referee
real value of energy efficiency

D4.1 – Offline REFEREE system

www.refereetool.eu

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101000136.

REFEREE: Real Value of Energy Efficiency
Results from the scoping analysis

Project Acronym	REFEREE
Project Title	Real Value of Energy Efficiency
Grant Agreement No	101000136
Project Start Date	1 October 2020
Project End Date	31 March 2024
Call Identifier	LC-SC3-EC-4-2020
Funding Scheme	Research and Innovation Action (RIA)
Project Website	http://refereetool.eu/

Deliverable Information

Deliverable No	D 4.1
Deliverable Title	Offline REFEREE System
Work Package No	4
Work Package Lead	MCRIT
Contributing Partners	ISINNOVA, CE, CSD, MCRIT, BAUM, EEB
Deliverable Type	Report
Dissemination Level	Public
Author(s)	Harold Del Castillo, Oriol Biosca, Efrain Larrea, Rafa Rodrigo, Andreu Ulied, Isaac Farradellas, Clara Sans
Contributors	-
Contractual Deadline	31st September 2022
Delivery Date	21st December 2022

Version Management

Version	Date	Author	Description of Change
1.0	21/12/2022	Harold Del Castillo, Oriol Biosca, Efrain Larrea, Rafa Rodrigoa, Andreu Ulied, Isaac Farradellas, Clara Sans	Draft Final

Partners

Partner	Short name	Principal Investigator
MCRIT	MCRIT	Mr Oriol Biosca

Table of Contents

1 Approach

1.1 About REFEREE

REFEREE is a European project, which started in October 2020 and will be in operation until April 2024.

REFEREE is developed to accelerate the efforts to improve the energetic efficiency of the residential sector, along with the tertiary and transport sectors.

REFEREE (Real Value of Energy Efficiency) as its own name indicates, aims to analyze and quantify the different impacts developed by the direct and indirect energy efficiency investments.

This goal will be accomplished by the tools developed under the program, in particular providing support to policy makers at the different territorial and sectoral levels needed.

REFEREE will help households, businesses, financing institutions, policy makers and other relevant stakeholders to evaluate the multiple impacts of their energy efficiency choices.

More information on REFEREE available at www.refereetool.eu.

1.2 Objectives of this report

This report deals with the REFEREE offline tool, that focuses on the dimension of European localities.

The approach of the offline tool for localities is to create and implement policies at local level and for different sectors (residential, tertiary and mobility) in order to improve the energy consumption patterns of localities, and reduce indirect impacts of energy consumption, such as the Greenhouse Gases (GHG).

The localities dimension of REFEREE is driven mostly from the needs of municipalities in dealing with energy efficiency, e.g. in the context of the Covenant of Mayors or the EU Heating and Cooling Strategy, and the Municipal Heating programs. Modelling and quantification builds upon key trends defined at Member State level on E3ME model.

The offline version of REFERRE is intended for experienced users (not requiring a user-interface), and developed in MS XLS enhanced with Visual Basic, linked to E3ME Lite.

The offline version of the REFEREE localities tool is a Draft version of the future online version, that is already being designed as a user-friendly interface

requiring no particular modelling expertise, but policy-expertise in the field of energy, socio-economic and environmental impact assessment.

But the offline version of the REFEREE localities tool is also the processing motor of the future online version. For this reason, the offline version is in continuous development and redefinition along with the online version.

At this point, however, the offline version is fully functional and a valuable standalone product for energy efficiency analysis at local level, and for the discussion of non-energy impacts derived from it.

The process for building the offline REFEREE tool included the following tasks:

- Pre-design of the system architecture. Identification of critical capabilities required based on the user-needs assessment, possible alternative system's architecture and technologic solutions, along with stakeholders in the context of our Advisory Group meetings.

- Prototyping. A rapid prototype of the REFEREE system was developed, just to facilitate a clearer understanding of the proposed structure, more particularly of the user-interface and its options to be customized to different policy-user needs, as well as the nature of the results that will be produced.

- Technological best solution. It was agreed that MS Excel was the best solution for the offline version of the REFEREE tool, as it may fit well on the practice of the technical body of servants at municipalities, one of our key targets. MS Excel allows for customization of tools and adaptations to meet the specific requirements and needs of specific localities.

- Development of the offline tool. The REFEREE localities offline tool was built up from European data gathered on the residential, tertiary and transport sector. For each sector policies were defined and customized to fit each sector. Finally, a screen with all results is set up and shows how policies apply to each sector and what are the impacts of these applied policies.

The next steps will be to:

- Integrate the offline tool for localities into the online tool, which already includes the member state level tool driven by ERME lite.

- Test bed. The tool will be pilot tested in a number of case studies across Europe to validate its form and functionalities and perform adjustments when needed. In particular, case studies are foreseen in Bulgaria, Denmark, Italy and Spain.

- Tool validation and documentation, in the context of deliverables to come during spring and early summer 2023.

2 Overview of the offline localities tool

In this chapter, the display of the different screens and interfaces used for the REFEREE offline system will be described and detailed for the different modules to get a better understanding of how the tool works, and what are the results obtained with it. The main point of this report is to help users understand what can be expected of the offline tool, what will be the nature of the results to be expected, what kind of inputs will be required, and how it will be dealt with policies to be assessed.

The following sections will be discussed:

2.1 Main page. In this section, the initial display of the offline tool is exhibited.

2.2 Definition of a city profile. As its name indicates the city profile is characterized and all inputs are detailed.

2.3 Definition of policies to be applied: Integrated Policy Selector. In this part, a dashboard of the different policies is displayed, for each sector. This policy selector shows how policies are applied and what are the impacts on each sector.

2.4 Extensive analysis on each sector. The analysis of the residential, tertiary and transport sector is done in this section and all policies applied are presented and can be modulated by defining a percentage value of the residential stock that wants to target, and at the same time the intensity of the policy can be decided.

2.5 Outputs. The results obtained are presented and displayed on four different levels and these will be shortly described.

2.6 Contextual data. In order to get a better understanding on the results obtained with the REFEREE offline tool, data from European countries was gathered and graphically represented.

3 Main page

In this module, defined as the main page of the tool, different boxes are shown. These can be divided into three main groups:

a. Inputs. The general characteristics of the city and its context is specified in this group. Here the definition of the country, the climatic area, the location... is done. The square which defines the inputs is '*Define a city profile*' (grey box).

b. Policies. Local policies for cities and regions are defined, and are found in six different divisions (yellow boxes):
   - Strategic Analysis.
   - Integrated policy selector.
   - Pathways for the domestic sector.
   - Pathways for the tertiary sector.
   - Pathways for transport.

c. Outputs. Results are shown in this chapter and are divided in different sets (green boxes):
   - Key Performance Indicators.
   - Contrast with policy targets.
   - Agent analysis.
   - Contextual data.

