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Promoting renewable energy sources for heating and cooling in EU-27 countries

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ABSTRACT

In addition to public policies aimed at improving the energy efficiency of buildings, EU authorities have also promoted the use of Renewable Energy Sources for heating and cooling uses (RES H&C). This paper analyses the main policy measures implemented in EU-27 countries up to 2009: i.e. subsidies, tax incentives, financial support and feed-in tariffs. Twenty-three Member States (MSs) have developed some of these policy measures.

The most widespread measure is the subsidy (22 MSs have implemented these) because from a political point of view, subsidies provide a straightforward approach to promote the use of RES H&C. Secondly, tax incentives have been used for reducing investment costs and making renewable energy profitable. Thirdly, financial incentives and feed-in tariffs have been used sparingly. While financial incentives might be used more extensively for promoting RES H&C if they are accompanied by other policy measures, feed-in tariffs are not likely to be implemented significantly in the future because this measure is not designed for household heat producers.

1. Introduction

Final energy use by households and the service sector accounts for 39.5% of the EU-27 total final energy consumption updated to 2007 (Eurostat, 2010a). Heating represents, on average, 70% of household energy consumption (including space and water heating) and about 14% of EU-27 greenhouse gas (GHG) emissions (Market observatory for energy, 2010). With reference to the EU-27 countries, the Odyssee-Mure project (2009) provides the following breakdown of approximate household energy consumption for 2007 in millions of tonnes of oil equivalent (Mtoe): space heating (300), water heating (50), cooking (10) and lighting (50). Space heating is by far the largest end-use in the EU15 countries[1] and accounts for 68.8% of total domestic consumption; water heating accounts for a further 13.8%; lighting and appliances account for 12.8% and cooking 4.6% (UK Parliamentary Office of Science and Technology, 2005). Besides household consumption, it is necessary to take into account the service sector's heating requirements which, up to 2008, accounted for 476 Mtoe (Eurostat, 2010a).

Due to the importance of total final energy consumption for heating and cooling of the household and service sectors, this paper refers to the measures employed to promote the use of RES H&C in buildings.

With respect to energy sources, the use of natural gas by these two sectors represents 35% of EU-27 total use of this energy source (Market observatory for energy, 2010). In the EU-27 context, district heating (DH) must be noted. The core element of a DH system is usually a cogeneration plant or combined heat and power (CHP) plant or a heat-only boiler station. Most of the space and hot water heating demand is satisfied by natural gas, propane and fuel oil.

The very considerable use of natural gas in Europe explains the dominance of this energy source in total imports in EU-27 MSs and adds pressure on the dependence of primary energy sources in the EU, which was 54.8% in 2008 (% of net imports in gross inland consumption and bunkers, based on tonnes of oil equivalent, IEA, 2010). For the same year, natural gas imports accounted for 75.8% of gross consumption of gas natural (Eurostat, 2010a).

This is a relevant issue, not only from a geopolitical point of view but also from an energy policy perspective because most of the natural gas supplies in Central Europe come from Asian deposits (mainly from the Caspian Sea) and are delivered through pipelines originating in Russia.

The recent crisis between Ukraine and the Russian operator Gazprom (first in 2006 and more recently in 2007–2008) has reinforced two of the four targets of the EU-27 energy strategy: the need to reduce primary energy dependency and also the

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[1] However, there is large difference between MSs. For the UK, space heating accounts for, on average, ~60% of household energy demands (UK Parliamentary Office of Science and Technology, 2005). The European Commission estimates it to account for up to 50% of household energy consumption (European Commission (EC), 2006).

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stress of demand on primary energy resources.[2] In addition, the GHG abatement due to a more intensive use of RES would contribute to improve the EU-27's target related to climate change, this being the fourth target in its energy strategy.

So far, the main EU strategy to reduce household and services sector energy consumption for heating has been oriented towards promoting more energy-efficient building designs. Improvements to new building standards have helped to reduce energy requirements for heating in newly built properties. As Odyssee-Mure project (2009) point out, since 1990, new properties require 60% on average less energy for heating than those properties that were built before. In the future, building renovations carried out in line with EPBD[3] 2010 will be a key aspect behind initiatives to reduce energy use. Given the long restoration cycle for existing buildings, new and existing buildings that undergo major renovations should therefore meet minimum energy performance requirements adapted to the local climate. It should be borne in mind that the technical characteristics of buildings, e.g. insulation standards, are important determinants of the space heating demand for private households. Holistic approaches that combine improvement of the building envelope (i.e. thermally well-insulated) together with improvements in the heating system should result in the greatest energy savings (Dovjak et al., 2010). In fact, Dovjak et al. (2010) recently pointed out that the insulation of buildings has a much greater effect on reducing energy requirements than do improvements in boiler efficiency. In addition to studies that have identified a relationship between the insulation of buildings and reductions in energy consumption (Howden-Chapman et al., 2009), other studies highlight the importance of the relationship between the insulation of buildings and the health of households (Preval et al., 2010).

In order to improve on energy efficiency, the most important EU policies for the households sector are the EPBD 2010, "The Energy Services Directive (ESD)" and "The Eco-design Directive". Other Directives from the building field are Directive CPD 89/106/EEC (Construction Products Directive) and the EU Directive of 21 December 1988 on the approximation of laws, regulations and administrative provisions of MSs relating to construction products should be mentioned.

EPBD 2010[4] stipulates measures to increase the number of buildings which not only fulfill current minimum energy performance requirements, but are also more energy efficient, thereby reducing both energy consumption and carbon dioxide emissions. For this purpose MSs should draw up national plans for increasing the number of nearly zero-energy buildings and regularly report such plans to the Commission (17, EPBD 2010 Preamble). Also, prospective buyers and tenants of a building should, in the energy performance certificate, be given correct information about the energy performance of the building and practical advice on improving such performance. Information campaigns may serve to further encourage owners and tenants to improve the energy performance of their building. Owners and tenants of commercial buildings should also be encouraged to exchange information regarding actual energy consumption, in order to ensure that all data are available to make informed decisions about necessary improvements. The energy performance certificate[5] should also provide information about the actual impact of heating and cooling on the energy needs of the building, on its primary energy consumption and on its carbon dioxide emissions (22 Preamble, EPBD 2010).

Additionally, the ESD expects that countries will achieve a 9% energy saving in the period 2008–2016. Although the ESD does not introduce specific policy measures, it will probably have significant influence in the implementation of new policy measures by MSs. Finally, the Eco-design Directive takes a step further by introducing minimum efficiency standards for the optimal use of energy. This Directive does not introduce directly binding requirements for specific products, but establishes a framework of conditions and criteria that need to be respected when introducing implementation measures.

These Directives have been implemented into the national legislation of each country.[6] Nevertheless, the EPBD only asks MSs to set requirement levels, without specifying what the minimum requirement levels are. As such, each country has set its own national levels which, according to Panek (2010), have led to significant disparity in the implementation of EPBD standards. From 2012, MSs are required to transpose EPBD 2010 into their national law.

