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Policies and measures on renewable heating and cooling in Europe

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Cover photo © solar thermal installation

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Executive summary

Key messages

- **The heating and cooling sector (H&C) is an increasingly important area for decarbonisation to achieve Europe's renewable energy and GHG emissions reduction targets.** Progress is steady in the EU overall but varies substantially between Member States.
- **Member States achieved increases in the share of RES in the H&C sector in different ways.** Solid biomass is the most important RES for heating and cooling. Other sources for heating and cooling, such as heat pumps and solar thermal, are growing and the relative contribution of biomass is decreasing. District heating and combined heat and power have been important enablers of a high penetration of RES for heating and cooling in Member States.
- **Member States have implemented numerous PaMs since 2000 to increase the share of RES H&C.** In total, 407 PaMs were identified. Most new PaMs started in 2009, also the publication year of the RES Directive. RES H&C PaMs show an important overlap with energy efficiency policies. By far the most frequently used policy instrument are grants, such as subsidies. For the period 2005-2016, RES H&C trends can be explained to some extent by policy interventions by the Member States.
- **The link between promoting RES H&C and GHG emission reductions is clear.** These emission savings are largely achieved in non-ETS sectors.
- **Reporting on climate and energy policies is currently not very integrated**. Consulting different information sources is needed to have an extensive overview of all policies and measures in this sector.

Summary

Final energy consumption for heating and cooling (H&C) accounts for 50% of energy consumption in Europe. However, the share of renewable energy sources (RES) in the heating and cooling sector is lagging behind the growth of RES in the electricity sector. In 2016 RES had reached an overall share of 19.1% of the H&C sector energy consumption in the EU-28, or 99.3 Mtoe.

There are currently large differences between Member States in the contribution of RES to the H&C sector. In 2016, RES ranged from less than 5% of H&C energy consumption to nearly 70% in some Member States. This range is a continuation of differences between Member States historically. Member States with higher RES H&C shares in 2005 experienced higher growth in RES in this sector to 2016 than Member States with a lower share; those which already had a high share of RES H&C in 2005 maintained greater growth of RES H&C.

The share of RES H&C can be influenced by many factors. Directly, this may be policies and measures (PaMs) that focus on promoting RES in the H&C sector. Indirectly, this may be PaMs that increase energy efficiency in the H&C sector or other actions that affect the total energy consumption in the sector. For example, the quantity of RES might stay the same, but demand-side measures reduce the total energy consumption in H&C resulting in an increase in the share of RES.

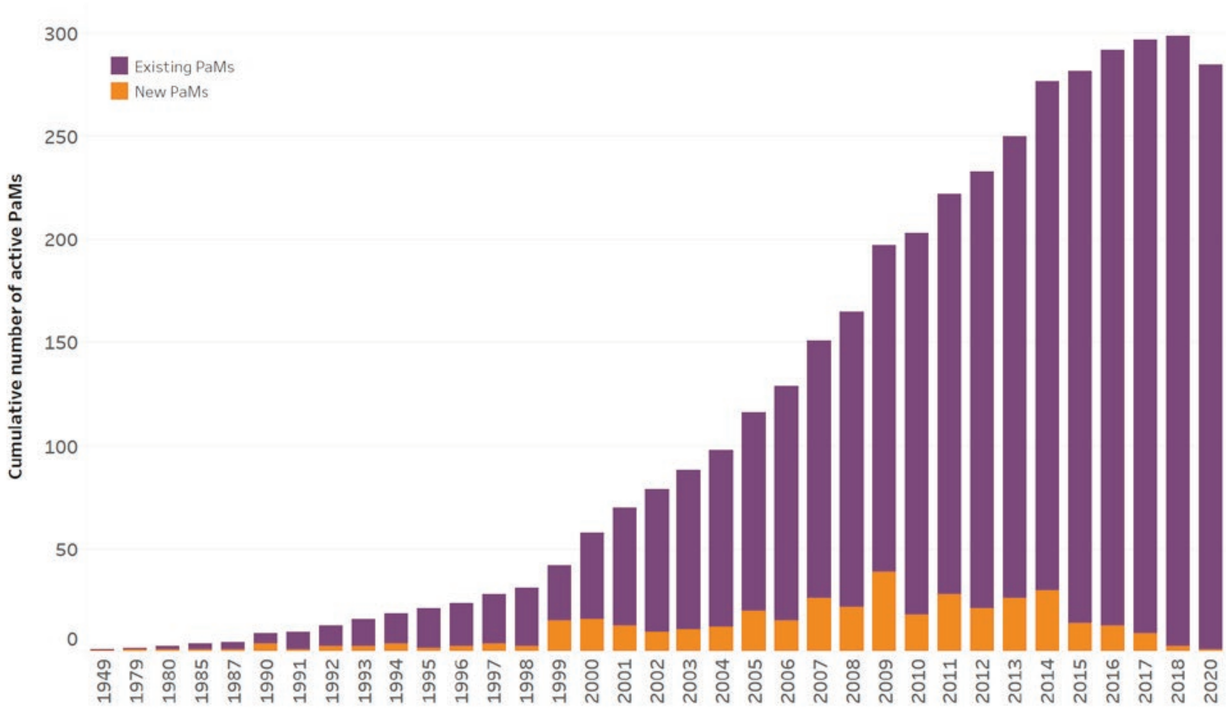
The number of PaMs targeting RES in the H&C sector has increased over the last two decades (Figure ES. 1). European Union legislation on the use of renewable energy in the heating and cooling sector has only been explicitly implemented since 2009 through the Renewable Energy Sources Directive (2009/28/EC).

A total of 407 PaMs related to RES H&C were identified in Member States, 74% of which were currently active.

Economic PaMs were the most common type of PaMs for RES H&C (44%) followed by regulations and plans/strategies. Over a third of PaMs (35%) had a grant-based aspect, and 'soft' loans to building owners were a common instrument type. Over half of PaMs were building-type neutral, but a quarter targeted RES H&C in the residential sector. Biomass was the most common source of renewable energy to be targeted by PaMs (approximately one third of PaMs).

Member States achieved increases in the share of RES in the H&C sector in different ways. Between 2005 and 2016, eight Member States increased the RES supply in the H&C sector whilst also decreasing the total energy consumption in the H&C Sector. In the same period, fourteen Member States increased the RES H&C supply with little change to total energy consumption. Six Member States saw an increase in the RES share without significant change to the RES supply, but with reductions in the total H&C energy consumption.

Figure ES. 1. Number of active renewable heating and cooling PaMs (EU-28) each year.



Sources: EEA (2018), IEA/IRENA (2018), RES Legal (2018), EurObserv'ER (2018).

Different sources of renewable energy have different trends in their contribution to the heating and cooling sector. Member States with a particularly high share of RES H&C are also typically the Member States with extensive district heating networks. These Member States had PaMs targeting the refurbishment of existing district heat networks to renewable energy sources. In contrast, Member States with extensive natural gas grids face barriers to high RES shares, particularly in residential buildings. However, this presents an opportunity for biogas using the existing grid infrastructure.

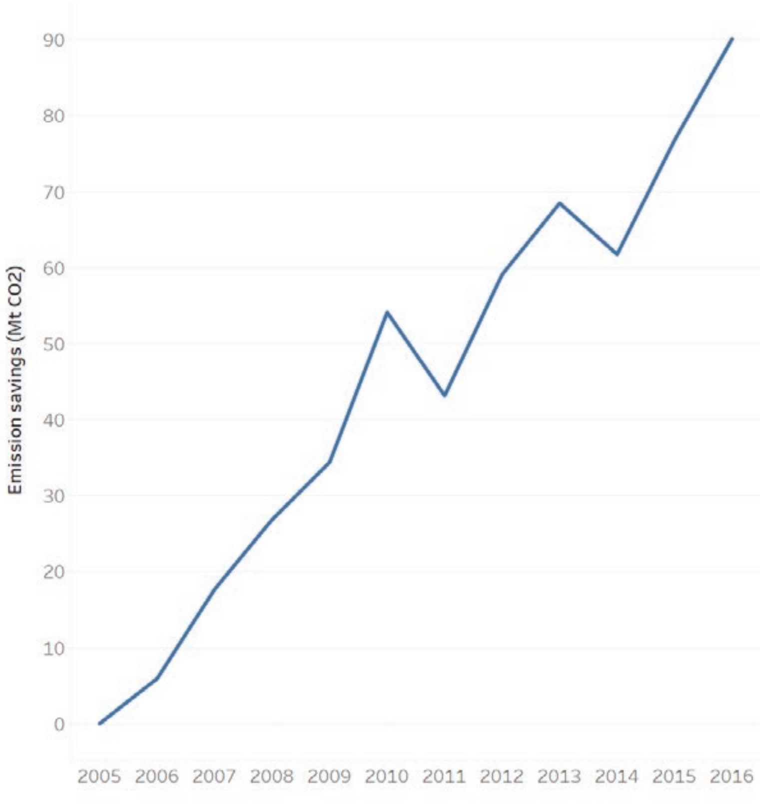
The largest contribution to RES H&C across Europe comes from solid biomass. Countries with large biomass resources have typically developed biomass as a renewable energy source to increase energy independency since the 1970s, such as Austria and Sweden. The sources of RES are diversifying however, as solid biomass saw slower growth between 2005 and 2016 than the total RES H&C sector, which grew by an average of 4% per annum.

Heat pumps have increased significantly in recent years, particularly in Member States with a cold climate and a lower connection rate to the natural gas grid. Stable residential construction markets and favourable price ratios of electricity and gas make heat pumps an attractive financial investment (EurObserv'ER, 2017).

For most Member States solar thermal contributes less than 1% of H&C energy consumption. However, in Member States with a favourable climate for solar and lower demand for heating, solar thermal is a more significant contributor, reaching over 15% in Cyprus, for example.

The link between promoting RES H&C and GHG emission reductions is clear. Based on a top-down calculation, RES H&C resulted in an emission reduction of 90 Mt CO_2 in 2016 compared to 2005 in the EU-28 (Figure ES. 2). These emission savings have mostly (78%) been achieved in non-ETS sectors. In five Member States increases in RES H&C resulted in GHG emission reductions of more than 5% of national total GHG emissions (excluding aviation and LULUCF) between 2005 and 2016.

Figure ES. 2. The increase of emission savings from RES H&C since 2005.



Source: SHARES (Eurostat 2018) and EEA (2018).

Reporting on climate and energy policies is currently not very integrated. Four policy data sources were used for the assessment in this report – the EEA database on climate change mitigation policies and measures in Europe (EEA 2018), IEA/IRENA global renewable energy policies and measures database (IEA/IRENA 2018), RES Legal (2018) and EurObserv'ER renewable energy policy profiles (2018). The EEA database has a specific climate focus as it holds information on climate mitigation PaMs reported under the EU Monitoring Mechanism Regulation (MMR), whereas the rest are focused on energy. All sources contained unique information and two thirds of the PaMs analysed only had information from one data source. The upcoming legislation on the Energy Union will increase the transparency and consistency of climate and energy data and policies needed to help ensure the EU and Member States are on track to meet their respective climate and energy targets.

1 Introduction

Final energy consumption for heating and cooling accounts for 50% of energy consumption in Europe. Decarbonizing the heating and cooling sector[1] therefore is pivotal in in reducing greenhouse gas (GHG) emissions in the short- and long-term. Between 2005 and 2016, the share of renewable energy sources for heating and cooling (RES H&C) in Europe has increased from 10.9% to 19.1%. While this constitutes a marked progress, the evolution in the electricity sector is much faster. The share of renewable energy sources in the electricity sector (RES E) is 10 %-points higher than for RES H&C in 2016. The growth of renewable energy sources has also been higher in electricity than in heating and cooling in the EU in recent years.

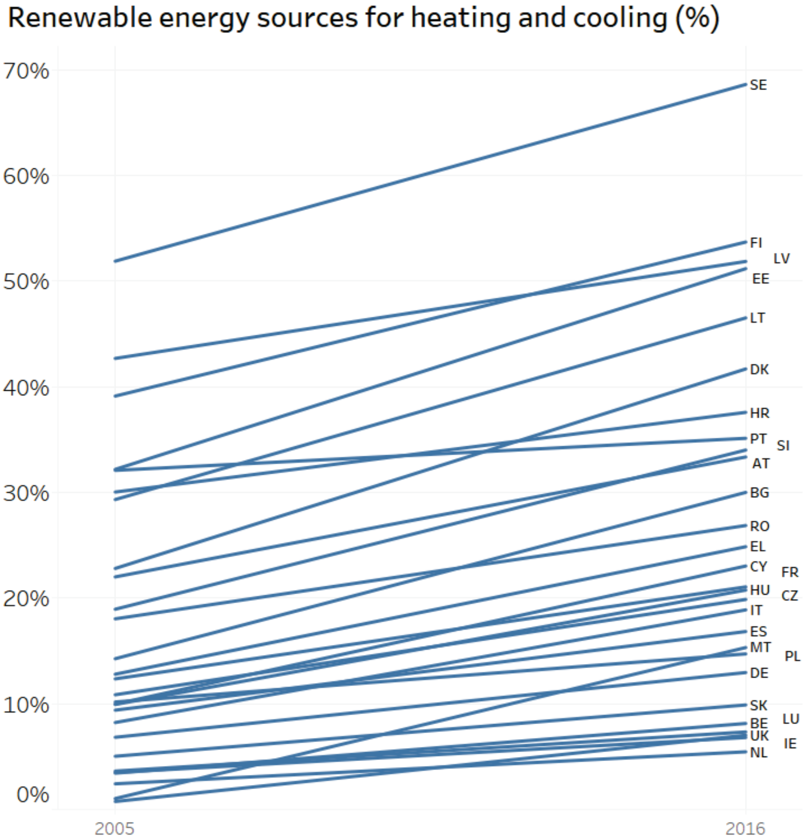
As the mid-term evaluation of the Renewable Energy Sources Directive showed the heating and cooling sector is underperforming (CE Delft et al., 2015). Recently, both at EU and individual Member State level governments are focusing more on decarbonizing the heating and cooling sector. In 2016, the European Commission presented its EU strategy on heating and cooling (EU, 2016). This strategy underscores the importance of actions in the building sector to remove barriers for increased energy efficiency and renewable energy.

Figure 1 shows how the share of RES H&C has changed in individual Member States between 2005 and 2016. This figure shows that in 2016 there are large differences among Member States in the share of renewable energy sources, ranging from less than 5% to almost 70% of energy sources. Looking at the trends between 2004 and 2016, it is evident that all countries increased the share of renewables in heating and cooling. However, there are also large differences among Member States in the increase in renewable energy sources. There is a wealth of scientific literature on the impact of different instrument types on the penetration of renewable electricity in the EU and other countries. This is less the case for the sector heating and cooling.

The **objectives** of this study are therefore two-fold. First, provide an extensive overview of past and existing policies and measures (PaMs) promoting RES H&C in all EU Member States (Chapter 2). Secondly, combine this information and quantitative information to explain recent trends in renewable energy production in the heating and cooling sector (Chapter 3).

[1] This covers all energy consumption for heating and cooling, mostly of residential, commercial or public buildings and excludes energy consumption for electricity production and transport.

Figure 1. Increase in the share of renewable energy sources for heating and cooling between 2004 and 2016 in EU-28 Member States.



Source: SHARES (Eurostat, 2018) and Euroheat (2018)

Box 1.1 Methodology

For each Member State information on policies and measures promoting renewable energy in the heating and cooling sector was collected from four different data sources:

- *EEA database on climate change mitigation policies and measures in Europe (EEA, 2018)*: data reported at least every two years by Member States pursuant article 13 of the Monitoring Mechanism Regulation on their policies and measures to reduce greenhouse gas emissions. Policies and measures were selected based on the predefined objective "increase share of renewable energy" and selecting policies and measures affecting the heating and cooling sector.
- *IEA/IRENA climate, renewable energy and energy efficiency policy database (IEA/IRENA 2018)*: data reported by countries and regularly updated. Policies and measures were selected that either affected 'heating and cooling' sector or 'multiple RES' sources. Policies and measures were selected based on the description.
- *RES Legal (2018)*: All policies and measures linked to heating and cooling sector were included in the database.
- *EurObserv'ER*: Analysed the latest EurObserv'ER's country reports of 2018, which includes information from Member State's National Renewable Energy Action Plans.

Information collected from these data sources was added to a database. This way information is available in a uniform and consistent way. Duplication was avoided by checking whether a policy and measure was not already included in the database. Information from different data sources was combined to have as much information in the database on a single policy or measure as possible.

2 Policies and measures implemented by Member States to increase the share of renewable energy sources for heating and cooling

2.1 The European policy framework promoting renewable energy sources for heating and cooling

European Union legislation on the use of renewable energy in the heating and cooling sector has only been explicitly implemented since 2009 through the Renewable Energy Sources Directive (2009/28/EC). Promotion measures for RES in electricity and transport were already in the scope of preceding EU legislation, which did not cover heating and cooling. The RES Directive required Member States, through the adoption of National Renewable Energy Action Plans (NREAPs), to lay down targets of RES usage for the heating and cooling sector. In addition, article 13 required Member States to effectively promote the use of renewables in new and renovated buildings, in heating systems, and in local energy infrastructure, such as district heating (EU, 2015). This includes:

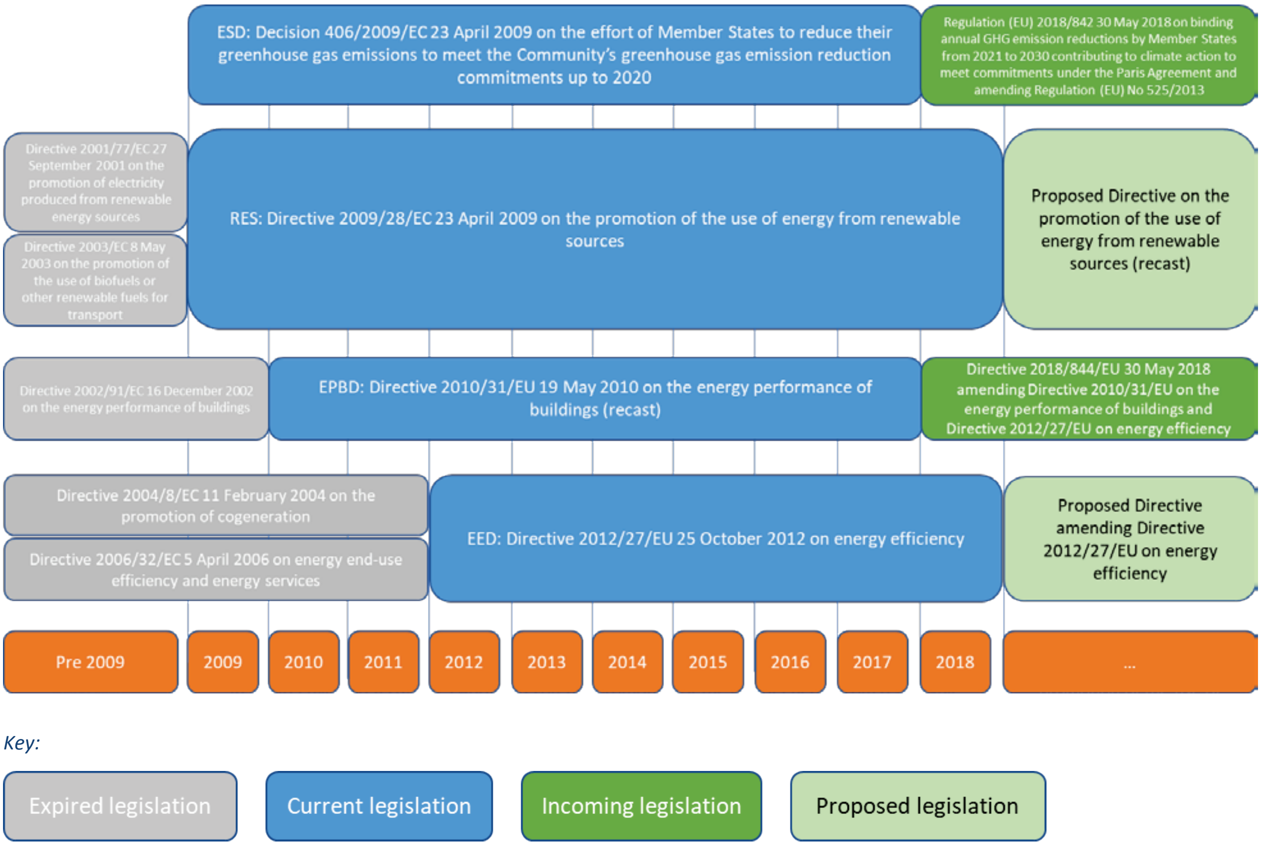
- encouraging local and regional administrative bodies to include heating and cooling from RES in the planning of city infrastructure (13(3));
- introducing by the end of 2014 requirements in building regulations and codes for new buildings and existing buildings that are subject to major renovation on the minimum levels of energy from RES, or by other means with equivalent effect (13(4));
- fulfilling an exemplary role at national, regional and local level concerning new and renovated public buildings (13(5));
- promoting RES heating and cooling systems using energy labels, eco-labels, certification or standards at national or Community level (13(6)).

An evaluation across all EU Member States however showed that only few countries have renewable energy requirements in building regulations and many still had to implement article 13(4) of the RES Directive on minimum use of RES in buildings in 2014 (CE Delft et al., 2015; EEG et al., 2014). The legal transposition deadline of Article 13(4) was by the end of 2014. A report of the Concerted Action Renewable Energy Sources Directive (Creasey et al., 2015) however, showed that the majority of Member States (22) do have clear provisions in place for increasing the share of renewables in buildings undergoing major renovation, but that different approaches are used, from regulation to financial incentives.

The use of renewable energy in the heating and cooling systems and buildings is further (directly and indirectly) promoted by the Energy Performance for Buildings Directive (2010/31/EU) and Energy Efficiency Directive (EED) (2012/27/EU). These policies promote RES directly as some RES technologies also contribute to energy efficiency improvements. Indirectly RES H&C is supported, for example by requiring Member States to develop national building renovation strategies and to assess the potential of district heating and cooling networks. The timing of these measures differs and some of these measures have only recently been implemented or still have to be implemented. The legal provisions on nearly-zero energy standards in buildings for example will only become applicable as of 2020. In the mid-term evaluation of the RES Directive, the authors note also that promoting RES in new or majorly renovated buildings alone in the RES Directive and EED leaves the huge potential in existing buildings untapped, where the largest potential lies (CE Delft et al., 2015). In combination with supportive policies at building level in EU countries however, the statistics show an increase and diversification of RES technologies in the heating and cooling sector in Europe. Larger installations, such as CHPs, might be part of the ETS and for these installations the ETS could be an additional incentive to switch to RES.

Figure 2 gives a graphical representation of the most important EU legislation affecting the RES H&C.

Figure 2. Timeline of key EU legislation affecting renewable energy sources in the heating and cooling sector.



Apart from the RES directive, GHG emissions from heating and cooling are affected by the two most important horizontal Union climate policies, the EU ETS and the Effort Sharing Decision (ESD). In the EU-28, 22% of avoided GHG emissions from heating and cooling are achieved by EU ETS installations (e.g. large biomass CHP installations) and the remaining 78% of avoided GHG emissions are achieved in ESD sectors (EEA, 2018).

The ESD sets mandatory GHG emission limits for EU Member States for sectors not covered by the EU ETS, such as transport, agriculture and waste. One of the more important sources of GHG emissions in the ESD is heating and cooling in buildings. The ESD was established in 2009, and covers the period 2013-2020. The ESD sets mandatory GHG emission targets for Member States that range between a reduction of 20% and an increase with 20% compared to 2005, depending on Member States' relative wealth. Although the ESD overlaps with sectorial Union legislation (such as the EPBD) and the ESD does not prescribe specific instruments to achieve the targets, it is an incentive for Member States to take further action when targets are not within reach. For the period 2021 to 2030 the Effort Sharing Regulation (2018/842) imposes further GHG emission cuts in sectors that are not covered by the EU ETS.

