating networks, or conversion of existing networks to be fuelled by biomass (rather than natural gas or oil) have been instrumental in stimulating large-scale biomass (and to a more limited extent solar thermal and heat pump) installations;

9. **Role of regional administrations:**
   The Länder in Austria have responsibility to deliver a variety of energy policy measures. This means that policy mechanisms can be better tailored to local concerns and resources, for example, access to feedstock, which can be more effective than a federal approach;

10. **Building regulations:**
    In Denmark, house builders are expected to adhere to legislation that requires certain levels of renewable heat capacity to be fitted, whilst in Germany, more stringent building efficiency requirements, which can be met by installation of RHTs, have had some impact;

11. **Collapse of the construction market:**
    Building regulations in some of the comparison countries may have driven some further deployment, the financial crisis hit house builders hard. Thus, related demand for RHTs fell significantly in 2008, albeit is now recovering; and

12. **Removal of support for RHTs in new buildings:**
    In both Denmark and the Netherlands new homes can no longer receive funding for some RHTs. This has negatively impacted the market at a time when installation levels in new builds were starting to recover from the collapse of the construction market.

## Changes in Costs of Technologies

The data from Germany shows that in a relatively mature market there have been some key changes associated with the costs of technologies over the last decade. Considering biomass technologies, CAPEX appears to have reduced as the deployment has increased – this is especially the case for pellet boilers. Many of the key technical changes that led to costs of the technology increasing have now been incorporated in to many of the technologies available on the market. The European biomass heat market is moving to a more competitive phase with a wider range of boiler suppliers available than ever before.

The reducing costs of biomass represent an opportunity for the UK to import the technologies from Europe; therefore adopting late mover advantage. However, the cost of importing biomass technologies represents some risks to the UK. Changes in exchange rates could increase the costs of the technologies and by importing the technologies the UK will have limited ability to make savings across the value chain. In response to these challenges we'd anticipate that over time the UK based would become more competitive. However, given that a large percentage of the capital costs relate to the cost of biomass equipment, the UK may not be the most competitive location to manufacture the equipment and would therefore be reliant upon imports.

Due to lack of heat pump data, it is difficult to consider how costs have changed in the German market. The number and variety of products available has changed significantly over the recent years, yet as more advanced products have become available, cost savings have been difficult to achieve. Additionally, a large proportion of the costs associated with heat pumps relate to the installation costs. Therefore we'd expect in the mature markets for the installation costs to be lower than those in less mature markets as greater competition would prevail. This represents a significant advantage for the UK for costs of the technology to be reduced over time.

For solar thermal technologies, the costs of the technology in Germany have shown some decrease, but in recent years have remained relatively static. Rather than reduced production costs, increased competition with other renewable technologies (e.g. air source heat pumps, Solar PV) may result in some savings in the future. However, installers are typically installing a range of technologies and therefore the extent to which the technologies might realistically 'compete' may be more related to the incentives provided for them. In the context of the UK, like the heat pumps market, there may be opportunities for savings to be made as the market matures. However, this is dependent (as in all cases) on a strong demand for the technologies over a sustained period of time.

## UK Growth Scenarios

The deployment of renewable heat in each of the comparison countries can be shown to be more mature than that of the UK. Figure 1 shows the latest deployment figures of the UK alongside similar figures of deployment in other comparison countries, or the earliest deployment data if no similar figures can be observed. We have been unable to find similar levels of deployment to the UK for all of the comparison countries in at least one of the technology groups. This in itself is telling as some of the data sets date back to 1980.

The growth rates are presented as annual geometric growth rates of the stock, i.e. the growth rate that if held constant would result in the same total growth seen over the period when applied to the stock of heat generation. However it should be noted that for use in projection of future changes, annual growth rates of stock can be used as ‘flow’ growth rates – meaning the increase in rate of installations – though the reverse is not necessarily true.

**Figure 1: Comparison of Renewable Heat Generated by Technology Relative to the Latest UK Deployment ($kW_{th}$ / Person)**


*Notes:* 1) *Data prior to 2002 is not available for Austria and therefore the earliest data is presented; this does not equal the same level of deployment the UK; and*
2) *Methods used to calculate the deployment of renewable heat generation vary by each country and therefore may not be directly comparable.*

For the UK we have provided a qualitative description of the key changes in an optimistic and pessimistic scenario.

**Bioenergy Technology Group**

Optimistic:

- Higher average growth rates than those experienced in other comparison countries (over 10% per annum) due to the high potential for growth in the UK market, but possibly limited to deployment seen in Austria in phase 1 (22% per annum).

Conservative:

- Steady growth of approximately 10% per annum, Similar to the growth rates in Germany (6% since 1990).

**Heat Pumps Technology Group**

Optimistic:

- Similar to growth rates seen in the Netherlands (28% per annum since 1994) and Germany (20% per annum since 2006).

Conservative:

- Similar to levels witnessed in Austria (5% per annum since 2002).

**Solar Thermal Technology Group**

Optimistic:

- Similar to rates achieved in Denmark in phase 1 (18 per cent) and Germany since 1990 (19 per cent)Continuation of exponential growth (over 25% per annum).

Conservative:

- Relatively static deployment, similar to the growth observed in all of the comparison countries markets in the last five years. (Except dedicated plant in Denmark).

## Summary of Findings

The research has shown a remarkable change in the deployment of RHTs over the past three decades for the comparison countries analysed for this study. Through interviews and literature review, we have explored a number of drivers for these changes, from which important lessons can be learnt by the UK as it aims to structure policy for renewable heat to enable meeting its renewable energy targets for 2020.

The drivers of growth in each of the comparison countries have often been unique and highly dependent on local characteristics. The analysis has identified a plethora of legislative and policy drivers dating back well in to the early 1990s and in some instances the late 1970s across the comparison countries.

There does not appear, however, to be a simple correlation between the number of these legislative and policy drivers and the levels of deployment; although it is apparent that stability in this respect has been is a critical factor.

For all of the countries underlying market condition have been observed to be a key driver in the renewable heat markets, and the relative costs of fossil fuels have been shown to be a key driver. As part of this assessment we have not sought to compare the overall costs of the deployment of the renewable heat technologies in the different markets, nor have we considered the differences in elasticity of demand for renewable heat technologies. However, our research has found that where oil or electric heating has prevailed, the switch to a renewable heating source is easier than otherwise.

For the UK, there appears to be a number of possible routes by which the market for each technology may evolve through to 2020. The key drivers and barriers highlighted in this section represent a key set of lessons, which should be taken into consideration when designing and new and revising existing policy mechanisms. Some issues, however, for example, global prices of fossil fuels, are beyond the control of Government, albeit the policy mechanisms that impact upon related prices could be adjusted via taxation and other mechanisms.

# Contents

# 1. Introduction

Eunomia Research & Consulting Ltd ('Eunomia') is pleased to present this report to the Department of Energy and Climate Change ('DECC') on the drivers of growth and costs in deployment of renewable heat technologies (RHT) in selected European countries.

As part of the UK's National Renewable Energy Action Plan (NREAP) heat production from renewable sources by 2020 is estimated to provide 12% of all heating and cooling needs in the UK. The experience and deployment history of other European countries that have made significant progress in heat markets can provide an invaluable insight into how long term growth within the UK can be achieved. Learning from the measures that have succeeded and those that have failed will help the UK focus its future actions to ensure that renewable energy targets can be achieved.

This report aims to build upon a previous report completed in early 2014 by Eunomia on behalf of DECC entitled 'European Experience of Renewable Heat Deployment'. The previous report aimed to provide information on the long-term deployment patterns of some of the key RHTs and, at a high level, describe the relevant policies in some of the more developed markets in other European countries.[3]

Provision of any explanation for the reasons for the deployment of RHTs was outside the scope of the previous study. This report, therefore, aims to provide an analysis of the drivers of growth and costs in selected European markets. The main aims of this study are to:

- Provide an explanation of how growth in RHTs has changed over time within the selected countries, including a discussion of the drivers and barriers;
- Identify data related to the changes in costs of RHTs over time in Germany and discuss how these changes have influenced growth;[4]
- Provide an indication of future scenarios of deployment of RHTs in the UK from 2014-2020; and
- Conduct a literature review focusing on the data available on biomass boiler efficiencies.

The main method of data gathering for this report has been by interviews with national experts and a review of relevant literature. It should be noted that by their very nature, views expressed by individuals are only a personal interpretation of the trends observed in each of the markets. Thus we recommend a degree of caution is exercised by all readers in interpreting the results.

In collating data for this research, we have aimed to gather the installed capacity of installations within the relevant heat markets. However, this data is not always available, and therefore we have gathered the data of the renewable heat generated. Additionally, we have supported this analysis with data on the number of new installations per annum where this is available.[5]

[3] These included Austria, Denmark, France, Germany, The Netherlands, Norway, Sweden and Switzerland.

[4] Germany was chosen as a 'pilot' country for gathering and analysis of cost data, with analysis of further countries potentially to be undertaken at a later date

[5] Note that this does not include decommissions.

The findings in this report are typically reported at a national level. No doubt specific individual, local or regional circumstances can impact on the deployment or otherwise of the RHTs over time and therefore some findings may not be entirely relevant to some parts/aspects of a country. In order to aid the discussion about the drivers for renewable heat deployment we have aimed to provide commentary in distinct 'phases'. It is acknowledged that there will be changes in the deployment during these phases.

Furthermore, it should also be recognised that the analysis is not supported by econometric modelling, and is based on the subjective views of the authors, limited by the availability of information.

## 1.1 Scope of the Report

The focus of the analysis is split according to geography and different RHTs. In the following sub-sections we have aimed to further elaborate on each of these criteria.

### Geographical Scope

To provide an appropriate comparative analysis with the UK, we have selected European countries which have broadly similar climates and energy markets. Theoretically this should ensure that the operation of RHTs is broadly similar to what we may observe in UK. The scope is limited to the assessment of four European Union (EU) Member States:

- Austria;
- Denmark;
- Germany; and
- The Netherlands.

### Renewable Heat Technologies

There are a wide range of renewable technologies currently being deployed throughout Europe. In order to ensure that a comparison with the UK can be made, we have considered only RHTs which are currently eligible for the Renewable Heat Incentive (RHI), as shown in Table 0-1. It should be noted that where data is not available for specific technologies, it is presented at the 'group' level instead.

**Table 0-1: Renewable Heat Technologies with Scope**

| Group Number | Technology Group Name | Technologies within Scope |
|---|---|---|
| **1** | Bioenergy | • Biomass boilers;[1]<br>• Biomass CHP;<br>• Biogas for CHP;[2] and<br>• Biomethane Injection.[2] |
| **2** | Heat Pumps | • Ground Source Heat pumps; and<br>• Air Source Heat Pumps |
| **3** | Solar Thermal | • Solar Thermal |

***Notes:***
1) ***Main focus of this technology group***
2) ***Only for Germany and The Netherlands***

# 2. Market Profiles

For the UK and the comparison countries, the underlying energy market context is an important feature that should be clearly understood in order for any comparisons to be made and lessons learnt to be gathered.

All of the countries included in this report are EU Member States and therefore, to a large extent, the overarching rules and principals that govern the energy markets are similar in nature. That being said, an integrated internal energy market in Europe has yet to be achieved, despite an ambition for it to be in place by the end of 2014.[6]

The lack of an integrated market makes an understanding of the market dynamics in each of the comparison countries particularly relevant. In the following sections we have provided a summary of some of the key features of the energy markets alongside a brief description of the renewable energy targets set within each of the selected Member States.

## 2.1 Retail Prices of Gas and Electricity

A key factor used to help understand the energy markets is the price of gas and electricity. Studies completed by the European Commission (EC) have aimed to explore the differences between retail costs of gas and electricity over the last decade. Detailed charts, showing the breakdown of the retail prices have also been provided.

Variations can be observed in the overall costs of gas and electricity, including the role of VAT and taxes in each of the selected Member States over the period 2004-2011. In Austria, average retail prices for gas supplied to households was on average €7 cents/ kWh in 2011. This compares to over €11 cents/ kWh in Denmark, nearly €8 cents/ kWh in the Netherlands, €6cents/ kWh in Germany and under €5 cents/ kWh in the UK. Thus the implications of these prices make gas fuelled heating technologies more competitive in the UK than in the other comparison Member States.

Similarly for prices of electricity, differences between the Members States are also apparent. Over the period 2004 to 2011, the UK again had the cheapest average retail price of electricity; mainly due to it applying the lowest level of related taxation (0.15cents/ kWh for retail prices in 2011 for the UK compared to a range of 0.17-0.2915cents/ kWh in the comparison Member States).

Typically higher priced conventional fuels act as an incentive to invest in renewable heat technologies. Another consideration is the impact of energy efficiency measures. Research synthesised by Ofgem found that in the long run, higher energy prices result in larger energy efficiency price elasticities.[7] Thus it is conceivable that higher prices also have led to more focus on energy efficiency measures in the comparison Member States than in the UK.

---

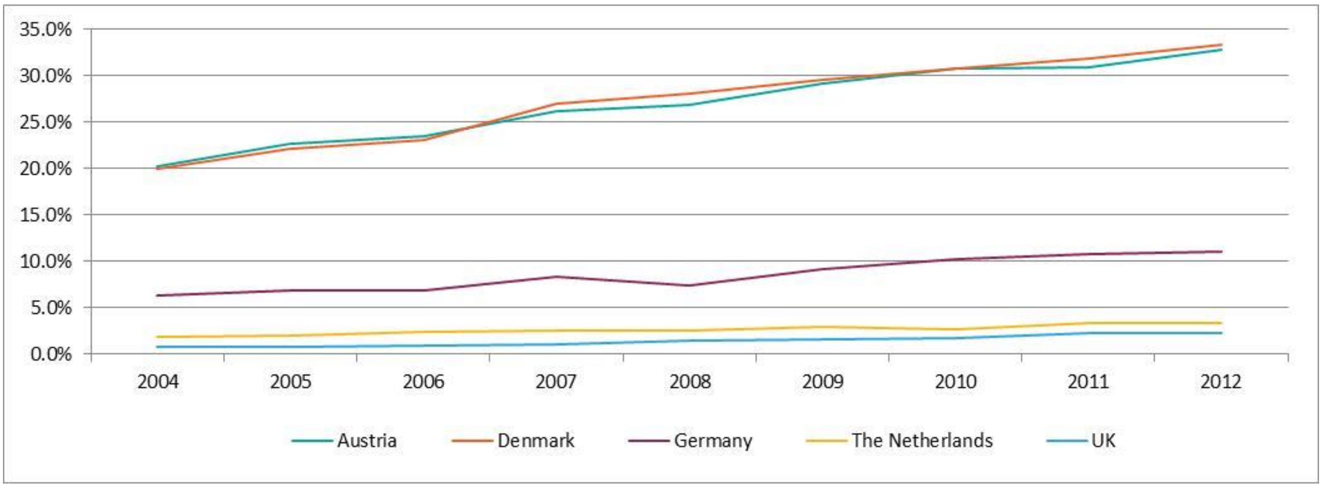
[6] European Commission (2014) *Progress towards completing the Internal Energy Market*, October 2014, http://ec.europa.eu/energy/gas_electricity/doc/2014_iem_communication.pdf

[7] Ofgem (2009) *Can Energy Charges Encourage Energy Efficiency*, July 2009, https://www.ofgem.gov.uk/ofgem-publications/57027/final-discussion-paper-22-july.pdf

## 2.2 Renewable Heat Deployment

Within each of the Members States there have been varying levels of renewable heat deployment, ranging from 2.3% (of all heat supplied) in the UK in 2012 to 33.3% in Denmark in 2012.[8] Figure 2 summarises the percentage of heating and cooling provided by renewable energy within each Member State since 2004. The data presented demonstrates the different growth rates shown in each of the Member States over the nine year period.

**Figure 2: Recent Share of Renewable Energy in Heating and Cooling**




*Source: Eurostat (2014)*[9]

Both the UK and the Netherlands have seen a modest overall contribution, but these countries have experienced the largest year on year percentage growth rate over the period. The UK has experienced an average year-on-year growth rate of 7% in renewable heat; the highest growth rate of all of the comparison countries. However, the rate is high as the market in the UK is relatively immature. This growth rate compares to 4% in Austria and Denmark, which both have relatively mature markets.

## 2.3 Renewable Energy Targets

A key driver associated with the deployment of renewable heat technologies in each of the Member States is a target for the proportion of overall energy supplied by renewable energy. Each of the Member States has adopted binding targets under EU Directive 2009/28 for the share of overall energy and heat energy from renewable sources.  he scale of each targets typically reflect the historic deployment of renewable energy in each Member State, but do act as a key driver for policy within each country and are an important consideration when examining the deployment of RHTs.

The renewable energy targets are summarised for each of the Member States National Renewable Energy Action Plans (NREAP) in Table 0-1, alongside the latest reported share of renewable heating and cooling as reported by Eurostat.

---

[8] Eurostat (2014) *Share of Energy from Renewable Sources (nrg_ind_335a)*, 2014, http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_ind_335a&lang=en

[9] Eurostat (2014) *Share of Energy from Renewable Sources (nrg_ind_335a)*, 2014, http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_ind_335a&lang=en

**Table 0-1: 2020 Renewable Energy Targets**

| Member State | 2020 Target (%) | Estimate Contribution from Renewable Heating and Cooling element of 2020 (%) | % of heating and cooling provided by renewable energy in 2012 |
|---|---|---|---|
| **Austria** | 34 | 32.6 | 32.8 |
| **Denmark** | 30 | 39.8 | 33.3 |
| **Germany** | 18 | 15.5 | 11.1 |
| **The Netherlands** | 14 | 8.7 | 3.4 |
| **UK** | 15 | 12 | 2.3 |

*Source: Adapted from Eurostat (2014)*[10] *and European Commission (2014)*[11]

The table shows that the UK has the second lowest forecast for the contribution of renewable heat and cooling of the five Member States. Denmark has the highest forecast of the Member States considered in the assessment. This generally reflects the proportion of renewable heating and cooling already supplied in the country.

## 2.4 Renewable Heat Market Segmentation

Alongside the percentage share of renewable heat of the total renewable energy market, the segmentation of the renewable heat market is also an important characteristic to consider. A detailed breakdown of the heat market segmentation has been provided. The detailed segmentation shows that there is some variation across the comparison countries in the contribution of each renewable heating technology, although all markets are similarly segmented at group level; with the bioenergy group representing the highest percentage share of renewable heat provided in all Member States.

## 2.5 Discussion of Growth Rates

Throughout the report, growth rates experienced are presented as annual geometric growth rates of the stock, i.e. the growth rate that if held constant for each year would result in the same total growth seen over the period when applied to the stock of heat generation. It should be noted that these differ from rates calculated by averaging the growth rates seen in each year – particularly where the rates fluctuate. This is also the reason that the rates shown are not presented as 'flow growth' (meaning increases in the rate of installations) because the flow rates fluctuate extensively for most technologies (though in many cases this may be a matter of reporting rather than actual changes). However for use in projection of future changes, annual growth rates of stock can be used as flow growth rates (though the reverse is not necessarily true).

[10] Eurostat (2014) *Share of Energy from Renewable Sources (nrg_ind_335a)*, 2014, http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_ind_335a&lang=en

[11] European Commission (2014) *National Renewable Energy Action Plans*, http://ec.europa.eu/energy/renewables/action_plan_en.htm

# 3. Renewable Heating in Austria

The renewable heating market in Austria can be considered to be one of the most mature markets in Europe. In the following sections a breakdown of the deployment of the three main renewable heating groups, bioenergy, heat pumps and solar thermal is provided. Additionally, a summary of the key drivers and a discussion of their relevance to the UK market is provided.

## 3.1 Bioenergy Technology Group

The 'low-temperature' (i.e. space-heating) heat market in Austria has traditionally been, and remains the most important market for biomass. Biomass currently provides around 25% of total heat use within the country and can be considered to be a mature technology.[12]

Figure 3 summarises the deployment of biomass in Austria from the mid 1990's onwards. Unfortunately, reliable data is not readily available for the deployment of biomass technologies prior to this time period, although they have been widely deployed since at least the 1950s. In the last decade, the annual number of new installations has grown for all biomass technologies. The largest year-on-year growth rate in new installations is observed for the pellet boilers, which have emerged as the most popular technology type.

Whilst data is not available to demonstrate the deployment of bioenergy in Austria from the point of inception, the findings from our interviews and literature review suggest that the sector can be divided in to two separate phases of growth. These can be summarised as follows:

- Phase 1: Emergence and early deployment - 1950s to the early 1990s; and
- Phase 2: Exponential growth - middle 1990s to the present day.

Data is also available on the quantity of renewable heat produced on an annual basis by bioenergy plants in Austria dating back to 2005. From 2005 to 2012, the amount of heat generated annually by the bioenergy technology group grew at a geometric growth rate of 15 per cent, but has shown large variation from year to year.[13]

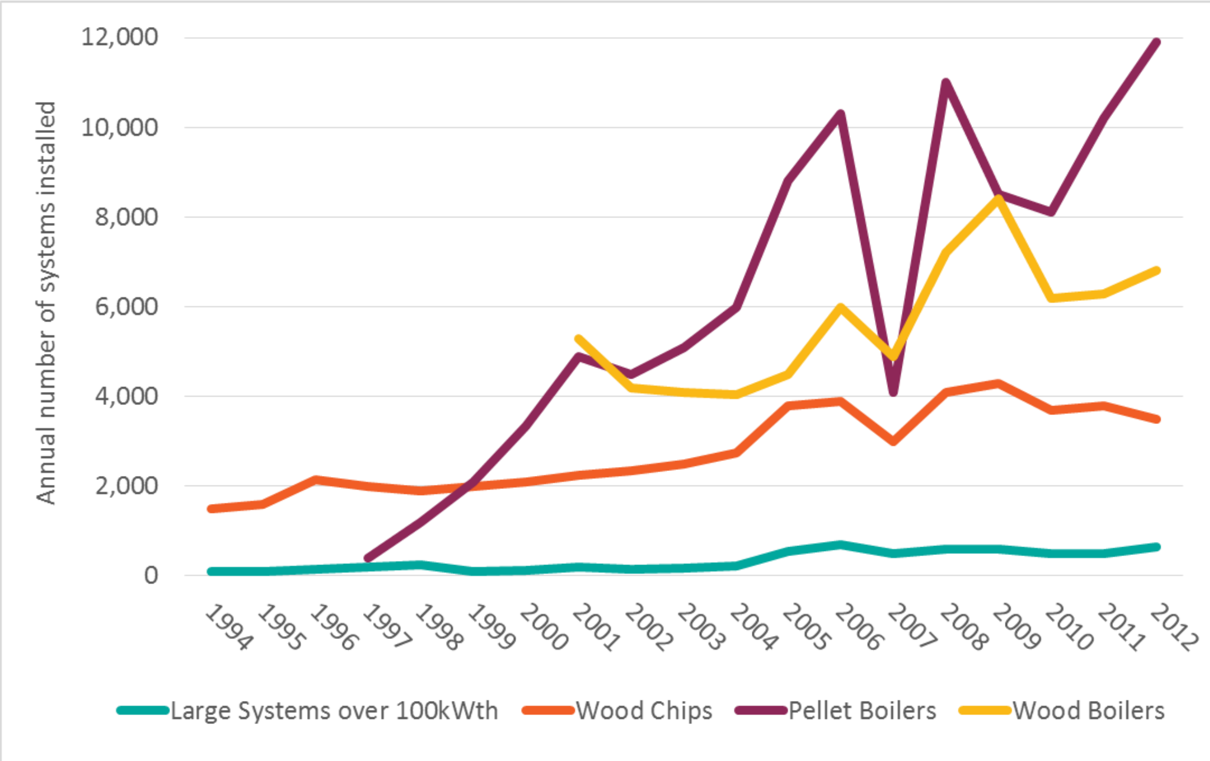
The determination of the two phases listed above is, by its very nature, arbitrary and not supported by empirical data relating to the long term deployment of the technologies highlighting clear tipping points in the quantity of renewable heat generated. However, through our research we have identified a number of different drivers which have contributed to drive deployment through time.

---

[12] Statistik Austria (2013) *Useful Energy Analysis: Final energy consumption 2012 by fuels and useful energy categories for Austria*, December 2013, http://www.statistik.at/web_en/statistics/energy_environment/energy/useful_energy_analysis/index.html

[13] Ibid.

**Figure 3: Deployment of Biomass Technologies in Austria (1994-2012)**




*Source: Adapted from Lebensministerium (2013)*[14]

For phase 1, the key drivers are:

- Spikes in energy costs - associated with the oil crises in the 1970's;
- Financial support – many of the Länder (Austrian regions)have provided grants for the installation of the RHTs, helping to reduce the upfront costs of the technology;
- Environmental movement - a significant environmental movement in the early 1980's helped increase awareness and acceptance of RHTs;
- Entrepreneurship - many of the technologies within Austria have been 'home grown' and initially developed by the forestry and agricultural sector;
- Natural resources - Austria is endowed with a high percentage of forestry cover with a longstanding forestry industry; and
- Stability of Energy Policy - the Länder have provided stable policy within each of the regions in Austria. They have responsibility to deliver aspects of energy policy and have successfully aligned energy policy with other policy areas (e.g. energy efficiency).

As the technology deployment has developed over time, the market in Austria has become more mature. Mass deployment has taken place from the mid 1990s in the second phase. The drivers in this phase are broadly the same as in the first phase, but with the additional impact of the introduction of pellet boilers in to the market in the late 1990s. Additionally, the longstanding stability of policies and incentives also contributed to providing a mature market. In the most recent period of phase 2 it is noted that the growth in the number of new pellet boilers has fluctuated, with some variable changes in growth. The first large change in 2007 is understood to be related to large

[14] Lebensministerium (Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management) (2013) *Erneuerbare Energie in Zahlen: Die Entwicklung Erneuerbarer Energie in Österreich im Jahr 2012 (Renewable Energy in Numbers: The Development of Renewable Energy in Austria in 2012)*, December 2013, http://www.bmlfuw.gv.at/dms/lmat/publikationen/umwelt/energie/energie_zahlen_2011/Erneuerbare-Energie-in-Zahlen_2012/Erneuerbare%20Energie%20in%20Zahlen_2012.pdf

changes in the costs of pellets, whilst the decline in 2009 and 2010 is believed to be in relation world-wide financial crisis.

## 3.2 Heat Pump Technology Group

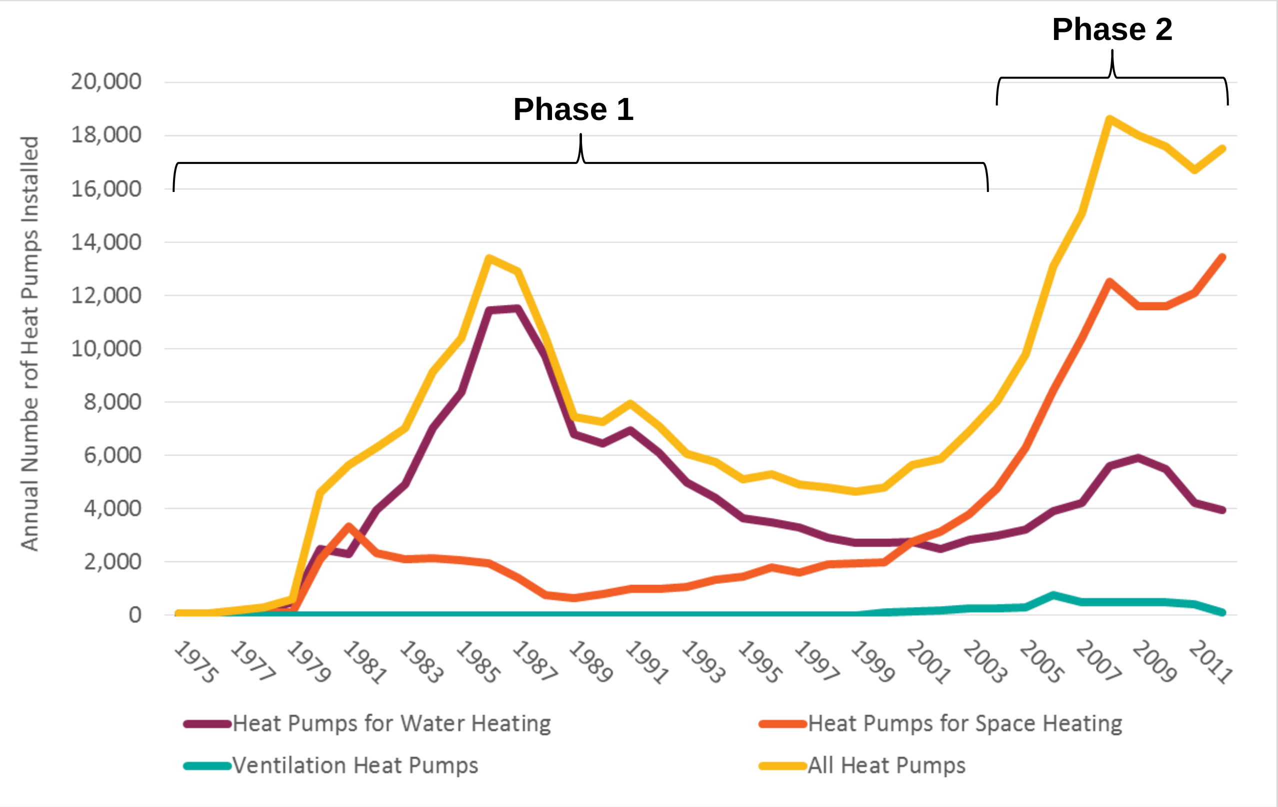
The heat pump market in Austria is one of few relatively mature heat pump markets in the world. Figure 4 summarise the deployment of the technology since 1975 and shows that the market has experienced both rates of growth and decline over the last 40 years.

The findings from our interviews and literature review suggest that the sector can be divided into three separate phases of growth. These can be summarised as follows:

- Phase 1: Emergence and early deployment – 1970s to 1990s; and
- Phase 2: Exponential growth – 2000s to the present day.