Most specialized literature has largely focused on new building standards related to energy requirements for heating and cooling[7] (Sheldrick, 1987; Haberl et al., 1998; Schuler et al., 2000; Roberts, 2008; Dongyan, 2009; Eichhammer and Walz, 2009; Howden-Chapman et al., 2009; Braun, in press; Dovjak et al., 2010; Preval et al., 2010; Ozgener and Ozgener, 2010). Nevertheless, besides policy measures aimed at improving the energy efficiency of buildings, EU authorities have also promoted the use of Renewable Energy Sources for heating and cooling uses (RES H&C) in order to reduce primary energy dependency and the stress of demand on primary energy resources.

From an energy policy perspective, the substitution of natural gas by RES for these uses would contribute to a reduction in primary energy dependency and reduce stress on natural gas energy resources, thereby leading to a higher level of GHG abatement as required by EU energy strategy.

However, although there is a wide range of technologies based on RES H&C, they cover only 2–3% of global energy demand for H&C (excluding traditional biomass; Seyboth et al., 2008). In fact, if biomass is included and we refer only to EU-27 MSs, the RES H&C consumption represented 11.9% of final heat use in 2008 (Eurostat, 2010b).

As IEA (2009) recently pointed out, part of the renewable energies growth is due to strong policy support. Over the last few years, several EU-27 MSs have developed a range of incentives to promote the use of RES H&C to increase national targets for renewable heat generation as a percentage of total heating and cooling energy demand. On February 14, 2006, the European Parliament adopted a report suggesting that the RES H&C share of total energy consumption should be increased up to 20% by 2020 (European Parliament resolution with recommendations to the Commission on heating and cooling from renewable sources of energy, 2006). Later, following the implementation of Directive 2009/28, every MS has developed its own National Action Plan that fixes specific objectives

[2] See European Commission (EC), (2007).

[3] Directive 2010/31/EU. Energy Performance of Buildings Directive (2010).

[4] MSs shall adopt and publish, by 9 July 2012 at the latest, the laws, regulations and administrative provisions necessary to comply with this Directive. Also they shall apply those provisions from 9 January 2013 at the latest and to buildings occupied by public authorities from 9 January 2013 (Article 28).

[5] Article 3 of the EPBD 2010 states how to adopt a methodology for calculating the energy performance of buildings.

[6] Country Reports on EPBD implementation can be found in BUILD UP, the European web portal for energy efficiency in buildings: http://www.buildup.eu/home.

For example, in Spain, the Royal Decree 314/2006 of the Building Technical Code covers EPBD (2002) articles 4, 5 and 6, while Royal Decree 1027/2007 covers EPBD (2002) articles 8 and 9, and 4, 5 and 6 for HVAC systems. Royal Decree 47/2007 on Certification of New Buildings must also be considered and a new Royal Decree on Certification of Existing Buildings is expected. Within the framework of the EPBD transposition into MS government policy, the Spanish government has also published a Document on the National Strategy for Energy Efficiency.

[7] Related issues like the impact of climate change on heating and cooling demand have also been treated (Zmeureanu and Renaud, 2008; Isaac and van Vuuren, 2009).

Table 1
National targets of RES H&C in 2005, 2010 and 2020.
Source: European Commission (EC, 2010a) and own elaboration.

	2005 (%)[b]	2010 (%)[b]	2020 (%)[b]
Austria	24.3	30.5	32.6
Belgium	2.3	3.5	11.9
Bulgaria	15.28	16.50	23.8
Cyprus	9.1	16.2	23.5
Czech Republic	8.4	10.2	14.1
Denmark	23.2	30.8	39.8
Estonia	16.3	19.2	17.6
Finland	40	37	47
France	13.6	17	33
Germany	6.6	9	15.5
Greece	12.76	14.7	19.7
Hungary	5.4	9.0	18.9
Ireland	3.5	4.3	12
Italy	2.8	6.53	17.09
Latvia	42.7	45.3	53.4
Lithuania	27	28	39
Luxembourg	1.7	2.1	8.5
Malta ([a])	—	7.9	6.2
The Netherlands	2.5	3.7	8.7
Poland ([a])	—	12.29	17.05
Portugal	31.9	30.7	30.6
Romania	18.72	17.86	22.05
Slovak Republic	6.1	7.6	14.06
Republic of Slovenia	20	22.3	30.8
Spain	8.8	11.3	18.9
Sweden	53.7	57	62.1
United Kingdom	0.7	1	12

[a] No data for 2005.
[b] These data represent the percentage of renewable heat generation as a proportion of total heating and cooling energy demand.

for each MS in the use of renewable energy sources for each sector, including heating and cooling. Table 1 shows the national targets of RES H&C in 2010 and 2020 compared with 2005 (base year used to determine the national renewable energy action plans).

MSs have introduced a range of incentives to achieve EU targets and implement National Action Plans with respect to RES H&C.

This paper analyses the main measures developed by MSs in EU-27 through to 2009 to promote the use of RES H&C. An extensive review of the literature since 1987 has been performed, focusing on the main policy measures implemented to promote RES H&C, not only by EU-27 MSs but also for other countries. Following this review we conclude that four types of public instruments warrant further study: subsidies, tax incentives, financial support and feed-in tariffs. These all are referred to in relation to the EU-27 MSs. In order to carry out this review, the main sources that we have taken into account, which are far from exhaustive, are the country reports in EREC (2009), the Intelligent Energy Europe (2010) report, the EuroACE (2009) report, the "Taxes in Europe" database published by the European Commission (EC, 2010b) and the "Energy Efficiency Policies and Measures" database of the Energy Investment Allowance (EIA, 2011). Also, to study the manner in which these policy measures have been implemented in each MS, the EU Directives relating to this issue and their implementation into national legislation have been analyzed (European Council (EC, 1989) and European Parliament and the Council (EP&C, 2002, 2009, 2010a, b) Directives).

This paper has been structured around seven sections. The importance of subsidies in promoting H&C in the UE-27 is analyzed in Section 2. An important fiscal measure to promote RES H&C, tax incentives, is examined in Section 3. Other political measures available are financial support and feed-in tariffs, which are treated in Sections 4 and 5, respectively. The pros and cons of these policy measures are considered in Section 6 and main conclusions are presented in Section 7.

2. Subsidies

Technologies that are most commonly supported through public subsidies in the EU-27 are based on biomass (16 MSs), solar-thermal (15 MSs) and geothermal (9 MSs) energy consumption. The level of subsidy is fixed as a percentage of the total cost of the investment, with legal maximums settled in nominal terms. Subsidies that consist of flat-rate aid are less common and used only in Belgium, Ireland, Republic of Slovenia and Slovak Republic. The granting of subsidies is not done automatically but is subject to public sector verification. Often, installers are required to be licensed by the responsible administration in order that the investment is subsidized. When subsidies are applied, they may discriminate depending on whether the beneficiaries are from the public or private sector, or, if they are from the latter, if they are households or companies.

Sometimes the benefit is conditional on the new installation replacing a previous one that did not use RES.[8] When different levels of government are involved (e.g. central and regional), the subsidy is usually co-financed by the governments implicated. This occurs in Austria, Belgium and Italy.

In order to evaluate the importance of this measure in the promotion of RES H&C, it is relevant to point out the main characteristics of the subsidies that are used to promote the three main energy sources, these being biomass, solar-thermal and geothermal.

The subsidies applied to promote biomass for H&C are the largest employed in the EU-27. Sixteen MSs have developed specific measures to promote the use of biomass for H & C (Belgium, Cyprus, Finland, France, Germany, Ireland, Italy, Latvia, Luxemburg, Malta, The Netherlands, Portugal, Spain, Republic of Slovenia, Slovak Republic and UK).