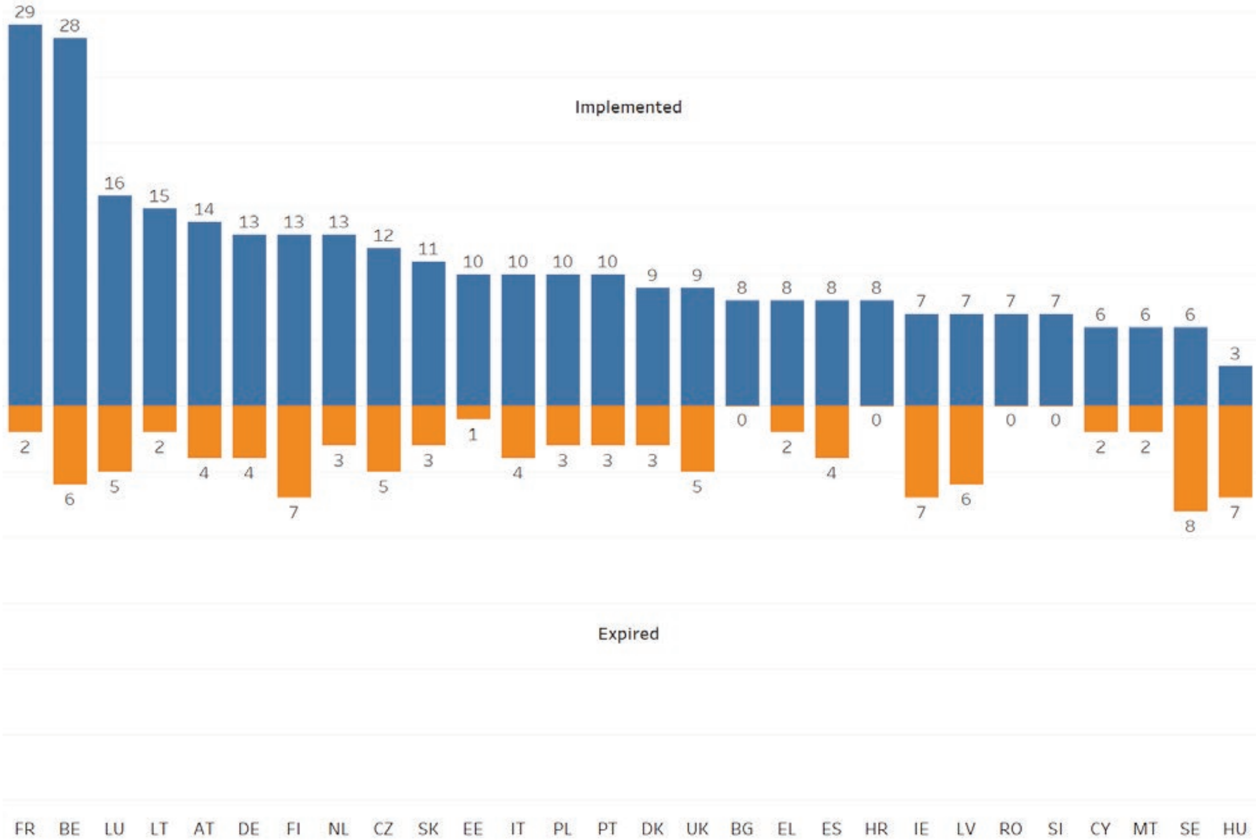
2.2 National policies and measures

A total of 407 PaMs related to renewable energy in the heating and cooling sector (RES H&C) were identified for the 28 EU Member States. 74% of these PaMs are currently in place, 1% are planned, 1% are adopted and 24% have expired. Belgium and France reported the most renewable heating and cooling PaMs, 34 and 31 respectively; Romania reported the fewest (7). The number of RES H&C PaMs does not necessarily correlate with the effectiveness of the PaMs.

Figure 3 presents the number of RES H&C PaMs by Member State and their current implementation status. It should be noted that of the 395 PaMs reported with a start date, only 120 also reported a finish date. It is therefore possible that the number of expired PaMs is underestimated.

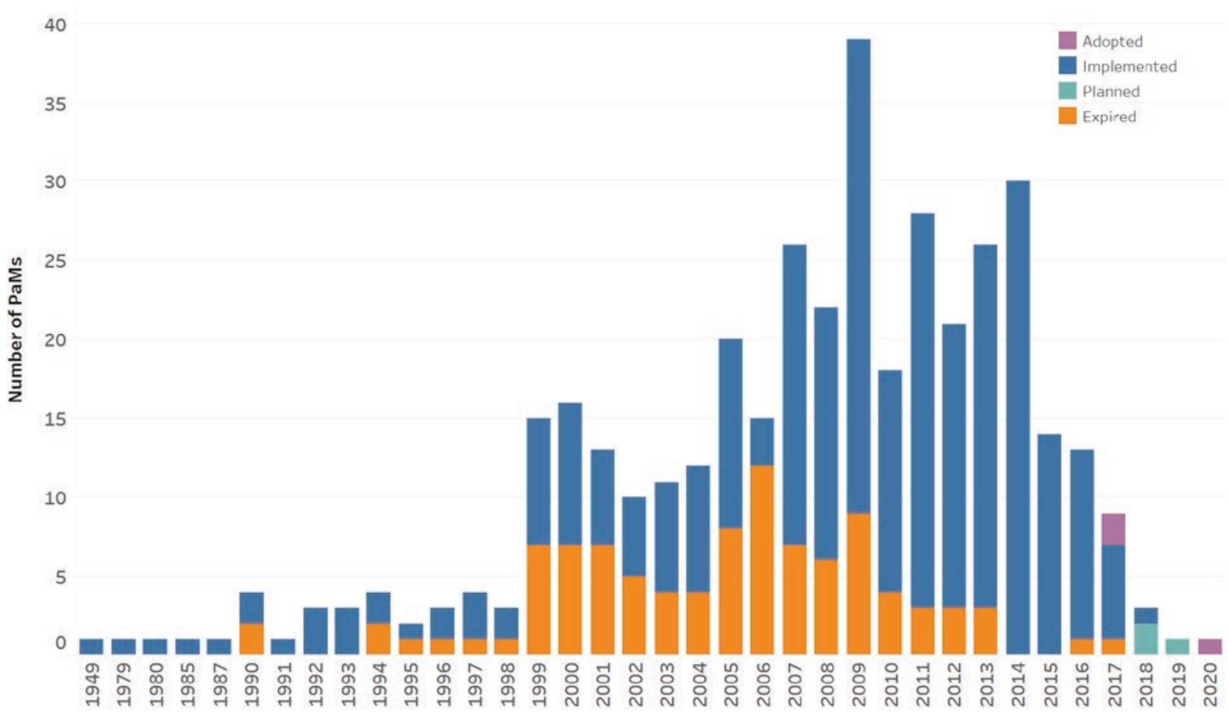
Figure 4 shows the timeline of implementation and current status of RES H&C PaMs, for the PaMs where a start year was identified. Twelve PaMs did not have a start date available.

Figure 3. Number of renewable heating and cooling PaMs by Member State and status of implementation.



Source: EEA (2018), IEA/IRENA (2018), RES Legal (2018), EurObserv'ER (2018).

Figure 4. Implementation status of renewable heating and cooling PaMs (EU-28) by start date.



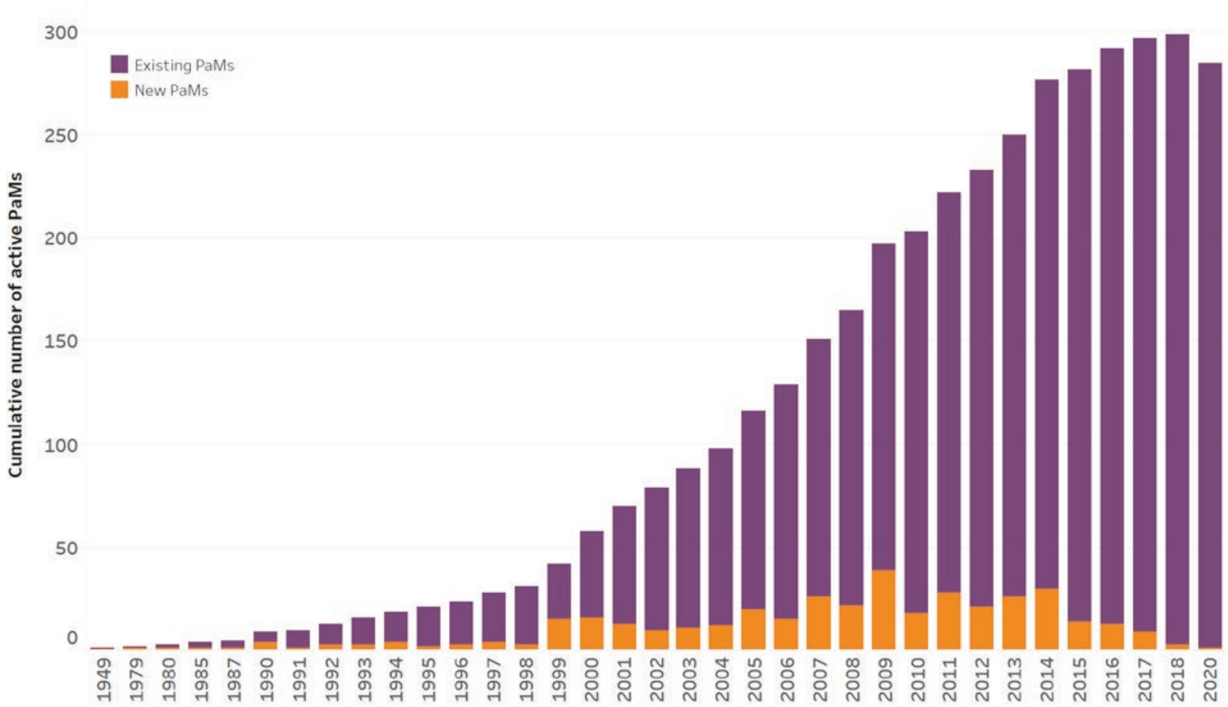
Sources: EEA (2018), IEA/IRENA (2018), RES Legal (2018), EurObserv'ER (2018).

Sixty heating and cooling PaMs[2] were directly linked to the RES Directive (EC, 2009), and 2009 was the year in which the most PaMs were implemented (30 PaMs). This might be in response to the RES Directive which required Member States reporting their first NREAPs to the Commission in 2010, so it's possible Member States focused the preparation of related PaMs in advance of the NREAP submissions. Klessmann et al. (2011) noted in 2011 that Member States had put less effort into supporting RES H&C in the past because of the absence of EU-wide targets and support requirements before the RES Directive.

Figure 5 shows the number of renewable heating and cooling PaMs in place per year, split by existing PaMs and new PaMs.

[2] In the EEA PaM database Member States have to report if and which Union policy was responsible for the implementation of the PaM. This information is not reported/included by all information sources, so the number could be an underestimation.

Figure 5. Number of active renewable heating and cooling PaMs (EU-28) each year.

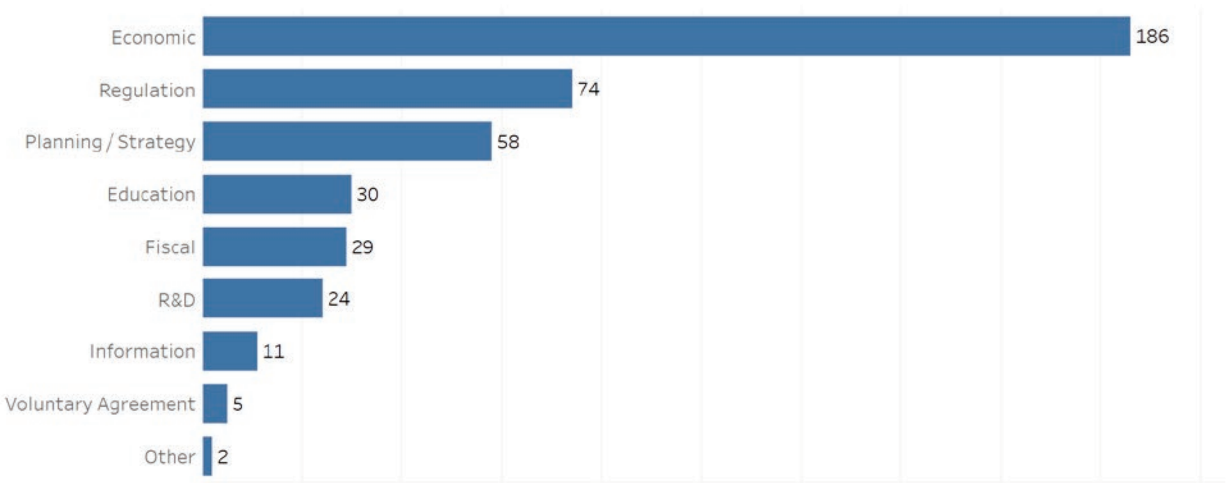


Sources: EEA (2018), IEA/IRENA (2018), RES Legal (2018), EurObserv'ER (2018).

Type of instruments

PaMs can be categorized by one or more instrument type. Economic PaMs were found to be the most numerous (44%) followed by Regulation and Planning/Strategy PaMs (Figure 6). Between these three types, 76% of PaMs are covered. Every Member State reported at least one economic PaM, and every Member State except Hungary reported at least one regulation PaM. Voluntary agreement PaMs are the least numerous, with only three Member States reporting PaMs for this type. Cyprus and Sweden reported one PaM each with an 'other' instrument type; a certification programme for RES installations, and a Sustainable Municipalities Programme.

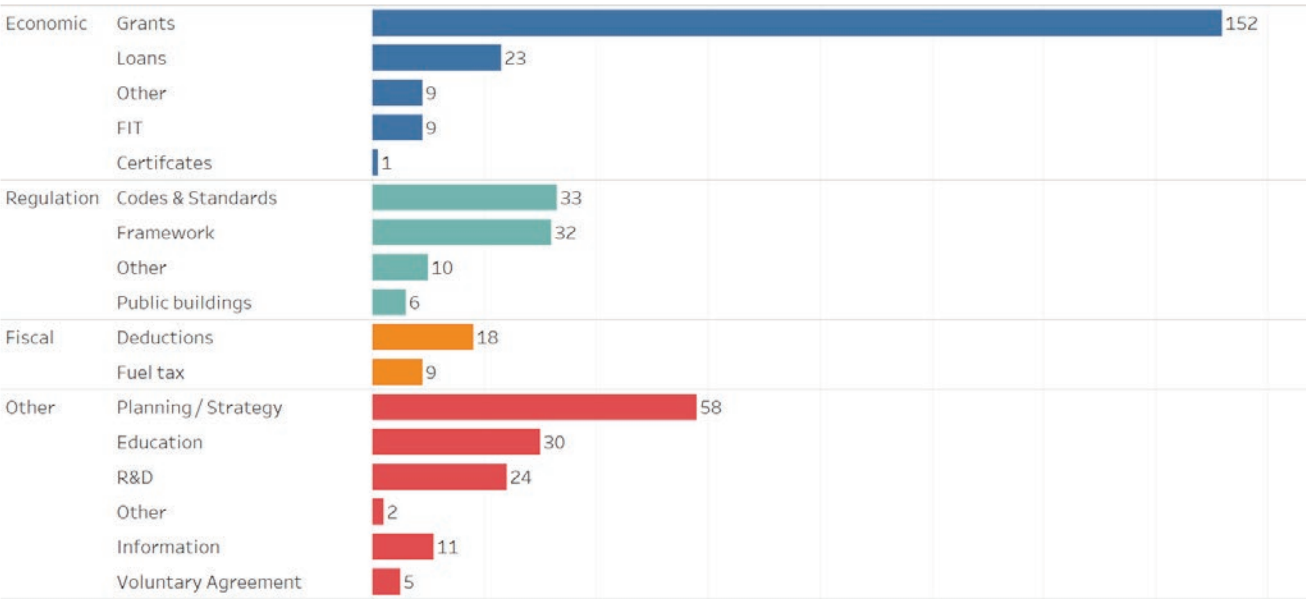
Figure 6. Number of PaMs by instrument type.



Sources: EEA (2018), IEA/IRENA (2018), RES Legal (2018), EurObserv'ER (2018).

At a more detailed level (Figure 7), over a third of PaMs (35%) had a grant-based aspect, and every Member State had at least one grant-based PaM. Soft loans to owners of buildings or installations are also a common economic instrument type to support RES H&C. While feed-in-tariff (FIT) schemes primarily support renewable electricity production or electricity production from combined heat and power (CHP) stations, in some cases renewable heating is supported as an additional surcharge.

Figure 7. Number of PaMs by detailed instrument type.

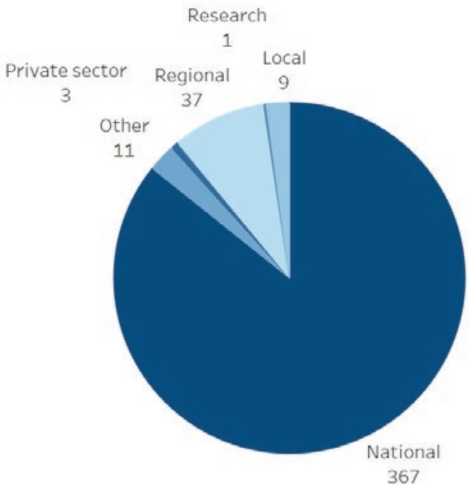


Sources: EEA (2018), IEA/IRENA (2018), RES Legal (2018), EurObserv'ER (2018).

Implementing entity

PaMs can have one or more implementing entities who are responsible for the implementation of the PaM. National level implementing entities were identified for the majority of PaMs (86%; Figure 8). Almost all of the regional implementing entities were in Belgium, with Belgian PaMs often being region-specific for Wallonia, Flanders and Brussels. Three Member States (Finland, France, and United Kingdom) reported 1 PaM each with a private sector implementing entity. The United Kingdom was the only Member State to report a PaM with a Research implementing entity – the Energy Technologies Institute, designed to act as a conduit between academia, industry and the government to accelerate the development of low-carbon technologies. There is a bias in most policy databases to focus on national PaMs, and thus national implementing entities are most important. For RES H&C implementation of PaMs and actions of local government is particularly relevant, especially to enable the development of (renewable) district heating and cooling (Bush et al., 2016). Local authorities across the EU have set-up actions to promote RES H&C, for example as part of the action plans under the Covenant of Mayors. National policy databases do not necessarily capture these actions effectively.

Figure 8. Number of PaMs by implementing entities.

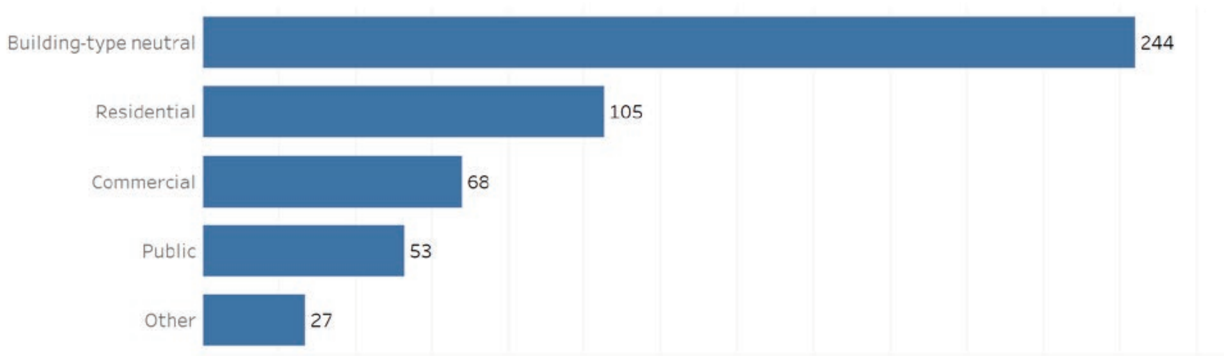


Sources: EEA (2018), IEA/IRENA (2018), RES Legal (2018), EurObserv'ER (2018).

Type of buildings

Renewable energy heating and cooling PaMs can be aimed at one or more specific building types or be building-type neutral (Figure 9). Residential buildings were specified in 105 PaMs, commercial buildings in 68 PaMs, and public buildings in 53 PaMs. Twenty-seven PaMs had 'other' as their only building type, which were mostly related to agriculture and farmers and some for the sector industry (including process heat). Every Member State had at least one PaM specifically addressing residential buildings.

Figure 9. Number of PaMs by targeted building type.



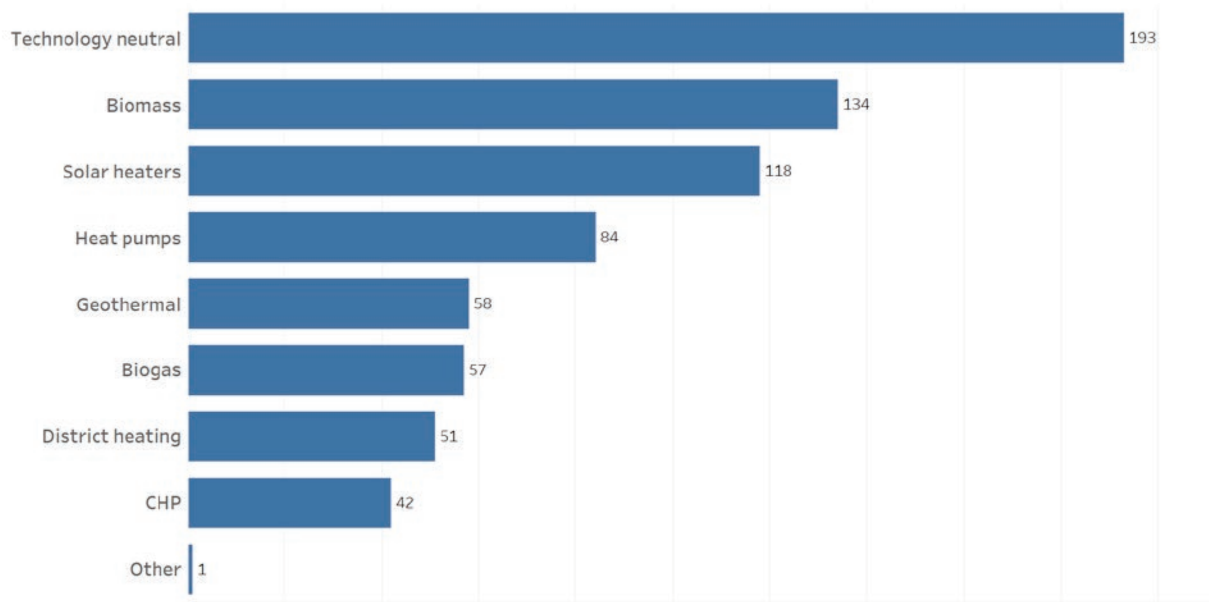
Sources: EEA (2018), IEA/IRENA (2018), RES Legal (2018), EurObserv'ER (2018).

Renewable energy sources

The PaMs analysed can be aimed at one or more sources of renewable energy or be technology neutral (Figure 10). 26 % of PaMs were not specific to one or more sources. Biomass was the most frequent renewable energy source identified in the PaMs, with 134 PaMs affecting biomass. This reflects the importance of biomass as a RES for heating and cooling. Over a third of biomass PaMs were from France, Luxembourg, Belgium and the United Kingdom. Austria reported one PaM with an 'other' energy source, for solar assisted air conditioning (the same PaM also covers solar heating and district heating).