The growth rate of renewable heat produced by heat pumps during phase 2 was 5 per cent.[15]

**Figure 4: Annual Deployment of Heat Pumps in Austria (1975 – 2012)**




*Notes: Air to Air source heat pumps represent less than 2% deployment numbers for ' Heat pumps for space heating'* [16]

*Source: Adapted from Lebensministerium (2013)*[17]

---

[15] Statistik Austria (2013) *Useful Energy Analysis: Final energy consumption 2012 by fuels and useful energy categories for Austria*, December 2013, http://www.statistik.at/web_en/statistics/energy_environment/energy/useful_energy_analysis/index.html

[16] http://www.nachhaltigwirtschaften.at/nw_pdf/1317_marktstatistik_2012.pdf

[17] Lebensministerium (Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management) (2013) *Erneuerbare Energie in Zahlen: Die Entwicklung Erneuerbarer Energie in Österreich im Jahr 2012 (Renewable Energy in Numbers: The Development of Renewable Energy in Austria in 2012)*, December 2013, http://www.bmlfuw.gv.at/dms/lmat/publikationen/umwelt/energie/energie_zahlen_2011/Erneuerbare-Energie-in-Zahlen_2012/Erneuerbare%20Energie%20in%20Zahlen_2012.pdf

In phase 1, the technology was mainly used for hot water heating, usually deployed as bivalent systems (i.e. used in conjunction with another heat source such as an oil boiler). Initially the deployment of heat pumps was driven by high oil prices, like all technology groups in Austria. This was followed by support for heat pumps in the form of tax 'breaks' for those installing new systems. When oil prices fell in the mid 1980's and 1990's, however, the annual deployment of heat pumps decreased from the highs of the early 1980's. Additionally it is also understand that many of the first installations were of poor quality and therefore confidence in the technologies was initially relatively low.

In phase 2 the deployment of heat pumps began to grow at higher rates.  The change in growth was due to a number of reasons, rather than one single factor. These are summarised as follows:

- Financial support – many of the Länder have provide grants for the installation of the RHTs, helping to reduce the upfront costs of the technology. Additionally in 2001 the Federal Government introduced the Federal Environment Fund which supported the installation of heat pumps;
- Education and training – many of the Länder and utility companies made a concerted effort to improve the skills within the heat pump industry; and
- Utility company support - some utility companies in Austria have provided preferential tariffs for the operation of heat pumps.

It is noted that in the most recent period (2008-2011) the rate of growth has plateaued. The reasons for this are unclear, but it is believed that the financial crisis has had some impact.

## 3.3 Solar Thermal Technology Group

Over the last 40 years, Austria has experienced large scale deployment of solar thermal technologies. As of 2012, it had installed a total capacity of 4.1 million $m^2$ of solar thermal technologies, equivalent to 2.0 $GW_{th}$ per annum.[18] The market in Austria can therefore be considered mature.

Data collected by Austria Solar, the trade association for the solar thermal industry in Austria, shows the level of deployment of solar thermal by size of collector area installed per annum since 1977, as shown in Figure 5. Data is also available on the quantity of renewable heat produced on an annual basis by solar thermal installations within Austria dating back to 2002. Unlike bioenergy technologies (and to a lesser extent, heat pumps), the generation of heat from solar thermal is not controlled by the user and thus the heat produced is directly correlated to the deployment of the technology.

The findings from our interviews and literature review suggest that the sector can be divided in to four separate phases of growth. These can be summarised as follows:

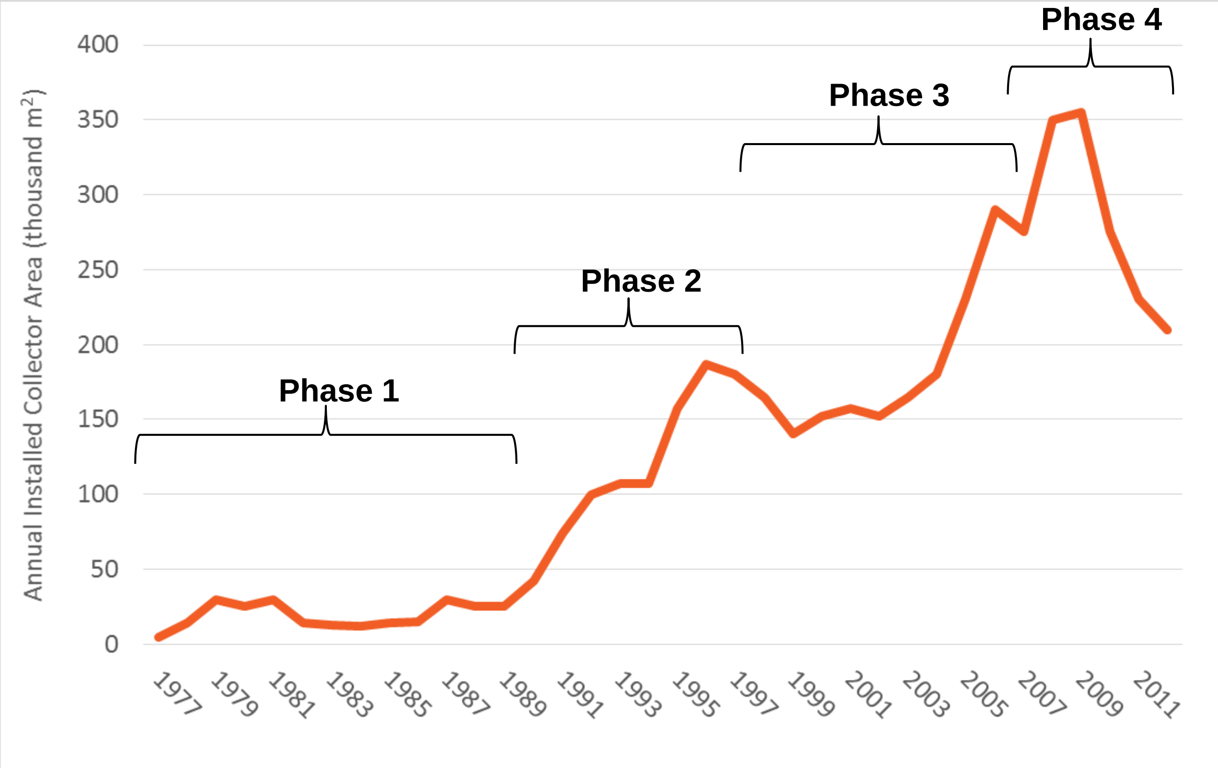
- Phase 1: Emergence and early deployment – 1977-1989;
- Phase 2: Exponential growth – 1990-1996);
- Phase 3: Steady growth – 1997 -2007; and
- Phase 4: Declining growth – 2008 -2013.

From 2002 to 2012, the amount of heat generated has grown steadily at a rate of 8 per cent.[19]

[18] Austria Solar (2013) *35 JAHRE SOLARENERGIE - RÜCKBLICK UND AUSBLICK*, 2013, http://www.solarwaerme.at/docs/917.pdf

[19] Statistik Austria (2013) *Useful Energy Analysis: Final energy consumption 2012 by fuels and useful energy categories for Austria*, December 2013, http://www.statistik.at/web_en/statistics/energy_environment/energy/useful_energy_analysis/index.html

**Figure 5: Annual Installed Collector Area in Austria - 1977-2012**




*Source: Adapted from Austria Solar (2013)*[20]

The drivers of deployment in Austria for solar thermal are similar to those identified for bioenergy and heat pumps. As for bioenergy, the drivers within the phases are less distinct and it is perhaps the long-term stability of the drivers that are most important. For phase 1 the key drivers were:

- Spikes in energy costs - associated with the oil crises in the 1970's; and
- Entrepreneurship - many of the technologies within Austria have been 'home grown' and initially developed by the forestry and agricultural sector.
- Environmental movement – an emerging environmental movement in the early 1980's helped increase awareness and acceptance of RHTs.

In phase 2, the deployment of solar thermal grew rapidly. Like the phase before, this was due to a number of factors combining together. Two key drivers have been identified in our research:

- Long term financial support - many of the Länder have provided grants for the installation of solar thermal, helping to reduce the upfront costs of the technology; and
- Education and training - as a first mover in the deployment of the technologies, Austria has developed long-term training and education programmes delivered at a regional level.

In the first part of phase 3, interest in self-building solar thermal systems declined, resulting in slower growth in the installed capacity. In the second part of the phase companies specialising in solar thermal technology were established, leading to renewed interest and growth in the installation of new systems. This was supported by a stable energy policy throughout Austria.

The decline in phase 4 is, as for heat pumps, due to competition with other renewable technologies, namely Solar PV and Air Source Heat Pumps. Additionally the financial crisis could also have had an impact during this phase.

---

[20] Austria Solar (2013) *35 JAHRE SOLARENERGIE - RÜCKBLICK UND AUSBLICK*, 2013, http://www.solarwaerme.at/docs/917.pdf

## 3.4 Comparison to the UK

Austria has one of the most mature renewable heating markets in Europe. The market began wide-scale development in the 1970's and the Austrian economy has benefited from first mover advantage for several of the technologies explored in this research. By comparison, the UK renewable heating market is comparatively immature and the economy has not benefited in such a way.

The deployment of the renewable heat technologies in UK was equivalent to 118 kWth/capita in 2013. In comparison, the earliest data available for Austria is from 2004 and reports deployment equivalent to 396 kWth/capita; over three times the deployment in the UK some nine years earlier.

For heat pumps the figures are also as striking, with deployment equivalent to 15 kWth/capita in 2013 in the UK. This is compared to a deployment equivalent to 98 kWth/capita in 2002 in Austria. Again for solar thermal the figures are in stark contrast. The UK reported deployment equivalent to 32 kWth/capita in 2013. This compares to 107 kWth/capita in Austria in 2002.

The drivers in the Austrian heating market are clearly different to those experienced in the UK. The prices of counterfactuals (e.g. oil boilers) in Austria have historically been subject to higher levels of taxation than the UK.[21] Therefore the costs of operating renewable heat technologies can be considered more competitive than in the UK.

With regard to the financial mechanisms offered by Government, support (in for the form of grants) for renewable heat technologies in Austria has been in place for over 25 years in many cases, and is provided in a relatively stable policy environment. The delivery agents in Austria have also remained stable and as a result, there is familiarity within the country on where support can be obtained. The same level of consistency has not been experienced in the UK, which goes some way to explaining the significantly lower levels deployment.

Key drivers for the bioenergy technology group in Austria have been the high level of availability of biomass feedstock and high levels of entrepreneurship within the agriculture and forestry sectors. Austria has been successful in harnessing the synergies between these two aspects to forge a highly competitive supply chain. In UK, however, whilst not bereft of feedstock and having a heritage of strong engineering and manufacturing capability, these two potential drivers have combined together to produce any significant supply chain.

## 3.5 Summary of Drivers

The Austrian renewable heat market has experienced a variety of drivers since the mid 1970's onwards. The key drivers identified in the research are summarised in Table 0-1. These are derived from the analysis provided in Annex 0.

[21] 30% of Austrian households are connected to the gas grid - Statistics Austria (2010) Electricity- and Natural Gas Consumption in Austrian Households 2008, 2010, http://www.statistik.at/web_en/static/electricity-_and_natural_gas_consumption_in_austrian_households_2008_057086.pdf

**Table 0-1: Summary of Key Renewable Heat Drivers in Austria**

| Driver | Description | Bioenergy | | Heat Pumps | | Solar Thermal | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1950s to mid-1990s | Mid 1990s to present day | 1970s to 1990s | 2000s to present day | 1970s to 1989 | 1990 to 1996 | 1997 to 2007 | 2008 to present day |
| **Taxation on energy** | Due to high levels of taxation on energy in Austria, counterfactuals to fossil fuels are typically cost effective | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **Spikes in energy costs** | The oil crisis in the early and late 1970s provided a key kick start to many technologies by providing an incentive to invest in alternatives to oil prices | ✓ | × | ✓ | × | ✓ | × | × | × |
| **Long term financial support** | Many of the Länder have provided grants for the installation of the RHTs, helping to reduce the upfront | ✓ | ✓ | × | ✓ | ✓ | ✓ | ✓ | ✓ |
| **Education and training** | As a first mover in the deployment of the technologies, Austria has developed long-term training and education programmes delivered at a regional level | ✓ | ✓ | ✓ | ✓ | × | ✓ | ✓ | ✓ |
| **Stability of Energy Policy** | The Länder have provided stable policy within each region. They have responsibility to deliver aspects of energy policy and have aligned it with other policy areas (e.g. energy efficiency) | ✓ | ✓ | ✓ | ✓ | × | ✓ | ✓ | ✓ |
| **Environmental movement** | A significant environmental movement in the early 1980's helped increase awareness and acceptance of RHTs | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **Entrepreneurship** | Many of the technologies within Austria have been 'home grown' and initially developed by the forestry and agricultural sector | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **Natural resources** | Austria is endowed with a high percentage of forestry cover with a longstanding forestry industry. | ✓ | ✓ | × | × | × | × | × | × |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Utility company support** | Some utility companies in Austria have provided preferential tariffs for the operation of heat pumps | × | × | × | ✓ | × | × | × | × |

# 4. Renewable Heating in Denmark

Alongside Austria, the renewable heating market in Denmark can be considered to be one of the most mature markets in Europe. In the following sections a breakdown of the deployment of the three main renewable heating groups, bioenergy, heat pumps and solar thermal is provided. Additionally, a summary of the key drivers and a discussion of their relevance to the UK market is provided.

## 4.1 Bioenergy Technology Deployment

As outlined in Section 0, the majority of all renewable heat in Denmark comes from bioenergy, including biodegradable waste, bioliquids, solid biomass (i.e. woody biomass), and biogas. In 2012, 91% (or 101 PJ) of all renewable heat generated was from these feedstocks.

Figure 6 shows the proportional share of each of these feedstocks from 1975 to 2012. The largest group of fuels is the solid biomass fuels, which made up 83% of the bioenergy total in 2012; a proportion which has remained similar over the last 30 years.

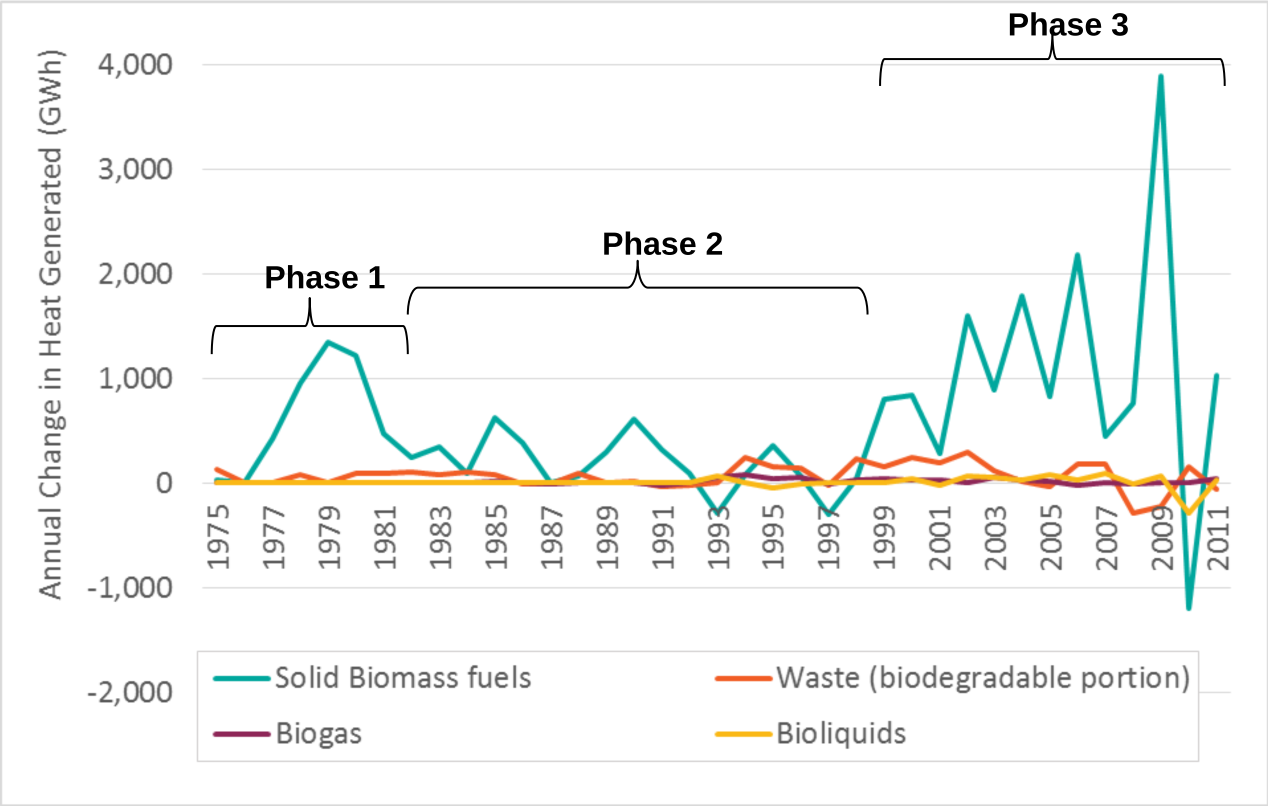
Per capita, Denmark has a large supply of solid biomass feedstocks, which has been a clear driver for the deployment across the domestic, non-domestic and district heating sectors. Over the years, Denmark has largely been self-sufficient in these feedstocks, although in more recent years', high levels of installations of pellet boilers led to around 25% of biomass being imported in 2012 – 60% of which was pellets.

Since 1975, the generation of renewable heat from biomass has grown at grown at an annual geometric growth rate of 7 per cent, but has shown large variation from year to year.

The findings from our interviews and literature review suggest that the sector can be divided in to two separate phases of growth. These can be summarised as follows:

- Phase 1: Emergence and early deployment - 1970s to the early 1980s: (22% avg. growth);
- Phase 2: Steady growth - early 1980s to 1990s: (3% avg. growth); and
- Phase 3: Exponential growth - 2000s to the present day: (7% avg. growth).

**Figure 6: Annual Heat Generated by Bio-Energy by Fuel Type, Denmark, 1975-2012**




*Source: Danish Energy Agency (2013)*[22]

During the first phase, the key drivers for the growth in bio-energy are:

- The second oil crisis in 1979; and
- The introduction of a tax on oil in 1977.

Both of these drivers led to large increases in the price of fuel for households. The majority of Danish households at the time were heated by oil boilers, so there was a clear incentive here to switch to a cheaper fuel.

The growth in the sector was significantly slower than in the early years in the second phase. The market was supported by the drivers outlined in Phase 1, but was hindered by the following barriers:

- The discovery of natural gas in the North Sea in 1982; and
- The associated large expansion of the heat and gas networks

During the final phase a number of new incentives have been introduced to encourage the installation of RHTs. These include:

- Building regulations requiring either a high degree of insulation or installation of RHTs;
- The 2000 law enabling mandatory connection to the district heating network; and
- Tax incentives for home renovations have led to pellet boilers being installed in the last ten years.

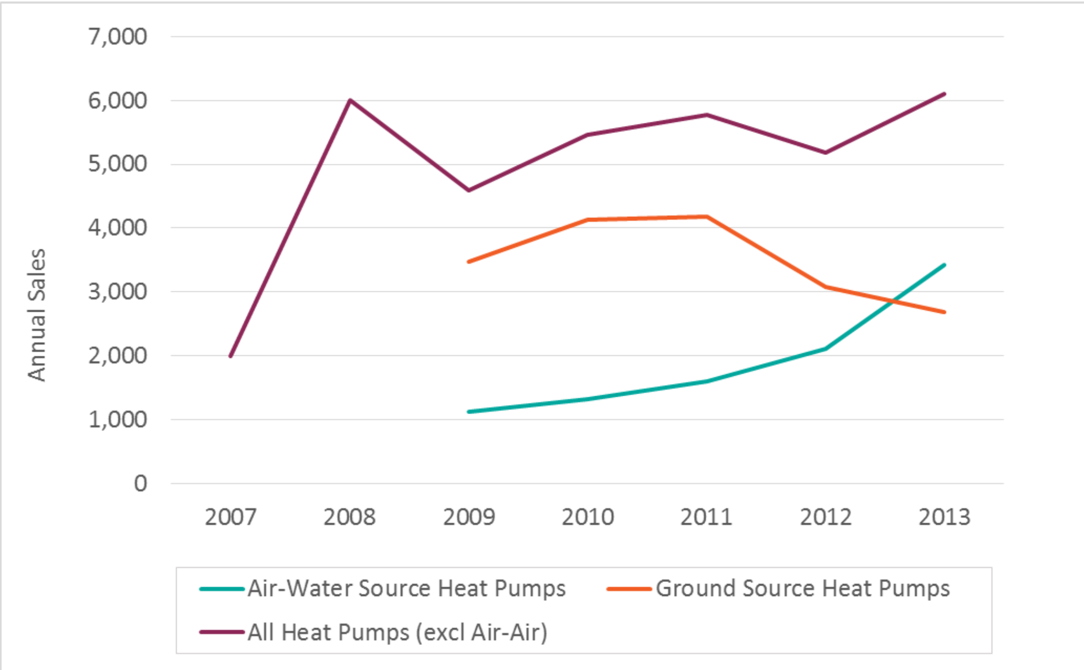
[22] Danish Energy Agency (2013) *Energy Statistics 2012*, 2013, http://www.ens.dk/sites/ens.dk/files/info/tal-kort/statistik-noegletal/aarlig-energistatistik/energy_statistics_2012.pdf

## 4.2 Heat Pump Technology Group

Heat pumps are not widely used in Denmark, whether in domestic or non-domestic properties. As Figure 22 shows, recent combined annual sales of GSHPs and ASHPs have totalled around 5,500 over the past six years, with an emerging trend for a shift towards ASHPs. It should be noted that air-to-air source heat pumps, which are relatively widespread in summer houses in Denmark (where the lack of a 'wet' heating system make them a more appropriate choice), are not included in this analysis.[23] The total combined number of GSHPs and ASHPs currently installed in Denmark is around 60,000.[24]

Heat produced by all types of heat pumps in Denmark (including air to air source heat pumps) totalled around 8.6 PJ in 2012, which represents around 8% of all renewable heat generated in Denmark. The average annual geometric growth rate of heat generated from 1975 to 2012 is 19 per cent. This includes air-to-air source heat pumps, however, and therefore it is unclear how much of this can be considered to be renewable.

**Figure 7: Annual Sales of Heat Pumps in Denmark - 2007-2013**




*Source: Catalyst Strategic Consultants (2013[25]) and Det Økologiske Råd (Danish Eco Council) (2014)*[26]

This sector has experienced very few drivers in the market when compared to other renewable heat technologies in Denmark. The key driver for heat pumps is similar to biomass, i.e. the imposition and regular increase in the level of taxation on fossil fuels. An additional incentive for heat pumps (over biomass), however, exists in the form of a lower tax on electricity for those who consume it for heating and use more than 4,000 kWh of electricity per year.

---

[23] Det Økologiske Råd (Danish Eco Council) (2014) *Varmepumper til Boligopvarmning (Heat Pumps for Household Space Heating)*, October 2014, http://www.ecocouncil.dk/documents/publikationer/1618-141007varmepumper/file

[24] At the same time, there have been around 16,000 air to air source heat pumps installed annually since 2007

[25] Catalyst Strategic Consultants (2013) *Nye Forretningsmodeller til Acceleration af Varmepumpe-Udrulning (New Business Models to Accelerate the Deployment of Heat Pumps)*, Report for Dansk Energi, June 2013, http://www.danskenergi.dk/~/media/Varmepumpe/NyeForretningsmodellerAccelerationVarmepumpe-udrulning.ashx

[26] Det Økologiske Råd (Danish Eco Council) (2014) *Varmepumper til Boligopvarmning (Heat Pumps for Household Space Heating)*, October 2014, http://www.ecocouncil.dk/documents/publikationer/1618-141007varmepumper/file

## 4.3 Solar Thermal Technology Group

Solar thermal has been installed in domestic households in Denmark since the late 1970s, although the technology has never had a large market share of the renewable heat market. In 2012, total generation from solar thermal was around 870 TJ, or 1% of total renewable heat. In 2013, it was estimated there were the equivalent of 535 MWth, almost 765,000 $m^2$, of solar thermal collectors installed in Denmark.[27] Of these, two-thirds are large-scale installations (more than 1,000 $m^2$ or 700 $kW_{th}$).

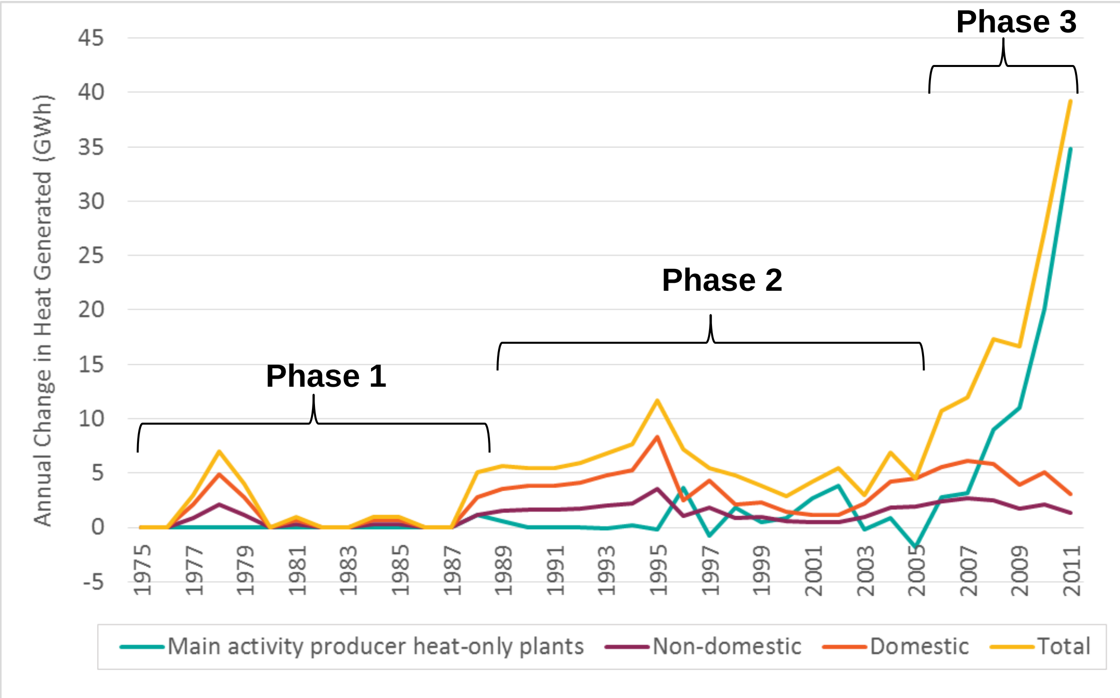
Figure 8 shows the division of the end users of the heat generated by the solar thermal installations. In 2012, approximately 40% was generated as part of district heating schemes (either to supplement gas-fired CHP or involving underground thermal storage of heat during summer for use in winter; usually in conjunction with a heat pump). A further 20% was generated directly by the non-domestic sector (including the public sector and multi-occupant dwellings) and the remaining 40% directly by the domestic sector. This profile has changed significantly since the situation 10 years ago, when only 10% was generated as part of district heating schemes and more than 60% was generated directly by the domestic sector. This clearly shows that recent developments in the solar thermal industry have been driven by large-scale projects.

Since 1978, the generation of solar thermal heat grew at an average annual geometric growth rate of 13 per cent. Growth, however, has not been uniform and can be divided in to three separate phases of growth. These can be summarised as follows:

- Phase 1: Emergence and early deployment – 1975-1989: (18% avg. growth);
- Phase 2: Steady growth – 1990-2007: (10% avg. growth); and
- Phase 3: Exponential growth – 2008 to the present day: (13% avg. growth).

[27] ESTIF (European Solar Thermal Industry Federation) (2014) *Solar Thermal Markets in Europe: Trends and Market Statistics 2013*, June 2014, http://www.estif.org/fileadmin/estif/content/market_data/downloads/solar_thermal_markets2013_v01.pdf

**Figure 8: Heat Generated by Solar Thermal Installations by End User, Denmark, 1975-2012**




*Notes: Heat-only plants refers to heat generated by District Heating*
*Source: Danish Energy Agency (2013)*[28]

Whilst there have been distinct phases of growth, many of the drivers for solar thermal have been consistent. Importantly, between 1979 and 2001, solar thermal collectors were supported via a government grant.[29] The long duration of this support has been of great importance to the development of the supply chain in Denmark.

Additional drivers during the first phase include:

- The second oil crisis in 1979; and
- The introduction of a tax on oil in 1977

During the second phase the market in Denmark began to mature, Solar thermal was seen as high priority during this period and the growth was supported by a number of drivers:

- Large-scale informational campaign by the Danish Energy Agency and by gas suppliers, which encouraged customers to install a solar thermal system with their new gas boilers. [30]
- Government grant (until 2001); and
- Taxation on fossils fuels.

In phase 3 of deployment, the market in Denmark has expanded once more. Denmark can now be considered the European leader in large-scale solar thermal projects. This recent expansion has largely been driven by large-scale projects aiming to avoid burning gas in district heating networks due to rising costs.