The most used technology is that of biomass micro-cogeneration systems which consist mainly of boilers that are required to meet certain energy efficiency conditions.

The use of biomass is complicated with respect to District Heating (DH) because using biomass to fire micro-cogeneration systems is less attractive for areas with low population densities, as the investment per household is considerably higher. Similarly, it is less attractive in areas with many small buildings (e.g. detached houses), than in areas with a few, much larger buildings (e.g. apartment blocks), because of the expense involved in making connections to each house.

In the EU-27 area,[9] DH represents an important share of the total heating map. The main reason is that DH has various advantages compared to individual heating systems. DH is usually more energy efficient due to the simultaneous production of heat and electricity in combined heat and power generation plants. However, DH is less attractive for areas with low population densities.[10] The importance of DH in EU-27 would justify a more intensive use of RES applied to this type of heating system, and must be considered in the design of energy policies. As is pointed out in this section, subsidies play an important role in RES promotion.

The core element of a DH system[11] is usually a cogeneration plant, or a combined heat and power (CHP) plant, or a heat-only

[8] This is the case in Latvia when biomass is used in lieu of fossil fuels. A similar situation occurs in the Czech Republic and Sweden when geothermal systems were introduced in place of electricity-driven systems.

[9] In a more comprehensive overview it must be noted that the Danish DH is the most developed European system (see Agrell and Bogetoft, 2005).

[10] The literature offers several case studies for MSs from different points of view; e.g. Westin and Lagergren (2002) studied the Swedish case where municipal district heating companies were obliged to operate in a commercial manner and offer competitive pricing.

[11] The legal framework in the MSs is currently influenced by the CHP Directive (Directive on the promotion of cogeneration based on a useful heat demand in the internal energy market and amending Directive 92/62/EEC, officially 2004/8/EC).

boiler station.[12] Due to the importance of fossil fuels in CHP most of the subsidies are oriented to encourage the introduction of RES (solar and geothermal) in heating systems. Technologies based on RES such as solar, geothermal, and biomass (in the co-firing and tricombustion systems[13]) can benefit from public subsidies if they are used for heating and cooling purposes.

Subsidies explain why there has been a partial substitution of fossil fuels for heating uses in favor of a progressive shift to the use of RES. First, although the heat is often obtained from a CHP plant burning fossil fuels, the biomass option is of increasing importance. Second, besides heat-only boiler stations, geothermal heating and central solar heating are also used.

The heating based on the use of RES is dominated by the use of biomass and in particular by the domestic consumption of wood. In the case of the use of wood, countries like France have achieved outstanding results.[14]

Increases in the use of efficient wood stoves and boilers, as well as biomass-based cogeneration for industrial use have been poor, despite their potential to reduce CO_2 emissions.

The second most important subsidized technology is that of solar-thermal energy.[15] In the United States, heating, ventilation and air conditioning systems account for over 25% of the energy used in commercial buildings and nearly half of the energy used in residential buildings (Apte et al., 2003). Solar thermal heating experienced record growth rates worldwide in 2007, driven strongly by China. According to the Worldwatch Institute report (2009), the solar thermal heating capacity increased by 19 GWth to reach 147 GWth in 2007. China accounts two-thirds of global capacity and installed 80% of all new systems in this year.

The EU's new Renewable Energy Directive is expected to boost demand even further in Europe. Europe's advantage is that it has the most comprehensive portfolio of applications, comprising hot water and space heating for residential buildings and hotels, district heating, space cooling and industrial processes (Euroactiv, 2009). Šúri et al. (2007) give information about sun hours in the EU. The main disadvantage of solar-thermal technologies is that large quantities of water are needed for heat transfer.

Fifteen MSs provide specific subsidies for solar-thermal technologies for H&C (Austria, Belgium, Cyprus,[16] France, Germany, Ireland, Italy, Luxemburg, Malta, The Netherlands, Portugal, Spain, Republic of Slovenia, Slovak Republic and Sweden).[17] The technique that is mainly promoted is that of solar collectors.

Finally, nine MSs have implemented specific subsidies to promote geothermal energy for heating uses (Austria, Belgium, Cyprus, Germany, Greece, Ireland, Luxemburg, Slovenia and Sweden). Obviously, this RES is not available in all countries and therefore its promotion is more limited.

For countries rich in geothermal energy resources, Thorsteinsson and Tester (2010) pointed out that an enormous opportunity exists for directly utilizing indigenous geothermal energy as an alternative source that is cleaner and almost emission-free. However, countries have frequently undervalued their portfolio of options concerning this alternative energy as a means of offsetting fossil fuel emissions while providing a local and reliable energy source for communities.[18] The associated technologies most commonly used are heat pumps and heat exchangers.

In the case of solar energy to heat water, public promotion is not only done through a grant for the collectors but also by establishing legal rules that force them to be installed in new buildings with certain characteristics. In Spain, solar thermal energy is mandatory for all Domestic Hot Water (DHW) installations, in all buildings types with a DHW demand. Moreover, photovoltaic solar energy is also mandatory for almost all non-residential buildings, with a minimum power that depends on the building size (Royal Decree, 314/2006).[19] Germany has stipulated a 15% minimum use of renewable energy for all new buildings (Erneuerbare Wärmegesetz, 08/2008). The ratio of renewable energy depends on the type of energy source and runs from 15% (solar energy) to 50% (biomass, geothermal). In some federal states the use of renewable energy is also required for major renovations of existing buildings.[20]

Table 2 offers an overview of subsidies considered in this section. It is possible to see a relationship between the type of RES eligible for subsidy in each MS and its indigenous nature. For this reason techniques based on geothermal energy are not eligible for subsidy in a large number of MSs, whereas techniques based on solar energy are applicable for most of them.

As an instrument of energy policy, subsidies have the interesting property that they are easy for public authorities to manage. A simple scheme based on an application, a check-comparison with legal standard characteristics and a possible review by authorities is all that is required to implement this type of policy measure.

3. Tax incentives

In addition to subsidies, RES H&C are often promoted through a range of tax incentives, although with a lower intensity compared with green electricity and biofuel promotions (Cansino et al., 2010; Uyterlinde et al., 2003). The main tax incentives used by EU-27 MSs are deductions, exemptions and reduced tax rates.[21] Table 3 provides an overview of the use of these tax incentives in the EU-27 MSs.

[12] Egeskog et al. (2009) estimated the heat sink capacity of DH systems in MSs and assessed the scope of biomass-gasification-based co-generation of synthetic biofuels for transportation and heat (CBH) for DH systems in EU countries. In a similar way Börjesson and Ahlgren (2010) point out that biomass gasification could also be used for the efficient production of biofuels for transport.

Madlener (2007) discussed the framework conditions for the diffusion of rural biomass district heating (BDH) in Austria. The author concluded that intensive lobbying and strong political and public support were necessary to successfully combat interventions by both the natural gas industry and influential gas-supplied industrial enterprises.

Holmgren and Gebremedhin (2004) concluded that in Swedish municipalities, it was economically feasible to invest in a waste incineration plant for heat production. An important measure to lower carbon dioxide emissions is to introduce combined heat and power production on the assumption that the local electricity production replaces by the electricity produced by burning coal. It must be taken into account that even displacing electricity from CC gas power stations can result in GHG emission reductions.

