RESULTS ORIENTED

FINAL REPORT

December 2016

Deliverable 6.10

Editorial team

European Geothermal Energy Council (EGEC)
European Solar Thermal Industry Federation (ESTIF)

Consortium

ehpa european heat pump association

creara ENERGY EXPERTS

energy saving trust

AEBIOM EUROPEAN BIOMASS ASSOCIATION

ADENE AGÊNCIA PARA A ENERGIA

AIT AUSTRIAN INSTITUTE OF TECHNOLOGY

ESTIF European Solar Thermal Industry Federation

IDAE Instituto para la Diversificación y Ahorro de la Energía
GOBIERNO DE ESPAÑA MINISTERIO DE INDUSTRIA, ENERGÍA Y TURISMO

KAPE

Quercus

Netherlands Enterprise Agency

EGEC GEOTHERMAL

ABOUT THE FRONT PROJECT

The FROnT project aims to develop strategies improved understanding of the costs by consumers and for a greater deployment of renewable heating and cooling technologies.

The project consortium is composed of European industry associations and national energy agencies from Spain, Portugal, The Netherlands, Poland, and UK assisted by the Austrian Institute of Technology, CREARA (consulting and energy management company), and Quercus (non-profit environmental organisation based in Portugal). More information available at http://www.front-rhc.eu/

Co-funded by the Intelligent Energy Europe
Programme of the European Union

CONTENT

INTRODUCTION

In the short, medium, and long-term, the EU energy and climate targets cannot be reached without a strong uptake of renewable heating and cooling (RES-HC or RHC). RES-HC technologies, including geothermal and solar thermal, biomass stoves and boilers, and efficient heat pumps, can be found in individual, hybrid, and district heating and cooling systems. But switching to renewables in the heating and cooling (H&C) sector is not only an opportunity to effectively reduce harmful greenhouse gases (GHG) emissions, but also to reduce the risk of energy shortages and price hikes, decrease energy imports, and develop a truly innovative and competitive domestic industry, which will create new jobs and boost sustainable growth within the European Union (EU).

In several countries, however, the development of RES-HC is still dramatically slow. To reverse this trend, the FROnT project - co-funded by the European Union through the Intelligent Energy Europe programme - has developed new tools and strategies. The project has promoted an active cooperation between the RES-HC industry and energy agencies, with the support of experts involved through extensive consultation processes in six EU countries, namely Austria, The Netherlands, Poland, Portugal, Spain, and the United Kingdom.

The key strategic objectives of the projects have been the following:

- Improving the understanding of end-user's decision factors;
- Increasing transparency over the life-cycle costs and prices of essential energy services such as space heating, domestic hot water (DHW), and space cooling, for both households and small enterprises;
- Developing ready-to-use and multi-lingual tools for the consumer to facilitate the initial assessment towards a new and more sustainable heating and cooling system;
- Inspiring policy-makers and civil servants in terms of strategic policy priorities and innovative support schemes.

This document presents the main results of the FROnT project and is structured as follows:

- Chapter 1 introduces the heating and cooling sector and the main RES-HC technologies;
- Chapter 2 looks at what is the perception of the consumers regarding their H&C system and RES-HC technologies;
- Chapter 3 presents new decision-making tools providing the consumer with a technical pre-feasibility assessment of alternative and more sustainable H&C systems;
- Chapter 4 focuses on the assessment and on the communication of costs and prices and presents a new tool, addressed to consumers and policy-makers, to estimate the life-cycle costs of various H&C options;

- Chapter 5 summarises the strategic policy priorities in the form of a roadmap and reports inspiring best practices on support schemes; and finally,

- Chapter 6 provides an action plan for public entities, civil society organisations and industry stakeholders, to continue the work started with the FROnT project to provide clear and transparent information to end-users.

This final report is addressed to consumers, national, regional, and local policy-makers, civil-servants, HVAC (heating, ventilation, and air conditioning) manufacturers, designers, and installers as well as any to any other professional interested in H&C services. All the tools and the reports presented in this document are available on the project website www.front-rhc.eu.

1. HEATING AND COOLING DEMAND & RES-HC TECHNOLOGIES

This chapter is a brief introduction to the H&C sector. It outlines the services involved and presents the main RES-HC technologies and their current market development in the EU.

1.1 UNDERSTANDING THE HEATING AND COOLING DEMAND

The H&C demand represents 46% of the total final energy consumption. Final users have specific demand profiles in terms of temperature, capacity, and timing; therefore, a variety of applications and sources are required. Table 1 below classifies the H&C services (excluding cooking and process cooling) by end-user, service, and temperature.

End-user	Services	Temperature level	Covered by RES-HC?
Households	Space heating / cooling and domestic hot water	Low-temperature (up to 60° C)	Yes
Tertiary (Supermarkets, malls, offices, hotels, swimming pools, etc.)	Space heating / cooling and domestic hot water	Low-temperature (up to 95° C)	Yes
Industry	Greenhouse heating Irrigation with warm water in agro-industries	Low-temperature (60-90° C)	Yes
	Heat and hot water for washing, rinsing, and food preparation.	Low-temperature heat (up to 95° C)	Yes
	Steam for industrial processes, notably to evaporate or dry	Medium temperature (95° C - 250° C)	Yes, in some cases
	Heat for the manufacture of metals, ceramics, glass (through hot flue gases, electric induction, etc.)	High-temperature heat (400° C up-1200° C)	Can be covered with electricity

Table 1: Examples of heating & cooling demand by service, end-user, and temperature.

Seventy-five per cent of this energy is generated by burning fossil fuels[1], which is unsustainable from an economic, environmental, and social point of view. There is therefore an urgent need to reduce energy demand and to supply fossil fuels with sustainable energy. RES-HC technologies can

[1] European Commission, SWD, Impact Assessment, Recast of the Renewable Energy Directive, part 1, 2016.

replace gas and other fossil fuels in the residential and tertiary sectors as well as for several industrial processes. Renewables in this sector can not only reduce energy imports and contribute to mitigate greenhouse gas emissions, but can also improve the efficiency of the resources used in the energy sector. In fact, for an efficient use of primary energy, technologies used should match as closely as possible the temperature levels of the thermal energy demand. Similarly, the sources used should be produced as closely as possible to the final consumer.

1.2 OVERVIEW OF RENEWABLE HEATING AND COOLING TECHNOLOGIES

There is a wide variety of renewables technologies already available in the market. They can cover several heating and cooling services for households, enterprises, and industry. While in the past renewables were known as a complementary option to conventional technologies, today they can be easily combined in micro, small and large-scale collective systems to cover 100% of the heating and cooling demand.

The following sections provide a brief presentation of the main RES-HC technologies, namely geothermal (including geothermal heat pumps), aerothermal and hydrothermal heat pumps, solar thermal, and biomass.

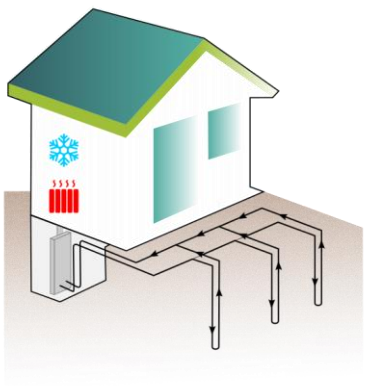
GEOTHERMAL ENERGY

Geothermal energy is the heat from below the earth. Geothermal technologies can supply energy at different temperatures (even up to 250°C, usually for industry), at different loads, and for different demands.

Geothermal heat pumps and other shallow systems

Shallow systems typically use heat at depths of up to 400m coupled with heat pumps to provide with a single device space heating, domestic hot water, and space cooling. Thermal energy can also be stored at these depths.

Shallow geothermal energy can be installed almost everywhere in Europe. Two techniques exist:



- Open loop systems extract groundwater, reinjecting it after the thermal energy has been used.
- Closed loop systems use a closed-circuit underground. Closed loop systems can either be horizontal closed loop, or vertical loop, also known as a borehole heat exchanger.

Storage systems are known as Aquifer Thermal Energy Storage (ATES) and Borehole thermal energy storage system (BTES system).

Figure 1: Shallow geothermal system, copyright EGEC / ReGeoCities.

Deep Geothermal for district heating, agriculture, and process heat

Geothermal is increasingly being used in district heating (some 260 geothermal heat plants are in operation in Europe) and in the agri-food industries.

Additionally, geothermal can supply energy for process heat. As an example, the 24MWth ECOGI project in Alsace, France, delivers energy to the "Roquette Frères" bio-refinery, to cover around 25% of the process heat needed on this industrial site.

Figure 2: ECOGI geothermal project in Alsace, France.

AIR-SOURCE AND HYDROTHERMAL HEAT PUMPS

A heat pump is a device that can provide heating, cooling, and domestic hot water for residential, commercial, and industrial applications. It converts energy from air (aerothermal), ground (geothermal) and water (hydrothermal) to useful heat. This conversion is done via the refrigerant cycle.

Typical capacities range from 2-20kW for single family buildings up to 100kW for multi-dwelling residential applications. For commercial applications, the capacity is even bigger, and for industrial and district heating installations, the capacity can reach the range of several MW.

A heat pump system consists of a heat source, the heat pump unit, and a distribution system to heat/cool the building.

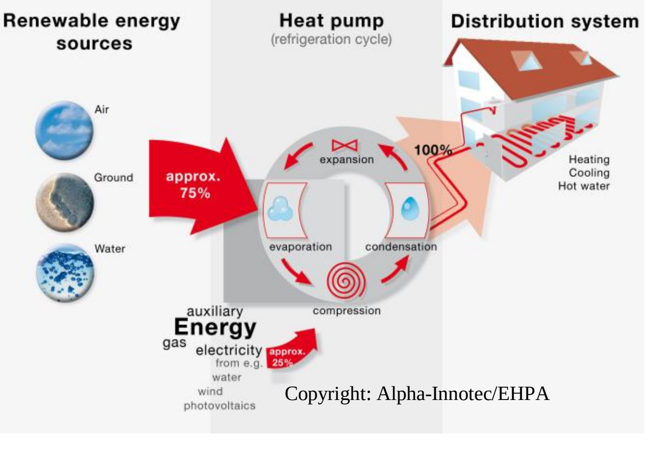


Figure 3: Illustration of a heat pump.

The main type of refrigeration cycle that is used is the electric compression cycle, that works in the following way: a transfer fluid (refrigerant) transports the heat from a low-energy source to a higher energy sink. Auxiliary energy is needed to run the compressor and the pumps (usually electricity or gas).

Heat pump systems can be used for heating or cooling. In the heating mode, outdoor ambient energy is the heat source and the building is the heat sink. In the cooling mode, the building is cooled down using the outside as heat sink.

Energy distribution: Heat pumps use air or water as heat distribution media inside the building. Depending on system design, they can use the air directly at the installation point or use a duct (air) or pipe (water) distribution system to provide energy to fans, radiators, or floor heating systems. Ductless heat pumps are installed on a wall and act as a localized heat source, like a wood/pellet stove. This is a typical solution for homeowners, particularly when cooling is also needed.

Air source heat pumps: This technology comes in several variants, with the most typical ones being:

1. compact (monobloc) units: all heat pump components are combined inside one case;

2. Split systems: the outside and the inside heat exchanger are installed in two cases, with one installed on the outside of the building and the other inside. Both are connected via a refrigerant line. In single family buildings, most often single split systems are used in which the outside unit is connected to one inside unit. In multifamily or commercial applications, typically multi-split solutions are used where one outside unit supplies several inside units.

Efficiency considerations: The efficiency of heat pumps depends mainly on the temperature difference that needs to be overcome. The higher the sink temperature required by the distribution system, the less efficient the heat pump. This fact makes heat pumps more suitable for the connection to low temperature heat distribution systems (fan coils, floor heating or low temperature radiators).

SOLAR THERMAL

The basic principle common to all solar thermal systems is simple: heat from solar radiation is conveyed to a transfer medium – usually a fluid but also air in the case of air collectors. The heated medium is used either directly or indirectly, by means of a heat exchanger which transfers the heat to its final destination. Solar thermal can be used in a wide variety of applications, including domestic water heating, space heating, space cooling, district heating, heat generation process for industry, etc.

Solar Domestic Hot Water (SDHW)

Figure 4: A Solar Domestic Hot Water system.

Solar Domestic Hot Water systems is the most common use of solar thermal energy worldwide. These are usually divided in thermosiphon and forced circulation systems. Collective SDHW are suitable for larger buildings.

Combined DHW and space heating & Cooling (Combi-systems)

In Central and Northern Europe, solar thermal systems that provide heat both for domestic hot water and for space heating are commonly installed. These combi-systems are often more complex than solar systems supplying DHW only and, as a result, system design must be adapted to the specific requirements of the building.

Different practices are used in different countries. In Southern Europe, combi-systems are still rarely used, but there is a huge potential for these systems to generate space heating in winter and air-conditioning in summer, as well as domestic hot water throughout the year.

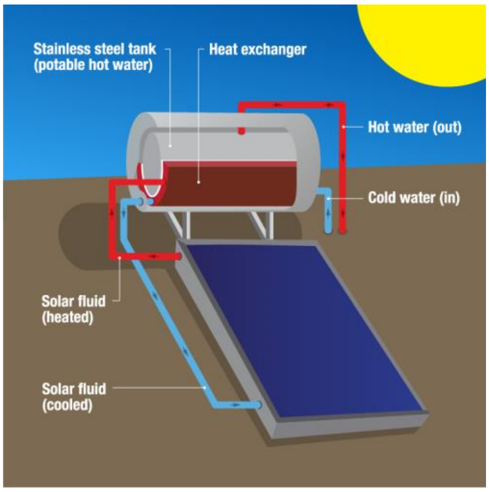


Figure 5: Illustration of combined domestic hot water and space heating solar collector

Solar cooling

The main feature of a solar cooling system, beyond the solar collector field, is the thermally driven chiller. On the thermal supply side, the solar thermal system is rather conventional, consisting of high quality solar collectors, a storage tank, a control unit and pipes.

For the cooling process, the main element is the thermally driven cooling machine but the process of heat rejection is also important. This means that cooling towers or other heat rejection solutions are required. The most common technological solution is an absorption cycle: the heat is used to chemically “compress” the refrigerant by desorbing (separating) it from a sorbent, cooling is produced as the “compressed” liquid is expanded in the evaporator to turn into gas.

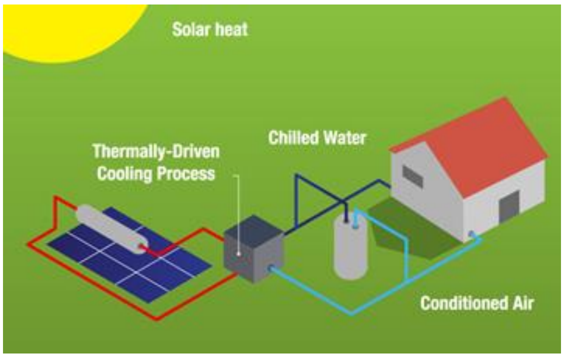


Figure 6: Illustration of solar cooling system.

BIOMASS

Biomass is the biodegradable fraction of products, wastes and residues from biological origin from

- agriculture (including vegetable and animal substances),
- forestry and related industries (including fisheries and aquaculture),
- industrial and municipal waste.

Biomass heating can be achieved with a wide variety of fuels such as wood pellets, wood chips, briquettes or wood logs and can be used in a wide variety of technologies. For domestic purposes, firewood or wood pellets are most frequently used.

Biomass stoves

Biomass stoves produce heat only, typically for one single room but sometimes more than a room. They are logwood, woodchip or wood pellets burning stoves that can complement your conventional boiler to supply heating. Traditional wood burning stoves are using wood logs. More sophisticated models run on wood pellets which are mainly made of compressed sawdust. The use of the resource is highly efficient as the thermal efficiency of modern stoves ranges from 80 to 91%.

- Firewood stoves: These stoves can be used to heat single rooms or small houses and are available with outputs from 3.5 kW to 20 kW. Stoves can be found in a wide variation in design, such as doors with or without viewing glass or casings of tiles or soapstone.

- Wood pellet stoves: Pellet stoves are more sophisticated than firewood stoves because of the automatic operation. Pellet stoves usually have a small fuel pellet storage, from which a small auger conveys the pellets to shaft from where they fall into the combustion chamber. A fan provides the air needed for combustion. Advantages as compared to firewood stoves are: fully automatic operation, higher efficiency, cleaner burning, and easier to use. Capacity range of domestic pellet stoves is between 1.5 kW to 12 kW

Biomass stoves are installed indoors, ideally central to the volume to be heated. A typical domestic biomass stove itself can be quite small, the size of a domestic washing machine. However, the fuel store can be bigger depending on how much fuel is needed and how often supplies are purchased.

Pellet stoves are equipped with a pellet tank to be refilled with bags of pellets once every 1-3 days. The frequency of recharge depends on the size of the storage unit and the heating demand. While storing, the wood based solid biofuels should be protected from humidity as the quality of the fuel is critical for the efficient running of the boiler.

Biomass boilers

Biomass boilers for residential purposes can be used to provide heat and domestic hot water, and can replace your conventional boiler as they can be fully automatic just like their oil and gas equivalents. Modern boilers are also highly resource efficient as they achieve efficiencies between 80 and 107%.

Firewood boilers are more suitable for houses and they are popular in rural areas. Firewood boilers are designed to be loaded with more wood than wood stoves. Wood is manually loaded into the appliance, and their capacity range is between 15 kW to 70 kW. The technology has been improved dramatically; two-stage combustion with automatic ignition, blower fan and reduced heat losses are examples of these improvements. Modern firewood boilers achieve efficiencies of more than 90%.

Wood chip-fuelled boilers may be used to provide heat in larger houses, for farm buildings, or for industrial furnaces. Automatic operation and low emissions because of continuous combustion are the advantages of wood chips heating systems. Wood chip-fuelled boiler capacity ranges between 15 kW and industrial scale.

Wood pellet boilers are used for capacities in the range between 15 KW and industrial scale. These boilers are usually installed in a basement or in a separate container outside the house; fuel storage should ideally be located close or next to the boiler room. Wood pellet boilers operate fully automatically, whether they are top feed, horizontal and underfeed burners. Ash removal is generally automated and the exterior ash box requires emptying once or twice a year.