In the following figure, all the sections mentioned are in the grey rectangle:

4 Definition of a city profile

In this module the definition of the city profile is done. The inputs for this part are:

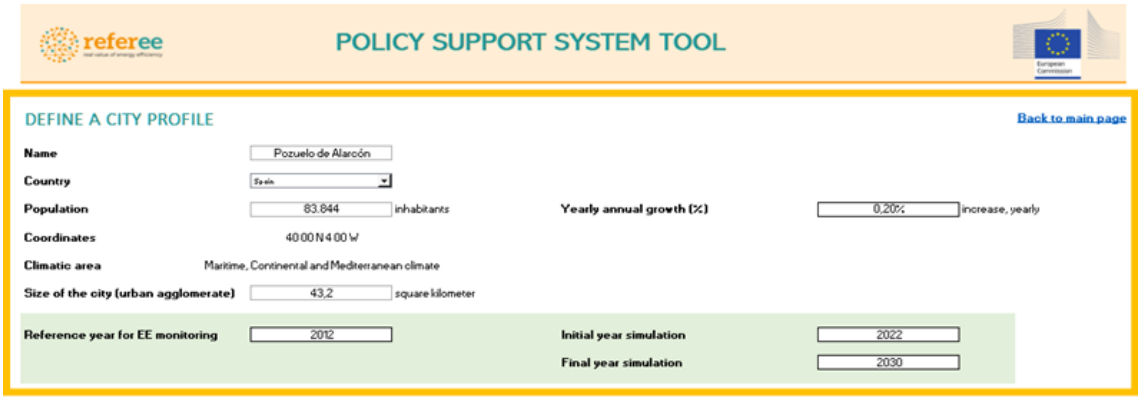
- Name of the City. City selected to apply the different selected policies which will be defined later.
- Population (number of inhabitants). It is the number of inhabitants that live in the city selected.
- Size of the city (urban agglomerate). Definition of the area occupied by the selected city.
- Yearly annual growth (%). This value will give the annual growth for the year selected.
- Reference year for EE[1] monitoring. This year is selected in order to use its data as a referential year.
- Initial and final year simulation. These years need to be defined since the simulation of the energy consumption data will be gathered between the years selected in this part.
- Total energy consumption. This value is the total energy consumed in the year and city selected.
- Energy consumption by type of energy. These values are the consumption of energy differentiated by the different energy types (electricity, natural gas, petrol, gas oil and other). The sum of all these gives the total energy consumption.
- Total energy consumption for each sector and by type of energy. These values are the detailed and classified energy consumption of each sector (residential, tertiary and transports) and type of energy (electricity, natural gas, petrol, gas oil and other).

Once all the input data is filled the outputs will be generated in the same module. In the next point the results from applying the chosen policies will be shown (2.3 Definition of policies to be applied: Integrated Policy Selector).

Below it can be seen how the input section of the tool is organized and it shows all the parts mentioned previously. In the figure the white fields are inputs, and the grey ones are outputs (commuted by operating different white boxes).

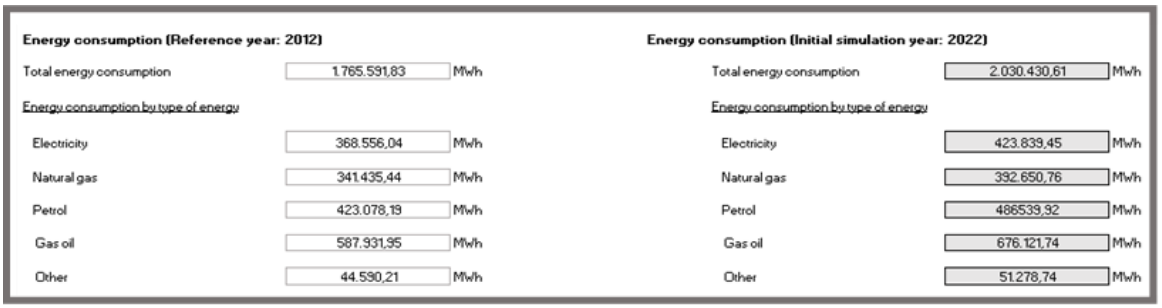
In the yellow rectangle the definition of a random city is shown, with its characteristics defined such as the population, size of the city and yearly annual growth. Also, the reference year chosen is 2012 while the simulation will be done from 2022 until 2030.

[1] EE stands for Energy Efficiency



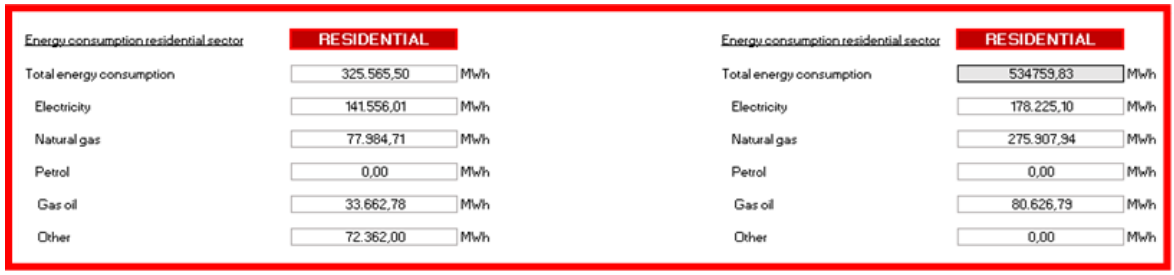
Definition of city profile

In the grey rectangle the energy consumption of the year 2012 is shown (left side) along with the different energy types. On the right side, the data from the initial simulation year (2022) is gathered.



Total energy consumption

In the red figure all the data from the residential sector is presented, at the beginning the energy consumption, followed by the distribution by types of energy of the reference year selected is found on the left, the initial year simulation data is on the right.



Definition energy consumption in residential sector

In the orange rectangle all the data from the tertiary sector is introduced, on the right column the first simulation year data and on the left the reference year data.

Energy consumption tertiary sector	TERTIARY		Energy consumption tertiary sector	TERTIARY	
Total energy consumption	232.338,82	MWh	Total energy consumption	413065,61	MWh
Electricity	144.661,19	MWh	Electricity	237.897,58	MWh
Natural gas	43.882,41	MWh	Natural gas	116.742,82	MWh
Petrol	0,00	MWh	Petrol	0,00	MWh
Gas oil	28.151,99	MWh	Gas oil	58.425,21	MWh
Other	15.643,24	MWh	Other	0,00	MWh

Definition energy consumption in tertiary sector

In the green figure all the data from the transport sector is displayed, both data from first simulation (on the right) and the reference base year (on the left) can be identified.

Energy consumption transport sector	TRANSPORT		Energy consumption transport sector	TRANSPORT	
Total energy consumption	742.523,17	MWh	Total energy consumption	1082605,17	MWh
Electricity	1.105,27	MWh	Electricity	7.716,77	MWh
Natural gas	1.891,84	MWh	Natural gas	0,00	MWh
Petrol	354.883,05	MWh	Petrol	486.539,92	MWh
Gas oil	379.359,51	MWh	Gas oil	537.069,74	MWh
Other	5.283,49	MWh	Other	51.278,74	MWh

Definition energy consumption in transport sector

5 Definition of policies to be applied: Integrated Policy Selector

This module is known as Integrated Policy Selector where the policies are defined and detailed for each sector, along with the key impacts and policy targets for each policy and sector.

The Integrated Policy Selector is understood as a dashboard where all the different sections are referenced so the policies on each sector (residential, tertiary and transport) can be changed. In this section, the current policies considered are displayed together with the intensity these policies are applied. The different policies are segregated into consumption origins: heating, cooling, water heating and appliances, for the residential and tertiary sector; and public transport and road transport, for the transport sector.

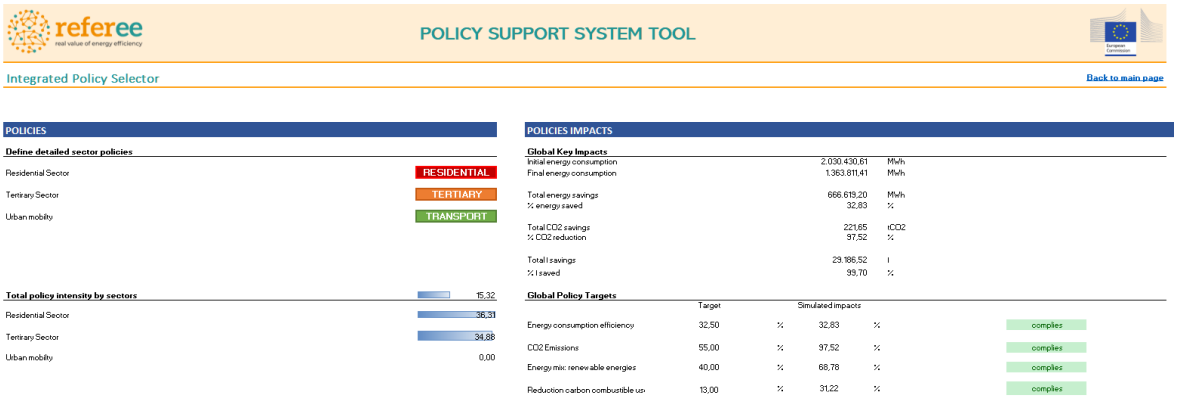
The main objective of this screen is to crate a synthesis of the results obtained by applying the policies defined in the offline REFEREE tool. Therefore, in this section there are no inputs, since all results from policies applied and outputs obtained by the application of those policies are displayed. Some of the outputs that are found in this page are:

- ✓ Total policy intensity by sectors.
- ✓ % Stock targeted.
- ✓ Policy intensity (%).
- ✓ Initial energy consumption.
- ✓ Final energy consumption.
- ✓ Energy saved and % of energy (not) saved.
- ✓ tCO_2 saved and the reduction of CO_2 in %.
- ✓ …

All the outputs of the module will be shown later and explained in more detail.

