Statistical Inventories of the heating systems market and development scenarios in the target regions

Report D3.2

Project Coordinator: Austrian Energy Agency – AEA

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Executive summary

With heating and cooling (HC) comprising 50% of final European energy consumption and over 68% of all gas imports, permanently reducing consumption and increasing the share of renewables in this sector is paramount for a successful Energy Union. In particular, the fact that 80 million out of 120 million installed space heating systems in Europe currently achieve an energy label class C or D gives rise to major concern.

REPLACE therefore aims to boost the phase-out of inefficient and old heating and cooling systems by targeting consumers, investors/owners as well as intermediaries (installers, plumbers, and chimney sweepers) and helps them to make or support the making of informed decisions.

Purpose: This report is related to the outcomes of the activities performed by partners in task T3.4., namely the development of statistical inventories of heating and cooling systems market potential for replacement. The focus is gathering existing information and preparing statistical inventories showing the current trend on heating/cooling systems without REPLACE in the selected regions of partner´s countries and compare it with the potential for replacement considering REPLACE activities.

Methodology:

In REPLACE project WP3, task 3.4., it is requested to prepare a statistical inventory of the heating systems market in the partner regions (depending on data availability) and the scenarios for replacement in order to identify a realistic activation potential for replacement activities.

In order to organize the compilation of data and simplify the process to obtain the results for the partner regions, an Excel file template was prepared by the WP leader (Escan), where partners should include their data and, by minor modifications of the file, automatically obtain the results. This is needed also homogenise the output.

The Excel file included three sheets:

- Home Evolution: it shows the progress (2020-2027) of the number of homes supplied with a certain fuel (oil, natural gas, biomass, etc.), based on the data available for a base year and the number of homes which substitute their system each year. This evolution is assessed for a Business as Usual (BAU) scenario, an Optimistic REPLACE scenario and a Pessimistic REPLACE scenario. In this sheet it is also calculated the energy savings and CO2 emissions reduction due to REPLACE actions. These estimations are determined with the data of the evolution of homes heated with each type of fuel, the annual average home heat consumption, and the emissions factor for each of the different energy sources. The home evolution data are used to estimate the energy savings.
- Boiler Evolution: it shows the progress (2020-2027) of the number the stock of boilers considering the fuel used (oil, natural gas, biomass, etc.), based on the data available for a base year and the number of boilers substituted per year. Boilers are divided in Individual, collective boilers and DH. This evolution is assessed for a Business as Usual (BAU) scenario, an Optimistic REPLACE scenario and a Pessimistic REPLACE scenario. Mostly a constant “surplus” boiler replacement number, triggered by the project, is estimated for the period of the scenario (average surplus number). A few regions partly have implemented dynamically growing numbers (instead of average surplus numbers). At can be seen where trends are linear or non-linear. During the first and second year of the project the estimated number of replacements impacted by REPLACE has been diminished by 2/3 and 1/3 because most

project actions facilitating boiler replacements will not show a full impact by that time. The boiler exchange numbers serve as basis to obtain the estimations of investment potentials.

- Investments: introduces the progress of investments expected in heating/cooling systems for both the Optimistic and Pessimistic REPLACE scenarios. The calculations use the number of boiler replacements provoked by Replace, an estimation of the average boiler power for each type and region, and their corresponding price per unit of power to estimate the total investment triggered by the project in each of the partner regions.

For the sake of simplification of the scenarios we calculated for our scope of activities, i.e. replacement of old and inefficient wood, oil, gas, coal and electricity heating units by modern, more energy efficient, clean and comfortable systems based on renewable energy sources or by district heat based alternatives. Although solar heat for sanitary water is a renewable energy source, it was not considered by most regions due to not being technically viable for space heating, as it is usually used only for hot water production. Moreover, it was not considered any impact of energy efficiency measures related to the building shell and in-houses distribution systems that should, and in reality at least partly, will be realized.