Figure 7: Biomass stove.

Wood pellets are stored in a dedicated storage place and transported automatically up to the combustion chamber. The amount of air in the combustion chamber is controlled to burn the wood as efficiently as possible, leaving very little ash and almost no smoke. Therefore, it requires emptying the ashes only 1 to 5 times per year. Like any other boilers, yearly maintenance from a professional is required. Above the combustion chamber, heat exchangers are used to heat water, which is then piped throughout the house's radiators.

The boiler and the fuel storage are generally installed in the cellar or garage. However, the installation can be flexible as the storage can be up to 20 meters away from the boiler. The storage is recharged generally once/twice a year using blower trucks.

1.3 MARKET DEVELOPMENT UP TO 2020

The figure below depicts the share of renewables and non-renewable energy in each of the 28 Member States. It shows that, except for a few Nordic countries, fossil fuels heavily dominate the heating sector in most of the EU Member States.

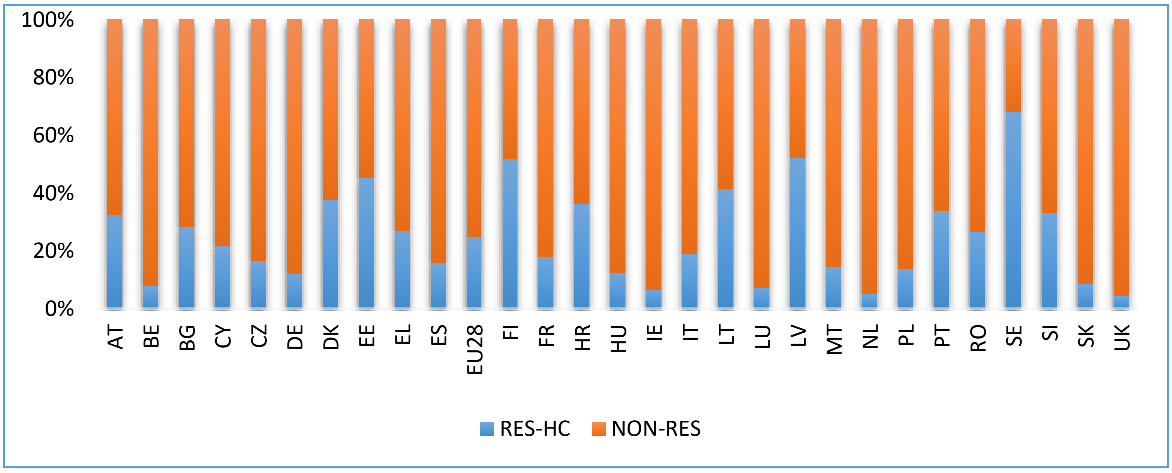


Figure 8: Share of RES-HC vs non-renewable heat in the EU Member States in 2014. Source: EUROSTAT.

Predicting market growth is subject to many different variables. However, it is expected that the combined energy supply of RES-HC in the EU will reach 111 Mtoe by 2020 or 21.4 % of the heating and cooling consumption. The chart below compares the combined targets for 2020 set by the National Renewable Action Plans (NREAPs) with the trend of RES-HC deployment included in the latest European Commission's progress report[2] (coming from the Green X model). Linear growth has been estimated between the 2014 and 2020 values of the EC's progress report. The scenarios of future deployment included in the latest European Commission's progress report show a decrease in the surplus of RES-HC contribution, which will lead to a deficit by 2020.

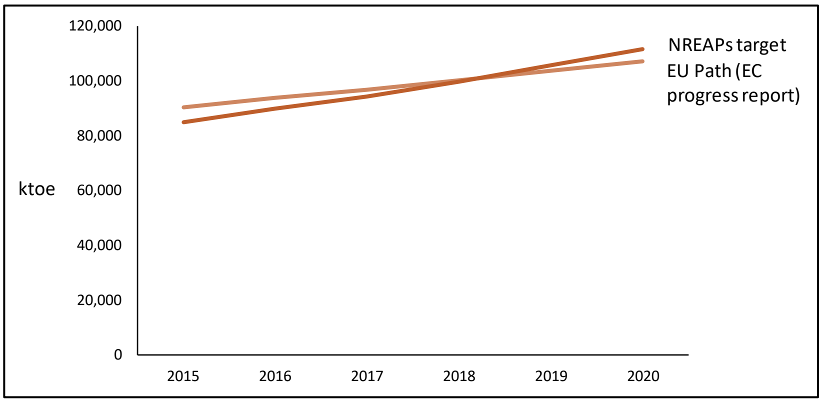


Figure 9: RES-HC targets vs trends. Source: Own calculation based on NREAPs and European Commission SWD (2015) 117

As highlighted by the European Commission in their Renewable energy progress report and in the post-2020 package "Clean energy for all Europeans", further policy measures and actions are required to achieve the renewable energy targets in the heating and cooling sectors. The tools and recommendations developed within the FROnT project and presented in the next chapters aim to pave the way for faster RES-HC deployment and towards the full decarbonisation of the residential, tertiary, and industry sectors.

[2] European Commission, Renewable energy progress report, Brussels, 15.6.2015, SWD (2015) 117 final.

2. THE SURVEY: WHAT ARE THE CONSUMERS' KEY PURCHASING FACTORS?

One of the objectives of the FROnT project was to improve the understanding of what are the end-user key purchasing factors for heating and cooling systems in five EU countries: Netherlands, Poland, Portugal, Spain, and the United Kingdom. The consortium has therefore carried out an extensive survey. This chapter details the results of this work.

Based on that, the project has proposed a set of recommendations for improving the communication towards the consumer and consumer-centered tools to facilitate access to simple and clear information and assist them on the purchase decision. All these proposals are presented in chapter 3 and 4.

The survey, conducted by specialised companies under the coordination of the respective energy agencies, has covered the residential, non-residential and industry sectors. The study examined why current systems are used, where users get information about thermal energy equipment, why they choose some systems rather than others, how they perceive different sources of energy, and their sensitivity to price changes.

The research was conducted to provide public authorities and businesses with information about how to effectively communicate with their audience about the energy choices they make, and to improve the understanding of how a shift to renewables can be achieved. The following sections provide a summary of the combined results, the methodology, and more specific findings for the residential, the non-residential, and the industrial sectors. The full five country-reports are available on the project website.

2.1 OVERALL RESULTS

Some clear trends were found from the data collected. For all sectors, professionals are the main source of information but private users also rely heavily on the advice of their relatives. Total economic savings is one of the most important factors when choosing a system; it's the most important factor for the residential sector and the second most important for others, coming just behind reliability.

Non-residential consumers present the greatest level of awareness on RES-HC technologies, followed by the industrial sector. Households are the least aware, suggesting the need for further information campaigns targeting this group of consumers. The industrial sector is the most willing to pay for RES-HC technologies.

In general, consumers think that renewables have high investment costs but deliver high economic savings. It is the need for an initial investment that stops most people installing renewables, followed by the perceived burden of structural changes involved and the need to require the approval by neighbours. Most people are largely satisfied with their existing system, but are unhappy about fuel prices.

2.2 METHODOLOGY

The overall number of interviews conducted was 4,195 in the residential sector, 896 in the non-residential sector and 585 in the industrial sector. The number of queries broken down by country and by sector is shown in the following figure. It also includes the related representativeness of each group.

SECTOR	COUNTRY	NUMBER OF QUERIES	CONFIDENCE LEVEL	SAMPLE ERROR
RESIDENTIAL	NETHERLANDS (NL)	560	95%	4.14%
	POLAND (PL)	960	95%	3.16%
	PORTUGAL (PT)	900	95%	3.27%
	SPAIN (ES)	1,250	95%	2.77%
	UNITED KINGDOM (UK)	525	95%	4.28%
NON-RESIDENTIAL	NETHERLANDS (NL)	15	95%	25.29%
	POLAND (PL)	150	95%	7.97%
	PORTUGAL (PT)	250	95%	6.16%
	SPAIN (ES)	300	95%	5.62%
	UNITED KINGDOM (UK)	181	95%	7.25%
INDUSTRY	NETHERLANDS (NL)	35	95%	16.55%
	POLAND (PL)	100	95%	9.78%
	PORTUGAL (PT)	100	95%	9.78%
	SPAIN (ES)	250	95%	5.62%
	UNITED KINGDOM (UK)	100	95%	9.78%

Figure 10: Number of interviews by country and by sector.

As an example, the figures below show how interviews have been conducted for the residential consumers. Question Q5 was not asked in all countries.

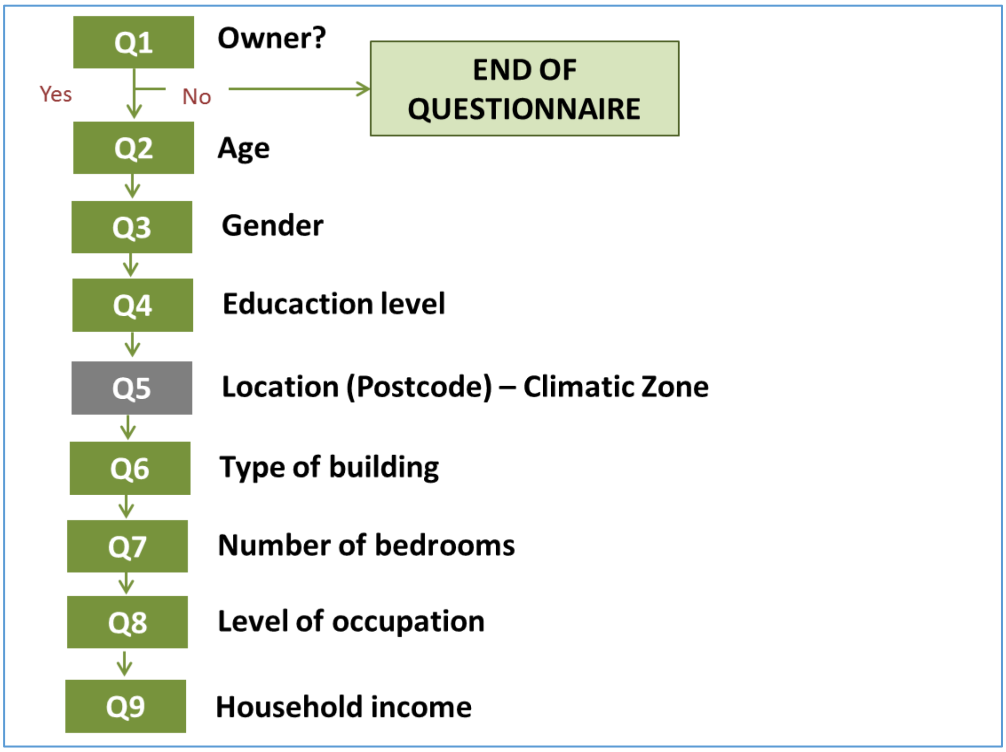


Figure 11: Characterisation of the sample for the residential sector.

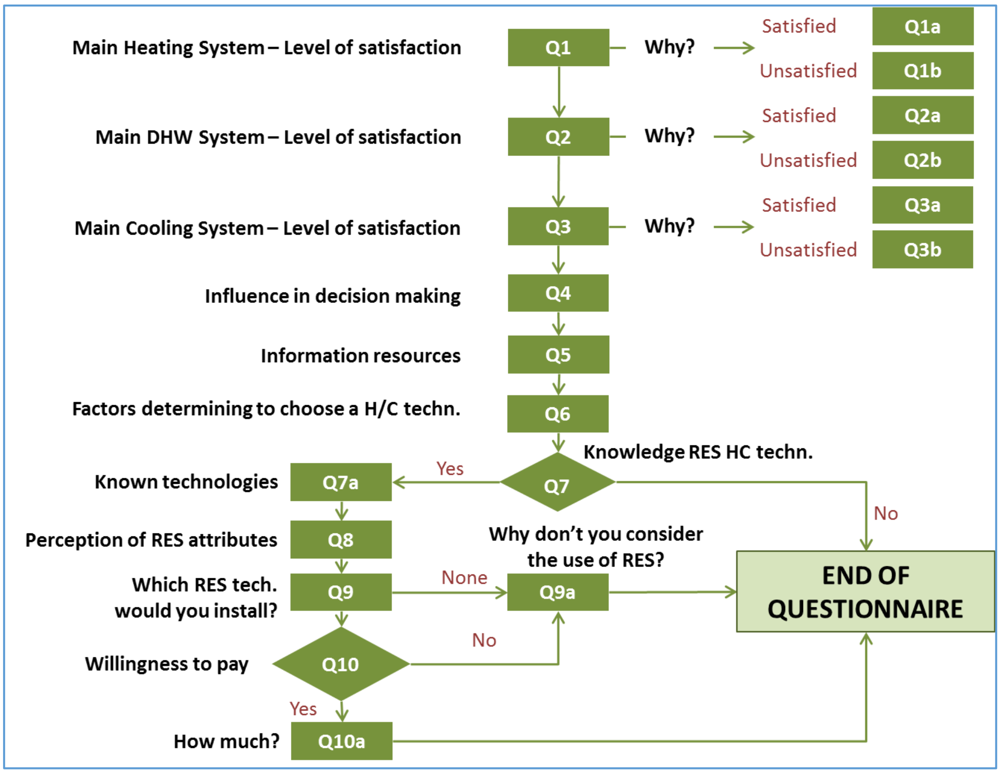


Figure 12: Flow diagram followed in questionnaires for the residential sector.

2.3 RESULTS IN THE RESIDENTIAL SECTOR

In general, the residential consumers interviewed seem to be quite satisfied with their current system and not very motivated to change. The main reason to use current heating and domestic hot water systems in dwellings is because they already exist there and because of the equipment price. Regarding cooling systems, the main reasons for acquiring the current technology were: equipment price, the existence of a prior system and the access to fuel and fuel costs. It is worth highlighting, however, that the clear majority of dwellings in the participating countries did not have any cooling system (85%). Obviously, the countries with the largest number of cooling systems were Spain and Portugal (28% and 20% of dwellings have cooling systems respectively). Existing cooling systems were mainly electric air conditioning systems.

The main source of information for the residential consumers is professionals (49%) followed by the internet (29%) and relatives and colleagues (25%). Consulting professionals is the preferred source in Spain and the Netherlands, the Internet is the preferred source in the United Kingdom and Poland. Lastly, sales agents are the preferred source in Portugal.

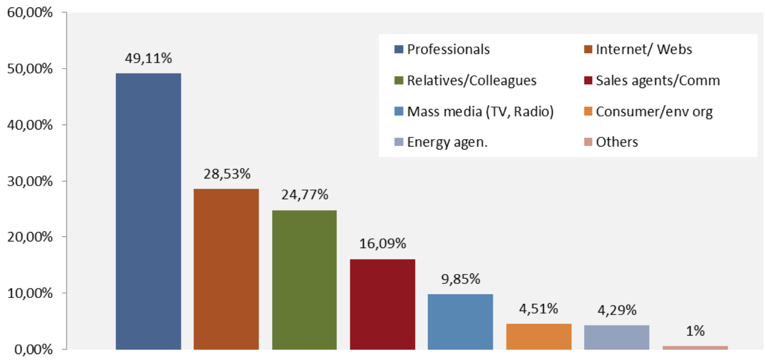


Figure 13: Information resources in participating countries. Residential sector.

In relative terms, men use the Internet more than women, while women rely on the opinion of relatives and colleagues. People between 41 and 59 years-old tend to consult professionals while young people and people with a high level of education prefer using the Internet. People from rural areas rely more on professionals and sales agents' opinions rather than the Internet. Those with income above the average prefer professional opinions and the Internet.

The key purchasing criteria identified for H&C systems for residential consumers in the five participating countries are illustrated in Figure 14.

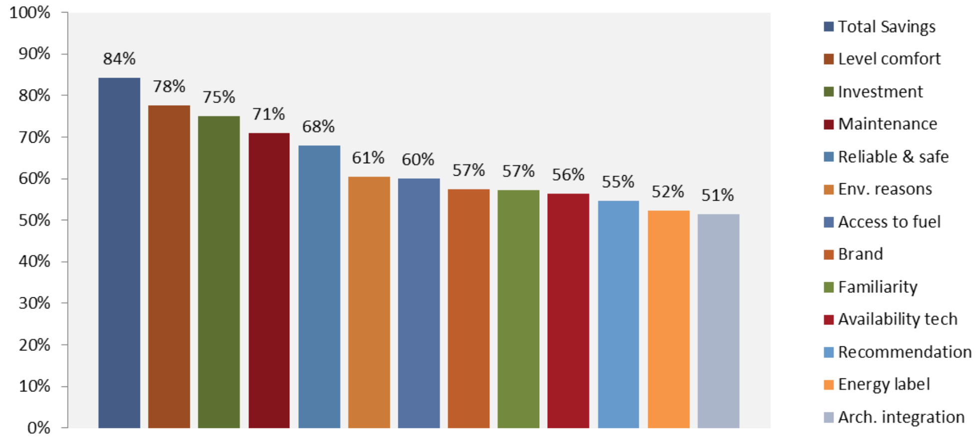


Figure 14: Key purchasing criteria in the participating countries. Residential sector.

Total economic savings is the most important criterion, followed by comfort level (78%). Initial investment is also important (75% of respondents). Total economic savings is the most important criterion in Poland. Comfort level is the most important factor in Spain, the Netherlands and Portugal. Reliability and safety is the major factor in the United Kingdom.

The following tables show the key purchasing factors considering the demographical features analysed. In general, architectural integration and environmental reasons are more relevant for women than for men. Economic savings, investment and maintenance are more important for people between 41 and 59 years-old than for young people. The importance of savings and recommendations from relatives for those who have primary education (higher than the average) is remarkable.

The results of the survey show that 65% of respondents are aware of the use of RES-HC systems. The deviation of each group compared with the total distribution of the number of answers is also shown. For instance, 65% of the total sample is aware of the use of RES for H&C, 73% of the total men sample and 58% of the total women sample, so the conclusion could be that men are more aware of RES-HC than women.