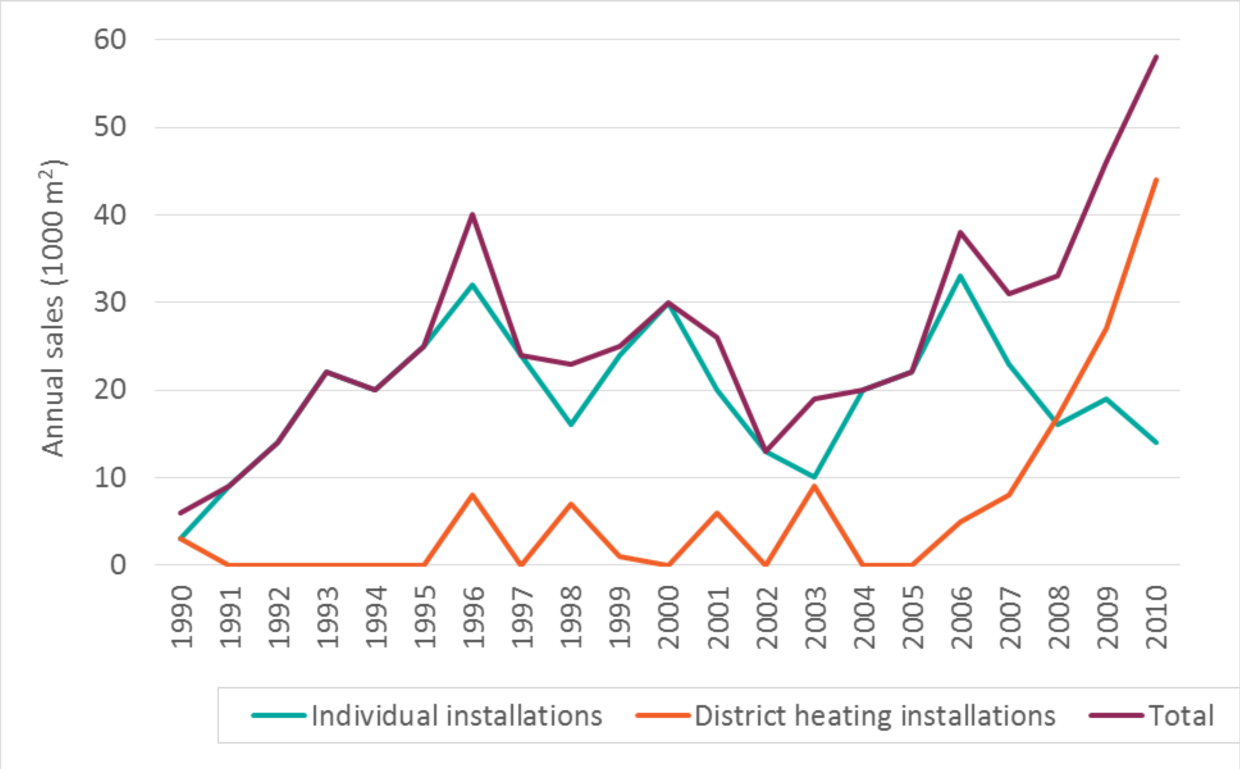
[28] Danish Energy Agency (2013) *Energy Statistics 2012*, 2013, http://www.ens.dk/sites/ens.dk/files/info/tal-kort/statistik-noegletal/aarlig-energistatistik/energy_statistics_2012.pdf

[29] Solvarme Center (2011) *Fakta om Solvarme: Markedudvikling (Facts about Solar Thermal: Market Development)*, August 2011, http://www.altomsolvarme.dk/solvarmecenter/dokumenter/faktaark/G10-markedsudvikling.pdf

[30] *Ibid*

Figure 9 shows recent sales figures of solar thermal installations over the past twenty years, which clearly shows the increase in new district heating schemes since 2008.

**Figure 9: Annual Sales of Solar Thermal Collectors, Denmark, 1990-2010**




*Source: Solvarme Center (2011*[31]*)*

## 4.4 Comparison to the UK

The renewable heating market in Denmark began wide-scale development in the 1970's and is, like Austria, one of the most mature markets in Europe. By comparison, the UK renewable heating market is immature.

The UK reported deployment of biomass equivalent to 118 kWth/capita in 2013. The earliest data available for Denmark is from 1980 and it reported deployment equivalent to 872 kWth/capita; over seven times the deployment in the UK some 33 years earlier.

For heat pumps the figures are also as striking, with deployment equivalent to 15 kWth/capita in 2013 in the UK. This is compared to a deployment equivalent to 17 kWth/capita in 1980 in Denmark. For solar thermal the UK reported deployment equivalent to 32 kWth/capita in 2013. This is similar to the levels of deployment in Denmark of 32 kWth/capita in 2010 in Denmark.

The drivers and type of deployment of renewable heat in Denmark are relatively distinct and there are a number of unique features which are not present in the UK market. The widespread deployment of district heating in Denmark has favoured the deployment of bioenergy technologies, and policies such as the 2000 law on mandatory connections to district heating networks have encouraged significant deployment. For the UK, the deployment of renewable heat via district heating networks is relatively rare. Additionally policy measures aimed at supporting the

[31] Solvarme Center (2011) *Fakta om Solvarme: Markedudvikling (Facts about Solar Thermal: Market Development)*, August 2011, http://www.altomsolvarme.dk/solvarmecenter/dokumenter/faktaark/G10-markedsudvikling.pdf

development of district heating networks are less authoritative in comparison to the policies observed in Denmark.

Like Austria, the price of counterfactuals (e.g. oil and gas boilers) in Denmark are subject to higher levels of taxation than in the UK. Therefore the costs of operating renewable heat technologies can be considered more competitive than in the UK.[32]

A key driver for the bioenergy technology group in Denmark is the availability of biomass feedstock in the form of straw. Denmark has invested significant research and development in to straw combustion technologies to maximise the potential for this feedstock and technology. In the UK, there has not been any such specific strategic focus on any one type of feedstock.

## 4.5 Summary of Drivers

Like the Austrian renewable heating market, the Danish market has experienced a variety of drivers since the mid 1970's onwards that has led to a mature market. The key drivers identified in the research are summarised in Table 0-1.

[32] Less than 16% of households in Denmark are connected to the gas grid (the total number of gas grid customers, including power stations and industry was 420,000 in 2013; the total number of households in Denmark is 2.6 million - http://www.naturgasfakta.dk/copy_of_miljoekrav-til-energianlaeg/naturgas-i-danmark

**Table 0-1: Summary of Key Renewable Heat Drivers in Denmark**

| Driver | Description | Bioenergy | | | Heat Pumps | Solar Thermal | | |
|---|---|---|---|---|---|---|---|---|
| | | 1970s to the early 1980s | Early 1980s to 1990s | 2000s to present day | 1970s to present day | 1975-1989 | 1990 - 2007 | 2008 to present day |
| **Spikes in energy costs** | The oil crisis in the early and late 1970s provided a key kick start to many technologies by providing an incentive to invest in alternatives to oil based heating. | ✓ | × | × | ✓ | ✓ | × | × |
| **Taxation on energy** | Due to high levels of taxation on energy in Denmark, counterfactuals to fossil fuels are typically cost effective.<br><br>Tax exemptions for biomass combined with high energy taxes on fossil fuels have enabled biomass to become a financially viable alternative for district heating and domestic installations. However, as businesses are eligible to have energy taxes on process heating refunded, this key financial driver has not been relevant for the industrial sector, leading to low levels of deployment of renewable heat technology for process heating | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **Long term financial support** | Government funding programmes have been key to ensuring deployment of supported technologies, particularly domestic solar thermal installations and biomass CHP | × | ✓ | ✓ | ✓ | ✓ | ✓ | × |
| **Building regulations** | The energy usage of new buildings has to be below a minimum level. Energy provided is multiplied by a particular factor, with factors for renewable heating technologies lower than for non-renewables, thus incentivising their installation in new builds. | × | × | ✓ | ✓ | × | × | ✓ |
| **Government regulations promoting district heating** | Due to policies such as mandatory connections to the district heating network and a ban on electric heating in new residential buildings and decentralised heating planning, district heating networks have been able to rely on a consistent number of customers, enabling them to make significant investments in renewable heat technology. | ✓ | ✓ | ✓ | × | × | × | × |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Access to biomass feedstock** | The availability of forestry and agricultural residues, along with a ban on burning straw on fields, has provided a steady source of biomass feedstock for both small- and large-scale installations. | ✓ | ✓ | ✓ | × | × | × | × |

# 5. Renewable Heating in Germany

The deployment of renewable heating technologies in Germany is relatively immature when compared to Austria and Denmark. In the following sections a breakdown of the deployment of the three main renewable heating groups, bioenergy, heat pumps and solar thermal is provided. Additionally, a summary of the key drivers and a discussion of their relevance to the UK market is provided.

## 5.1 Bioenergy Technology Deployment

Bioenergy represents the largest proportion of the renewable heat sector with around an 88% share. The majority of bioenergy is used within the domestic sector in the form of woody biomass which constitutes 50% of the entire German renewable heat sector. The next largest sector is biogas at 9% of the total renewable heat sector.

### Biomass

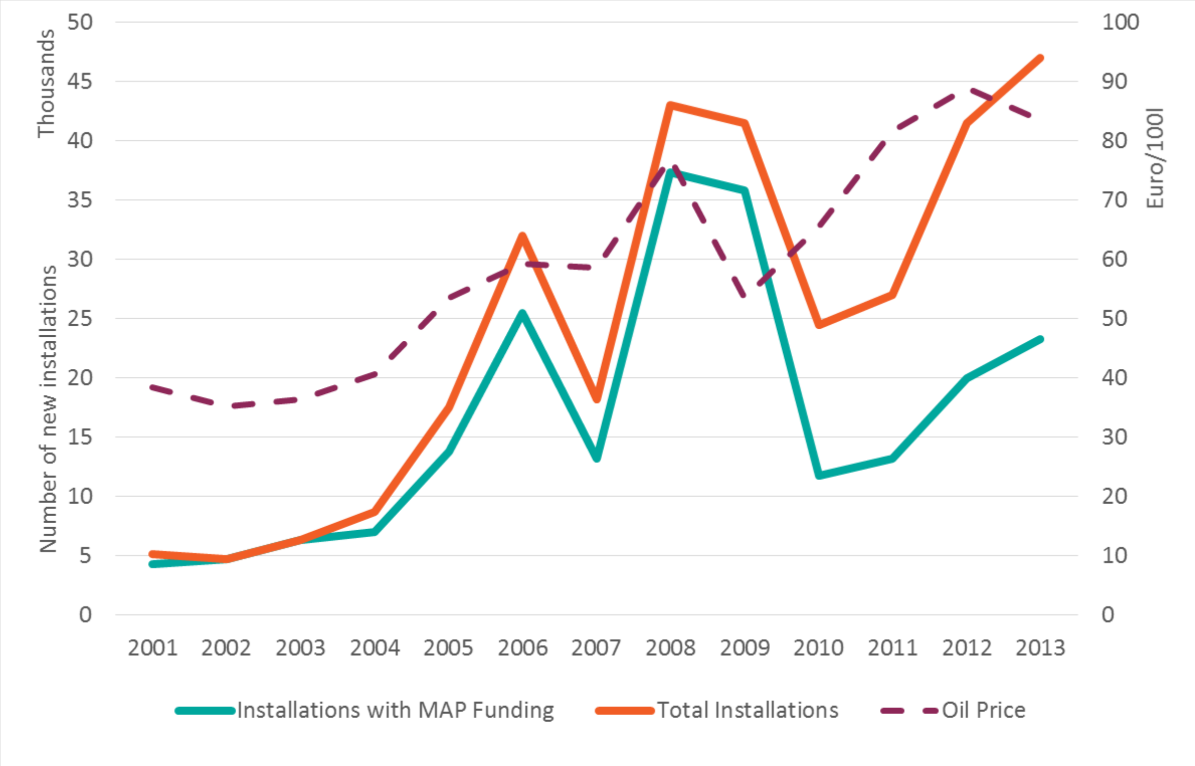
The number of pellet boiler installations has increased gradually since 2001. This is shown in Figure 10, which charts this increase alongside changes in the price of oil during this period.[33] [34] Figure 10 also charts the number of installations funded and not funded under the Market Incentive Program (MAP) program, a Government support scheme.

Data is also available on the quantity of renewable heat produced on an annual basis by biomass plants within Germany dating back to 1990. Since 1990 to 2012, the amount of heat generated by the bioenergy technology group has grown at an annual geometric growth rate of 6 per cent, but has shown large variations from year to year that cannot be characterised in distinct phases.

[33] All of the experts interviewed for this study concurred with the assertion that the retail oil prices were and are the largest single factor in the increase of biomass boilers

[34] Oil prices are 'Light fuel oil' supplied to households in €/100 litres in 2010 prices from the national energy statistics provided by the BMWi.

**Figure 10: Pellet Heating System Installations and Funding in Germany**




*Source:* [*www.biomasseatlas.de*](http://www.biomasseatlas.de)

There have been relatively few key drivers in the market. These have been identified as:

- The introduction of new pellet boiler technologies in the late 1990s;
- Government support, through the MAP (the main funding mechanism for renewable heat installations), which has been in place from 2000; and
- Taxation on fossil fuels, which have made renewable heat technologies more competitive.

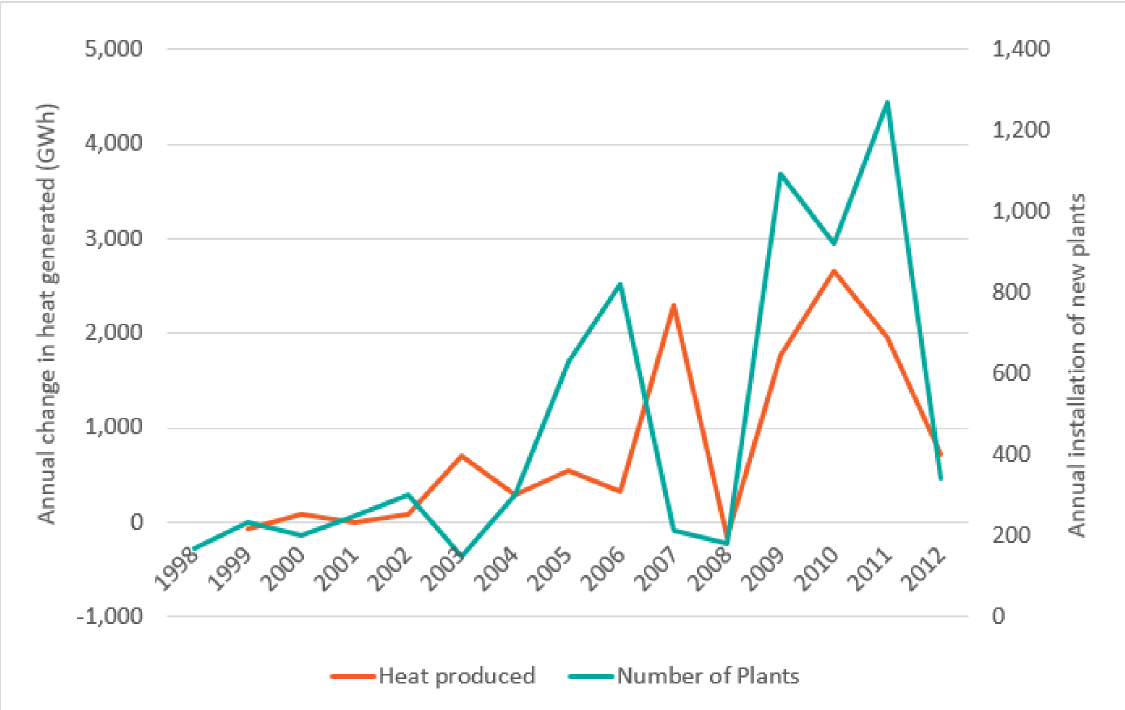
## Biogas

Around 50% of the biogas that is produced in Germany is burned in on site gas engines, with the heat generated potentially then exported for use locally. The remaining 50% is sent by pipelines to other CHP plants or treatment plants for upgrading to biomethane prior to direct injection into the natural gas network.

According to discussions with the German Biogas Association, 90% of biogas that is converted to biomethane for grid injection is then subsequently burned in gas-fired power plant (which may generate CHP) with the rest being used as a transport fuel. A very small amount is theoretically ‘sent’ to households for heating and cooking as some gas suppliers provide tariffs that allow householders to choose to use biomethane in a similar way that some electricity suppliers have ‘green’ tariffs for renewable electricity. The growth in renewable heat generated from biogas in Germany has grown at an annual average geometric growth rate of 17 per cent, though it is noted that there have been a number of fluctuations within this period.

The drivers for the deployment of biogas in Germany are believed to largely driven by Government funding. Currently, funding for biogas generation can be sourced from a combination of BAFA – the government agency administering MAP subsidies and loans from KfW, a government owned development bank. Biogas CHP plants that are connected to a district heat network can be eligible for funding from BAFA of up to €10 million per project or a maximum of 40 per cent of the capital costs, although there are very stringent rules in place for the receipt of this funding. The specific drivers explaining the fluctuations in 2007-2008 and in 2012 have not been identified in the research, however it is understood that the financial crisis may have had an impact.

**Figure 11: Biogas Plant Numbers and Heat Produced in Germany[35]**




*Source: INER (2014)*

## 5.2 Heat Pump Technology Group

A summary of the deployment of heat pumps in Germany is provided in Figure 12. The figure shows key changes in the market in Germany since 2001.

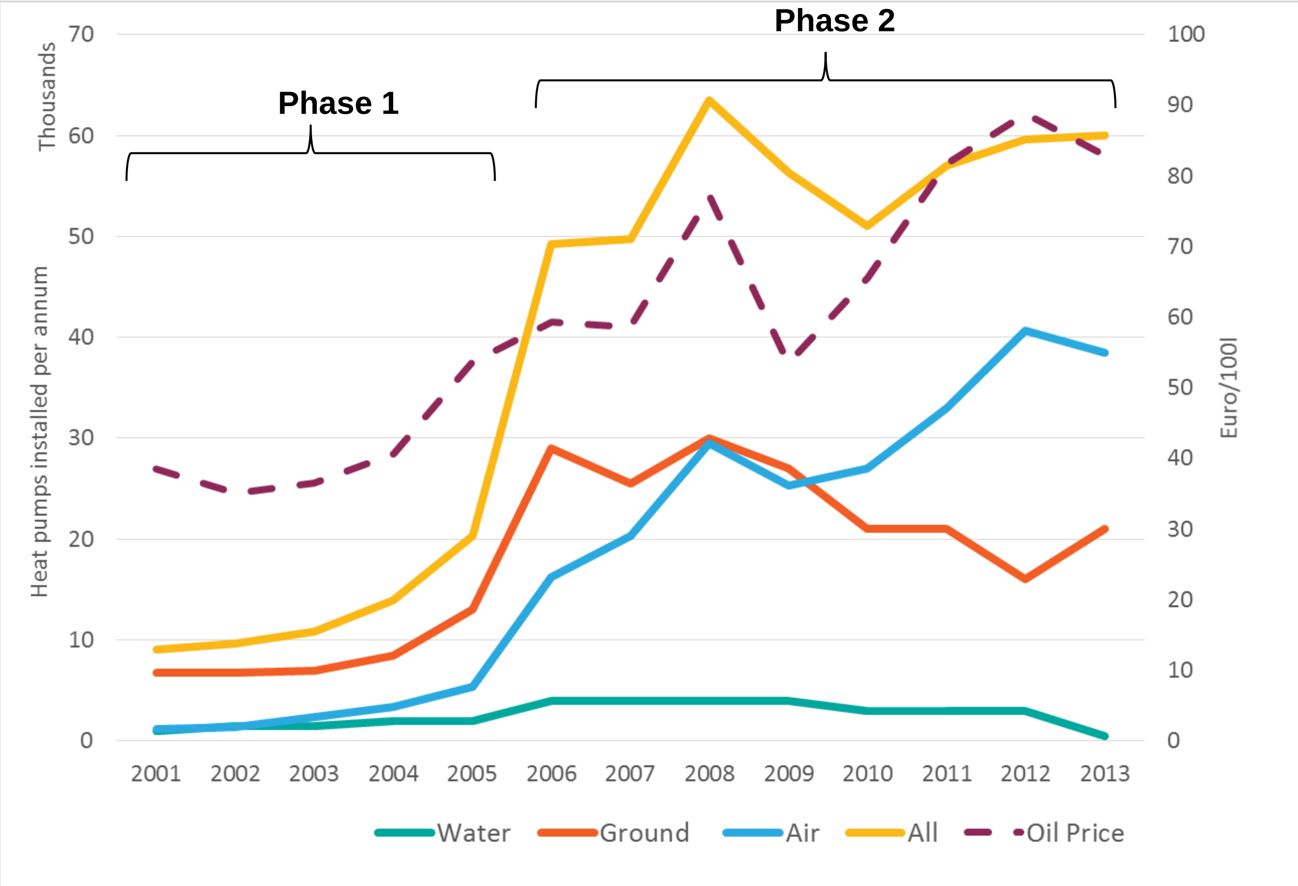
Data on the quantity of renewable heat produced on an annual basis by heat pumps within Germany since 1990 is shown in Figure 12. The figure shows that the growth rate over the last 10 years has fluctuated quite widely, but has achieved an annual geometric growth rate in heat generated of 7 per cent.

The sector can be divided in to two separate phases of growth. These can be summarised as follows:

- Phase 1: Emergence and early deployment – 1990s to 2005: (2% annual growth); and
- Phase 2: Exponential growth – 2006 to the present day: (20% annual growth).

[35] Includes CHP plants.

**Figure 12: Heat Pump Installations by Technology Type**[36]




*Source: German Heat Pump Association*

In phase 1, the market for heat pumps was relatively stable. As per biomass, discussed in Section 0, the growth in the heat pump market can be attributed to rising fossil fuel prices, which peaked in 2008.

During the second phase, mass deployment took place. A number of drivers have been identified as stimulating the growth during this phase:

- Stringent building efficiency requirements dictated by the Energy Saving Ordinance (EnEV) (responsible for a rapid rise in deployment in 2006);[37]
- Government support through MAP funding – introduced for heat pumps in 2007,

In addition to the drivers, there were also some barriers to the deployment. MAP funding was briefly cut in 2010 and soon after this new homes were also deemed ineligible for funding. These developments saw the total number of annual installations fall slightly before regaining an equilibrium of just below the high point of 2008.

MAP funding for heat pumps is now a fairly small part of the market which signifies that the technologies are sufficiently mature to be economically competitive. It is interesting to note that the supply chain for heat pumps in Germany was able to accommodate the rapid change in growth during phase 2.

[36] Air Source heat pumps include air-water and air-air source heat pumps.

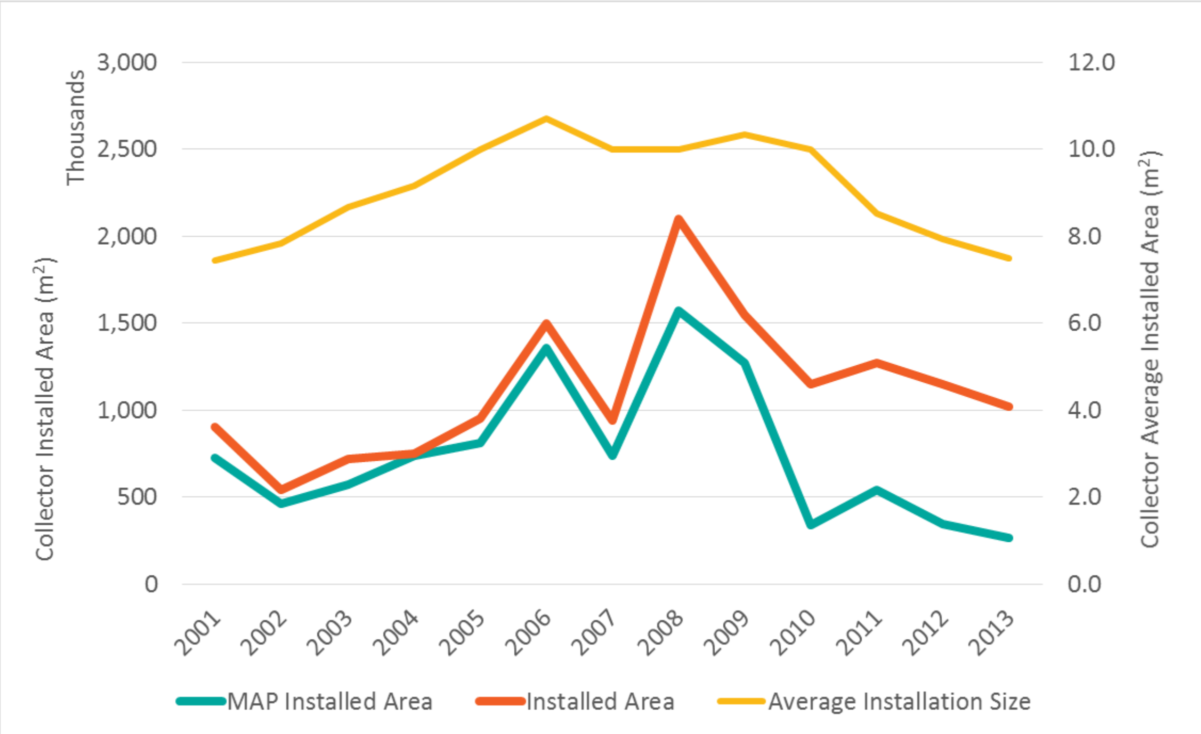
[37] Note that in 2007 the VAT rate was increased in Germany from 16% to 19% and this is believed to have also contributed to the spike in 2006.

## 5.3 Solar Thermal Technology Group

Figure 13 shows how the market for solar thermal has developed since 2001. Similar to trends seen in the other technology groups, the early part of the 2000s saw many of the installations of solar thermal being supported by MAP funding.

Data is also available on the quantity of renewable heat produced on an annual basis by solar thermal installations in Germany dating back to 1990. Since 1990, the amount of heat generated by solar thermal has grown at an annual geometric growth rate of 19 per cent, and has shown relatively steady growth throughout the period.

**Figure 13 – Area of Solar Thermal Installation and Funding in Germany**




*Source: www.solaratlas.de*

The deployment of solar thermal is understood to have been largely driven by government support. Up to the late 1990s, there was no consistent federal policy to support solar thermal deployment; however, the market was able to grow through the support from individual states across Germany. These states implemented different systems, including some which supported costs of solar thermal of up to 25%.

In 1998, the MAP program started and provided funding for solar thermal technologies, but as mentioned above, this occasionally ran out of funds and even stopped for a few months in 2010. This has caused uncertainty in the market, both for households and businesses considering solar thermal, but also investors.

## 5.7 Comparison to the UK

The renewable heat market in Germany is less mature than those in Austria and Denmark, but nonetheless is still regarded as one of the most mature markets in Europe.

In comparison to Germany, the UK reported deployment of biomass equivalent to 118 kWth/capita in 2013. The earliest data available for Germany is from 1990 and it reported deployment equivalent of 386 kWth/capita; over three times the level of deployment in the UK some 14 years earlier.

For heat pumps, UK deployment was equivalent to 15 kWth/capita in 2013. This is compared to a deployment equivalent of 20 kWth/capita in 1990 in Germany.

For solar thermal, the UK reported deployment equivalent to 32 kWth/capita in 2013. In comparison, the level of deployment in Germany reached a similar level of 31kWth/capita in 2004 – nearly a decade prior to the UK.

Despite the market being more mature than the UK, the market in Germany developed later than the markets in Austria and Denmark. However, like these markets, deployment has largely been driven by taxation on fossil fuels.[38] As discussed in earlier sections this driver is far less of a force at present in the UK market and therefore the equivalent cost of operating a fossil fuelled heating system is cheaper in the UK than in Germany. Additionally, the total price associated with installing a gas fired boiler is higher in Germany than in the UK. Consequently, counterfactuals in the UK are more attractive from a financial perspective.[39]

The most recent growth in the market has been driven by the MAP scheme which has phased in (and out) support for renewable technologies since 1998. The amount of financial support offered to renewable heating technologies, however, has experienced great volatility in recent years. It has therefore had the effect of both incentivising and de-incentivising further market development, albeit the net effect appears to have been positive. Whilst no direct comparison can be made to the UK, there are some similarities associated with the reliance of a single centralised scheme (controlled by central Government – in contrast to the Lander control in Austria) as a key driver to support the deployment of renewable heating technologies.

Building regulations have also been highlighted as a driver for the deployment of renewable heating technologies in Germany. The impact of this driver is ultimately dependent on the number of new homes being created each year, but there are similarities between this driver in Germany and in the UK.

The offer of utility company support for the heat pumps in Germany via cheaper tariffs is well established and has been found to be a key driver to their deployment. Equivalent initiatives are not understood to be in place in the UK and therefore this driver is not currently present in the UK.

## 5.5 Summary of Drivers

Like other Member States, the German renewable heating market has been influenced by a number of drivers over the last four decades. However, reflecting the fact that the German market is less mature than those observed in Austria and Denmark, the number of drivers is lower than in those markets. Additionally unlike Austria and Denmark, long term stable policy is a key driver that has not always been present in Germany. The key drivers identified in the research are summarised in Table 0-1.

[38] With 42% of households connected to the gas grid, natural gas is the most important source of heat in German houses = http://www.bmwi.de/DE/Themen/Energie/Konventionelle-Energietraeger/gas.html

[39] Delta Energy & Environment Ltd (2014) Comparing the future of the Dutch and French heating markets, 8 May 2014, http://www.delta-ee.com/images/RS_Webinar_FR_NL_comparison_May_2014.pdf

**Table 0-1: Summary of Key Renewable Heat Drivers in Germany**

| Driver | Description | Bioenergy | Heat Pumps | | Solar Thermal |
|---|---|---|---|---|---|
| | | 1990s to present day | 1990s to 2005 | 2006 to present day | 1990s to present day |
| **Taxation on energy** | Due to high levels of taxation on energy in Germany, counterfactuals to fossil fuels are typically cost effective. The second oil crisis in the late 1970s provided a key kick start to many technologies. | ✓ | ✓ | ✓ | ✓ |
| **Building regulations** | Building regulations have promoted the installation of renewable heat technologies in new buildings | ✓ | ✓ | ✓ | ✓ |
| **Government Capital Funding (MAP)** | Initially a large driver in the uptake of technologies that were not as competitive cost wise as oil and gas initially. However, the cuts (and subsequent reinstatement) to the funding in 2010 has created volatility in the market. | ✓ | × | ✓ | ✓ |
| **Utility company support** | Some utility companies in Germany have provided preferential tariffs for the operation of heat pumps. | × | ✓ | ✓ | × |

# 6. Renewable Heating in the Netherlands

The deployment of renewable heating technologies in the Netherlands is immature and similar levels of deployment can be observed when compared to the UK. In the following sections a breakdown of the deployment of the three main renewable heating groups, bioenergy, heat pumps and solar thermal is provided. Additionally, a summary of the key drivers and a discussion of their relevance to the UK market is provided.