Every Member State except Finland had at least one PaM specifically addressing solar heating. In contrast, only 17 Member States had at least one PaM specifically addressing combined heat and power (CHP). CHP is not necessarily a RES H&C technology and was only added if the PaM included a specific section on heat, as renewable energy CHP plants often only receive support for the produced electricity.

Figure 10. Renewable energy sources identified in PaMs.



Sources: EEA (2018), IEA/IRENA (2018), RES Legal (2018), EurObserv'ER (2018).

Cross-analysis

From cross-analysing different elements of the PaMs, certain characteristics can be drawn, as shown in the tables below. For example, if the PaM is technology neutral, then it is most likely an economic, regulation or planning/strategy PaM. As economic PaMs were most common, and biomass and solar heater PaMs were most common, it is unsurprising that economic PaMs addressing biomass and solar heaters are the most numerous. Education and R&D PaMs are most likely to be technology neutral.

Table 1. Number of PaMs by renewable energy source and instrument type.

Source/Instrument	Economic	Fiscal	Regulation	Planning / Strategy	Information	Education	R&D	Voluntary Agreement	Other
Solar heaters	79	11	12	1	1	11	1	0	1
Heat pumps	55	10	9	1	0	9	0	0	1
Geothermal	37	7	5	2	1	4	1	0	1
Biomass	89	13	10	8	7	7	5	0	1
Biogas	41	8	6	2	2	0	2	1	0
District heating	32	2	13	1	0	0	2	0	0
CHP	29	1	7	3	0	0	2	0	0
Technology neutral	49	11	47	49	4	18	15	4	1
Other	1	0	0	0	0	0	0	0	0

Sources: EEA (2018), IEA/IRENA (2018), RES Legal (2018), EurObserv'ER (2018).

Residential and commercial building PaMs are most likely to focus on solar heaters, biomass and heat pumps. The most common type of biomass, biogas, district heating and CHP PaMs are building neutral. If PaMs targeted a specific building type, it was most common to target residential buildings. The residential market has historically faced several barriers to RES deployment due to mismatches between costs in the rental market, for example, so effective PaMs targeting residential buildings are desirable.

Table 2. Number of PaMs by renewable energy source and building type.

Source/Building	Residential	Commercial	Public	Building-type neutral	Other
Solar heaters	67	36	24	32	10
Heat pumps	50	31	16	19	8
Geothermal	28	26	15	19	9
Biomass	49	36	21	61	15
Biogas	13	17	7	28	9
District heating	11	7	6	38	2
CHP	3	4	3	35	1
Technology neutral	25	26	27	139	11
Other	1	1	1	0	0

Sources: EEA (2018), IEA/IRENA (2018), RES Legal (2018), EurObserv'ER (2018).

All education and R&D PaMs were building type neutral. This is logical as most trainings and certification schemes for installers do not depend on the type of buildings. Economic PaMs were almost as likely to be residential type PaMs as they were to be building type neutral. Almost all planning/strategy PaMs were building type neutral. Residential, commercial and public building PaMs were most likely to be economic PaMs, or regulation PaMs.

Table 3. Number of PaMs by instrument type and building type.

Instrument/Building	Residential	Commercial	Public	Building-type neutral	Other
Economic	69	46	32	77	23
Fiscal	15	9	1	10	3
Regulation	20	12	14	47	0
Planning / Strategy	0	0	4	55	0
Information	1	1	3	6	2
Education	0	0	0	30	0
R&D	0	0	0	23	1
Voluntary Agreement	0	0	1	4	0
Other	0	0	1	2	0

Sources: EEA (2018), IEA/IRENA (2018), RES Legal (2018), EurObserv'ER (2018).

Information sources

When undertaking an analysis across several data sources, it is important to critically assess the data sources themselves. The data in this chapter has been derived from four data sources. These are evaluated for strengths and weaknesses below.

EEA database on climate change mitigation policies and measures in Europe (EEA 2018)

This database contains PaMs implemented, adopted or planned by EU Member States to reduce GHG emissions as reported by Member States under the EU Monitoring Mechanism Regulation (MMR) every two years. There are several mandatory data fields which are required to be completed for each PaM reported, including the name, description, sectors, GHGs, objective, type and related Union policies. Member States also provide detail on *ex ante* and *ex post* quantifications of GHG reductions, and costs and benefits, where available.

Strengths: Being backed by biennial legislative reporting requirements ensures that the data source is kept up to date with comprehensive detail on the PaMs reported. The related Union policy data field allows direct links to the relevant EU legislation such as the RES Directive. The data is available as an online database that can be searched on the main characteristics of the PaMs, such as sector, instrument type, country, objective, implementing entity, etc.

Weaknesses: Heating and cooling is not a specified sector, so a manual search was needed to identify relevant PaMs for this analysis.

IEA/IRENA global renewable energy policies and measures database (IEA/IRENA 2018)

This database contains information on PaMs implemented or planned to encourage the uptake of renewable energy in all IEA and IRENA Member countries and signatories, which includes all EU Member States. It contains information on each PaM including jurisdiction, start date, policy type, target, sector, description and URL link to the country's documentation. Anyone can submit information via the database website, which the IEA verifies with country representatives before including the new information in the database.

Strengths: The database is specifically for renewable energy PaMs, and heating and cooling is a specified subsector. The database is searchable via country, policy type, policy target, years, jurisdiction and status. The database was established in 1999 and is therefore collecting information on energy and climate PaMs for a long time. If a PaM is replaced by another PaM this information is also included in the section ('this record is superseded by').

Weaknesses: The information is structured in different data fields, such as country, year, policy status, policy type. While the most important information is provided, not all data fields are filled in for each PaM. The updates appear irregular (i.e. as shown in the dates when entries were last modified), although delegates from IEA member countries are given the opportunity to review information in the databases twice a year. There is no finish date field (although there is a policy status field for e.g. 'In Force' or 'Ended').

RES Legal (2018)

RES Legal is "the website on regulations on renewable energy generation", an initiative of the European Commission. It contains information on support schemes, grid issues and policies for renewable energy sources for electricity, heating and cooling and transport. The data covers EU Member States as well as EFTA countries and Members of the Energy Community. A summary of RES for each country is provided, as well as a summary of policies in each of the energy sectors. A summary of information about individual policies is provided, with links to the country's documentation.

Strengths: The database is specifically created to provide information on renewable energy PaMs, and heating and cooling is a specified sector. The database is very well structured, around different sectors (electricity, heating and cooling, and transport) and instrument types (support schemes, grid issues, and policies). The database also has detailed information on training, certification and RD&D policies. The database is closely linked to the national (or regional) energy legislation, with information and links to the relevant legal source.

Weaknesses: Information is structured, for example for each support scheme information is presented on eligible technologies, amount, addressees, procedure and distribution of cost, but the level of detail for each policy differs. The database is updated regularly, but not at the same time for all countries (for example the latest update for Latvia is end of 2017, while some countries such as Germany were updated January 2019). The information for the database is provided by an external partner, but it is unclear if the information is validated by countries. The database can only be searched by country.

EurObserv'ER renewable energy policy profiles (2018)

The EurObserv'ER group includes Observ'ER (FR), the Energy research Centre of the Netherlands (ECN, NL), the Renewables Academy (RENAC, DE), Frankfurt School of Finance and Management (DE), Fraunhofer-ISI (DE) and Statistics Netherlands (CBS, NL). The group produces reports on renewable energy sectors in Europe, as well as policy and statistics reports by Member State. The renewable energy policy profiles contain a summary of RES and RES policies in the country, figures and data of RES over time, projections, and RES from different sources.

Strengths: Includes information from Member State's NREAPs. The profiles provide links to data sources used and further information.

Weaknesses: The profiles are irregularly updated and some are outdated. For example, the profiles for Member States on specific technologies, e.g. on solar thermal, are dated 2011. The information in each profile is less easily accessible than other databases that have online and searchable databases.

Table 4 shows the number of PaMs that each data source provided. The same PaM can be from multiple data sources. The scope of the data sources can in part explain the differences in number of PaMs. For example, the EEA database is likely to only contain expired PaMs if the impacts of the PaM continue, whereas over one quarter of RES H&C PaMs in the IEA/IRENA database are expired. EurObserv'ER provided only one PaM that was not contained in any of the other three sources.

Table 4. Number of PaMs obtained from each data source.

	EEA	IEA/IRENA	RES-Legal	EurObserv'ER
Number of PaMs from each data source	129	231	160	80

Note: The same PaM can be in more than one data source.

Table 5shows how many data sources contributed to each PaM. Two thirds of PaMs analysed only had information drawn from one data source, and a quarter of PaMs had information from two data sources. Only 13 PaMs had information drawn from all four data sources. Corroborating information across multiple data sources is preferred, but the Table 5 data is perhaps unsurprising given the unequal number of PaMs from different sources shown in Table 4. When comparing PaMs across the data sources the features of PaMs were manually checked to ensure no duplication when the same PaM had a slightly different title (for example) between sources.

Table 5. Number of PaMs with information from one or more data sources.

	1 data source	2 data sources	3 data sources	4 data sources
Number of PaMs with information from	266	102	26	13

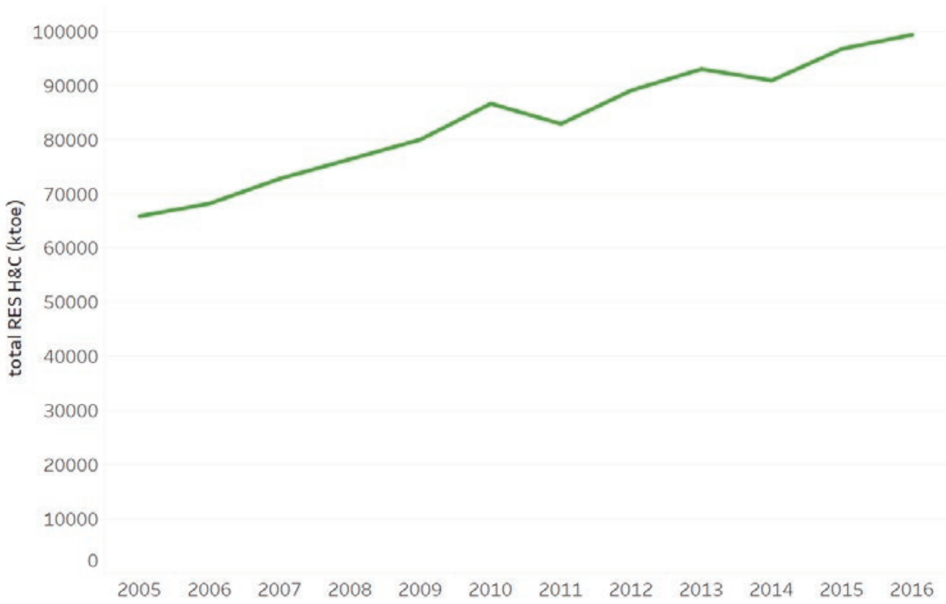
3 Increase in the share of renewable energy sources for heating and cooling

3.1 All renewable energy sources for heating and cooling

European Union

The share of RES in the heating and cooling sector reached an overall share of 19.1% in the EU-28 in 2016. This share has been growing annually by an average of 4% between 2005 and 2016 (Figure 11). The heating and cooling sector however does not perform as well as the electricity sector when it comes to decarbonisation. The share of RES in the electricity sector reached a level of 29.6% in 2016 and has been growing on average by 6% between 2005 and 2016. In total gross final consumption for RES H&C was 99.3 Mtoe (million tonnes of oil equivalent) in 2016 in the EU-28.

Figure 11. The change in renewable energy sources for heating and cooling between 2005 and 2016 in the European Union.



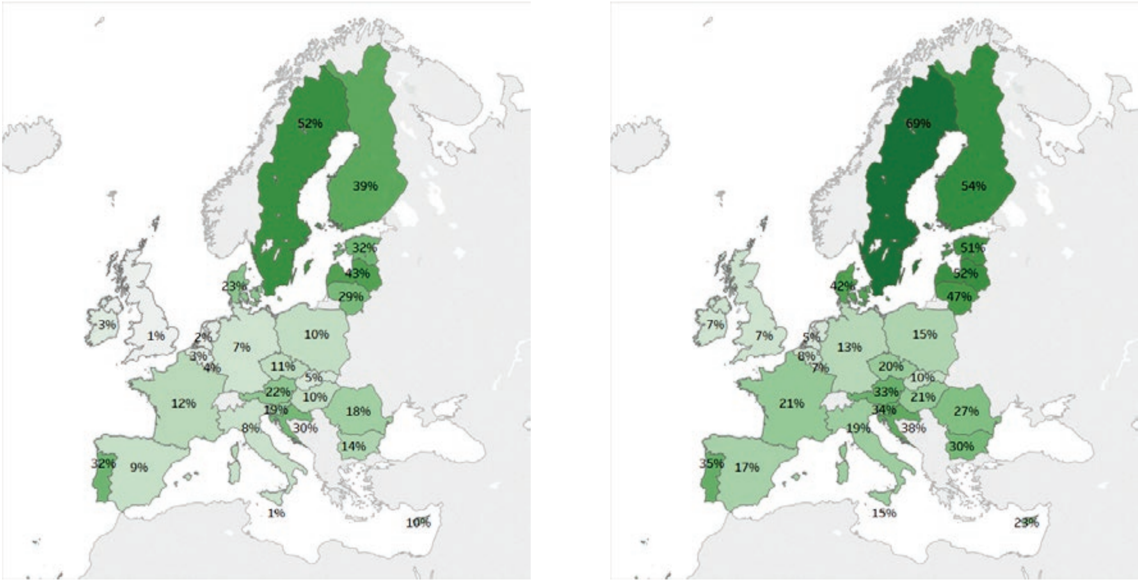
Source: SHARES (Eurostat, 2018).

The number of national PaMs to promote RES H&C have been growing in the same period.

Individual Member States

The share of RES H&C in the EU masks important differences among EU Member States. Figure 12 shows the share of RES H&C in 2005 and 2016. Nordic countries such as Sweden, Latvia, Finland, Estonia, and Lithuania have clearly higher shares of RES H&C than most other countries. The United Kingdom, Ireland and the Benelux countries (Belgium, the Netherlands and Luxembourg) have the most modest shares of RES H&C.

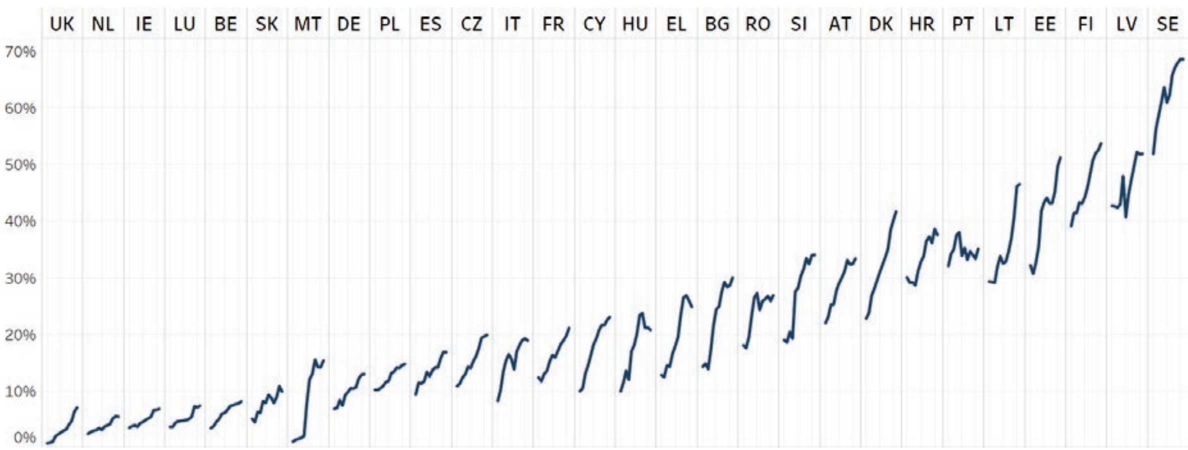
Figure 12. Share of renewable energy sources for heating and cooling in EU Member States in 2005 and 2016.



Source: SHARES (Eurostat, 2018).

Figure 13 shows the evolution between 2005-2016 of the share of RES H&C for each Member State in more detail. The share of RES H&C in 2005 differs markedly for each Member State from 1% in the United Kingdom to 52% in Sweden. The graph also shows that there are clear differences in the trend between the Member States. For some Member States the evolution has been steadily increasing (such as for Cyprus, Denmark and Finland), while for other Member States the evolution had been more discontinuous (such as for Hungary, Portugal, and Romania).

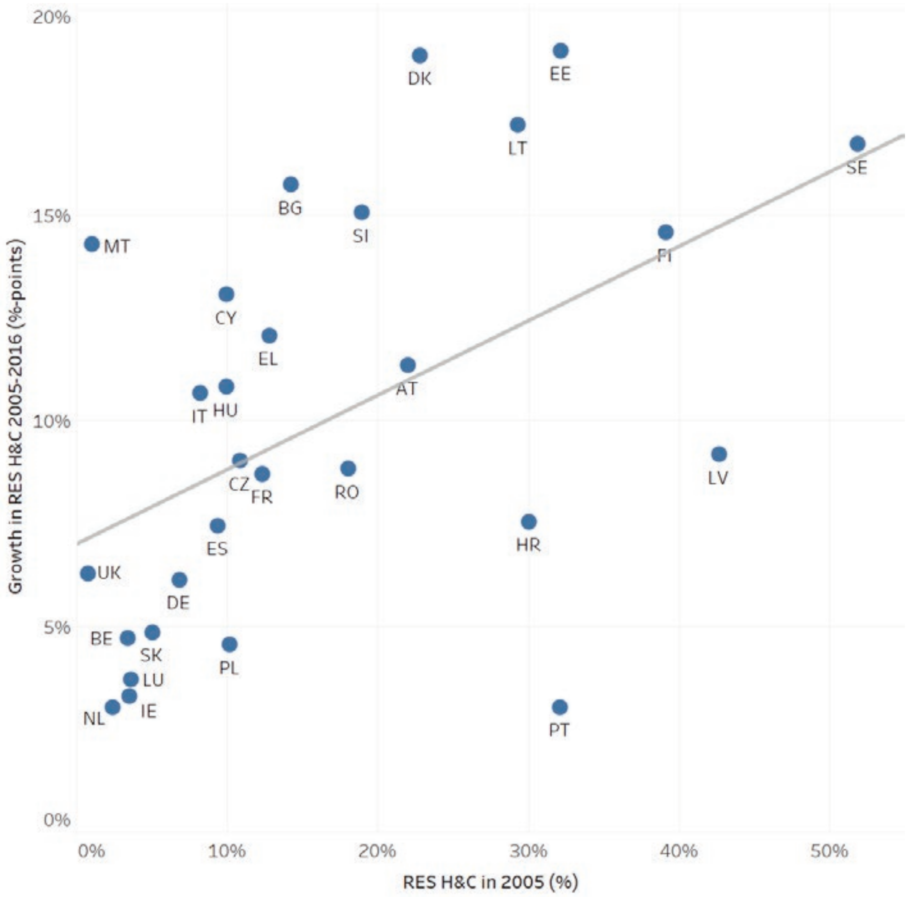
Figure 13. Trend of the renewable energy sources for heating and cooling share (in %) in EU Member States between 2005-2016.



Source: SHARES (Eurostat, 2018).

Countries with a higher share of RES H&C in 2005 have increased their share of RES in 2016 more (in %-points) than Member States that had a lower share of RES H&C in 2005 (Figure 14). For example, the share of RES in Sweden grew with 17 %-points between 2005 and 2016 (from 52% to 69%), while the share of RES in France grew only with 9 %-points between 2005 and 2016 (from 12% to 21%). Countries which already had a high share of RES H&C in 2005 thus maintained a higher than average growth. This is also apparent in Figure 13. Member States on the left (with a low share of RES H&C in 2005) tend to have a much less steep trend line than Member States on the right (with a higher share of RES H&C in 2005) that tend to have a much steeper curve. This also reveals important differences among countries. Member States such as Croatia, Latvia, Poland, and Portugal have increased the share of RES H&C between 2005 and 2016 to a lesser extent than their peers. Member States such as Bulgaria, Denmark, Estonia, Lithuania, Malta, and Slovenia have increased the share of RES H&C from 2005 to 2016 to a higher extent than their peers.

Figure 14. Correlation between the share of renewable energy sources for heating and cooling in 2005 (in %) and increase in 2016 (%-points).



Source: SHARES (Eurostat, 2018).

The changes in RES H&C can be affected by two different factors.

1) The gross final consumption of heating and cooling with renewable energy sources. If this increases, the share of RES H&C will increase in most cases as well.
2) The gross final energy consumption for heating and cooling as a whole. If this decreases, the share of RES H&C will increase in most cases.

The share of RES H&C will therefore not only be determined by PaMs promoting heating and cooling, but also by PaMs to increase energy efficiency for heating and cooling. The interlinkages and overlaps between renewable energy and energy efficiency policies at the EU level have been described and analysed in detail (e.g. Del Rio, 2010).

To understand what is contributing to the increase in RES H&C in individual countries the change in RES H&C and total energy consumption for heating and cooling could be compared.

Figure 15 shows the change in RES H&C and gross final energy consumption for heating and cooling compared to 2005. The y-axis denotes changes in the RES H&C production and the x-axis denote changes in the gross final consumption of energy for heating and cooling.

There are a number of Member States where the gross final consumption of RES H&C clearly increased more, whereas energy efficiency did not contribute much to a reduced gross final energy consumption. This is the case for Austria, Belgium, Cyprus, the Czech Republic, Denmark, Estonia, Finland, Germany, Hungary, Luxembourg, Malta, Netherlands, Poland, and Sweden.

Member States where both changes in RES H&C and gross final energy consumption contributed to an increased RES H&C share were Bulgaria, France, Ireland, Italy, Lithuania, Slovakia, Slovenia, and the United Kingdom.