How it works?

As the figure shows, there are two clear spaces were the definition of policies for each sector is defined and the total intensity of policies for each sector (left column). On the right column, the global impacts of the policies are described, along with the initial and final consumption, the energy saved and the CO_2 savings. As follows, the global policy targets are defined together with the simulated impacts given by the policies applied.



POLICY SUPPORT SYSTEM TOOL

Integrated Policy Selector

Back to main page

POLICIES

Define detailed sector policies

Residential Sector	RESIDENTIAL
Tertiary Sector	TERTIARY
Urban mobility	TRANSPORT

Total policy intensity by sectors 15,32

Residential Sector	36,31
Tertiary Sector	34,88
Urban mobility	0,00

POLICIES IMPACTS

Global Key Impacts

Initial energy consumption	2.030.430,61	Mwh
Final energy consumption	1.363.811,41	Mwh
Total energy savings	666.619,20	Mwh
% energy saved	32,83	%
Total CO2 savings	221,65	tCO2
% CO2 reduction	97,52	%
Total l savings	29.186,52	l
% l saved	99,70	%

Global Policy Targets

	Target		Simulated impacts		
Energy consumption efficiency	32,50	%	32,83	%	complies
CO2 Emissions	55,00	%	97,52	%	complies
Energy mix: renewable energies	40,00	%	68,78	%	complies
Reduction carbon combustible us	13,00	%	31,22	%	complies

Followed by the definition of the policies applied for the residential sector (left column) which are divided in four groups: heating, cooling, water heating and cooking. This division is done based on the different energy consumption sources used in a residential building. On the other side, the results from the policies applied are shown as impacts and targets, as said before the values of consumption (initial and final), energy savings and CO_2 saved. The green boxes show the existing target used and if met the box will be green and with the message 'target met', but if not, it will be red and with the message 'target unaccomplished'.

Policies applied to the residential sector

	% residential stock targetted	Policy intensity (%)
Heating	**15,00**	**39,75**
User behavior change. Average temp. selection	35,00	85,00
Building efficiency	5,00	100,00
New heating technology	5,00	100,00
Cooling	**15,00**	**39,75**
User behavior change. Average temp. selection	35,00	85,00
Building efficiency	5,00	100,00
New cooling technology	5,00	100,00
Water heating	**15,00**	**39,75**
User behavior change. Average temp. Selection	35,00	85,00
Building efficiency	5,00	100,00
New water heating technology	5,00	100,00
Cooking	**5,00**	**10,00**
Building efficiency	5,00	100,00
Efficient lighting	5,00	50,00
Efficient appliances	5,00	50,00

Policies impacts for the residential sector

Key impacts and targets	Existing target	Results of simulation		
Initial energy consumption		374.400,33	Mwh	
Final energy consumption		328.930,90	Mwh	
Total energy savings		45.469,43	Mwh	
% energy saved	15,00	12,14	%	target unaccomplished
Total CO2 savings		20,54	tCO2	
% CO2 reduction in sector	15,00	25,40	%	target met
CO2 reduction from policies applied at local level		*18,52*	*tones*	
CO2 reduction from exogenous gains on cleaner electricity mix		*2,02*	*tones*	
Initial cost of consumption in sector		45.625,36	l	
Final cost of consumption in sector		37.605,94	l	
Total l savings		8.019,42	l	
% l saved		17,58	%	

For the tertiary sector, the distribution is the same as in the residential sector. The policies applied are shown on the left side and divided by sources used in the sector (heating, cooling, water heating and cooking). On the other side, the impacts of these policies are shown.

Policies applied to the tertiary sector

	% residential stock targetted	Policy intensity (%)
Heating	**15,00**	**41,50**
User behavior change. Average temp. Selection	35,00	90,00
Building efficiency	5,00	100,00
New heating technology	5,00	100,00
Cooling	**15,00**	**39,75**
User behavior change. Average temp. Selection	35,00	85,00
Building efficiency	5,00	100,00
New heating technology	5,00	100,00
Water heating	**15,00**	**39,75**
New water heating technology	35,00	85,00
Building efficiency	5,00	100,00
User behavior change. Average temp. selection	5,00	100,00
Cooking	**5,00**	**10,00**
Building efficiency	5,00	100,00
New lighting	5,00	50,00
New appliances	5,00	50,00

Policies impacts for the tertiary sector

Key impacts				
Initial energy consumption		267.189,65	MWh	
Final energy consumption		232.939,55	MWh	
Total energy savings		34.250,10	MWh	
% energy saved	15,00	12,82	%	target unaccomplished
Total CO2 savings		16,09	tCO2	
% CO2 reduction in sector	15,00	27,68	%	target met
CO2 reduction from policies applied at local level		*14,39*	*tones*	
CO2 reduction from exogenous gains on cleaner electricity mix		*1,71*	*tones*	
Initial cost of consumption in sector		35.351,53	l	
Final cost of consumption in sector		28.407,47	l	
Total l savings		6.944,06	l	
% l saved		19,64	%	

For the transport sector, the policies applied in this sector are only divided in two areas: the public transport and the road transport. On the right side, the policies impact in the transport sector are shown as in the previous cases.

Policies applied to the transport sector

	% residential stock targetted	Policy intensity (%)
Public transport	**26,67**	**100,00**
Investment in new vehicles (fleet renovation)	20,00	100,00
Energy efficiency gains from electric buses	40,00	100,00
Better fleet management	20,00	100,00
Road transport	**35,67**	**100,00**
Increase mean vehicle occupation (car pooling, urban toll,...)	5,00	100,00
Transfer road users to public transport	2,00	100,00
Increase vehicle efficiency	100,00	100,00

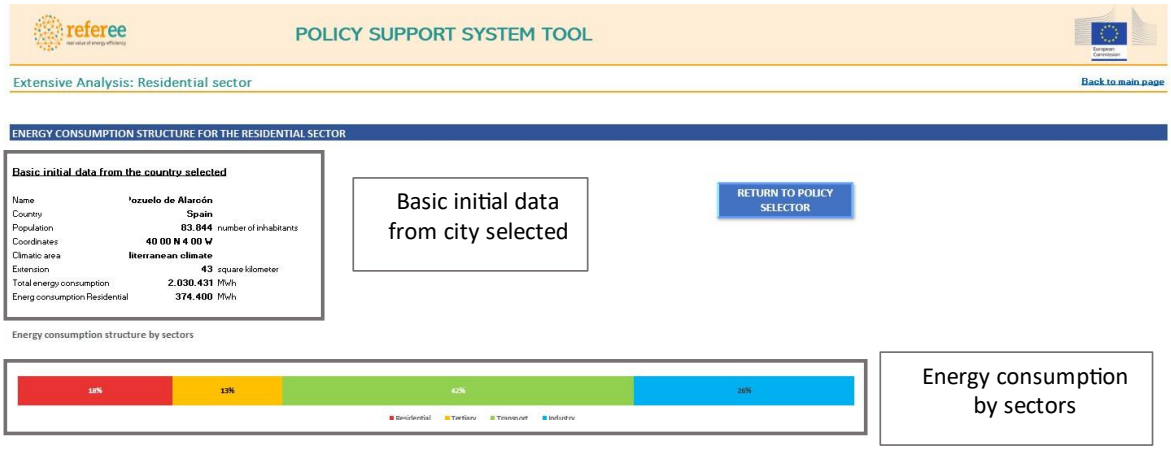
Policies impacts for the transport sector