Related to data sources for the home and boiler estimations, they have been collected by partners from existing reliable sources when available, complemented with own sources (eg. by own reports, by means of meetings with or information from authorities/experts or references from website news). The availability of these sources varies in each region. Some sources are useful for both boilers and homes calculations while some others are useful for one of them, also depending on the specific region. Overall the data used have been obtained from:

- National and Regional Governments and Institutions: Energy Plans, data from Ministries (Energy, Industry)
- National Statistics organizations
- National or Regional Energy Agencies
- European Statistics, associations, or other relevant bodies
- Manufactures and their associations.
- Consumers Associations
- Market Regulator
- Workshops or roundtables or meetings with professionals (and/or their associations), consumers (and/or their associations), public institutions, energy agencies, universities/research, etc.
- News or articles published in Internet by reliable sources

The impact of REPLACE in terms of the increase in the replacement rate in each region; both for an pessimistic and optimistic REPLACE scenario, has been estimated based on a certain impact of the project beyond the BAU scenario. An annual fixed number of replaced boilers and homes was considered in each region (different for each one) taking into account a reasonable potential (pessimistic or optimistic) impact of the project activities in the current market conditions and previous experiences from the project partners.

The report shows the results for the overall project and for each partner region.

Key Finding and Conclusions:

Overall, this report reflects the status and transition from the use of fossil fuels and inefficient heating and cooling systems for residential buildings to cleaner and more environmentally friendly alternatives

in ten EU regions. It describes the impact of the REPLACE project on the number of boilers and homes replacing old inefficient systems by new sustainable ones, as well as the energy savings, CO2 emissions reduction and level of investment triggered. It was observed that the market itself was already transitioning into these changes and with the support of the REPLACE project the targets will be achieved at a higher speed, supporting the EU 2030 and 2050 targets to a carbon neutral Europe.

The main type of heating boilers being replaced are the ones fuelled by fuel oil and coal and old inefficient biomass boilers. These boilers are pushed to be replaced by new automatic efficient biomass technologies, although it depends on the variety of biomass available in the EU regions. Other sustainable alternatives for replacement found are district heat or heat pumps, partly combined with solar heating, depending on local conditions. Natural gas in a couple of regions is expected to continue rising due to a natural market evolution, but this fact is not as a result of REPLACE.

There are several impacts expected from the project. As a direct result of REPLACE, additional to the normal market trend, the partner regions are estimated to promote the substitution of the space heating systems in up to 65,000 homes by more sustainable ones until five years after project end (2027). This will mean reaching over 250 GWh/y final energy consumption savings by the year 2027. This savings can be translated to over 100,000 tons of CO2eq/y for the 10 target regions. Considering the indirect effects, as the project will reach other regions in the EU due to the communication and dissemination actions, the positive impacts should be much higher. Among other impacts, the investment triggered will generate many jobs while the population of the regions acquire new knowledge about cleaner and more efficient methods to heat their residences.

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1 | Introduction

1.1 About the project

Half of Europe's energy consumption is used for heating or cooling. However, two thirds of the heating systems installed in Europe – that is 80 million units – are inefficient.

In order to achieve the climate targets and make Europe independent of oil, coal and natural gas, changes in this sector are essential.

The aim of REPLACE is to motivate and support people in nine different countries to replace their old heating systems with more environmentally friendly alternatives. Simple renovation measures that reduce overall energy consumption are also part of the program.

To reach that goal, REPLACE project brings together installers, chimney sweeps, politicians, and other key players at one table, regionally.

1.2 About T3.4

In REPLACE project WP3, task 3.4., it is requested to prepare a statistical inventory of the heating systems market in the partner regions (depending on data availability) and scenarios for replacement, to identify a realistic activation potential for replacement activities. For each region, inventories are divided in three sections: Home evolution, which introduces the number of homes that have a certain heating system fuel; Boiler evolution, which introduces the progress of the boiler stock for the different regions; and Investment triggered, which will assess the amount of investment that will induce REPLACE.

More in detail, the home evolution section introduces the number of homes which have a certain heating system fuel (or electricity for heat pumps) considering three scenarios: Business as usual – BAU (normal progress that would happen without REPLACE), Optimistic REPLACE (Overachieving REPLACE goals) and Pessimistic REPLACE (Underachieving REPLACE goals). The results show the evolution of the number of homes with a certain heating system, the energy savings comparing BAU and REPLACE, and the $C0_2$ reduction during the period 2019-2033.

