FROnT
FAIR RHC OPTIONS AND TRADE

Guidelines: Using the RHC costs' estimation methodology

Work Package 3 - Estimating RHC energy costs

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1. GENERAL INFORMATION REGARDING THE TOOL

1.1 AIM OF THE TOOL

The overall objective of the tool is to assess the competitiveness of renewable energy technologies (biomass, solar thermal, air-source heat pump and ground-source heat pump) against traditional fossil fuels.

The output compares the constant cost of generating one kWh of heat/ cold over the lifetime of the renewable energy technology (this concept is known as the Levelised Cost of Heating and Cooling – LCoHC) with the LCoHC of the conventional (non-renewable) system.

In addition, three financial parameters measuring the profitability of replacing the conventional system by the renewable one are provided, and the environmental impact (reduction in the consumption of energy commodities and in the emission of greenhouse gases) are calculated.

1.2 INTRODUCTION TO LCOHC CONCEPT

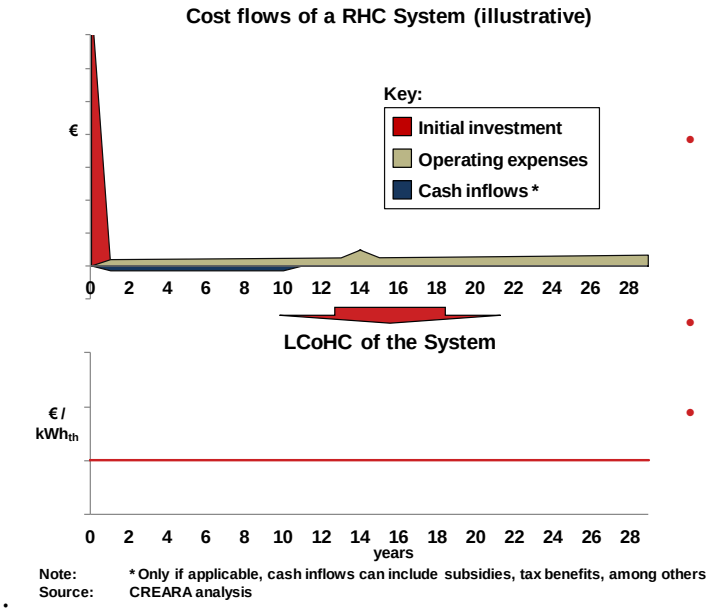
To make energy projects comparable in terms of costs[1] a common used metric is the Levelised Cost of Energy (in this case, Heat or Cold) hereinafter referred to as LCoHC. The LCoHC is defined as the constant and theoretical cost of generating one kWh of heat/cold, which is equal to the discounted expenses 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:

[1]This is particularly relevant when deciding between an investment with high upfront costs and relatively low operating costs (e.g. solar thermal water system) and one with a different cash flow pattern (e.g. natural gas water heater).



- **The LCoHC accounts for all costs associated with the RHC system over its life**
  - These include initial investment, O&M costs and corporate taxes, among others
- **It assumes a constant value per year and is expressed as cost per kWh_{th}**
- **It considers the return required from the investment, to discount future costs (and energy generation) to present**

Figure 1: Ilustration of LCoHC

To assess the competitiveness of a given RHC technology, it is necessary to derive the costs of a particular system (accounting for its particular 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, by definition, 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 many cases, the alternative methodologies used differ in terms of 2 main characteristics that define the parameters to use when estimating costs: the **point of view** of the analysis and the **level of detail** (or complexity) used.

The analysis could be performed from two main points of view:

- Project as a whole
- Investor (i.e. the consumer)

Our methodology estimates costs from the perspective of the project as a whole. As such, it excludes financing considerations within the cash flows used.

Limitations of LCOE method:

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

1.3 WHAT WILL BE FOUND IN THE OUTPUT?

The 'Output' section in each technology's sheet is subdivided in three types:

- LCoHC: provides the levelised cost of heating and cooling results
- Financial parameters: Payback, NPV and IRR results are provided
- Environmental parameters: Greenhouse gases (GHG) emission reduction and energy resources consumption results are included

1.3.1 LCOHC OUTPUT

For biomass, air-source heat pump and ground-source heat pump three LCoHC results are given:

- Renewable LCoHC: represents the LCoHC for the RHC option excluding residual value
- Renewable LCoHC (incl. RV): provides the LCoHC for the RHC option including residual value
- Ref. system LCoHC: corresponds to the LCoHC for the reference system

For solar thermal two additional results (to those previously mentioned) are given:

- Hybrid LCoHC: represents the LCoHC for a RHC / reference hybrid system (where RHC generates as much energy as possible and the reference system provides the remainder to satisfy all energy needs)
- Hybrid LCoHC (incl. RV): Idem but including residual value

In addition, the tool provides the user with another output: an LCoHC range which is based on a sensitivity analysis conducted for each technology.

The results of the analysis enable the identification of the parameters with a greater impact on LCoHC results.

In the case of biomass, this parameter is represented by pellet price growth; for solar thermal, by initial investment; and for both air-source heat pump and ground-source heat pump the parameter is represented by electricity price growth.

For the reference system, the parameter considered is energy price growth.

These parameters have been used to create a maximum-minimum LCoHC range that is presented along with the LCoHC result in a plot.

1.3.2 FINANCIAL PARAMETERS OUTPUT

For all technologies, three parameters have been considered:

- Simple payback time, Net Present Value (NPV) and Internal Rate of Return (IRR)

For NPV and IRR two values are given: including and excluding residual value.

Finally, the cumulative cash flow has been represented in a plot, where the payback time can be graphically identified.

1.3.3 ENVIRONMENTAL PARAMETERS OUTPUT

This section provides three different outputs:

- GHG emissions reduction is provided for all technologies comparing the reference

system emissions with the ones from the RHC system

- Energy resources consumption difference is the result of the comparison between the reference system consumption and the RHC consumption for each energy source.
- In addition, energy resources consumption is represented in a plot where any 'bar' on the left side (negative) means a reduction and any 'bar' on the right side (positive) is an increase.

2. TOOL STRUCTURE

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

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

- General information: it includes the user type selection (person or corporation[2]), and the location and energy services choice. 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 your current 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 RHC technology to be assessed. Following the energy services selection made in step 1, the user has to choose among the RHC technologies (biomass, solar thermal, air-source heat pump and ground-source heat pump) available. Thus, for instance, selecting cooling as a desired service will disable biomass and solar thermal.