## 6.1 Bioenergy Technology Deployment

In the Netherlands bioenergy has seen the largest growth in deployment of all RHTs, contributing a 75% share to renewable heat production in 2013. Heat produced from the combustion of municipal solid waste (MSW) provides the largest contribution to renewable heat production, followed by biogas.

Data is also available on the quantity of renewable heat produced on an annual basis by biomass plants within the Netherlands dating back to 1990. Since 1990, the amount of heat generated by bioenergy technology group has grown at an annual geometric growth rate of 1 per cent, though 5 per cent for biogas.

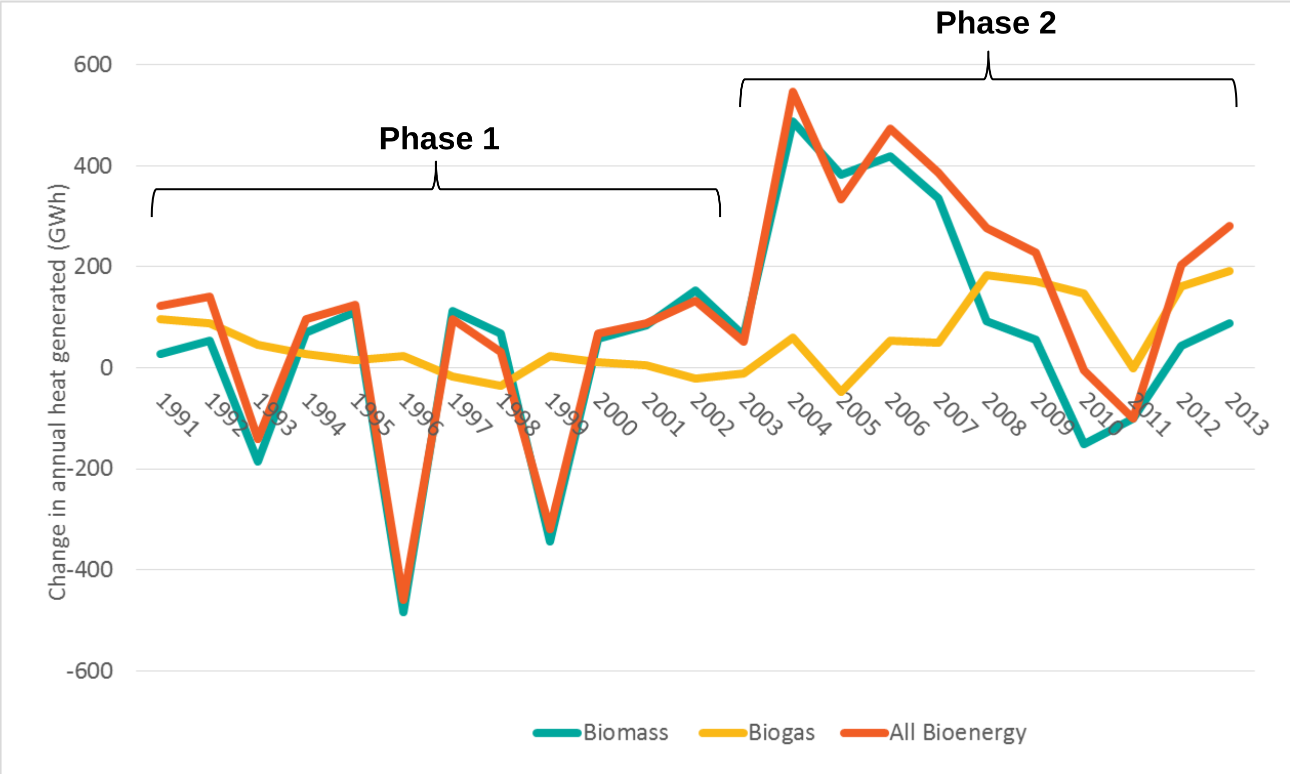
The biomass technology group can be divided in to two separate phases of growth since 1990. These can be summarised as follows:

- Phase 1: Declining Deployment – 1990 to 2002: annual geometric rate of decline of heat generated by biomass of -1 per cent; and
- Phase 2: Variable growth – 2003 to the present day: annual geometric rate of growth of heat generated by biomass of 3 per cent.

During the first phase (1990 and 2002), the generation of renewable heat from biomass decreased; the only market to show a decline. It is understood that there were relatively few drivers during this phase, and that often the technology was competing with natural gas, which was the cheapest source of heating. Unlike a number of the other markets, the Netherlands has a large percentage of households (>95%) connected to the natural gas grid, a heat source which is typically cheaper than biomass.[40] Additionally, the Netherlands in not endowed with large sources of forest cover, and therefore any significant demand would rely upon imports.

[40] http://www.iea.org/publications/freepublications/publication/Oil&GasSecurityNL2012.pdf

**Figure 14: Heat Generation from Bioenergy in the Netherlands 1990-2013**




*Source: Statline (2014)*[41]

During the second phase (2003 – now), the market in the Netherlands has been stimulated by Government funding to support the installation of biomass technologies. The key funding schemes commenced in 2003 and include the MEP and subsequent SDE schemes.[42] [43] Beyond government support, our research has found that there have been relatively few key drivers in the market, albeit the advent of the city of Rotterdam as Europe's self-proclaimed 'biomass hub', has reduced the costs of imported feedstocks, and therefore is likely to have contributed to growth. Additionally, it is unclear why growth in the heat deployed by biomass has remained static since 2008.

For biogas, the drivers are unclear prior to 2008, but since then the market has been stimulated by the introduction of the SDE, which provides financial support for biogas generated from waste water treatment, anaerobic digestion and the gasification of biomass and wastes.

## 6.2 Heat Pump Technology Group

As shown in Figure 15, heat generation from heat pumps has grown significantly in the Netherlands since the early 1990s. The non-domestic sector has seen the highest levels of deployment.[44] The

[41] http://statline.cbs.nl/StatWeb/publication/?DM=SLEN&PA=7516ENG&D1=0&D2=a&D3=2&D4=a&LA=EN&VW=T

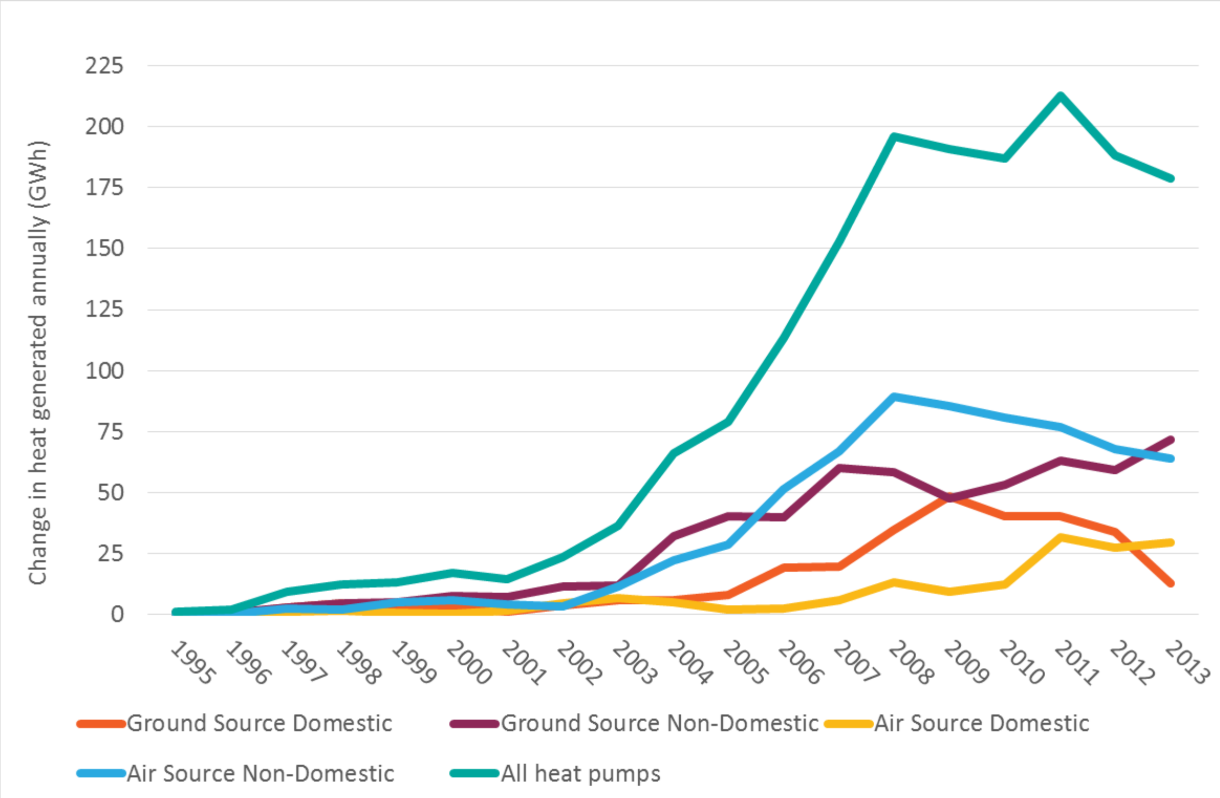
[42] The MEP scheme (Milieukwaliteit van de Elektriciteitsproductie) was introduced in 2003 and was a Government subsidy scheme paid to domestic producers of electricity from renewable sources and CHP who feed-in to the national grid on a per kWh basis

[43] The SDE (stimulering duurzame energie )scheme was introduced in 2008, following the closure of the MEP scheme. The scheme was amended and renamed the SDE+ in 2011. The scheme incentives are structured as feed-in premiums and are financed through a levy on the energy bill of end consumers

[44] It should be noted that air source for non-domestic include air-to-air source heat pumps in addition to air-to-water source heat pumps

growth rate of heat generated has increased exponentially, with an annual geometric growth rate of 28 per cent.

**Figure 15: Annual Heat Generation from Heat Pumps in the Netherlands 1990-2013**




*Notes: Based on the data presented by Statline it is not possible to conclude whether air source heat pumps include air to air source heat pumps.*

*Source: Statline (2014)*[45]

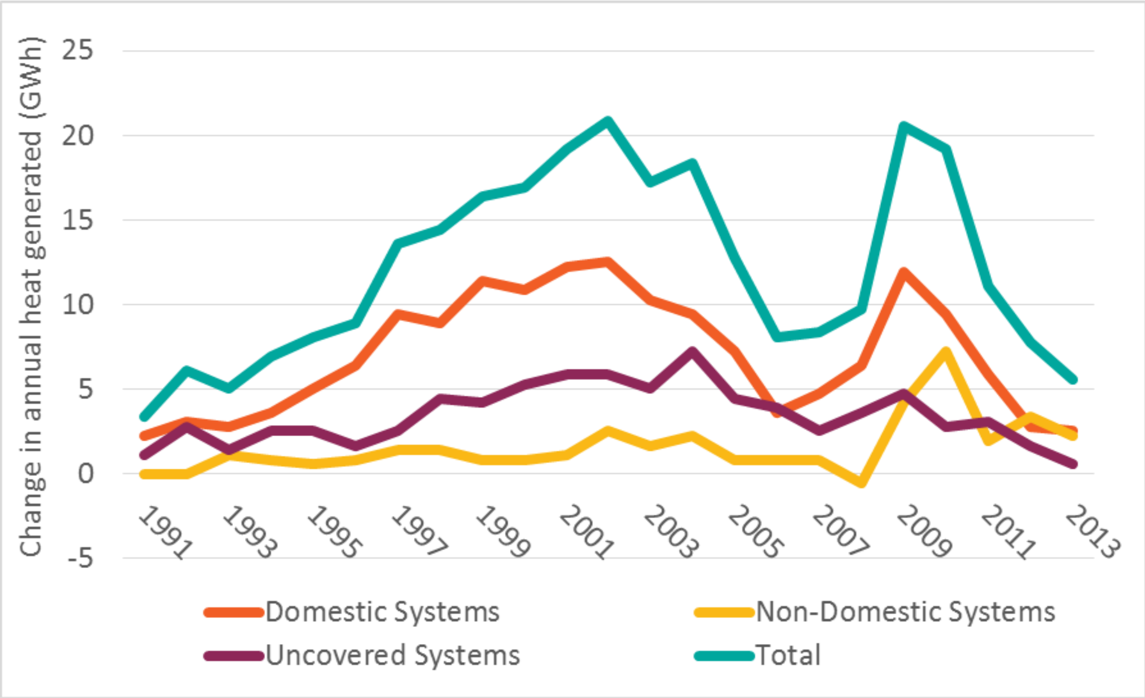
The growth in heat generated by heat pumps has been largely market-led, particularly in the non-domestic sector where there is high demand for cooling as well as heating. This has driven the increased use of 'reversible' air-to-air source heat pumps (the heat from which might not always be considered to be renewable) and open ground loop systems for GSHPs. In the most recent period the growth rate has plateaued. The causes of this are unclear, though it might be somewhat related to the financial crisis in 2008.

## 6.3 Solar Thermal Technology Group

In 2013, solar thermal generation contributed 3 per cent to renewable heat generation and accounted for 1 per cent of total renewable energy generation in the Netherlands. Approximately 55 per cent of solar thermal generation came from domestic solar collectors, 10 per cent was generated by large non-domestic solar collectors and the remaining 35 per cent was generated by 'uncovered' solar collectors, primarily used to heat swimming pools, often in conjunction with a heat pump. Figure 16 shows the growth of solar thermal deployment in the Netherlands since 1990. The annual geometric growth rate of rate generated has been 11 per cent since 1990.

[45] http://statline.cbs.nl/StatWeb/publication/?DM=SLEN&PA=7516ENG&D1=0&D2=a&D3=2&D4=a&LA=EN&VW=T

**Figure 16 – Annual Heat Generation from Solar Thermal in the Netherlands 1990-2013**




*Source: Statline (2014)*[46]

The key drivers in the market in the Netherlands appear to be longstanding Government support. Whilst this has not necessarily been stable (as individual support schemes have changed) support dates back to 1988 with the introduction the first grant scheme for new installations.

## 6.4 Comparison to the UK

Perhaps out of all of the comparison countries considered in this assessment, the Netherlands is the most similar to the UK.

That said, the UK reported deployment of biomass equivalent to 118 kWth/capita in 2013. The earliest data available for the Netherlands is from 1990 and shows a level of deployment equivalent to 263 kWth/capita; over twice the deployment in the UK some 14 years earlier. Similarly, for heat pumps the level of deployment of 15 kWth/capita in 2013 in the UK is effectively lower than the 14 kWth/capita achieved by 2006 in the Netherlands.

Solar thermal is the only market in which the UK has experienced a higher level of deployment, achieving a level of 32 kWth/capita in 2013, compared with 18kWth/capita in the Netherlands in 2012.

In respect of the drivers for renewable heat, the UK and the Netherlands have some similarities. In terms of the counterfactuals to renewable heating technologies, the Netherlands has experienced similar prices of gas to the UK, and therefore the costs of alternatives to renewable heating technologies tend to be highly competitive.[47]

Unlike the UK, the current make-up of the heating market in the Netherlands perhaps offers fewer opportunities for the further deployment of the renewable heat technologies. This is due to the

---

[46] http://statline.cbs.nl/StatWeb/publication/?DM=SLEN&PA=7516ENG&D1=0&D2=a&D3=2&D4=a&LA=EN&VW=T

[47] 95% of households in Netherlands are connected to the gas grid - http://www.iea.org/publications/freepublications/publication/Oil&GasSecurityNL2012.pdf

widespread penetration of the gas grid in the Netherlands. In contrast, RHTs in the UK in many cases only need to compete with existing oil boilers in large swathes of the country which remain unconnected to the gas grid.

Like the UK, the Netherlands has utilised a range of successive financial support mechanisms for the deployment of renewable heat technologies. Perhaps similarly to the German market as well, changes in this level of support provided by the successive mechanisms resulted in large volatility in the market.

## 6.5 Summary of Drivers

Unlike the other Member States considered in this assessment, there have been low levels of deployment of renewable heat technologies in the Netherlands. Consequently, only a small number of drivers in the renewable heat market have been observed. The key drivers identified in the research are summarised in Table 0-1.

**Table 0-1: Summary of Key Renewable Heat Drivers in the Netherlands**

| Driver | Description | Bioenergy | | Heat Pumps | Solar Thermal |
|---|---|---|---|---|---|
| | | 1990 to 2002 | 2003 to nowadays | 1990 to nowadays | 1990 to nowadays |
| **Government Funding** | Through successive schemes (MEP and SDE schemes), the Dutch Government have provided a subsidy for the deployment of certain renewable heat technologies. | × | ✓ | ✓ | ✓ |
| **Research and Development** | The Dutch Government have financed a number of demonstration plants aimed at proving the operation of the technologies. | ✓ | ✓ | ✓ | ✓ |

# 7. UK Growth Scenarios

The deployment of renewable heat in each of the comparison countries can be shown to be more mature than that of the UK. Figure 17 shows the latest deployment figures in the UK alongside similar figures of deployment in these other countries (or the earliest deployment data if no similar figures can be observed). We have been unable to find similar levels of deployment to the UK for all of the comparison countries in at least one of the technology groups. This in itself is telling as some of the data sets date back to 1980.

**Figure 17: Comparison of Renewable Heat Generated by Technology Relative to the Latest UK Deployment ($kW_{th}$ / capita)**


*Notes:*

1) *Data prior to 2002 is not available for Austria and therefore the earliest data is presented; this does not equal the same level of deployment the UK; and*
2) *Methods used to calculate the deployment of renewable heat generation vary by each country and therefore may not be directly comparable.*

In the following sections we have aimed to provide a qualitative description of the possible deployment scenarios for the UK from 2014 to 2020 based on our knowledge and understanding of the heat markets in Austria, Denmark, Germany and the Netherlands.

As with predications of this nature, which are based on only limited data gathering and analysis (within the scope of the study) our estimates should be viewed in context and with some caution. Econometric modelling has not been utilised, whilst the potential deployment of RHTs in the UK depends on the interaction of a number of supply and demand factors, and additional factors such as taxation of fossil fuels, historic culture of self-building, and wider support for district heating will also play a role, and are unlikely to be consistent between the UK and the comparison countries.

In this study, our qualitative forecasts are predicated on the following assumptions:

1) The regulatory and policy landscape (relating to both renewable heat and electricity) in the UK does not change significantly between now and 2020;
2) The economy continues to grow at the levels predicted by the Office for Budget Responsibility (OBR); and
3) RHTs continue to be optimised, although no new commercially proven technologies appear on the market.

**Table 0-2: Scenarios for UK Deployment of Bioenergy**

| Scenario | Changes in Growth Rate | Factors Affecting Growth |
|---|---|---|
| **Optimistic** | ▶ Higher average growth rates than those experienced in other comparison countries (over 10% per annum) due to the high potential for growth in the UK market, but possibly limited to deployment seen in Austria in phase 1 (22% per annum) | **Key Factors:**<br>▶ Fossil fuel prices increase, making biomass relatively more attractive (Germany, Austria and Denmark);<br>▶ A coherent policy environment is established and maintained which includes incentives, (building) regulations and information (as experienced in Austria and Denmark);<br>▶ The costs of deployment falls over time due to economies of scale (as shown in the price data for Germany);<br>▶ RHI tariffs remain relatively stable and investors and customers grow in confidence (as experienced in Austria);<br>▶ More efficient and more user-friendly technologies are developed and deployed (as seen in all comparison countries);<br>▶ District heating is encouraged further with barriers specifically targeted (as experienced in Denmark);<br>**Other Factors:**<br>▶ Green Deal Assessments grow and increase awareness of biomass and associated technologies;<br>▶ Likely to be led by small-scale installations using domestic feedstock, but also significant contribution from biomethane;<br>▶ Multiple support schemes are developed to incentivise the deployment of biomass technologies (Austria and Denmark);<br>▶ Technologies are imported at lower costs, resulting in benefits of being a 'late mover';<br>▶ The Biomass Suppliers List results in a more transparent market and further price competition is established amongst fuel suppliers; and<br>▶ Recycling rates for wood, and particularly for food waste, continue to grow. |
| **Conservative** | ▶ Steady growth of approximately 10% per annum, similar to the growth rates in Germany (6% since 1990) | **Key Factors:**<br>▶ Ongoing degression of RHI tariffs damages confidence in the biomass market (similar Germany and the Netherlands);<br>▶ Fossil fuel prices remain relatively stable, thus the incentive to invest in alternatives is reduced (as experienced in the Netherlands);<br>▶ Awareness of the RHI continues to be low, as it is not heavily promoted by DECC, or installers;<br>**Other Factors:**<br>▶ Recycling rates for food wastes remain static, which limits the feedstock available for biomethane;<br>▶ Lack of confidence in the installer market grows dues to poor service and performance of installations (similar to processes observed in all markets in early deployment phases);<br>▶ Likely to be led by small-scale installations using domestic feedstock<br>▶ RHI air quality criteria constrain biomass deployment in urban/semi-urban environments; and<br>▶ The Biomass Suppliers List results in the domestic market being dominated by a small number of suppliers, which reduces price competition. |

**Table 0-3: Scenarios for UK Deployment of Heat Pumps**

| Scenario | Changes in Growth Rate | Factors Affecting Growth |
|---|---|---|
| **Optimistic** | ▶ Similar to growth rates seen in the Netherlands (28% per annum since 1994) and Germany (20% per annum since 2006) | **Key Factors:**<br>▶ A coherent policy environment is established and maintained which includes incentives, regulations and information (as experienced in Austria and Denmark);<br>▶ The costs of deployment fall over time due to economies of scale (in particular drilling costs for GSHPs);<br>▶ Retail gas prices increase, but retail electricity prices remain relatively static or are supported (for those using heat pumps) by utility companies (as experienced in Denmark, Germany and Austria);<br>▶ Number of installers trained to install the heat pumps grows and competition in the installer market intensifies (as experienced in Austria).<br>▶ Building regulations stipulate the deployment of renewable heating technologies and energy efficiency measures (as experienced in Germany, Austria and Denmark)<br>▶ More efficient and more user-friendly technologies are developed and deployed (as experienced in Austria);<br>▶ RHI tariffs remain relatively stable and investors and customers grow in confidence (Austria and Denmark);<br>**Other Factors:**<br>▶ Likely to be led by domestic ASHPs, but also significant contribution from non-domestic GSHPs;<br>▶ Green Deal Assessments grow and increase awareness in ASHP and GSHP grows; and<br>▶ Technologies are imported at lower costs, resulting in benefits of being a 'late mover'; |
| **Conservative** | ▶ Similar to levels witnessed in Austria (5% per annum since 2002) | **Key Factors:**<br>▶ Electricity prices increase at faster rate than gas and oil prices, such that the relative costs of heat pumps rises in comparison to gas and oil boilers;<br>▶ Awareness of the RHI continues to be low, as it is not heavily promoted by DECC, or;<br>▶ RHI tariffs make other technologies, e.g. biomass, too attractive and investment moves away from heat pumps;<br>▶ Inefficient technologies with low seasonal performance factors (SPFs) dominate the market resulting in low confidence (as initially experienced in Austria);<br>**Other Factors:**<br>▶ Likely to be led by domestic ASHPs only;<br>▶ Regulation of the RHI is poor and the market is undermined by ineligible installations receiving payments; and<br>▶ Lack of confidence in the installer market grows due to poor service and performance of installations (similar to processes observed in all markets in early deployment phases). |

**Table 0-4: Scenarios for UK Deployment of Solar Thermal**

| Scenario | Changes in Growth Rate | Factors Affecting Growth |
|---|---|---|
| **Optimistic** | ▶ Similar to rates achieved in Denmark in phase 1 (18 per cent) and Germany since 1990 (19 per cent) | **Key Factors:**<br>▶ Competition from Solar PV (in terms of availability of funds) wanes, as does competition from ASHPs;<br>▶ The costs of deployment falls over time due to economies of scale;<br>▶ Technologies are imported at lower costs, resulting in benefits from being a late mover;<br>▶ Fossil fuel prices increase, making solar thermal relatively more attractive (as experienced in Germany, Austria and Denmark);<br>▶ More efficient and more user-friendly technologies are developed and deployed (as witnessed in all comparison countries); and<br>▶ A coherent policy environment is established and maintained which includes incentives, (building) regulations and information (as experienced in Austria and Denmark); and<br>▶ RHI tariffs remain relatively stable and investors and customers grow in confidence (as observed in Austria).<br>**Other Factors:**<br>▶ Likely to be led by the domestic market, but also the emergence of large-scale, non-domestic collectors (potentially linked to underground heat storage and networks as observed in Phase 3 in Denmark);<br>▶ Green Deal Assessments grow and increase awareness in solar thermal; and<br>▶ Number of installers trained to install solar thermal grows and competition in the installer market intensifies (as observed in all in comparison countries). |
| **Conservative** | ▶ Relatively static deployment, similar to the growth observed in all of the comparison countries markets in the last five years. (Except dedicated plant in Denmark) | **Key Factors:**<br>▶ Awareness of the RHI continues to be low, as it is not heavily promoted by DECC or;<br>▶ RHI tariffs and other incentives make other technologies more favourable and investment is directed towards Solar PV and ASHPs (similar to the trend observed in all other comparison countries); and<br>▶ Fossil fuel prices remain relatively stable, thus the incentive to invest in alternatives is reduced (as experienced in the Netherlands).<br>▶ Lack of confidence in the installer market grows dues to poor service and performance of installations (similar to processes observed in all markets in early deployment phases). |

# 8. Changes in Costs in Technology Groups

The formation of cost data for each of the renewable heat technologies is unique and highly variable. For each heating technology a range of capital expenditure (CAPEX) and operational expenditure (OPEX) items impact on the overall costs:

**CAPEX:**

- **Equipment**: the cost of the main and associated equipment; and
- **Installation**: the cost of installation and commissioning.

**OPEX:**

- **Manpower**: in larger bioenergy plant, the costs of staff to run the installation;
- **Maintenance**: the cost of servicing / maintenance; and
- **Feedstocks**: typically fuel costs such as biomass and electricity.

Previous research has been conducted on behalf of DECC on the costs of renewable heat technologies and cost data is collected routinely from applications for the RHI.[48] However, the development profile of costs in other countries is not clear. In the following sections we provide a summary of evidence on changes in costs of the three technology groups in Germany, though little work has been conducted on the impact of costs of increased deployment.

## 8.1 Bioenergy

### Biomass Capex

Data for the aggregated costs of installation and equipment purchase were found from a national online database, ***biomassatlas.de.*** It was originally supported by the German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety Construction (BMUB) although now it is funded through fees generated from businesses and individuals seeking access to localised data.

The information held on the portal comes from the database of applications to the MAP program and therefore does not include installations that have not received any MAP funding. The plants in the database are assigned to the year in which the system was commissioned, rather than that in which the associated finance was raised. This is only likely to impact on the larger plants. Detailed data collection began in 2001 and is published on the portal on a monthly basis.

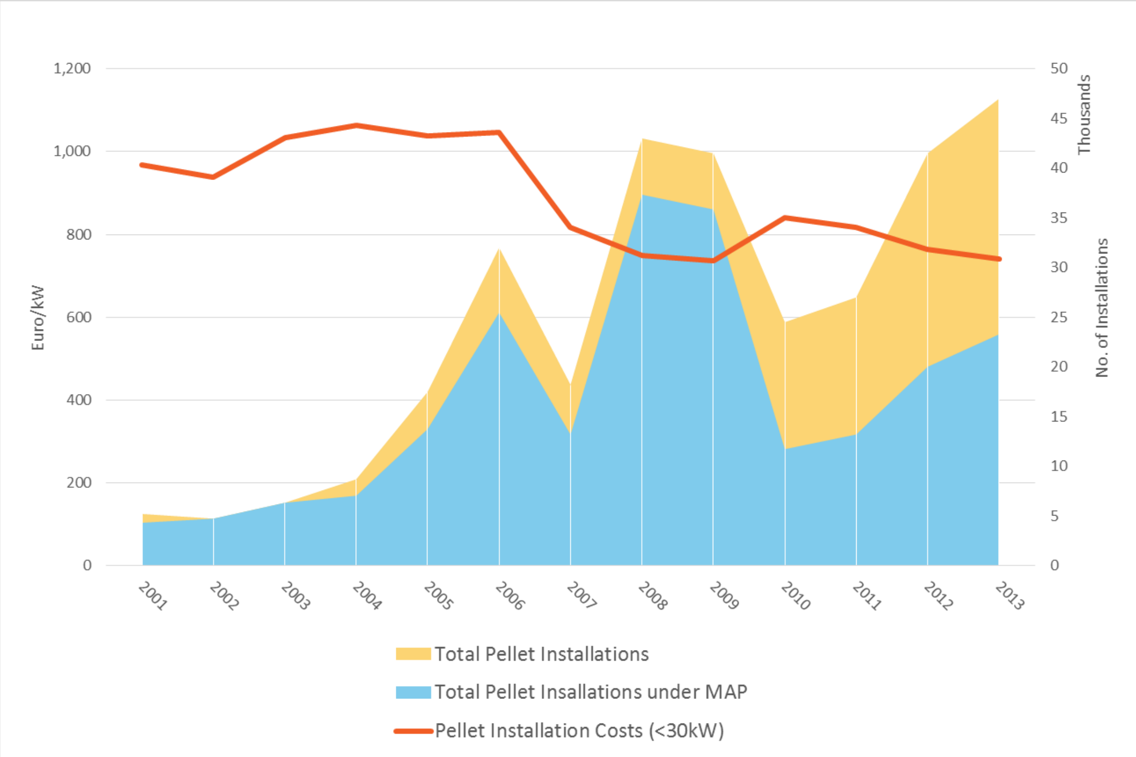
Figure 18 shows the cost changes for installation of pellet biomass boilers - including installation and equipment costs with a focus on domestic boilers of less than 30kW. The graph also displays the number of installations that were funded by MAP and the total installations (including MAP funded).