		Gender		Age				Level Education				Location of the building		
	%	*Male*	*Female*	*18-40*	*41-60*	*>60*	*Ind.*	*Prim.*	*Sec.*	*Sup.*	*Ind.*	*City Centre*	*Urban Area*	*Rural Area*
Yes	65%	73%	58%	67%	69%	59%	73%	53%	64%	76%	63%	65%	69%	62%
No	35%	27%	46%	33%	31%	41%	27%	47%	36%	24%	38%	35%	31%	38%

		Type of building				Nº Bedrooms			Level occupation			Income average		
	%	*Apartment*	*Row house*	*Detached*	*Other*	*Less 2*	*3*	*More 4*	*<12h*	*12-16h*	*>17h*	*Higher*	*Lower*	*Ind*
Yes	65%	64%	59%	72%	67%	61%	64%	72%	69%	69%	61%	62%	76%	57%
No	35%	36%	41%	28%	33%	39%	36%	28%	31%	31%	39%	38%	24%	43%

		Country				
	%	*ES*	*NL*	*PL*	*PT*	*UK*
Yes	65%	63%	47%	73%	63%	79%
No	35%	37%	53%	27%	27%	21%

Note - Ind: Indeterminate

Table 2: Awareness of RES-HC by sample features. Residential sector.

As shown in Table 3 below, the most well-known technology for those who are familiarised with RES-HC (65%) is solar thermal energy, followed by biomass:

TECHNOLOGY/SOURCE	HEATING/DHW	COOLING
Solar thermal	96%	37%
Biomass	49%	18%
Air-source heat pumps	40%	19%
Geothermal heat pumps	42%	19%
RES-based District Heating/Cooling	21%	11%

Table 3: List of the known RES-HC technologies. Residential sector.

In terms of perception, most of the respondents think that RES-HC is more respectful of the environment and more expensive than non-renewable technologies. However, they are aware that RES-HC technologies imply more economic savings, lower operating costs and higher safety compared with fossil fuel technologies.

Features of the sample such as age and gender do not have a strong influence on the answers to this question, although men are slightly more likely than women to think that RES-HC technologies are slightly more expensive. Those with primary education think that RES-HC technologies are more reliable although they involve more operating costs. Analysing the results by country, it is interesting to note that respondents in Spain and the Netherlands think that the installers are much less specialised on renewables than in other non-renewable heating technologies.

With regards to the main rejection reasons for using RES in heating or domestic hot water systems are the initial investment (42%) and structural changes required in dwelling (35%). The figure on the left shows the answers distribution for the rest of reasons. The main rejection reasons also apply for using RES in cooling systems.

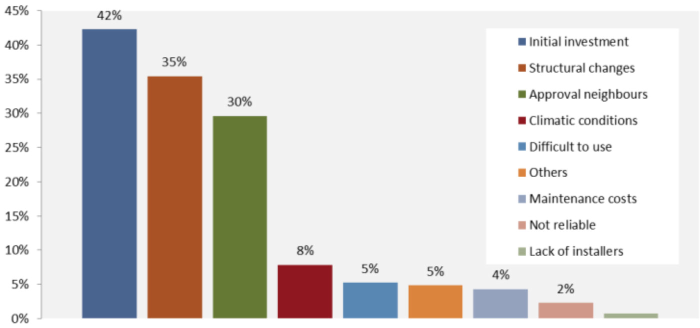
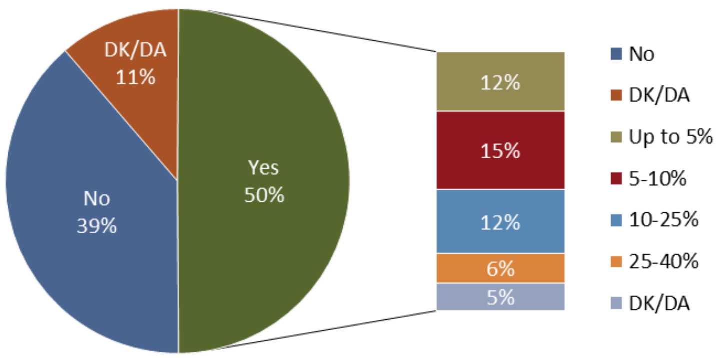


Figure 15: Rejection reasons for using RES in heating and DHW systems in participating countries. Residential sector.

Seventy-one percent of respondents who are familiar with RES-HC (65%) consider the installation of some RES technologies for heating or domestic hot water (2% of respondents did not answer this question). In that regard, the preferred technology to be used would be solar thermal energy (56%), which indeed is very popular in two Southern project countries of Portugal and Spain.

Fifty percent of the respondents who are familiarised with RES-HC (65%) would be willing to make a higher initial investment to install a RES-HC system, 39% would not, and 11% did not answer this question. Figure 16 below shows the percentage of respondents who are willing to pay for a RES-HC system. Twelve percent of respondents would pay up to 5% more, 15% would pay between 5% and 10% more, 12% would pay between 10-25%, 6% would pay between 25-40%. Five (5%) did not answer this question.

It is also noteworthy that men, young people, and those with a university level education, are more willing to make a higher up-front investment for a RES-HC system than the rest. This is also the case for people who live in the countryside. Finally, the willingness to pay is lower in Portugal than in the rest of countries.



Note - DK/DA: Do not know/do not answer

Figure 16: Willingness to pay for RES-HC technologies. Residential sector.

2.4 RESULTS IN THE NON-RESIDENTIAL SECTOR

The satisfaction level of the non-residential consumers interviewed with their current system was very high (satisfied: 86%; no answer: 2%; dissatisfied: 12%) and the main reasons were the good comfort levels (62%) and ease of use, reliability, and safety (26%). Satisfaction is higher for natural gas users and lower for heating oil and this is mainly for the higher fuel price of the latter. Of the non-residential buildings, 37% did not have any cooling system, but 43% have electrically-driven air conditioning systems. Heat pumps (aero- and hydro- thermal) are quite common in Spain and the Netherlands and they represent together 14% of the total sample. The rest of systems are not very used in the participating countries so their percentage is negligible. In general, cooling system satisfaction is very high because of their high comfort levels (61%) and their easy use (23%). The main reason for the use of current systems in non-residential buildings for heating and domestic hot water applications is that they are already installed, showing again a strong inertia in the H&C sector.

Regarding the main source of information before changing the H&C system, managers of public buildings prefer mainly energy agencies and the Internet, while managers of private buildings prefer professionals' advice. The internet is more used by office buildings. Finally, the health-care sector prefers energy agencies.

For the non-residential consumers, reliability and safety is most common criterion to choose H&C systems, followed by total economic savings and comfort levels. The initial investment is also very important. Total savings and initial investment are the most relevant criteria in Poland. Reliability and safety is the most common factor in Spain and the United Kingdom. Finally, maintenance, comfort levels and environmental reasons are the most relevant criteria in the Netherlands while in Portugal it is the initial investment.

Of the respondents in all the participating countries, 88% were aware of the use of RES-HC technologies. The following table details the results by country and business activity.

		Building owner		Main of activity							Pool	
	%	*Public*	*Private*	*Offices*	*Comm.*	*Health Centres*	*Hotels*	*Educational Centres*	*Sport Cen-*	*Others*	*Yes*	*No*
Yes	88%	92%	84%	94%	88%	81%	86%	82%	85%	100%	92%	87%
No	12%	8%	16%	6%	12%	19%	14%	18%	15%	0%	8%	13%

		Occupation				Surface				ESCO			ENERGY AUDIT		
	%	*Below 100*	*100-1000*	*Above 1000*	*DK/DA*	*Below 1000*	*1000-5000*	*Above 5000*	*DK/DA*	*Yes*	*No*	*DK/DA*	*Yes*	*No*	*DK/DA*
Yes	88%	89%	87%	87%	84%	91%	94%	90%	73%	88%	91%	59%	92%	89%	65%
No	12%	11%	13%	13%	16%	9%	6%	10%	27%	12%	9%	41%	8%	11%	35%

		Country				
	%	*ES*	*NL*	*PL*	*PT*	*UK*
Yes	88%	81%	100%	100%	100%	69%
No	12%	19%	0%	0%	0%	31%

Note - DK/DA: Do not know/do not answer

Table 4: Awareness about RES-HC by sample feature. Non- residential sector.

Regarding the perception of adequacy of RES-HC for non-residential buildings, 25% of respondents who are familiarised with RES-HC (88%) do not think that any of the RES technologies are adequate for heating or domestic hot water systems. In general, managers of public buildings, offices, commerce, those without any energy audit, and those that do not receive any service from an energy service company (ESCO) are more reluctant to install RES-HC technologies. This percentage is above the average in Poland, Portugal, and the United Kingdom (28%, 32%, and 36% of respondents respectively). Regarding the incorporation of renewable energies in cooling systems, 25% of the total does not support this option. Of this group, managers of public buildings are the most reluctant. The rejection percentage is above the average in Poland (26%) and Portugal (42%).

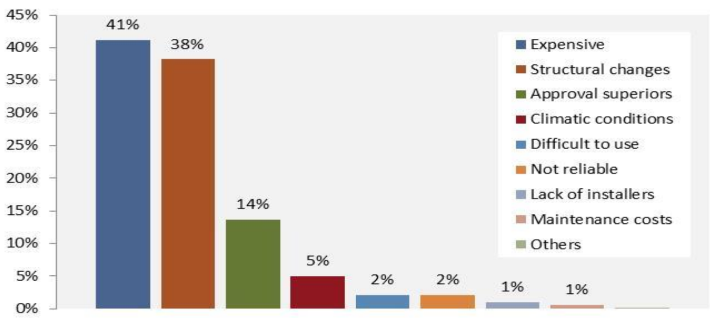


Figure 17: Rejection reasons for RES-HC heating and DHW systems in participating countries.

The main reasons for rejecting RES in heating or domestic hot water systems are the initial investment (41%) and structural changes required in buildings (38%) (see Figure 17). Similar reasons explain the lack of a RES system for cooling.

It is also interesting to note that less than half (42%) of those non-residential consumers aware of RES-HC technologies would be willing to pay, initially, more money for a RES-HC system. Businesses seem to be more willing to pay in the Netherlands, Spain, Poland, and the United Kingdom and less in Portugal.

2.5 RESULTS IN THE INDUSTRIAL SECTOR

For the industrial consumers taking part in the survey, the level of satisfaction with their current systems is high (91%) and is not really dependant on the industrial sub-sector. Industries with seasonal production are, in general, less satisfied than the others. Satisfaction does not depend on the fuel, but rather on the level of system adaptation to the process conditions (58%), the facility of use, reliability, and safety (29%) and the equipment price (24%). On the other hand, respondents were not fully satisfied with fuel price.

As for households and non-residential consumers, professionals are the preferred source of information for the industry as well. In relative terms, professionals are more consulted by the rubber and plastic sector, while colleagues (other technicians) are preferred by the machinery sector. Energy audits seem not to be very influential.

Regarding the purchasing criteria, reliability and safety is the most relevant criterion (97%), followed by economic savings (96%) and process requirements (95%). Architectural integration and brand are the least important criterion for industrial respondents (74% and 70%, respectively).

Of the survey respondents in all the participating countries, 76% are aware of the use of RES-HC technologies for industrial processes. The most popular source is biomass for heating. However, 37% of respondents familiarised with RES-HC do not believe any RES-HC technology would be suitable for their own heating systems. In general, respondents from the chemical and metal industry are the most reluctant. This percentage is above the average in the United Kingdom.

With regards to the incorporation of RES in cooling systems, 25% of respondents familiarised with RES-HC do not believe any are appropriate, while 49% did not answer this question. In this case the textile, paper, chemical and metal industries are more reluctant than the average. The rejection percentage is above the average in the Netherlands (36%), Portugal (42%), and the United Kingdom (70%).

The main rejection reasons for using RES for heating in industrial processes are the initial investment (44%), and the need for structural changes (22%). Figure 18 shows the distribution of the rest of rejection reasons.

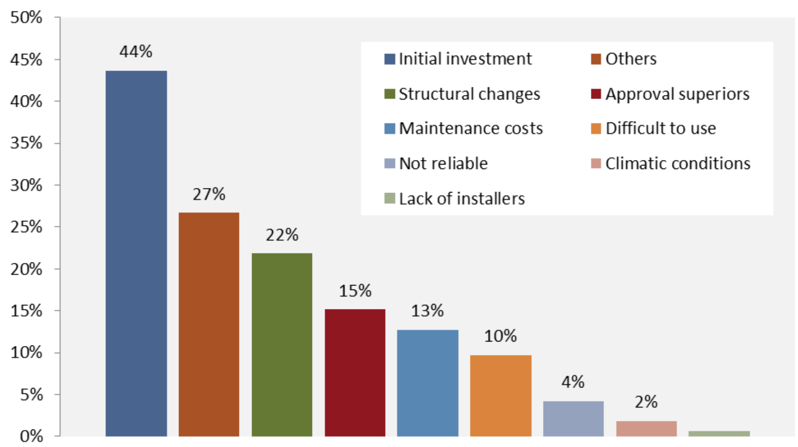


Figure 18: Rejection reasons for RES for heating in industrial processes in participating countries.

Regarding cooling from renewable energy, 55% of the respondents familiar with the technology would consider installing one for their industrial processes. The textile industry favours solar thermal energy, while the wood and machinery sectors favour biomass. In Portugal, solar thermal energy shows above average rates of approval, while in Spain biomass is preferred.

3. TECHNICAL PRE-FEASIBILITY ASSESSMENT: ON-LINE TOOLS FOR SUPPORTING CONSUMERS

The survey presented in the foregoing chapter resulted, among other things, in valuable findings about the perception of consumers in the residential, non-residential, and industrial sectors. Based on that information, the FROnT project has developed a few suitable tools to support the end-users on their decisions to install or replace elements of their H&C systems and to inform about useful instruments such as buildings' energy performance certificates and the more recent energy labelling system for heating and domestic hot water devices. By using these tools, the consumer will be better prepared before consulting one or more professionals.

The tools, available in English, German, Spanish, Portuguese, Dutch, and Polish, have been developed making the best use of the competencies of the different partners and with the aim to develop accurate, yet accessible information for all consumers. Briefly, they translate complex topics into clear and simple information for end-users. They aim to facilitate the dissemination of the main technical details and other relevant information required to decide on H&C systems and information on enabling factors. The following sections will present the decision-making tool, the fact-sheets, and the video developed to prepare the consumer before he/she contacts one or more professionals.

3.1 THE FRONT DECISION-MAKING TOOL

The project consortium has developed a decision-making tool which can be used as a pre-feasibility technical assessment before consulting technical experts for a more detailed analysis. As exemplified below, in a systematic process, the tool guides the consumer through some simple questions to find the best available RES-HC for his/her specific needs and conditions.

First, the end user will be asked what are his/her specific needs in terms of heating and cooling services. In the beginning, all the possible RES-HC options are available (see figures 19 and 20 overleaf).

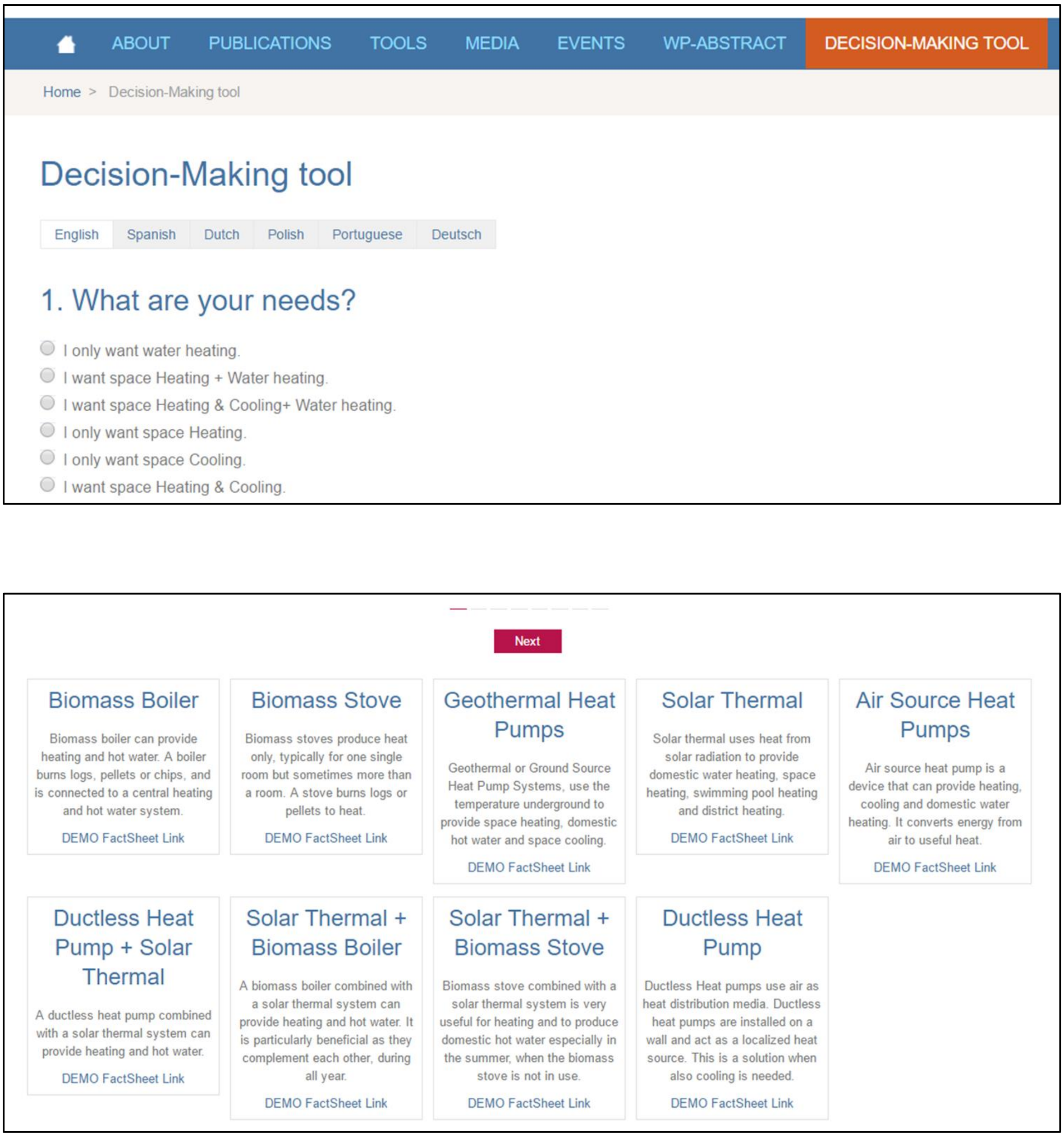


Figure 19 Step 1 of the FROnT Decision-making tool

Then, the end-user is guided through a few questions. Depending on the answers, the tool will remove the RES-HC options which are not feasible for technical reasons and display only the options which satisfy the needs of the end-user and that can be practically realised. Figure 20 depicts the example of a user willing to install RES-HC systems for space heating, space cooling and for domestic hot water.