- Demand estimation: information regarding daily DHW consumption and the insulation level of the user's building or its living area is asked to estimate the energy demand. However, it can be directly plugged-in by the user if he can provide a more accurate value.

- Renewable system definition. The user is asked to fill in some relevant inputs related to the RHC 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 symple payback period are calculated.

- Environmental parameters: the tool analyses whether greenhouse gases 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.

[2] 'Corporation' refers to any form of organization with commercial activity

2.1 STEP 1: GENERAL FORM

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

The following figure illustrates the inputs asked in this first step of the tool:

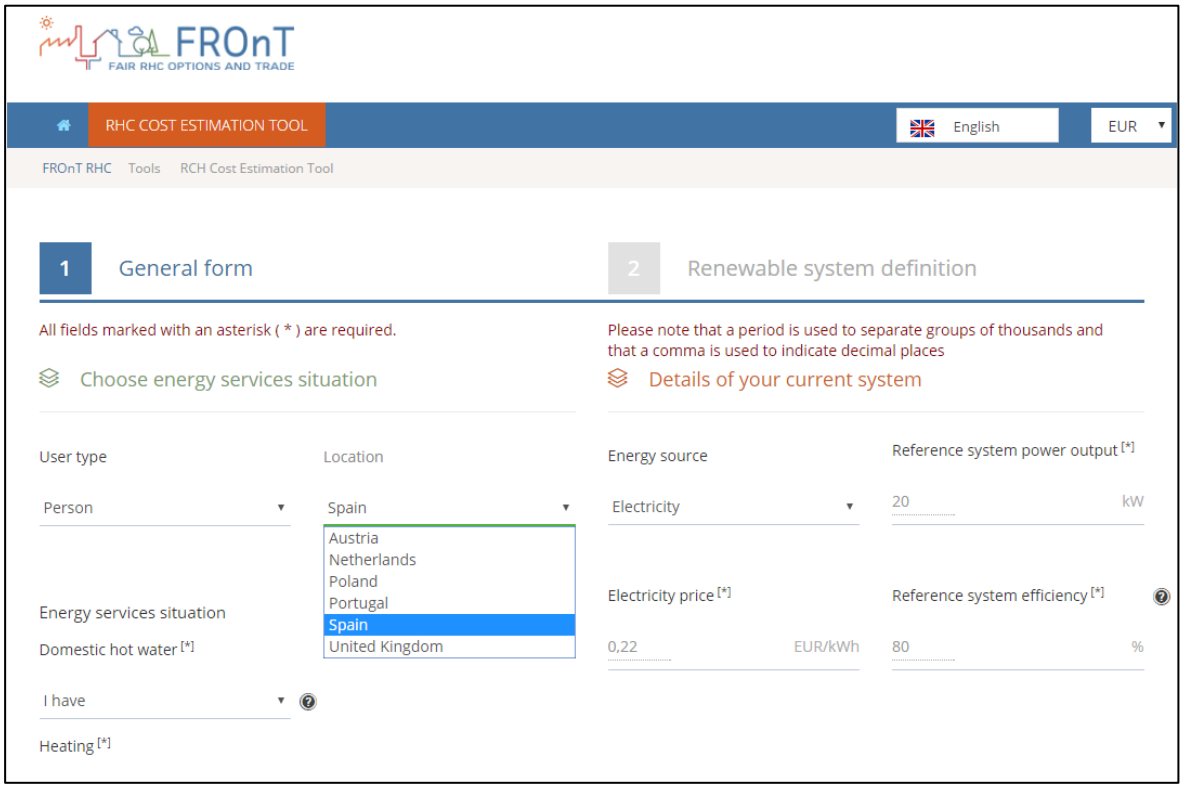


Figure 2: Step 1 of the FROnT tool

As shown in the figure, step 1 can be subdivided into two parts: 'Choose energy services situation' and 'Details of your current system'.

The first subsection includes the selection of the user type: both person and corporation are available.

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

Then the user is asked to insert the location to be analysed. The six reference locations of the FROnT project, (Austria, Netherlands, Poland, Portugal, Spain and the United Kingdom) have been made available for the study.

The third input of the first subsection of Step 1 is the energy services selection. The energy services considered in the tool are domestic hot water, space heating and space cooling.

Three options are available for domestic hot water and space heating: 'I have and I want', 'I do not have but I want' or '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 'I neither have nor want' and 'I do not have but 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 RHC technologies analyzed, such as air-source and ground-source heat pumps.

The energy services selection will affect the availability of the RHC 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.

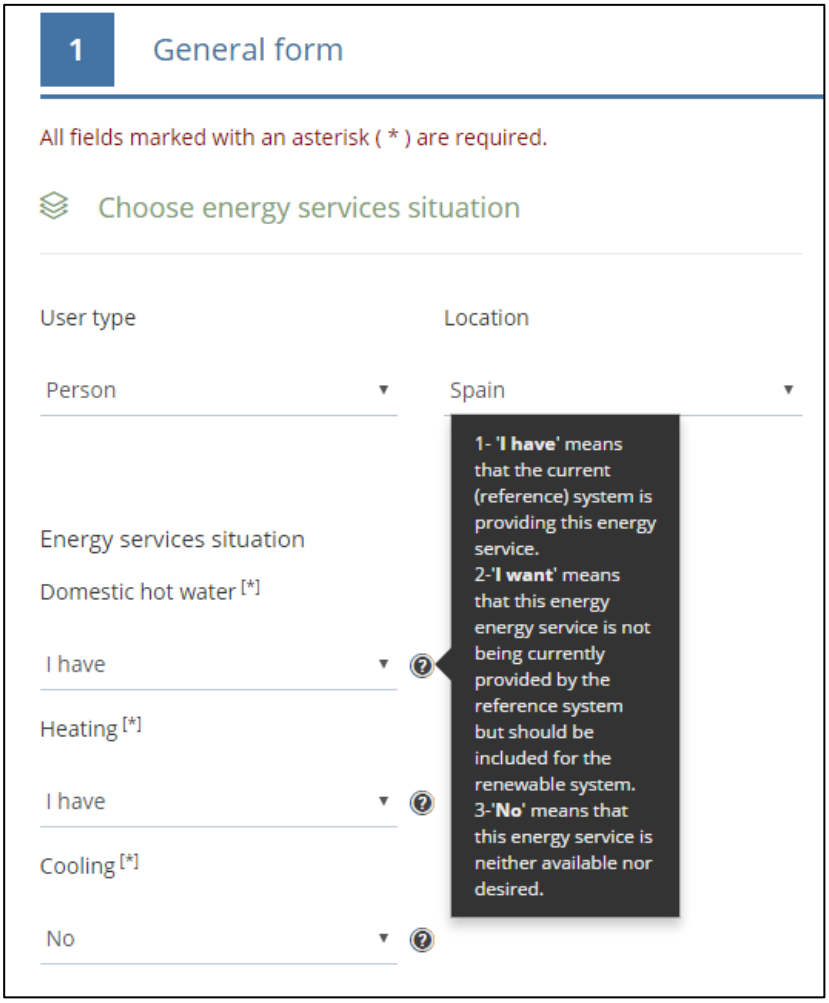


Figure 3: Energy services selection

The second subsection contained in Step 1 refers to the definition of the reference (conventional) system of the user.