Also for the Swedish case, Börjesson and Ahlgren (2010) have particularly stressed the fact that biomass-based integrated gasification combined cycle (BIGCC) plants could, in CHP generation, increase the power-to-heat ratio compared to conventional biomass steam turbine plants.

[13] This is the case in Italy. There, units of diffuse small-scale cogeneration have a subsidy of 40% for tri-generation.

[14] In 2005, the Wood Energy Plan allowed a 23% increase in sales of equipment based on wood energy for homes.

[15] Solar thermal energy (STE) is a technology for harnessing solar energy for thermal energy (heat), this being different from photovoltaic energy that converts solar energy directly into electricity.

[16] See Maxoulis et al. (2007).

[17] Outside the EU-27 zone, for New Zealand, solar water heating has been studied by Roulleau and Lloyd (2008).

[18] A recent energy performance evaluation of a geothermal heated building has been made by Kalinci et al. (2009).

[19] See, Molina and Álvarez (2009).

[20] See Erhorn and Erhorn-Kluttig (2009).

[21] In this section, in addition to the country-specific information, we have taken into account the country reports in EREC (2009) titled "Renewable Energy Policy Review", the Intelligent Energy Europe (2010) report titled "Re-Shape Renewable Energy Country Profile", the EuroACE (2009) report on tax incentives that affect buildings in Europe, and the "Taxes in Europe" database published by the European Commission.

Table 2
Member States that use subsidies to promote RES H&C.
Source: Own elaboration.

MS	All RES	Solar thermal	Geothermal	Biomass heat-only boiler station
Austria		Up to 30%[a]	20–40% (for private investment)	
Belgium	Valonia: 40%. Brussels: 20%+other specific measures (max 200,000€/building per year)	Valonia: 1500€ when floor panel between 2 and 4 m^2+100€ for every additional m^2. Brussels: 50%[b]	Heat-only boiler station. Valonia: 75% (max 1500€ for new buildings and 750€ for water heating with no exception). Brussels: 50%.	Valonia: 250 to 3500€[c].
Bulgaria	20%			
Czech Republic	Up to 75%			
Cyprus		30–45% for water heating; 40–55% for space heating and cooling[d].	30% for firms (max 170,860€) and for households and non-profit organizations (max 15,377€)	10–30% depending on firm size[e]
Finland				The construction costs of the renewable energy plant are co-financed by the government and beneficiaries, with subsidies of up to 30% in the case of companies.
France		50% (for households)		Combustion. 50% of the cost of equipment (for households to buy fuel efficient boilers) and for business.
Germany		Solar collector < 40 m^2. Investment subsidies (main home and small firms). From 2007, Collector solar thermal > 40 m^2. Up to 30%		
Greece			35%	Large plants for heating by burning biomass. Large CHP plants for biomass combustion (both 35%)
Hungary	Subsidy not expressed as a percentage			
Ireland[f]		Up to 30%	Up to 30%	Up to 30%
Italy		Up to 30%		Up to 30%[g]
Latvia				Up to 40%
Luxemburg		50%	40% (geothermal heat pumps) 50% (geothermal heat exchanger)	25–30%
Malta		25% (max 233€)		
The Netherlands		Subsidy not expressed as a percentage		Subsidy not expressed as a percentage
Portugal	35%[h]	70%[i]		
Slovak Republic	Up to 95% (public sector) and up to 50% (private sector)			Small heat-only boiler stations. 25%. Max 750€
Republic of Slovenia[j]		20–50%	20–50%	Up to 20% of investment cost
Spain		Up to 60% (public sector, firms and households < 7 m^2 collector)		Up to 60% (including wood pellet burners)
Sweden		800€ per household. 30% in the case of public buildings	3500€ when electric heating is removed.	
UK				Subsidy not expressed as a percentage

[a] When the subsidy is expressed as a percentage it is calculated as a proportion of the total cost of investment. For this country, the subsidy is borne by the federal government for firms and by the local government for households.
[b] Valonia: max. 6000€ plus the ability to obtain other incentives if the total amount of aid is a maximum of 75%. Brussels: Max. 6000€ for space heating and 300€ for water heating.
[c] Depending on the boiler power, the type of biomass, the nature of investors (private or public) and the operating system. Max: 50% with a maximum cost equal to 25,000€.
[d] There is a 20% subsidy for domestic solar systems that replace the previous system. There is also a 30–45% subsidy for water heating in swimming pools.
[e] There is a 55% subsidy for household space heating and cooling systems (max. 18,795€).
[f] Figures are referred to firms. For households, different quantities must be considered: Thermal solar hot water plate 250€/m^2 [~21%], Thermal solar hot water tube 300€/m^2 [~20%], heat-only boiler station 3000€ [~28%], Biomass stoves between 1100€ [~39%] and 1800€ [~34%].
[g] With a max of 300,000€ for systems that use a mix of natural gas and biomass. The percentage increases to 40% in tri-generation cases.
[h] Only small firms are eligible, with a maximum of 250,000€ for every project. SIESTA program only for the Azores (1.5% of national demand). This program is applied to energy production from renewable sources in the residential and commercial sectors.
[i] SIESTA program only for the Azores (1.5% of national demand).
[j] Figures are referred to firms. For households, different quantities must be considered: up to 40% (max. 125€/m^2 in the case of solar collector). In the case of heat pumps, up to 40% (max. 2080€).

3.1. Deductions

At present, six MSs offer different direct tax deductions to encourage the use of RES H&C (Belgium, Finland, Greece, Italy, The Netherlands and Sweden).

In Belgium, all RES H&C technologies benefit from a tax deduction from taxable profits. For all RES and CHP installations, companies can receive a tax deduction of 13.5% for all investments in equipment used to reduce energy consumption. Since January 2003, the Federal Public Service of Belgium offers tax

Table 3
Member States that use tax incentives to promote RES H&C.
Source: Own elaboration.

	Deductions	Exemptions	Reduced tax rates
Austria		●	
Belgium	●		
Bulgaria		●	
Cyprus			
Czech Republic			
Denmark		●	
Estonia			
Finland	●	●	
France			●
Germany		●	
Greece	●		
Hungary			
Ireland			
Italy	●		●
Latvia			
Lithuania			
Luxembourg			
Malta			
The Netherlands	●		
Poland			
Portugal			
Romania			
Slovak Republic			
Republic of Slovenia			
Spain			
Sweden	●	●	
UK		●	●

reductions for individuals undertaking energy efficiency and certain renewable energy investments in their homes. In 2009 and 2010, a tax reduction of 40% of the investment cost was introduced on personal income tax with a maximum of 2770€ for investment in heat pumps and biomass heating, and 3600€ for investments in solar boilers. However, for every investment, the taxpayer can only obtain the maximum support for 4 years.

In Greece, a 20% deduction is available on personal income tax, up to 700€, for money spent on the installation of RES, such as solar panel systems, thermal insulation and district heating. In Italy, personal income tax deductions up to a total of 55% of the investment outlaid on solar thermal systems (and any other energy efficiency investment), spread over 10 years, can be obtained. This deduction decreases to 36% if the national fund set aside for each year is exhausted.