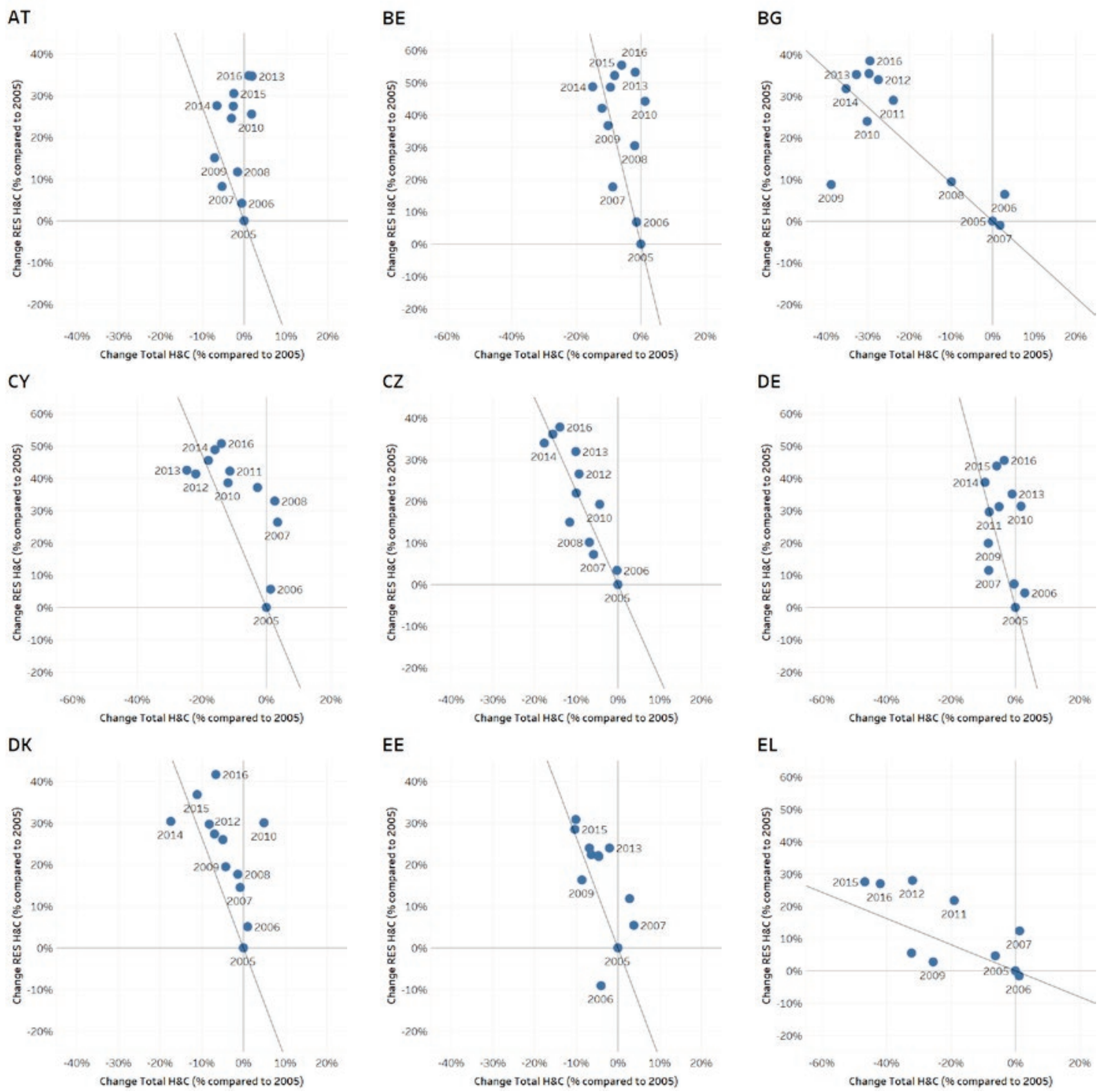
In six Member States the gross final consumption of RES H&C did only marginally change, whereas the gross final energy consumption changed more. This was the case for Croatia, Greece, Latvia, Portugal, Romania, and Spain. For Croatia and Portugal, the gross final consumption of RES H&C in 2016 was even lower than in 2005. Despite this negative trend, the share of RES H&C was still higher due to a much larger decrease in final energy consumption for heating and cooling in the same period. Croatia, Latvia, and Portugal were among the countries with a relatively modest growth in RES H&C between 2005 and 2016.

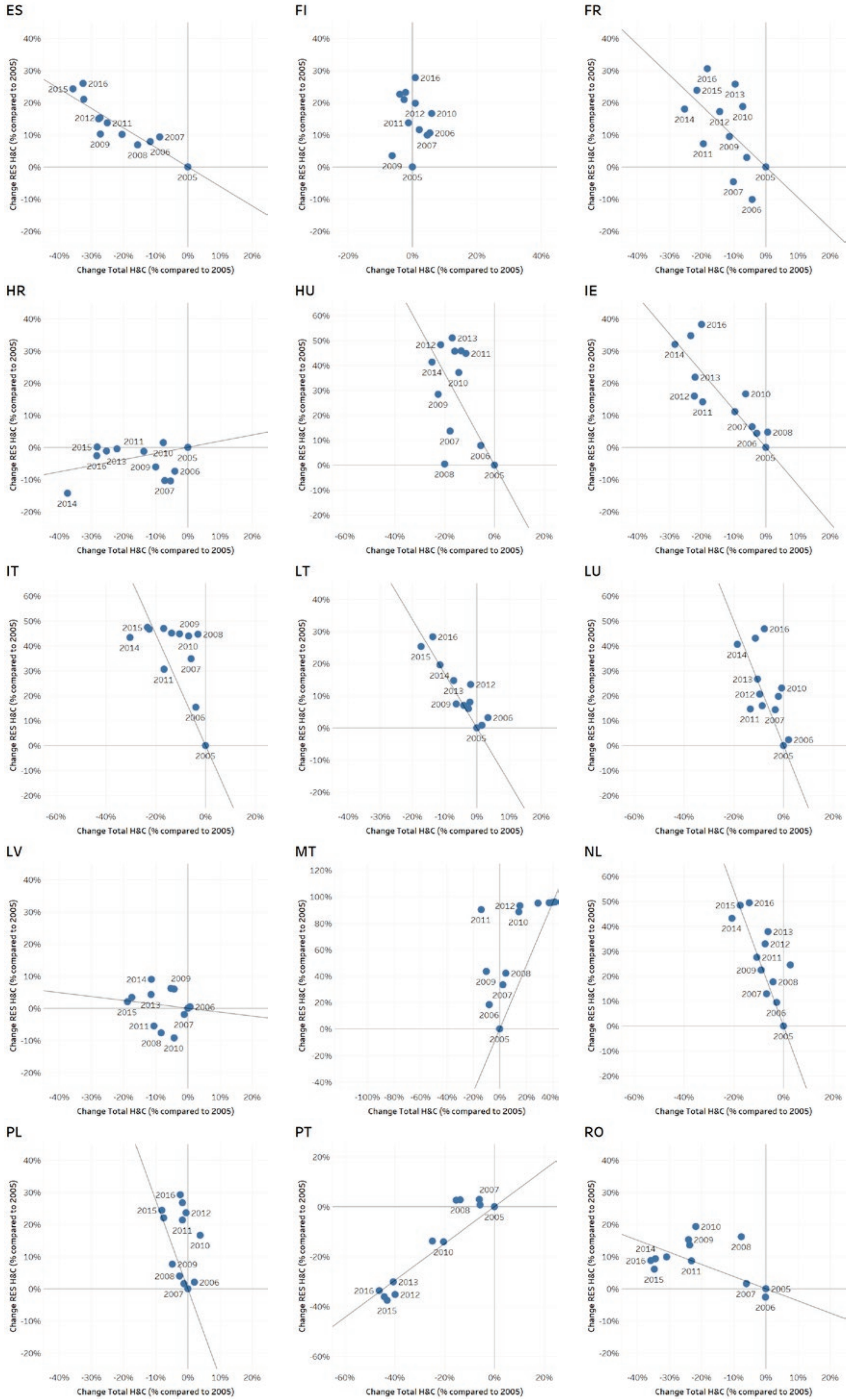
Figure 15. Annual percentage change in final energy consumption of renewable energy sources for heating and cooling and in gross final energy consumption for heating and cooling (compared to 2005).

A: Gross final energy consumption in the heating and cooling sector decreased whilst the final energy consumption from RES in the heating and cooling sector increased.

B: Gross final energy consumption in the heating and cooling sector increased whilst the final energy consumption from RES in the heating and cooling sector increased.

C: Gross final energy consumption in the heating and cooling sector decreased whilst the final energy consumption from RES in the heating and cooling sector decreased.




ES
FI
FR
HR
HU
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IT
LT
LU
LV
MT
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PL
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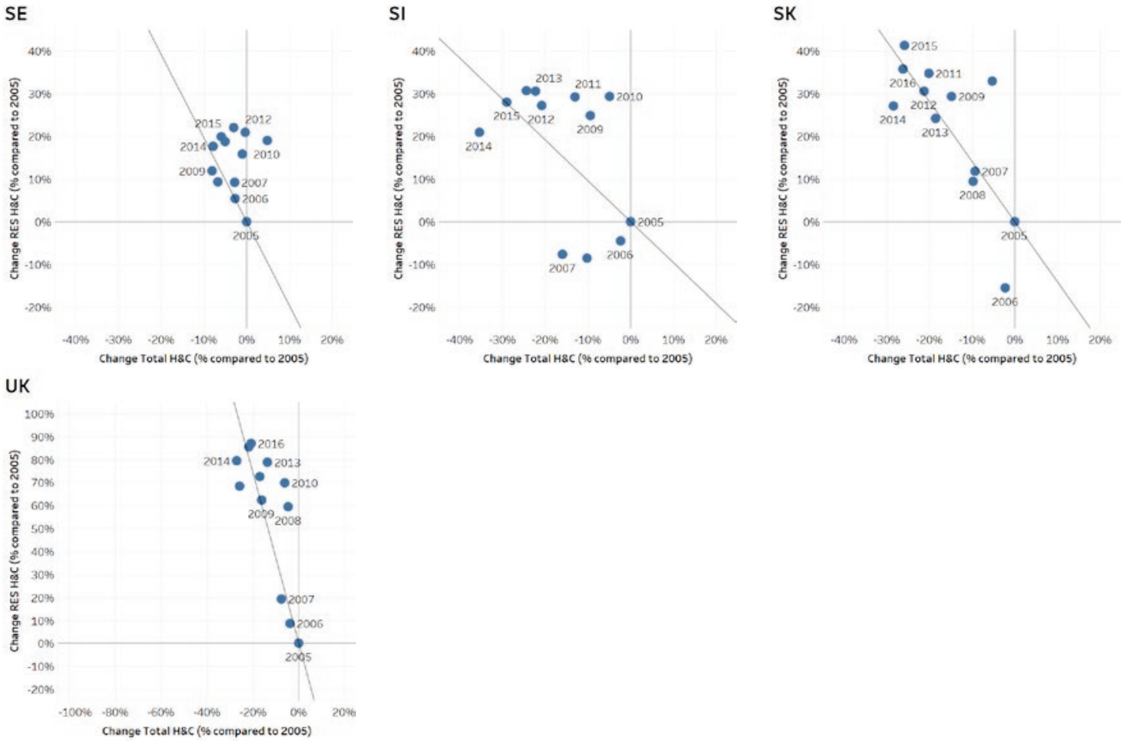
RO
Change RES H&C (% compared to 2005)
Change Total H&C (% compared to 2005)



Source: SHARES (Eurostat 2018).

3.2 District heating and combined heat and power

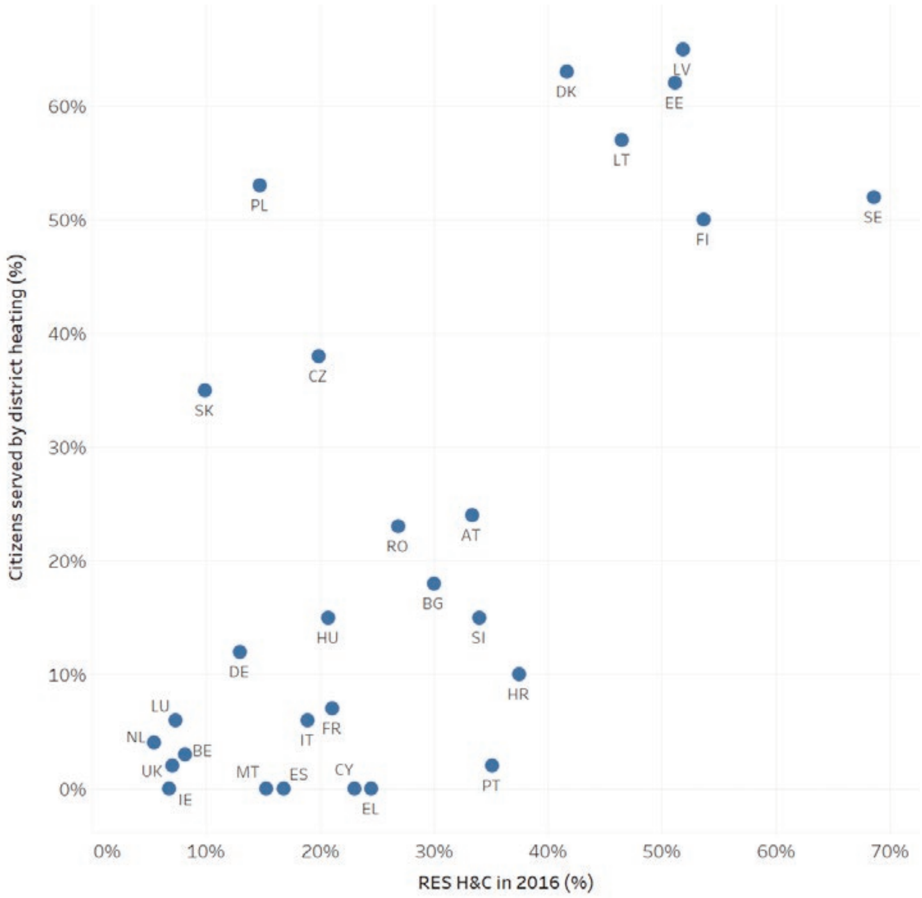
European Union

CHP technology is an effective way to increase energy efficiency. In 2004, the EU implemented the CHP Directive (2004/8/EC), which aims to promote high-efficiency cogeneration. This covers both fossil and renewable CHP plants. The directive established a harmonized methodology for calculating the efficiency of cogeneration plants and required Member States to carry out an analysis of their national cogeneration potentials. The CHP Directive was repealed by the EED. The EED also required each Member State to carry out a comprehensive assessment of the national potential of cogeneration and district heating and cooling by December 2015. All Member States submitted these assessments, which are available online. This is also the basis for establishing National strategies and PaMs to promote district heating and cooling (and CHP) where this is cost-effective. While the emphasis is on energy efficiency, there are also potential co-benefits to promote RES such as biomass, geothermal and centralized solar. The position of district heating on the EU energy and climate policy agenda is changing, with increased interest for heating and cooling, and is now a prominent part of the EU's heating and cooling strategy (EU, 2016). Recent years have also seen an expansion of EU funded research into district heating and cooling (e.g. heat roadmap Europe and Planheat).

Individual Member States

While district heating or heat networks are not solely linked to renewable energy sources, analysis shows that district heating is an enabling factor for higher shares of RES H&C. EU Member States with a particularly high share of RES H&C are also the Member States with extensive district heating networks. This applies in general for Denmark, Finland, Sweden, and the Baltic countries. They were established decades ago with government support and operated with heat produced from fossil fuels, often linked to coal or gas CHP plants. District heating networks were often established before the liberalization of the energy market in these countries. Some were set up specifically to exploit renewables from the onset. District heating systems are cost effective in densely-populated areas and in countries or regions that have an above-average heat demand. They are also increasingly used in small-scale networks to service large buildings or groups of buildings.

Figure 16. The correlation between the share of RES H&C and the extent of district heating networks.



Source: SHARES (Eurostat 2018) and Colmenar-Santos et al. (2016).

Refurbishment of existing district heat networks to renewable energy sources facilitates the rapid increase of RES H&C shares. This step however still required policy intervention and the Member States with high shares of district heating and RES H&C all have implemented policies in the heat sector.

Poland is a notable exception, as a country with a large district heating network but a relatively modest share of renewable energy. Unlike Nordic and Baltic countries, Poland has been slower to move from fossil fuels (mostly coal) to renewable energy sources for district heating. With the aging district heating infrastructure, the focus of Poland is on renovating the existing heat networks and increasing the share of CHP in district heating. No specific PaMs are in place supporting the adoption of renewable energies in district heating. Renewable heat from CHP is supported, but only indirectly through support for the production of renewable electricity (Poland, 2015).

The PaMs identified to support district heating are principally economic instrument types, although there is also a large share of regulations (Figure 17), especially compared to other RES H&C technologies. District heating requires countries to set-up national legislation to regulate the heating market. In addition, regulations have been implemented to support RES H&C in district heating. For some EU Member States that currently lack extensive district heating systems, expanding the supply of heat through district heating is seen as a major part of their low-carbon heat strategies (e.g. the UK and Netherlands). This includes also actions at city level (IRENA, 2018).

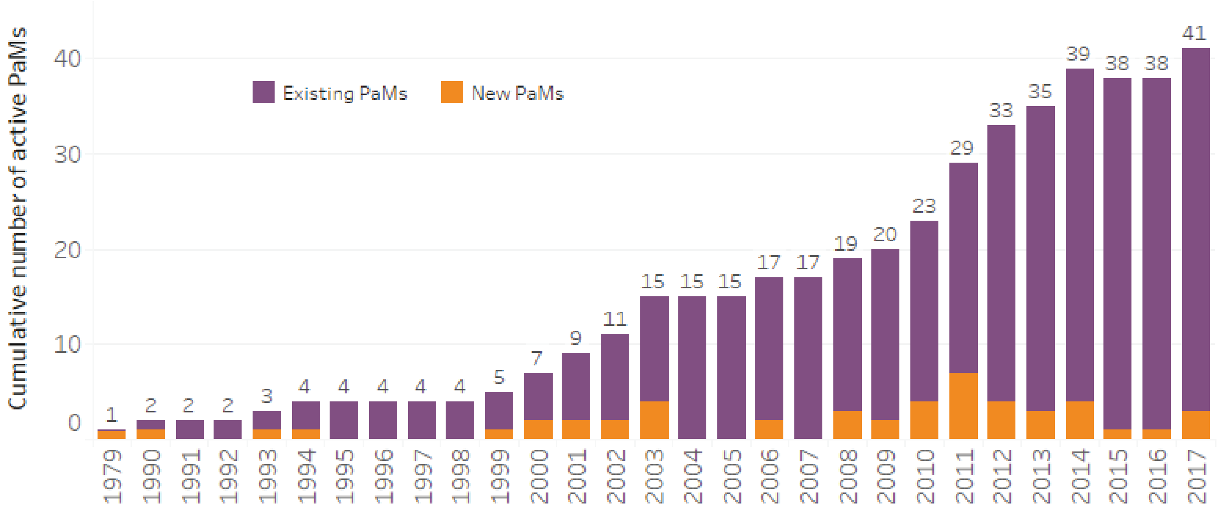
In countries with the most extensive district heating networks, policies relating to district heating are also more established. Expansion of district heating systems occurred often in a period when the market was still not liberalized. Policy developments in these countries therefore focused on preparing the market for this liberalization.

- The *Heat Supply Act* in Denmark was introduced in 1979 and enables the ban of electric heating in new buildings located within a district heating or natural gas supply network and, since 1994, to ban conversion to electric heating in existing buildings. Other provisions include the obligatory connection to the district heating or natural gas supply network, the promotion of co-generated heat and electricity and establishing rules for heat pricing. The obligation for all buildings in a given area to connect to the district heating has increased the coverage of district heating considerably. In addition, about 80% of district heating is co-produced with electricity due to the Heat Supply Act. As a result, Denmark has the most extensive co-generated heat and electricity system in EU, with more than half of all Danish electricity co-generated with heat. The principle for heat pricing stipulates that heat supplies must be sold on a non-profit basis or, to increase the utilization of renewable energy resources and industrial surplus heat, sold with a profit that is determined by the Danish Energy Agency (IEA, 2018).
- In Germany the *Combined Heat and Power Act* (KWKG) promotes the construction and development of heating networks and storage, although not exclusively using renewable energy sources. Newly constructed or modernized plants are eligible for compensation payments if the share of heat from CHP is at least 75% or the combination of CHP, heat from renewable energies or industrial waste heat is at least 50%. The importance of this law on renewable energy technologies is minor, but is complemented by the *Renewable Energy Sources Act* (EEG) which provides more favourable financial incentives for these technologies.
- In Lithuania, the *Law on the Heat Sector* and connection to the grid was established in 2003, and since then has been amended several times, most recently in 2017 (RES Legal, 2018). The law is part of the restructuring of the Lithuanian heat sector that began in 1997 which regulates the management of the heat sector, the activities of the heat sector entities, their relations with heat consumers, interrelations and responsibilities.
- In Sweden no special district heating regulation was implemented, even though development started already in 1948 (Werner, 2017), because this was mainly driven by local actions from municipalities. Over the years however there was an increased need for tighter and harmonized rules, resulting in the *District Heating Act* of 2008. Up until 1980, most district heating networks used fossil fuels. Over the next decades Sweden diversified the energy sources for the district heating network and in 2015 only a small portion of energy supply (7%) comes from fossil fuelled district heating and the majority from waste, excess and ambient heat, and biomass (Werner, 2017).

Options for the most cost-effective renewable heat supply for district heating vary between Member States. There are also different options to integrate renewable energy in district heating, such as through heat pumps, geothermal energy, solar thermal energy, municipal waste and different biomass resources. In the Baltic countries, district heating systems have switched away from imported natural gas to using local biomass. Geothermal heat, e.g. from local hot aquifers, is used variably depending on resource availability. In Denmark, large-scale solar thermal systems are contributing renewable supplies to district heating grids (Collier, 2018).

Figure 17. Overview of district heating PaMs.

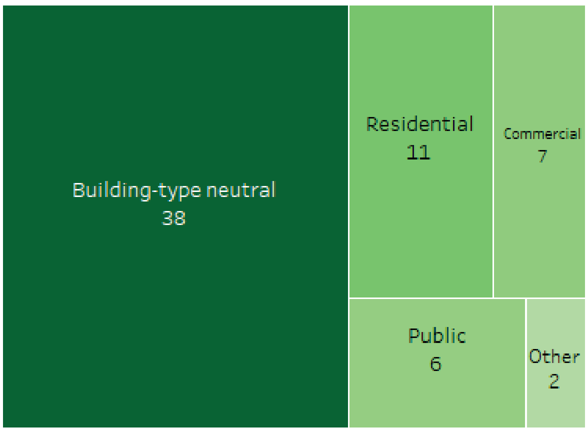
Number of active District heating PaMs each year



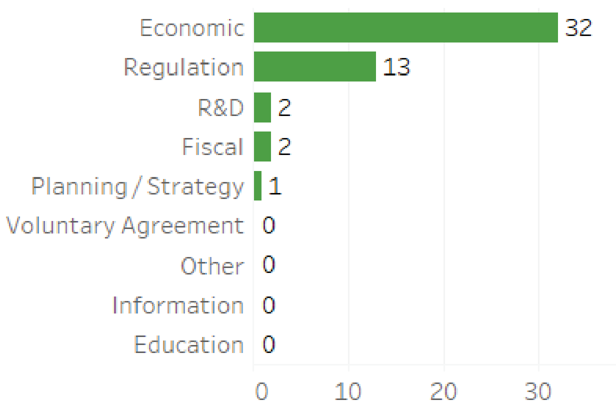
Number of District heating PaMs by Member State and status

Status	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
Implemented	5	2	1	0	0	1	2	3	3	0	1	2	0	0	0	1	4	2	0	0	2	1	0	1	1	3	1	0
Adopted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0
Expired	2	0	0	0	0	0	1	1	1	0	0	0	0	0	2	0	0	0	2	0	2	0	0	0	2	0	0	0

Number of District heating PaMs by building type



Number of District heating PaMs by instrument type



Number of District heating PaMs by instrument type and building type

Building	Instrument: Economic	Education	Fiscal	Information	Planning / Strategy	R&D	Regulation	Voluntary Agreement	Other
Building-type neutral	24	0	1	0	1	2	9	0	0
Commercial	5	0	1	0	0	0	1	0	0
Public	5	0	0	0	0	0	1	0	0
Residential	7	0	0	0	0	0	4	0	0
Other	2	0	0	0	0	0	0	0	0

Sources: EEA (2018), IEA/IRENA (2018), RES Legal (2018), EurObserv'ER (2018).