First, the user selects the energy source of the reference system. Four energy commodities have been included in the tool: electricity, natural gas, oil and liquefied petroleum gas (LPG). Once the energy source has been selected, the user is asked to insert the price and the annual growth in the price of that concrete energy source. As shown in Figure 4, default values are included to facilitate the task. Nonetheless, these values can be improved by overwriting in case the user can provide a more accurate value.

It should be underlined that these prices, as well as the rest of the default values included in the tool, do not include VAT. VAT is added automatically by the internal calculations of the tool when the user selected is 'person'. Therefore, any value replacing the default data should not incorporate VAT neither. However, energy commidities' prices do account for all other relevant costs, including the fixed component of the price.

Given that the four renewable technologies considered require electricity for their auxiliary consumption, the inputs associated to electricity will be asked even though if the user has selected another energy source.

The rest of the values required for the completion of the second subsection of Step 1 are the power output of the reference system, its efficiency and the annual operation and maintenance cost associated to it.

While no guidance is given for the first input, reference efficiencies and operation and maintenance costs by location are provided, as shown in the figure below:

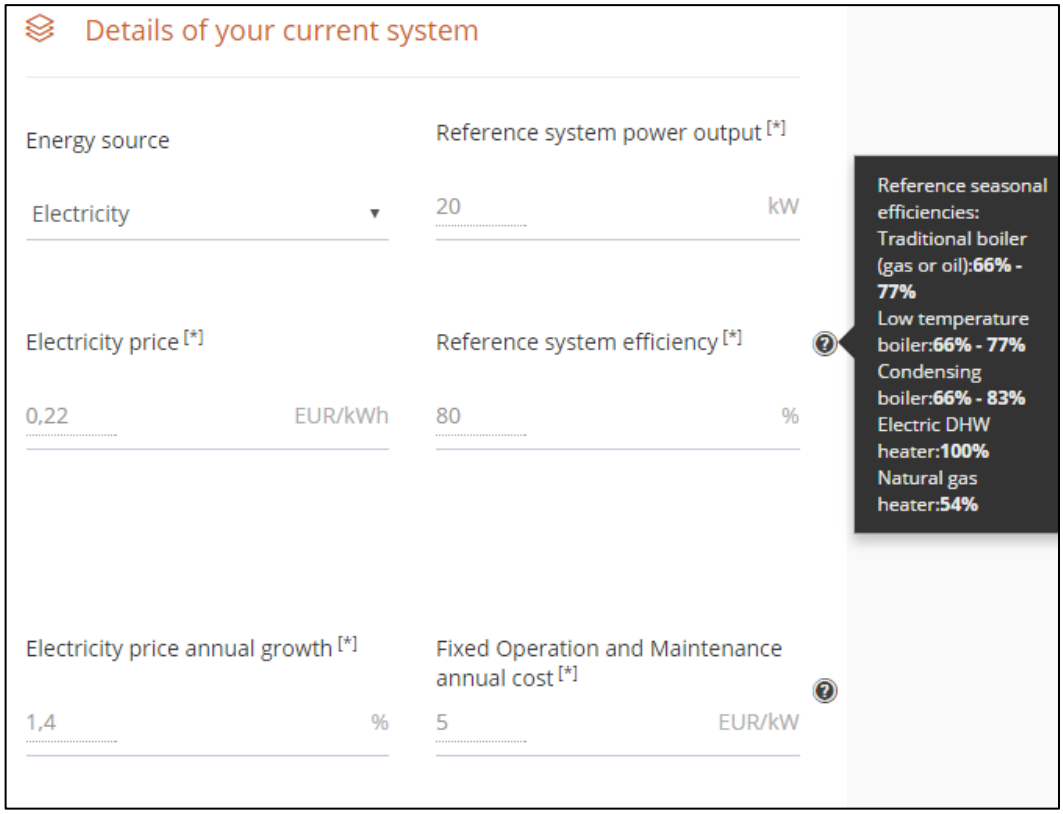


Figure 4: Reference system definition

2.2 STEP 2: RENEWABLE SYSTEM DEFINITION

Step 2 starts by asking the user to select the RHC technology to be assessed.

The RHC technology selection is made through the interactive diagram shown in the figure below. When selecting a RHC technology, the diagram shows the energy services that speficic system can provide.

For those cases where the energy services selection made in step 1 does not match the RHC 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.

