# HARP Project – Methodology of the HARP online tool for labeling existing heating appliances

The main idea behind the project is to motivate individuals to plan the replacement of their often old and inefficient heating appliances, with more efficient alternatives. To this end, the HARP project (Heating Appliances Retrofit Planning) developed an online tool that calculates the energy label of the existing space heating and water heaters. Furthermore, users and professionals have the possibility to evaluate the solutions on the market and compare the performance of the old appliance with the one of the new products.

Among the 126 million boilers installed in the EU, a staggering 60% are inefficient (performing as a C or lower energy class) but individuals are rarely aware of the inefficiency of their heating systems and associated costs. To motivate consumers to replace these inefficient heating systems, the HARP project has designed an application named HARPa that will enable individuals to get an indication of the labelling classification of their actual heating system.

60% of the heating stock consists of inefficient boilers (class C or lower)
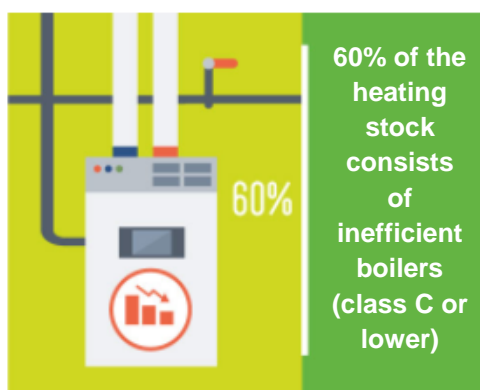
HARPa will provide further information useful for users in order to plan the replacement of their heating systems. For instance, in the first step the application will provide an estimation of the energy class of the installed heating system. In a second step, the most efficient alternatives available on the market and the benefits associated with installing them, such as energy and cost savings, reduction of CO_2 emissions will also be listed out by the application.

Finally, HARPa will also list incentives available at national level to replace inefficient heating appliances with more efficient alternatives, and provide indicative guidance to contact heating professionals.

The online tool will have two options available for different users, a basic one for consumers and a more advanced one for heating professionals.

Labeling existing heating appliances with the HARP Tool

As previously presented, the main aim of the HARP online tool is to estimate an energy label for space heating and water heaters old appliances, in accordance to what the EU Energy label regulations. The label output will include the following values.

- **Seasonal space heating energy efficiency (η_s)**: it represents the ratio between the space heating demand for a designated heating season, supplied by a space heater, a combination heater, a package of space heater, temperature control and solar device or a package of combination heater, temperature control and solar device, and the annual energy consumption required to meet this demand, expressed in percentage.

- **Water heating energy efficiency (η_{wh})**: refers to the ratio between the useful energy in the drinking or sanitary water provided by a combination heater or a package of combination heater, temperature control and solar device, and the energy required for its generation, expressed in percentage.

- **Energy class**: it is related to the energy and cost saving. Regulation introduces a new labeling scale from A^{++} to G for the space heating function of the existing heating systems.

The HARP online tool allows the user to choose between two different heating systems to calculate the correspondent labels. The users will have to select the climate zone in which the system is installed, which as it will be further presented below, will be an important factor when labeling heating appliances, especially heating pumps.

Colder

Average

Warmer
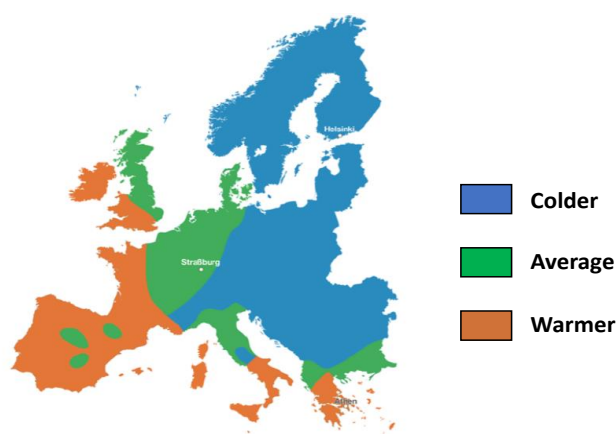
Map of the climate zones

Boilers

The regulation defines them, for this purpose, as a space heater that generates heat using the combustion of fossil fuels and/or biomass fuels, and/or using the Joule effect in electric resistance heating elements.

Keeping this definition of boiler in mind, the equations necessary for the calculations made by the tool are presented below.

$$\eta_s = \eta_{son} - \sum F_{(i)}$$

$$\eta_{son} = 0.85 \cdot \eta_1 + 0.15 \cdot \eta_4$$

Where:

- η_s refers to seasonal space heating energy efficiency and it has already been defined before.