Combined Heat and Power

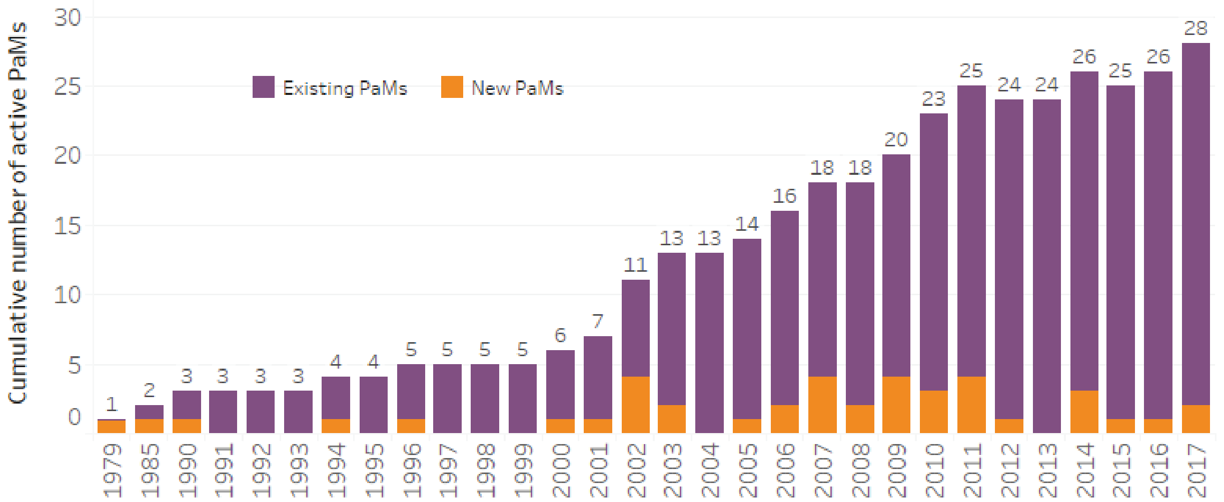
Across EU Member States PaMs have been implemented to increase the share of biomass used in CHP. CHP installations often already benefit from support mechanisms such as a feed-in tariffs (e.g. Finland, Ireland, and Luxembourg), quota systems (e.g. Belgium) or investment subsidies (e.g. Austria, Estonia) and regulations (e.g. Slovenia). These policies have been implemented by Member States to increase energy efficiency, but when combined with renewable energies also contribute to increased renewable energy shares and avoided GHG emissions. In several Member States, policies have been implemented to increase the use of RES in CHP installations (Figure 18).

To boost the uptake of renewables, mainly biomass, in CHP and district heating networks, Estonia uses financial resources from the sale of CO_2-allowances ("GIS") and the European Regional Development Fund.

In some European countries heat use from biogas plants is facilitated by CHP bonuses. In Finland, a "heat bonus" is given for biogas and biomass cogeneration on top of the feed-in tariff. In Germany the introduction of the so-called 'CHP bonus' in the amendment of the Renewable Energy Act in 2004 resulted in a significant increase of heat utilization of biogas plants. In addition to the basic feed-in tariff, the law had foreseen the additional payment if the waste heat of the CHP plant was also used. From 2012, this feed-in tariff system was replaced by an obligation to use the heat of new biogas plants.

In Slovenia, the *Energy Act* establishes that at least 50% of the yearly amount of the heat distribution shall be produced from renewable energy sources or 50% shall come from waste heat or 75% from high-efficiency cogeneration or 75% from a mix of before listed sources in 2020.

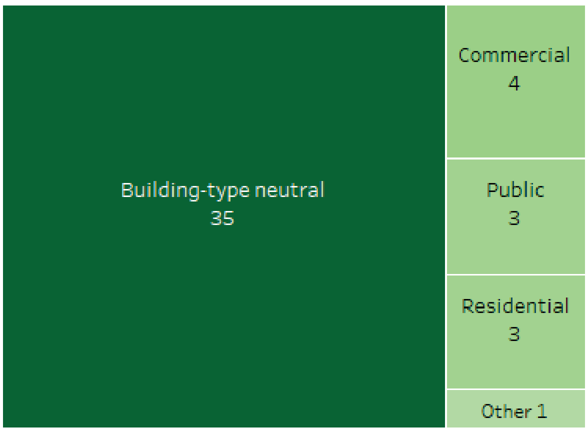
Figure 18. Overview of Combined Heat and Power PaMs.



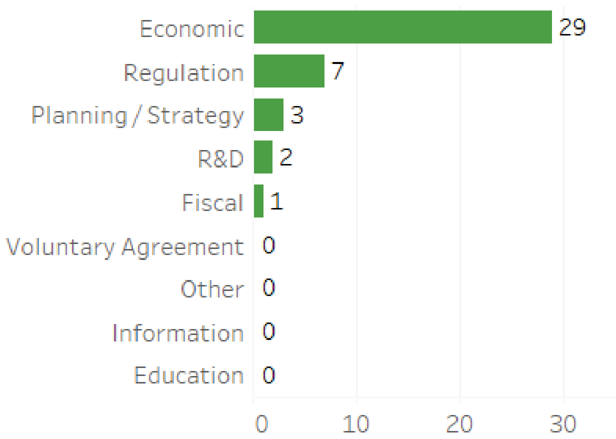
Number of CHP PaMs by Member State and status

Status	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
Implemented	1	2	0	0	0	2	1	2	3	0	1	0	0	0	1	0	1	2	1	0	2	3	1	0	0	0	1	1
Adopted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0
Expired	1	0	0	0	0	0	0	0	1	0	0	0	0	0	2	0	2	3	2	0	2	1	0	0	0	0	0	1

Number of CHP PaMs by building type



Number of CHP PaMs by instrument type



Number of CHP PaMs by instrument type and building type

Building	Instrument: Economic	Education	Fiscal	Information	Planning / Strategy	R&D	Regulation	Voluntary Agreement	Other
Building-type neutral	24	0	0	0	3	2	6	0	0
Commercial	3	0	1	0	0	0	0	0	0
Public	3	0	0	0	0	0	0	0	0
Residential	2	0	0	0	0	0	1	0	0
Other	1	0	0	0	0	0	0	0	0

Sources: EEA (2018), IEA/IRENA (2018), RES Legal (2018), EurObserv'ER (2018).

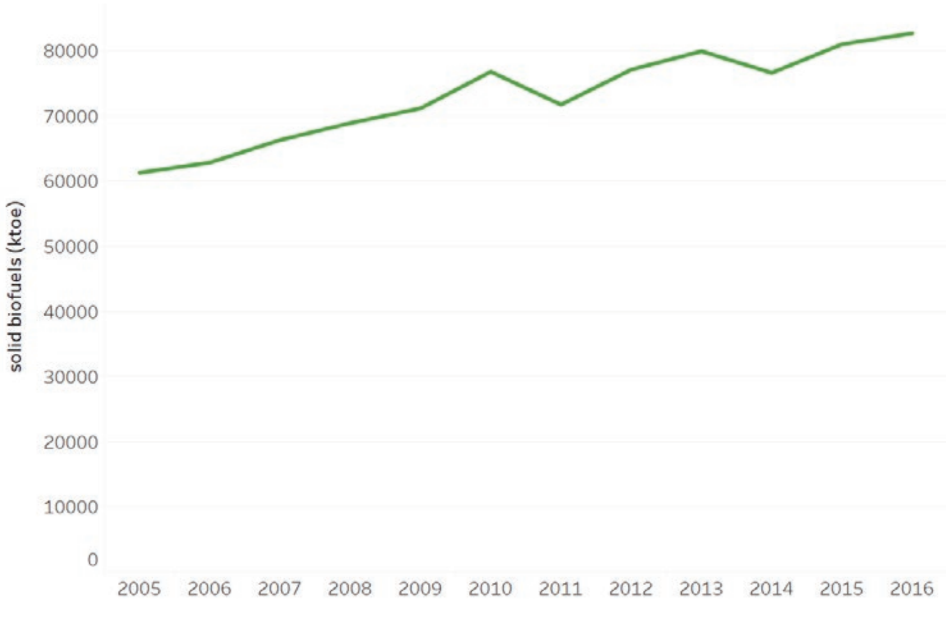
3.3 Solid biofuels

European Union

By far the largest contribution to RES H&C comes from solid biomass. The consumption of renewable heat originating from solid biomass (including renewable waste) increased from 79.9 Mtoe in 2015 to 82.7 Mtoe in 2016. The compound annual growth rate for heat from solid biomass was 3% over the period 2005-2016. This means that growth of biomass has been slower than the growth of RES H&C as a whole, illustrating that RES H&C is diversifying. Solid biomass, such as wood pellets and other wood fuels, contributed by far the most compared to renewable waste; 95% versus 5% in 2016. Biomass heating is currently used mainly in households for heating space, while a consistent biomass amount feeds small-scale heating plants and district heating systems (EU, 2014).

In 2005, the European Commission published its Biomass Action Plan (EU, 2005). In it the European Commission argued that biomass is an important component of the measures needed to achieve the mitigation and renewable energy objectives and that measures are needed to increase biomass for heating and cooling. Biomass is still seen as a means to help diversify Europe's energy supply, create growth and jobs, and lower GHG emissions. An important element of biomass are related sustainability aspects, which are also accounted for in the RES Directive.

Figure 19. The change in renewable energy sources for heating and cooling from solid biofuels (incl. renewable wastes) between 2005 and 2016 in the European Union.



Source: SHARES (Eurostat, 2018).

Individual Member States

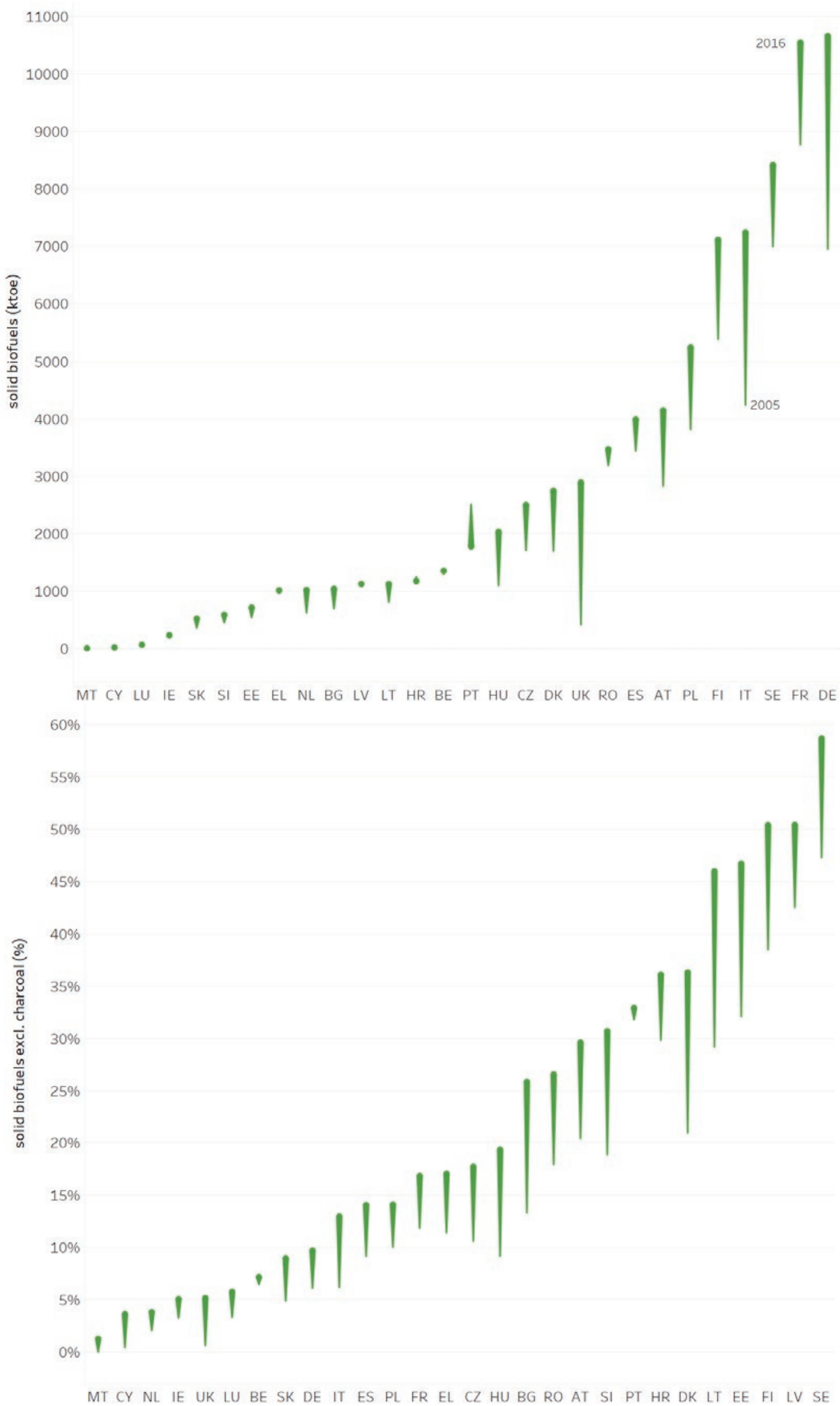
The Member States with the highest absolute contribution of solid fuels in RES H&C are Germany, France, Sweden, Italy, and Finland. All countries have seen an expansion of solid fuel gross final energy consumption between 2005 and 2016, except for Portugal. Estonia, Finland, Latvia, Lithuania, and Sweden have the highest relative share of solid biofuels in their gross final energy consumption.

Countries with high biomass resources (as exemplified by the production of fuel wood per capita) have a higher share of biomass in the total absolute energy consumption for heating and cooling. In these countries the development of biomass as a renewable energy source for heat was often already promoted since the 1970s to increase energy independency, mainly by taxation of fossil fuels and investment grants for heat plants using biomass. This was for example the case in Sweden (IEA, 2016) and Austria (Taylor et al., 2016).

However, there is no strong relationship between biomass resources and the relative share of biomass in the RES H&C mix. This means that while biomass resources have been important to scale up the share of RES in the heating and cooling sector in some Member States, solid biomass constitutes a very significant part of RES H&C in almost all Member States. This is to a large extent irrespective of the availability of natural solid biomass resources.

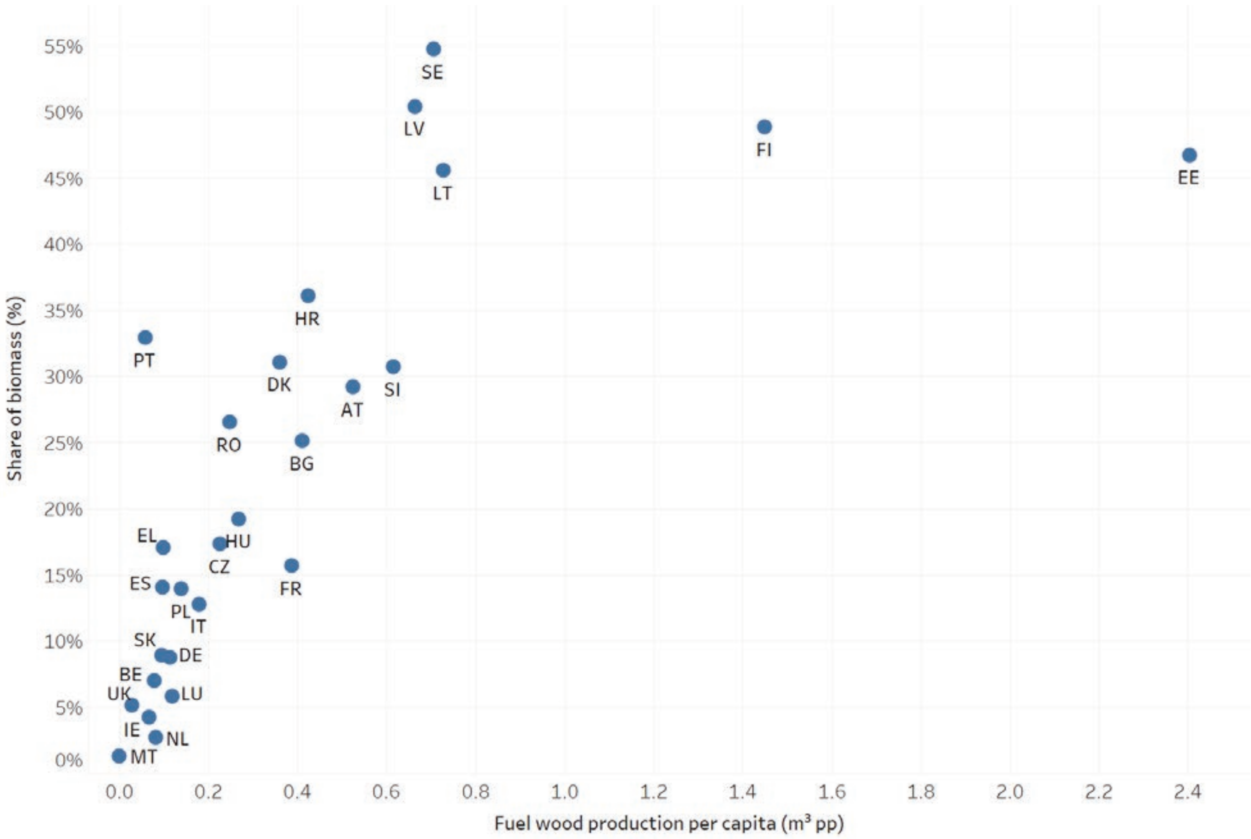
The national PaMs to promote biomass are mostly economic and fiscal instruments (Figure 23). The end-users that are targeted are for many PaMs not specified (i.e. apply for different types of buildings either residential, commercial, public or industrial). The latter are for example training programs, certification schemes, promotion of CHP and district heating, and plans and strategies to enhance the supply for biomass.

Figure 20. The absolute (ktoe) and relative (share) contribution of solid biofuels (excluding renewable waste and charcoal) to gross final energy consumption in 2005 and 2016.



Source: SHARES (Eurostat, 2018).

Figure 21. Relationship between fuel wood production and the share of biomass in total energy consumption for heating and cooling and the share of biomass in the RES H&C mix in 2016.



Source: SHARES (Eurostat), FAOStat.

For example, the French government has introduced a heat fund ("*Fonds Chaleur"*) to support the production of RES H&C in industry. From 2009 onwards, call for tenders are published annually for large biomass plants, while the support for other RES projects is administered on a regional level by regional agencies. Based on Campana et al. (2018) the *Fonds Chaleur* resulted in an accumulated increase of 172.5 Mtoe per year of RES H&C in 2017, of which 36% where biomass projects.

In Germany the market incentive program (MAP) was introduced in 1999 and serves to expand heat generation from biomass, solar power and geothermal energy. Smaller installations of private investors are supported with grants. In the residential sector, the focus of the policy is on the promotion of solar thermal collector systems, heat pumps and biomass heaters (pellet systems and wood gasification boilers). Between 2005 and 2016, Germany has seen a steady and consistent growth of biomass RES H&C.

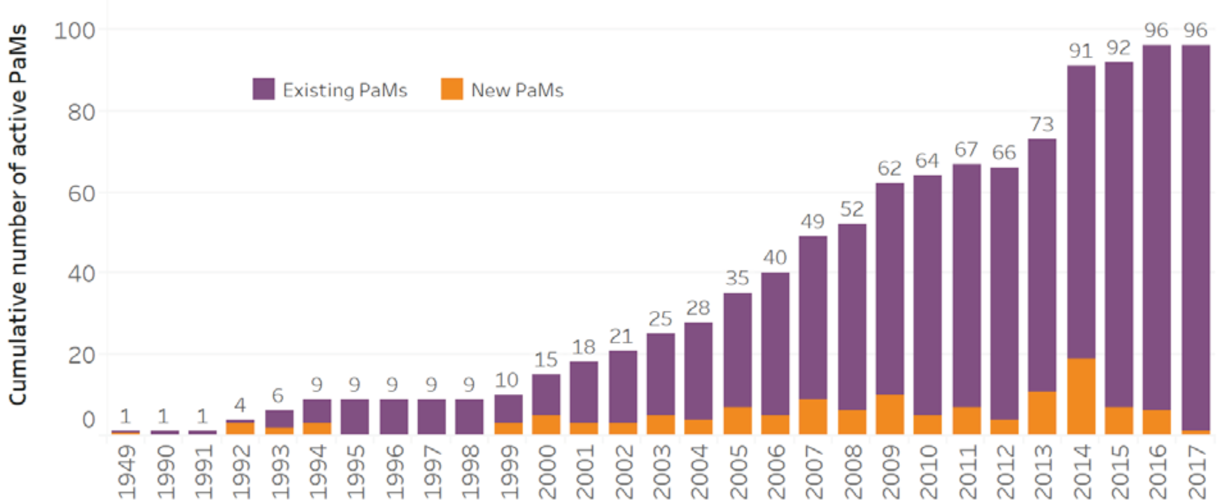
Figure 22. The contribution of solid biomass in the residential sector to RES H&C (in ktoe) between 2005 and 2016 in a selection of Member States.

Source: SHARES (Eurostat, 2018)

In Portugal the decline of biomass RES H&C since 2009 is evident, first in the residential and commercial sector (in 2009) and later also in industry (2011). Recent policies supporting RES H&C in Portugal focused on solar thermal and to a much lesser extent on promoting biomass. No financial incentives are available for biomass. In addition, the lack of mandatory quality controls to check biomass fuel quality and poor statistics on biomass consumption added an additional barrier for biomass implementation in heating (Trennepohl et al., 2015).

Figure 23. Overview of biomass PaMs.

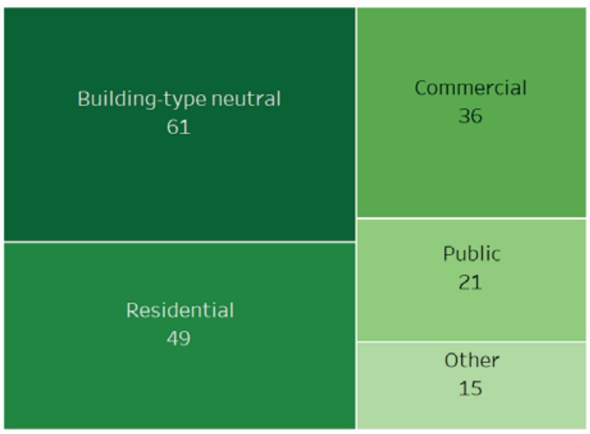
Number of active Biomass PaMs each year



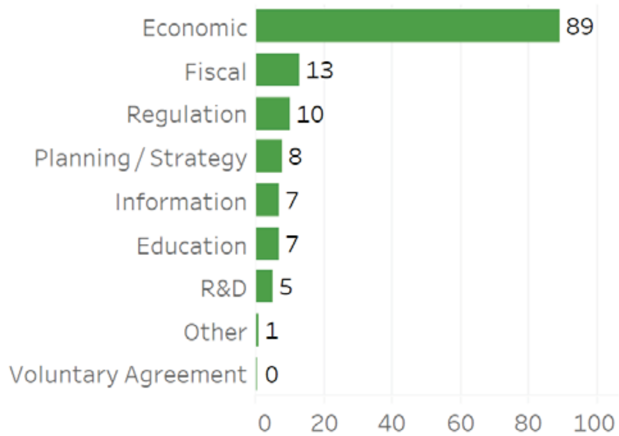
Number of Biomass PaMs by Member State and status

Status	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
Implemented	4	9	2	1	5	3	1	2	3	2	3	14	2	0	2	3	5	9	1	0	4	5	0	2	0	6	5	4
Adopted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
Expired	2	2	0	1	2	0	1	0	1	1	1	1	0	1	3	2	0	3	1	0	2	1	0	0	2	0	2	5

Number of Biomass PaMs by building type



Number of Biomass PaMs by instrument type



Number of Biomass PaMs by instrument type and building type

	Instrument								
Building	Economic	Education	Fiscal	Information	Planning / Strategy	R&D	Regulation	Voluntary Agreement	Other
Building-type neutral	33	7	2	5	7	5	5	0	1
Commercial	29	0	4	0	0	0	3	0	0
Public	17	0	0	1	1	0	3	0	0
Residential	35	0	9	0	0	0	5	0	0
Other	14	0	1	1	0	0	0	0	0

Sources: EEA (2018), IEA/IRENA (2018), RES Legal (2018), EurObserv'ER (2018).