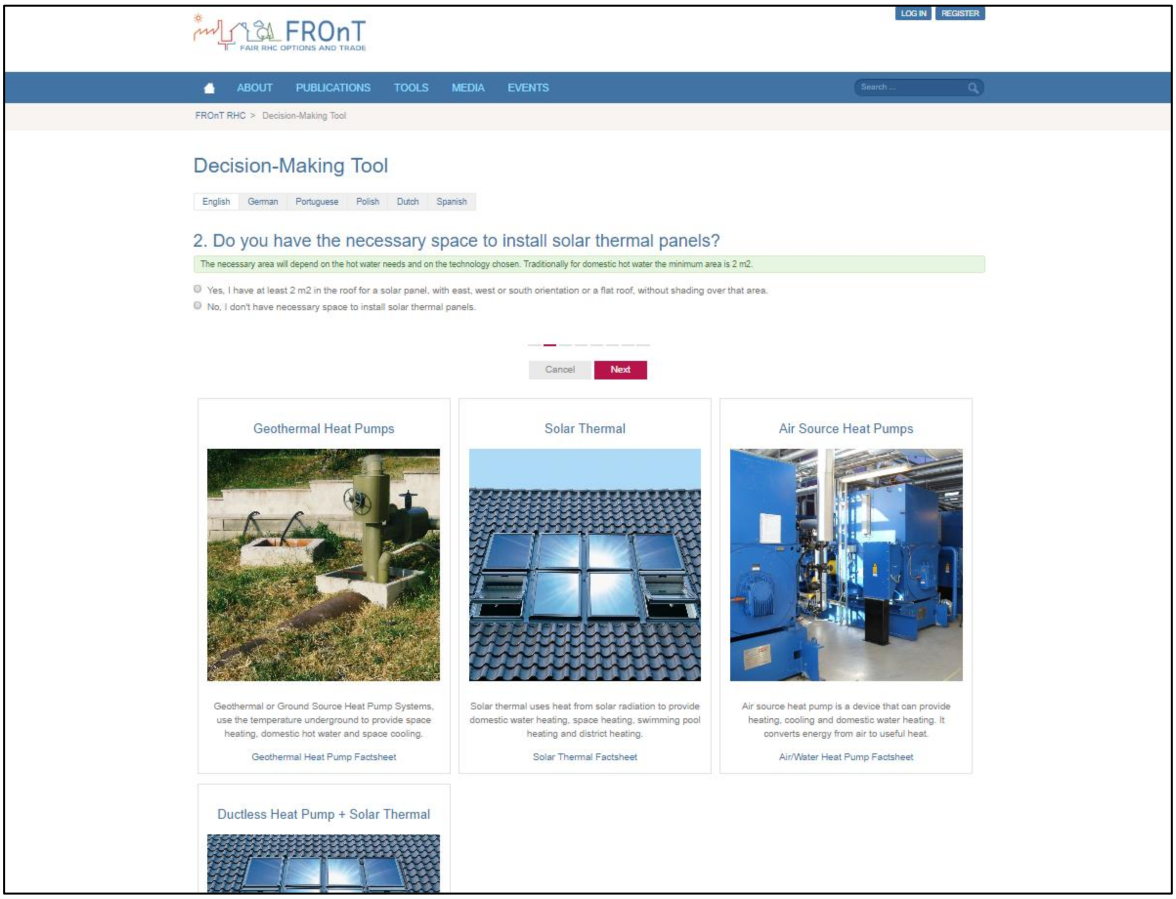


Figure 20 Step 2 of the FROnT decision-making tool - Example for space cooling-only options

At the end of the exercise, only the viable options will be displayed. The consumer is therefore informed of what are the possibilities to install a renewable option for his/her specific needs and conditions. For more information, fact sheets describing the RES-options displayed are made available. Finally, the bottom of the page displays a note providing further advice, information on energy labelling and a link to the websites of energy agencies.

3.2 FRONT FACT SHEETS & FAQs

As illustrated in the figure overleaf, specific information on existing RES-HC technologies can be consulted through the fact sheets available in English, Portuguese, Dutch, Polish, and German for the following RES-HC technologies:

- Air/water heat pump systems,
- geothermal heat pumps,
- biomass, and solar thermal.

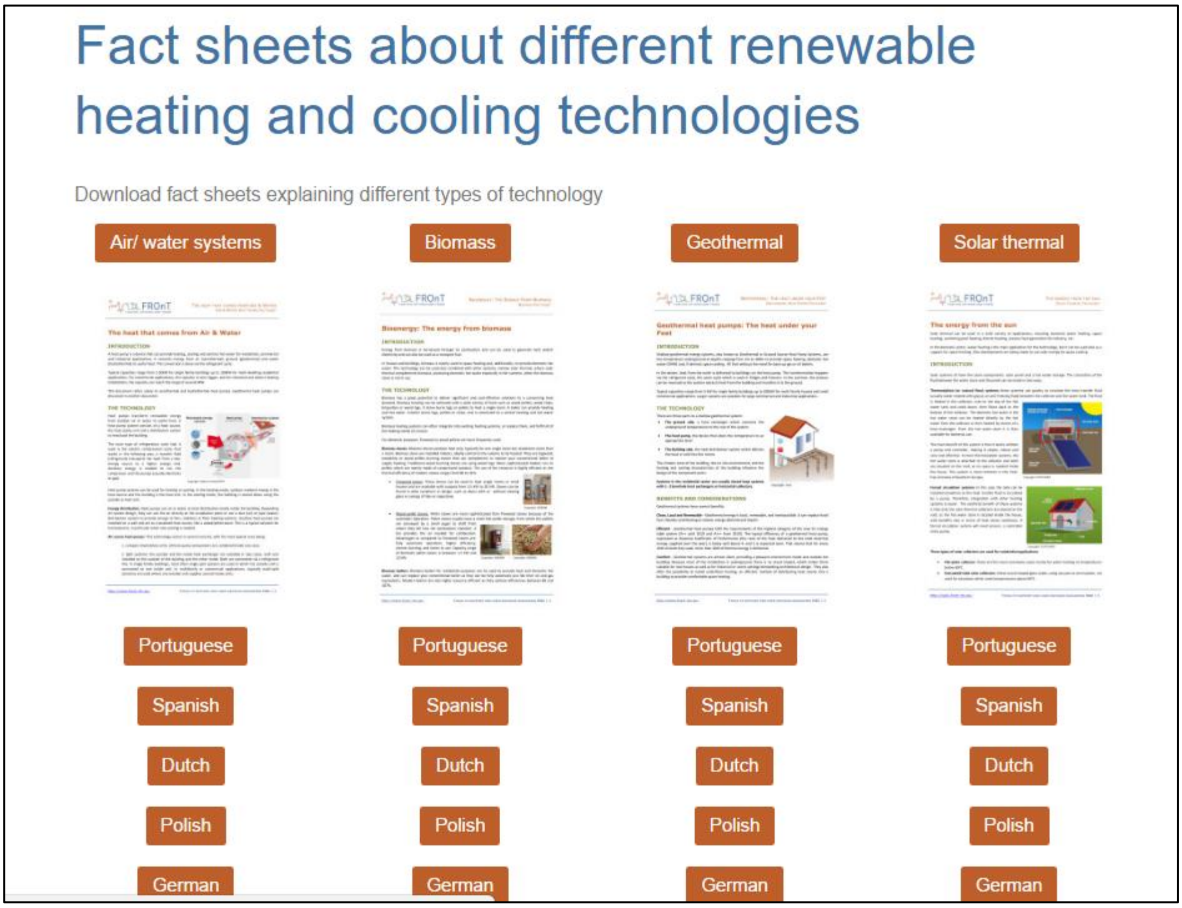


Figure 21 Fact sheets about RES-HC technologies as available on the project website

The fact sheets are addressed to households and small enterprises such as a small hotel. Additionally, FAQs for existing and new buildings were developed, providing more information to empower the consumer on its decisions before contacting professionals for more precise advice.

3.3 THE FRONT VIDEO ON RES-HC TECHNOLOGIES

To complement the above-mentioned decision-making tool and the fact sheets and FAQs, a video explaining all RES-HC technologies and possible combinations is available on the project website and on YouTube. The video provides users with clear basic information about heating and cooling services and the functioning of geothermal and air-source heat pumps, biomass stoves and boilers, solar thermal systems, and district heating using RES-HC.

The figure below presents screenshots of the video, which is available on the project website and on YouTube.

Figure 22: The FROnT video for consumers.

4. COSTS AND PRICES: TOOLS & RECOMMENDATIONS FOR TRANSPARENCY AND COMPARABILITY

An essential part of FROnT was the analysis of the relevant factors behind the determination of costs and prices for H&C technologies and the development of an online tool for end-users. This tool will facilitate transparency and comparability of H&C options; it will constitute a reliable basis for energy production value estimates that can provide objective criteria for legislation and support schemes across Europe. Likewise, an assessment of levelised costs of heating and cooling has been performed to measure up RES-HC solutions against reference fossil fuel technologies.

This section describes the methodology followed for the development of the tool and provides the guidelines for the use of the tool and an analysis of a case study.

4.1 INTRODUCTION ON COSTS AND PRICES OF HEATING AND COOLING SERVICES

To make energy projects comparable in terms of costs, a common metric used is the Levelised Cost of Energy (in this case, Heat or Cold), hereinafter referred to as LCoHC. The LCoHC is defined as the constant and theoretical cost of generating one kWh of heat/cold, which is equal to the discounted expenses incurred throughout the lifetime of the investment.

To calculate the LCoHC three main parameters must be determined:

- **Heat/cold generation** throughout the life of the system.
- **Total expenditures** throughout the life of the system, including capital expenditures, operating expenditures, decommissioning costs, and financial costs if applicable.
- The appropriate **discount rate**.

The following is an illustration of the LCoHC derivation:

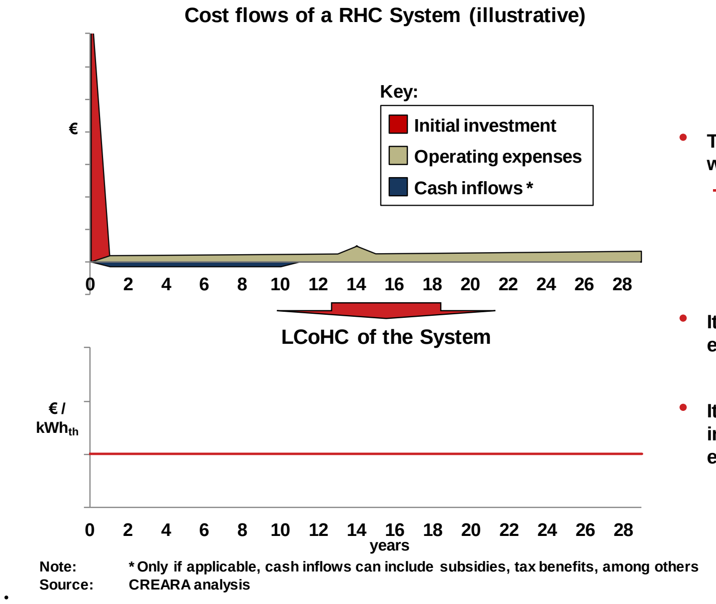


Figure 23: Illustration of costs flows of RES-HC system.

To assess the competitiveness of a given RES-HC technology, it is necessary to derive the costs of a system (accounting for its characteristics: technology, quality, size, location, etc.) and compare them with the specific cost of the alternative technology. In this sense, it should be stressed that the LCoHC remains constant throughout the life of the system. Therefore, it should be compared to the levelised cost of the alternative technology (i.e. accounting for the estimated future price increases).

In doing so, the following elements have been considered in the analysis: discount rate, investment costs, depreciation of fixed assets, replacement costs, operating costs, economic and technical life, residual value, incentives, taxes - income and Value-Added Tax (VAT), and energy generation.

The methodology developed estimates costs from the perspective of the project as a whole. As such, it excludes financing considerations within the cash flows used. The resulting mathematical derivation is presented as follows:

Equation 1: LCoHC equation (2)

$$LCoHC = \frac{\mathrm{I} + \sum_{t=1}^{T} \frac{C_t - \mathrm{S_t} - \mathrm{RV}}{(1+\mathrm{r})^{\mathrm{t}}}}{\sum_{t=1}^{T} \frac{E_t}{(1+\mathrm{r})^{\mathrm{t}}}}$$

Where:

NOMENCLA-TURE	UNIT	MEANING
LCoHC	*€/kWh$_{th}$*	Levelised Cost of Heat/Cold
T	*Years*	Economic lifetime of the investment
t	-	Year t
C_t	€	Operating costs on year t (O&M, fuels, as applicable)
RV	€	Residual Value
S_t	€	Subsidies and other incentives
E_t	*kWh$_{th}$*	Energy generated on year t
I	€	Initial investment
r	*%*	Discount rate (WACC)

Limitations of LCOE method:

One should bear in mind that the LCoHC methodology only accounts for quantifiable costs, therefore potential costs such as environmental emissions (difficult to quantify) are not included in the analysis.

However, it is a benefit worth quantifying, albeit as a separate metric. In the electronic tool two externalities have been estimated: greenhouse gases emissions and energy resources consumption

Apart from LCoHC and environmental emissions, there are financial parameters that help investors assess the attractiveness of the alternative options. The electronic tool calculates three of the most common ones:

- Net Present Value (NPV):

A positive NPV indicates that the project is profitable.

When choosing between alternative projects, that with the highest NPV should be undertaken.

- Internal Rate of Return (IRR):

An IRR higher than the required return indicates that the project is profitable.

When choosing between alternative projects, that with the highest IRR are not necessarily the most attractive one; in this case, the NPV rule should be followed.

- Payback period:

All else equal, a project is more attractive if the payback period is lower than a particular desired term.

This indicator should only be used in conjunction with another metric. It is important to note that a RES-HC project will provide savings as cash inflows (derived from its lower operational costs). Thus, to estimate these financial parameters, it is required to base the analysis on a "reference system" (i.e. the fossil fuel-driven system that is already in place or is being assessed as alternative to the RES-HC one).

ONLINE TOOL CONSIDERATIONS

This sub-section aims to provide an insight on certain aspects, approximations and assumptions considered in the methodological development of the electronic tool, and were not specifically mentioned (since they are not part of the mathematical model but part of the implementation of the tool).

The tool has been developed to estimate LCoHC for four RES-HC technologies, namely:

- Biomass
- Solar thermal
- Air-source heat pumps
- Ground-source heat pumps

Two different user types have been identified:

- Natural person: It represents private individuals.
- Corporation: It represents any user paying corporate taxes and VAT exempted.

The following table summarizes the methodological differences between the two user types, which is focused in three aspects: taxes, debt, and subsidies.

USER TYPE	CORPORATE TAX	DEBT	VAT	SUBSIDIES	TAX CREDITS
Natural person	No	No	Yes	Yes	No
Corporation	Yes	Yes	No	Yes	Yes

Table 5: User type effect on methodology.

Six locations are available in the tool, one for each FROnT partner's home country:

- Austria
- Netherlands
- Poland
- Portugal

- Spain
- United Kingdom

The location is a relevant input as it affects several constants and user inputs in the tool.

The tool is prepared to account for three different energy service demand:

- Domestic hot water (DHW)
- Space heating
- Space cooling

However, not every considered technology can satisfy all three energy services. The following figure shows the relationship between energy services and RES-HC technologies:

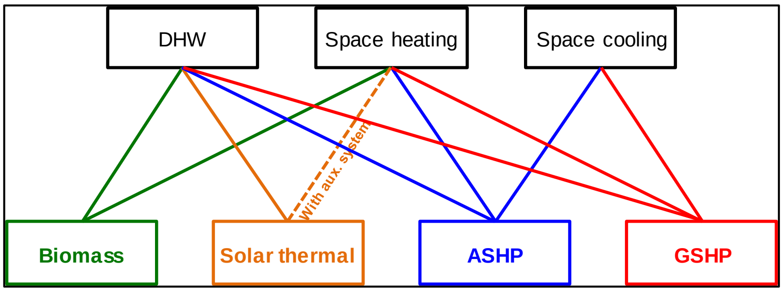


Figure 24: Energy services and RES-HC technologies.

This creates some inconsistency issues. For example, in the case where cooling is marked as a “desired service”, a reference system providing only heating will be compared with one that can provide both heating and cooling. In such case, LCoHC can be calculated using the aforementioned methodology but, on the other hand, financial parameters estimation requires some clarification:

- Financial parameters estimation is based on the cash flows of installing a RES-HC system (including savings from replacing the existing reference system).
- When additional energy services, such as cooling, are required, an estimation of its benefits should be estimated. This would require a complex analysis and its result might have great uncertainty.
- Therefore, a simplification has been done by isolating comparable energy services between the renewable energy system and the reference system.
- Mathematically, this has been translated into a current demand-weighted cash flow (i.e. RES-HC installation savings are calculated comparing the reference system costs with the RES-HC system costs). The following equation represents the current demand-weighted system costs calculation:

Equation 2: Current demand-weighted costs estimation

$$C_d = C_T \cdot \frac{E_h}{E_T}$$

Where:

NOMENCLA-TURE	UNIT	MEANING
C_d	€	Current demand-weighted costs
C_T	€	Total costs
E_h	*kWh*	Current demand
E_T	*kWh*	Total energy demand

Solar thermal energy presents another issue when dealing with energy services. Given that a solar thermal system's generation is subject to the availability of solar hours, a back-up system is often required to provide space heating (and in cases domestic hot water). Thus, apart from the LCoHC of the solar thermal energy, the tool displays the LCoHC of the so-called 'hybrid system', which accounts for the back-up system (i.e. solar thermal will be treated as a feedstock consumption reduction element in this case and not as a substitute).