The boiler evolution section introduces the progress of the boiler stock. The outlook of this sheet is similar to "Home evolution" and shows the progress of the number of boilers in the region, considering the number of a base year and a figure for the annual replacement. There are typically 3 segments of boiler sizes (individual, collective and district heat), and this might vary from region to region so each partner will divide the boilers in groups to make it fit with the local conditions. It shows the three different scenarios (Business as usual, Optimistic, and Pessimistic).

The Investment section shows the investment cost data for the partner regions based on the total heating power to be installed (in kW) and its unitary price (in €/kW). It is calculated the investment of only the boiler or the complete heating/cooling system. With this, the investment triggered by REPLACE for individual, collective and DH systems is calculated.

2 | General overview of stakeholders' inventories in partners regions and its development

A general overview of all the partners working on this task in the Replace project was elaborated with the data of all ten regions involved. It shows a summary of the 2019 stock for three different boiler categories and the number of homes heated with a certain type of fuel for three different scenarios. These scenarios correspond a) to a situation where the Replace project would never take place (Baseline); b) a situation where the project has a large impact (Optimistic); c) or a moderate impact (Pessimistic).

The report shows firstly the number of homes with a certain fuel that substitute that fuel by a more sustainable one and secondly the number of boilers replaced (boilers stock change) averaged per year during the period 2019-2033. The Replace scenarios have a larger impact in the evolution of boilers used over the years, being the optimistic scenario the most optimal. The difference between the number of replacements between the Replace scenarios and the baseline one is also shown to quantify the actual impact of the two different situations. A positive number of replacements in each of the scenarios refers to an increase of installed systems while a negative one refers to a decrease.

In the case for the different types of fuels to heat homes in the target regions, it is observed that the fuel oil is the fuel that is being most replaced followed by inefficient biomass. This study estimates that the Replace project will help the transition to more efficient boilers such as new biomass systems, heat pumps or district heating. Although, solar heating was not considered by most regions due to not being technically viable as space heating system by itself.

Homes		Baseline	Optimistic REPLACE	Pesimistic REPLACE	Optim-Base	Pesim-Base
Old fuel oil	Replacements	- 14.709	- 19.788	- 17.463	- 5.079	- 2.754
	Stock 2019	357.184	357.184	357.184	-	-
Old other boiler	Replacements	- 2.141	- 3.108	- 2.585	- 967	- 444
	Stock 2019	74.694	74.694	74.694	-	-
Natural gas	Replacements	8.354	6.141	6.981	- 2.213	- 1.373
	Stock 2019	837.415	837.415	837.415	-	-
Electric heating	Replacements	- 829	- 1.175	- 1.027	- 346	- 198
	Stock 2019	85.933	85.933	85.933	-	-
Solid biomass	Replacements	12.044	18.239	15.243	6.195	3.199
	Stock 2019	395.196	395.196	395.196	-	-
Old coal	Replacements	- 1.100	- 1.618	- 1.284	- 518	- 184
	Stock 2019	53.982	53.982	53.982	-	-
Inefficient biomasss	Replacements	- 9.130	- 10.550	- 9.775	- 1.420	- 645
	Stock 2019	203.770	203.770	203.770	-	-
Heat pumps	Replacements	8.535	12.079	10.431	3.544	1.896
	Stock 2019	135.198	135.198	135.198	-	-
District Heating	Replacements	2.681	5.355	3.917	2.674	1.236
	Stock 2019	322.309	322.309	322.309	-	-
Solar heating	Replacements	15	20	15	5	-
	Stock 2020	76	76	76	-	-

Table 1. General overview of yearly replacement impact for homes in the target regions by REPLACE.

The stock of boilers in the European regions is similar to the home situation. For individual boilers, the largest Replace impact is estimated in the high number of installations of new heat pumps and new biomass boilers replacing natural gas mainly, but also inefficient biomass and fuel oil boilers. Collective boilers follow the way of individual boilers with heat pumps installation numbers surpassing new biomass systems. Lastly, for district heating it is estimated that these types of installations will continue to rise in the next decade, being natural gas, the main fuel used for these systems followed by biomass.