Boiler prices have decreased almost 30% from a high of just over €1,000 per kW installed capacity in 2004 to €740 in 2013. The price changes are best understood not as a steady decline, but a single step change. In 2007 a significant drop in costs was experienced, coinciding with the fall in the deployment of pellet boilers in the same period due to fears that a supply shortage of pellets would

[48] Sweett (2013) *Research on the costs and performance of heating and cooling technologies*, February 2013, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/204275/Research_on_the_costs_and_performance_of_heating_and_cooling_technologies__Sweett_Group_.pdf

occur. Whilst it is difficult to apply causation to this observation, it is likely that margins were cut across the supply chain to try to incentivise take-up. Post 2007, prices have remained relatively stable, around €800 per kW, although there does appear to be an inverse relationship between the level of deployment and cost, which suggests that economies of scale may have helped reduce costs during this period.

**Figure 18: Installation Costs and No. of Installed Pellet Boilers <30kW**




*Source: www.biomasseatlas.de*

**Figure 19: Installation Costs and No. of Installed Wood Chip and Log Fire Boilers <30kW**

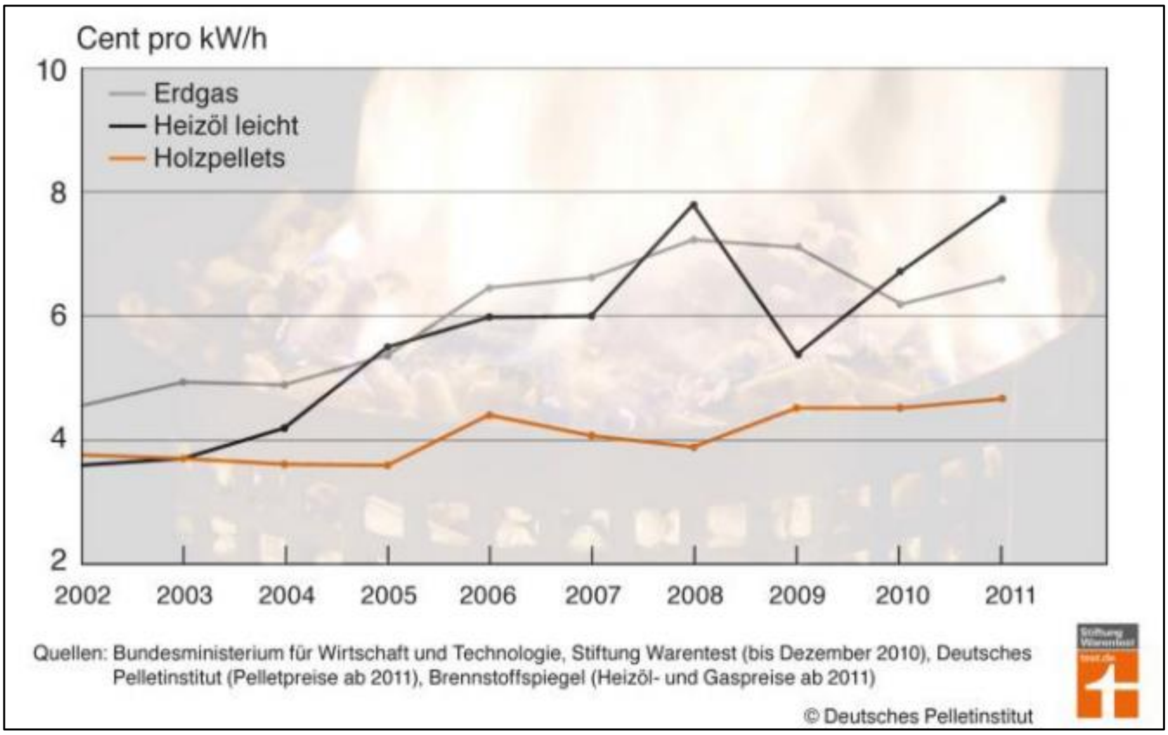

*Source: www.biomasseatlas.de*

Wood chip systems have also been eligible for funding under MAP from 2004, but only around 1,500 systems have since been installed with the aid of MAP funding and only 22 were installed in 2013. The costs for log-fired systems have also remained relatively unchanged over the previous 12 years. Figure 19 summarises the changes in costs observed in the wood chip and log-fired installations. Whilst prices appear to be stable for these technology types, it is difficult to provide any conclusive remarks due to the small sample sizes.

## Biomass Opex

An important aspect associated with the costs of biomass is feedstock prices. As shown in Figure 20, the price of wood pellets has experienced only a moderate increase since 2002. The average annual rate of price increase was 3.1 % (2002-2011), which corresponds to the average rate of inflation in Germany, as compared to an average increase in gas prices of 3.5%, and 8.2% for fuel oil. As described in Section 0, however, in contrast to the UK, Germany is fully self-sufficient in the supply of wood pellets and thus domestic prices are not subject to fluctuations in the global biomass market.[49] To some extent changes in pellet prices follow the price of oil and gas, as fossil fuels are often required in the pellet production process and certainly in their transportation. In Germany, the effect of the latter will be limited, however, as pellets are not generally imported by ship from overseas.

**Figure 20: Biomass Fuel Costs in Germany (2008 – 2014)**




*Notes: Translations are: Erdgas = Natural gas, Heizöl Leicht = Light fuel oil, Holzpellets = wood pellets*
*Source: Cross Border Bioenergy (2012)*[50]

### Biogas

Although there is no direct time-series data to corroborate this, the Biogas Association of Germany asserted that the costs of biogas equipment and installation have changed very little over the period since commercialisation. The reason suggested for this is because the regulatory requirements for biogas plants have steadily increased over the years, which has resulted in extra or more expensive equipment being specified in order to reach these requirements, and that this has nullified any cost reductions resulting from economies of scale and technical efficiencies from maturation of the associated technologies.

Whilst these thoughts from the Biogas Association may be entirely valid, they should be taken in context as the views of a trade association, which works for its members. In light of current cuts to FiTs for biogas in Germany (as described in Section 0), therefore, it perhaps does not have an interest in demonstrating there have been any significant cost reductions.

## 8.2 Heat Pumps

The German Heat Pump Association declined to contribute to this report (citing constraints on its time), and therefore related data could not be obtained. Furthermore, the ***warmepumpenatlas.de*** portal (again originally funded by the BMUB) that contains data from MAP-funded installations only began to collect information on installed capacity of heat pumps (which is needed to calculate the investment per kW) from 2011 onwards. Consequently, whilst the data shows that from 2007, MAP funded installations fell in overall cost from €18,000 per installation to €16,000, no indication is given of the capacity of the installations, the decreasing level of which could be the reason for the

[50] Cross Border Bioenergy (2012) *EU Handbook Small Scale Heating Markets*, October 2012, http://www.crossborderbioenergy.eu/fileadmin/crossborder/SCH_MarketHandbook.pdf

observed fall in costs. At the same time, the three years of data which do include capacity (in kW) indicate a stable CAPEX cost of around €1,200 per kW installed.

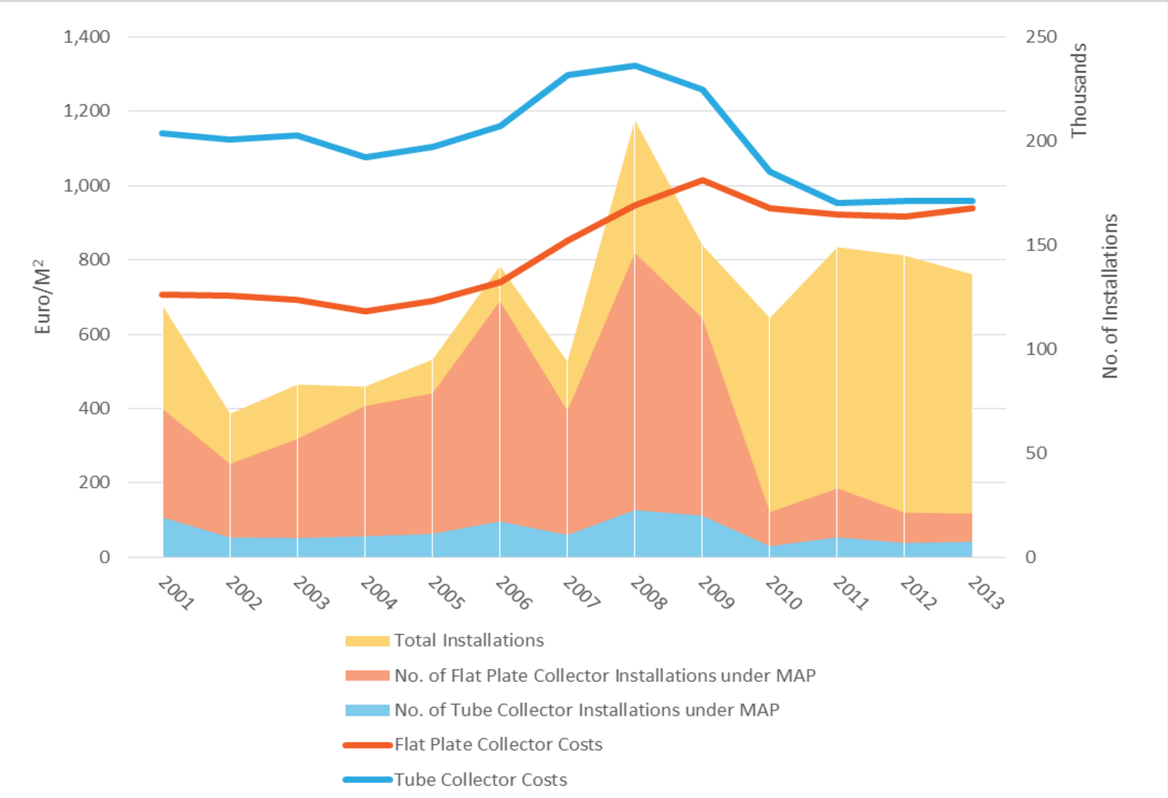
## 8.3 Solar Thermal

Data for the aggregated costs of installation and equipment purchase for solar thermal generation was found from a national online database ***solaratlas.de***. As for biomass and heat pumps, the funding for the portal was originally supported by the BMUB[51], and the same caveats and details of the data also apply as described above. The costs data for solar collectors is split by technology type into 'tube collectors', and 'flat plate collectors', the latter by far the more prevalent.

Figure 21 shows how the costs for the two technologies have changed over time. From 2004, the cost of flat plate collectors actually increased by almost 30% to its peak in 2009, despite the high number of installations around that time. Conversely the tube collector has decreased in cost over the same time, albeit with a similar cost peak in 2008/9. It has since dropped to a similar level as the flat plate collector, such that it may gain market share in the future.

Most installations were supported by MAP tracked until the MAP funding 'break' took place in 2010 and the subsequent removal of the grant for new homes. This means that the MAP cost data (post-2010) are a less useful indicator of the market as a whole. From 2011 onwards the market reached a period of stabilisation both in the numbers of installations and the costs of the equipment.

**Figure 21 - Costs of Solar Collectors in €/m2 and Numbers of Installations**




*Source: solaratlas.de*

[51] Although now it is funded through fees generated from businesses and individuals seeking access to localised data by post code

## 8.4 Summary

The data from Germany shows that in a relatively mature market there have been some key changes associated with the costs of technologies over the last decade. CAPEX associated with biomass technologies have reduced as the level of deployment has increased, especially for pellet boilers. Many of the key technical changes that led to costs of the technology have now been incorporated in to many of the technologies available on the market. The European biomass heat market is now within a more competitive phase with a wider range of boiler suppliers available than ever before.

These falling boiler costs make it attractive for the UK to import the technologies from Europe. This approach presents some risk, however, in that the UK has to some extent become dependent upon a supply chain which is subject to fluctuations in exchange rates, which could increase not only CAPEX but also maintenance costs. Consequently, unless technologies begin to be manufactured in the UK, costs are likely to be volatile going forward.

Due to lack of data it is difficult to provide any further detailed analysis of the changing costs of heat pumps in the German market. It is understood that as more advanced, more efficient technologies have become available over time, cost savings have been difficult to achieve. Furthermore, a large proportion of the costs associated with the technology, particularly for GSHPs, relate to installation. As the technology is deployed further in the UK, we'd expect both competition from installers and economies of scale to drive down overall costs over time.

Solar thermal costs in Germany have shown some decrease over time, but in recent years have remained relatively static. Rather than lower production costs, increased competition, for consumer attention, from other renewable technologies (for example, air source heat pumps and Solar PV) may result in some savings in the future. Consequently, as per the heat pump market, there may be opportunities for savings to be made as the wider market matures. This is likely to be dependent on a strong demand for the technologies over a sustained period of time.

# 9. Changes in Biomass Efficiencies

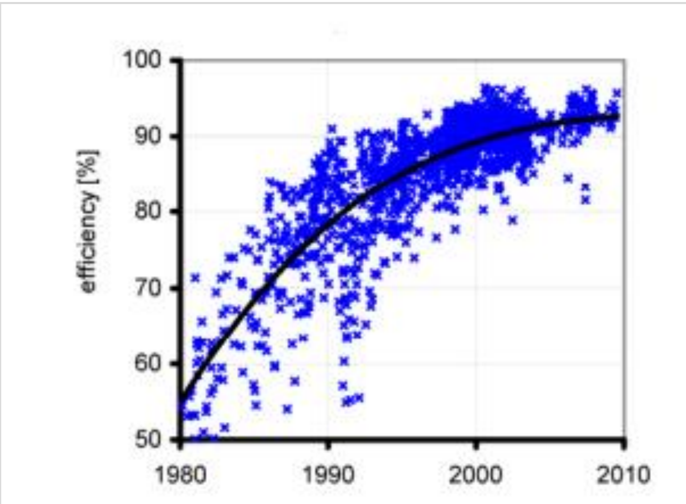
Given that the majority of renewable heat across the comparison countries is generated by biomass technologies, it is important to understand how biomass heat generation efficiencies have changed over time. Highly efficient boilers will result in lower emissions and OPEX and therefore improve the attractiveness of biomass technologies. For this study we have identified and provided analysis of empirical evidence which demonstrates the rate of change in efficiency observed over time within the comparison countries.

## 9.1 Data from Steady State Tests

Over the last two decades significant effort has been expended on testing and improving the efficiency of biomass boilers throughout Europe. In 1998, a common standard for the testing of small scale biomass boilers (<500kW) was developed - EN 303-5.

Evidence has been provided from test results under this standard and demonstrates that, over time; efficiencies have improved (see Figure 22) and converged to reported figures of over 90%.

**Figure 22: Efficiency of Small Scale Wood Boilers in Germany**




*Source: BIOENERGY 2020+ GmbH (2011)*[52]

However, results from EN 303-5 can be misleading for the following reasons:[53]

- Efficiency and emissions are determined under steady state conditions. The European test does not require biomass boilers to be tested at low burn rates (<30%). Consequently, they are not representative of ‘real life’ operating conditions (and may raise false expectations among customers); and

[52] BIOENERGY 2020+ GmbH (2011) *Determination of annual efficiency and emission factors of small-scale biomass boiler*, 2011, http://www.bioenergy2020.eu/files/publications/pdf/Schwarz_etal_-_Annual_Efficiency.pdf

[53] BIOENERGY 2020+ GmbH (2011) *Determination of annual efficiency and emission factors of small-scale biomass boiler*, 2011, http://www.bioenergy2020.eu/files/publications/pdf/Schwarz_etal_-_Annual_Efficiency.pdf

- Steady state comparisons do not sufficiently allow the differentiation between excellent, good and poor technologies. This differentiation arises in unsteady or transient operating conditions (start-up, load change, shut down).

Whilst the performance of biomass technologies has no doubt improved over time, such data from steady state tests can result in confusion and uncertainty for customers. In order to provide a more realistic overview of improvements in efficiency, the evidence presented below relates to changes in **in-situ** efficiencies of biomass installations quantified in long term field tests.

## 9.2 Carbon Trust Field Trials

A Carbon Trust report published in 2009[54] summarises the results from a programme of monitoring undertaken on 19 operational biomass boilers between February 2008 and September 2009. The programme assessed a range of parameters including the efficiency of the boilers, which was calculated directly and indirectly.

- The direct efficiency was calculated based on the useful heat output divided by the energy input, although this proved problematic as the programme relied on operator-provided usage figures which were shown to be inaccurate.
- The indirect calculation method used the calculation method in BS845. This standard is applicable to a wide range of boiler technologies and calculates a flue loss based on the fuel composition, calorific value, flue gas CO2 concentration and flue gas temperature. This method was also subject to uncertainties but was considered to provide a better indication of whether a boiler was working as expected.

The results of trial do not suggest a clear trend across the data sample as indirect efficiencies ranged between 73% and 85%, whereas direct efficiencies ranged from 29% to 79%. The lack of correlation between the data sets was attributed the difficulties collecting fuel usage data from each site.

## 9.3 BIOENERGY 2020+ Trials

In 2011 Bioenergy 2020+ funded a small trial in order to provide an alternative method for the determination of annual efficiency and emission factors. The study proposed a test cycle designed for solid fuel boilers in residential homes to determine more reliable fuel consumption and $CO_2$ emissions than under the EN 303-5 standard. The trial tested pellet, wood chip and log wood boiler types and found that efficiencies were some 5-10% lower when compared to the same boilers measured using the EN 303-5 standard. [55]

Further research has also been conducted as part of the KOMBINE project.[56] Research conducted under this project reported annual efficiencies between 73% and 76% for small pellet boilers, when compared to a 92% efficiency report under EN 303-5.[57]

[54] This report was considered as commercially confidential and has been made available to Eunomia and DECC solely for use within this study

[55] BIOENERGY 2020+ GmbH (2011) *Determination of annual efficiency and emission factors of small-scale biomass boiler*, 2011, http://www.bioenergy2020.eu/files/publications/pdf/Schwarz_etal_-_Annual_Efficiency.pdf

[56] See: http://www.ait.ac.at/departments/energy/research-areas/energy-infrastructure/thermal-energy-systems/kombine/?L=1

[57] Bioenergy2020+ *SYSTEM PERFORMANCE OF A STORAGE INTEGRATED PELLET BOILER*, http://www.bioenergy2020.eu/files/publications/pdf/paper_2CV_4_23_Aigenbauer.pdf

## 9.4 DECC Study

In 2014, DECC released a desk-based review of performance and installation practices of biomass boilers.[58] The study found no suitable and impartial information about performance standards and installation practices in the UK for schemes above 45kW. The authors of the study did, however, make contact with 41 companies involved in the installation of biomass heating systems and with 27 of their customers, ranging from large public sector bodies and private sector companies, to small estates and not-for-profit enterprises. As a result, the study reports on actual performance data on 106 schemes (in terms of fuel purchased and heat outputs). Based on the authors 'expert' judgment it was estimated that the average (central) performance standard is 76.75% (equal to 23.25% overall losses) with a range from 72% at worst to 81.5% at best.

## 9.5 Supplier Views

Vyncke, a Danish technology supplier and project developer of plant in the 4-15 MWth bracket provided some useful insights, which we have also corroborated with UK suppliers. Essentially, Vyncke stated that the thermal design efficiency of a biomass boiler is usually 87% and up to a maximum of 91% for their plant. The related guarantee they provide to customers is linked to a particular type of fuel and moisture content, and there is also a formula for customers to use if they decide to use fuel with a higher moisture content, and want to check efficiency. Importantly, however, Vyncke stated that it is extremely rare that any customer ever challenges the guarantee, and this is largely because the plants do perform at least as well, if not above, the guaranteed efficiency, which is set a small way below the level they believe the plant can achieve.

Whilst this is the view of a technology vendor, and so should be taken in context, it should not perhaps be viewed as a surprise, as non-domestic biomass boilers (predominantly using wood chip) are a very mature technology.

## 9.6 Summary

Consequently, we would not expect efficiencies for boilers fuelled by wood chip to have shown dramatic increases in the last decade (which echoes the results under steady state testing in Figure 22 above) and would not expect any notable greater efficiencies up to 2020. Whilst domestic scale wood pellet boilers are less mature, there is no evidence to suggest that there have been significant gains in efficiencies during the last decade, nor will there be to 2020

Our brief research has shown that there has been limited research on in-situ efficiencies of biomass installations. Where evidence has been found, efficiency values some 5 to 20 per cent lower than those produced under tests using the EN 303-5 standard have been observed. Whilst it is generally understood that improvements in efficiencies of have been made over time, to provide a more in-depth analysis of the efficiencies of biomass technologies, further practical research is required in this area.

**Table 0-1: Summary of Evidence on Biomass Efficiencies**

| Source | EN 303-5 | Carbon Trust Field Trials | Bioenergy 2020+ Trials | KOMBINE Project | DECC Study |
|---|---|---|---|---|---|
| **Efficiency** | 90% + | 73% - 85%, | 80% - 85% + | 73% - 76% | 72% - 81.5% |

[58] DECC (2014)Desk-based review of performance and installation practices of biomass, boilershttps://www.gov.uk/government/uploads/system/uploads/attachment_data/file/376805/Review_of_biomass_performance_standards.pdf

| | | | | | |
|---|---|---|---|---|---|
| **Type** | Lab | In-situ | Lab | Lab | In-situ |
| **Country** | N/A | UK | Austria | Austria | UK |

# 10. Summary of Findings

The research has shown a remarkable change in the deployment of RHTs over the past three decades in the comparison countries analysed for this study. Through interviews and literature review, we have explored a number of drivers for, and constraints to, these changes. From these important lessons can be learnt by the UK as it aims to structure policy for renewable heat to enable meeting the 2020 targets set under the EU 'Renewable Energy Directive' (RED).

The analysis has identified a plethora of legislative, policy and cultural drivers dating back well in to the early 1990s and in some instances the late 1970s across the comparison countries. The drivers of growth in each of the comparison countries have therefore often been unique and highly dependent on local characteristics.

There does not appear to be a simple correlation between the *number* of these drivers and the *levels* of deployment; although it is apparent that stability, in respect of legislative and policy drivers, is a critical factor.

For all of the countries, underlying and wider market conditions, in particular, changes in the costs of fossil fuels, have been observed to have a key impact upon the growth in deployment of RHTs. Within the scope of this study we have not sought to compare the overall costs of deployment (relative to fossil fuel heating) in the comparison countries, nor have we considered the differences in elasticity of demand for RHTs. Our research has found, however, that where oil-fired or electric (rather than cheaper gas-fired) heating is prevalent, the switch to RHTs happens more rapidly than it would otherwise.

The key drivers and barriers for each of the comparison countries can be summarised as follows:

1. **Oil and gas prices:**
   The second oil crisis in the late 1970s provided a key kick start to many RHTs, whilst taxation of fossil fuels is also significant in Austria and Denmark. At the same time, however, in the Netherlands, relatively cheap natural gas has acted as a disincentive for RHTs;

2. **Environmental movement:**
   The growth of the 'green' movement in the 1970s and early 1980s in all comparison countries led to high public acceptance and enthusiasm for RHTs. In Austria (and to a lesser extent, Denmark), this also led to a 'do-it-yourself' culture for domestic scale plant and an entrepreneurial spirit, which stimulated the domestic supply chain; and

3. **Poor quality installations:**
   In most comparison countries, but particularly in Austria, as a very early adopter of many RHTs, the industry suffered from poor technology performance. In response, significant effort was made to introduce quality standards and training to build trust and confidence in RHTs;

4. **Availability of biomass feedstock:**
   Austria, Denmark and Germany are endowed with a high percentage of forestry cover and therefore have easy access to biomass supplies. This is in contrast to the Netherlands, which relies upon imported fuels (via Rotterdam, which is widely regarded as the EU's main biomass hub);

5. **Financial support from Government:**
   State funding programmes have been the key driver for deployment of RHTs across all comparison countries, but particularly in Germany, in which the MAP was relatively stable until 2010. In contrast, policy in the Netherlands has been far more inconsistent, which has impacted upon public and investor confidence and thus hindered deployment;

6. **Competition from other renewable heat technologies:**
   In all of the comparison countries, there has been competition between the RHTS. This has often been influenced to a large degree by the amount of financial support available from Government, which has in some cases had unintended consequences by 'skewing' the market significantly in favour of a particular technology;

7. **Competition from Solar PV:**
   Due to frequent public misunderstanding of the difference between solar PV and solar thermal, alongside an 'either-or' mentality at a time of limited funds, many households and businesses have opted for solar PV, which has been driven by high levels of government support. To a lesser extent, this has also had an impact on other non-solar RHTs;

8. **Government support for district heating:**
   In both Austria and Germany, but particularly in Denmark, additional levels of support for the development of new district heating networks, or conversion of existing networks to be fuelled by biomass (rather than natural gas or oil) have been instrumental in stimulating large-scale biomass (and to a more limited extent solar thermal and heat pump) installations;

9. **Role of regional administrations:**
   The Länder in Austria have responsibility to deliver a variety of energy policy measures. This approach is such that policy mechanisms can be better tailored to local concerns and resources, for example, access to feedstock, which can be more effective than a federal approach;

10. **Building regulations:**
    In Denmark, house builders are expected to adhere to legislation that requires certain levels of renewable heat capacity to be fitted, whilst in Germany, more stringent building efficiency requirements, which can be met by installation of RHTs, have had some impact;

11. **Collapse of the construction market:**
    Whilst building regulations in some of the comparison countries may have driven some further deployment, the financial crisis hit new house builders hard. Consequently, related demand for RHTs (which are more cost effective in new-builds than retrofits) fell significantly in 2008, albeit is now recovering; and

12. **Removal of support for RHTs in new buildings:**

In both Denmark and the Netherlands new homes can no longer receive funding for some RHTs. This has negatively impacted the market at a time when installation levels in new builds were starting to recover from the collapse of the construction market.

For the UK, there appears to be a number of possible routes by which the market for each technology may evolve through to 2020. The key drivers and barriers highlighted in this section represent a key set of lessons, which should be taken into consideration when designing and new and revising existing policy mechanisms. Some issues, however, for example, global prices of fossil fuels, are beyond the control of Government, albeit the policy mechanisms that impact upon related prices can be adjusted via taxation and other mechanisms.

# APPENDICES

# Prices of Gas and Electricity

A summary of the recent changes in average retail prices for gas and electricity are shown in Figure 23 and Figure 24.

**Figure 23: Comparison of Average Retail Gas Prices (€ cent/kWh)**


*Source: Adapted from European Commission (2014)*[59,60,61,62,63]

---

[59] European Commission (2012) *Denmark Energy Market Overview 2011*, 2012, http://ec.europa.eu/energy/gas_electricity/doc/dk_energy_market_2011_en.pdf

[60] European Commission (2012) *UK Energy Market Overview 2011*, 2012, http://ec.europa.eu/energy/gas_electricity/doc/uk_energy_market_2011_en.pdf

[61] European Commission (2012) *Austria Energy Market Overview 2011*, 2012, http://ec.europa.eu/energy/gas_electricity/doc/at_energy_market_2011_en.pdf

## Figure 24: Comparison of Average Retail Electricity Prices (€cent/kWh)


*Source: Adapted from European Commission (2014)*[64,65,66,67,68]

[62] European Commission (2012) *Germany Energy Market Overview 2011*, 2012, http://ec.europa.eu/energy/gas_electricity/doc/de_energy_market_2011_en.pdf

[63] European Commission (2012) *The Netherlands Energy Market Overview 2011*, 2012, http://ec.europa.eu/energy/gas_electricity/doc/nl_energy_market_2011_en.pdf

[64] European Commission (2012) *Denmark Energy Market Overview 2011*, 2012, http://ec.europa.eu/energy/gas_electricity/doc/dk_energy_market_2011_en.pdf

[65] European Commission (2012) *UK Energy Market Overview 2011*, 2012, http://ec.europa.eu/energy/gas_electricity/doc/uk_energy_market_2011_en.pdf

[66] European Commission (2012) *Austria Energy Market Overview 2011*, 2012, http://ec.europa.eu/energy/gas_electricity/doc/at_energy_market_2011_en.pdf

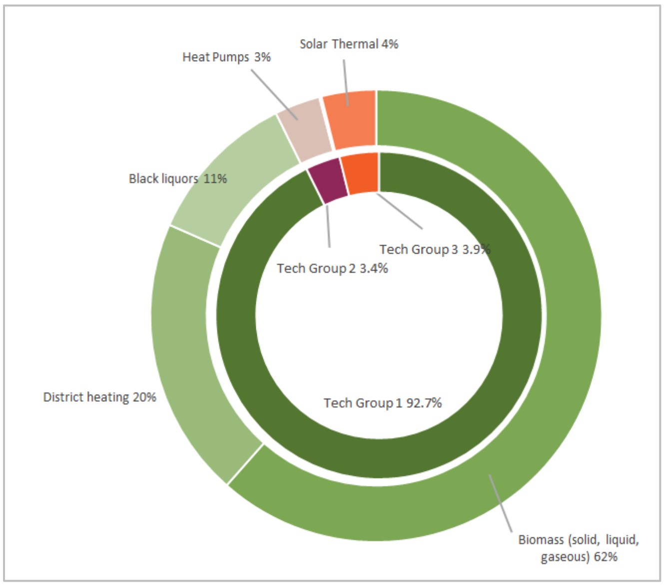
[67] European Commission (2012) *Germany Energy Market Overview 2011*, 2012, http://ec.europa.eu/energy/gas_electricity/doc/de_energy_market_2011_en.pdf

[68] European Commission (2012) *The Netherlands Energy Market Overview 2011*, 2012, http://ec.europa.eu/energy/gas_electricity/doc/nl_energy_market_2011_en.pdf

# Segmentation of the Renewable Heat Market

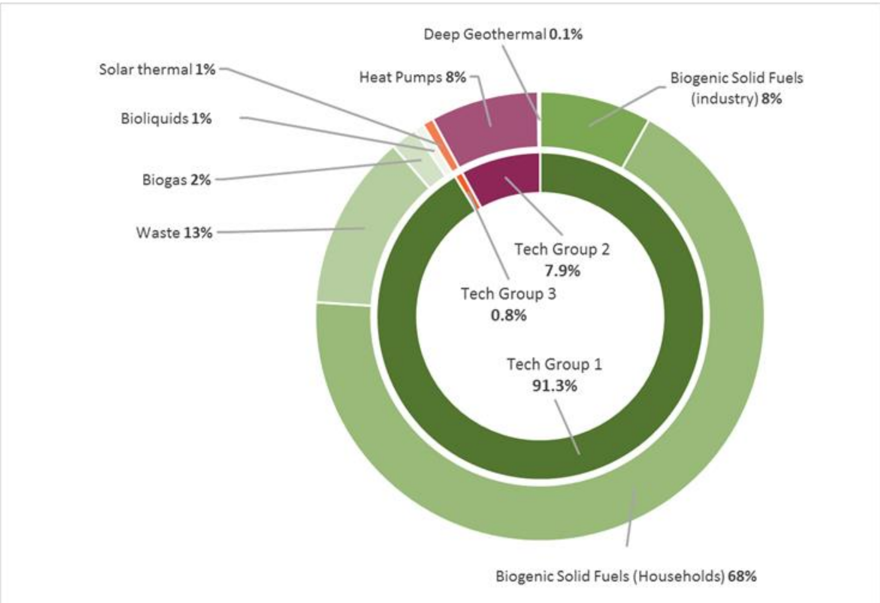
The share of renewable heat generated by the technology groups described in Figure 25 to Figure 29.