Key impacts				
Initial energy consumption		2.030.430,61	MWh	
Final energy consumption		1.443.530,94	MWh	
Total energy savings		586.899,67	MWh	
% energy saved	15,00	28,91	%	target met
Total CO2 savings		185,02	tCO2	
% CO2 reduction in sector	15,00	35,29	%	target met
CO2 reduction from policies applied at local level		*173,40*	*tones*	
CO2 reduction from exogenous gains on cleaner electricity mix		*5,67*	*tones*	
Initial cost of consumption in sector		164.443,43	l	
Final cost of consumption in sector		150.220,40	l	
Total l savings		14.223,04	l	
% l saved		8,65	%	

6 Extensive analysis on each sector

The module for policy definitions is standardized for each of the three sectors considered: residential, tertiary, and transport. The rationale and structure of each one of them is presented next:

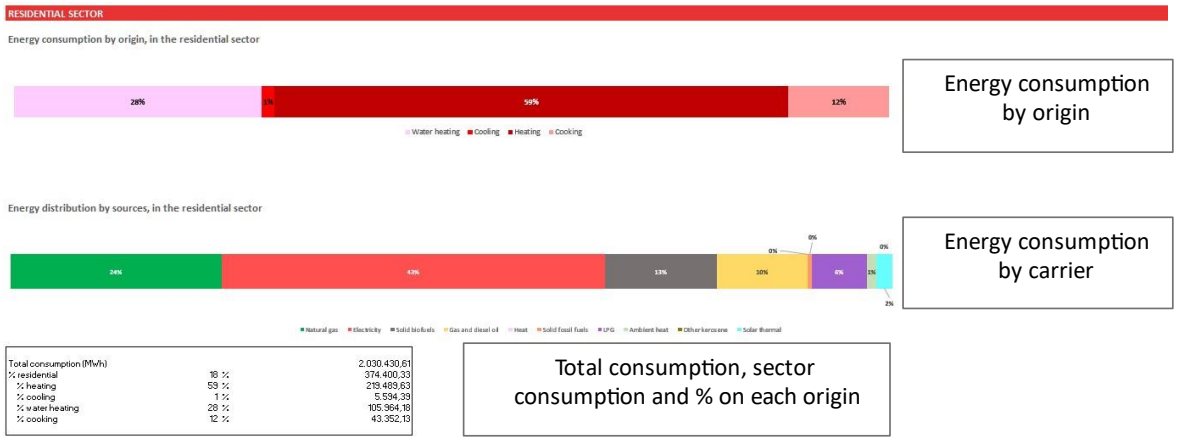
In each module at the beginning there is the definition of the basic initial data from the country selected, all this data is an input defined previously in the 2.2 Definition of a city profile. Hereafter the energy consumption distribution by sectors is represented graphically.



Next, the distribution of the energy consumption within the sector selected is displayed. This can be the residential sector, the tertiary or the transport sector. Two distributions are displayed:

- by consumption origin (e.g. water heating, colling, heating and appliances)
- by energy carrier (e.g. fuel, gas, electricity, …)

At the end, a table with the total consumption is shown and the percentage for the sector analyzed along with the percentages of the energy consumption by origin are presented.



In case of the transport sector, the distribution is the same as for the built environment (residential and tertiary buildings), considering as energy

consumption origins the private road transport, and the public transport (within the localities).

Energy consumption by carrier

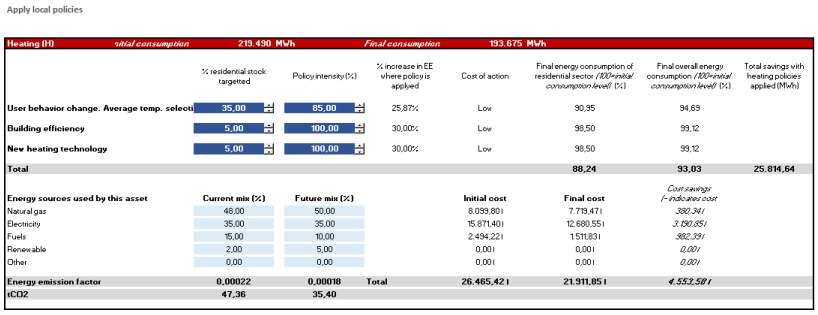
Total consumption, sector consumption and % on each policy

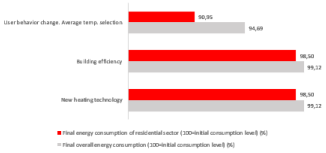
After this, the different policies are defined and based on the sector, and policies will be classified by origin (for the residential and tertiary sectors), although for the transport sector these are classified by public transport and road transport. For each case, the initial (no policies applied) and final consumption (policies applied) are presented.

How it works?

Below, three policies are described although they can be substituted depending on the objectives of the city. Each policy needs to define a percentage value of the residential stock that wants to target, and at the same time the intensity of the policy needs to be chosen. On the other hand, the energy mix can also be changed in order to compare the results from the current mix and the future one. This will give the values of energy emission factor and the tones of CO_2 emitted. Next to the energy mixes the cost of each energy source consumed is calculated, along with the savings obtained with the future mix.

The graphical representation of the impact of policies is also shown.





In the end, a summary of the results can be found:

- Total energy consumed initially.
- Total savings from origin[2] (policies applied).

[2] Origin will be heating, cooling, cooking, or water heating for the residential and tertiary sector, while for the transport sector there are no origins defined but will be used public transport and road transport differentiation.

- % Savings relative to initial origin consumption.
- Final energy consumption from origin.
- Total tCO_2 emitted initially.
- Total tCO_2 saved, this is also disaggregated into tCO_2 saved from energy efficiency, changing energy sources and cleaner electricity mix.
- Total tCO_2 emitted finally.

On the other side, the smaller table shows the total consumption of the origin by energy source, initial and final consumption.

Heating (H) total savings		
Total energy consumed initially	219.490	MWh
Total savings from heating (policies applied)	25.815	MWh
% savings relative to initial heating consumption 12%		
Final energy consumption from heating	193.675	MWh
Index 100 = initial consumption 88,2		
Total tCO2 emitted initially	47,36	tCO2
Total tCO2 saved	11,97	tCO2
tCO2 saved from energy efficiency (less consumptio	*5,57*	*tCO2*
tCO2 saved from changing energy sources (cleaner	*5,24*	*tCO2*
tCO2 saved from cleaner electricity mix (exogenous	*1,16*	*tCO2*
Total tCO2 emitted finally	35,40	tCO2

Heating total consumption by energy source (MWh)		
	Initial consumption	Final consumption
Electricity	76.821	67.786
Natural gas	105.355	96.837
Petrol	0	0
Gas oil	32.923	19.367
Other	4.390	9.684
Total	**219.490**	**193.675**

For each of the four origins, the outline will be the same, both for the residential and the tertiary sector. On the other hand, for the transport sector the only difference is that instead of origins the analysis is developed for public transport and road transport.