Individual Boilers		Baseline	Optimistic REPLACE	Pesimistic REPLACE	Optim-Base	Pesim-Base
Old fuel oil	Replacements	- 10.966	- 12.522	- 11.760	- 1.556	- 794
	Stock 2019	262.336	262.336	262.336	-	-
Old other boiler	Replacements	- 1.316	- 2.052	- 1.809	- 736	- 493
	Stock 2019	51.789	51.789	51.789	-	-
Natural gas	Replacements	9.118	6.608	8.638	- 2.510	- 480
	Stock 2019	768.705	768.705	768.705	-	-
Electric heating	Replacements	56	- 323	- 159	- 379	- 215
	Stock 2019	139.317	139.317	139.317	-	-
Solid biomass	Replacements	8.984	10.647	9.211	1.663	227
	Stock 2019	312.694	312.694	312.694	-	-
Old coal	Replacements	- 1.588	- 2.645	- 2.009	- 1.057	- 421
	Stock 2019	71.425	71.425	71.425	-	-
Inefficient biomasss	Replacements	- 10.981	- 12.663	- 11.816	- 1.682	- 835
	Stock 2019	442.360	442.360	442.360	-	-
Heat pumps	Replacements	6.825	11.414	8.942	4.589	2.117
	Stock 2019	95.689	95.689	95.689	-	-
Solar heating	Replacements	10	50	15	40	5
	Stock 2020	20	20	20	-	-

Table 2. General overview of yearly replacement impact for individual boilers in the target regions by REPLACE.

Collective Boilers		Baseline	Optimistic REPLACE	Pesimistic REPLACE	Optim-Base	Pesim-Base
Old fuel oil	Replacements	- 720	- 1.045	- 909	- 325	- 189
	Stock 2019	29.444	29.444	29.444	-	-
Old other boiler	Replacements	- 236	- 309	- 247	- 73	- 11
	Stock 2019	13.475	13.475	13.475	-	-
Natural gas	Replacements	454	368	371	- 86	- 83
	Stock 2019	34.434	34.434	34.434	-	-
Solid biomass	Replacements	208	509	356	301	148
	Stock 2019	46.409	46.409	46.409	-	-
Heat pumps	Replacements	101	203	159	102	58
	Stock 2019	-	-	-	-	-
Electric heating	Replacements	30	50	25	20	- 5
	Stock 2020	3.715	3.715	3.715	-	-

Table 3. General overview of yearly replacement impact for collective boilers in the target regions by REPLACE

District Heating		Baseline	Optimistic REPLACE	Pesimistic REPLACE	Optim-Base	Pesim-Base
Biomass DH	Replacements	17	46	29	29	12
	Stock 2019	925	925	925	-	-
Natural gas DH	Replacements	3	5	3	2	0
	Stock 2019	291	291	291	-	-
Diesel DH	Replacements	-	-	-	-	-
	Stock 2019	2	2	2	-	-
Other DH	Replacements	- 1	- 2	0	- 1	1
	Stock 2019	22	22	22	-	-

Table 4. General overview of yearly replacement impact for DH in the target regions by REPLACE

An important clarification needs to be made regarding natural gas boilers. The REPLACE project does not aim to support the switch towards new natural gas installations, especially individual boilers. While a few decades back, the usual replacement for old boilers tended towards natural gas due to their higher performance economic savings. New technologies have emerged with better characteristics such as even higher performances and a reduction in carbon emissions, being friendlier with the environment. The evolution of the natural gas boiler is basically market driven since the technology was the most wildly used and most users do not know better options. This leads to one of the main reasons of this project, to create a bigger awareness of the new and cleaner technologies and slow down the inertia of natural gas boilers use. The estimation of a growing of stock of natural gas boilers over the years is not correlated to any of the REPLACE activities. To the contrary, REPLACE aims to reduce this growth, persistent in many regions where no effective mitigating policies are in force yet.

2.1 Home evolution

In this section it is represented the evolution of the number of households with a certain heating system for each region and the overall for the REPLACE partner regions.