- η_{son} stands for the seasonal space heating energy efficiency in active mode and, according to the regulation, means:

  o For fuel boiler space heaters and fuel boiler combination heaters: a weighted average of the useful efficiency at rated heat output and the useful efficiency at 30 % of the rated heat output, expressed in %.

  o For electric boiler space heaters and electric boiler combination heaters: the useful efficiency at rated heat output, expressed in percentage.

  o For cogeneration space heaters not equipped with supplementary heaters: the useful efficiency at rated heat output, expressed in %.

  o For cogeneration space heaters equipped with supplementary heaters: a weighted average of the useful efficiency at rated heat output with supplementary heater disabled, and the useful efficiency at rated heat output with supplementary heater enabled, expressed in percentage.

- F can assume different values. Depending on the particular situation, a given formula will be applied to obtain the number for F, the possibilities are:

  o No temperature controls

  o Auxiliary electricity consumption

  o Standby heat losses

  o Ignition burner

- η_1 and η_4 are referring to the useful efficiency at different points:

  o η_1: at 30% of rated heat output and low-temperature regime.

  o η_4: at rated heat output and high-temperature regime.

Heat pumps

A heat pump space heater, in accordance to the regulation, is referred to as 'heat pump', means a space heater using ambient heat from an air source, water source or ground source, and/or waste heat for heat generation; a heat pump space heater may be equipped with one or more supplementary heaters using the Joule effect in electric resistance heating elements or the combustion of fossil and/or biomass fuels.

The efficiency depends on the climate and the type of heat pump. The tool calculates the label as a function of these two parameters.

Taking into account the previously presented calculations for each of the heating systems the HARPa will obtain the efficiency and the corresponding label. The tool will then return a label presenting the energy class of the heating appliance, within the ranges of efficiency values presented in the following figure.

Efficiency	From (included)	To (excluded)	Classes
	150		A+++
	125	150	A++
	98	125	A+
	90	98	A
	82	90	B
	75	82	C
	36	75	D

Entering the data

As previously mentioned, the tool has two possible configurations, a more basic one for consumers and an advanced one for professionals. Depending on the user's choice, HARPa will ask for more detailed data.

- Simplified version for consumers:

   - Boiler: the user will have to answer basic questions about the current system, like power and location, and the tool will gather information based on this data.

   - Heat pump: in this case the user will only have to choose the type of heat pump.
     - Air to air heat pump
     - Air to water heat pump
     - Air (from exhausted air) to water heat pump

- ▪ Water to water heat pump

- A more detailed version for professionals' use:

  - o Boiler: the professional must enter technical characteristics about the boiler, such as the part (30 %, η_{30}) and full load (100 %, η_{100})efficiency and the standby heat loss (P_{stby}).

  - o Heat pump: the tool will ask only for the heat pump type.

In general, both versions follow the same procedure. Different questions will be addressed to the user. These questions will be related to different aspects such as the location, the size of the heating area, and the fuel used, among others.

Energy demand and energy consumption calculation

Once the required inputs are introduced by the user, HARPa will present the following results:

- **Space heating energy demand** *(MWh / year)***:**

The tool's first output is the space heating energy demand. To obtain this value (in MWh/year), the following equation is used:

Energy demand [kWh/m2] × Heating space = Calculated Energy demand [MWh/year]

The space heating Energy Demand depends on both the country and the year of installation of the current heating system. The tool works with specific ranges based on the country and age of installation.

- **Domestic Hot Water (DHW) energy demand** *(MWh/year)***:**

The DHW energy demand (not available in the current version of HARPa) will take into account the person needs of hot water (60°C) per day considering the average water temperature of a specific country.

- **Energy consumption** *(MWh / year)***:**

For the calculation of the energy consumption, the equation is:

Calculated Energy demand × System efficiency = Energy consumption (MWh/year)

- **Energy cost (MWh/year):**

In the case of the energy cost, the equation will be the following:

Energy consumption × Energy cost [€/kWh] = Calculated Energy cost [€/year]

The formula will take into account the average energy price.

New system savings

The HARPa tool will provide the expected energy cost and savings suggesting new heating appliances. Further questions related to the user's needs (storage space availability, electricity capacity, etc.) will be addressed.

For the calculation of the thermal power, the equation will be the following:

$$Max\ Power\ [W/m^2] \times Heating\ space = Calculated\ Max\ Power\ [kW]$$

The tool will take into account an average space heating energy demand (in kWh/m2) per country and according to the building age.

The tool will provide the following parameters:

1. Energy consumption = Energy demand
2. Energy cost = Energy consumption × Energy price (fuel)
3. CO_2 emissions = Energy consumption × unit emissions (fuel and market)
4. Average Investment. Considering location, system and power.
5. Energy savings (kWh/year)
6. Money savings (€/year)
7. CO_2 savings (tons of CO_2/year)

As the final step of the assessment, the tool will provide suggestions for different technologies feasible for the user. Users can explore the characteristics of each of them and have an idea of the possibilities available on the market for the substitution of their old and inefficient heating appliances. HARPa will also provide a list of financial incentives, and guidance to heating professionals and installers that can be contacted by the user.

This article presents the methodology and calculations behind the HARPa online tool, for further information about the HARP project or the HARPa tool, visit the HARP website.