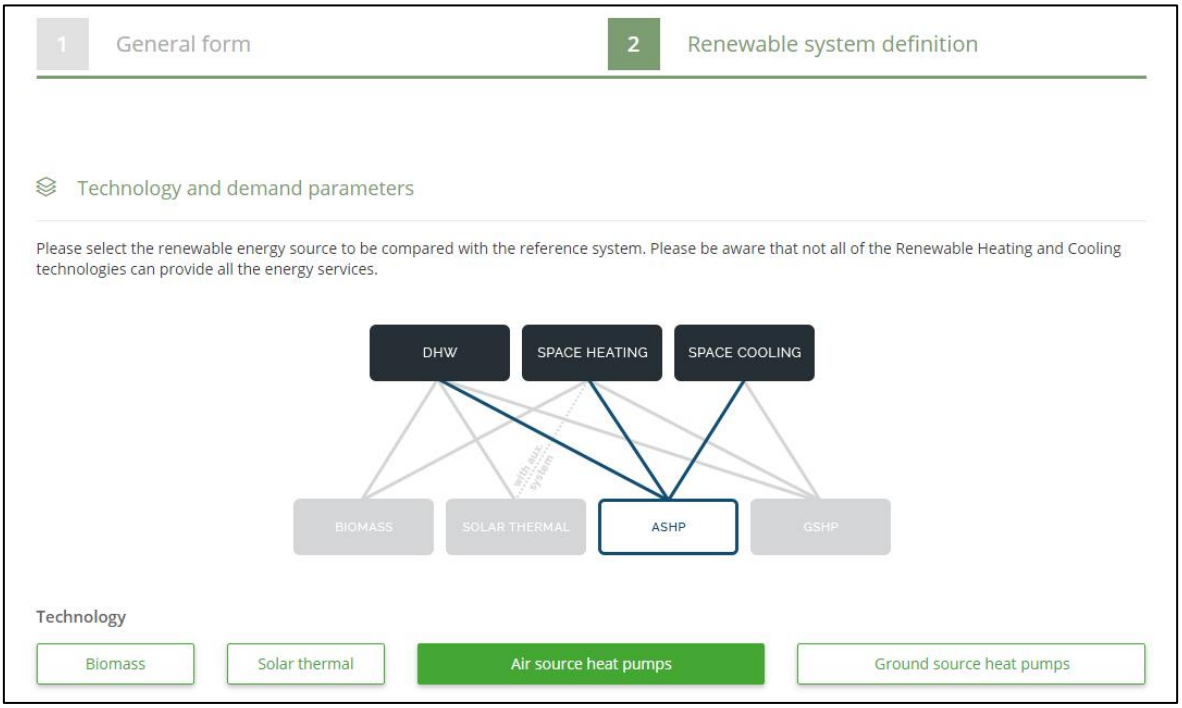


Figure 5:RHC technology selection

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.

To estimate the heating (and cooling, if applicable) demand the user fills in the living area of his household 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, as Figure 6 illustrates.

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 Figure 6.

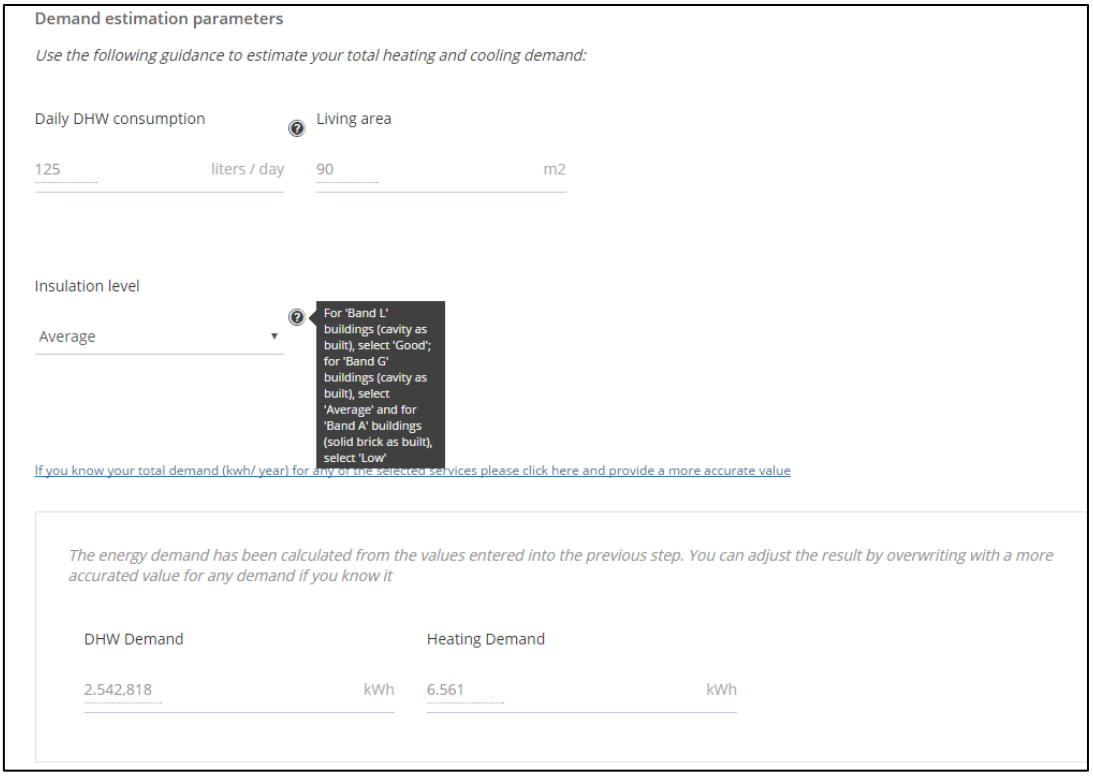


Figure 6: Demand estimation

Once the RHC technology to be assessed has been chosen and the demand parameters have been calculated, the user is asked to define the features of the renewable system to be installed.

The following subsections will cover the main inputs to be inserted for each of the four technologies included in the tool.

However, there is another common subsection that can be found at the end of each renewable system form. For the sake of simplicity, it will be shown here, altough it would be found at end of step 2 following the real flow of the tool.

That subsection consists of some data related to the project that has to be filled in to carry out the simulation.

The required return for investor, used to discount future cost flows of both systems to present, incudes a default value and guidance for three scenarios: high, mid and low risk.

The technical lifetime inlcudes guidance in the form of a default value, while specific guidance is provided for the economic lifetime, indicating that it cannot be higher than the technical lifetime since no re-investments are considered. Figure 7 outlines the three inputs to be inserted:

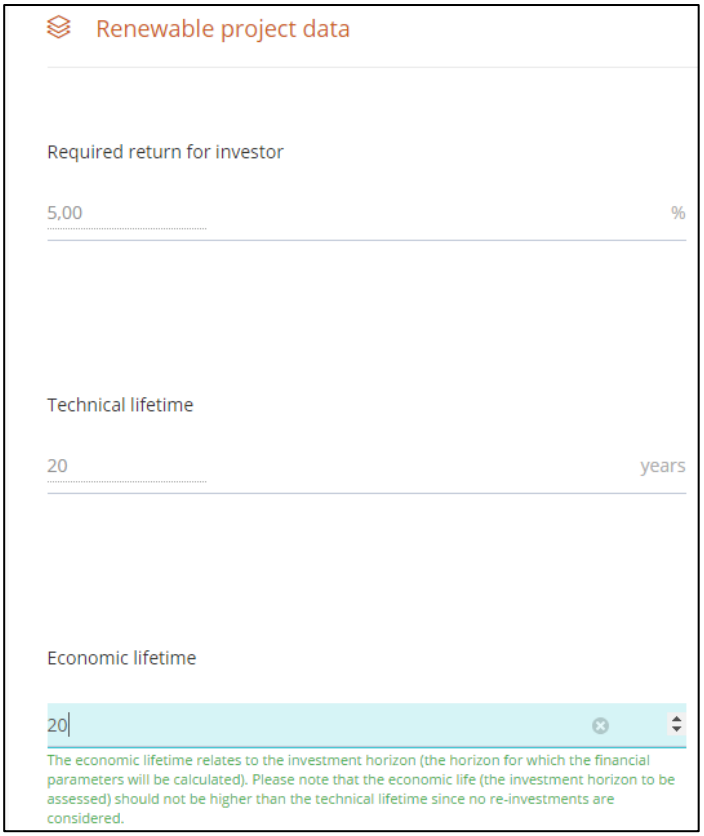


Figure 7: Renewable project data

2.2.1 BIOMASS

The first input to define the biomass system is the power output to consider. By default, this value is equaled to the power output inserted for the reference system. However, it can be overwritten by the user if he has a specific system in mind.

Both the efficiency of the system and the initial investment associated to it include a default value to ease the completion task.

As for the operation-related data, the user has to insert values for the annual operation and maintenance costs, the price of the pellet and its annual growth. Country-specific guidance in the form of default values is provided for each of the three inputs.

Finally, this section allows the user to account for incentives and subsidies to RHC technologies in the analysis. Two different types of incentives are considered for 'person' users across the four technologies:

- Investment-based incentives: both on the initial investment and on the capacity installed
- Operation-based incentives

Incentive fields are optional (i.e. the tool allows the user to carry out the simulation without filling in the cells). Links to a website containing the updated characteristics of available incentives per country are included in the guidance messages.

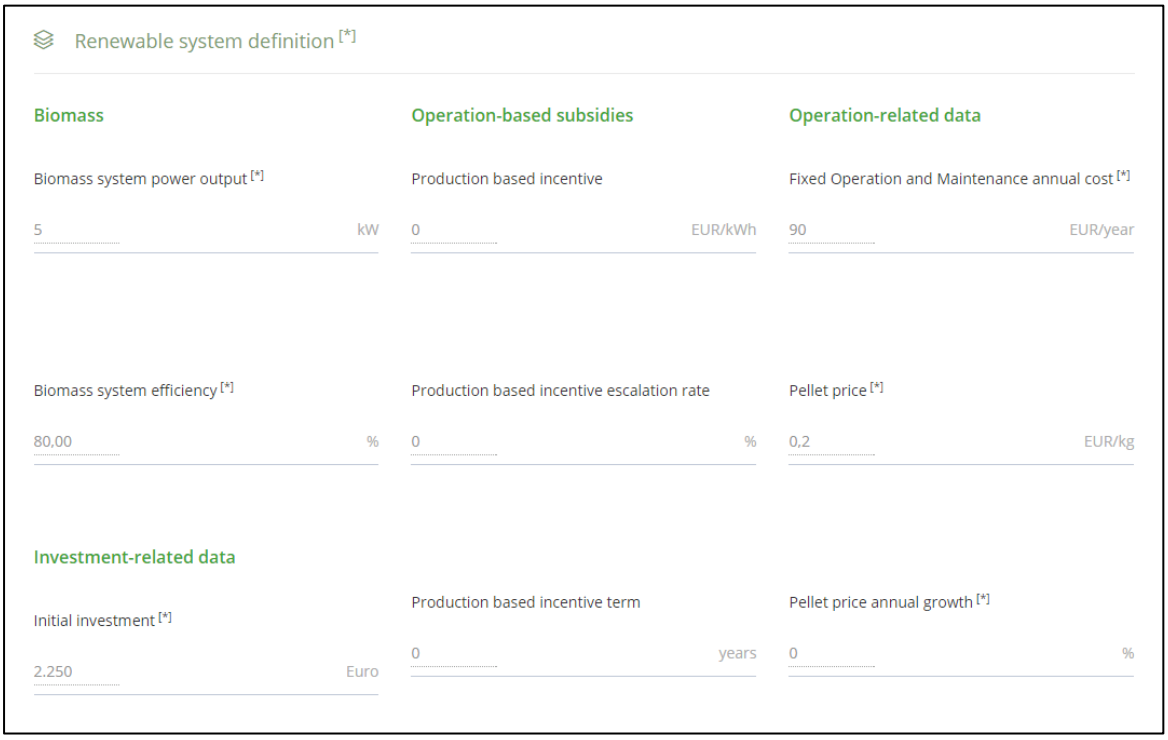


Figure 8: Biomass inputs

2.2.2 SOLAR THERMAL

If the user has selected Portugal or Spain as the location to analyse in Step 1, he will have to choose the solar thermal system type to be included in the study (between forced circulation and termosiphon systems). For the cases of Austria, Netherlands, Poland and the United Kingdom, forced circulation systems have been assumed. The selection of the system affects some of the default values provided for the following inputs.

The next input consists of the total area of the system to be installed. Default values, which vary depending on the system type and the energy services selected, are given to the user.

The initial investment, the annual replacement cost and the annual operation and maintenance cost include default values with the aim of providing the user with reference data. As in the rest of the cases, those values can be however overwritten by the user if he can provide a more accurate figure.

Finally, the optional incentive fields are available to account for existing subsidies in the location studied. The help messages, when applicable, include links to a specialized website providing information on specific incentives that might be considered in the analysis.