The number of households start with the estimation for 2019 “Stock 2019” and it increases or decreases in a fixed amount “Replacements” every year in each of the European regions. Due to the regional campaigns will start in 2021, it has not been considered any variation until the year 2022 when REPLACE impact and measures will have been implemented. Since there are many differences in the conditions and lifestyle of the European regions of the project, these differences are translated into the type of fuel used in each of the regions to heat their homes. Three different scenarios have been studied, also in other section of this document, for heating systems evolution in households:

- Baseline scenario (BS): shows the evolution for home heating systems if the REPLACE project did not exist. In this scenario, the number of replacements is a fixed value for each of the partners regions and type of heating system, except for the first and second years since the beginning of the project. These values have been estimated by each of the partners with the help of historical data of heating systems replacements.
- Optimistic Replace Scenario (RS OP): shows the evolution for the home heating systems if the REPLACE project has a large impact (positive) in the regions. In this scenario the number of replacements consider a percentage increase in regards to the original estimated impact of the Replace project in the Grant Agreement.
- Pessimistic Replace Scenario (RS PE): shows the evolution for the home heating systems if the REPLACE project has a moderate impact (positive) in the regions. In this scenario, the number of replacements consider a percentage decrease in regards the original estimated impact of

the Replace project in the Grant Agreement (GA). The scenarios were revised as the GA numbers were estimated 2.5 years in the past.

The results for a sample of the target technologies in the Replace project, biomass boilers, biomass district heating, and heat pumps are shown for the three scenarios for all the partner's regions in the following table and graphs regarding the evolution of the heating systems in households:

	Total biomass home evolution					
	Biomass homes			District heating connection		
Scenario	BS	OP	PS	BS	OP	PS
Replacements	12.044	18.239	15.243	2.681	5.355	3.917
2019	395.196	395.196	395.196	322.309	322.309	322.309
2020	399.171	401.215	400.226	323.194	324.076	323.602
2021	407.120	413.252	410.287	324.963	327.610	326.187
2022	419.164	431.491	425.530	327.644	332.965	330.104
2023	431.208	449.729	440.773	330.325	338.320	334.021
2024	443.252	467.968	456.017	333.006	343.675	337.938
2025	455.296	486.206	471.260	335.687	349.030	341.855
2026	467.340	504.445	486.503	338.368	354.385	345.772
2027	479.384	522.683	501.746	341.049	359.740	349.689

Table 5. Total evolution of homes with biomass systems, 3 scenarios.

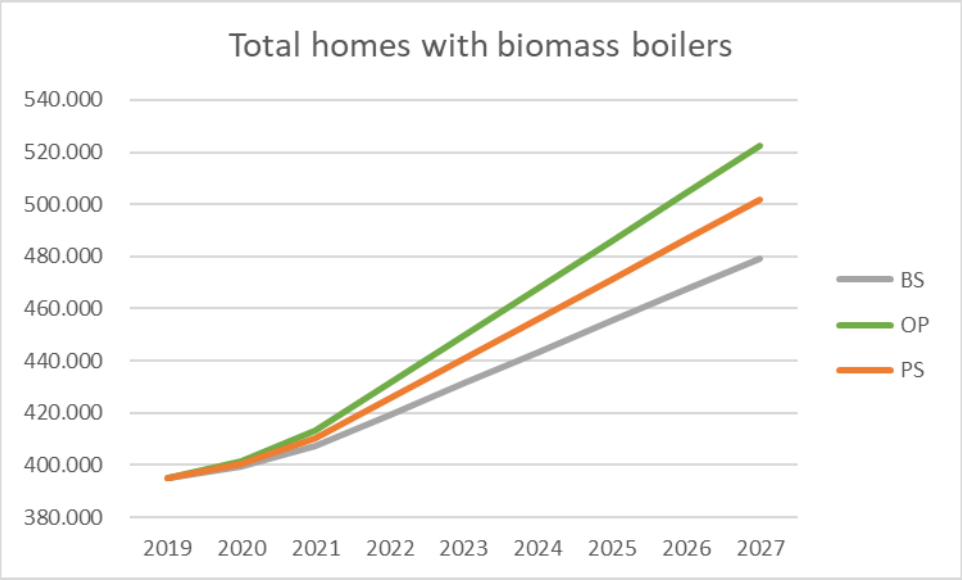

Figure 1. Total evolution of homes with biomass boilers, 3 scenarios.