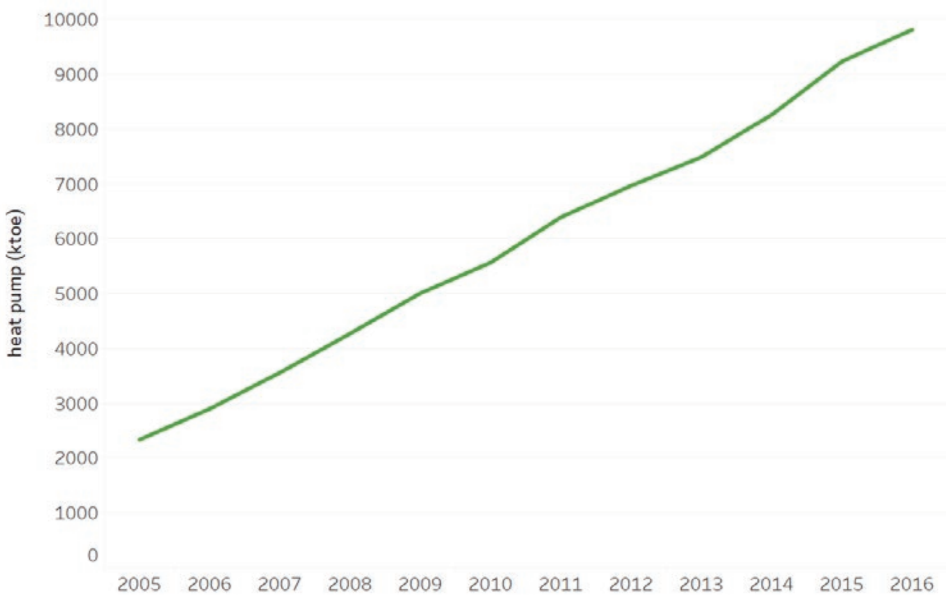
3.4 Heat pumps

European Union

In the EU-28, renewable energy from heat pumps grew from 2.3 Mtoe in 2005 to 9.8 Mtoe in 2016 (Figure 24). In northern Europe, most heat pumps are used for heating, but elsewhere there is also a market for cooling.

The use of heat pumps increased considerably in several EU Member States. Especially in recent years the market for heat pumps has seen a significant increase (EurObserv'ER, 2017). Drivers of this increase are the stable home construction market and a favourable price ratio of electricity and gas, which results is attractive recovery costs for home owners (EurObserv'ER, 2017). In the 2016 *Heating and Cooling Strategy* (EU, 2016) major deployment of heat pumps are also an important part in the energy strategy.

Figure 24. The change in renewable energy sources for heating and cooling from heat pumps between 2005 and 2016 in the European Union.



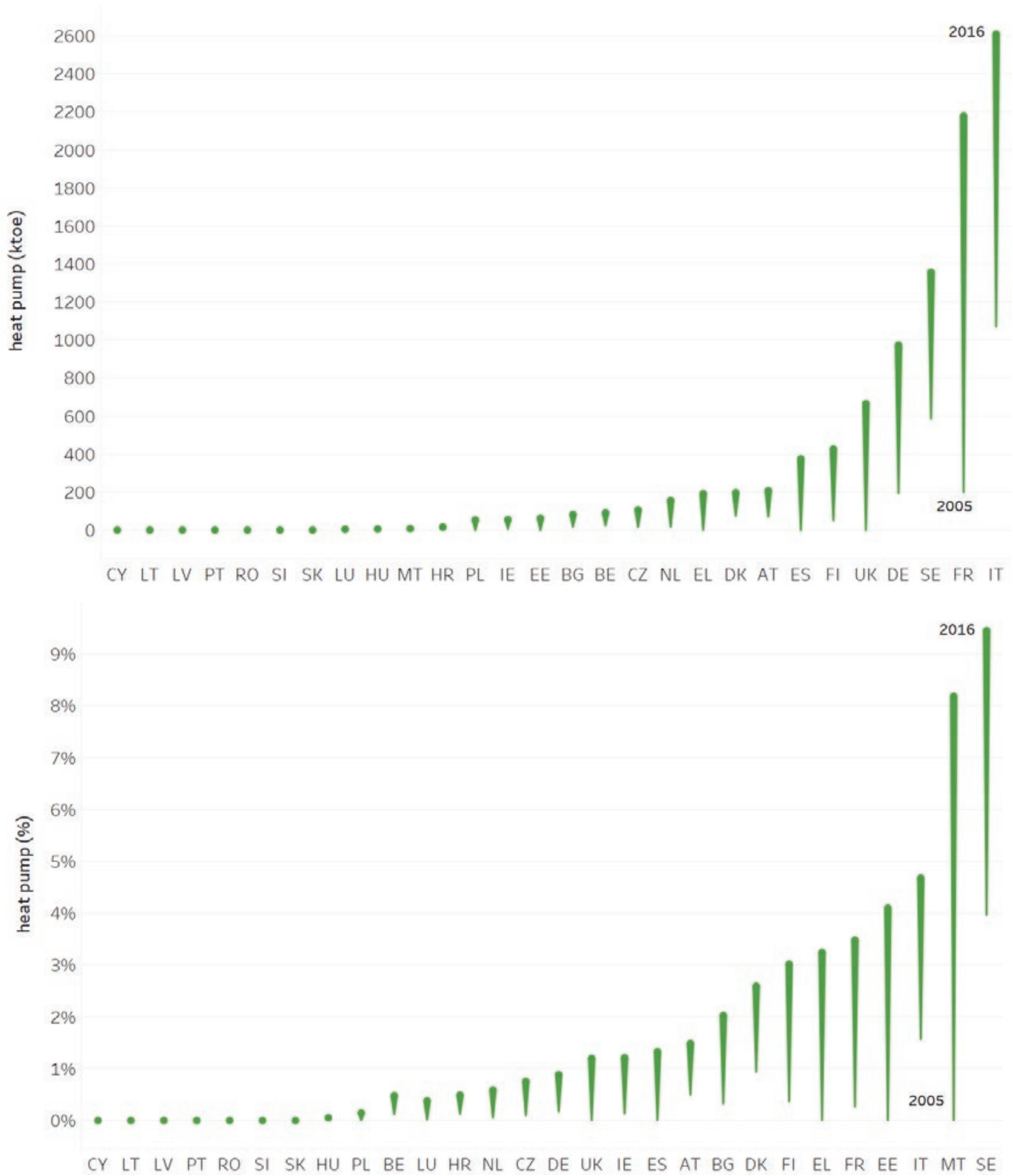
Source: SHARES (Eurostat, 2018)

Both EU renewable energy and energy efficiency policies contribute to the increase of heat pumps in Europe. Additionally, the Eco-design Directive sets environmental standards of heat pump equipment placed on the market.

Individual Member States

Figure 25 shows respectively the total (ktoe) contribution and share (%) of heat pumps to gross final energy consumption in 2005 and 2016. Italy, France and Sweden have the largest absolute contributions. The share of heat pumps in heating and cooling is highest in Sweden, Malta, Italy, Estonia, France, Greece, and Finland.

Figure 25. The absolute (ktoe) and relative (share) contribution of heat pumps to gross final energy consumption in 2005 and 2016.



Source: SHARES (Eurostat, 2018)

Hanna et al. (2016) analysed best practices in heat decarbonisation policies. For heat pumps, they pointed to contextual reasons for differences in heat pump penetration. A cold climate creates a large demand for heat (e.g. Nordic countries and Austria) and a lower connection rate to a natural gas grid (e.g. in Estonia, Finland, and Sweden) enable heat pumps in the market. On the other hand, access to significant conventional gas reserves (e.g. the Netherlands and the United Kingdom) and a well-developed gas grid, favours conventional fossil fuel boilers.

In the case of Finland, heat pump expansion picked up in 2003 (Hannon, 2015). Since 2003, Finland implemented energy grants for households. These provide financial support of investments in energy efficiency and renewable energy, up to 25% of the total investment cost. Hannon (2015) identified a number of key policy drivers:

- fossil fuel or CO_2 taxation is a disincentive to invest in fossil fuel heating;

- stringent building codes that account for the carbon intensity of the building's heat supply;
- subsidies;
- a strong new-build sector where heat pumps are installed in over half of new buildings;
- comprehensive product and installer certification and training;
- research and development.

Italy implemented in 2013 the *Thermal Account*, which is the first nationwide direct incentive scheme for the generation of renewable thermal energy. More specifically, the incentive scheme is addressed to both Public Administrations and private parties: these beneficiaries may implement the actions via an ESCO, by means of a third-party financing contract, an energy service contract or an energy performance contract (Enea, 2015). In 2017 this was amended to the *Thermal Account 2.0* and is estimated to save 1.47 Mtoe/year of final energy use. Previously, Italy implemented a tax rebate (*eco-bonus*) for energy efficiency investments in 2007. All tax payers can apply for a rebate of 55% of investments in the increased thermal insulation of buildings, replacement of existing heating systems or installation of solar panels. The rebate is spread over 10 years. In 2013 (65%) and 2017 (70 or 75%) the tax rebate was further increased. The program boosted retrofit investment in the residential sector between 2007 and 2009. In 2009, building owners submitted 240 000 tax credit claims worth a total investment in buildings retrofit of more than $3.6 billion, primarily in households (96%) (IEA, 2018).

The growth in heat pump installations has been rapid in Sweden during the past years (Nordic Council of Ministers, 2017). PaMs included in the database show that Sweden implemented a tax reduction for households since 2009 for all works in single-family houses and in apartments. Between 2006 and 2010, grants were available as incentive to switch from direct electrical heating and oil-fired boilers to district heating, biofuels or a geothermal/ground/lake heat pump. As Norden (2015) illustrate, Swedish policy has also focused on research and development and disseminating information.

Some Member States have managed to increase the share of heat pumps significantly in recent years, such as Greece (2009), Estonia (2011), Malta (2012), and the United Kingdom (2014).

Like most Baltic countries, Estonia focuses heavily on strengthening, expanding and decarbonizing the district heating networks. But unlike Lithuania and Latvia, Estonia also has increased the contribution of heat pumps as RES H&C to supply local and on-site heating (EREA, 2016). In 2014, Estonia implemented a grant to support the replacement of liquid fuel heating systems by renewable energy sources in small residential houses.

In Malta, RES H&C policy support has been more extensive for solar heating, for which a financial incentive has been in place since 2006. While this has resulted in a significant growth in solar thermal energy production, heat pumps contribute more to total RES H&C. The heat pump market started to increase in 2012. In Malta, with limited heating demand, heat pumps are mostly used for cooling. In 2017, Malta announced a grant specifically designed for heat pump water heaters, supporting up to 40% of investment cost. This grant will mean an increased use of heat pump technologies in future.

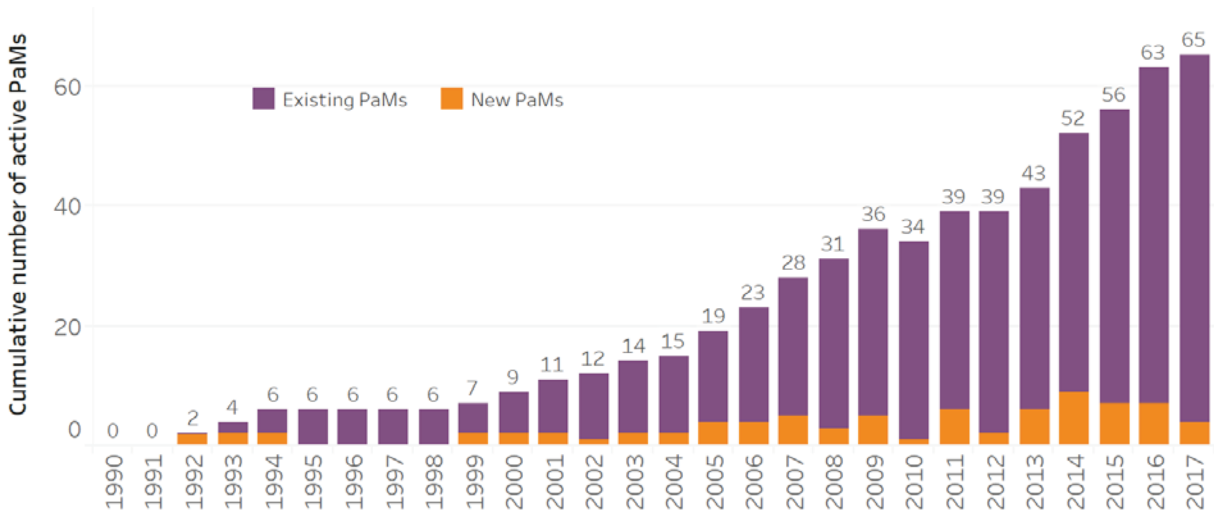
The most recent development in the United Kingdom promoting heat pumps is the extension of the *Renewable Heat Incentive* (RHI) to domestic users. The RHI provides financial incentives to install renewable heating in place of fossil fuels to non-domestic consumers (since 2011) and households (since 2014). This incentive is paid as a per kWh tariff for renewable heat produced. For (air-source) heat pumps, the extension of the RHI to households meant a significant increase in the number of applications for heat pumps (Chambers, 2017), which explains the rise in heat pump output from 2014 onwards.

Figure 26. The contribution of heat pumps to renewable energy sources for heating and cooling (in ktoe) between 2005 and 2016 in a selection of Member States.

Source: SHARES (Eurostat, 2018)

Figure 27. Overview of heat pump PaMs.

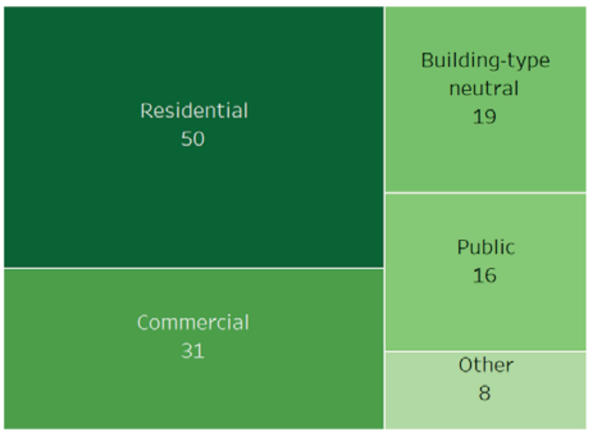
Number of active Heat pump PaMs each year



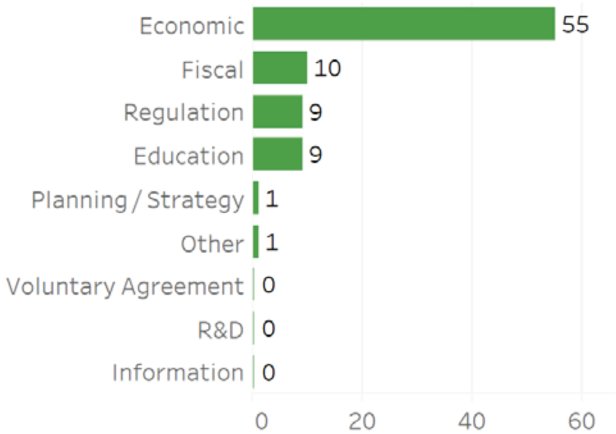
Number of Heat pump PaMs by Member State and status

Status	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
Implemented	2	10	2	1	3	3	3	2	3	1	0	6	1	0	3	2	3	6	0	1	3	4	0	2	1	2	3	2
Adopted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Expired	0	1	0	1	2	0	0	0	0	1	0	0	0	1	1	0	0	1	1	1	1	0	0	0	1	0	0	2

Number of Heat pump PaMs by building type



Number of Heat pump PaMs by instrument type



Number of Heat pump PaMs by instrument type and building type

	Instrument								
Building	Economic	Education	Fiscal	Information	Planning / Strategy	R&D	Regulation	Voluntary Agreement	Other
Building-type neutral	4	9	2	0	1	0	3	0	1
Commercial	24	0	4	0	0	0	3	0	0
Public	13	0	0	0	0	0	3	0	0
Residential	39	0	5	0	0	0	6	0	0
Other	7	0	1	0	0	0	0	0	0

Sources: EEA (2018), IEA/IRENA (2018), RES Legal (2018), EurObserv'ER (2018).

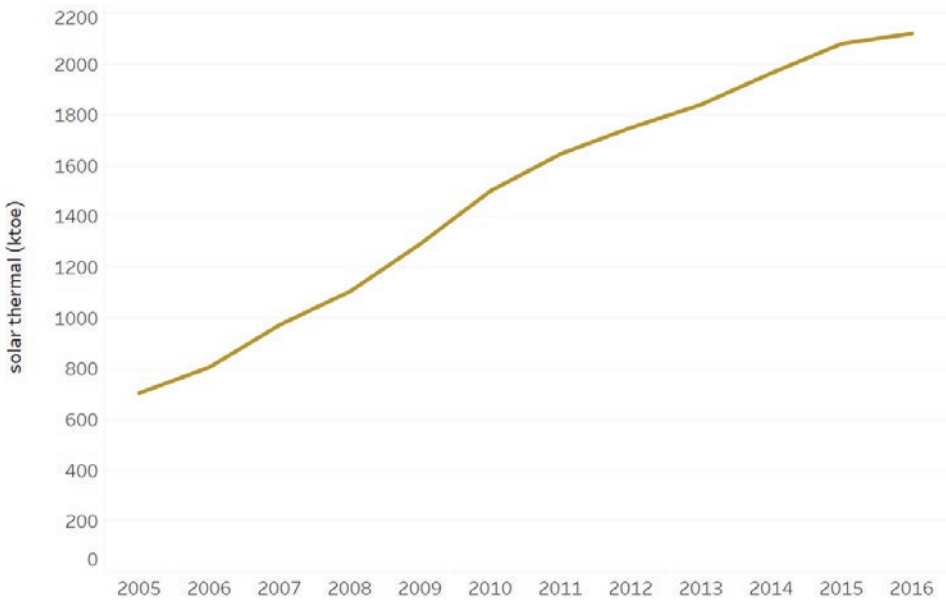
3.5 Solar thermal

European Union

The production of renewable heat from solar thermal technology increased by 11% per year over the period 2005-2016, growing from 0.7 Mtoe to 2 Mtoe in Europe.

Solar thermal collectors 'harvest' heat from the sun for hot water or space heating. The European solar thermal market has been contracting since 2008 and installed surfaces decreased from 4.6 million m^2 in 2008 to 2.6 million m^2 in 2016 (EurObserv'ER, 2017). EurObserv'ER attributes this to the low price of natural gas, which affects solar heat's ability to compete by giving the advantage to the condensing gas boiler market, stop-start and regressive subsidy policies operating in some countries and competition from alternative technologies. However, Denmark installed 0.5 million m^2 in 2016, of which 99% was intended to supply heating networks. Other countries are also interested in converting their heating networks to incorporate more solar thermal technologies (EurObserv'ER, 2017).

Figure 28. The change in renewable energy sources for heating and cooling from solar thermal between 2005 and 2016 in the European Union.



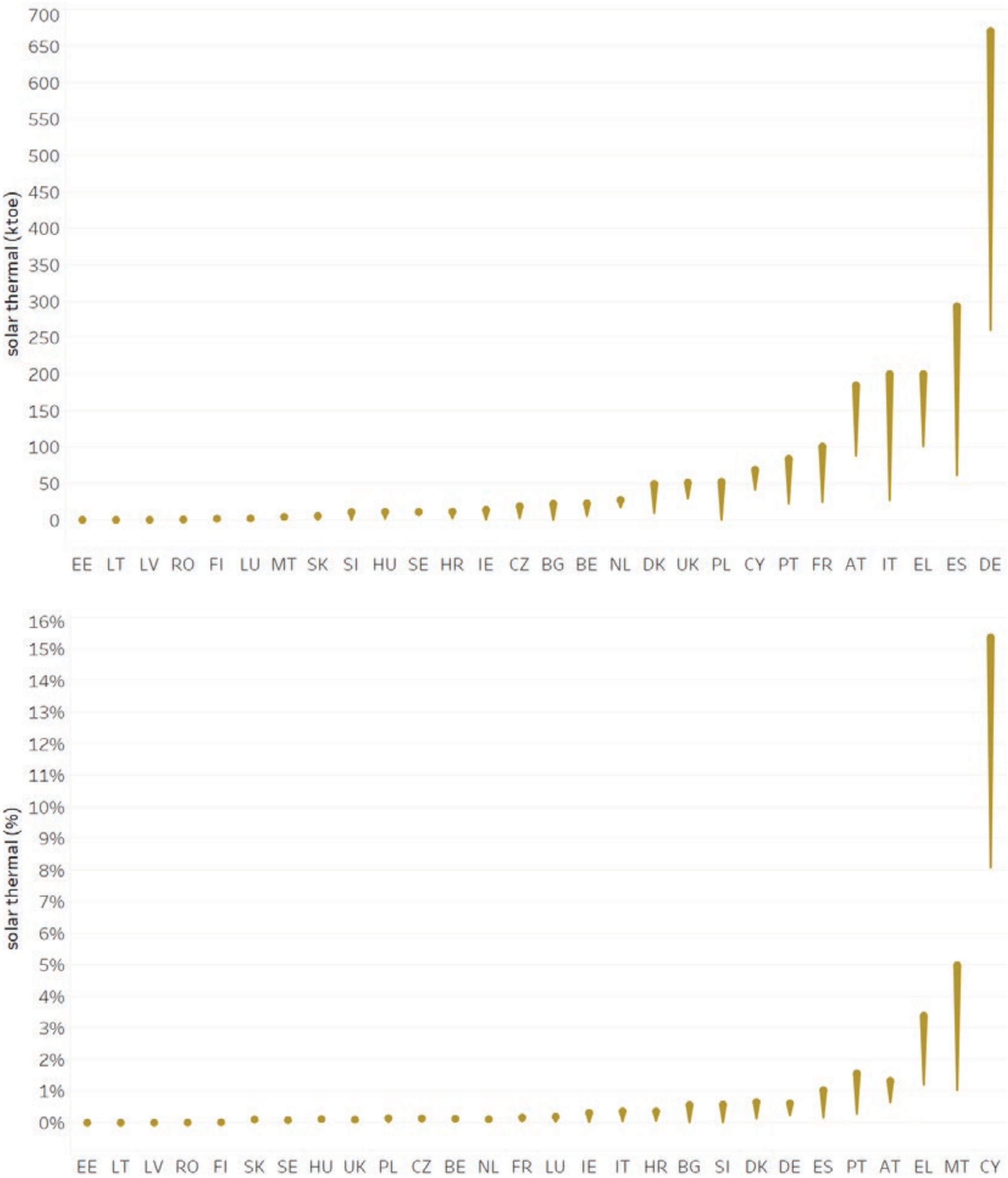
Source: SHARES (Eurostat, 2018).

Individual Member States

The Member States with the largest (absolute) contribution of solar thermal to gross final energy consumption are Germany, Spain, Greece, Italy, and Austria. Compared to gross final energy contribution however, solar thermal is most important in Cyprus, Malta and Greece. For most EU Member States, the contribution of solar thermal is well below 1% of final energy consumption for heating and cooling.

The period between 2005 and 2016 has shown the largest increases in solar thermal RES in several Mediterranean countries, such as Cyprus, Malta, Greece, Portugal and Spain. Climatic conditions are obviously very favourable for solar technologies while demand for heating and cooling is lower.