In The Netherlands, in order to stimulate investments in RES, a scheme implemented by SenterNovem and the Dutch Tax Authorities allows Dutch companies that invest in RES (including those related to H&C) a deduction of 44% on such investments from their fiscal profit up to a national maximum of 108€ million per year. The investment threshold is 2200€ and no investment allowance is granted for investments exceeding 113 million € in a tax year.[22] Among the criteria for the deduction is whether the purchased equipment is on the 'Energy List'. The allowable list of technologies included in the Energy List has varied over the years around an average of 50. The Energy List 2011 contains examples of investments that have proven, in practice, that they meet the Energy Investment Allowance (EIA) criteria established by NL Agency (2011). These examples are not exclusive—all investments that meet the energy-performance criteria are eligible for EIA support. However, if investments are not listed among the examples, entrepreneurs will need to prove that they meet the EIA criteria. For example, solar-thermal systems are on this list.

[22] A more detailed study of these measures can be found in the report for the RES-H Policy Project by Menkveld and Beurskens (2009).

Sweden sponsors innovative programs to promote the use of alternative fuels for home heating. For example, a central furnace that consumes biological fuels if it is used to provide hot water for nearby homes. Oil furnaces have been replaced by boilers that use wood-based pellets, thereby dramatically reducing Sweden's dependence on oil for home heating. Among the actual fiscal measures that exist in Sweden to promote the use of alternative fuels, tax rebates for consumers to stimulate market adoption of renewable technologies should be mentioned. This measure is reinforced with a high carbon tax on fossil fuels (by applying the Polluter Pays Principle). According to the EuroACE (2009) report (related to the fiscal incentives that are applied to European buildings), since 2006, households in Sweden benefited from a 30% tax credit when converting from direct electric heating and oil-based heating to systems based on biomass or heat pumps. Solar heating support was prolonged until 2010.

Finally, Finnish consumers can also benefit from tax deductions provided the expenses are used to promote the use of more efficient systems and RES. Since 2006, a 60% household tax deduction has been available to offset labor costs incurred in replacing, upgrading and repairing the heating systems of small residential houses. The maximum amount of the tax deduction per household is 6000€ (EuroACE, 2009).

3.2. Exemptions

Seven MSs have implemented tax exemptions to promote RES H&C (Austria, Bulgaria, Denmark, Finland, Germany, Sweden and UK).

In Denmark, solar heating plants are exempt from energy tax, while in Finland, RES are exempt from the tax on heating, as this is calculated based on net carbon emissions. In Sweden, bioenergy, solid waste and peat are tax-exempt for most energy uses while taxes on fossil fuels have risen. In Austria, biomass fuels used for heating are also exempt from fossil fuel taxes. Similarly in Germany, to promote environment-friendly sources of energy for heating, there is a tax exemption on the energy tax for all solid biofuels used for heating as stated in the Energy Duty Law.

In the UK, renewable heat installations commissioned since July 2009 are due to receive a Feed-In Tariff, or the Renewable Heat Incentive of around 0.06€ per kWh. This income received by domestic users and other income tax payers will not be taxed.

Finally, according to the EuroACE (2009) report, a Building Tax Exemption has been in place in Bulgaria since 2005. From 6 July 2007, the Amendment to the Local Taxes and Fees Act established that the owners of buildings, having obtained a category A certificate issued under the terms of the Energy Efficiency Act and Building Certificate Regulation, are exempt from building tax for a term of 10 years. This exemption starts from the year after the year of issue of the certificate, and is only valid if RES are used in the building's energy consumption. Under the same terms and conditions, buildings with a category B certificate are exempt from building tax for a term of 5 years.

3.3. Reduced tax rates

While the use of reduced tax rates to promote RES is an instrument largely used in RES promotions such as biofuel use (see Del Río and Gual, 2004; Uyterlinde et al., 2003), only three MSs (France, Italy and the UK) have introduced reduced value-added tax (VAT) rates on components and materials required for eligible heating and cooling systems (EuroACE, 2009).

In France, a reduced VAT of 5.5% is applied to the supply of heat if this is produced from at least 60% biomass, geothermal energy from waste, and recovered energy. Consumers in Italy can also benefit from a reduced VAT (10% instead of 20%) in the case

of the refurbishment of a house when this includes the installation of solar-thermal systems. Finally, in the UK, a reduced VAT of 5% is charged on certain energy-saving materials if these are used in non-business buildings or village halls.[23] Also, this reduced rate covers all installations (including conventional systems) if they are applied in the sole or main residence of a person over 60 years of age. These installations concern the following: grant-funded contractor installations of central heating systems and heating appliances, grant-funded installations of factory-installed hot water tanks, domestic combined heat and power units, and heating systems that use renewable energy.

Also in the UK, all new homes meeting the zero carbon standard and costing up to GBP 500,000 (605,080€) pay no stamp duty, while zero carbon homes costing in excess of GBP 500,000 (605,080€) receive a reduction in their stamp duty bill of GBP 15,000 (18,150€).

4. Low interest loans

Financial support measures are also instruments used to promote RES H&C. However, they have had a very low uptake by MSs, similar to what happened in the green electricity promotion case (Cansino et al., 2010). In fact, only four MSs (Germany, Portugal, Slovak Republic and Republic of Slovenia) offer reduced-interest loans to fund systems based on RES H&C. However, it should be taken into account that this measure has only recently been introduced and therefore its uptake is likely to increase. Germany has offered low-interest loans since 2007 for the financing of solid biomass and solar thermal plants for heating and cooling. German Development Bank Kreditanstalt für Wiederaufbau (Kfw), which is owned by the German government, offers long-term, low interest loans with fixed interest rates that are 1.04–1.98% lower and additional redemption-free year.

In the Slovak Republic, loans are granted at a below-market interest rate. In this case, the beneficiaries are private companies that undertake investments in solar thermal systems for heating and cooling. This measure assumes that the companies offer attractive prices to their end customers. The resources for these loans are obtained from Environmental Fund.

In Slovenia, the Environmental Fund of The Republic of Slovenia awards low interest rate loans to finance projects based on the use of RES for heat production. This low interest loans can cover between 50% and 90% of the predicted investment cost. The maximum for an individual loan is 2 million €, the minimum 50,000€. This amount covers up to 100% of investment costs for private citizens.

From 2007 to 2013, low interest rate loans will be offered in Portugal for 5 years with a 2-year grace period up to a maximum amount of 750,000€, for the installation of systems using any type of RES for heating and cooling. These loans are granted by a group of private banks with which the National Energy Agency (ADENE) has signed a protocol.

5. Feed-in tariffs

In the case of heating, feed-in tariffs are used in a small minority of countries, namely the four MSs comprising Austria, Estonia, Luxemburg and the UK. However, feed-in tariffs are widespread in the case of production of electricity from RES (Cansino et al., 2010).

In 2000, Austria pioneered the introduction of feed-in tariffs for heating derived from solid biomass for CHP. In 2007, Estonia began applying this measure, but their feed-in tariffs vary between 33.3 and 54 EUR/MWh, depending on whether wood or other RES material is used in the CHP.

In 2008, Luxembourg introduced a "*heat premium*" measure that varies according to the technology used. In the case of solid biomass, biogas and waste wood, the producer receives 30€ per MWh.