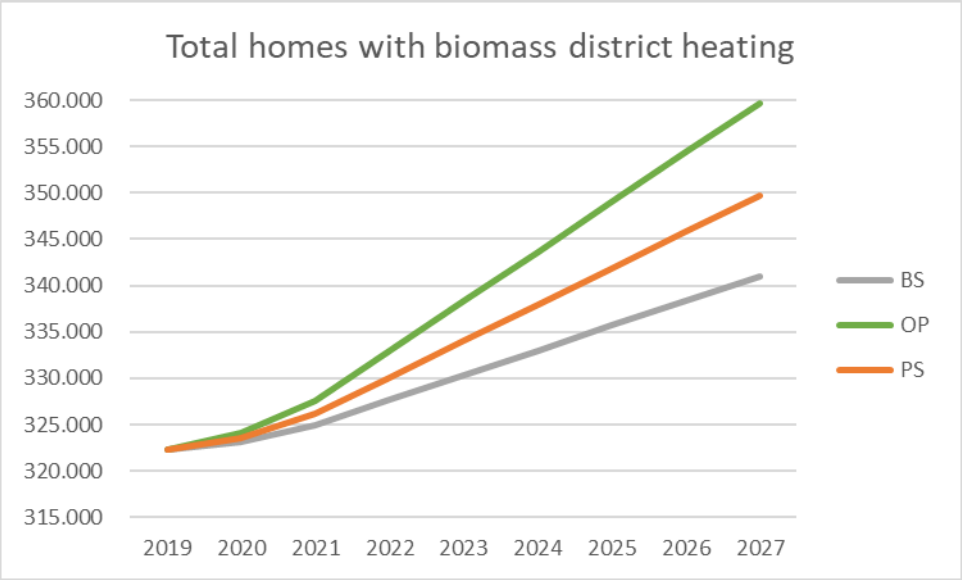

Figure 2. Total evolution of homes with biomass district heating connection, 3 scenarios.

	Total heat pump home evolution		
	Heat pump homes		
Scenario	BS	OP	PS
Replacements	8.535	12.079	10.431
2019	135.198	135.198	135.198
2020	138.015	139.184	138.640
2021	143.648	147.156	145.525
2022	152.183	159.235	155.955
2023	160.718	171.314	166.386
2024	169.253	183.392	176.817
2025	177.788	195.471	187.248
2026	186.323	207.550	197.679
2027	194.858	219.629	208.110

Table 6. Total evolution of homes with heat pumps, 3 scenarios.

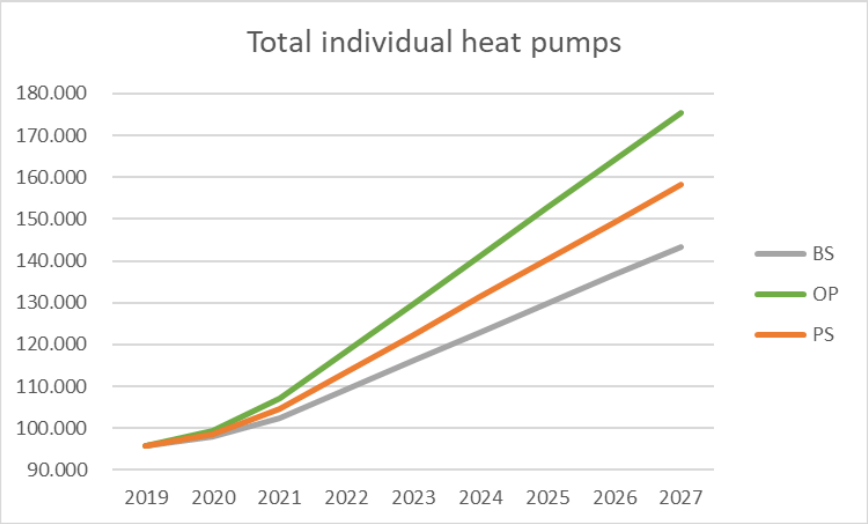

Figure 3. Total evolution of homes with heat pumps, 3 scenarios.

The study has been made using trustworthy sources for each region and a linear estimation over the following years in terms of the number of replacements considered. This means that the number of replacements is not subjected to variations due to subsidy funds or other variables which are difficult to predict. The replacement for each of the three scenarios in the following tables show the average replacement numbers for the period 2019 to 2027. As stated before, a positive number of replacements in each of the scenarios refers to an increase of installed systems and a negative one to a decrease. On another hand, while the optimistic and pessimistic Replace scenarios show an increase in the absolute number of replacements for each type of technology, the optimistic scenario increases a larger number of replacements. Both scenarios aim to show the upper and lower limit of the Replace impact in Europe.