Apply local policies

Public Transport	*Initial consumption*	304.565 MWh	*Final consumption*	190.876 MWh				
	% transport stock targetted	Policy intensity (%)	% increase in EE	Cost of action	Final energy consumption of transport sector *(100=initial consumption level)* (%)	Final overall energy consumption (100=initial consumption level) (%)	Total savings with policies applied (MWh)
Investment in new vehicles (feet renovation)	20,00	100,00	15,00%	Low	97,00	98,74	
Energy efficiency gains from electric buses	40,00	100,00	87,50%	Low	65,00	85,28	
Better fleet management	20,00	100,00	3,00%	Low	99,40	99,75	
Total					**62,67**	**83,99**	**113.688,78**

Energy sources used by this asset	**Current mix (%)**	**Future mix (%)**	**Initial cost**	**Final cost**	*Cost savings (- indicates cost*
Petrol and petrol hybrids	0,00	0,00	0,00 €	0,00 €	*0,00 €*
Diesel	80,00	40,00	18.296,29 €	5.909,05 €	*12.387,24 €*
Plug in + electric	20,00	60,00	12.584,69 €	21.423,91 €	*-8.839,21 €*
LPG	0,00	0,00	0,00 €	0,00 €	*0,00 €*
Natural gas	0,00	0,00	0,00 €	0,00 €	*0,00 €*
Hydrogen and fuel cells	0,00	0,00	0,00 €	0,00 €	*0,00 €*
Biofuel	0,00	0,00	0,00 €	0,00 €	*0,00 €*
Other	0,00	0,00	0,00 €	0,00 €	*0,00 €*
Energy emisison factor	**0,00026**	**0,00020**	**30.880,98 €**	**27.332,95 €**	*3.548,03 €*
tCO2	**79,00**	**38,70**			

At the end of the module the summary tables of energy saved, tCO_2 saved, final consumption and tCO_2 emitted are presented. And on the right side the initial and final consumption for each origin.

Public Transport total savings		
Total energy consumed initially	304.565	MWh
Total savings from Public Transport (policies applied)	113.689	MWh
% savings relative to initial Public Transport consumption 37%		
Final energy consumption from Public Transport	190.876	MWh
Index 100 = initial consumption 62,67		
Total tCO2 emitted initially	79,00	tCO2
Total tCO2 saved	40	tCO2
tCO2 saved from energy efficiency (less consumptio	29,49	tCO2
tCO2 saved from changing e 100 = initial consumption	8,85	tCO2
tCO2 saved from cleaner electricity mix (exogenous	2	tCO2
Total tCO2 emitted	39	tCO2

Public Transport total consumption by energy source (MWh)		
	Initial consumption	**Final consumption**
Electricity	60.913	114.525
Natural gas	0	0
Petrol	0	0
Gas oil	243.652	76.350
Other	0	0
Total	**304.565**	**190.876**

Hereafter, the smaller tables show the total savings on energy consumption and CO_2 on the left, and on the other side it is shown how much the energetic mix has changed into renewable energies.

For the bigger tables, the left one gives the values of total energy and tones of CO_2 saved per origin (as said before, this will be the same for the residential and tertiary sector although for the transport sector instead of origins there will be public transport and road transport). On the other hand, the table on the right shows the final energy consumption and tones of CO_2 emitted per origin taking into consideration the policies, therefore, these values are obtained by applying the different policies mentioned before.

Total savings on the energy consumption and CO2 (on residential sector)	
Energy	58%
CO2	25%

Renewable energies	
Energy mix: renewable energies	3,29%

Total energy saved and tCO2 per origin		
Heating	25.815	MWh
tCO2 saved on heating	12,0	tCO2
Cooling	963	MWh
tCO2 saved on cooling	0,6	tCO2
Water heating	15.414	MWh
tCO2 saved on water heating	6,3	tCO2
Cooking	3.278	MWh
tCO2 saved on cooking	1,7	tCO2
Total energy saved	45.469	MWh
Total tCO2 saved	21	tCO2

Final energy consumption and tCO2 per origin		
Heating consumption	193.675	MWh
tCO2 emitted by heating	35,4	tCO2
Cooling consumption	4.632	MWh
tCO2 emitted by cooling	0,7	tCO2
Water heating consumption	90.550	MWh
tCO2 emitted by water heating	16,5	tCO2
Cooking consumption	40.074	MWh
tCO2 emitted by cooking	7,7	tCO2
Final energy consumption	328.931	MWh
Final tCO2 emitted	60	tCO2

Below, an energy and costs scoreboards are presented along with the reduction of GHG emissions and the electricity carbon footprint.

The energy scoreboard shows the initial, final consumption and savings of each origin, also the tones of CO_2 emitted initially, finally and its savings. For each sector at the end there is the sum of the total energy consumed initially, finally and saved, the same with the CO_2 emitted and saved. On the other hand, the costs scoreboard shows the initial cost, the final cost and the savings obtained by applying the policies in each origin and a final sum of initial and final costs along with its savings.

Energy scoreboard	Initial	Final	Savings
Heating	219.489,63	193.674,99	25.815 MWh
tCO2 on heating	47,36	35,40	11,97 tCO2
Cooling	5.594	4.632	963 MWh
tCO2 on cooling	1,28	0,70	0,58 tCO2
Water heating	105.964	90.550	15.414 MWh
tCO2 on water heating	22,87	16,55	6,32 tCO2
Cooking	43.352	40.074	3.278 MWh
tCO2 on cooking	9,36	7,68	1,68 tCO2
TOTAL energy	374.400,33	328.930,90	45.469,43 MWh
Total Co2	80,87	60,33	20,54 tCO2

Costs scoreboard	Initial cost	Final cost	Savings
Heating	26.465,42 €	21.911,85 €	4.553,58 €
Cooling	1.155,81 €	823,12 €	332,69 €
Water heating	12.776,85 €	10.244,59 €	2.532,26 €
Cooking	5.227,27 €	4.626,38 €	600,90 €
Total	45.625,36 €	37.605,94 €	8.019,42 €

Finally, there is a table with all reduction of tones CO_2 emissions of GHG sorted by origin and the smaller table shows the carbon footprint of electricity with the reference year and the simulation years.

Origin of GHG emission reductic (tonnes CO2)	Heating (H)	Cooling (AC)	Water heating (WH)	Cooking	TOTAL	
tCO2 saved from energy efficiency (less consumptio	5,57	0,22	3,33	0,71	9,82	47,83%
tCO2 saved from changing energy sources (cleaner	5,24	0,28	2,45	0,73	8,70	42,34%
tCO2 saved from cleaner electricity mix (exogenous	1,16	0,08	0,54	0,24	2,02	9,83%

Electricity carbon footprin	current scenario
2012	0,000333
2020	0,000177
2022	0,000229
2030	0,000160

7 Outputs

This section gathers all the results obtained by the application of the different policies established in section 2.4 Extensive analysis on each sector.

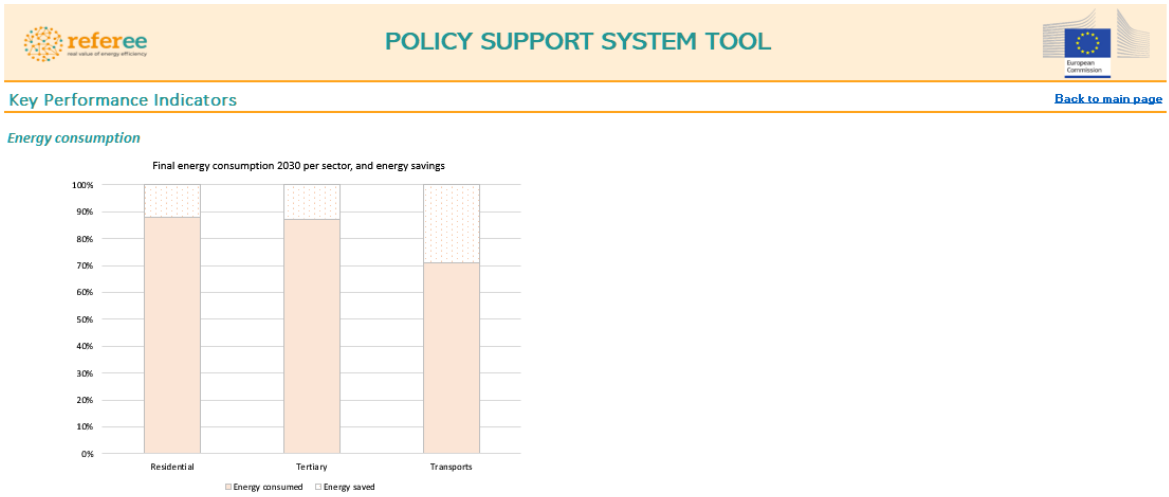
Next, the different results obtained from the REFEREE offline tool are displayed into different levels and will be discussed shortly:

- Energy Key Performance Indicators (KPI)
- Non-energy impacts
- Contextualization with policy targets

7.1 Energy Key Performance Indicators (KPI)

In the following module, the results obtained in the previous section (2.5 Extensive analysis on each sector) are graphically represented.