Finally, the UK has introduced premium tariffs through renewable heat incentives. These tariffs range from 1.18 to 21.79€/MWh, depending on the installation's size and technology. The renewable heat incentives will start operating in April 2011.

6. Discussion

The logistical pros and cons of the different measures implemented by EU-27 MSs to promote the use of energy-efficient H&C are discussed in this section. We also summarize the incentives that have been used by each MS and the efforts that have been implemented to achieve compliance with national targets by 2020.

Columns II–V in Table 4 summarize the government-implemented measures that have been used to promote efficient H&C uptake by EU-27 MSs. Column VI shows the percentage of renewable heat generation as a proportion of the total heating and cooling energy demand of 2005. Column VII shows the percentage increase of renewable heat generation as a proportion of the total heating and cooling energy demand between 2005 and 2010. Column VIII shows the percentage of renewable heat generation as a proportion of the total heating and cooling energy demand set for 2020.

A close look at the results highlights the important efforts that some MSs have gone to in order to reach objectives in their National Renewable Energy Action Plan for 2020.

Importantly, it can be seen that those MSs that have had the most significant increases in the percentage of renewable heat generation as a proportion of total heating and cooling energy demand between 2005 and 2010, are often the same MSs that, in 2005, had to make a greatest advances to achieve objectives set for 2020. In fact, seven of the top 10 MSs with major growth between 2005 and 2010 are among the top 10 MSs that were committed taking the biggest steps to achieve objectives set for 2020. Those MSs are Denmark, Cyprus, Italy, Hungary, France, Latvia and Spain.

The MSs that have shown major growth (from 6.2–7.6%) are Austria, Denmark and Cyprus, followed by another group consisting of Italy, Hungary, France and Sweden that have grown by around 3.5%. Thereafter, a third group of MSs (Estonia, Latvia, Spain, Germany and Slovenia) showed a 2.4% growth.

In general it may be noted that these promotional measures have not been implemented by MSs in the same way. Rather, the specific characteristics of MSs, and more so that of regions, play a key role in setting public policy measures. In this sense, as is evidenced by the IEA (2007) report, two facts explain why government-implemented measures should be specifically related to the RES H&C features of the areas where they are applied: the fact that the heat generated from RES has to be used locally because it is not possible to feed it back into a distribution grid, and the fact that there are no major operators given that most producers are households. Therefore, the diversity of measures taken by countries is in line with that expected.

If we analyze the measures undertaken, it can be seen that most MSs have used subsidies (except Denmark, Estonia and Hungary) and fiscal incentives (except Cyprus, Hungary, Estonia,

[23] The reduced VAT covers installations of solar panels, wind and water turbines; ground-source and air-source heat pumps and micro-CHP; and wood/straw/similar vegetal matter-fueled boilers.

Table 4
Summary of policy measures to promote heating and cooling in EU-27 MSs. Improvements in national targets between 2005 and 2010.
Source: Own elaboration.

UE-27 (I)	Subsidies (II)	Fiscal Incentives (III)	Financial Incentives (IV)	Feed-in Tariffs (V)	Per cent 2005[a] (VI)	Percentage growth (VII)	2020 (%)[a] (VIII)
Austria	•	•		•	24.3	6.2	32.6
Belgium	•	•			2.3	1.2	11.9
Bulgary		•			15.28	1.2	23.8
Cyprus	•				9.1	7.1	23.5
Czech Rep.					8.4	1.8	14.1
Denmark		•			23.2	7.6	39.8
Estonia				•	16.3	2.9	17.6
Finland	•	•			40	−3.0	47
France	•	•			13.6	3.4	33
Germany	•	•	•		6.6	2.4	15.5
Greece		•			12.76	1.9	19.7
Hungary					5.4	3.6	18.9
Ireland	•				3.5	0.8	12
Italy	•	•			2.8	3.7	17.09
Latvia	•				42.7	2.6	53.4
Lithuania					27	1.0	39
Luxembourg	•			•	1.7	0.4	8.5
Malta[a]	•				—	0.0	6.2
Netherlands	•	•			2.5	1.2	8.7
Poland[a]					—	0.0	17.05
Portugal	•		•		31.9	−1.2	30.6
Romania					18.72	−0.9	22.05
Slovakia	•		•		6.1	1.5	14.06
Slovenia	•		•		20	2.3	30.8
Spain	•				8.8	2.5	18.9
Sweden	•	•			53.7	3.3	62.1
UK	•	•		•	0.7	0.3	12

[a] Data not available for 2005.

Latvia, Spain and Slovenia). In fact, Denmark has only used fiscal incentives and showed a growth of 7.6%, while Cyprus has only used subsidies and shown a 7.1% growth. Government financial support is seen therefore as a necessary and appropriate instrument to ensure the development and uptake of technology based on RES for H&C.

Subsidies are the most widely used instrument employed by MSs. The main reason is that they encourage the adoption of specific technologies that are usually capital intensive by reducing in a straightforward manner the high costs of investment.

Also, subsidies are an easy way to promote RES for H&C because their application is based on a simple scheme. First of all, the size of the subsidy is easily fixed as a percentage of the total cost of the investment. Second, subsidies allow authorities to discriminate between not only the technologies promoted, but also the type (public or private) of beneficiaries. In the case of private beneficiaries, subsidies also allow authorities to provide different benefits depending upon whether the beneficiary is a household or a business.

Moreover, the type of subsidized technology is conditioned by the local availability of primary energy sources. For this reason, the most widely supported technologies are those that use solar energy.

However, subsidies have the disadvantage of being closely linked to budgetary resources and therefore to budgetary constraints. Thus, in the current scenario of budgetary constraints, the number of funded projects is limited. Moreover, the subsidies could lead to increased equipment costs because manufacturers tend to raise prices in anticipation of the discounts granted to customers. For these reasons, according to the report of the World Energy Council (2008), it would be desirable to progressively reduce the use of subsidies by looking for alternative ways to cut down costs or to seek alternative forms of finance.

Furthermore, subsidies also have the disadvantage of being an ex-ante incentive. Investors are required to apply for fundings and pre-approval before installation. This implies that investors are caught up in bureaucratic processes that slow their investments and may even deter them from proceeding. In contrast, the use of tax deductions has the advantage of being an ex-post incentive due to investors being able to receive financial compensation after they have carried out the installation of equipment. In this last case, the compensation procedures are faster and simpler. Therefore, as stated by Sawin (2006), this type of instrument is appropriate, especially in those cases where investment costs are relatively high. The implementation of incentives through income and corporate taxes seems to be the most appropriate way to encourage uptake because the household and service sectors are the most important in the overall use of energy for heating and cooling, making them therefore the main beneficiaries of the tax deduction. Occasionally, these tax incentives might also be used to reduce taxes on property.

Nevertheless, being an ex-post incentive, such tax deductions do not lower the hurdle of the initial upfront payment and therefore do not help low-income households. Some MSs have therefore used reduce tax rates (VAT) to cut down on overall investment costs without requiring any additional bureaucratic procedures.

Along with the reduction of investment costs, tax incentives can also be used to make the energy generated from renewable energy sources relatively more profitable than that generated by alternative energy sources. In this sense, exemptions play an important role, particularly if they are linked to tax measures that increase the price of other energy sources, such as fossil fuels. This policy instrument has been successful, for example, in Sweden (Ericsson, 2009), one of the MSs that showed a high growth of renewable heat generation from 2005 to 2010. However, all these fiscal incentives are also conditioned by budgetary constraints.