SENSITIVITY ANALYSIS AND LCOHC RANGE

The tool contains a sensitivity assessment for all four technologies. The analysis has been done for all important parameters to select the most influential one and, then, use it to estimate a Max-Min LCoHC range to be presented along with the value obtained using user input values. The selection of this parameter has been done considering both its marginal effect on LCoHC and its uncertainty (i.e. its expected variation range).

4.2 ON-LINE TOOL FOR ESTIMATING THE LIVELISED COSTS OF HEATING AND COOLING

The following guidelines provide the most relevant indications to effectively use the tool for the estimation of H&C costs as developed in the framework of the FROnT project.

The FROnT on-line tool is divided into three main steps:

Step 1: General form. The user is asked to fill in two different input types:

- General information: it includes the user type selection (person or corporation), and the choice of location and energy services. Six reference locations are available (Austria, The Netherlands, Poland, Portugal, Spain, and the United Kingdom) while three energy services (domestic hot water, space heating and space cooling) can be selected.
- Details of the reference system: this section consists of several key inputs to define the current (non-renewable) system of the user.

Step 2: Renewable system definition. This step can be subdivided into three minor sub-sections:

- Selection of the RES-HC technology to be assessed. Following the energy services selection made in step 1, the user must choose among the RES-HC technologies (biomass, solar thermal, air-source heat pumps, and ground-source heat pumps) available.
- Demand estimation: information regarding daily DHW consumption and the insulation level of the user's building or his/her living area is asked in order to estimate the energy demand. However, the user can directly input it if he/she can provide a more accurate value.
- Renewable system definition. The user is asked to fill in some relevant inputs related to the RES-HC system to be installed such as initial investment, power output and efficiency of the system or the existence of applicable incentives or subsidies, among others.

Step 3: Output. The tool provides the user with three different outputs:

- LCoHC comparison: the results of the levelised costs of heating and cooling (EUR-cent/kWh) are shown in a chart, including a range representing the sensitivity analysis results.
- Financial parameters: The Net Present Value (NPV), the Internal Rate of Return (IRR) and the simple payback period are calculated.
- Environmental parameters: the tool analyses whether GHG emissions and energy commodities consumption are reduced by the replacement of the conventional system or not.

The following sections study the three steps defined, providing screenshots from the final version of the tool and additional guidance and information when relevant.

STEP 1

Step 1 compiles both user-specific inputs and reference system data.

The user type selection has an incidence on the subsidies and tax credits considered in the analysis, as well as in the inclusion of the corporate tax rate or the VAT in the calculations.

Regarding the energy services selection, three options are available for domestic hot water and space heating: 'I have and I want', 'I do not have but I want' and 'I neither have nor want'. 'I have and I want' means that the current system is providing the energy service and that it should be included for the renewable system. 'I do not have but I want' means that the energy service is not being provided by the reference system but should be included for the renewable system, and 'I neither have nor want' means that the energy service is neither available nor desired.

For cooling, however, only 'No' and 'I want' are available. Therefore, the tool does not consider conventional systems providing cooling services but accounts for the cooling production of some of the RES-HC technologies analysed, such as air-source and ground-source heat pumps.

The energy services selection will affect the availability of the RES-HC technologies to be assessed in step 2. As shown in the figure below, guidance (black box) is provided to the user to ease the selection.

The reference system subsection includes inputs such as energy commodity prices or reference system efficiency or power output. Both guidance and default values are included in the tool to facilitate the task. Default values (shown in grey in Figure 25) can be improved by overwriting in case the user can provide a more accurate value.

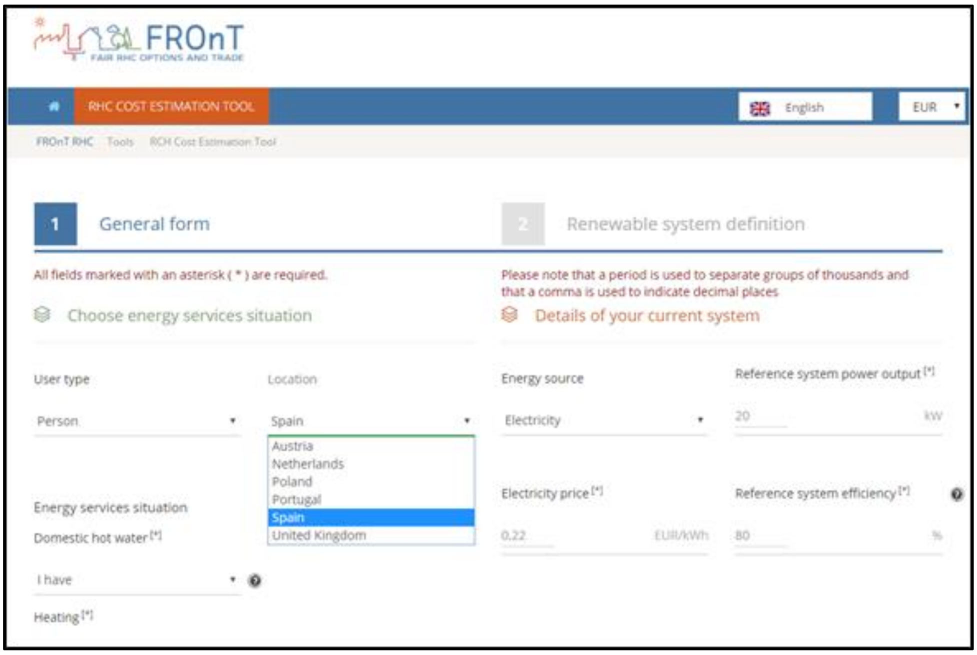


Figure 25: Step 1 of the FROnT cost evaluation tool

STEP 2

The RES-HC technology selection is made through the interactive diagram shown in the figure below. When selecting a RES-HC technology, the diagram shows the energy services that specific systems can provide.

For those cases where the energy services selection made in step 1 does not match the RES-HC technology's features, that specific technology will be disabled. For instance, a user selecting 'I do not have but I want' for cooling services will not be allowed to choose neither biomass nor solar thermal, although he will be able to note what energy services those technologies can provide through the diagram.

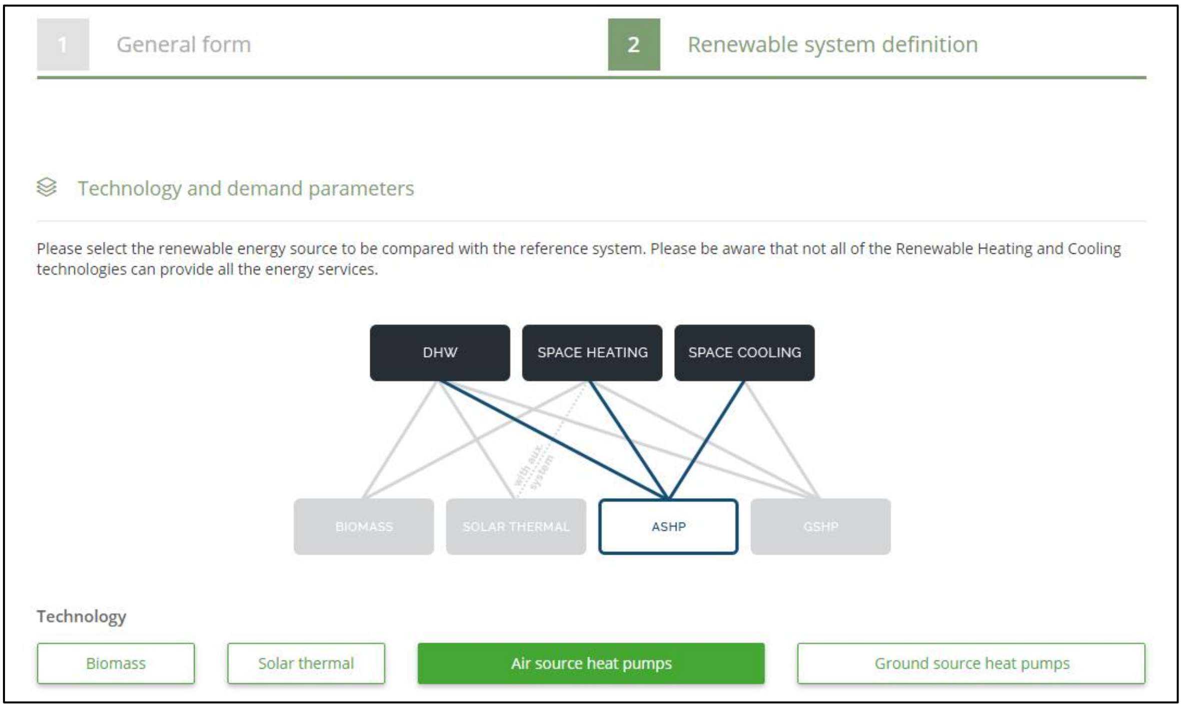


Figure 26: Step 2 of the FROnT cost evaluation tool: RES-HC technology selection.

The next subsection within step 2 relates to the energy demand estimation.

In doing so, the tool first asks the user to input the total daily DHW consumption. Specific guidance for each of the 6 locations considered is provided. Users should note that while the guidance provided is expressed in liters/person/day, the value to be inserted is measured in liters/day.

To estimate the heating (and cooling, if applicable) demand the user fills in the living area of his house-hold and selects an insulation level from three different options: good, average and low. While no guidance is given for the former input, the selection of the insulation level is accompanied by a help message.

The tool estimates the energy demand to be included in the calculations from those inputs. However, advanced users can improve the result by overwriting with a more accurate value, as shown in the figure overleaf.

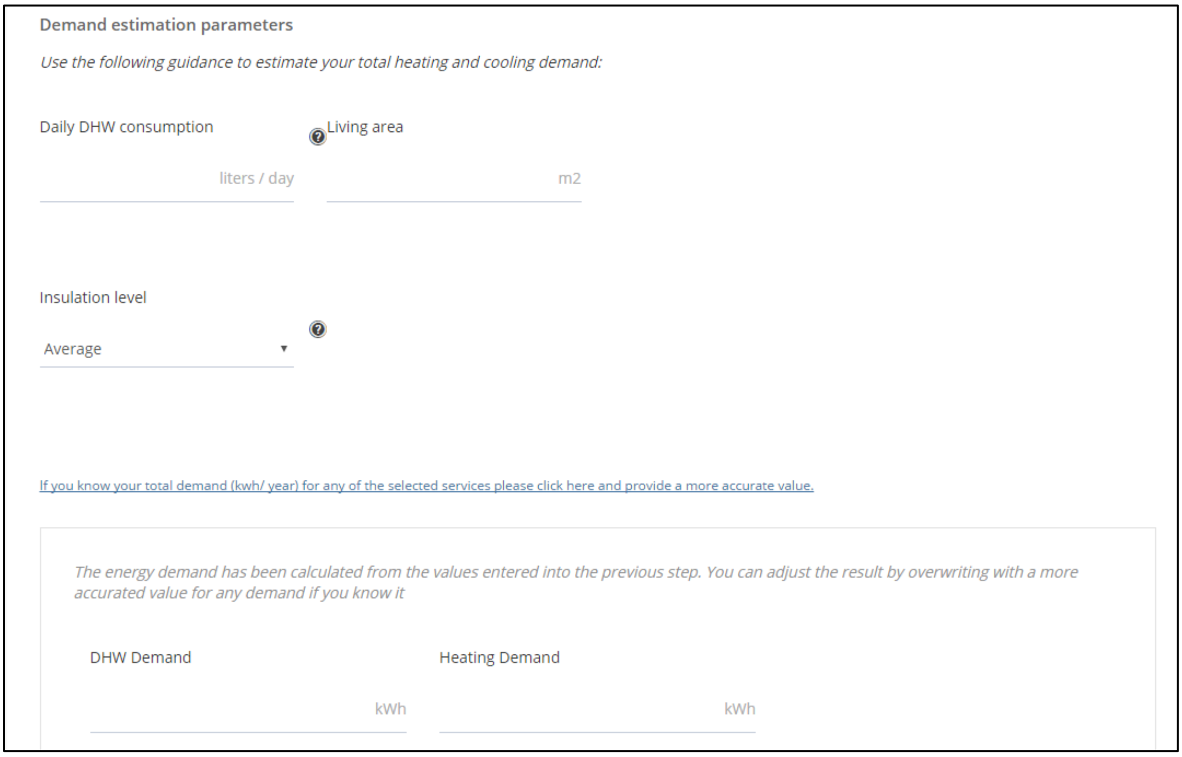


Figure 27: Step 2 of the FROnT cost evaluation tool: Demand estimation.

To finalize step 2, the user should input some specific data related to the RES-HC technology selected for the comparison.

Thus, inputs such as operation and maintenance costs, the initial investment or the RES-HC system's power output should be filled in.

Guidance and interactive default values, including differences among countries, are provided when applicable.

This section also allows the user to account for subsidies and incentives (based on investment or capacity installed, among others) to RES-HC technologies in the analysis. Country-specific guidance on existing incentives is provided.

The following illustration presents an example of some of the inputs to fill-in for the analysis of an air-source heat pump:

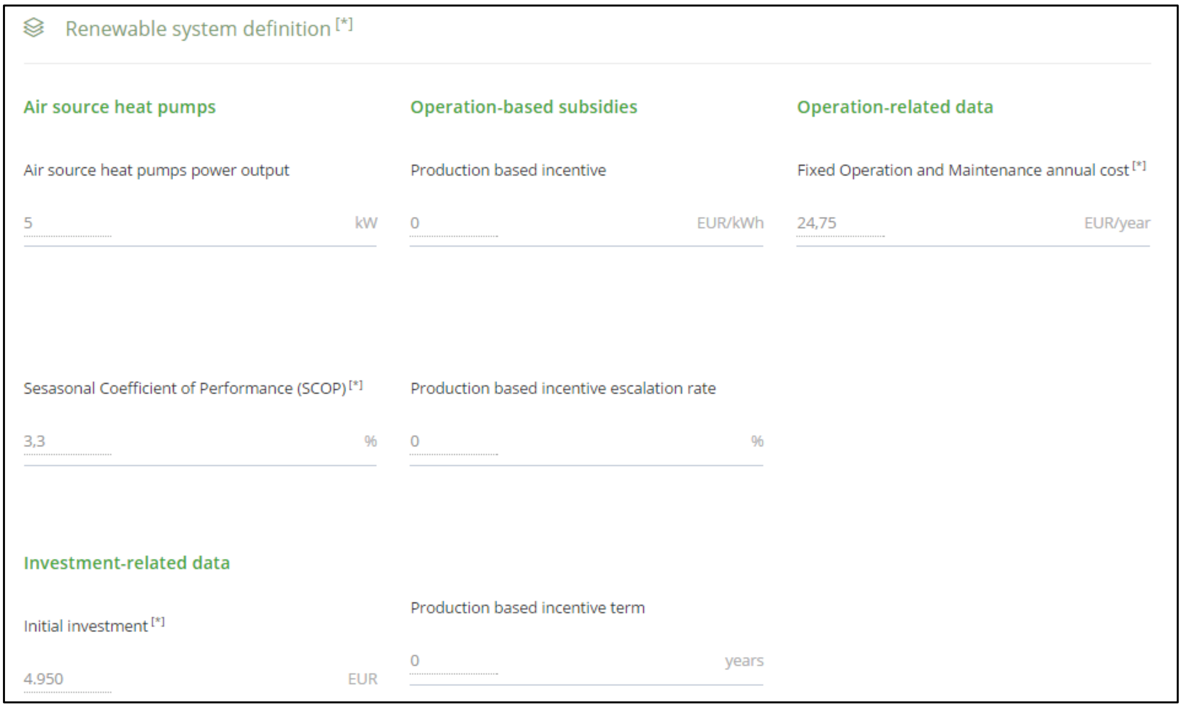


Figure 28: Step 2 of the FROnT cost evaluation tool: Renewable system inputs

OUTPUT

Three different outputs are calculated:

- LCoHC comparison (including range and residual value)
- Financial parameters
- Environmental parameters

Specific and intuitive guidance is provided for each of the three categories. Thus, for instance, an explanation of the residual value, the reduction of GHG emissions or of the economic implications of the replacement of the conventional system by the RES-HC technology is given.