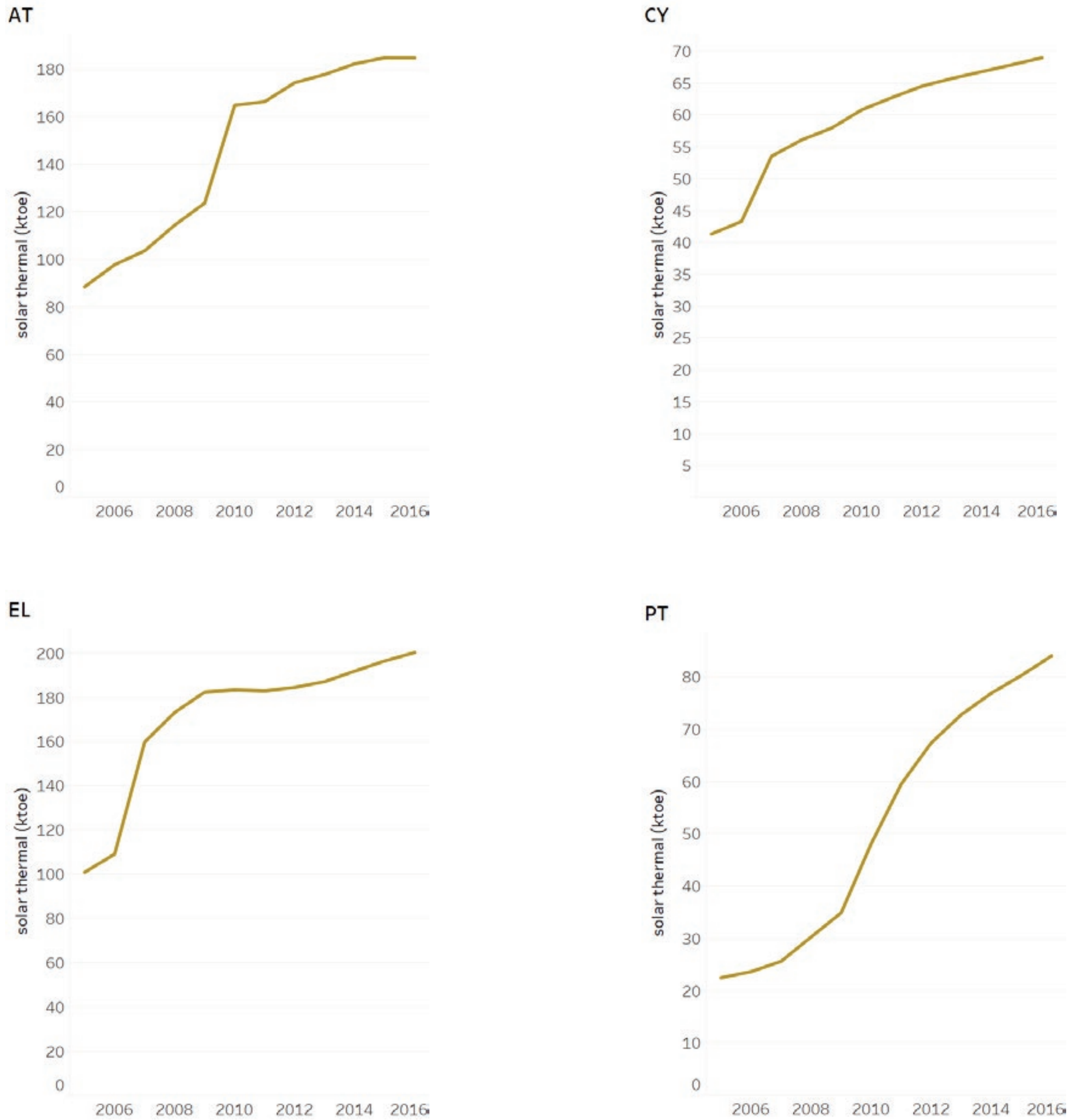
Figure 29. The absolute (ktoe) and relative (share) contribution of solar thermal to gross final energy consumption in 2005 and 2016.



Source: SHARES (Eurostat, 2018)

RES H&C policies in Cyprus are very focused on solar thermal technology. This includes subsidies pre-dating 2005 promoting installation of solar thermal energy and, since 2009, a regulation making it mandatory to install solar water heaters to supply sanitary hot water in all new residential buildings. As a consequence, Cyprus is the EU country with the largest capacity of solar thermal per inhabitant (EurObserv'ER, 2017).

Figure 30. The contribution of solar thermal to renewable energy sources for heating and cooling (in ktoe) between 2005 and 2016 in a selection of Member States.



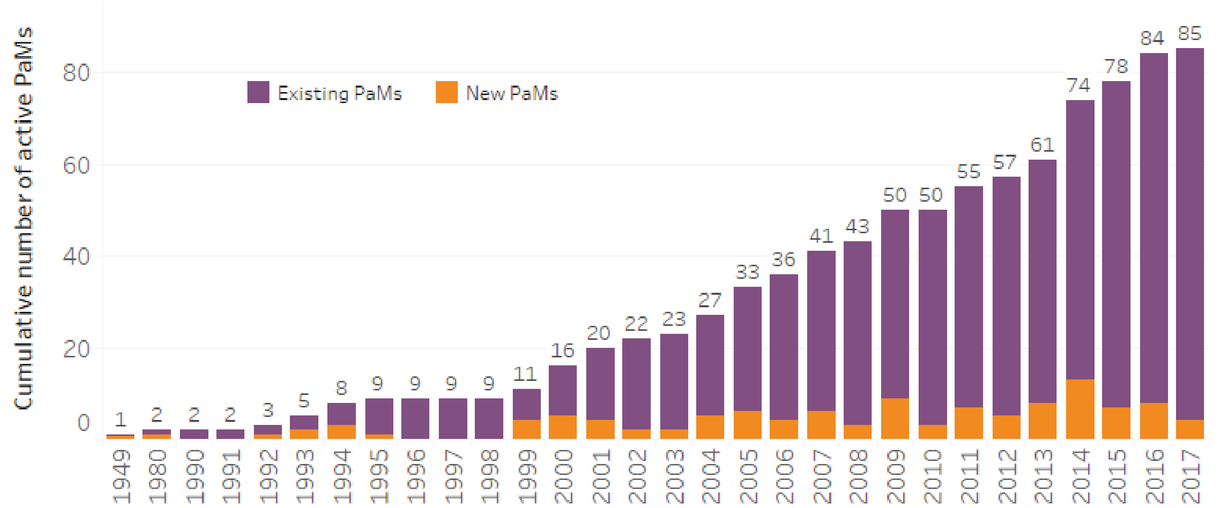
Source: SHARES (Eurostat, 2018).

In Greece, support of RES H&C for solar heaters is provided via a fiscal tax deduction for natural and legal persons who have performed an energy improvements of their building either at their own expense or through participation in national programs (e.g. Exoikonomo). Since, 2010 the rapid increase of solar thermal RES H&C has slowed down and only modest increases have been achieved due to the economic crisis.

Since 2006, there is an obligation in Portugal to use solar thermal collectors for heating water in new or renovated buildings. The obligation is only applicable whenever there is suitable solar exposure. Solar thermal obligations are considered effective instruments because, unlike financial incentives, they are independent from budgetary constraints. Article 13(4) of the RES Directive 2009/28/EG required Member States to establish solar obligations by 2015, where appropriate. In some Member States, including Germany, Italy, Portugal, Slovenia, and Spain, this was already implemented before 2015 (CE Delft, 2015).

Figure 31. Overview of solar heater PaMs.

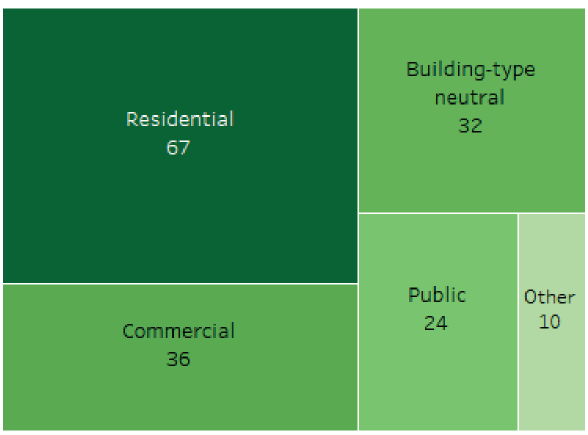
Number of active Solar heater PaMs each year



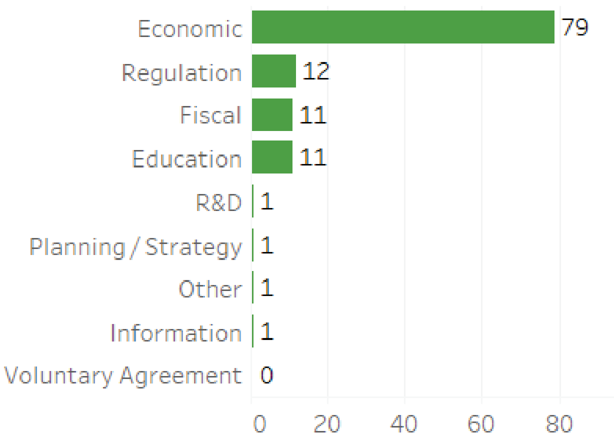
Number of Solar heater PaMs by Member State and status

Status	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
Implemented	4	12	2	3	2	2	2	2	4	2	0	8	1	0	3	3	3	7	0	5	5	4	4	3	1	3	3	2
Adopted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Expired	2	3	0	2	2	1	0	0	1	1	0	1	0	2	1	1	0	1	1	1	1	0	1	0	2	0	1	2

Number of Solar heater PaMs by building type



Number of Solar heater PaMs by instrument type



Number of Solar heater PaMs by instrument type and building type

Building	Economic	Education	Fiscal	Information	Planning / Strategy	R&D	Regulation	Voluntary Agreement	Other
	Instrument								
Building-type neutral	10	11	3	1	1	1	3	0	1
Commercial	29	0	4	0	0	0	3	0	0
Public	19	0	1	0	0	0	4	0	0
Residential	53	0	6	0	0	0	8	0	0
Other	9	0	1	0	0	0	0	0	0

Sources: EEA (2018), IEA/IRENA (2018), RES Legal (2018), EurObserv'ER (2018).

In 2009 Portugal operated a financial incentive program to promote the installation of solar thermal on buildings. The incentive program applied to the purchase of a solar thermal "kit", comprising of panels and ancillary equipment, installation of the panels, yearly maintenance for six years, and a six year guarantee. The government guaranteed a competitive price for the kit (negotiated with manufacturers) and provided an immediate rebate for the purchase of a solar thermal kit. Financial institutions also provided reduced loans rates. In addition, the incentive scheme can be combined with existing tax credit provisions for the installation of such systems, in place since 1999 (IEA, 2018). This program was effective and resulted in significant increases in the sale of solar thermal kits. After 2010, the market however contracted again significantly (ESTIF, 2014).

Among the countries with less favourable conditions for solar thermal energy, Austria has the highest share of solar thermal (compared to gross final energy consumption for heating and cooling). This is not only the case in 2016 but already in 2005. Solar thermal has been promoted by national and regional governments. The Environmental Aid Act provides for the general support of schemes to protect the environment and is divided into several fields of action. Incentives to use energy from RES H&C are provided in the Environmental Assistance in Austria field of action. At the national level there are special investment incentives for solar thermal installations, heat pumps, geothermal energy and biomass heating plants, especially for businesses. This is supplemented with different financial measures from the nine federal states. Regional support schemes for solar heaters started as early as the 1980s (Kranzl et al., 2010) and created a long-term and stable financial support scheme. Additionally, the regional governments also implemented training and education programs (Taylor et al., 2016). Since 2010 the increase in solar thermal has slowed down, mainly because a larger share of solar thermal installations entering the market are replacing decommissioned installations (EurObserv'ER, 2017).

3.6 Other fuel types

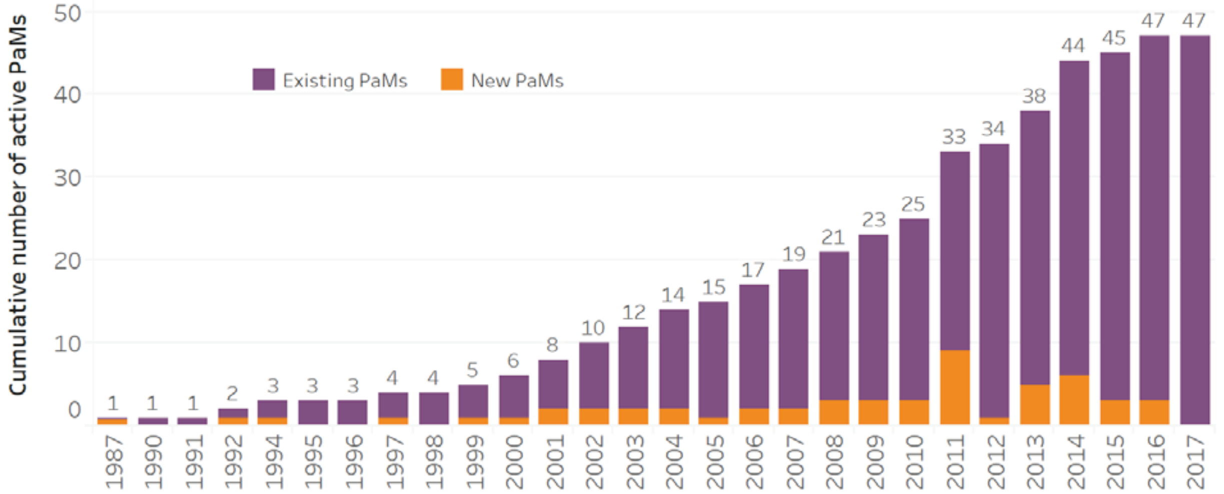
European Union

RES H&C other than solid biofuels, heat pumps and solar thermal constitute only a marginal share of total RES H&C in Europe. Three sources are important: biogases, liquid biofuels and geothermal energy.

Individual Member States

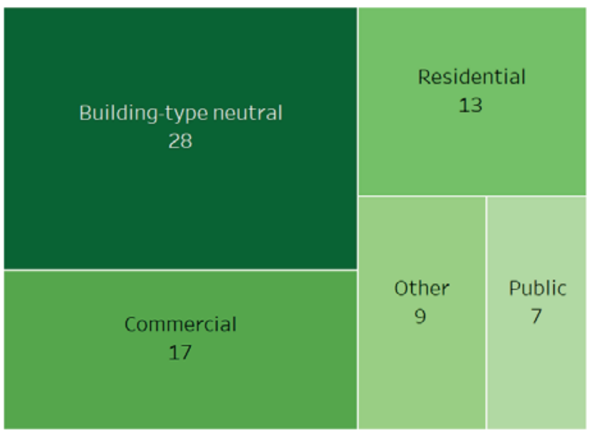
As already mentioned in section 3.2, heat production from biogases has been promoted in several countries as part of the support to CHP. As a consequence, biogas use has increased in the EU-28. More than 50% of the growth in gross final energy consumption of biogas for heating and cooling has been achieved by Germany alone. Promotion of biogas has been mainly achieved by economic instruments (Figure 32). The policies tend to be building-type neutral, e.g. by promoting biogas production, use in CHP or injection in the natural gas grid.

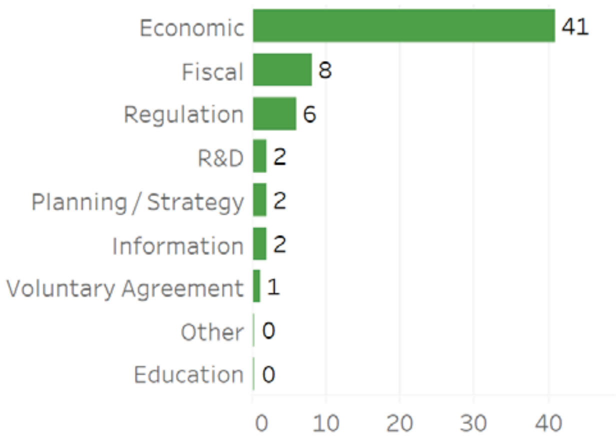
Figure 32. Overview of biogas PaMs.



Number of Biogas PaMs by Member State and status

Status	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
Implemented	1	5	1	0	2	1	2	1	2	0	3	4	1	0	0	1	5	4	2	0	2	3	0	2	1	0	2	3
Adopted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Expired	1	0	0	0	0	1	0	0	0	0	0	1	0	1	0	1	0	0	1	0	2	0	0	0	0	0	0	0





Number of Biogas PaMs by instrument type and building type

Building	Instrument: Economic	Education	Fiscal	Information	Planning / Strategy	R&D	Regulation	Voluntary Agreement	Other
Building-type neutral	20	0	2	1	2	2	4	1	0
Commercial	13	0	3	0	0	0	1	0	0
Public	6	0	0	0	0	0	1	0	0
Residential	6	0	5	0	0	0	2	0	0
Other	9	0	0	1	0	0	0	0	0

Sources: EEA (2018), IEA/IRENA (2018), RES Legal (2018), EurObserv'ER (2018).

The United Kingdom is another Member State that increased the gross final energy consumption of biogas considerable in the period 2005-2016. Unlike Germany, a significant part of the recent growth has been achieved by blending bio-methane in the natural gas grid. In 2016, more than 25% of RES H&C with biogas came from biogas blended in the gas grid. This has increased from close to zero in 2014. A first demonstration project started in 2010 in the United Kingdom, but it was with the expansion of the *non-domestic renewable heat incentive* to biogas projects in 2014 that projects started to be implemented. In 2016, 90 plants were in operation. The extensive natural gas grid in the UK (and in a number of other EU Member States, such as Belgium and the Netherlands) is considered one of the barriers for a higher penetration of RES H&C, especially in residential buildings. Using this existing infrastructure could therefore be beneficial, even if it requires higher quality standards for the injected biogas (Ecofys, 2018).

Other EU Member States have implemented policies to support the injection of biogas into the gas grid as well. The funding of which is supported through investment support such as in Austria (*Federal Environment Fund*), Belgium – all three regions offer an investment subsidy for RES H&C, Bulgaria (*Bulgarian Energy Efficiency Fund – BGEEF*), Estonia, Greece (*Development Law*) and Italy (*Conto Termico*). In addition, several Member States have implemented national PaMs specifically aimed at increasing the development of biogas, either used directly for the production of heat or to support injection in the national gas grid.

Croatia implemented feed-in tariffs and a premium system for the support of the use of renewable energy sources in electricity generation and in efficient cogeneration plants. The main mechanism for encouraging biogas for electricity generation and the construction of biogas cogeneration plants are incentive prices (feed-in tariffs) that depend on the type of source, power plant size and amount of generated electricity. Although an incentive is only given for the production of electricity, the system also supports heat production in cogeneration.

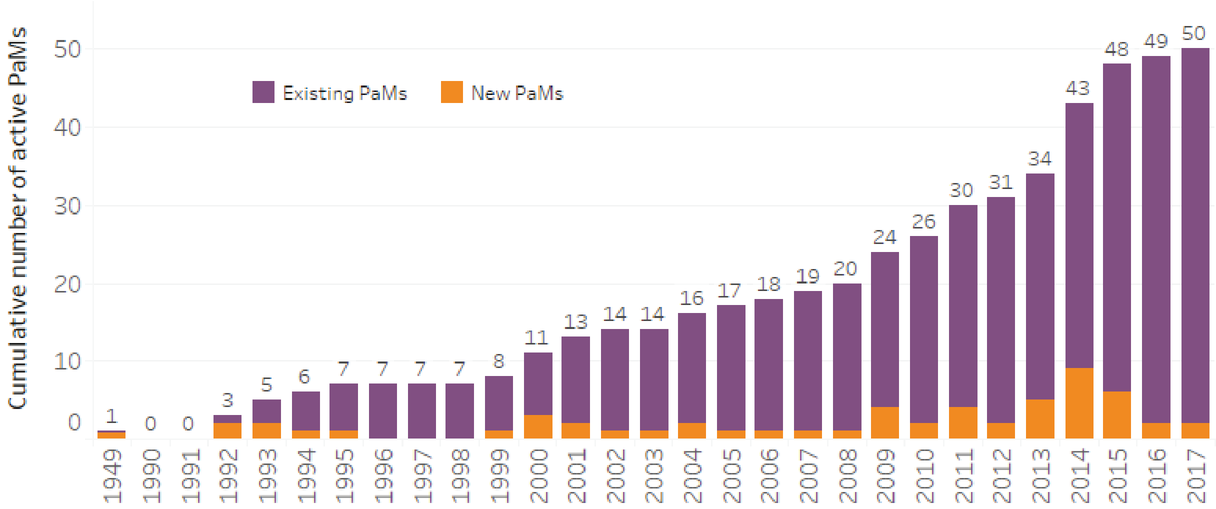
Denmark supports use of biogas for heating purposes through a direct premium tariff for each gigajoule of used biogas. The *Energy Policy Agreement* continued funding biogas for CHP and introduced a subsidy equality so that biogas sold to the natural gas grid receives the same subsidy as biogas used at CHP plants.

Since 2011, France has implemented a feed-in-tariff for bio-methane injection into the natural gas grid. A fixed tariff is offered for a period of 15 years. Any producer wishing to inject bio-methane into the natural gas transport and distribution networks is eligible for a purchasing obligation at a tariff set in advance. This enables the coverage of the investment and exploitation costs and overall profitability of the project.

The share of geothermal and bio liquids in their contribution to either the total gross final energy consumption for heating and cooling or their contribution to the share of RES H&C is only marginal. Policies have been implemented by Member States to promote this (Figure 33).

Figure 33. Overview of geothermal PaMs.

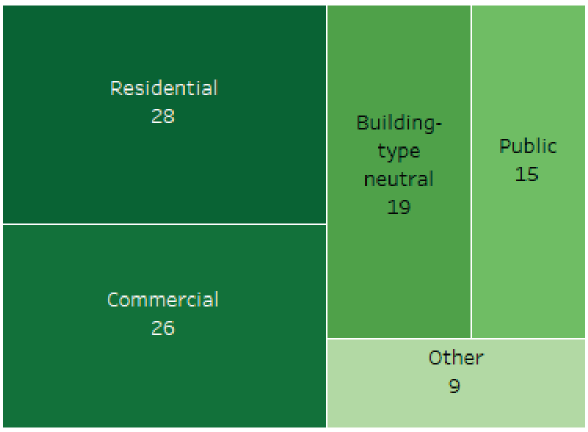
Number of active Geothermal PaMs each year



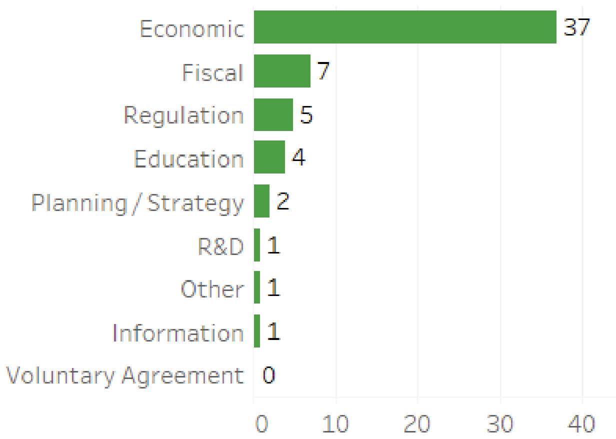
Number of Geothermal PaMs by Member State and status

Status	AT	BE	BG	CY	CZ	DE	DK	EE	EL	ES	FI	FR	HR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
Implemented	1	8	1	1	2	2	1	1	3	1	0	4	1	0	0	1	3	4	0	0	5	3	0	3	0	3	1	1
Adopted	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Expired	0	0	0	1	2	1	0	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0

Number of Geothermal PaMs by building type



Number of Geothermal PaMs by instrument type



Number of Geothermal PaMs by instrument type and building type

	Instrument								
Building	Economic	Education	Fiscal	Information	Planning / Strategy	R&D	Regulation	Voluntary Agreement	Other
Building-type neutral	7	4	3	1	2	1	0	0	1
Commercial	19	0	4	0	0	0	3	0	0
Public	11	0	1	0	0	0	3	0	0
Residential	20	0	3	0	0	0	5	0	0
Other	8	0	1	0	0	0	0	0	0

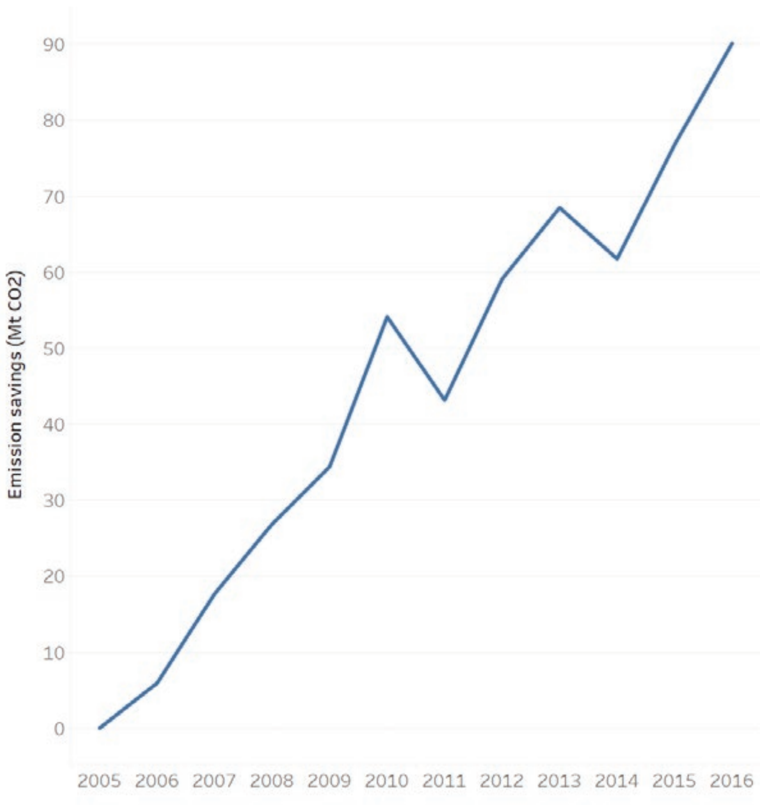
Sources: EEA (2018), IEA/IRENA (2018), RES Legal (2018), EurObserv'ER (2018).