Low interest loans have been used sparingly by MSs. Of the MSs that have had a major increase in the percentage of renewable heat generation, Germany is the only one that has used them to encourage uptake. However, this type of approach has the advantage that it can bring down the average cost per unit and

can be easily implemented by banking institutions. Furthermore, these incentives do not lead to substantial budget increases if adequate arrangements are established with private banks. For these reasons, as stated in the World Energy Council report (2008), these measures should be enhanced. However, such incentives do not always lead to investments being made in the most appropriate technologies, and for this reason they need to be accompanied by regulations to ensure the features of the new facilities and a framework for information distribution such as information campaigns, training, etc. (IEA, 2007).

Feed-in tariffs have only had a minor impact on RES H&C promotion in comparison to the case of green electricity where such tariffs were one of the main stimulators of the promotion. This difference in outcomes for these two scenarios is due to the fact that feed-in tariffs are designed to guarantee an income to companies. While this is easy to apply in the case of companies that produce green electricity, it has no real benefit in the case of RES H&C because the main heat producers are households.

7. Conclusions

The overall use of energy for heating and cooling systems by the household and services sectors in EU-27 countries represents a significant proportion of total energy use, thereby justifying the importance of concentrating on these sectors from the viewpoint of energy policy.

Literature related to energy requirements for heating and cooling has largely focused on new building standards. Government interventions in heating and cooling have mainly consisted of establishing construction standards for buildings in an attempt to increase energy efficiency with respect to heating and cooling requirements. This effect has been evident not only in the EU-27 but also in other developed countries. In the EU-27, EPBD 2010, indicates the need for building requirements to reduce both energy consumption and emissions of carbon dioxide, which can be achieved by installing systems that use renewable energy sources.

After analyzing the energy policies of EU-27 MSs and examining government interventions concerning energy use with respect to heating and cooling, we have found that 23 MSs have adopted additional measures to promote the use of RES for heating and cooling. The implementation of such measures corroborates the opinion of those experts who explain that the increased use of RES can only be achieved if it is accompanied by increased support from government authorities.

In the EU-27, the most widespread measure to promote RES for H&C is the provision of subsidies; this has occurred in 22 of the 27 MSs. In our opinion, this is due to the fact that subsidies are an easy way to promote RES for H&C; their application is based on a simple scheme and their straightforward manner to implement encourages the adoption of technologies that are capital intensive. Nevertheless, they are conditioned by budgetary constraints.

Twelve MSs have used tax incentives with a dual purpose, to reduce investment costs and to make renewable energy profitable through a decrease in relative prices. In the first case, the use of tax deductions has the advantage of involving ex-post incentives, although they do not lower the hurdle of the initial upfront payment. Some MSs have thus resorted to reducing tax (VAT) rates to overcome this. In the second case, these measures have been relatively successful when they have been accompanied by other measures that tend to increase the price of alternative energy sources. In both cases, these measures are conditioned by budgetary constraints.

Low interest loans have only been used by four countries. However, the establishment of this type of action may be appropriate in the context of budgetary constraints since these incentives do not lead to substantial budget increases if adequate arrangements are established with private banks. Finally, feed-in tariffs play only a minor role in RES H&C promotion as this promotional measure is designed to guarantee an income to companies and not to households, the latter most likely to be the main heat producers in the case of RES H&C.

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References

Agrell, P.J., Bogetoft, P., 2005. Economic and environmental efficiency of district heating plants. Energy Policy 33 (10), 1351–1362.

Apte, J., Dariush, P.E., Huang, Y.J., 2003. Future advanced windows for zero-energy homes. Avalilable at 〈http://windows.lbl.gov〉 (last access January 25). Solar thermal energy 'on the up'.

Börjesson, M., Ahlgren, E.O., 2010. Biomass gasification in cost-optimized district heating systems—a regional modeling analysis. Energy Policy 38 (1), 168–180.

Braun, F.G., 2010. Determinants of households' space heating type: a discrete choice analysis for German households. Energy Policy 38 (10), 5493–5503.

Cansino, J.M., Pablo-Romero, M., de, P., Román, R., Yñiguez, R., 2010. Tax incentives to promote green electricity: an overview of EU-27 countries. Energy Policy 38 (10), 6000–6008.

Dongyan, L., 2009. Fiscal and tax policy support for energy efficiency retrofit for existing residential buildings in China's northern heating region. Energy Policy 37 (6), 2113–2118.

Dovjak, M., Shukuya, M., Olesen, B.W., Krainer, A., 2010. Analysis on energy consumption patterns for space heating in Slovenian buildings. Energy Policy 38 (6), 2998–3007.

Del Río, P., Gual, M., 2004. The promotion of green electricity in Europe: present and future. European Environment 14, 219–234.

Egeskog, A., Hansson, J., Berndes, G., Werner, S., 2009. Co-generation of biofuels for transportation and heat for district heating systems—an assessment of the national possibilities in the EU. Energy Policy 37 (12), 5260–5272.

Eichhammer, W., Walz, R., 2009. Indicators to measure the con-tribution of energy efficiency and renewable to the Lisbon targets monitoring of energy efficiency in EU 27, Norway and Croatia (ODYSSEE-MURE). Available at: 〈http://www.odyssee-indicators.org〉.

Energy Investment Allowance (EIA), 2011. Energy Efficiency Policies and Measures. Database. 〈http://www.iea.org/textbase/pm/?mode=pm〉 (last access 3 February, 2011).

Erhorn, H., Erhorn-Kluttig, H., 2009. Germany: impact, compliance and control of legislation. ASIEPI, p. 177 〈http://www.buildup.eu/publications/7049〉. (last access 18 January, 2011).

Ericsson, K., 2009. Introduction and development of the Swedish district heating systems critical factors and lessons learned. RES-H Policy (last accesed 7 February 2011).

EREC, 2009. Renewable energy policy review. EREC, Belgium.

EuroACE, 2009. Current financial and fiscal incentive programs for sustainable energy in buildings from across Europe. EuroACE, Belgium.

European Commission (EC), 2010a. National Renewable Energy action plan of Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, The Netherlands, Poland, Portugal, Romania, Slovak Republic, Republic of Slovenia, Spain, Sweden, United Kingdom. Available at 〈http://ec.europa.eu/energy/renewables/transparency_platform/action_plan_en.htm〉 (last access 1 September, 2010).

European Commission, 2010b. Taxes in Europe. Databas. 〈http://ec.europa.eu/taxation_customs/taxation/gen_info/info_docs/tax_inventory/index_en.htm〉.

European Commission (EC), 2006. Communication from the Commission to the Council and the European Parliament about the Renewable Energy Road Map: Renewable energies in the 21st century. Building a more sustainable future COM(2006) 848 final, Brussels, Belgium.

European Commission, 2007. Communication from the Commission to the European Council and the European Parliament of 10 January 2007, "An energy policy for Europe" [COM(2007) 1 final—Not published in the Official Journal].