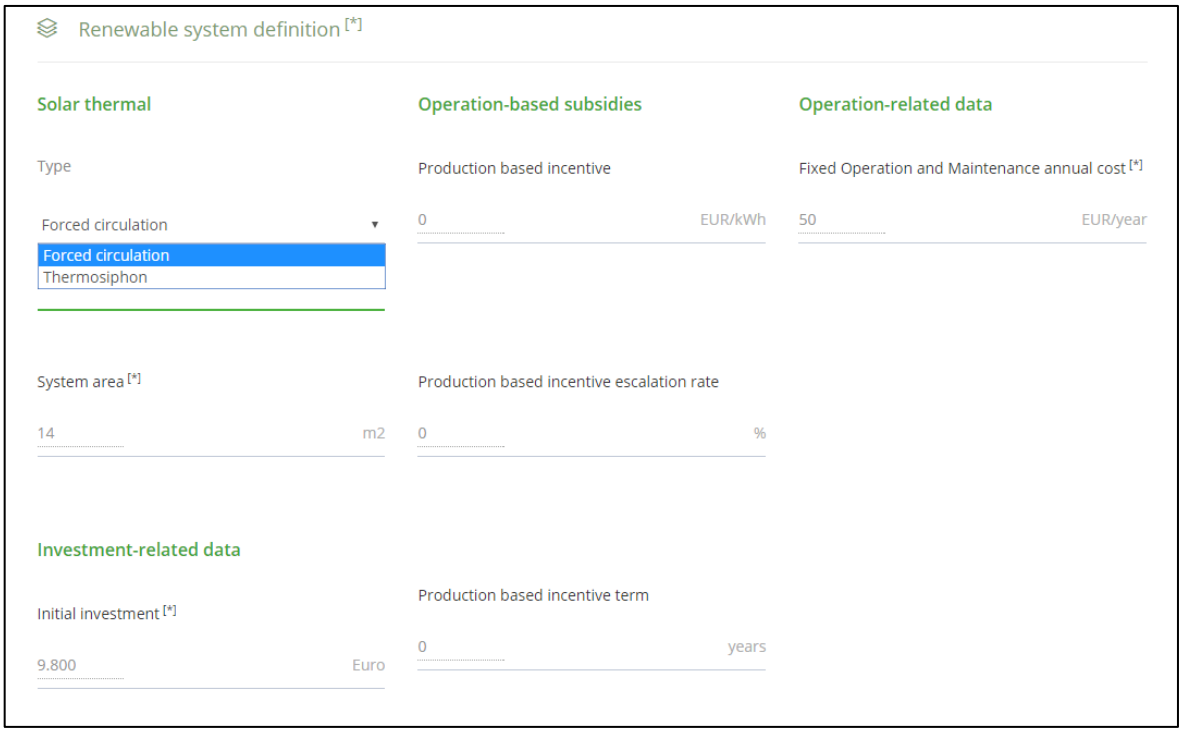


Figure 9: Solar thermal inputs

2.2.3 AIR-SOURCE HEAT PUMP

By default, the power of the air-source heat pump is equal to the output power of the reference system. However, if the user has a specific system in mind, he can overwrite the cell with a more appropriate value.

The initial investment data, the seasonal coefficient of performance and the annual operaton and maintenance costs are inputs for which guidance is provided.

Finally, some optional fields, accounting for investment-based incentives, capacity-based incentives and production-based incentives are included.

The help messages included for those inputs contain links to a website detailing the characteristics of available incentives in each country when applicable.

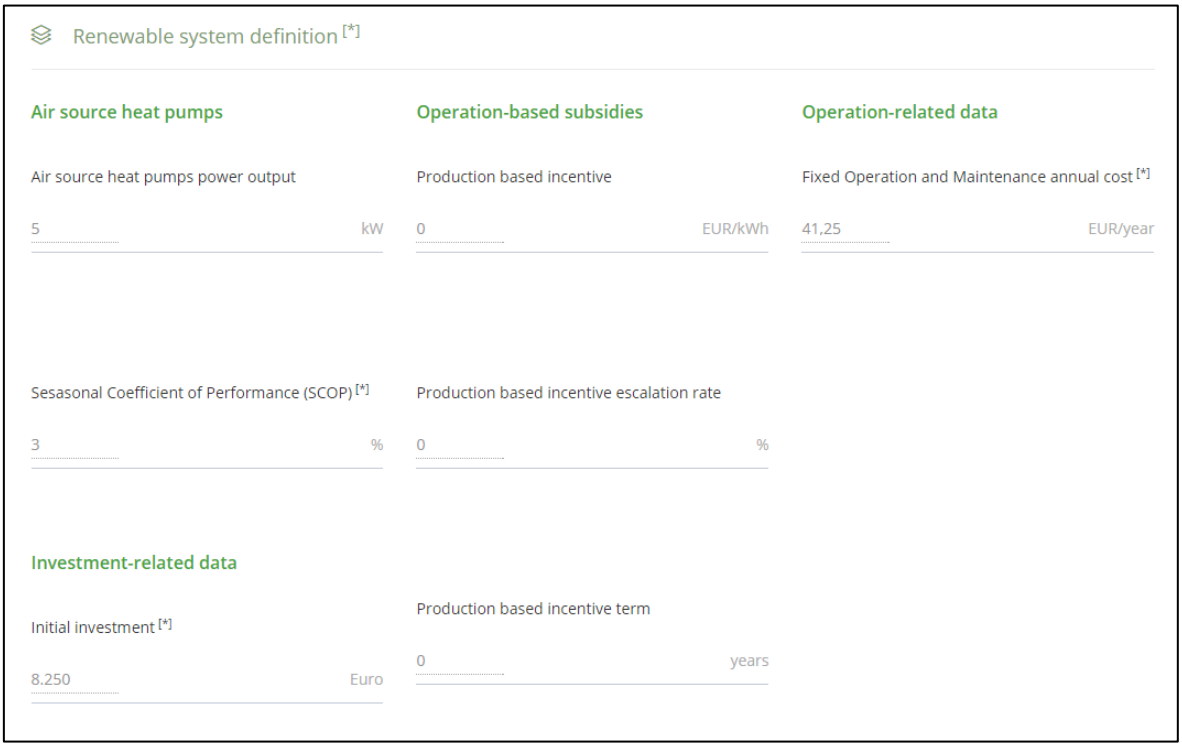


Figure 10: Air-source heat pump inputs

2.2.4 GROUND-SOURCE HEAT PUMP

The user is asked to input the power output of the ground-source heat pump considered, which is by default equaled to the power inserted for the reference system.

Then, information regarding the seasonal performance coefficient of performance of the heat pump and the initial investment and the operation and maintenance costs associated to it is requested. The tool includes default values with the aim of facilitating the completion of those cells.

Finally, the user can fill in the optional incentives and subsidies fields. Guidance consisting of links to an updated website including information of available incentives per country is included when relevant.