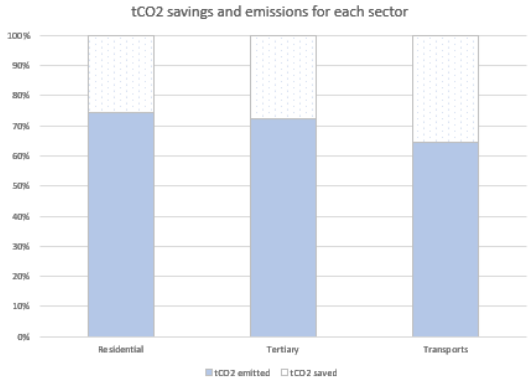
At first, the final energy consumption in 2030 per sector and the energy savings are illustrated.



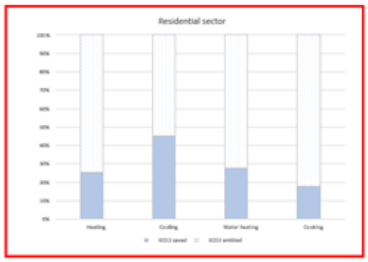
Followed by a disaggregated scheme of each sector's energy consumed and saved per origin.

Later, the tones of CO_2 emitted and saved for each sector is also given.

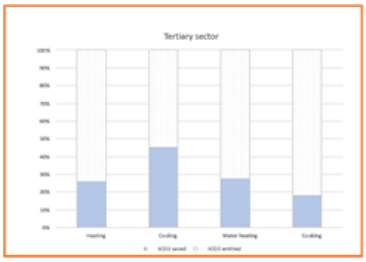
CO2 emissions



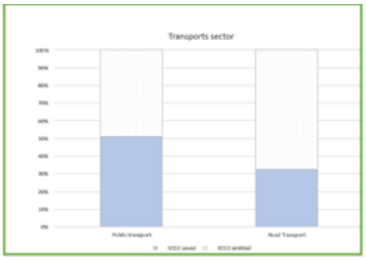
Followed by each sector's savings and emissions of tCO_2 per origin.



Residential sector



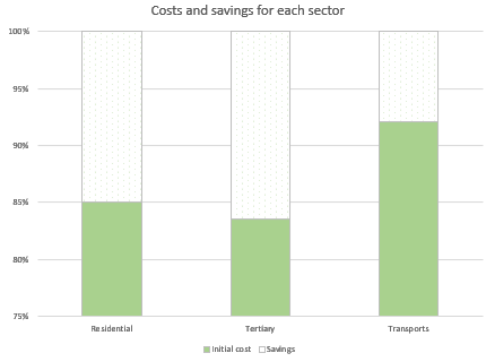
Tertiary sector



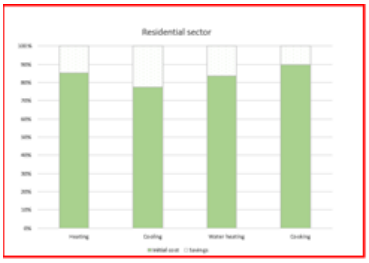
Transports sector

On the other hand, the costs and savings reached for each sector are also represented.

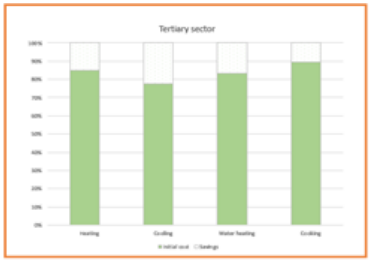
Costs & savings



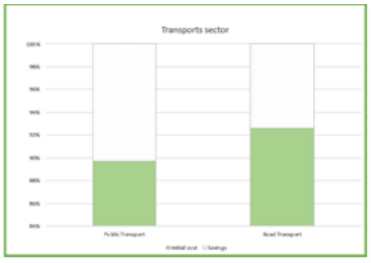
Finally, each sector's costs and savings per origin are illustrated as follows.



Residential sector



Tertiary sector



Transports sector

7.2 Non-energy impacts

In the following section, different indicators will be defined and used for the purpose to observe the evolution of the different indicators relative to the non-energy impacts, considering the localities dimension.

These indicators are derived from the assessment framework defined at EU level and Member States level as obtained from the E3ME lite model and adjusted to the reality of localities.

In this section there will be two main scenarios:

- The definition of the economic, environmental and social indicators.
- A simulation balance of the three indicators (economic, environmental and social) will be displayed.

Next, the following economic indicators are defined and applied at local state and member state levels. According to the figure, the results of each indicator is compared at each level (local and member state).

- ⇨ Gross Domestic Product (GDP).
- ⇨ Labour productivity.
- ⇨ Public budget as share of GDP.
- ⇨ International competitiveness.
- ⇨ Fuel imports.

Economic indicators		Local state
Gross Domestic Product (GDP)		0,00%
Total GDP (l)	2.241.195.000	
I saved	29.187	
Labour productivity		-6%
GDP (l)	26.367	
I saved	29.187	
Number wor	43.567	
Public budget as share of GDP		
International competitiveness		*not relevant at local level*
Fuel imports		*not relevant at local level*

Hereinafter, the environmental indicators are briefly described. The indicators discussed are:

- ⇨ Fossil fuel consumption.
- ⇨ Energy intensity.
- ⇨ Energy cost impact.
- ⇨ Air pollution and emissions.
- ⇨ Air pollution damage costs.
- ⇨ Water used in electricity generation.
- ⇨ Material use.

As in the case of the economic indicators, the results obtained are compared at local and member state levels.

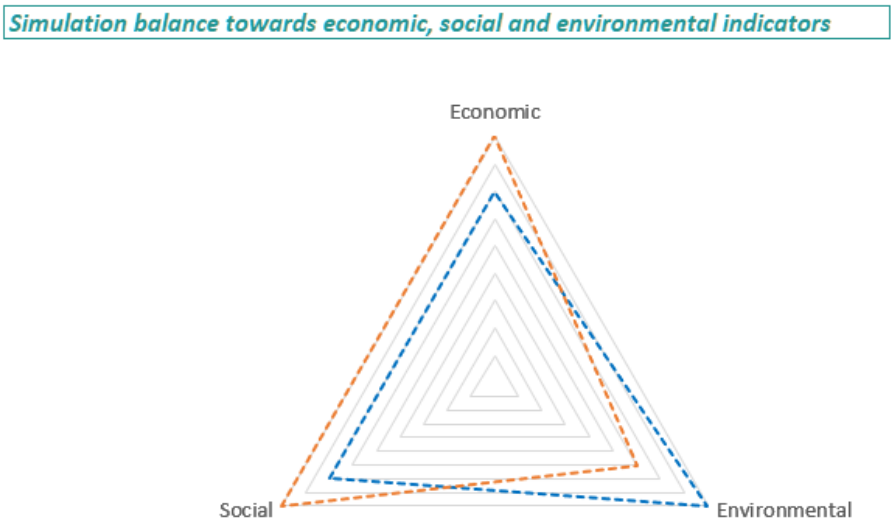
Environmental indicators		
		Local state
Fossil fuel consumption		↑ 77%
Initial consumption (MWh)	26.000	
Final consumption (MWh)	20.000	
Energy intensity		↑ 44%
GDP	26.367	
Energy con:	60.000	
Energy cost impact		*not relevant at local level*
Air pollution and emissions		↑ 250
O3	30	
NO2	60	
CO2	130	
PM	30	
Air pollution damage costs		↑ 2
O3	0,5	
NO2	0,2	
CO	0,8	
PM	0,25	
Water used in electricity generation		*not relevant at local level*
Material use		*not relevant at local level*

Finally, the social indicators studied are the following ones and are compared between local state and member state level.