European Parliament resolution with recommendations to the Commission on heating and cooling from renewable sources of energy, OJC 290E, 29.11.2006, p. 115.
European Council (EC), 1989. Directive 89/106/EC. Directive of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products. European Commission, 1988 Brussels, Belgium. 〈http://ec.europa.eu/enterprise/construction/internal/cpd/cpd.htm〉 (2 September 2010).
European Parliament and the Council (EP&C), 2002. Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings, Brussels, Belgium.
European Parliament and the Council (EP&C), 2009. Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, Brussels, Belgium.
European Parliament and the Council (EP&C), 2010a. Directive 2010/30/EC of the European Parliament and of the Council of 19 May 2010 on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products, Brussels, Belgium.
European Parliament and the Council (EP&C), 2010b. Directive 2010/31/EC of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast), Brussels, Belgium. 〈http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2010:153:0013:0035:EN:PDF〉 (3 September 2010).
Eurostat, 2010a. Energy balance sheets 2007–2008.
Eurostat, 2010b. Energy Statistics – quantities. Available at 〈http://epp.eurostat.ec.europa.eu〉 (last access 05 July, 2010). 〈http://www.aid-ee.org/documents/000003KfWbuildingprogramme-Germany.pdf〉.
Euroactiv, 2009 Available at 〈http://www.euractiv.com〉 (last access January 25).
Haberl, H., Adensam, H., Geissler, S., 1998. Optimal climate protection strategies for space heating. The case of Austria. Energy Policy 26 (15), 1125–1135.
Holmgren, K., Gebremedhin, A., 2004. Modeling a district heating system: introduction of waste incineration, policy instruments and co-operation with an industry. Energy Policy 32 (16), 1807–1817.
Howden-Chapman, P., Viggers, H., Chapman, R., O'Dea, D., Free, S., O'Sullivan, K., 2009. Warm homes: drivers of the demand for heating in the residential sector in New Zealand. Energy Policy 37 (9), 3387–3399.
Intelligent Energy Europe, 2010. RE-SHAPING Renewable Energy Policy Country Profiles. Intelligent Energy Europe. Utrecht, The Netherlands 〈http://www.solarthermalworld.org/node/1157〉.
International Energy Agency, OECD, 2007. Renewables for heating and cooling. IEA 〈http://www.dekoepel.org/documenten/Renewable_Heating_Cooling_Final_WEB.pdf〉 (last access 3 February, 2011).
International Energy Agency. OECD, 2009. World Economic Outlook 2008.
International Energy Agency (IEA), 2010. Key World Energy Statistics, 2008..
Isaac, M., van Vuuren, D.P., 2009. Modeling global residential sector energy demand for heating and air conditioning in the context of climate change. Energy Policy 37 (2), 507–521.
Kalinci, Y., Balta, M.T., Hepbasli, A., 2009. Performance assessment of a geothermal heated building. Energy Policy 37 (4), 1502–1508.
Madlener, R., 2007. Innovation diffusion, public policy, and local initiative: the case of wood-fuelled district heating systems in Austria. Energy Policy 35 (3), 1992–2008.
Market observatory for energy, 2010. REPORT 2009 Europe's energy position—markets & supply. doi:10.2768/20104.
Maxoulis, C.N., Charalampous, H.P., Kalogirou, S.A., 2007. Cyprus solar water heating cluster: a missed opportunity? Energy Policy 35 (6), 3302–3315.
Menkveld, M. y, Beurskens, L., 2009. Renewable heating and cooling in the Netherlands. Energy Research Centre of the Netherlands.
Molina, J.L., Álvarez, S., 2009. Spain: Impact, compliance and control of legislation. ASIEPI, p. 172. 〈http://www.buildup.eu/publications/7050〉 (last access 18 January, 2011).
NL Agency, 2011. Energy & businesses. Dutch Ministry of Economic Affairs, Agriculture and Innovation. 〈www.agentschapnl.nl/eia〉 (last accessed 25 April, 2011).
ODYSSEE-MURE project 2009. Energy Efficiency Trends and Policies in the EU 27 Results of the ODYSSEE-MURE project. Paris. Available at 〈http://www.odyssee-indicators.org〉.
Ozgener, O., Ozgener, L., 2010. Energetic assessment of EAHEs for building heating in Turkey: a greenhouse case study. Energy Policy 38 (9), 5141–5150.
Panek, A., 2010. Impact, compliance and control of legislation Summary report. ASIEPI. 〈http://www.asiepi.eu/fileadmin/files/Files/SummaryReports/ASIEPI_ImpactComplianceAndControl_SummaryReport.pdf〉 (last access 18 January, 2011).
Parliamentary Office of Science and Technology, 2005. Post note. Household Energy Efficiency, number 249. UK.
Preval, N., Chapman, R., Pierse, N., Howden-Chapman, P., The Housing Heating and Health Group, 2010. Evaluating energy, health and carbon co-benefits from improved domestic space heating: a randomized community trial. Energy Policy 38 (8), 3965–3972.
Royal decree 314/2006, de 17 de marzo de 2006, Código Técnico de edificación, BOE n74, 28 de marzo, 2006.
Roberts, S., 2008. Infrastructure challenges for the built environment. Energy Policy 36 (12), 4563–4567.
Roulleau, T., Lloyd, C.R., 2008. International policy issues regarding solar water heating, with a focus on New Zealand. Energy Policy 36 (6), 1843–1857.
Sawin, J.L., 2006. Policies. In: Assmann, D., Laumanns, U, Dieter, U (Eds.), Renewable Energy—A Global Review of Technologies Policies and Markets. Earthscan, London, pp. 71–168.
Schuler, A., Christoph Weber, C., Fahl, U., 2000. Energy consumption for space heating of West-German households: empirical evidence, scenario projections and policy implications. Energy Policy 28 (12), 877–894.
Sheldrick, B., 1987. Hard-to-heat estates: evaluating the benefits of heating and insulation improvements. Energy Policy 15 (2), 145–157.
Seyboth, K., Beurskens, L., Langniss, O., Sims, R.E.H., 2008. Recognizing the potential for renewable energy heating and cooling. Energy Policy 36 (7), 2460–2463.
Šúri, M., Huld, T.A., Dunlop, E.D., Ossenbrink, H.A., 2007. Potential of solar electricity generation in the European Union member states and candidate countries. Solar Energy 81, 1295–1305.
Thorsteinsson, H.H., Tester, J.W., 2010. Barriers and enablers to geothermal district heating system development in the United States. Energy Policy 38 (2), 803–813.
Uyterlinde, M.A., Daniels, B.W., De Noord, M., De Vries, H.J., De Zoeten-Dartenset, C., Skytte, K., Meibom, P., Lescot, D., Hoffman, T., Stronzik, M., Gual, M., del Rio, P., Hernández, P., 2003. Renewable electricity market developments in the European Union. Final Report of the Admire Rebus Project, ECN-C-03-082. ECN, Pettern, Netherlands.
Westin, P., Lagergren, F., 2002. Re-regulating district heating in Sweden. Energy Policy 30 (7), 583–596.
World Energy Council, 2008. Energy efficiency policies around the world: review and evaluation. World Energy Council, London 〈http://www.worldenergy.org/documents/energyefficiency_final_online.pdf〉 (last accessed 7 February 2011).
Worldwatch Institute, 2009. Solar thermal heating up sharply. Worldwatch Institute, Washington.
Zmeureanu, R., Renaud, G., 2008. Estimation of potential impact of climate change on the heating energy use of existing houses. Energy Policy 36 (1), 303–310.