3.7 Avoided GHG emissions

Emission savings from RES H&C

In the EEA's Renewable Energy in Europe report, the impact of renewable energy on emission savings have been quantified (EEA, 2018). The total GHG emission reductions in 2016 from increased renewable energy consumption, compared to 2005, were 460 Mt CO_2. Most of these emission reductions were achieved by renewable energy sources for electricity production, but 20% (or 90 Mt CO_2) of gross avoided CO_2 emissions could be attributed to RES H&C. Emission savings have been increasing in line with increasing use of RES for heating and cooling. These emission savings have mostly (78%) been achieved in non-ETS sectors.

Figure 34. The increase of emission savings from RES H&C since 2005.

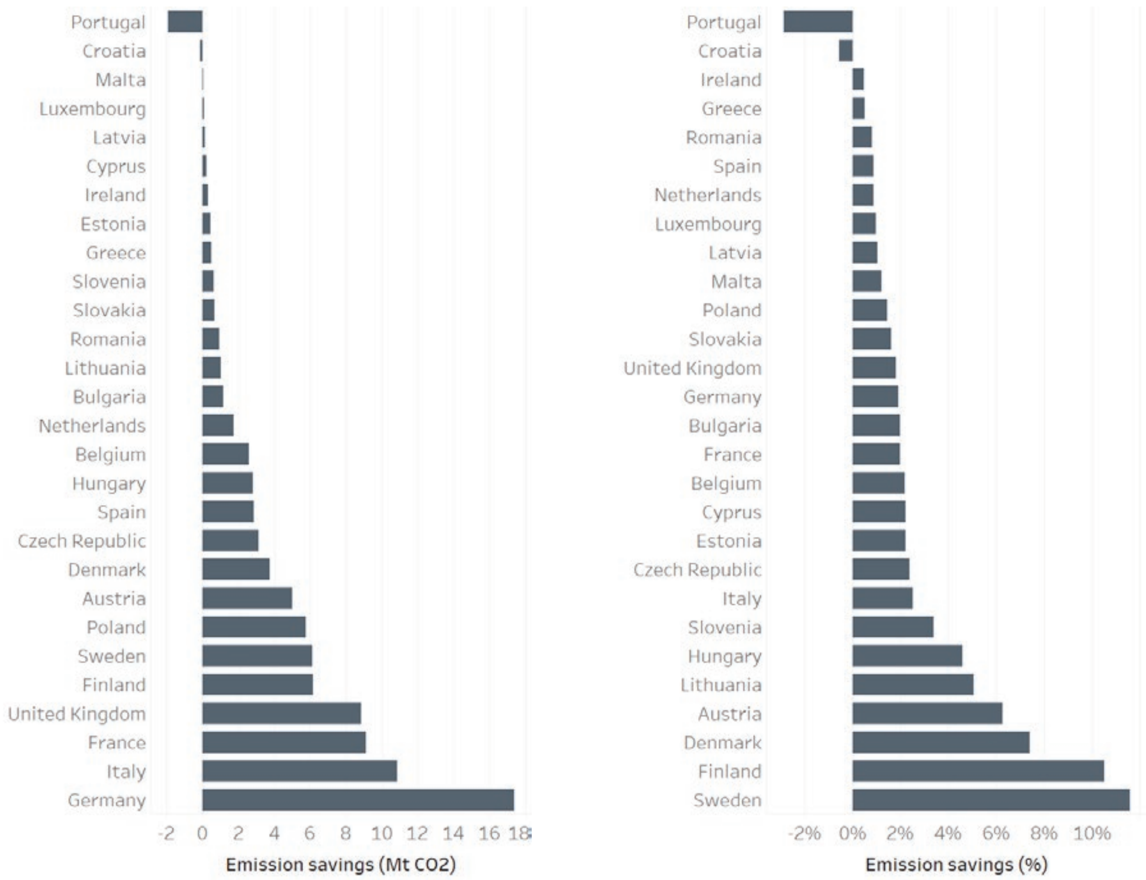


Source: SHARES (Eurostat 2018) and EEA (2018).

In terms of gross avoided GHG emissions in 2016, the countries with the largest estimated gross reductions from RES H&C were Germany, Italy, France and the United Kingdom. In Portugal and Croatia, the emission savings are negative (increase in emissions in 2016, compared to 2005) because of the slower development and growth of RES H&C. Portugal and Croatia were also the two countries where the increase in the share of RES H&C was most obviously caused by changes in overall energy consumption for heating and cooling, rather than an increase in RES.

In relative terms, significant GHG emission reductions (of 5% or more of the total national GHG emissions, excluding international aviation and LULUCF) were recorded in Sweden, Denmark, Finland, Austria, and Lithuania. It should be noted again that these figures reflect the development of RES since 2005 and that avoided GHG emissions through RES before this year are not accounted for.

Figure 35. The absolute and relative gross emission savings from RES H&C in EU Member States in 2016.



Source: EEA (2018)

Emission savings from RES H&C: individual cases

This section provides a non-exhaustive list of Member States' example of evaluations and quantifications of the impact of promoting RES H&C on avoided GHG emissions.

Austria: Emission savings form RES H&C.

Heat from renewable energy sources is assumed to replace the average of the Austrian mix in the heating sector. The emission factor in 2015 was 195.3 g CO_2-eq./kWhth (BMLFUW, 2016).

Belgium: Tax incentive for energy efficiency measures.

A tax reduction was awarded for investments to improve insulation (floor, wall, roof and glazing) and to install efficient installations (condensing boilers, heat pumps, PV, solar thermal, thermostats) in residential buildings. From 2012 onwards, only roof insulations were subsidized. From 2015 onwards, regions are responsible for the measure.

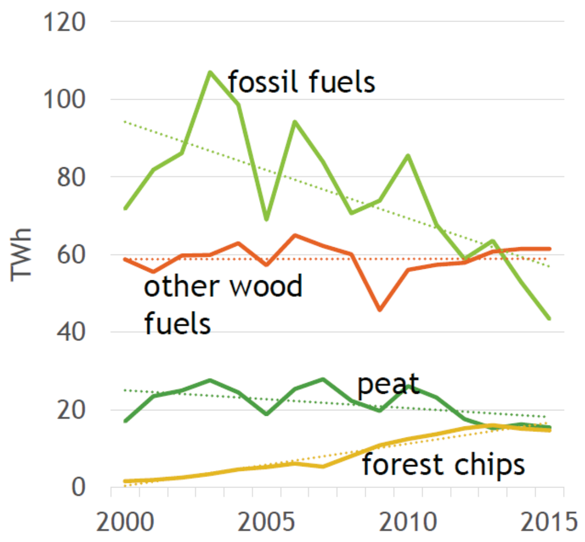
The impact of this measure was estimated in the report by ICEDD (2017). For RES H&C only heat pumps are relevant. For this technology a unit energy saving of 62.5 GJ/installation/year was used, which corresponds with a reduction of 1 929 kg CO_2/year. The unit emission reduction for heat pumps was taken from the VITO/Econotec (2015) report. This factor is based on an average capacity of 8 kW, 2000 full load hours and a Coefficient of Performance (COP) of 3.5.

Finland: Promoting wood chips.

The PaM started in 1992 and includes investment subsidies for heat and power production plants using forest chips, subsidies for harvesting of forest chips, electricity tax subsidies, a feed-in tariff and information measures. The measures affects both heating and electricity production.

For the impact assessment it is assumed that all use of wood chips is due to the PaM. The wood chips can replace several fuel types, but evaluation of trends of fuel consumption show that at the boiler level wood chips replace peat and at energy system level wood chips replace fossil fuels (Hilden, 2018). The average emission factor for the fuels replaced by wood chips is 350 t CO_2/GWh, which is based on the emission factors for coal, natural gas and peat. In 2016 the measure resulted in an emission reduction of more than 5 Mt CO_2-eq. Most of these emission reductions are achieved in the ETS sector (97%), while only use of wood chips at agricultural farms contributes to emission savings in the non-ETS sector.

Figure 36. Displacement of different fuels by forest chips in Finland as shown by fuel mix at national level.



Source: Hilden, 2018.

France: Heat Fund (Fonds Chaleur).

The *Heat Fund* is managed by ADEME in France, who keeps detailed statistics on all projects financed via the fund. This implies that statistics on the level of support, number of projects, total capacity, and annual energy production are available (Campana et al., 2018). This also includes avoided GHG emissions. The GHG emission reductions are the result of the substitution of fossil fuels with renewable energies for the production of heat. It is assumed that the *Heat Fund* contributes to the substitution of gas, as new fossil heat production plants often operate on gas (France, 2017). GHG emission savings are calculated by using the difference between the emission factor of gas and the emission factor of the renewable energy used by the facilities funded by the *Heat Fund*. A typical energy efficiency of the facilities is used to obtain the emission factors in kg CO_2-eq./toe. The GHG emission savings from the *Heat Fund* amounted to 3 359 Mt CO_2-eq. in 2015.

No description is given on how distinction between ETS and non-ETS emissions is reported. Information on the sectoral distribution mentions that about 45% of RES production is allocated to the industrial sector and 55% to the residential/tertiary sector (France, 2017). The production of renewable heat in the agricultural sector is deemed negligible.

Table 6. Emission factors used to calculate avoided GHG emissions from the Fonds Chaleur.

		Emission factor kgCO2e/toe net calorific value (LCA)[1]	Typical energy efficiency[2]	Share of each energy type[3]
Thermal uses – fossils	Gas	**2826**	**90%**	**100%**
RE Heat Fund	Wood	151	86%	74.4%
	Geothermal energy	896	92%	6.4%
	Biogas	942	75%	3.8%
	Solar energy	837	92%	0.4%
	Biomass heating networks	186	82%	5.5%
	Heat recovery	0	95%	8.3%
	Weighted average	**219**	**85%**	

[1] Source: EcoInvent base
[2] Source: Annex II of the delegated regulation 2015/2402
[3] Source: Heat Fund 2009–2015 assessment

Source: France, 2017.

France: Building regulation.

The building regulation includes promotion of measures to improve the energy efficiency of new buildings. Buildings must have an average primary energy consumption rating lower than 50 kWh/m²/year, which promotes insulation but also RES H&C. For example, buildings using wood-fired heating systems and low-CO_2 district heating networks benefit from an adjustment of the primary energy consumption threshold.

The impact assessment is based on the difference between the with existing measures (WEM) 2014-2015 projections for which 100% of new builds in the residential and tertiary sectors adhered to 2012 thermal regulation over the 2012-2035 period, and the projections for which 100% of new builds in the residential and tertiary sectors adhered to 2005 thermal regulation over the same period (France, 2017).

The measure resulted in a GHG emission saving of 1 075 kt CO_2-eq. in 2015, including energy efficiency and RES impacts.

Germany: Emission savings from RES H&C.

Several research projects were carried out on the survey of energy consumption by private households. The aim is to obtain meaningful information on the energy consumption of private households in Germany by means of a sample survey. About 10 000 households were consulted extensively on their consumption of the respective energy sources, the housing conditions and the characteristics of the inhabited building. On the basis of detailed extracts from these surveys substitution factors for renewable heat from solar thermal and heat pump systems as well as single wood firing systems were derived.

Where ever possible data from the Centralised System of Emissions (ZSE) are used, additionally the “Emissionsbilanz” also contains emissions from a life-cycle-analysis. So the analysis for both (renewables and fossil technologies) includes emissions from construction, maintenance and operation.

To calculate avoided emissions from district heating, specific assumptions on biomass CHP installations are assumed. For the emission factor for the displaced fossil fuel technologies an emission factor specific to district heating is used, based on the share of fossil fuels in district heating networks.

For heat pumps a seasonal performance factor (SPF) of 2.96 is used. Emissions from increased electricity consumption are taken into account.

Germany: KfW Renewable Energies Programme

The policy supports RES for both electricity and heat. Electricity and heat produced in the plants supported by the RE Standard programme replaces energy produced from fossil and nuclear fuel. The savings in fossil fuel are determined by the type of power plant substituted (e.g. coal, natural gas, etc.).

They are calculated starting with the electricity or heat produced by the newly built plants. Specific substitution factors allow quantifying the amount of fossil energy replaced by each type of RES. The fossil fuel savings are derived by applying primary energy factors to the quantities of substituted electricity/heat.

To estimate the emission savings, emission reduction factors based on the substitution factors are used (from the German Umweltbundesamt). This considers net reduction effects: additional emissions from using RES (e.g. methane emissions during biogas production) are subtracted from the reduction in emissions from fossil fuels (ZSW, 2016). A distinction between the impact of RES E and RES H&C on avoided GHG emissions was not assessed.

Ireland: Emission savings from RES H&C.

In the report of SEAI (2018), a detailed description is given of how avoided emissions from RES H&C were estimated. This is not linked to specific PaMs, but rather the total emission savings from increased use of renewables for heating and cooling.

This method assumes that the thermal energy from RES (solid biomass, biogas, geothermal and the thermal portion of waste water biogas) displaces thermal energy from oil-fired boilers having an efficiency of 85%. The CO_2 avoided from thermal renewable energy is equated with the CO_2 emissions that would have arisen from this oil consumption.

The avoided emissions from heat pumps is estimated by assuming that the ambient heat displaces heat from gasoil. Emissions from the electricity consumed by the heat pumps is deducted from the emission savings.

Sweden: Emission savings from RES H&C.

For all heat production, the emission factor for district heating mix has been used, including heat pumps and solar heaters, “which is a very simplified assumption” (Sweden, 2011). Emission factors have been used that take into account a life-cycle perspective. For fuel supplied to cogeneration in district heating networks, the energy allocation method has been used: fuel energy is allocated to electricity and heating proportional to the generated amount of energy of each.

4 Conclusions

- RES for heating and cooling is important to achieve renewable energy and GHG emission reduction targets in the short- and long-term, considering the amount of energy consumption for heating and cooling in Europe. The increase in the share of RES H&C is however lagging compared to RES in electricity.
- Member States have implemented numerous new PaMs to support RES H&C since 2000. There was especially an increase in new PaMs in 2009, also the publication year of the RES Directive. These policies show an important overlap with energy efficiency policies. Most PaMs are not specific to a certain building type or technology. For those PaMs where this is specified, residential buildings and biomass are most frequently addressed. Grants, such as subsidies, are by far the most frequently used instrument type.
- In 2016, the share of RES H&C increased to 19.1%. This was achieved by further increases of biomass consumption, which is by far the most important RES for heating. Compared to 2005, the relative contribution of biomass decreased and there is more diversification of different RES technologies, most notably in heat pumps and solar thermal.
- District heating and CHP are important enablers of RES H&C. It allows for a more rapid uptake and penetration of renewables. While some countries with extensive district heating networks have already refurbished these from fossil to renewable energy sources, other countries still rely heavily on fossil fuels for district heating. Expanding district heating networks is also often driven by actions at the local level, which are not covered by national policy databases.
- The link between promoting RES H&C and GHG emission reductions is clear. Based on a top-down calculation, RES H&C resulted in an emission reduction of 90 Mt CO_2 in 2016 compared to 2005 in the EU-28. These emission savings are mostly achieved in non-ETS sectors (78%).
- For assessing the impact of RES H&C policies on avoided GHG emissions, bottom-up approaches are often used (e.g. French Heat Fund and Belgian tax reduction). In most cases only direct GHG emissions reductions are accounted, although some Member States also account for downstream emission increases and decreases.
- There are clear differences between information sources on the number of PaMs for heating and cooling. This can be linked to the structure of the information source (e.g. the RES legal database, structures PaMs in three categories: support schemes, policies and grid issues) how PaMs are split, and the history (e.g. the IEA databases can build on extensive previous reporting which means it includes more historic and expired PaMs).
- Despite the differences in the number of PaMs in each information source, all sources contained unique information. This included PaMs not listed in the other information sources and more detailed information on the nature of the PaMs.
- Information sources are not always consistent and key characteristics of the PaM could be different (e.g. start year).
- Reporting on climate and energy policies is not very integrated, looking to different information sources in the domain of energy or climate. This results in differences in the level of detail and completeness. The reporting under the MMR tends to focus on those PaMs that have a direct effect on GHG emissions.

5 References

BMLFUW, 2016, Erneuerbare energie in zahlen 2016 entwicklung in Österreich datenbasis *2015*.

Bush, R.E., Bale, C.S.E., Taylor, P.G., 2016, Realising local government visions for developing district heating: Experiences from a learning country. Energy Policy, 98, 84-96.

Campana, M., Tissier, M.-S., Nataf, J.-M., Rostagnat, M., 2018, Mission portant sur la transformation des aides à l'investissement du Fonds chaleur en aides à la production de chaleur renouvelable.

CE Delft, Ecologic Institute, Ricardo-AEA, REKK, E-Bridge, 2015, Mid-term evaluation of the Renewable Energy Directive. A study in the context of the REFIT programme.

Chambers, P., 2017, Renewable Heat – UK Policy. IEA Renewable heating and cooling policy workshop, 7 February 2017.

Collier, U., 2018, Renewable heat policies. Delivering clean heat solutions for the Energy transition. IEA Insight Series.

Colmenar-Santos, A., Rosales-Asensio, E. Borge-Diez, D., Blanes-Peiró, J.-J., 2016, District Heating and Cogeneration in the EU-28: Current Situation, Potential and Proposed Energy Strategy for Its Generalisation. Renewable and Sustainable Energy Reviews 62:621–639.

Creasey, E., Downy, F., Carmichael, E., 2015, Core theme interim report Concerted Action Renewable Energy Sources, core theme RES Heat.

Del Rio, P., 2010, Analysing the interactions between renewable energy promotion and energy efficiency support schemes: The impact of different instruments and design elements. Energy Policy 38, 4978-4989.

Ecofys, 2018, Gas for Climate. How gas can help to achieve the Paris Agreement target in an affordable way.

EEA, 2018, EEA database on climate change mitigation policies and measures in Europe, http://pam.apps.eea.europa.eu/

Enea, 2015, Energy Efficiency trends and policies in Italy.

ESTIF, 2014, Solar Thermal Markets in Europe. Trends and Market Statistics 2013.

Estonian Renewable Energy Association, 2016, Renewable Energy Yearbook 2016.

EU, 2005, Communication from the Commission: Biomass action plan. COM(2005) 628 final.

EU, 2014, Commission Staff Working Document: State of play on the sustainability of solid and gaseous biomass used for electricity, heating and cooling in the EU. SWD(2014) 259 final.

EU, 2015, Commission staff working document. REFIT evaluation of the Directive 2009/28/EC of the European Parliament and of the Council. SWD(2016) 416 final.

EU, 2016, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. An EU strategy on heating and cooling. COM(2016) 51.

EEA, 2018, Renewable Energy in Europe – recent growth and knock-on effects.

EurObserv'ER, 2018, Member State Renewable Energy Policy Factsheets, https://www.eurobserv-er.org/eurobserver-policy-files-for-all-eu-28-member-states/

France, 2017, Report Pursuant to Article 13.1 of the Regulation No. 525/2013 on a mechanism for monitoring and reporting greenhouse gas emissions.

Hanna, R., Parrish, B., Gross, R., 2016, UKERC technology and policy assessment. Best practices in heat decarbonisation policy: A review of the international experience of policies to promote the uptake of low carbon heat supply. Working paper

Hannon, M.J., 2015, Raising the temperature of the UK heat pump market: Learning lessons from Finland. Energy Policy 85: 369–375.

Hilden, M., 2018, Policy evaluation in practice. The Finish experience. Presentation at the 2018 Joint NRC EIONET meetings on Energy and Climate Change Mitigation.

IEA, 2016, Countries' Report. Bioenergy policies and status of implementation.

IEA/IRENA, 2018, Global Renewable Energy Policies and Measures Database, http://www.iea.org/policiesandmeasures/renewableenergy/

Klessmann, C., Held, A., Rathmann, M., Ragwitz, M., 2011, Status and perspectives of renewable energy policy and deployment in the European Union—What is needed to reach the 2020 targets? Energy Policy 39, 7637-7657.

Kranzl, L., Kalt, G., Müller, A., Hummels, M., Egger, C., Öhlinger C., Dell, G., 20, Renewable energy in the heating sector in Austria with particular reference to the region of Upper Austria. Energy Policy 59, 17-31.

Norden, 2015, Strategic Nordic Products – Heat pumps.

Nordic Council of Ministers, 2017, Nordic heating and cooling. Nordic approach to EU's Heating and Cooling Strategy.

Poland, 2015, Comprehensive assessment of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling in Poland. Report submitted to comply with Article 14(1) of Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC (EED).

RES Legal, 2018, Legal sources on renewable energy, www.res-legal.eu

SEAI, 2018, Energy-related CO_2 emissions in Ireland 2005-2016.

Sweden, 2011, Sweden's first progress report on the development of renewable energy pursuant to Article 22 of Directive 2009/28/EC.

Taylor, S., Hann, S., Bines, C., Ettlinger, S., 2016, Drivers of growth and cost changes in European renewable heat technologies. Report for DECC.

Trennepohl, N., Ferreira, L., Cancela de Abreu, I., 2015, Keep on Track! Project. National Report: Portugal.

Werner, S., 2017, District heating and cooling in Sweden. Energy 126: 419-429.

ZSW, 2016, Assessment of environmental and social impacts of the "KfW Renewable Energies Programme – Standard" for the year 2014.

Abbreviations

CHP	Combined Heat and Power
EEA	European Environment Agency
EED	Energy efficiency directive
ETS	European Emission Trading System
FIT	Feed in tariffs
GHG	Greenhouse gas
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
kt	Kilotonnes
MMR	Monitoring Mechanism Regulation
Mt	Million tonnes
Mtoe	Million tonnes of oil equivalent
NREAPs	National Renewable Energy Action Plans
PaMs	Policies and measures
RES	Renewable energy sources
RES E	Renewable energy sources for electricity
RES H&C	Renewable energy sources for heating and cooling
RHI	Renewable Heat Incentive
SPF	Seasonal performance factor

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