- ⇨ Energy poverty.
- ⇨ Employment.
- ⇨ Share of energy consumption.
- ⇨ Share of total space heat demand.

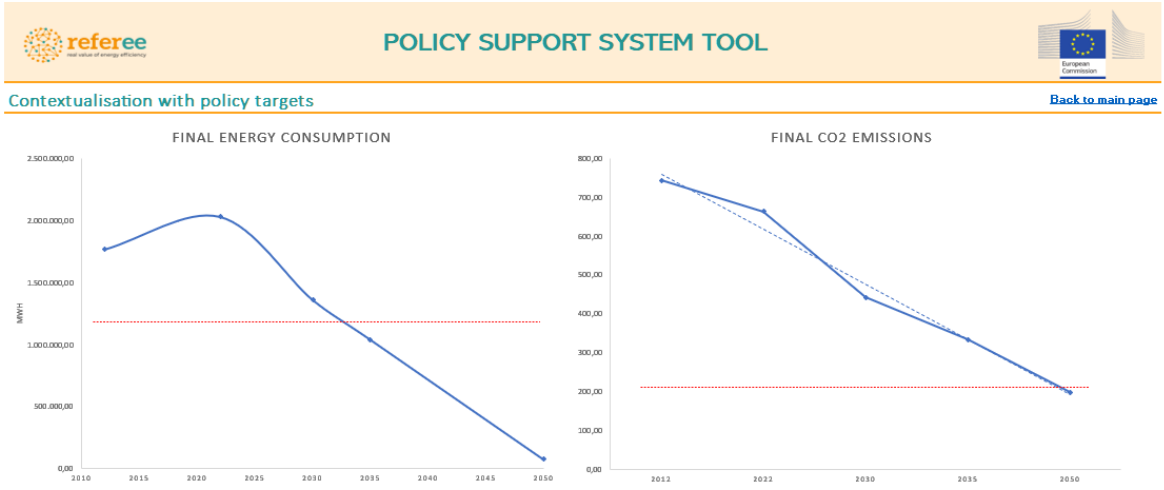
Social indicators		
		Local state
Energy poverty		↑ 17
Arrears	3,1	
Keep warm	1,5	
Electricity	0,214	
Gas	0,065	
Leak	9,4	
Employment		*not relevant at local level*
Share of energy consumption		*not relevant at local level*
Share of total space heat demand		*not relevant at local level*

On the other hand, a simulation balance between the three indicators mentioned previously is done. Here, the objective is to see how the changing of the different indicators will affect on the others.



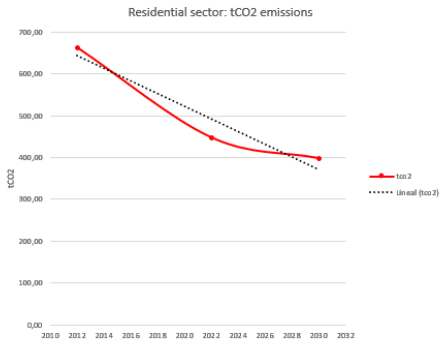
7.3 Contextualization with policy targets

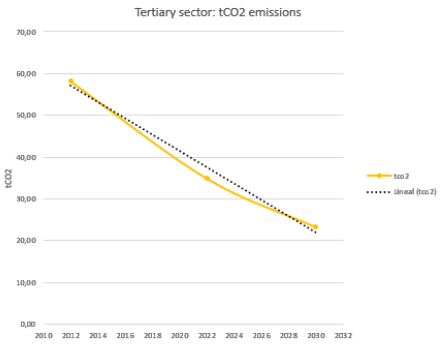
In this module, the comparison between the final energy consumption and its targets is represented along with the final CO_2 emissions and the targets established. The targets are presented by the European Commission in the Sustainable Energy and Climate Action Plan (SECAP), for both years 2009 and 2016. The evolution of these objectives during the years is graphically represented in units of MWh and also GEH tones of CO_2.

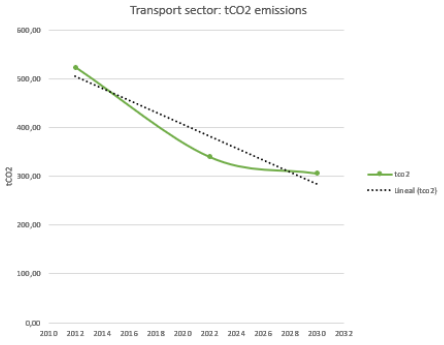


Hereafter, the evolution of the three sectors previously analyzed is also represented. For the three sectors there is the graphical representation of the evolution of CO_2 emitted from 2010 until 2032 along, represented together with the target defined by the EU. The residential sector is represented in red; the tertiary is in yellow; and the transport sector is on green.

CO2 emissions for each sector







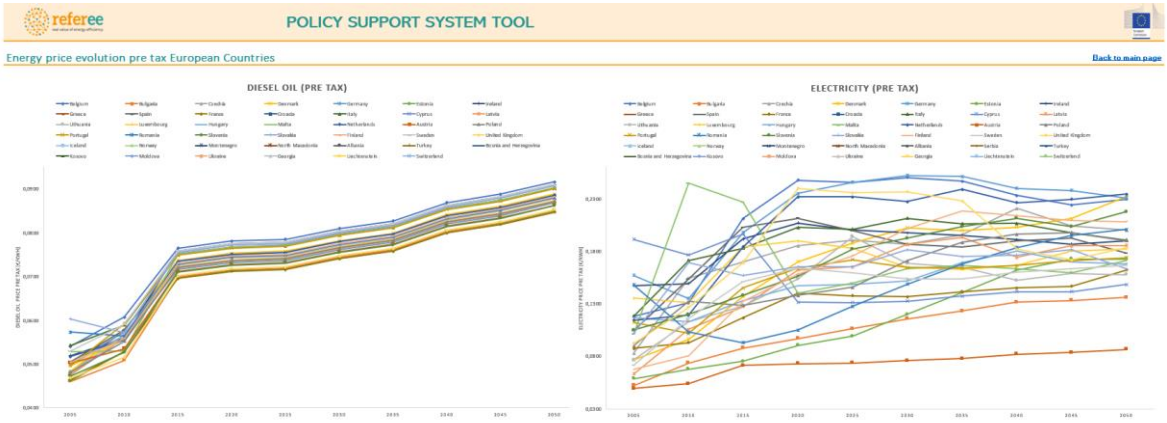
8 Contextual data

This module will show contextual data considered at the REFEREE offline tool, such as the price evolution on energy sources in the European context, the typical distribution at member state level of municipal energy consumption contribution of the residential, tertiary and transport sectors, also the origins of energy consumption within each of these sectors (e.g., water heating, cooling, heating, appliances).