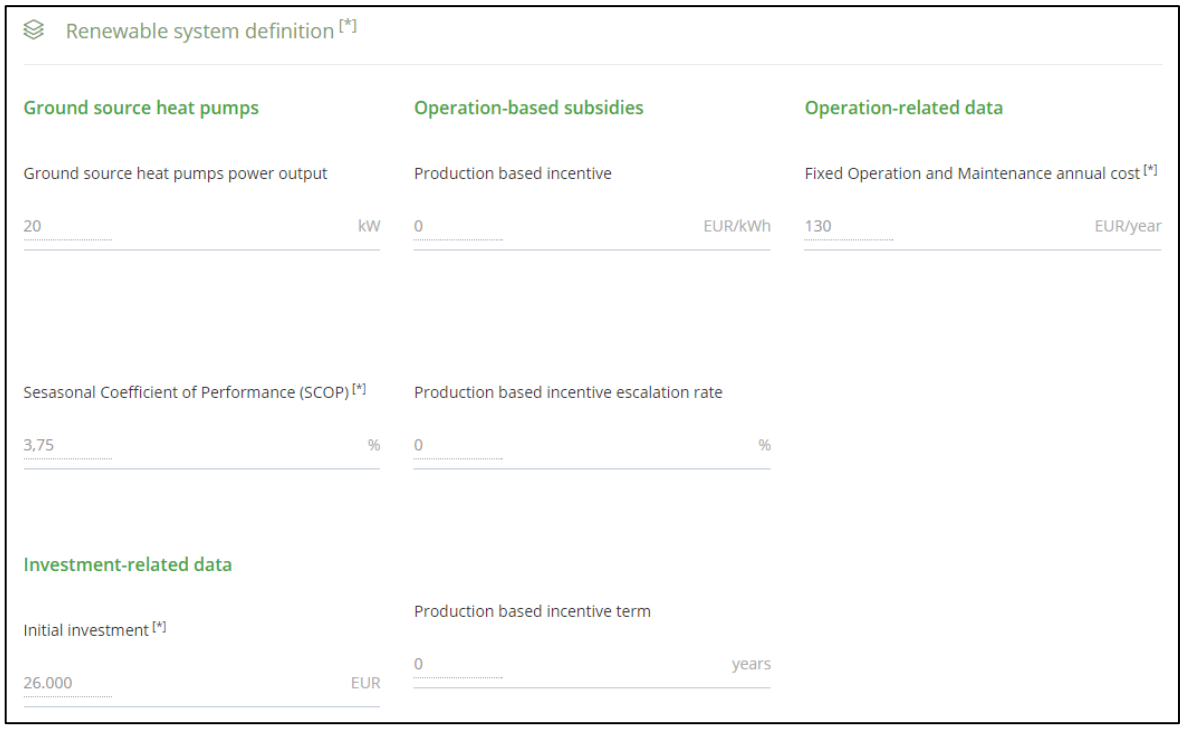


Figure 11: Ground-source heat pump inputs

2.2.5 CORPORATION-SPECIFIC INPUTS

It is worth mentioning that there are some additional fields when the user of the tool selects 'Corporation' as the user type in Step 1.

The flow of the tool remains constant in Step 1, but there are some variations with regard to Step 2.

First, two new incentives are available for the four technologies considered: investment tax credits and production tax credits.

Second, the renewable project data incorporates three additional inputs: corporate tax rate (default values varying from one country to another are provided), debt fraction and loan interest rate.

The output section does not present any variation from the 'person' version of the tool, although the calculations will vary from case to case.

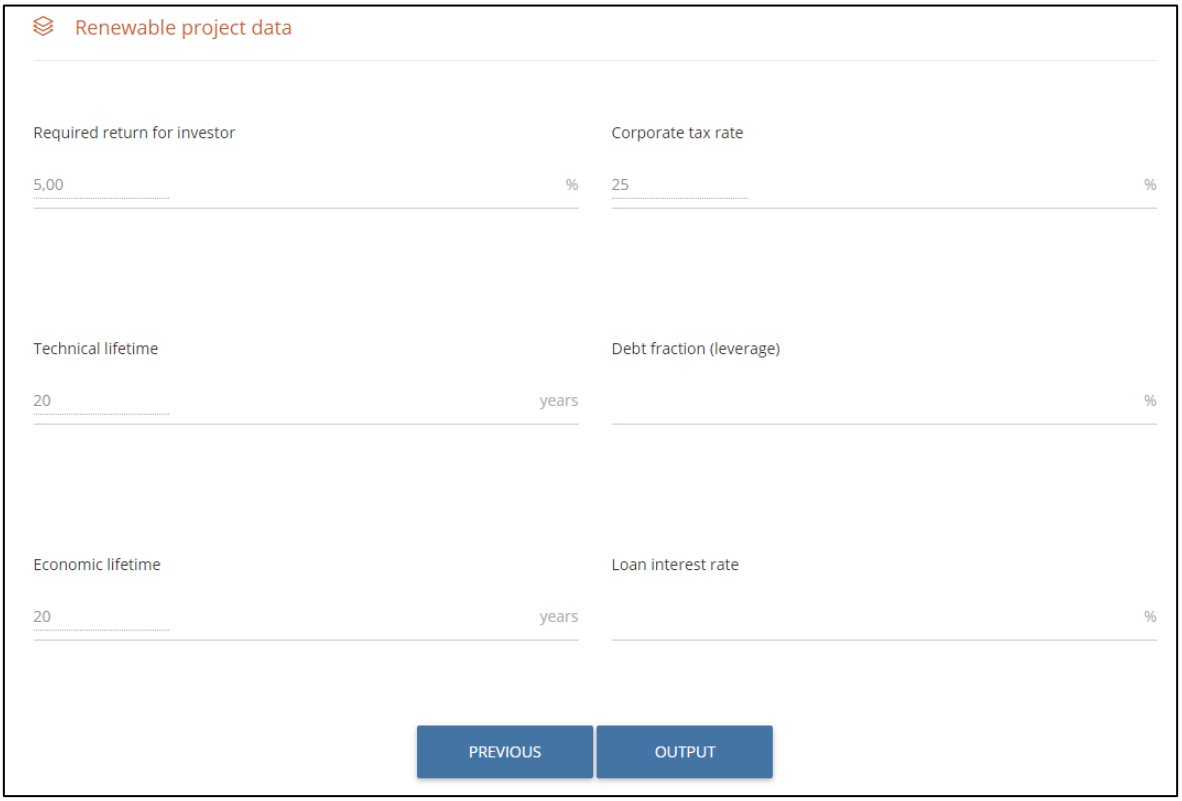


Figure 12: Corporation-specific inputs

2.3 OUTPUT

At the beginning of the output section some intuitive guidance for non-expert users is provided.

The initial investment required to carry out the replacement of the conventional system, the average yearly savings obtained by doing it and the necessary years for the savings to cover the initial investment are highlighted.