**Figure 25: Structure of Renewables Based Heat Supply in Austria (2012)**




*Source: The Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (2013)*[69]

**Figure 26: Structure of Renewables Based Heat Supply in Denmark (2012)**

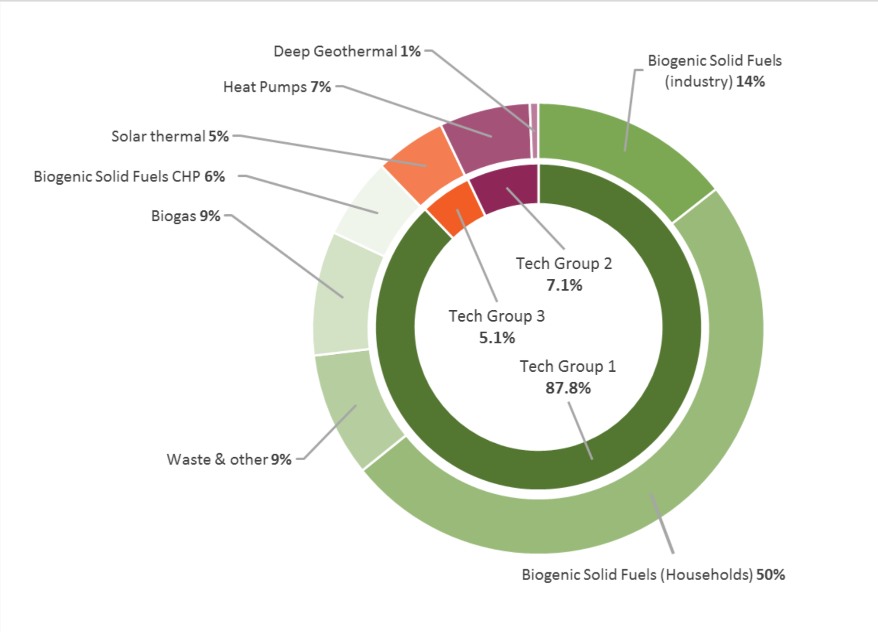



*Source: Danish Energy Agency (2013)* [70]

[69] The Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (2013) *Erneuerbare Energie in Zahlen 2012*, December 2013, http://www.bmlfuw.gv.at/publikationen.html

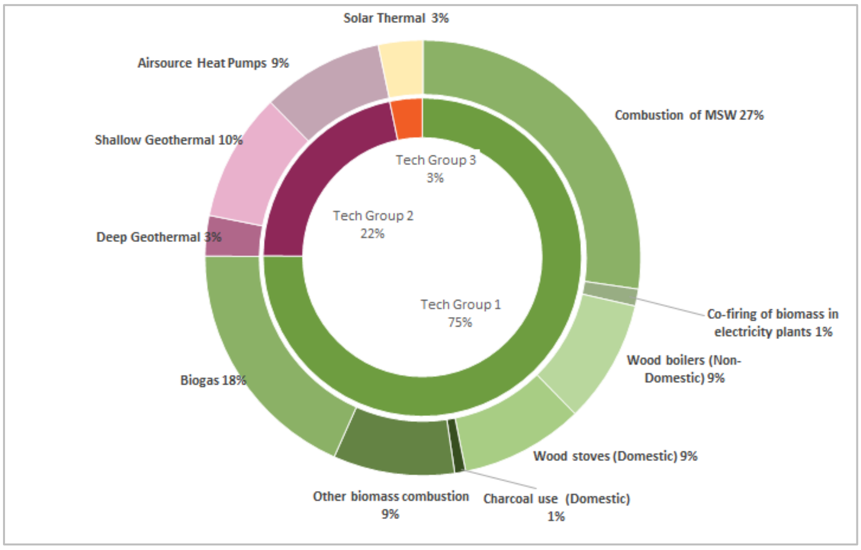
[70] Danish Energy Agency (2013) *Energy Statistics 2012*, 2013, http://www.ens.dk/sites/ens.dk/files/info/tal-kort/statistik-noegletal/aarlig-energistatistik/energy_statistics_2012.pdf

## Figure 27: Structure of Renewables Based Heat Supply in Germany (2013)




*Source: Federal Ministry for Economic Affairs and Energy (2014)*[71]

## Figure 28: Structure of Renewables Heat Supply in the Netherlands (2013)



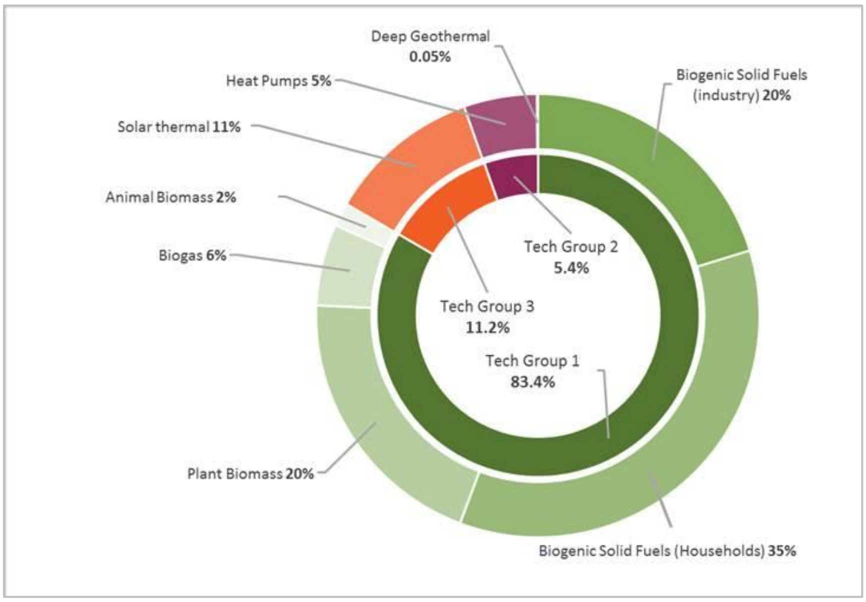

*Source: Centraal Bureau Voor de Statistiek (2014)*[72]

---

[71] Federal Ministry for Economic Affairs and Energy (2014) *Renewable Energy Sources in Germany 2013*, February 2014, http://www.bmwi.de/BMWi/Redaktion/PDF/A/agee-stat-grafiken-und-tabellen-eng,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf

[72] Centraal Bureau Voor de Statistiek (2014) *StatLine*, http://statline.cbs.nl/Statweb/

**Figure 29: Structure of Renewables Based Heat Supply in UK (2013)**




*Source: DECC (2014)* [73]

[73] Department of Energy and Climate Change (2014) *Digest of United Kingdom energy statistics (DUKES) 2014*, July 2014, https://www.gov.uk/government/statistics/digest-of-united-kingdom-energy-statistics-dukes-2014-printed-version

# Austria

## Bioenergy Technology Group

The deployment of biomass technologies can be understood to have developed in distinct phases. These are elaborated further in the following sub-sections.

### Phase 1: Emergence and Early Deployment - 1950s to the early 1990s

The deployment of biomass technologies in Austria started in the 1950's within the agriculture sector and in particular, sawmills through market drivers. During this time, approximately only a half of the material harvested from trees had a market value and therefore there was a significant unused resource available to be marketed.[74] Many of the participants in this period were motivated by the volatile prices for agricultural products, and therefore were looking for possibilities to create a market for forestry residues.[75]

Cooperatives of farmers and forest owners emerged and worked together to develop small-scale biomass systems which could be used for space heating. The concept was further developed and in the 1980's when small-scale district energy systems using biomass were deployed in rural areas.

Considering the demand side drivers, the second oil crisis in 1979 also acted as a key factor. Individuals were motivated to discover alternative reliable and stable sources of energy as the costs of oil heating increased dramatically. Additionally, this early phase also coincided with a significant green movement within Austria at the time which also acted as a driver. On 5th November 1978 a national referendum on nuclear energy was held, which resulted in defeat of the Government, which had supported new nuclear power stations being developed in the country.[76] At the same time, the Austrian Green Party was also established. [77]

During the 1980s and early 1990's, the biomass manufacturing market in Austria began to emerge. Competition amongst woodchip boiler providers led to improved efficiencies and reduced emissions from biomass technologies. By the mid-1990s higher quality and more efficient boilers were widely available, but ultimately the market was constrained by the fact that wood chip boilers were not suitable for all customer types – despite the wide prevalence of waste wood in the country.

In addition to market based drivers, there were also a number of political drivers during this phase of deployment. Like for other technologies, these were primarily led by regional administrations in Austria (the Länder), which took the lead in setting renewable energy targets and thus developed a policy framework in order to help meet these targets. Unlike the UK, Austria has a federal political structure. Energy policy is made at three levels: the federal government, the regional or Länder governments, and local government. During the early 1990's, Regional administrations started to develop 'energy action plans' which set specific targets for the deployment of renewable heat technologies, including biomass

---

[74] O.O. Energiesparverband (2013) *Biomass heating in Upper Austria Green Energy, Green Jobs*, 2013, http://www.esv.or.at/fileadmin/redakteure/ESV/Englisch/Publikationen/Biomass_heating_Upper_Austria_engl_US_Letter_216x279_2013_Sicht.pdf

[75] O.O. Energiesparverband (2013) *Biomass heating in Upper Austria Green Energy, Green Jobs*, 2013, http://www.esv.or.at/fileadmin/redakteure/ESV/Englisch/Publikationen/Biomass_heating_Upper_Austria_engl_US_Letter_216x279_2013_Sicht.pdf

[76] U.S. Library of Congress *The Green Parties*, http://countrystudies.us/austria/121.htm

[77] Interview with O.Ö. Energiesparverband, October 2014

within regional administrations. The plans also included implementation elements, including annual monitoring and reporting systems. The plans were also linked to regional development (job creation), agricultural and social policy, which broadened their appeal to the public.[78]

Financial support from Government, typically in the form of grants from regional administrations, also helped to establish the industry. Residential grant programs from regional administrations have been in place since the late 1980s and early 1990s and these have historically supported the installation of biomass technologies – sometimes providing up to 50% of the cost of capital.[79]

Taxation of fossil fuels, including natural gas and oil, is also a key policy that has aided the biomass industry. For example, in 2008, wood pellets in Austria cost around €3.5 cents/kWh, compared to €6.3 cents for gas and €9.1 cents for heating oil.

The deployment of all renewable technologies in Austria has also been supported the regional administrations through low interest and long term loans for house construction, renovation and purchase which have been on offer since the end of World War II.[80] The conditions of the loans allow regional administrations to exert control on how buildings are built, heated, and insulated. Although means tested, these provisions are available to 90% of households in Austria and since 1993 have been subject to minimum energy efficiency requirements, which are tightened every year.[81]

Alongside Government support for individual plants, loans from regional administrations have also been provided to organisations setting up district heating networks. 'Biomassefonds' (available in Upper Austria) is an example of a fund set up in 1993 with €3.6 million to provide attractive loans, especially to cover the financing gap of the first one to two years of the operation of a biomass district heating networks.[82] Furthermore, financial support has also been provided to dedicated Energy Supply Companies (ESCos), which manage the production and sale of heat from networks.

In addition to financial support measures, regional administrations in Austria also aimed to improve awareness of bioenergy via various other initiatives. For example, 'Regional Technology Managers' were introduced to provide information and support to users of renewable technologies, including biomass.

### Phase 2: Mass Deployment - middle 1990s to nowadays

The uptake of biomass boilers in the residential sector was relatively slow until 1997, when wood pellets were introduced.[83] Within less than ten years of market introduction, the annually installed capacity of pellet boilers increased significantly. From 2002 to 2006 this annually installed capacity exceeded the annual installation of wood log boilers.[84] This growth was driven by technical innovation by boiler

---

[78] RES-H Policy (2011) *Report on European harmonised policy to promote RES-H/C*, April 2011, http://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/res-h_policy_report_on_eu_harmonised_policy_to_promote_reshc_en.pdf

[79] O.O. Energiesparverband (2013) *Biomass heating in Upper Austria Green Energy, Green Jobs*, 2013, http://www.esv.or.at/fileadmin/redakteure/ESV/Englisch/Publikationen/Biomass_heating_Upper_Austria_engl_US_Letter_216x279_2013_Sicht.pdf

[80] Department for Trade and Industry (2003) *Global Watch Mission Report: Energy from biomass – a mission to Austria and Denmark*, March 2003, http://www.fuelcellmarkets.com/content/images/articles/biomass_mission_report.pdf

[81] Association for the Conservation of Energy (2010) *Biomass heating in Upper Austria*, September 2010, http://transatlanticenergyefficiency.eu/sites/default/files/Upper%20Austria%20case%20study%20(final%20draft).pdf

[82] RES-H Policy (2009) *Regional Report:The RES-H/C market in Upper Austria*, June 2009, http://www.res-h-policy.eu/RES-H_Policy_Market-Report-Upper-AT_(D3)_engl_final.pdf

[83] Department for Trade and Industry (2003) *Global Watch Mission Report: Energy from biomass – a mission to Austria and Denmark*, March 2003, http://www.fuelcellmarkets.com/content/images/articles/biomass_mission_report.pdf

[84] RES-H Policy (2009) *Renewable Energy in the Heating and Cooling sector in Austria*, March 2009, http://www.res-h-policy.eu/RES-H_Policy_Market-Report-AT-Styria_(D3)_english.pdf

manufacturers, typically based in Austria, who aimed to provide a product that was more user-friendly than traditional log boilers.

Like the preceding phase, financial support has been provided for biomass systems during this period. This is largely because prices for domestic biomass boilers are far in excess of those of the natural gas or oil alternatives, with total installed costs for a single family house pellet boiler being in the region of €7,000-€10,000 (compared to natural gas boilers €750-€1,500 (UK price range).[85] During this period, households have been able to receive €800 from the national Government if they opt for biomass heating, or up to €4,500, or 30% of system cost, from some regional administrations. There are also further subsidies for replacing old oil-fired systems with biomass, and large incentives for installations in the commercial sector.[86]

The drivers were not only financial. Austria has found that a great deal of education was required to increase awareness of the technology at all levels; from fuel producers, boiler manufacturers, service engineers, right through to delivery drivers of pellet tankers. [87] Courses in 'eco-energy' in the early 2000's were also established by regional administrations. These focused on training plumbers to install biomass heating systems - as well as ground source heat pumps and solar thermal systems. The adoption of quality standards for pellets also helped 'unlock' the domestic sector. In 1998 the Austrian standard 'ÖNORM M 7135' was introduced – this was the first pellet standard in the world and helped to build confidence amongst users of wood pellets.[88] This standardisation of pellets also enabled boiler manufacturers to develop lower-emission technologies. At the same time, standards for wood pellet logistics and storage were also introduced.[89]

Despite the high levels of growth, there have also been constraints and barriers to expansion. For example, in 2007 the number of installations of pellet boilers fell dramatically compared to preceding years deployment. This was mainly attributed to high increases in pellet prices during this period. The cause of the high prices was generally attributed due to a fear of lack of supply of pellets, yet it appears that these fears were unfounded.

## Heat Pump Technology Group

The deployment of Heat Pump technologies can be understood to have developed in distinct phases. These are elaborated further in the following sub-sections.

### Phase 1: Emergence and Early Deployment - 1970s to the 1990s

The use of heat pumps in this early phase was mainly for hot water heating, usually deployed as bivalent systems (i.e. used in conjunction with another heat source such as an oil boiler). Initially the deployment of heat pumps was driven by high oil prices, like all technology groups in Austria. This was followed by support for heat pumps in the form of tax 'breaks' for those installing new systems. When oil prices fell in the mid 1980's and 1990's, however, the annual deployment of heat pumps decreased from the highs

---

[85] Department for Trade and Industry (2003) *Global Watch Mission Report: Energy from biomass – a mission to Austria and Denmark*, March 2003, http://www.fuelcellmarkets.com/content/images/articles/biomass_mission_report.pdf

[86] Cleantech magazine (2009) *Spotlight on: Austrian biomass heating*, http://www.cleantechinvestor.com/portal/spotlight/2379-cleantech-spotlight-on-austrian-biomass-heating.html

[87] Department for Trade and Industry (2003) *Global Watch Mission Report: Energy from biomass – a mission to Austria and Denmark*, March 2003, http://www.fuelcellmarkets.com/content/images/articles/biomass_mission_report.pdf

[88] Pellet Atlas (2009) *Pellet market country report: Austria*, September 2009, http://www.pelletsatlas.info/pelletsatlas_docs/showdoc.asp?id=090909154850&type=doc&pdf=true

[89] O.O. Energiesparverband (2013) *Biomass heating in Upper Austria Green Energy, Green Jobs*, 2013, http://www.esv.or.at/fileadmin/redakteure/ESV/Englisch/Publikationen/Biomass_heating_Upper_Austria_engl_US_Letter_216x279_2013_Sicht.pdf

of the early 1980's. Furthermore, the industry was hampered by the removal of the aforementioned tax breaks.[90]

### Phase 2: Commercial Deployment - 2000s to nowadays

During the early 2000's the deployment of heat pumps started to edge towards and exceed the levels of annual deployment seen in the early 1980's. The deployment of heat pumps for space heating has grown significantly during this period, which has been driven by grants from regional administrations and the offer of cheaper electricity tariffs by utility companies. Utility companies have also helped with building confidence in the sector by providing support to customers (in respect of making claims to installers or manufacturers) in the event of failure of the technology.[91]

In addition, it is understood that a number of actions have been undertaken to improve confidence in the technology. This includes the introduction of a certified training program for installers in 2001.[92]Courses in 'eco-energy' in the early 2000's were also established by regional administrations.

## Solar Thermal Technology Group

The deployment of solar thermal technologies can be understood to have developed in distinct phases. These are elaborated further in the following sub-sections.

### Phase 1: Emergence and Early Deployment (1977-1989)

During the late 1970s and 1980s, there was sporadic growth in solar thermal technologies in Austria. The technologies initially deployed were usually designed and installed by self-build homeowners (using 'homemade' collectors), rather than being procured from manufacturers and installed by professionals.[93] The drivers for this initial deployment appear to be complex. They are mainly comprised of social and economic factors which appear to have influenced individuals to consider alternatives to more conventional heating systems at the time (e.g. coal, wood and oil). A significant part of the populous within Austria were motivated by green issues and the desire to use renewable forms of energy during the late 1970's and 1980s. The phase of deployment of solar thermal coincides with a number of significant political events, which are also believed to be contributory factors.

During this early phase of development, solar thermal installations become slightly more formally organised, typically led by small self-construction groups. The practise of do-it-yourself methods in a group was based on a local tradition in Austria and built on the skills and traditions from the agricultural sector.[94] In 1987, the first solar thermal 'build-it yourself' guide was produced. Training seminars were organised for construction group leaders and other interested persons who wanted to familiarise themselves with the methods of solar thermal self-building.[95]

Government support measures were also introduced in Austria to stimulate demand. These were (and continue to be) financed and implemented by regional administrations, rather than at a national level.

---

[90] European Heat Pump Association (2005) *HEAT PUMPS TECHNOLOGY AND ENVIRONMENTAL IMPACT*, July 2005, http://ec.europa.eu/environment/ecolabel/about_ecolabel/reports/hp_tech_env_impact_aug2005.pdf

[91] European Heat Pump Association (2005) *HEAT PUMPS TECHNOLOGY AND ENVIRONMENTAL IMPACT*, July 2005, http://ec.europa.eu/environment/ecolabel/about_ecolabel/reports/hp_tech_env_impact_aug2005.pdf

[92] European Heat Pump Association (2005) *HEAT PUMPS TECHNOLOGY AND ENVIRONMENTAL IMPACT*, July 2005, http://ec.europa.eu/environment/ecolabel/about_ecolabel/reports/hp_tech_env_impact_aug2005.pdf

[93] Interview with Austria Solar, September 2014

[94] MICHAEL ORNETZEDER (2001) Old Technology and Social Innovations. Inside the Austrian Success Story on Solar Water Heaters, *Technology Analysis & Strategic Management*, Vol.Vol. 13

[95] *Ibid*

Grants for solar thermal installations in Upper Austria, for example, have been running (without interruption) since 1981.[96]

## Phase 2: High Growth (1990 -1996)

Throughout the early 1990's Austria experienced very high growth rates of solar thermal deployment, with an approximate growth rate, in terms of number of installations, of 600% over a 6 year period. The drivers during this phase of growth are diverse. No doubt increased awareness and the commercialisation of the technology were key, but the role of regional administrations is also believed to have helped drive deployment. As discussed above, regional administrations in Austria have historically taken the lead in energy policy and typically employed a range of mechanisms including regulatory measures, financial support schemes and information dissemination programmes.

Importantly, regional administrations started to develop 'energy action plans' during the early 1990's which set specific targets for the deployment of renewable heat technologies, including solar thermal. The plans also included implementation elements, including annual monitoring and reporting systems. The plans were also linked to regional development (job creation), agricultural and social policy, which broadened their appeal to the public.[97]

At the same time, financial support measures played a role in this phase of deployment. Many of the regional administrations continued to provide fiscal support (grants) for solar thermal installations throughout this period. Furthermore, since 1991, regional administrations have provided free energy advice to customers.[98]

## Phase 3: Mature Deployment (1997 -2007)

During the late 1990s and early 2000's growth in solar thermal deployment was relatively flat until towards the ends of the period when it accelerated again. The drivers for the growth within this phase are similar to those described above for the mid-1990's.

Again, the role of regional administrations was a key contributing factor during this period, with the related policy packages becoming more sophisticated. For example, some regional administrations started to mandate the installation of renewable heat technologies on certain types of buildings. For example, in 1999 Upper Austria mandated that all new or renovated buildings public buildings must use solar thermal or another RHT for space heating and hot water.[99] The use of heat meters on installations was also encouraged during this phase. Information dissemination on solar thermal technologies was also developed further during this period, including national publicity campaigns. Support for technical innovation also contributed; in 2000 the Austria Solar Innovation Centre was created. This is a research and development institute committed to the intensification of research in the field of solar technology.[100]

---

[96] RES-H Policy (2009) *Regional Report:The RES-H/C market in Upper Austria*, June 2009, http://www.res-h-policy.eu/RES-H_Policy_Market-Report-Upper-AT_(D3)_engl_final.pdf

[97] RES-H Policy (2011) *Report on European harmonised policy to promote RES-H/C*, April 2011, http://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/res-h_policy_report_on_eu_harmonised_policy_to_promote_reshc_en.pdf

[98] Association for the Conservation of Energy (2010) *Biomass heating in Upper Austria*, September 2010, http://transatlanticenergyefficiency.eu/sites/default/files/Upper%20Austria%20case%20study%20(final%20draft).pdf

[99] Office of Science & Technology Austria (OSTA) (2010) *Carrots, Sticks and Tambourines: How Upper Austria became the World's Leading Solar Thermal Market*, December 2010, http://ostaustria.org/s-t-policy/13-categories-all/author-index/index.php?option=com_content&view=article&id=5302&Itemid=1435

[100] Austria Solar Innovation Centre (2014) *Mission & Vision*, http://www.asic.at/Mission_Vision.22.0.html?&L=1

### Phase 4: Recent Decline in Growth Rate (2008 - 2013)

During this most recent period the annual rate of solar thermal installations deployed in Austria has declined (from 350,000m$^2$ in 2009 compared to 200,000m$^2$ in 2012). The reasons behind this decline are believed to be related to the wider energy market in the Austria and connected strongly to the deployment of other RHTs in the domestic market. Austria Solar, the solar thermal trade association in Austria, interviewed for this study, cited the key reason as being the wide scale deployment of ASHPs, which are cheaper to install than solar thermal.[101] In addition, it is also understood that the relative 'revenue' associated with Solar PV has contributed to the reduction in growth rate.[102]

Despite the declining growth rate of the number of new installations, grants continue to exist for solar thermal installations within the domestic and non-domestic sector. Increasingly there is a focus on the non-domestic sector, with particular support mechanisms for larger solar thermal installations. In 2010 a finance programme was introduced at the federal level which supports the installation of solar thermal installations with a collector area between 100 and 2000m$^2$ in the following four thematic areas:

- Solar process heat in production companies;
- Integration of solar thermal energy in district heat supply (micro net, district heating networks);
- Solar thermal systems with high solar fraction for trade and service companies; and
- Solar cooling with solar hot water production and heating in times without cooling demand.[103]

It has not been possible to determine the extent of the influence of this finance programme, but it is likely to have contributed to a number of new installations.

[101] Interview with Austria Solar, September 2014

[102] Interview with O.Ö. Energiesparverband, October 2014

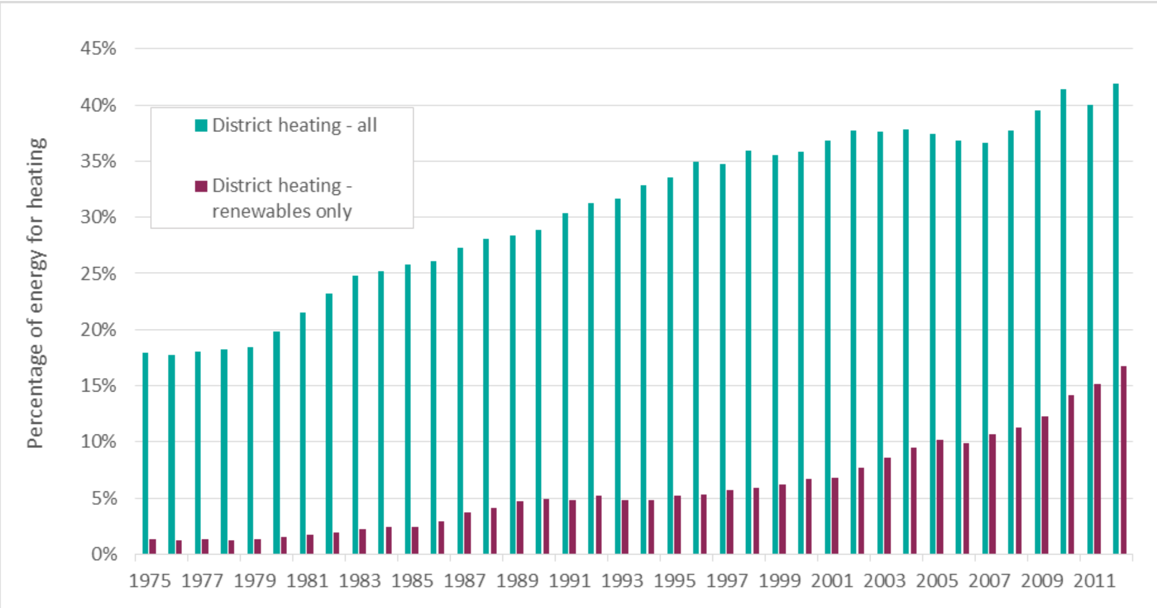
[103] Ref: http://www.estif.org/solarkeymarknew/images/downloads/QAiST/qaist-country_report-austriasept10.pdf

# Denmark

Denmark has also been a European leader on renewable energy for both electricity and heating for many years. Spurred on by the two oil crises in 1973 and 1979, which hit Denmark particularly hard,[104] heating (mainly space heating) was identified as an area with high energy usage, where there was a lot of potential to decrease the heavy reliance on oil, while also decreasing the overall energy used in this sector.[105] This resulted in several new energy and heating plans hastily being drafted. These plans focused on many areas, the key ones being self-sufficiency and security of supply, saving energy, using waste heat from power stations and focusing on renewable energy. At the same time, however, Denmark discovered oil and, a few years later in 1982, gas in the North Sea, which meant that main fuels used for heating throughout the late 1970s and 1980s were fossil fuels: oil, coal and gas.