The figure overleaf provides an example of the output interface:

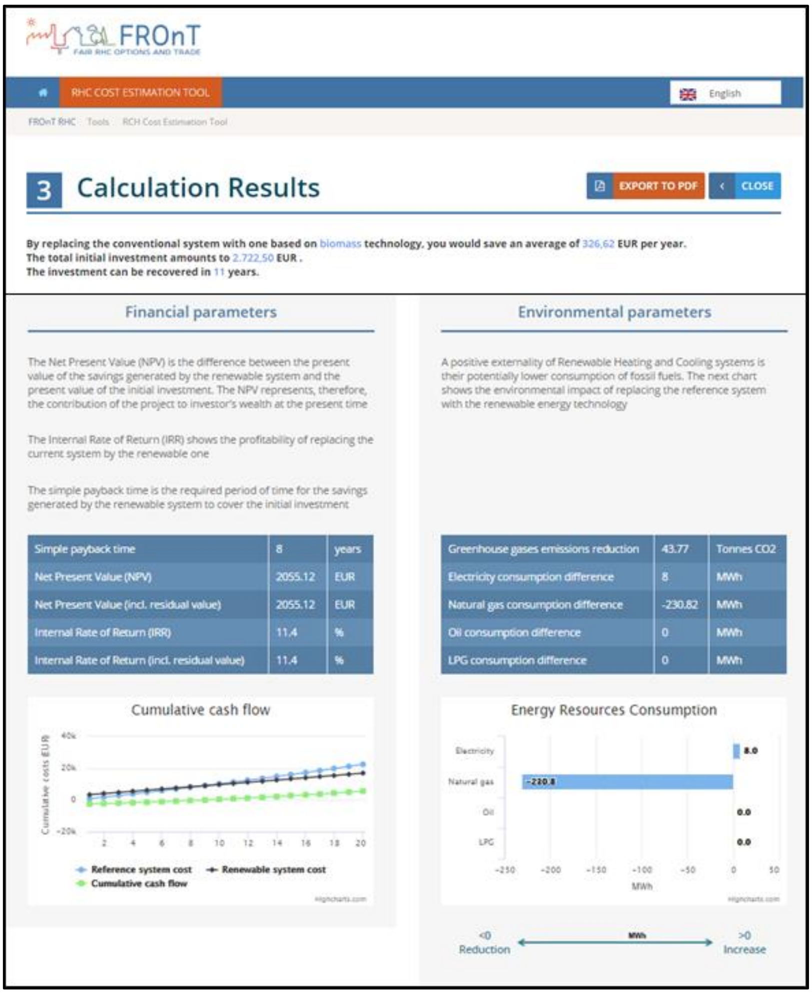


Figure 29: FROnT cost evaluation tool: Output

4.3 CASE STUDIES: ASSESSMENT OF LEVELISED COSTS OF HEATING AND COOLING

The main objective of this section is to show examples of how the levelised costs of heating and cooling for the four renewable technologies is calculated in the tool in four reference locations: Athens, Madrid, Stockholm and Würzburg.

Two case studies have been selected for each of the four technologies considered: biomass, solar thermal, and air-source heat pumps, while one case is analysed for ground-source heat pumps. The resulting cases are the following:

- **Biomass:**
  - Domestic hot water and space heating in a refurbished multi-family house in Stockholm
  - Domestic hot water and space heating in a refurbished single-family house in Würzburg
- **Solar thermal:**
  - Domestic hot water and space heating in a new built single-family house in Athens
  - Domestic hot water in a refurbished single-family house in Würzburg
- **Air-source heat pumps:**
  - Domestic hot water and space heating in a new built single-family house in Stockholm
  - Domestic hot water, space heating and cooling in a refurbished single-family house in Madrid
- **Ground-source heat pumps:**
  - Domestic hot water and space heating in a refurbished single-family house in Würzburg

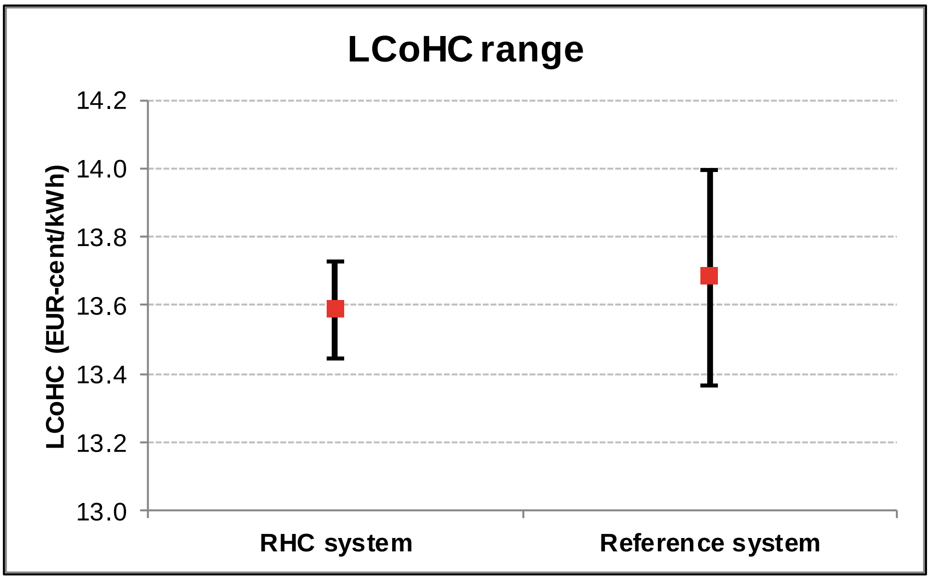
Three different outputs have been calculated for each case study:

- LCoHC output: the Levelised Cost of Heating and Cooling is provided for both the renewable and the reference (current) systems.
- Financial parameters output: the simple payback time, the Net Present Value and the Internal Rate of Return are calculated for all the case studies. In addition, the cumulative cash flow is represented in a plot, where the payback time can be graphically identified.
- Environmental parameters output: GHG emissions reduction is provided for all the case studies, as well as the energy resources consumption difference between the reference system and the RES-HC technology.

An example of one of the seven case studies analysed is described below as a reference:

CASE-STUDY: GEOTHERMAL HEAT PUMP PROVIDING DOMESTIC HOT WATER AND SPACE HEATING IN A REFURBISHED SINGLE-FAMILY HOUSE IN WURZBURG

Renewable LCOHC	13.59	EUR-cent/kWh
Ref. system LCOHC	13.69	EUR-cent/kWh



The analysis shows that the LCoHC of an 8.9 kW Geothermal or Ground-source heat pumps (GSHP) providing DHW and space heating in Würzburg equals 13.59 EUR-cents/ kWh, while the reference system's (a 7.5 kW oil boiler) LCoHC is 13.69 EUR cents/ kWh.

GSHP are therefore competitive against fossil fuel systems in Würzburg, as the cost of generating one kWh of heat with GSHP is lower than the cost of doing so with an oil boiler. In addition, the uncertainty associated to the 'reference' system is higher, as reflected by the longer range in the chart.

FINANCIAL PARAMETERS

Simple payback time	12	years
NPV	133	EUR
IRR	5.1%	%

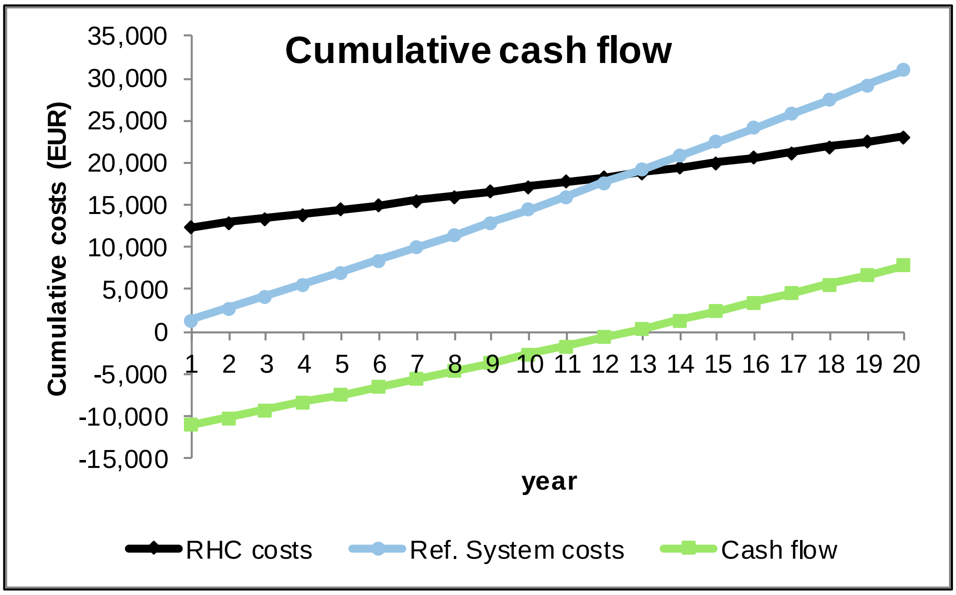
The three financial parameters analysed show that the replacement of the oil boiler by the ground-source heat pump is profitable in Würzburg.

The Net Present Value indicates that investor's wealth would be increased by 133 present euros after the 20 years of technical and economic lifetime considered in the analysis.

The Internal Rate of Return provides a more intuitive indication on the profitability of the project. Thus, by replacing the reference boiler by the renewable technology, the investor would obtain a profitability of 5.1% (for a required return of 5%).

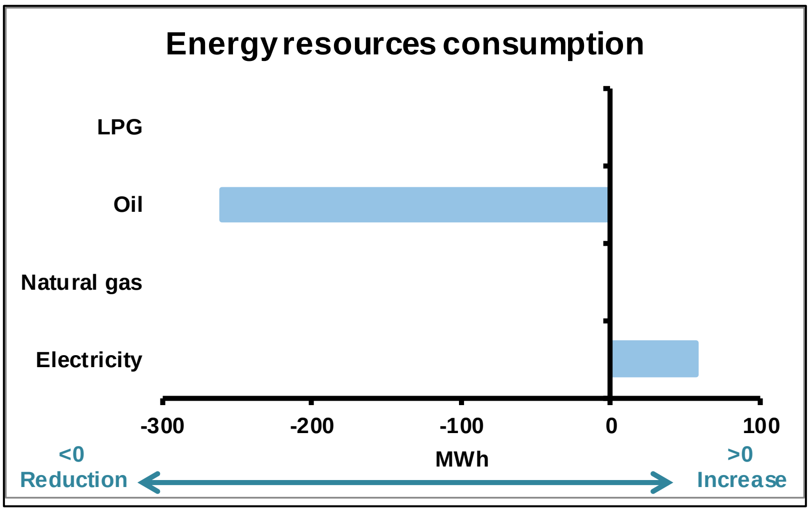
Finally, the simple payback time shows that after 12 years the savings generated by the ground-source heat pumps would cover the initial investment assumed by the investor.

The chart below shows the cumulative cash flow of the project, providing another insight on the payback period:



ENVIRONMENTAL PARAMETERS

GHG emissions reduction	42	tonnes CO2
Electricity consumption difference	58	MWh
Natural gas consumption difference	0	MWh
Oil consumption difference	-261	MWh
LPG consumption difference	0	MWh



The replacement of the oil boiler by the ground-source heat pumps would lead, in addition, to a reduction in GHG emissions by 42 CO_2 tonnes. Oil consumption would be reduced by 261 MWh as well, while the increase in the electricity consumption associated to the GSHP would only amount to 58 MWh given the higher efficiency of the renewable energy technology.

5. STRATEGIC POLICY PRIORITIES AND BEST PRACTICE FOR SUPPORT SCHEMES

With current legislative frameworks and market conditions across the EU, it is very difficult for RES-HC technologies, such as biomass, solar thermal, geothermal and heat pumps, to compete with installations using conventional fuels. However, these solutions are necessary if we want to decarbonise the heating and cooling sector, which represents 50% of EU's total energy consumption.

To allow RES-HC to become competitive and deploy significantly on the heating and cooling market, more action is needed to drive consumers' choices towards renewable solutions, and financial tools need to be efficiently set up to support this uptake.

This chapter starts with an analysis of why RES-HC should be supported and with summarising the main barriers to RES-HC deployment and challenges for policy-makers. Then, it addresses the identified barriers with policy recommendations at EU, national and local levels. Finally, it presents the work on key successful factors for establishing support schemes and the related FROnT manual of good practices. The set of recommendations developed address EU, national and local policy-makers.

5.1 WHY SUPPORTING RES-HC TECHNOLOGIES?

The primary objective of public intervention in the private domain is to correct market failures, thereby promoting the general interest. In the energy sector, market prices for the consumer do not fully capture negative externalities from fossil fuels such as climate change. Similarly, markets do not automatically reflect all the positive externalities from sustainable renewable energy sources, including the creation of more stable jobs, allowing for cleaner air, reducing economic leakage from Europe towards third countries due to fossil fuel imports.

Economists tell us that the most efficient way to internalise negative externalities of energy conversion would be through taxation or a cap and trade system (e.g. the EU Emissions Trading System). Yet, they also recognise that this adjustment alone may not be sufficient to develop the wide range of technologies at the speed needed to decarbonise the economy by mid-century[3]. This is because other market failures occur, including knowledge spill-overs in R&D, time-inconsistent preferences, information asymmetries, non-competitive markets, principal–agent problems. Additionally, despite their lower operating costs, most renewable technologies require higher initial investment which hampers their widespread deployment. This is the main reason some form of support is needed to help accelerate the market uptake of RES-HC technologies that are not yet competitive under current market conditions. Support is also intended to help increase confidence on

[3] Linares P., Batlle, C., Perez-Arriaga, I. (2013), Environmental Regulation. In Perez-Arriaga, I. (ed.), Regulation of the Power Sector, London, 2013, 539-579.

the RES-HC technologies and, ultimately, contribute to widely affordable and sustainable heating and cooling solutions to European citizens and businesses alike.

5.2 BARRIERS IDENTIFIED

Two of the main barriers to the deployment of RES-HC identified by the survey on end-user side (see chapter 2 of this report) are, still, the poor consumer awareness on the availability of RES-HC technologies and the higher initial investment cost compared to fossil installations and the financing difficulties linked to it.

- Poor awareness, quality, and engagement: the survey shows that awareness of all RES technologies, and especially the benefits they provide to the consumers and the society is very low in all sectors: residential, non-residential, and industrial sectors. This, together with the sometimes-necessary structural changes and the need of approval by neighbours or managers, represents an important barrier to the deployment of RES-HC technologies. This poor awareness is also a reality among European and national policy-makers and represents similarly an important barrier as RES-HC technologies are often not properly identified when policy making and therefore not properly incentivised. Furthermore, RES-HC installations not properly installed or not properly used are underperforming and their benefits are therefore not maximised. This deteriorating the public perception of these solutions that should be properly installed (quality control) and regularly maintained (performance assurance).

- The financing challenge: RES-HC technologies' investment costs might be higher than traditional fossil fuel equipment. Even if the total economic savings throughout the lifetime of the RES-HC equipment is greater than the fossil equipment, this higher initial cost is a true barrier and represents the main reason for rejecting RES-HC technologies, at least in the residential sector.

In addition, project partners have identified two additional barriers on the supply side of RES-HC installations: the lack of strategic priorities in EU and national policy-making and unfair market conditions.

- Lack of strategic priorities and governance: Inconsistencies can be noticed between different pieces of current legislation but also between short and long-term objectives. This reflects a lack of overall long-term strategy with short and long-term priorities. It is translated into counter-productive legislation, leading to lack of stability and trust that are hampering the deployment of renewables.

- Persistent market failures: it is currently impossible to compare the cost of fossil and RES installations, if, in most EU Member States, fossil-based heating appliances (e.g. condensing gas and oil boilers) remain subsidised, fossil fuel prices remain regulated and carbon is not consistently priced. A valid cost-efficient approach requires a pre-existing state of perfect competition. This is not the case today. It is therefore challenging for RES-HC technologies – despite their consistency with EU climate objectives – to develop and deploy in such an unfair market. In that respect, EU institutions are encouraged to work on a new heat market design, complementing the work on the power and gas markets.

The FROnT surveys revealed several additional barriers impacting upon increased deployment of RES-HC technologies, covering both technical and perceived consumer obstacles. However, the project consortium has decided to focus on these four key barriers considered as the most important ones. The following section summarises the proposed policy recommendations to EU, national or local policy-makers to overcome these barriers.

5.3 CHALLENGES FOR POLICY-MAKERS

In devising policies for RES-HC, it is necessary to consider the following factors:

- **Investors and end-users are very diverse**

They include:

- Large and small-scale utilities;
- Large and medium-sized industrial and commercial users;
- Energy Service Companies (ESCOs);
- The public sector;
- Commercial property developers;
- Social housing associations;
- Millions of private house owners and tenants.

Each of these stakeholders has different investment priorities and perceptions of risk. Distinguishing among industrial, commercial, public, and household investors is likely to be more successful than a "one-size-fits-all" policy.

- **RES-HC interaction with energy efficiency**

In general, there are many synergies between RES-HC and energy efficiency: for instance, the integration of RES-HC is facilitated in energy efficient buildings that have low-temperature heating systems. As for energy efficiency measures, building regulations strongly influence the deployment of RES-HC (e.g. through minimum energy performance, minimum requirements of renewable energy use, etc.). Additionally, investors in RES-HC may be the same as for energy efficiency (e.g. building owners and the industry sector), which may lead to some degree of competition, especially when direct competing technologies (e.g. condensing oil and gas boilers) are promoted within the framework of wider energy efficiency programmes.

In designing a support scheme, the wider regulatory framework in place should therefore be considered, notably building regulations. The new /reformed support scheme should be in line with short, medium, and long-term objectives.

- **RES-HC technologies are heterogeneous and have different levels of maturity**

RES-HC technologies can vary significantly in terms of scale, value chain, risk-profile, and applications (See Annex I for more information). Additionally, they are not all at the same level of development and commercial market uptake and their maturity level may vary from one location to another.

Obviously, supporting a promising niche technology like solar cooling in Southern Europe is different from promoting bioenergy in forests-rich Nordic countries with renewables policies already in place for more than 40 years. In its 2011 study "Deploying Renewables: Best future policy practice"[4], the International Energy Agency advises policy makers to adjust priorities as renewables' deployment grows, taking a dynamic approach in the different phases of inception, take-off, and consolidation (see figure 30 overleaf for an adaptation to the H&C sector).

Widespread diffusion requires time and efforts. While the first attempts to influence the introduction of a new technology may fail, continuous support is needed to overcome initial shortcomings. The choice of the financial instruments, which is eventually a matter of national preference, could be differentiated according to market maturity and the technical characteristics of each technology (e.g. cost, size, risk profile, project lead time). This would ensure stability for newer technologies and a more cost effective deployment of a sufficiently broad portfolio of renewable energies.