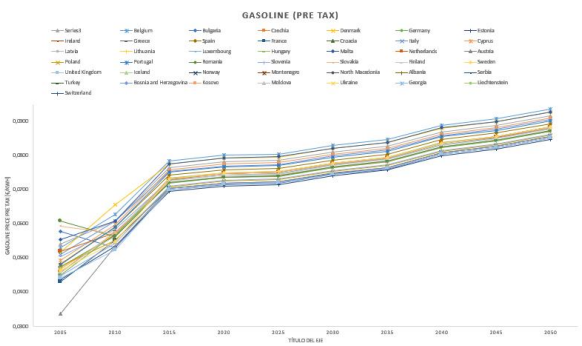
Next, the example of energy prices history and future estimates is displayed, as shown in the REFEREE offline localities tool. In the following figures the annual evolution of the four most used sources is illustrated and the appeared results can be compared. The sources which appear in this comparison are:

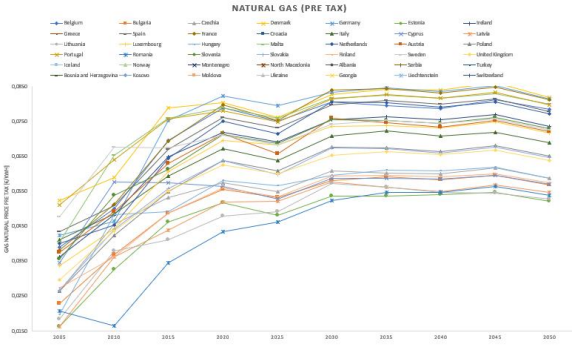
Diesel oil	Gasoline	Electricity	Natural gas

On the left side, the evolution of diesel oil price is represented and it can be said that the price of diesel oil will rise almost an 85% for each country, from 2005 to 2050. On the other hand, on the right side the average electricity price is represented, for this source it can be seen how the evolution between countries is very different and depends on each year but for almost each country the price will also increase 83% from 2005 to 2050.

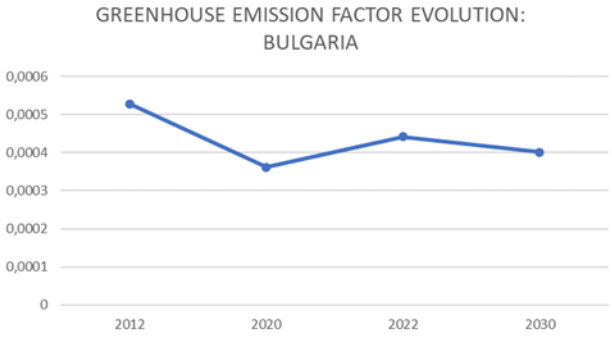


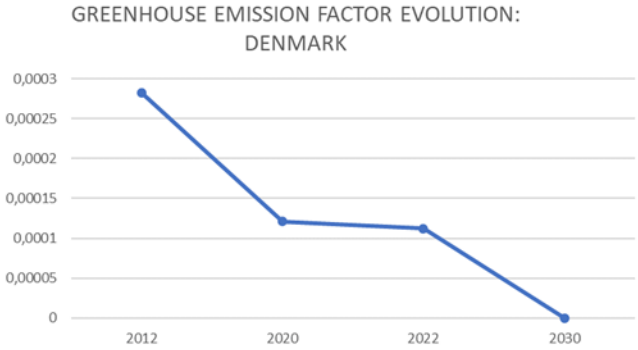
Followed by the evolution of gasoline (left) and natural gas (right). For gasoline, the price evolution is quite constant and similar for all countries, i.e. there is only a sharp price increase between 2010 and 2015. The expected growth from 2005 until 2050 is almost 83%. On the other side, the energy price growth for natural gas is also, for almost all countries, quite homogeneous, although sharp changes can be observed in countries such as Romania and Georgia, and the expected growth between 2005 and 2050 is about 83%.

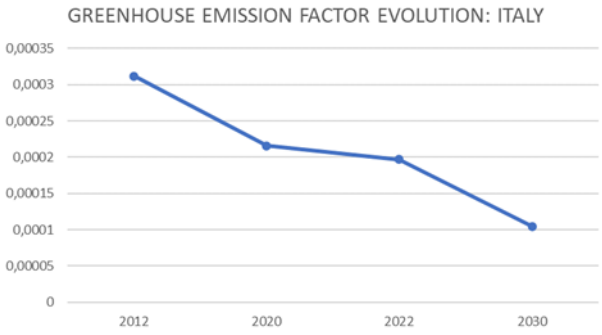


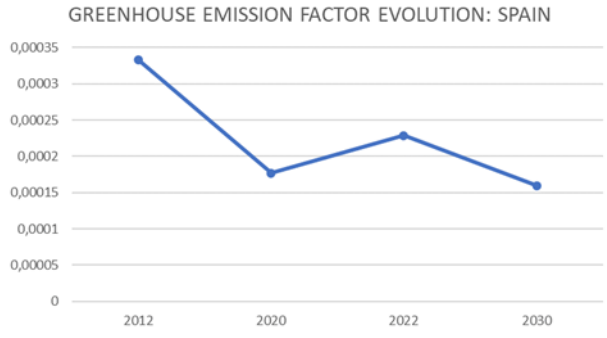


Other contextual data is the historical evolution of the GHG emissions factor of the electric mix, per country. This factor changes for each country depending on its electricity mix and increases and decreases throughout the years based on the relative use of each of the sources. Following, examples from Bulgaria, Denmark, Italy and Spain's are presented, as displayed in the offline tool.









Other contextual data corresponds to the split of energy consumptions by origin and energy source for the residential sector.

Example of contextual data for the energy consumption in the residential sector by origin classified into heating, cooling, water heating and appliances.

TIME	heating	cooling	water heating	appliances
GEO (Labels)				
Belgium	239.446,63	216,000	39.775,753	5.533,267
Bulgaria	47.184,90	430,276	16.428,524	7.752,170
Czechia	203.351,23	248,000	49.607,560	18.140,252
Denmark	110.064,98	:	41.420,523	3.129,450
Germany	1.522.589,33	4.544,294	393.283,096	143.627,234
Estonia	29.116,87	:	4.676,328	2.028,060
Ireland	73.091,54	:	23.773,025	2.700,285
Greece	94.688,14	8.475,779	22.852,265	10.595,582
Spain	241.420,36	6.153,368	116.551,799	47.683,742
France	1.075.513,37	7.624,667	189.625,945	92.136,101
Croatia	62.851,18	1.860,656	9.703,599	6.572,390
Italy	864.618,61	11.038,450	157.029,826	85.034,336
Cyprus	5.667,60	1.594,523	3.363,060	1.174,735
Latvia	32.641,97	0,000	9.225,853	3.446,183
Lithuania	42.542,99	:	5.229,102	4.033,697
Luxembourg	14.797,33	87,808	1.512,084	652,351
Hungary	168.015,47	569,401	31.226,281	11.842,227
Malta	827,83	508,604	1.114,534	573,432
Netherlands	247.338,35	966,456	67.654,778	8.418,750
Austria	194.760,98	30,082	39.873,554	7.521,608
Poland	487.413,32	0,000	133.122,516	68.977,928
Portugal	37.249,98	1.047,262	21.287,060	37.769,439
Romania	201.727,17	1.061,759	44.283,148	32.618,124
Slovenia	27.687,18	335,725	7.418,329	1.852,907
Slovakia	80.562,73	133,920	13.898,440	4.778,500
Finland	155.846,15	374,400	36.086,574	2.436,306
Sweden	170.700,42	:	43.841,434	4.891,500
United Kingdom	1.011.551,33	:	260.570	:
Iceland	:		:	:
Norway	126.529,78	178,258	24.882,913	2.970,990
Montenegro	:		:	:
North Macedonia	14.309,72	523,440	1.898,565	1.606,801
Albania	6.838,13	1.610,237	4.934,199	6.610,458
Serbia	73.527,03	576,295	16.748,859	8.780,494
Bosnia and Herzegovina	51.078,45	436,982	6.957,069	3.591,394
Kosovo	17.196,22	928,267	1.738,613	1.913,011
Moldova	35.264,38	31,594	5.190,405	6.420,819