One of the key areas of focus in the late 1970s and early 1980s was the use of waste heat from power stations. Although Denmark already had the beginnings of a well-developed district heating network, with small decentralised heating plants providing around 18% of the total heat required in 1975, most electricity was delivered by a few very large centralised power stations, only a few of which were combined heat and power. A clear focus of the 1980s was thus to build more combined heat and power (CHP) stations, with financial incentives provided to encourage this transition as well as mandatory targets for installed capacity of CHP plants.[106] As shown in Figure 30,in 2012, district heating accounted for more than 40% of the total heat produced in Denmark.

**Figure 30: Development of District Heating, Denmark, 1975 - 2012**




*Source: Danish Energy Agency (2013) Energy Statistics 2012, 2013, http://www.ens.dk/sites/ens.dk/files/info/tal-kort/statistik-noegletal/aarlig-energistatistik/*

Key to enabling the district heating network to be rolled out across the country were the partnerships that were set up in the late 1970s and early 1980s. These energy planning committees consisted of both

[104] Denmark, Netherlands and the USA struggled under a trade embargo which threatened to cut off oil supplies from one day to the next.

[105] Tornbjerg, Jesper (est. 2015) *Green Energy for All*, not yet published.

[106] Combined Heat and Power agreement of 1986.

central government planners, local authority representatives and the energy suppliers. This meant that new power plants were situated in optimal locations to enable them to supply waste heat to district heating networks.[107] Furthermore, a new law in 1982 gave local councils the option of making the connection to either the natural gas network or the district heating network mandatory for consumers, assuming such a connection was possible. Finally, electric heating has been banned from new buildings since 1988 and from being established in existing stock since 1994. Both of these laws were crucial for enabling local authorities and energy suppliers to invest in district heating networks and CHP plants as they provided security that there would be customers for the heating networks.[108]

As outlined in subsequent sections of the report, Denmark has not only been successful in increasing the proportion of renewables in the district heating network, but also in incentivising the switch-over from non-renewable heat supply to renewable in households, and to a lesser extent, industry and businesses. However, the larger context of the history of Denmark's district network is key to understanding how and why this development has taken place.

## Bioenergy Technology Group

There have been several distinct phases to the development of the deployment of solid biomass fuels: In the first phase, deployment rose very rapidly, tripling between 1978 and 1983 (in terms of heat produced). In the second phase, deployment continued to rise, though at a much slower pace, barely doubling in the twenty years between 1983 and 2003. In the final phase, the last ten years since 2003, deployment has once again 'rocketed', doubling the total heat generated from 2003 to 2012.

### Phase 1: Emergence and Early Deployment - 1970s to the early 1980s

The increase seen in the first phase of market development, from the late 1970s to the early 1980s, where deployment rose rapidly, was driven by the increased use of biomass stoves in households. The key driver for this increase, as described in Annex 0 was the second oil crisis in 1979 and the introduction of a tax on oil in 1977, both of which led to large increases in the price of fuel for households. The majority of Danish households at the time were heated by oil boilers, so there was a clear incentive here to switch to a cheaper fuel.

Due to a large availability of biomass (at this time largely in the form of waste wood and other wooden debris), installing biomass stoves meant that people were switching to a free fuel, as the majority of the fuel was self-sourced.[109] Furthermore, financial support through the UVE (Udviklingsprogrammet for Vedvarende Energi) provided grants for the installation of biomass boilers (and other renewable heat technologies) for 20 years between 1981 and 2002. It is not clear, however, what impact this specific programme had on the profile of deployment.  Within the industrial sector, the use of straw for heating also increased during this time, although it is not clear whether there were any additional drivers for this expansion aside from those already described above.

[107] Interview with EA Energianalyse, 1 October 2014.

[108] Energistyrelsen (Danish Energy Agency) (2004) *Varmeforsyning i Danmark: Hvem Hvad Hvor og - Hvorfor (Heat Supply in Denmark: Who What Where and - Why)*, October 2004, http://www.losningfjernvarme.dk/gfx/brugerupload/documents/Varmeforsyning_pixibog.pdf

[109] Interview with the Danish Eco Council, 24 September 2014.

## Phase 2: Large Scale Deployment - early 1980s to 1990s

During the 1980s and 1990s, the initial political focus and overall aim of new energy policies and agreements in Denmark was to ensure self-sufficiency and security of supply, as described in greater detail in Annex 0. This was done by encouraging decentralised energy planning and incentivising energy suppliers to co-generate electricity through mandatory targets for new capacity of co-generation plants, financial support for transforming old electricity-only plants into CHP stations and a feed-in tariff for electricity co-generated with heat. In addition, the discovery of natural gas in the North Sea in 1982 quickly made gas the fuel of choice for the majority of the new plants. This initially resulted in a large number of decentralised gas-fired combined heat and power (CHP) plants, as existing coal plants with access to the gas grid and gas heating-only plants were converted.[110]

During this decade, installations of new industrial, commercial and domestic biomass boilers were uncommon, with only small increases in the amount of heat generated by such 'direct users' over the 20 year period. As shown in subsequent sections of the report, these years saw great increases in the number of solar thermal and heat pump installations. It thus appears that, after an initial burst of biomass installations due to financial concerns over high oil prices in the late 1970s and early 1980s, few heat consumers switched to biomass in the 1980s and 1990s. The large expansion of the heat and gas networks functioned as a clear barrier to the large-scale deployment of any single renewable heat technology for individual users, as these networks removed the financial incentives which were otherwise in place.

Despite these barriers, a small number of new large-scale biomass plants were commissioned during the mid-late 1980s. Furthermore, during the 1990s, some plants without access to the gas grid (both oil and coal) were converted to biomass-based CHP and heating-only plants.[111] Financial support from Government provided funds for research and development (R&D) into biomass-fired heating plants (particularly on solving corrosion issues associated with the use of straw) since the early 1980s. This paved the way for these new plants, which was also helped along by the steady increase through the 1980s and 1990s of energy and carbon taxes on fossil fuels, both of which gave direct financial incentives for energy suppliers to innovate and change the way they supplied heat.[112] Furthermore, the 1989 ban on burning straw on agricultural fields provided a source of cheap feedstock (and thus a further incentive to develop technology that could utilise it), while a mandatory target from 1992 for biomass inclusion within heat and power generation by 2000 also forced innovation within the sector.[113]

## Phase 3: Mature Deployment - 2000s to nowadays

Over the last ten years, the focus in Denmark has shifted away from establishing new CHP plants to switching them to be fuelled by biomass. The increase is largely driven by a small number of centralised very large-scale coal-fired power stations converting partially or fully to biomass, albeit there has also been a marked increase in the use of domestic (mostly pellet-fired) biomass boilers.

In terms of large-scale CHP, the deployment has been driven by clear financial incentives. The very high taxes on fossil fuels made coal-fired power stations very expensive to run. Furthermore, it is understood that uncertainties related to the long term viability of fossil-fuelled plant has also contributed to some

---

[110] Energistyrelsen (Danish Energy Agency) (2004) *Varmeforsyning i Danmark: Hvem Hvad Hvor og - Hvorfor (Heat Supply in Denmark: Who What Where and - Why)*, October 2004, http://www.losningfjernvarme.dk/gfx/brugerupload/documents/Varmeforsyning_pixibog.pdf

[111] Energistyrelsen (Danish Energy Agency) (2004) *Varmeforsyning i Danmark: Hvem Hvad Hvor og - Hvorfor (Heat Supply in Denmark: Who What Where and - Why)*, October 2004, http://www.losningfjernvarme.dk/gfx/brugerupload/documents/Varmeforsyning_pixibog.pdf

[112] Interview with EA Energianalyse, 1 October 2014.

[113] Interview with the Danish Eco Council, 24 September 2014.

CHP plant and associated heat networks being sold to local authorities, giving them an opportunity to influence the further development of such plant.

With regard to domestic biomass boilers, it appears that a number of drivers are in play, all of which are related to financial incentives. In recent years, a number of new incentives have been introduced to encourage the installation of RHTs. Both building regulations requiring either a high degree of insulation or some RHTs, as well as tax incentives for home renovations have led to pellet boilers being installed in the last ten years. Energy companies have also had targets for the reduction of their energy use, which has led to some suppliers providing some financial support for the installation of RHTs, although their focus tends to be on insulation rather than grants for new installations.[114] None of these drivers are biomass-specific, however, so it is thus not clear why many have chosen pellet boilers. Possible options relate to:

- The general familiarity with wood-burning for domestic heating (the Danish Eco Council estimates that 8-900,000 households currently have a wood-burner or biomass boiler);[115]
- The general political focus on biomass, e.g. through informational campaigns; and
- Possibly even the proximity to Germany, which provides cheaper fuel due to the difference in VAT between Denmark and Germany.[116]
- The lower upfront costs associated with a pellet boiler compared to a ground source heat pump. This is particularly relevant as most properties which need of a new heating system are those with oil boilers, which tend to be rural (i.e. outside the gas or district heating networks) and thus also more economically disadvantaged and less able to provide a large amount of upfront cash.[117]

## Barriers to Deployment of Bioenergy Technologies

There have been a number of barriers to biomass deployment, which have impacted all end users. First of all, in relation to district heating (largely for the residential sector), many of the small-scale decentralised gas-fired CHP plants that were established in the 1990s are under severe strain despite a large amount of Government support being provided over the last ten years. For some operators, it is no longer financially viable to co-generate with electricity, due to recent falls in electricity prices resulting from large-scale deployment of solar photovoltaics (PV) and wind. This means that these plant are no longer able to receive the co-generation feed-in tariff, thus depriving them of one key source of income. It appears that many of these plants would benefit from switching to biomass, but are constrained from doing so due to an existing 'ban' on switching from natural gas to another fuel. [118] The reasons for the ban relate to the Government's historic reliance on the income from the taxation of gas, as well as the Government's need to have an off-take for the national production of gas.

At the same time, industrial manufacturers hoping to develop district heating networks and sell excess heat are hindered by many areas already being 'saturated' by the gas grid. Furthermore, existing district heating networks are difficult to access due to the low prices on offer from existing heat providers.[119]

---

[114] Interview with EA Energianalyse, 1 October 2014

[115] Interview with the Danish Eco Council, 24 September 2014

[116] Force Technology (2013) *Det Danske Træpillemarked 2012 (The Danish Wood Pellets Market 2012)*, Report for Energistyrelsen (Danish Energy Agency), December 2013, http://www.ens.dk/sites/ens.dk/files/info/publikationer/det-danske-traepillemarked-2012/det_danske_traepillemarked_2012.pdf

[117] Interview with the Danish Eco Council, 24 September 2014

[118] Interview with the Danish Eco Council, 24 September 2014

[119] Interview with the Danish Energy Agency, 7 October 2014

In terms of deployment in non-domestic sector, take-up of renewable heat in general has been relatively low. This is largely the result of industries which use fossil-based fuels for process heating being able to claim back the energy and carbon tax paid on these fuels. This mechanism is to ensure that Danish industry remains competitive against those in other countries, where similar taxes are not as high. In addition, no specific financial support mechanisms exist to encourage the switching of heating systems for space and/or water heating in the commercial sector. As companies that are 'auto-producers'[120], however, are eligible for support to convert to CHP, recent confusion over the interaction between this scheme and a new 'Renewable Energy for Process Heating' scheme has not encouraged take-up of either.

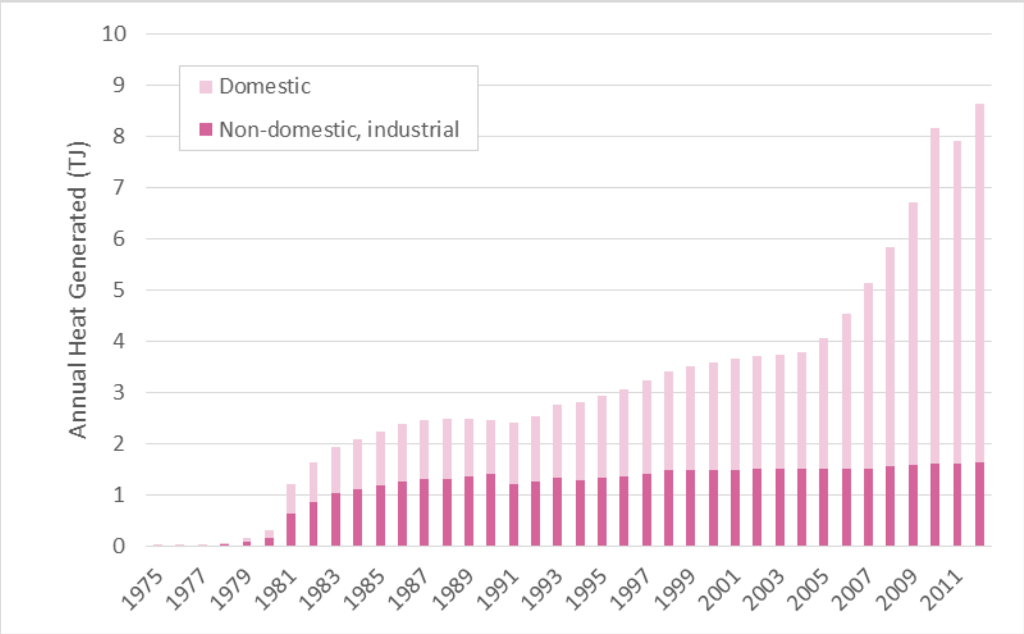
## Heat Pump Technology Group

Figure 31 shows that the vast majority of this has been generated by heat pumps in the domestic sector (thus a significant amount can be attributed to air to air source heat pumps) and that this is also where the main growth has been over the last 30 years. It is not clear from discussions with experts or a review of literature, however, what the specific drivers have been for heat pumps.

As mentioned in Annex 0, there are a number of generic financial drivers which have affected the installation of RHTs in domestic properties, all of which are financial. The most important is the imposition and regular increase in the level of taxation on fossil fuels, such as oil and natural gas. This has given a clear financial incentive to those not connected to the gas grid or near a district heating network to replace old oil boilers. Due to their rural location, such properties also usually have space available near the house for the required ground works for GSHPs. At the same time, however, the potential of availability of fuel locally and space for fuel storage makes them also equally suited to biomass. An additional incentive for heat pumps (over biomass) comes via a lower tax on electricity for those who consume electricity for heating and use more than 4,000 kWh of electricity per year. Furthermore, a fund to support the replacement of old oil boilers, which was open from 2010 to 2011, provided a flat-rate grant for the installation of an efficient heat pump (or solar thermal system or for connecting to a nearby district heating network). Biomass boilers were specifically excluded from this scheme. It is not clear from the data available, however, whether either of these two specific financial incentives had an impact on the level of deployment.

[120] These are entities generating heat wholly or partially for their own use as an activity which supports their primary activity

**Figure 31: Heat Generated from Heat Pumps (including Air-Air) by End User, Denmark, 1975-2012**




*Source: Danish Energy Agency (2013*[121]

## Barriers to Heat Pump Deployment

There are currently and have been a large number of barriers which are likely to have affected the deployment of heat pumps. First of all, the high upfront capital cost is a large barrier for many people and organisations. Loans are either not easy to access or attractive, particularly when security for the debt is tied to the value of a property. Furthermore, many rural houses may not be able to use a low-temperature heat pump without an upgrade to the heating system or installation of energy efficiency measures, as many are also of older stock. Such requirements further increase the capital costs required to install a heat pump.[122]

Finally, there have also been a number of problems in relation to both installers and the performance of heat pumps. Installers have been said to provide a wide range of value of quotes with widely varying pipework designs, which does not build confidence in the sector. At the same time, the advertised efficiencies of heat pumps (usually expressed as seasonal performance factors – SPFs) are rarely achieved in practice.[123]

Although experts differ on the degree to which this is the case, the fact that 'failed' heat pumps have been on officially recommended lists drawn up by the Danish Energy Agency seems likely to have had an impact on perceptions of the technology. Some negative perceptions are likely due to a lack of understanding of the technology; for example, heat pumps are often designed to achieve an indoor temperature of 18°C, whilst customers expect 21°C or 22°C.[124]

[121] Danish Energy Agency (2013) *Energy Statistics 2012*, 2013, http://www.ens.dk/sites/ens.dk/files/info/tal-kort/statistik-noegletal/aarlig-energistatistik/energy_statistics_2012.pdf

[122] Catalyst Strategic Consultants (2013) *Nye Forretningsmodeller til Acceleration af Varmepumpe-Udrulning (New Business Models to Accelerate the Deployment of Heat Pumps)*, Report for Dansk Energi, June 2013, http://www.danskenergi.dk/~/media/Varmepumpe/NyeForretningsmodellerAccelerationVarmepumpe-udrulning.ashx

[123] Interview with the Danish Eco Council, 24 September 2014.

[124] *Ibid*

## Solar Thermal Technology Group

The key drivers for the deployment of solar thermal installations in domestic properties are financial. Generally speaking, sales figures have followed the price of oil, which appears to explain both the peak in annual sales in the mid-1990s and the further peak in the mid-2000s.[125]

Importantly, between 1979 and 2001, solar thermal collectors were supported via a government grant.[126] The long duration of this support has been of great importance to the development of the supply chain in Denmark. Although the grant was first set at a flat-rate 30% of the capital cost of an installation, it was later changed to be related to the expected output. This encouraged innovation and further development of more efficient technology. In the 1990s, solar thermal was also seen as high priority, which was reflected in a large-scale informational campaign by the Danish Energy Agency and by gas suppliers, which encouraged customers to install a solar thermal system with their new gas boilers. [127]

Many of the solar thermal systems installed in domestic properties in Denmark are for hot water only. It has been suggested that 'do it yourself' focused households are most likely to install solar thermal, due to the relative lower complexity of the system (compared with other RHTs), although it is not clear how many of solar thermal systems have been installed by households themselves. Furthermore, although a new water heater is required with a new solar thermal system, the supply chain for this element is well-developed in Denmark. [128]

During the last 5-7 years in particular, the market for individual installations has slowed considerably. This is for three key reasons:

- Grant provision (which started in 1979, as mentioned above) ceased in 2001 when a new government came into power. The he effect of which is clearly shown in the sales figures in Figure 9 above;
- There has since also been a very significant focus on solar PV – with new Governmental support and publicity campaigns resulting in a very large number of new panels installed on domestic properties. There is a sense that the difference between solar PV and solar thermal may not be entirely clear to consumers, hence there is an 'either/or' mentality;
- A focus on biomass in recent years has also been detrimental to solar thermal. [129]

At the same time, new building regulations requiring capped energy usage levels for new build properties are thought to have the potential to encourage the installation of solar thermal, as the requirements can either be met either through insulation or the installation of a RHT. [130]

The deployment of solar thermal for district heating has increased almost ten-fold in the ten years to 2012 (in terms of heat produced) and Denmark can now be considered the European leader in large-scale solar thermal projects. This started with a few demonstration projects in the late 1980s and has developed steadily, resulting in innovation and a supply chain that can support greater levels of deployment.

[125] Interview with Danish Solar Thermal Association, 1 October 2014

[126] Solvarme Center (2011) *Fakta om Solvarme: Markedudvikling (Facts about Solar Thermal: Market Development)*, August 2011, http://www.altomsolvarme.dk/solvarmecenter/dokumenter/faktaark/G10-markedsudvikling.pdf

[127] Solvarme Center (2011) *Fakta om Solvarme: Markedudvikling (Facts about Solar Thermal: Market Development)*, August 2011, http://www.altomsolvarme.dk/solvarmecenter/dokumenter/faktaark/G10-markedsudvikling.pdf

[128] Interview with the Danish Eco Council, 24 September 2014

[129] Interview with Danish Solar Thermal Association, 1 October 2014

[130] Solvarme Center (2011) *Fakta om Solvarme: Markedudvikling (Facts about Solar Thermal: Market Development)*, August 2011, http://www.altomsolvarme.dk/solvarmecenter/dokumenter/faktaark/G10-markedsudvikling.pdf

The specific drivers behind this increase are not entirely clear, although as described in Section 4 with regard to biomass, many existing CHP plants linked to heat networks are struggling due to the very high costs associated with the use of gas, whilst they are also banned from switching to another fuel. A loophole seems to exist, however, in that solar thermal does not count as a 'fuel' and therefore operators can switch some of their heat production from gas to solar thermal.[131] This has led to significant increases in the number of large-scale solar thermal fuelled district heating schemes currently in operation in Denmark. The next challenge for many of these systems is to develop efficient storage systems for the heat – an approach which has already been successfully developed in several parts of Denmark.

## Notes on Danish Data Calculations

Although very comprehensive annual energy statistics are published by the Danish Energy Agency, calculations outlining the total renewable energy used for heating are not included and have thus been calculated by us. The methodology for the calculation of progress towards the EU Renewable Energy targets have been followed as far as possible and resulting calculations are within less than 1 percentage point of the figures for 2009 – 2012, which have been publicised in Denmark's biannual progress reports to the European Commission.

The following calculations have been done:

The total energy used for non-renewable heating/cooling is calculated as the sum of:

- the total production of district heating, including energy used to produce it and distribution losses;
- the energy used for direct heating minus any district heating used for direct heating (to avoid double-counting); and
- the energy used by industrial processes minus electricity used by industrial processes minus district heat used by industrial processes.

The total energy used for renewable heating/cooling is calculated as the sum of:

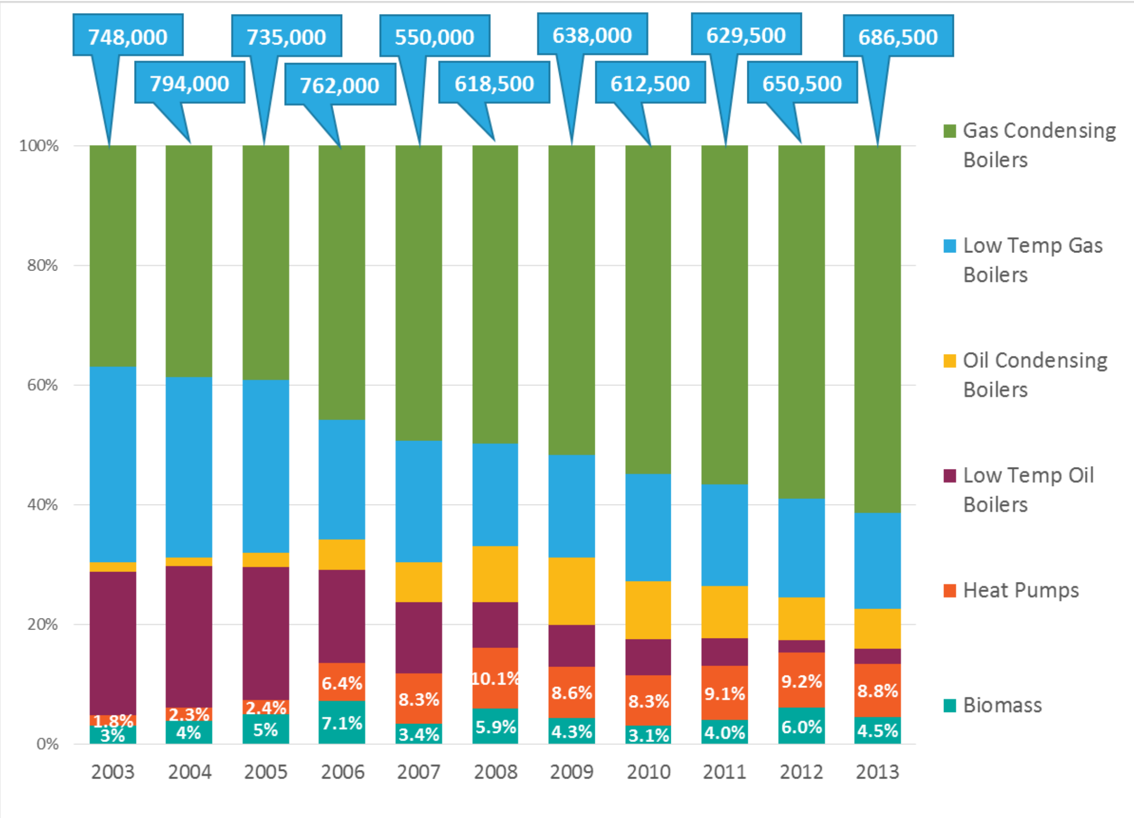
- the total (gross) production of district heating from renewable sources;
- the total renewable heat used directly for space and water heating in the commercial & leisure and public sectors and households; and
- the total renewable heat used directly by the industrial sector, excluding transport.

[131] Interview with the Danish Eco Council, 24 September 2014

# Germany

► The overall structure of the heating system market is shown in Figure 32.Gas condensing boilers have risen to dominate the market in recent years and now account for 61% of installed heating systems. This has displaced the less efficient low temperature gas boilers which are surprisingly still installed in quantities greater than that of heat pumps and biomass combined. Gas installations are now 77% of the market. Oil has fallen from a 26% share to 10% in ten years after surrendering its market share between gas and renewables. Biomass and Heat pumps account for 13.3% of the 686,500 installations in 2013 from 4.8% in 2003.

**Figure 32 - Market Share of Heating Systems by Number Installed**

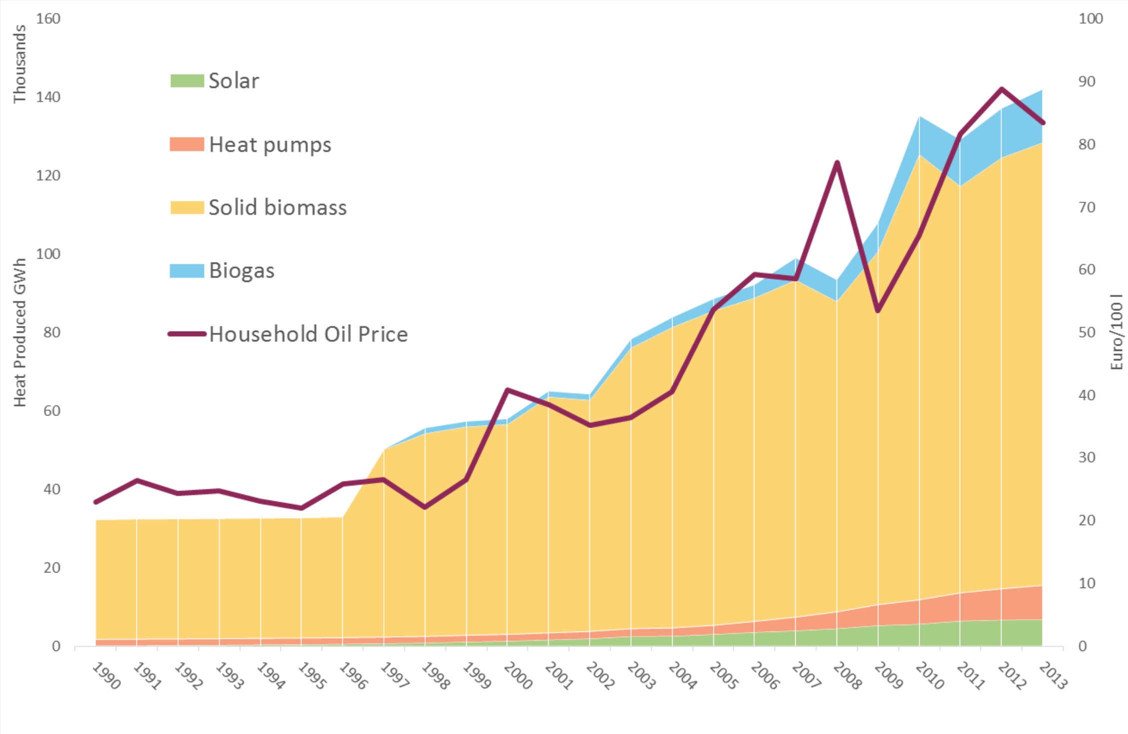



*Source: Renewable Energies Agency*

► It is also important to recognise that the total heat output shown in Figure 32 would suggest more biomass boilers were being installed than heat pumps, but the sales figure in Figure 33 disagree. This is largely due to the types of buildings these technologies are installed in. Broadly speaking heat pumps are installed in new buildings with better insulation and thus, less energy demand overall. Single biomass installations can be capable of much higher heat outputs than heat pumps which is often needed for older buildings and renovation projects.

As seen in Figure 33 biomass is also the largest growth sector within renewable heat in Germany from the point of view of heat production. This stacked area chart also shows the growth of the industry as a whole over the last 23 years. The oil prices are based on 'Light fuel oil' supplied to households in €/100 litres in 2010 prices from the national energy statistics provided by the BMWi. These prices will be used throughout the German sections of this report as a comparator to growth within each of the technology groupings. Industrial light fuel oil prices follow a similar trend, but with a slightly lower baseline starting position.

**Figure 33- Domestic Heating Oil Prices & Renewable Heat Growth for Germany**




## Renewable Heat Funding in Germany

The main funding mechanism for renewable heat installations that has been in place from 2000 is the Market Incentive Program (MAP)[132]. This has been identified as one of the key drivers for renewable heat in Germany by the organisations interviewed as part of this study. The specifics of how this funding mechanism has affected each technology group will be explored in the relevant sections.

The Renewable Energy Heating Act was passed in 2008 and came into effect on 2009. This was needed in order to support the binding EU target to increase the share of renewable heat to 14 per cent by 2020. The act focuses primarily on new buildings and stipulates that they should generate a certain share of their heat demand from renewable sources. Unfortunately there appears to be significant loop holes within the act that allow house builders to for fill their obligations by simple changes such as increasing insulation. Although this would reduce energy demand as a whole, it does not help towards the renewable heat target. In 2011 an amendment to the act expanded the obligation to existing buildings in the public sector, putting the onus on public buildings to provide an example to others during refurbishment projects.

Previously MAP funding was available for all buildings, however, due to the Renewable Energy Heating Act being aimed at new homes it was decided that MAP should only be obtainable for existing buildings and refurbishments.

In 2009 MAP funding was suspended briefly by the government. This was widely reported at the time in the German media. Unfortunately, when the funding was reinstated only months later, there was considerably less media coverage. Several of the organisations interviewed commented on this contributing to a slowdown of renewable heat uptake in recent years. From 2012 funding was

[132] This is overseen and allocated by the Federal Office of Economics and Export Control (BAFA).

substantially increased to the amounts found in Table 0-1. The effects of this and the funding cuts in 2009 will be discussed by technology further on in this report.