[4] IEA/OECD, Deploying Renewables 2011 – Best and Future Policy Practice, IEA Publications. Available online: https://www.iea.org/publications/freepublications/publication/deploying-renewables-2011.html

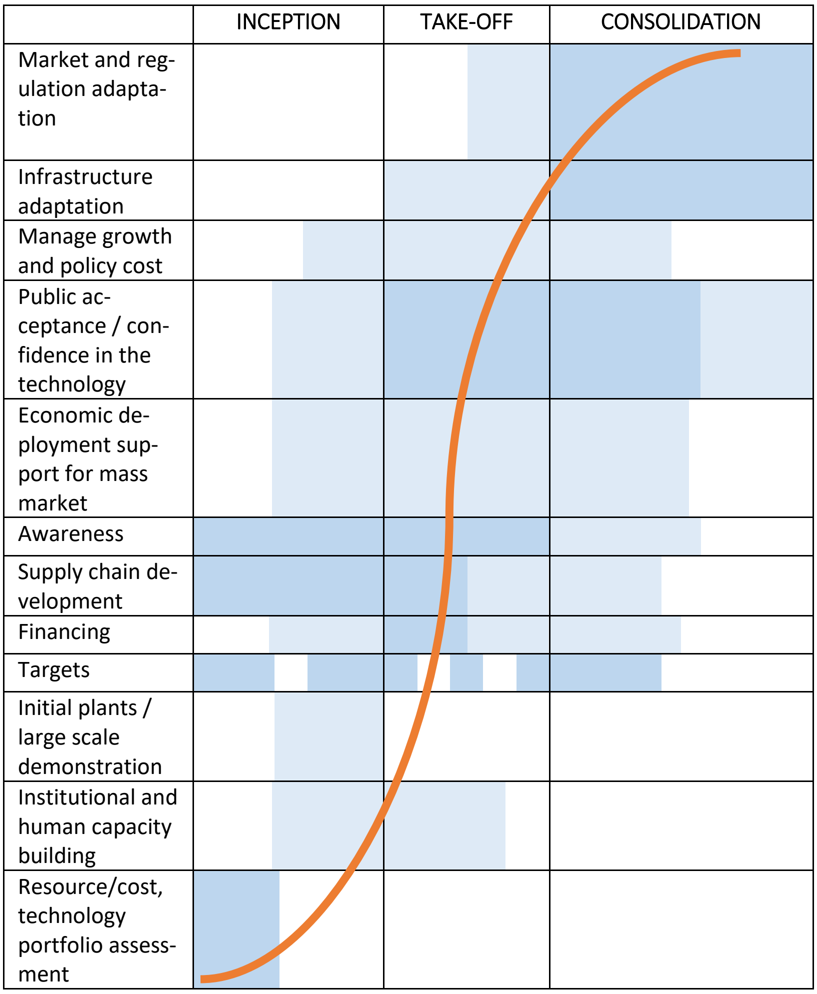


Figure 30: Deployment journey of RES-HC technologies. Adapted from IEA/OECD (2011).

5.4 STRATEGIC POLICY PRIORITIES

The policy recommendations developed by FROnT to rapidly increase the share of RES-HC are summarised below and in the table overleaf.

STRATEGIC PRIORITIES AND GOVERNANCE

Overall strategic priorities need to be established in the first place to give a clear and coherent signal to markets and drive consumers/local authorities choices towards cleaner solutions in the H&C sector. More specific recommendations are:

- **Develop a long-term decarbonisation roadmap, including plans and milestones for 2030 and 2050**

The EU has set itself the objective of reducing greenhouse gas emissions by 80-95% compared to 1990 levels by 2050. To achieve this goal, significant investments need to be made in renewable energy, energy efficiency and grid infrastructure. Investments in H&C infrastructure are made for a period ranging from 15 years for individual heating systems to 60 years for larger plants and infrastructure. For this reason, policies that create a stable business climate and promote investments in the decarbonisation of the H&C sector through energy efficiency and fuel switch to renewables must begin today and be finalised by 2050. It is therefore crucial to ensure consistency of current and upcoming legislation with long-term objectives.

National, regional, and local governments have an important role to play in ensuring that the EU common long-term objectives are met. National long-term strategies with short, medium, and long-term plans and milestones should be developed, including strong measures and financing mechanisms available.

Strategic priorities and governance	Market conditions	Awareness, quality and engagement	Financing
Develop a long-term decarbonisation roadmap, including plans and milestones for 2030 and 2050	Phase out fossil fuels	Disseminate information on RES-HC technologies available through communication campaigns targeting professionals, consumers and citizens, and promoting energy labelling	Understand the need to finance RES-HC solutions until the market conditions have been fixed
Develop consistent and mutually supportive legislation	Internalise negative externalities from fossil fuels	Improve quality of the training, qualification and engagement of professionals	Establish well-designed support schemes available for RES-HC to reduce costs and foster cost-efficient deployment of RES-HC
Pursue full decarbonisation of the building sector and support RD&I	Establish off-budget funds from carbon pricing mechanisms	Streamline administrative procedures related to support schemes	Increase awareness of existing support and financing opportunities
Develop policies to trigger renovation of existing buildings		Improve visibility through energy performance certificates of buildings (EPCs)	Have appropriate and streamlined administrative procedures related to permitting/authorisation for all RES technologies
Develop favourable building codes		Engage stakeholders in dialogue when defining policy	Promote demand aggregation at local level
Improve the parameters of the modelling used for projections of heating and cooling		Promote district heating and the use of RES in DH, and block heating	Raise the involvement of private financial institutions to develop new financial tools
Establish EU-wide definition and methodologies to take cooling into account in building codes, national statistics, and support schemes			

- **Develop consistent and mutually supportive legislation**

Consistency among short and long-term objectives is crucial. Consistency across the different political objectives (energy efficiency, development of RES and GHG emissions reduction) is also important for policy objectives to be delivered in an effective manner. As pointed out by the 2016 IRENA report "Renewable energy in cities" (p. 13) "it is important to avoid investment in marginally more efficient technologies, so as not to create a "technology lock-in". For example, replacing an old oil-fired boiler with one that is slightly more efficient (instead of a significantly more efficient heat pump) can inhibit efficiency improvements for many years, given the long lifetime of the equipment".

The European institutions are revising the EU legislative framework to reach EU 2030 and 2050 climate and energy objectives. In this regard, policy-makers should avoid provisions that are locking-in technologies non-compatible with the decarbonisation objective and that hamper the development of renewable energy technologies, especially in the heating and cooling sector. In the case of Article 7 of the EED, eligible savings should be clarified to avoid the interpretation of energy efficiency legislation in a way that would allow subsidies for any fossil fuel technologies.

- **Prioritise action on buildings**

It is important to understand the potential that lies in the building sector to decarbonise the H&C sector. Indeed, RES-HC technologies such as efficient heat pumps, solar thermal, biomass and geothermal installations are today mature and available to deliver. Fully decarbonising the building sector is technically feasible today. Political will and market conditions are missing.

For decarbonising the building sector, it is crucial to reduce energy demand of buildings through energy efficiency measures and simultaneously increase the share of renewable energy sources in the remaining energy consumption. This will allow maximising energy efficiency and RES synergies and decarbonise the building sector cost-effectively.

To this end, the project recommends that national government set long-term national refurbishment strategies with mechanisms triggering renovation cycles by 2050. Additionally, for nearly Zero Energy Buildings (nZEB) the definition should extend the "very significant amount of RES" to an increasing "minimum requirement of RES" in new buildings. Furthermore, on top of primary non-renewable energy, the definition of nZEB should include a CO_2 emissions indicator.

- **Improve the parameters of the modelling used for H&C projections**

Energy models should identify and consider new technological trends and look more in details into the non-ETS sectors, including buildings and small enterprises. A complete assessment of economic and societal benefits of fuel switch in H&C would also be useful as it would highlight not only the environmental benefits of the different policy options but also their impact in terms of economic growth, job creation, energy dependency, energy poverty, etc.

- **Establish a EU-wide methodology to calculate cooling from renewable sources**

Although not visible in statistics, demand for cooling is on the rise everywhere in Europe, especially in the tertiary sector. Today, cooling from renewable energy technologies is often neither recognised in legislation nor captured in statistics. And when renewable cooling is calculated at the national level, this is not accounted at EU level. In the revised RES Directive, for instance, there is a need to develop a definition and a methodology to consider renewable cooling.

MARKET CONDITIONS

If EU Member States want to achieve their long-term energy and climate objectives, fossil fuels must be phased out. A three-step approach is recommended for the heating and cooling sector:

- Stop direct and indirect subsidies to fossil fuels
- Ban fossil fuels in new buildings
- Phase out fossil fuels in existing buildings

- **Stop direct and indirect subsidies to fossil fuels and related equipment**

The European Council conclusions of 22 May 2013 are urging Member States to phase-out fossil fuel subsidies and to focus incentives on non-fossil fuel based heating and cooling systems. At the same time, new fossil fuel energy production (including the second largest fossil-fuel power station in the world: Belchatow lignite-fired power station in Poland) are subsidised under the ETS Directive (Article 10c) in the name of modernising electricity generation in certain member states. The same situation takes place under the Energy Efficiency Directive (EED). Individual fossil fuels condensing boilers are subsidised on the name of energy efficiency.

The Council conclusion to phase-out fossil fuel subsidies should prevail and consistency across EU legislation is the only way to reach long-term decarbonisation goals. To carry out a consistent approach in the phasing out of fossil fuels, the decarbonisation of the heating and cooling sector must also consider the CO_2 content of electricity-driven heating appliances. The process of decarbonisation of the electricity and of the heating and cooling sectors must therefore run in parallel to avoid the replacement of carbon intensive fossil fuels for heating with carbon intensive or inefficient electric heaters.

Vulnerable consumers should be part of the energy transition, and deserve special attention. Different support levels to switch to green heating and cooling solutions, adjusted on the basis of the income level of households should be established in order to address energy poverty cost-efficiently.

- **Phase-out fossil fuels in buildings**

Policies are necessary to foster the energy transition. A combination of ‘carrots’ (financial supports) and ‘sticks’ (clear and ambitious regulations) seems the most appropriate approach to achieve a decarbonised energy system. This would ensure a coherent regulatory framework and provide investment security for the private sector.

As the “stick”, legislation forcing a gradual phase out of fossil fuel heating installations should be put in place in each Member States. It could start with new buildings where it is easier to integrate a RES-HC installation in the design phase of the house and where the cost of the installation is diluted in the whole construction cost. Then it could be equally applied to existing buildings with a long-term renovation strategy. In this regard a positive example comes from Denmark where, since 2013, the installation of oil-fired boilers and natural gas heating is banned in new buildings. Since 2016, the Danes have also banned the installation of new oil-fired boilers in existing buildings in areas where district heating or natural gas is available.

- **Internalise negative externalities from fossil fuels in non-ETS sectors**

The EU Emission Trading System (ETS) covers combustion installations with a rated thermal input above 20 MW. In addition, emissions from the upstream electricity generation (used for heating 12%) is also regulated under the EU ETS. The total heat supply which is covered by the EU ETS is therefore estimated to be around 25% of the total heat supply. The rest of the energy use in the heating sector falling to the non-ETS sector is generated by natural gas (44%), petroleum products (17%), coal (3%), and renewables (11%).

In sectors outside ETS, negative externalities generated by the use of fossil fuels are not internalised, which creates a burden for the society. In response, the 'Polluters Pays Principle' should be adopted in these sectors through the introduction of a carbon tax or other levies. This system would have the advantage to put pressure on the polluting sectors. Indeed, CO_2 emissions having a price will indirectly support alternatives, including energy efficiency and the switch to renewable energy.

AWARENESS, QUALITY, AND ENGAGEMENT

- **Disseminate information on RES-HC technologies available through communication campaigns targeting professionals, consumers, and citizens and promote energy labelling**

To address the lack of awareness, there is a need to reinforce the Renewable Energy legislation and improve implementation at national and local level. The current RES legislation requires Member States to ensure that information on support measures and on benefits, costs and energy efficiency of equipment is available, and that with the participation of local authorities, Member States shall develop information, awareness raising, guidance or training programmes.

Education can also play an important role in raising awareness. Local authorities should be incentivised to organize communication and educational campaigns, considering local specificities and available resources.

Another way to inform and empower end-consumers is to promote clear and efficient energy labelling on heating systems. Support should be conditional, and only granted to best performing heating systems.

- **Improve quality of training, qualification, and engagement of professionals**

Shortage of trained professionals (architects, installers, and builders) has been mentioned as one of the challenges and barriers in the implementation of the EU Heating and Cooling Strategy (European Commission, 2016). Training of professionals was referred to as one of the tools for the improvement of the strategy objectives in the building sector.

To increase professionals' awareness on RES-HC installations, and indirectly end-consumers' awareness, the number of installers trained and the quality of these trainings should be largely improved. RES-HC technologies being new and innovative technologies, a high-quality installation is crucial to maximise its economic and environmental benefit, and therefore building a positive reputation for the technology.

To do so, the RES Directive referring to certification and qualification schemes should be reinforced and better implemented by member states: Member States shall ensure that certification schemes or equivalent qualification schemes become or are available by 31 December 2012 for installers of small-scale biomass boilers and stoves, solar photovoltaic and solar thermal systems, shallow geothermal systems and heat pumps.

Imposing certification to installers of renewable equipment might have an adverse side-effect of diminishing the supply of renewable energy equipment in buildings due to the extra burden imposed. The FROnt consortium rather recommends creating a market for RES-HC technologies through a set of policy measures and building codes and a principle of mutual recognition between EU Member States, that would incentivise installers voluntarily receive training in order to supply a growing demand for RES-HC installations.

- **Improve visibility through energy performance certificates of buildings (EPC)**

Today, EPCs of existing buildings include recommendations for future measures to be incorporated in the building to improve energy efficiency. This should also be accompanied by the obligation to include investment and operating/life-cycle costs, as well as a brief cost-benefit analysis linked to the future measure(s). By considering life-cycle costs, including external costs, this would bring a positive competition among heating systems.

Among the support schemes analysed by the project, the UK´s Renewable Heat Incentive for domestic installations is the only one to consider 'Energy Performance Certificate' to identify the heat demand of the property. The German region of Baden-Wuerttemberg has successfully implemented a system where EPCs include renovation roadmaps, with tailored advice to owners and investors on how to improve the energy performance of their buildings. France and the region of Flanders in Belgium are developing similar concepts.

- **Engage stakeholders in dialogue when defining policy**

Energy dialogues should take place with stakeholders and consumers representatives about how to decarbonise the energy sector, including H&C. This should result in concrete long-term policies and actions, designed, and shared by all stakeholders.

Example: The Dutch Energy Dialogue

The energy dialogue is an initiative of the Dutch Minister of Economic Affairs. Between April and July 2016, more than 125 meetings were organised by 72 organisations and in which over 3000 people discussed about the Dutch use and supply of energy in the future. Entrepreneurs, scientists, civilians, NGO's, and other stakeholders expressed their ideas and discussed about the preferred energy situation in 2050. A junior energy dialogue also took place in primary schools and through on-line debates.

The opening meetings were about sustainable heating and cooling in residential and non-residential buildings, sustainable heating and cooling in industry and the use of waste heat and sustainable transport and electricity. New technologies, business models, collective heat supply, energy efficiency and the role of (natural) gas in the energy transition were discussed. The outcomes of the energy dialogue will be used in the long-term energy policy/energy agenda for a transition towards a sustainable energy solution in the Netherlands (low CO2, safe, reliable, affordable energy system).

- **Promote the use of RES in DH and block heating**

Today, around 74% of DH systems run on fossil fuels (European Commission, 2016b). There is a need to set (increasing) minimum shares of renewables for existing district heating. This could be integrated in the framework of refurbishment and upgrading works. This obligation could be fulfilled with existing and future funding opportunities.

FINANCING

As mentioned above, it is very difficult to compare the real cost of renewable and fossil installations with today's market conditions. The unfair market conditions are analysed above in the section dedicated to overcome market condition issues.

However, it is crucial to understand that, in emerging markets, RES-HC technologies are still dependent on public support not only because these technologies are not yet widely deployed and have not reach economies of scale capable of bringing costs drastically down, but also because they compete with fossil fuels technologies that are still subsidised.

The FROnT project has worked on the identification of best practice to implement the key success factors for establishing integrated support scheme. This work is presented in the next section.

5.5 KEY SUCCESSFUL FACTORS AND FRONT MANUAL ON BEST PRACTICES FOR SUPPORT SCHEMES

There are direct (i.e. financial aid and/or obligations) and indirect forms (e.g. favourable building codes, R&D funding) to support RES-HC technologies at different levels of maturity. The FRoNT project has particularly focused on issues related to financial incentives. It has identified key successful factors and best practices collected in a specific manual available on the website.

The content of the manual is primarily based on the findings of the assessment of 28 support schemes implemented in nine EU Member States. Through such review, the consortium has identified the following factors considered to be critical to the success of a support scheme:

- Contribution of different stakeholders;
- Stability and predictability;
- Transparency and accountability;
- Balance between financial adequacy and efficiency; and
- Ensuring quality & performance.

Additionally, ensuring easy to understand and non-burdensome administrative procedures, reducing administrative costs, providing support to applicants as well as communication and marketing throughout the different phases of a support scheme are also considered very relevant factors.

The above factors have then been validated in each of the 5 project countries (Austria, Spain, Portugal, The Netherlands, and the United Kingdom) through national consultation platforms. The validation was also extended to a European Advisory Committee composed of experts from different sectors. Along the consultation process, a number of other relevant factors have emerged, notably the need to ensure non-burdensome administrative procedures and support to applicants as well as the essential role of communication and marketing throughout the different phases of a support scheme.

The full version of manual available at www.front-rhc.eu/library (see figure 31) provides case-studies and recommendations to implement the key successful factors and establish successful support schemes for RES-HC. It covers technical, economics, financial, legal and marketing aspects.

The good practices reported are not exhaustive, but are rather inspiring examples of how successful support schemes could be implemented across Europe. The solutions depend on the market conditions of each individual country. For instance, markets with lower RES-HC uptake, probably indicating barriers related to poor awareness and confidence in newer technologies, may require a different approach, including in terms of monitoring and control.

Figure 31 The Manual of good practices for support scheme as available on the FROnT website

As an example, the box below presents one of the best practices reported in the manual: the Innovation Bonus in Germany's Market Incentive Programme. The scheme supports more innovation and innovative technologies in integrated multi-technology support schemes through a higher level of support.

BOX 5.1: EXAMPLE OF BEST PRACTICE IN THE FRONT MANUAL ON SUPPORT SCHEMES

Reward of innovation in Germany's Market Incentive Program (MAP)

In Germany, since April 2015 innovative designs and applications going beyond the state of the art are rewarded with an innovation bonus and are applicable to new buildings despite a minimum renewable energy obligation.