Apart from these messages, three different outputs are calculated, as stated at the beginning of the document:

- 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 RHC technology is given.

The following figure provides an example of the output interface:

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RHC COST ESTIMATION TOOL | English

FROnT RHC Tools RCH Cost Estimation Tool

3 Calculation Results

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By replacing the conventional system with one based on biomass technology, you would save an average of 326,62 EUR per year.
The total initial investment amounts to 2.722,50 EUR .
The investment can be recovered in 11 years.

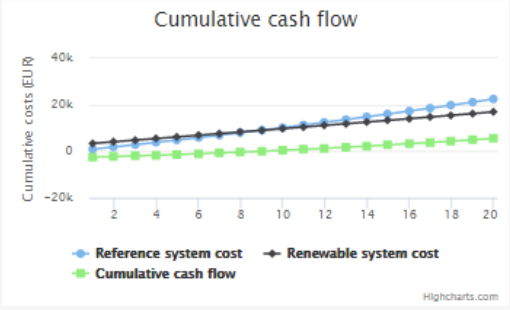
Financial parameters

The Net Present Value (NPV) is the difference between the present value of the savings generated by the renewable system and the present value of the initial investment. The NPV represents, therefore, the contribution of the project to investor's wealth at the present time

The Internal Rate of Return (IRR) shows the profitability of replacing the current system by the renewable one

The simple payback time is the required period of time for the savings generated by the renewable system to cover the initial investment

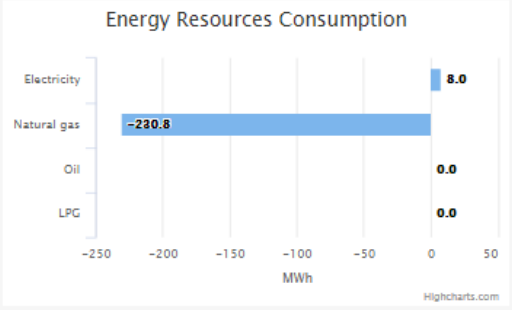
Simple payback time	8	years
Net Present Value (NPV)	2055.12	EUR
Net Present Value (incl. residual value)	2055.12	EUR
Internal Rate of Return (IRR)	11.4	%
Internal Rate of Return (incl. residual value)	11.4	%



Environmental parameters

A positive externality of Renewable Heating and Cooling systems is their potentially lower consumption of fossil fuels. The next chart shows the environmental impact of replacing the reference system with the renewable energy technology

Greenhouse gases emissions reduction	43.77	Tonnes CO2
Electricity consumption difference	8	MWh
Natural gas consumption difference	-230.82	MWh
Oil consumption difference	0	MWh
LPG consumption difference	0	MWh



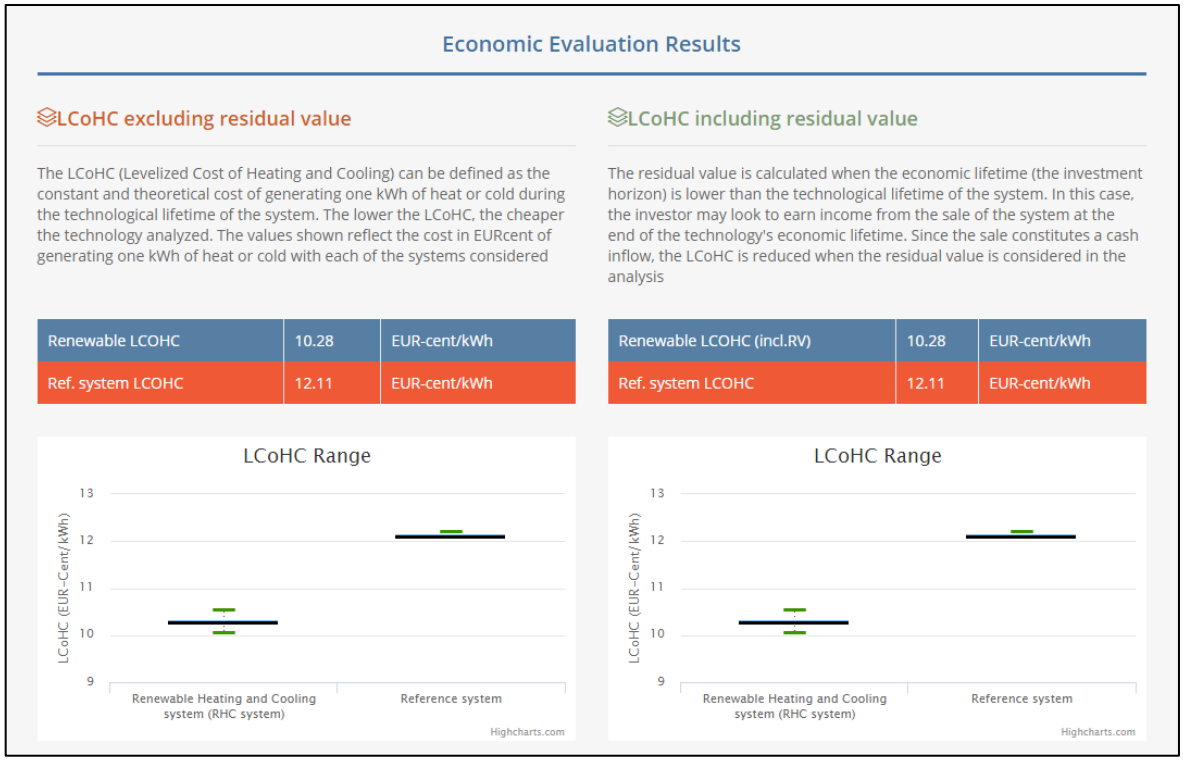


Figure 13: Output

3. ANNEXES

3.1 ACRONYMS

Acronym	Meaning
ASHP	Air Source Heat Pump
DHW	Domestic Hot Water
EUR	Euro
FROnT	Fair RHC Options and Trade
GHG	Greenhouse gases
GSHP	Ground Source Heat Pump
IRR	Internal Rate of Return
LCoHC	Levelised Cost of Heating and Cooling
m^2	Square meter
NPV	Net Present Value
O&M	Operation and Maintenance
RHC	Renewable Heating and Cooling
RV	Residual Value
TR	Corporate Tax Rate
VAT	Value Added Tax
WACC	Weighted Average Cost of Capital
WP	Work Package

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