**Table 0-1 - MAP Funding from 2012 onwards**

| Technology | Funding Amount |
|---|---|
| **Solar collector systems** | |
| **Up to 40 m $^2$ gross collector area** | €1,500 to €3,600 |
| **between 40 to 100 m $^2$ gross collector area** | €3,600 to €18,000 |
| **Biomass plants** | |
| **Pellet stoves** | €1,400 to €3,600 |
| **Woodchip boiler** | €1,400 |
| **Heat pumps** | |
| **Ground and Water source heat pumps** | €2,800 to €11,800 |
| **Air source heat pump** | €1,300 to €2,100 |

Recently MAP grants can also be combined with a loan from the KfW, a government owned development bank. The KfW Förderbank promotes renewable technologies primarily for housing and environmental protection in Germany by providing loans at favourable rates. They have also developed a rating system[133] "KfW Efficiency House" where grants of up to €18,750 can be obtained for new buildings that reach specific levels within that system. The rating system also allows those who have taken loans to repay less if they can prove high efficiency levels.

# Obtaining Data

Very little data on renewable heat technologies is available in the English language, therefore the contact with industry experts within Germany was of paramount importance to find the data sources necessary. In almost every case no data exists from before unification in 1990 and certainly not on a national basis. Most of the data used in the German sections of this report is from 2000 onwards due to most records being kept at a federal state level up until this point.

The experts interviewed included:

- Erneuerbare Energien –AEE (Renewable Energies Agency)
- Institut für Regenerative Energiewirtschaft (Institute for Renewable Energy)
- Bundesverband Solarwirtschaft (Federal Solar Industry Association)
- Institut für nachhaltige Energie und Ressourcennutzung -INER (Institute for Sustainable Energy and resource use)
- Fachverband Biogas (German Biogas Association)

# Bioenergy Technology Group

## Biomass

Most of the data used to characterise the biomass sector in Germany was obtained via the Institute for Sustainable Energy and Resource Use (INER). INER recently finalised a two year study relating to innovations and challenges for the renewable heat sector within Germany, which was funded by the

[133] https://www.kfw.de/inlandsfoerderung/Privatpersonen/Bestandsimmobilie/

Federal Ministry of Economy and Energy. [134] The evidence has also been supported by interviews with national experts, as shown in Annex 0.

Demand for a flexible fuel, with lower risk (than fossil fuels) of price rises to replace oil in off-gas grid areas has driven significant production of wood pellets in Germany. So much so, that it currently has an over capacity of wood pellet production by around 2:1, with excess production not currently exported. High levels of growth in the sector early in the 2000s fuelled the expansion of the industry, which is now waiting for demand to catch up. This mismatch could cause significant issues for suppliers with the prospect of facility closure unless the biomass boiler market grows considerably.

In the early years, almost all installations were funded under MAP as pellet boilers were considered to be an emerging technology and therefore less competitive than established heating technologies. From 2005 onwards there is a sharp increase in the number of installations, which appears to track the oil price. However, in 2007 a decrease is observed. In Austria a similar decrease was experienced due to increases in the costs of biomass pellets. Whilst this would have impacted Germany to some extent, the same drop appears in all technology groups for that year and therefore it may have been caused by the wider economic crisis which started in Summer 2007.

Following the decline in 2007, the market then saw a massive boost in 2008 in line with the peaking of oil prices, which carried into 2009 as fears of continuing high prices pervaded despite a slight fall during that year.

The year 2010 was another defining moment, as MAP funding was briefly rescinded for a few months. According to the experts interviewed for this study, this not only had the effect of reducing the growth of biomass boilers for that year, but subsequent years have also been affected as confidence has been lost. With its reliance on the availability of funding, MAP was always a moving target. The effect of funding being cut entirely, however briefly, left investors, manufacturers and installers uncertain as to whether they could count on financing. Whilst the funding cut was widely publicised at the time, its reinstatement was not and therefore although the total number of installations per year has since recovered (in line with oil prices again) the proportion funded by MAP is only around half. This may however, be a positive sign that pellet boilers are becoming sufficiently competitive that funding is no longer as necessary to drive uptake.

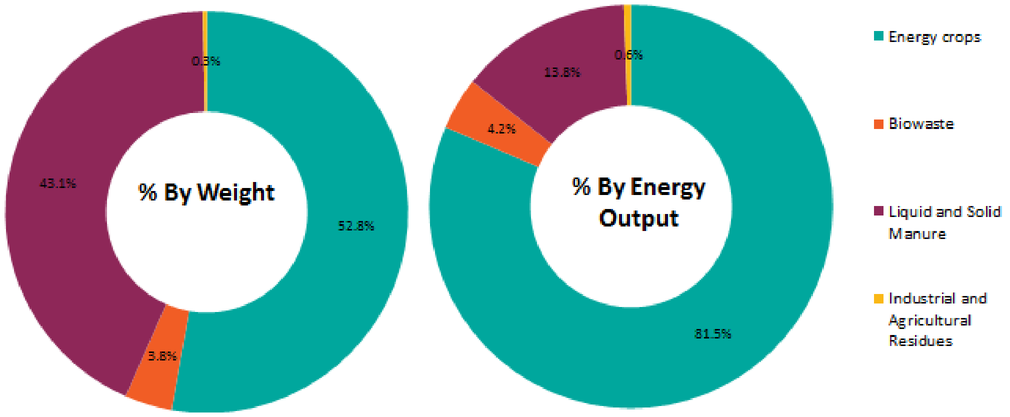
### Biogas

The largest driver for growth over the past decade has been the introduction of the feed in tariff (FiT) in 2004 via the Renewable Energy Sources Act (EEG). The effect of this can be seen in Figure 11 with rapid growth in plant numbers and heat output soon thereafter. The FiT has provided guaranteed income based on electricity generation by paying producers per kilowatt hour (kWh) delivered to the grid. All plants had to be CHP enabled, which meant that it was also necessary to produce useful heat.

Average feedstocks for biogas plants in 2012 in Germany are shown in Figure 34. The figure shows that energy plants constituted the largest feedstock, though liquid and solid manure also has a significant contribution.

[134] Bernd Wenzel, and et al. (2014) *Renewable energies for individual heating and cooling Innovations and challenges on the road in the heat market*, Report for Federal Ministry of Economy and Energy, 2014

**Figure 34: Feedstock in German Biogas Plants (2012)**




*Source: German Biogas Association (2013)*[135]

During the years 2007-8, high crop prices meant market growth stalled somewhat, albeit rapid growth followed for the next three years until growth again has since stalled slightly.[136] The German Biogas Association attributes this to plants generally being less financially viable as a result of increased regulation relating to abatement equipment, which has contributed significantly to capital costs.

On the 1st of August 2014, an amendment to the EEG was approved, which threatens to hinder the growth of biogas within Germany. The most significant changes to the EEG are that support for biogas production will be capped to 100 MW annually, and feed in tariffs will be gradually withdrawn from all new plants above 100 kW. This lowering (or removal) of tariffs is likely to threaten the viability of *existing* plant that are fuelled by non-waste based feedstocks, including energy crops. The revision of the EEG has already impacted on *planned* projects; for example, in July 2014, RWE Innogy GmbH announced that it had decided not to build a planned 4.2MW plant. The full extent to which the amendment will affect the industry is yet to be determined but the German Biogas Association believes that growth in the industry will be severely limited by this change.

## Heat Pump Technology Group

As per biomass, discussed in Section 0, the growth in the heat pump market can be attributed to the oil prices that peaked in 2008. This, along with a breakthrough in the new building sector—partly due to more stringent building efficiency requirements dictated by the Energy Saving Ordinance (EnEV)—caused a rapid rise in deployment in 2006, as shown in Figure 35. MAP funding began for heat pumps in 2007, which then helped to fuel the growth in the sector during 2008 and 2009. During these two years around 50% of installations were part funded by MAP. Shortly after this period, however, MAP funding was briefly cut in 2010 and soon after this, new homes were also deemed ineligible for funding. These developments saw the total number of annual installations fall slightly before regaining an equilibrium of just below the high point of 2008. MAP funding for heat pumps is now a fairly small part of the market which signifies that the technologies are mature enough to be economically competitive.

The slowdown in growth after 2008 was attributed by the experts partly to a reduction in the quantity of new homes being built within Germany as a result of the financial crisis. Whilst no data could be provided to substantiate this, however, GSHPs, in particular, are easier to install in new homes than to retrofit, so a market slowdown in new builds is likely to have had a substantial impact.

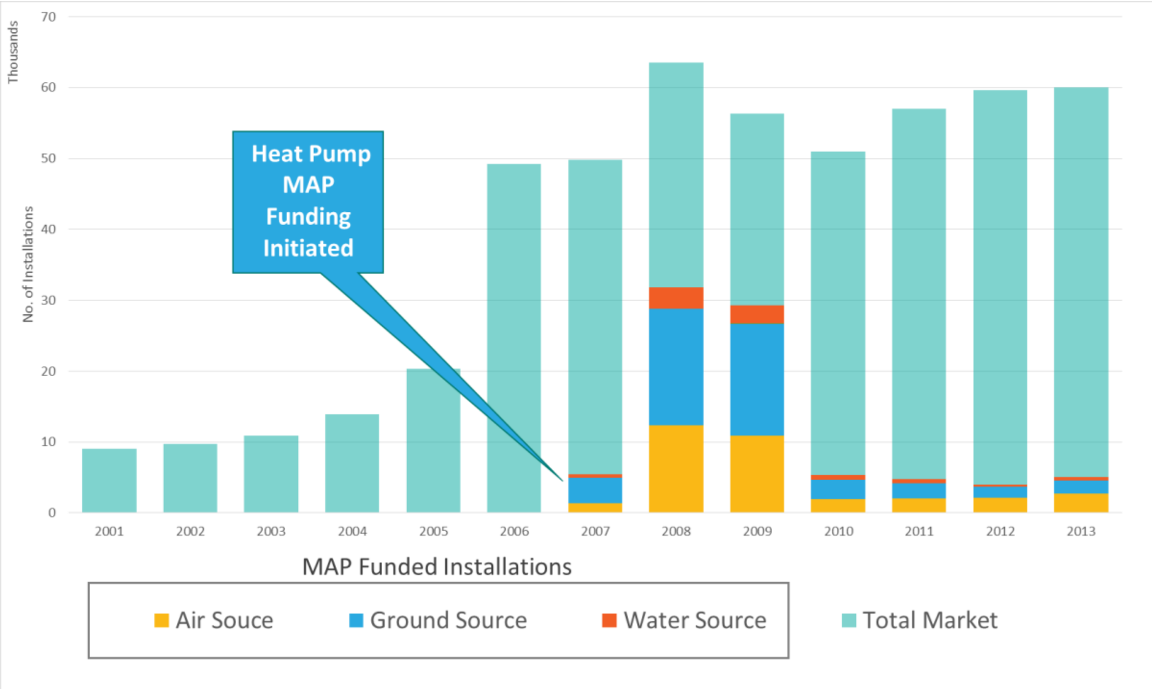
[135] Clemens Findeisen, German Biogas Association (2013) Biogas - Trends in Germany, October 2013, http://www.giz.de/fachexpertise/downloads/2013-en-findeisen-biogas-in-germany.pdf

[136] Note that under the scheme, a bonus is available for energy crops.

One of the main factors for the market remaining in a state of relative equilibrium after 2009 is the increased deployment of ASHPs, as shown in Figure 12.

By 2011, ASHPs accounted for the majority of the heat pump market and in 2013 represented 64% of all heat pump sales. The reason for this increase was down to the maturation of the technology to a point where efficiencies comparable to those delivered by GSHPs, but with significantly smaller installation costs i.e. no large ground works are necessary.

**Figure 35: Proportion of MAP-funded Annual Heat Pump Installations**




*Source: Wärmepumpenatlas.de*

Another driver identified in the research has been electricity prices within Germany. As described in Section 0, Germany has the highest relative electricity price of the five countries (including the UK) reviewed in this study and indeed the whole of the EU. Whilst this would ordinarily be a significant barrier to heat pump growth, electricity suppliers have in the past often tried to bolster heat pump installations by offering a less expensive electricity package for heat pump users. The incentive for doing so was because electricity suppliers could rely upon heat pump users drawing a constant amount of power at certain times of day, including during off peak (overnight) periods. Such incentives, however, are generally either no longer offered or the tariffs have since been increased.

## Solar Thermal Technology Group

Much of the anecdotal information and data for this technology group was provided by the Federal Solar Industry Association (BSW). In the early 1990s the Bundesimmissionsschutzverordnung (Federal Emission Regulation) mandated that pre-1978 heating systems were to be replaced to minimise emissions. It is unclear how this has directly impacted the renewable heat market, but it is likely to have driven the deployment of a range of technologies.

Up to the late 1990s, there was no consistent federal policy to support solar thermal deployment. The individual states across Germany all implemented different systems, including some which supported costs of solar thermal of up to 25%. In 1998, the MAP program started, but this occasionally ran out of funds and even stopped for a few months in 2010. This has caused uncertainty in the market, both for households and businesses considering solar thermal, but also investors.

From 2010 the program has only provided support for space and hot water heating in refurbishments; i.e. it has excluded new homes. Under the Renewable Heat Act (detailed in Section 0, however, new homes are now required to install a certain amount of renewable heat capacity and therefore lack of funding is theoretically no longer a constraint for such properties.

From 2012, the MAP also introduced a 'minimum funding' for small scale solar thermal installations up to $40m^2$, with at least €1,500 awarded to each project. This has resulted in many people designing smaller systems than they might otherwise require in order to receive a higher 'grant to expenditure' ratio. The extent to which this has had an effect on capacity deployed is not yet clear, albeit Figure 13 shows that the average installation size has fallen significantly since its high of around $10m^2$ to less than $7.5m^2$ in 2013.

In contrast to Denmark, the market for larger and industrial systems in Germany is currently very limited. Of all systems installed, only about 3-5% are 'collective systems', i.e. for multi-dwelling buildings and only a very small number are installed in industry. In this context, it is notable that a recent programme launched in August 2012, which offered a 50% subsidy for industrial uses of solar thermal, only received 150 applications in total. It is not clear, however, whether this was due to lack of attractiveness of the support package or the lack of promotion of the programme by Government.

The main driver of the 'boom' year for solar thermal during 2008, however, was the ever increasing oil price. The stabilisation of oil prices during the intervening period then reduced this effect, as people got more familiar with the price of oil. The sudden drop in MAP funded installations in 2010 is due to the aforementioned complete stoppage of the scheme that year. This did not, however, appear to significantly affect the total installation area, which suggests there is a good economic case for solar thermal even without funding. The level of capacity funded from MAP had still not recovered in 2013, which is probably to be expected given that support is now only available for refurbishments, as discussed above.

Solar thermal has also suffered from competition from heat pumps in the new buildings sector and from solar PV, which competes both for roof space and limited budgets. Furthermore, following a merger if the solar heating and photovoltaic industry associations, only a quarter of the members of the merged association are from the solar heating industry and therefore their interests are not as highly represented to Government. This, coupled with guaranteed FiT income from photovoltaics has resulted in lower levels of annual deployment of solar thermal.

# The Netherlands

The Netherlands has an overall target of 14.5% of share of energy generated from renewable sources in gross final energy consumption by 2020. For heating and cooling, a target of 9% of heat consumption must be met by renewable sources in 2020.

In order to achieve its targets the Netherlands has established comprehensive legal and administrative framework dating back since the mid 1990's. Historically, the Netherlands has utilised a large number of financial incentives. These have been aimed a wide range of RHTs including solar thermal, biomass, deep geothermal and heat pumps.

The most prominent mechanism to aid the deployment appears to be the SDE + (stimulering duurzame energie) scheme, which was introduced in 2011. The scheme replaced the MEP (Milieukwaliteit van de Elektriciteitsproductie) scheme and provides a premium on top of the market price to the producers of renewable energy, including RHTs. The scheme is only available to organisations and does not support individual domestic installations.

Additional government incentive schemes in the Netherlands include the Energy Investment Allowance (EIA) and the Green Funds scheme. The EIA provides tax relief for companies investing in energy efficient technologies or renewable energy technologies, typically the average tax benefit of the EIA is 10% of the investment costs[137].

The Green Funds scheme was launched in 1995 to support investment in green initiatives. The scheme covers a broad range of environmentally beneficial projects, including RHTs, which are eligible for 'green funds' provided by the majority of Dutch banks. Green funds provide investment at a lower interest rate than the market value. Individuals investing such schemes benefit from exemption from capital gains tax and less income tax on their green capital. The total tax advantage is 2.5% which means investor can accept a lower interest rate or dividend on the investment.

Historically the Netherlands has seen large scale deployment of heat pumps, solid biomass and biogas. Growth of solar thermal systems has been slower than other technologies. Despite the upward trend in renewable heat technology deployment and the incentives in place, progress towards 2020 targets has been slow. The renewable energy share of gross final energy consumption in the Netherlands in 2013 was 4.5%, with biomass accounting for 70% of renewable energy production followed by wind energy with a share of 19%[138].

The Netherlands is a net exporter of natural gas and has plans to become the gas roundabout of Europe, this has been attributed as a key factor to the slow progress of renewable energy[139]. Increased use of gas for electricity production, moving away from coal-fired plants, has also contributed to the reduction of $CO_2$ emissions. This has led some to suggest that the Netherlands is going through a two stage transition to a low carbon economy, first by switching to gas and then to renewable energy[140].

In 2013 over forty organisations including central, regional and local governments, trade bodies, financial institutions and environmental groups signed the Energy Agreement which aims to drastically

---

[137] RVO (Netherlands Enterprise Agency) Renewable Energy report 2013

[138] RVO (Netherlands Enterprise Agency) Renewable Energy report 2013

[139] Interview with Duurzame Energie Koepel (Renewable Energy Council), September 2009

[140] Interview with Duurzame Energie Koepel (Renewable Energy Council), September 2009

increase renewable energy production to achieve the 2020 targets and realise the economic benefits of doing so through the creation of 15,000 full time jobs within the energy sector.

# Bioenergy Technology Group

## Biomass

Agriculture has been a large growth area for biogas and biomass, particularly since the introduction of the MEP[141] and subsequent SDE schemes[142]. Agricultural businesses, such as glasshouses and timber production processes have previously installed gas-powered CHP plants to provide onsite power and heat.

Increases in gas prices over the last decade, coupled with a reduction in electricity prices due to a flow of cheap electricity via interconnectors from other European countries such as Germany, is reducing the profitability of such schemes. As a result, agricultural businesses are switching to biomass (or biogas) to fuel CHP plant as they can often produce their own fuel and receive the SDE for the electricity and heat produced. This is particularly attractive for the glasshouses which no longer benefit from subsidised gas.[143] Uptake of solid biomass in the small-scale non-domestic sector has been limited, as the SDE scheme only supports boilers over 500kW, although wood-burning biomass stoves have been popular in the timber and furniture industry where waste wood can be utilised.[144]

Domestic heat generation from biomass has remained relatively constant since 1990. This is likely to be the result of both the relative price of boilers and fuel compared with their gas-fuelled equivalents, and the lack of an incentive scheme to encourage deployment.

Sustainability of biomass is a key concern in the Netherlands.[145] This is because domestic resources are limited; for example, the feedstock required to fuel a recent conversion of a 40MW CHP plant from gas to biomass is equivalent to half of the domestically grown feedstock. [146] As a result, large scale biomass generators in the Netherlands are subject to fluctuating global feedstock prices, which also raises environmental issues. Public concern has arisen relating to the competition for land between crops for fuel and crops for food, importing wood fuel from other countries and potential 'land-grabbing' in other countries for the production of fuel.[147] There is also increasing public opinion that the Netherlands should grow its bio-based economy, cascading the use of biomass materials for other products and only using waste products as fuel for heat and electricity production.[148]

---

[141] The MEP scheme (Milieukwaliteit van de Elektriciteitsproductie) was introduced in 2003 and was a Government subsidy scheme paid to domestic producers of electricity from renewable sources and CHP who feed-in to the national grid on a per kWh basis.

[142] The SDE (stimulering duurzame energie )scheme was introduced in 2008, following the closure of the MEP scheme. The scheme was amended and renamed the SDE+ in 2011. The scheme incentives are structured as feed-in premiums and are financed through a levy on the energy bill of end consumers.

[143] Interview with RVO (Netherlands Enterprise Agency), September 2009

[144] RES-H Policy (2009) *Renewable heating and cooling in the Netherlands*, June 2009, http://www.res-h-policy.eu/RES-H_Policy_Market-Report-NL_(D3)_english.pdf

[145] Interview with Duurzame Energie Koepel (Renewable Energy Council), September 2009

[146] Interview with RVO (Netherlands Enterprise Agency), September 2009

[147] Interview with Duurzame Energie Koepel (Renewable Energy Council), September 2009

[148] Interview with RVO (Netherlands Enterprise Agency), September 2009

### Biogas

Biogas deployment has been stimulated by the introduction of the SDE in 2008, which provides financial support for biogas generated from waste water treatment, anaerobic digestion and the gasification of biomass and wastes.

Biogas is also injected into the existing natural gas grid in the Netherlands. Whilst gas used in the grid has a lower calorific value in the Netherlands than the UK, it is still necessary to upgrade biogas to reduce the $CO_2$ content. The high cost of upgrading biogas (or of installing gas engines to generate electricity) is such that agricultural plant often pipe gas to a larger generator or a local CHP plant.[149]

## Heat Pump Technology Group

There is little historic Government support for heat pumps in the Netherlands. In 1995 a programme of support was introduced by NOVEM (now known as the Netherlands Enterprise Agency) which provided grant funding and aimed to improve the market through demonstration projects and related publicity. It became clear, however, that there were several barriers to the technology, not least the fact that gas prices (for heating) were cheaper than electricity prices, and the grant scheme was terminated in 1996. Around the same time, the third Energy Memorandum published by the Dutch Government excluded heat pumps, as it was considered that their use in industry could not be counted as 'renewable' as many (but not all) such technology designs draw residual heat from fossil fuel derived sources, for example, waste heat from refrigeration.[150] Currently heat pumps do not benefit from the SDE+ but are supported by the EIA and Green Funds scheme.

The aforementioned growth in heat generated by heat pumps has therefore been largely market-led, particularly in the non-domestic sector where there is high demand for cooling as well as heating. This has driven the increased use of 'reversible' air to air source heat pumps and open ground loop systems for GSHPs.

Open ground source heat pumps utilise aquifers to extract water which is subsequently pumped back into the aquifer. Research into these systems began in 1993/1994 with grants for feasibility projects provided by the Dutch Government. This led to the Energy Storage Aquifers (MEA) programme which supported feasibility studies, investment and projects. Although there is currently no support mechanism for open loop systems (except tax relief), the technology is financially attractive for large buildings with a high heating/cooling demand and as a result, 30-40% of new offices have open loop systems installed.[151] This specific market is well-established with the industry providing training, design guidelines and quality requirements.[152]

Whilst the demand for cooling, as well as heating, has driven the heat pump market in the Netherlands there is some concern as to how this affects presentation of renewable energy statistics for the country. A significant amount of heat pump data relates to cooling (which does not count as 'renewable' energy under the EU Renewable Energy Directive) and as a result 50% of generation was removed from the Government's presentation of this information (in 'Statline' data) before it was published. Research continues to ascertain how much of the remaining generation is used for heating purposes.[153]

---

[149] Interview with RVO (Netherlands Enterprise Agency), September 2009

[150] RES-H Policy (2009) *Renewable heating and cooling in the Netherlands*, June 2009, http://www.res-h-policy.eu/RES-H_Policy_Market-Report-NL_(D3)_english.pdf

[151] Interview with RVO (Netherlands Enterprise Agency), September 2009

[152] RES-H Policy (2009) *Renewable heating and cooling in the Netherlands*, June 2009, http://www.res-h-policy.eu/RES-H_Policy_Market-Report-NL_(D3)_english.pdf

[153] Interview with RVO (Netherlands Enterprise Agency), September 2009

## Solar Thermal Technology Group

Support for solar thermal technology in the Netherlands dates back to 1988 with the introduction the first grant scheme for new installations. The grant subsidised up to 40% of the installation costs for solar collectors with a maximum collector surface area of $4m^2$. Following the introduction of the grant scheme, the 'Solar Boiler Campaign' was launched in 1991 with the aim of increasing deployment. A key aspect of the Campaign was an agreement secured by the Dutch Government with utility companies to contribute to improving sustainability. Solar thermal boilers were among the measures available and in the following two years 80% of annual sales were supported by the scheme.

In 1993 the Dutch Cabinet were concerned that budgets were running out faster than expected. Consequently the grants available were reduced, thus stabilising the market. In 1994, however, a group of key stakeholders signed a long-term agreement to increase deployment of solar thermal technology. Among the stakeholders were the Dutch Ministry of Economic Affairs, Holland Solar (a trade body) a number of distribution companies and Novem (now known as the Netherlands Enterprise Agency). The agreement aimed to reduce the price of solar thermal installations by around 40% between 1991 and 1997 and for utility companies to increase the number of installations from 1,800 to 14,000 per year. The Ministry of Economic Affairs agreed to continue subsidising the cost of solar equipment through the grant scheme although in 1995 grants were award based on the efficiency of the installation rather than collector area. A quality certificate was also developed and introduced. The agreement was successful and growing demand, increasing efficiency and innovation in production resulted in the price of an installed system falling by around 35% between 1991 and 1995.

Building on this success, the solar market received a further boost in 1995 with the Dutch Government's publication of the Third Energy Memorandum. The memorandum set indicative targets for increased deployment of solar systems, aiming for 80,000 in 2000 and 400,000 by 2010. The grants scheme, which was due to end in 1997, was also extended to 2000, although this was not publicised until the end of 1998 leading to low uptake that year, as is seen in the slight fall in annual growth rate in Figure 16.

The long term agreement initiated under the Solar Boiler Campaign came to an end in 1997 and was succeeded by the 'Solar Boiler Covenant', which ran to 2001. Signed by the Dutch Ministries of Economic Affairs and Housing, Spatial Planning and the Environment and over 30 stakeholders, the aim of the Covenant was to deliver a market for solar thermal which would enable the 2010 target to be achieved. To realise this, the Covenant included agreements from manufactures and installers to improve the quality of solar thermal systems and placed an obligation of 'best intent' on utility companies to install 40,000 systems in 2000 rising to 65,000 in 2002.

Despite the Covenant, the Government's target for 80,000 solar installations in 2000 was not reached. There had also been an expectation that the energy performance standards set for new housing developments would lead to the automatic deployment of solar thermal but this was not the case, perhaps due to the emergence of highly efficient gas boilers which introduced significant competition.

The subsequent introduction of targets under the EU Renewable Energy Directive (RED) led to a reconsideration of energy policy in the Netherlands. In 2001 the Dutch Government announced that priority should be given to renewable energy technologies that can provide the largest contribution to the 2020 target, such as large scale offshore wind and biomass, including co-firing in existing coal-fired plants.[154] At the time the Dutch Ministry of Economic Affairs suggested that other smaller-scale technologies, such as solar thermal, PV and heat pumps were not expected to make a substantial contribution until after 2020. As a result such technologies were no longer considered for specific support and the Solar Boiler Covenant was terminated in 2002.

---

[154] Interview with RVO (Netherlands Enterprise Agency), September 2009

Although specific support was no longer provided, solar thermal systems did benefit from support under energy efficiency schemes such as the Energy Premium Scheme (EPR) which ran from 2001 and 2003. The EPR was limited to existing dwellings rather than new builds, which was considered the main limitation to deployment at this time.[155] Similarly, the introduction of the Clean and Efficient Programme in 2007 led to the provision of a new grant for solar thermal systems in existing dwellings only. Consequently there has been an increase in deployment of domestic systems, albeit the grant ended in 2011.[156]

In recent years non-domestic solar thermal systems have been supported by the SDE+, although only systems greater than $100m^2$ are eligible for financial support from the EIA and Green Funds mechanisms.[157] This size requirement has not only been a key barrier for solar thermal at a domestic level, but also for SMEs and consequently the market development potential for solar thermal has been constrained.[158]

## Barriers to Deployment

Ultimately, despite the various forms of historic support for solar thermal technology in the Netherlands progress has been slow. This has been attributed to a number of factors but is predominantly driven by the shift in energy policy towards wind and biomass generation, which it is perceived can provide greater contributions to the 2020 RED target.[159] This has led to a start/stop of incentive measures which has undermined confidence in the market, lengthening the period of return on investment (ROI).[160]

Driven by the SDE+, the installation of solar thermal on new buildings was expected to be a high growth area in recent years but the stagnation of the construction market since the 2008 recession, which has seen a 50% reduction, meant that this has not been realised. [161]

As in most of the other Member States reviewed for this study, solar thermal in the Netherlands has also suffered from competition with Solar PV which is often seen as easier to install and manage, particularly for new buildings, as it is easier to meter. With constrained budgets, this has meant both businesses and households often opting for PV over solar thermal, as part of an ‘either or’ decision-making process.

---

[155] RES-H Policy (2009) *Renewable heating and cooling in the Netherlands*, June 2009, http://www.res-h-policy.eu/RES-H_Policy_Market-Report-NL_(D3)_english.pdf

[156] Interview with Duurzame Energie Koepel (Renewable Energy Council, September 2009

[157] Interview with RVO (Netherlands Enterprise Agency, September 2009

[158] Interview with Duurzame Energie Koepel (Renewable Energy Council), , September 2009

[159] Interview with RVO (Netherlands Enterprise Agency, September 2009

[160] Interview with Duurzame Energie Koepel (Renewable Energy Council), September 2009

[161] Interview with RVO (Netherlands Enterprise Agency), September 2009

Department of Energy & Climate Change
3 Whitehall Place
London SW1A 2AW
www.gov.uk/decc
URN **15D/519**