Therefore, geothermal and air-source heat pumps achieving a seasonal performance factor of 4.5 are eligible for standard support if installed in new buildings and for a higher support (more €500) if installed in existing buildings.

For solar installations with 20 to 100 m² gross collector area, they are limited to residential buildings with three or more parties, other buildings with a minimum of 500 m² floor space, and hotels with minimum of six rooms as well as 1- to 2-family buildings with a solar share of more than 50 % of the heat demand:

- Solar water heaters in new buildings: 75 EUR/m² gross collector area
- Solar water heaters in existing buildings: 100 €/m² gross collector area
- Combi Systems for hot water and space heating in new buildings: 150 €/m²
- Combi systems for hot waters and space heating in existing buildings: 200 €/m² gross collector area
- Provision of process heat for newly built or existing buildings: 200 €/m² gross collector area
- Solar cooling in existing buildings: 200 €/m² gross collector area

Alternatively, the incentive for innovative designs can be paid as a performance based incentive calculated with the following formula:

> 0.45 EUR/kWh and year according to the additional table of the Solar Keymark certificate of the collector, calculated for site Würzburg, Germany, and a collector temperature of 50 °C

The main recommendations developed within the manual in the checkbox overleaf, which is a useful and easy to use tool for policy-makers and civil-servants. If selected and adapted to the specific national circumstances (e.g. market maturity, resource availability and national preferences, traditions, and culture), the good practices and recommendations proposed in the manual could contribute to the further development of competitive, affordable, and sustainable RES-HC solutions.

STRATEGIC POLICY MAKING	DESIGN AND IMPLEMENTATION	EVALUATION AND OTHER ASPECTS
☑ Differentiate financial instruments according to the market conditions and the technical characteristics and maturity of each technology ☑ Avoid long-periods between announcement of a financial incentive and its actual application ☑ Run the scheme for at least 5 years in order to provide stability ☑ Avoid stop and go policies and assess the establishment of off-budget financial instruments (e.g. funds from carbon tax like in Switzerland or levies for the gas bill) ☑ Avoid conflicting support schemes (e.g. to fossil-based heating systems) ☑ Consider/request robust data and clear information in the design of any new scheme	☑ Ensure the contribution of different stakeholders ☑ Launch on-line public consultations and /or well-organised meetings with experts and civil society ☑ Avoid that consultation brings about delays and abrupt interruptions ☑ Establish clear and transparent eligibility criteria ☑ Differentiate the methodology for setting support levels by target group ☑ Complement the scheme with a built-in revision mechanism to adapt the support level to falling technology costs ☑ Implement a robust control mechanism or alternative measures to secure the participation of competent professionals, certified equipment and the execution of durable systems ☑ Provide a mechanism through which the consumer can register their complaints and receive public advice /support ☑ Reduce the administrative procedures to a minimum ☑ Check compliance with State aid regulations ☑ Promote innovation in new buildings and through bonuses	☑ Undertake periodic evaluation to track whether policy objectives are being met. ☑ Pay attention on the impact for those more susceptible to energy poverty ☑ Communicate the gains and success of the support scheme to help policy makers and the public understand the distributional impact of a scheme ☑ Earmark some budget for marketing and communication ☑ Assess the possibility to provide proactive support and advice ☑ Use the information gathered during the evaluation phase to help on the design of new support schemes ☑ Use the information gathered during the evaluation to promote training sessions for people running the scheme ☑ Make sure that information gathered during different phases of the scheme is shared with stakeholders (trade associations and installers), whenever adequate ☑ Write the final report on the scheme and share it with the public after excluding sensitive information ☑ Generate useful indicators about the scheme that can be easily understood and used by market agents

6. REACHING OUT TO CONSUMERS: USING MULTIPLYING EFFECTS AND NEXT STEPS

The outcomes of the work done in the framework of the FROnT project endure beyond the project. The validity of the outputs varies according to the type of content. Some may remain relevant for some months or a couple of years, others are expected to endure for much longer.

Therefore, it is possible, and important, that these results continue to be disseminated over the coming years. One of the concerns of FROnT partners is how to facilitate the continuation of that process. In this regard, considering the characteristics of the heating and cooling sector, the target groups for that dissemination are diverse and with different roles. Furthermore, they are not easy to reach, particularly when there are limited resources for dissemination. Therefore, the FROnT initiative focuses on multipliers (i.e., those that can bring the information and training to a large group of stakeholders that will finally have an impact in the uptake of renewable heating and cooling).

A part of this work was done during the FROnT project. However, it is important to ensure the continuity of these tasks beyond the end of the project. This last chapter provides indications on how public entities, civil society organisations and industry stakeholders can play an active role in disseminating project outputs, with the aim of providing clear and transparent information to consumers. It refers to some of the capacity building and dissemination work done within the project and indicates the next steps for continuing such work beyond the project.

6.1 REACHING OUT TO A DECENTRALISED AND DIVERSE SECTOR

One of the main characteristics of the H&C sector is the decentralised demand, served mainly with decentralised supply. Its diversity is also one of the reasons explaining the complexity of the sector. The demand for heating and cooling can be covered by district heating networks but it is, in most cases, generated locally, at the consumer home or building.

Consumers have a major role to play when they choose their energy system. In some cases, they are the only decider, in other cases different factors impact their decisions (owner/tenant dilemma, regulations, technical limitations). This means that a change leading to a fuel switch (from fossil fuels to renewables) can be driven by public authorities via policies, regulations or support schemes but systematically requires the engagement of citizens.

Then, a challenge is how to create this engagement. The FROnT project developed several tools targeting consumers, as well as proposals aiming to better inform consumers on their heating and cooling systems and assist them in their decisions. These tools and recommendations must reach consumers. Considering that FROnT had limited resources for promotion and dissemination, it had to potentiate multiplying effects.

The FROnT partners have targeted several “multipliers”, i.e., entities with a responsibility and active role in providing clear and transparent information to end-users about energy costs. It was particularly important to inform and train people in “hot spots” regarding the contact with consumers and relevant to market agents, such as employees of energy agencies, municipalities, or companies.

These actions shall continue beyond the duration of the project. It must be stressed that several FROnT partners have multiple roles, both as policy influencers and as information multipliers. Regarding the role as policy influencers, the project includes entities that play such a role as part of their regular activities (e.g. energy agency, trade association, environmental NGOs.

Regarding the role of information multipliers, partners will continue to promote the tools made available by the project. Trade associations will continue to promote these towards manufacturers, so they can bring the information to the actors in direct contact with consumers (installers, distributors, system designers). Energy agencies will focus on their capacity to pull demand, making use of their competencies, within their regular activities, in empowering end-users with better and clearer information (e.g. on their online resources or on materials addressing end-users).

6.2 VALIDITY OF AVAILABLE RESOURCES

The outcomes of the work done in the framework of the FROnT project endure beyond the project's duration. The validity of the resources created during the project varies per the type of content.

The report on support schemes or the survey on key decision factors may become outdated in the coming years. The methodology for calculating the Levelised Costs of Heating and Cooling, on the other hand, is expected to last for a long period. The online calculation tool will be useful and usable for a longer period. The calculations are still feasible based on the data inserted by the user, though its usability will benefit from the update of default and reference values used for the calculation. This update is ensured at least for a period of two years.

6.3 MULTIPLIERS

As referred above, and considering the limited resources of the project, the FROnT initiative considers that using multiplying effects would be the best way to reach out the stakeholders who have an essential role to play in the uptake of renewable heating and cooling technologies. This means that information and training would be provided to groups that can, by means of their regular activities and responsibilities, disseminate it to the right target groups.

The main groups identified as multipliers for the FROnT outputs are:

- Policy-makers at the national, regional or local levels
- Technical staff and energy experts
- Industry
- Consumer organisations and environmental NGOs

- **Policy-makers at the national, regional or local levels**

The focus is placed on raising awareness about the strategic policy priorities for the RES-HC sector in Europe and the key success factors for RHC integrated support schemes. With this information, the targeted group can actively contribute to policies, regulations or support schemes that better address the market barriers to the uptake of renewable heating and cooling solutions.

- **Technical staff and energy experts**

This group may include architects or engineers working, training and teaching about heating and cooling systems, energy consultants, experts within ESCOs, construction companies, and professionals and professional organizations related to the heating and cooling sector. In this case the focus is placed in raising awareness about RES-HC. This includes the common methodology for estimating the value of energy supplied by RES-HC systems (solar, heat pumps, biofuels) and the assessment of the costs for heating and cooling. It is also important to discuss with them the key decision factors of end-users and the tools tailored to empower them.

- **Industry**

The definition of “industry” is broader than just manufacturing companies. It can cover companies intervening at different stages of the value chain. In this case, the focus shall be on recommendations on how to better communicate with consumers. One of the critical elements would be the Levelised Costs of Heating and Cooling, which should be translated by a standard procedure to translate the costs of RES-HC into a measure using units which consumers can understand (such as Euros per kWh). It is equally important that industry players know the results of the consumer survey and the key decision factors of end users.

- **Consumer organisations and environmental NGOs**

This group includes consumer organisations or non-governmental environmental organisations active at national, regional, and local levels. In some cases, some of their role as multipliers can intersect and interact with energy agencies. Regarding this group, the focus is on presenting and discuss key decision factors of end users and the tools tailored to empower them. Likewise, it is important that they understand, use, and disseminate the common methodology for estimating the value of energy supplied by RHC systems (LCoHC), as well as the online tool.

6.4 TARGET GROUPS

To reach the goals of FROnT, it is important to target with the project resources groups that have important roles in the decision process and lead to the installation in a building (residential or commercial) or in a production line (for industrial processes) of heating and/or cooling systems using renewable energy.

The main target groups identified by the FROnT partners were:

- Potential buyers
- Installers
- Building developers
- Building administrators
- Architects
- ESCOs
- Public authorities

- Local authorities
- Financial institutions
- Consumers associations
- RES manufacturers
- RES associations

These were the main target groups, meaning that they have the capacity take decisions, to affect decisions or to affect conditions with an impact on decisions leading to the acquisition of a renewable heating and cooling system.

The approach to these target groups shall vary depending on their characteristics. Also, the prioritisation of the actions towards different target groups may depend on concrete characteristics defined below.
For the characterisation of the target groups the following elements were considered:

- Engagement
- Power
- Technical knowledge
- Economical Knowledge

These elements are different from country to country and even from one region to another. Therefore, it is difficult to characterise these target groups in a homogeneous way across different contexts. In this regard, the depiction in the figure below tends to be a convergence of the different realities known to the FROnT partners.

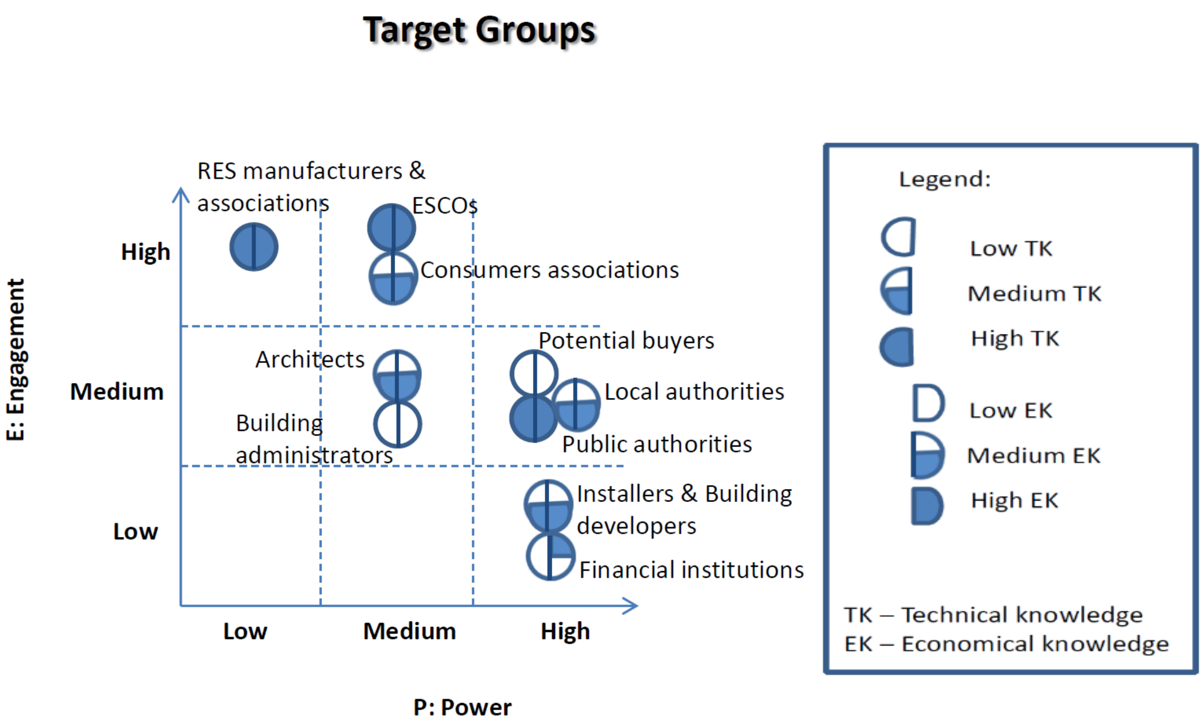


Figure 32: Characterisation of the target groups in the FROnT project

Will and ability
The characterisation of target groups shall consider their will and ability to contribute to the uptake of renewable heating and cooling solutions. This may be decomposed into the will and the ability to affect an outcome. In this case, will is described as engagement and ability as power.

- **Engagement**

This element represents the engagement of the target group regarding renewable heating and cooling technologies. These technologies present challenges in their implementation. These may be related to upfront costs, technical conditions, (alternative) incentives, regulations, or other factors. Therefore, when characterising a target group, it is important to assess their engagement, their attitude towards this type of technology.

For instance, it has been observed in several markets that installers and building developers might be averse to incorporating RES-HC options in their proposals. This might be related to training requirements, to additional technical complexity of the installation or because the commercial conditions are more attractive for incumbent technologies. Obviously, in this group, as in others, there are exceptions and some installers specialise in RES-HC. Still, considering the majority, the lack of engagement from installers and building developers shall be taken into account when addressing the group, namely on how to do it.

- **Power**

Another important element to take into account is the power of the actor, this means, the capacity to affect an investment (purchase) decision. The "power" of a target group is something that is hardly changed by the resources made available by the project. Therefore, the priority shall be oriented towards groups with a more direct impact on decisions. Though, groups with low power but high engagement are still relevant, as they may intervene as facilitators in some cases, besides supporting the dissemination efforts.

Knowledge
When deciding which resources might be relevant for a specific target group, we shall take into account what their level of knowledge is. The relevant knowledge is hard to describe, particularly in such a broad range of actors spread around different realities. For practical purposes, this was decomposed into technical and economical knowledge.

- **Technical knowledge**

Technical knowledge in this context is described as the understanding of the technical specificities connected to the application of these technologies in the context of the main activity related to the given target group. Obviously, installers will have a better technical understanding of the requirements for an installation than an ESCO.

Though the evaluation is done in terms of what is relevant for their activity, and in this case, it is considered that a large majority of installers lack qualifications to deal with different renewable heating and cooling technologies. On the other side, it is considered that ESCOs and public authorities have a good technical understanding of the different RES-HC in terms of what is needed for their activity.

- **Economical Knowledge**

Some relevant barriers hindering a stronger deployment of RES-HC are related to economic and financial factors, namely the emphasis on the high upfront costs rather than the lower lifecycle costs or the costs per energy unit, where RES-HC shows to be competitive with incumbent technologies.

Overcoming these barriers requires that different target groups have a good understanding of the different economic and financial factors that affect the assessment of lifecycle costs. And this is what is, in this context, "economical knowledge".

It is therefore logical that ESCOs and RES associations are considered to have good economic knowledge while financial institutions have only a medium level. Regarding the financial intuitions, this is not because they do not have the capacity and the general knowledge on financial services and products (which obviously, they do), it is rather related to the understanding of the elements affecting the assessment of an investment and its risks. While financial institutions have good knowledge about economic factors related to investments in renewable electricity, when it comes to renewable heating and cooling (and energy efficiency), that is not the case.

6.5 CAPACITY BUILDINGS ACTIONS

The Capacity Building Actions (CBA) are focused on multipliers. These are different from dissemination activities, in the sense that they need to pass on not only information but also competencies that will allow multipliers to transfer that knowledge on. Taking this into account, CBAs can consist of training sessions addressing key persons, as described above: policy-makers at the national, regional, or local levels, technical staff and energy experts, industry, consumer organisations and environmental NGOs. The size, the duration and the content of the sessions may vary. There isn't a one size-fits-all solution. These actions need to be adapted to the goals and available conditions/resources. Organising a specific session is a possibility but it is not necessarily the most efficient way to do it. The availability of the participants, the costs related to their participation (travel costs or time used) and with the organisation of the meeting (room rentals, catering for meals or coffee breaks, trainers' time/fees) are factors to take into consideration.

The size of the session, in terms number of participants and its duration shall also be considered. For such actions. The balance between the quantity of participants and the quality of the session is important to assess. A session with a smaller group allows for more interaction, a more practical approach, and more flexibility, adapting the message to the receivers. The number of participants in the capacity building actions within FROnT varied depending on different factors. Still, a number around fifteen participants for a half-day session was considered a good balance in terms of quantity of participants and quality of the results.

Therefore, it is often easier and more cost effective to gather participants in connection with other events, instead of organising a dedicated one. For instance, it may be a session within an annual meeting of energy agencies, or an additional module on training for installers or a training session within a trade fair on construction products or heating systems.

Figure 33: Pictures from FROnT capacity buildings' events

Some examples of the capacity building actions carried out by the FROnT partners are available on the website. These include an overview of the target groups, the topics covered and some of the main issues raised. These files can be used as a basis for developing new capacity building actions.

FROnT

FAIR RHC OPTIONS AND TRADE

Co-funded by the Intelligent Energy Europe Programme of the European Union