The main outputs for the number of households classified by the heating systems used, are:

BS Homes Heating		Austria Salzburg	Bosnia Canton Sarajevo	Bulgaria Rhodope	Croatia PG County	Croatia Zagreb	Germany Oberland	Macedonia Skopje	Serbia Sabac	Slovenia Slovenia	Spain Castilla y León	TOTAL
Old fuel oil	Replacements	- 1.315	-	-	-	- 125	- 1.159	- 50	-	- 4.560	- 7.500	- 14.709
	Stock 2019	51.422	-	-	-	10.423	49.431	645	-	90.796	154.467	357.184
Old other boiler	Replacements	-	- 28	-	- 500	- 26	-	- 247	- 600	-	- 740	- 2.141
	Stock 2019	-	3.995	-	11.776	306	931	8.000	23.620	-	26.066	74.694
Natural gas	Replacements	323	482	50	100	45	764	30	250	- 250	6.560	8.354
	Stock 2019	16.900	61.599	2.700	7.945	186.980	27.789	954	10.430	37.496	484.622	837.415
Electric heating	Replacements	- 474	-	- 50	50	10	-	-	-	- 365	-	- 829
	Stock 2019	25.418	-	3.700	33.741	11.232	9.313	-	-	2.529	-	85.933
Solid biomass	Replacements	749	285	540	1.500	45	230	50	330	7.835	480	12.044
	Stock 2019	45.812	38.722	27.500	50.744	113.305	11.938	6.800	350	90.605	9.420	395.196
Old coal	Replacements	-	- 680	- 230	-	-	-	-	- 180	- 10	-	- 1.100
	Stock 2019	-	43.751	6.900	-	-	-	-	3.300	31	-	53.982
Inefficient biomasss	Replacements	-	-	- 1.000	-	-	-	-	-	- 8.130	-	- 9.130
	Stock 2019	-	-	101.500	-	-	-	-	-	102.270	-	203.770
Heat pumps	Replacements	2.042	10	160	1	-	76	240	80	4.926	1.000	8.535
	Stock 2019	23.521	100	7.600	3	-	1.710	-	300	50.486	51.478	135.198
DH	Replacements	253	-	-	100	10	88	10	120	1.600	500	2.681
	Stock 2020	74.464	1.600	-	8.638	84.584	5.163	-	-	144.335	3.525	322.309
Solar heating	Replacements	-	-	-	15	-	-	-	-	-	-	15
	Stock 2021	-	-	-	76	-	-	-	-	-	-	76

Table 7. Number of home heating systems replaced per year (Baseline) all regions.

	Baseline Homes Heating (expected evolution without REPLACE)									
	Old fuel oil	Old other boiler	Old coal	Inefficient biomass	Heat pumps	Electric heating	Natural gas	Solid biomass	DH	Solar heating
Replacements	- 14.709	- 2.141	- 1.100	- 9.130	8.535	- 829	8.354	12.044	2.681	15
2019	357.184	74.694	53.982	203.770	135.198	85.933	837.415	395.196	322.309	76
2020	352.330	73.987	53.619	200.757	138.015	85.659	840.172	399.171	323.194	81
2021	342.622	72.574	52.893	194.731	143.648	85.112	845.685	407.120	324.963	91
2022	327.913	70.433	51.793	185.601	152.183	84.283	854.039	419.164	327.644	106
2023	313.204	68.292	50.693	176.471	160.718	83.454	862.393	431.208	330.325	121
2024	298.495	66.151	49.593	167.341	169.253	82.625	870.747	443.252	333.006	136
2025	283.786	64.010	48.493	158.211	177.788	81.796	879.101	455.296	335.687	151
2026	269.077	61.869	47.393	149.081	186.323	80.967	887.455	467.340	338.368	166
2027	254.368	59.728	46.293	139.951	194.858	80.138	895.809	479.384	341.049	181

Table 8. Evolution of home heating systems stock per year (Baseline) all regions.

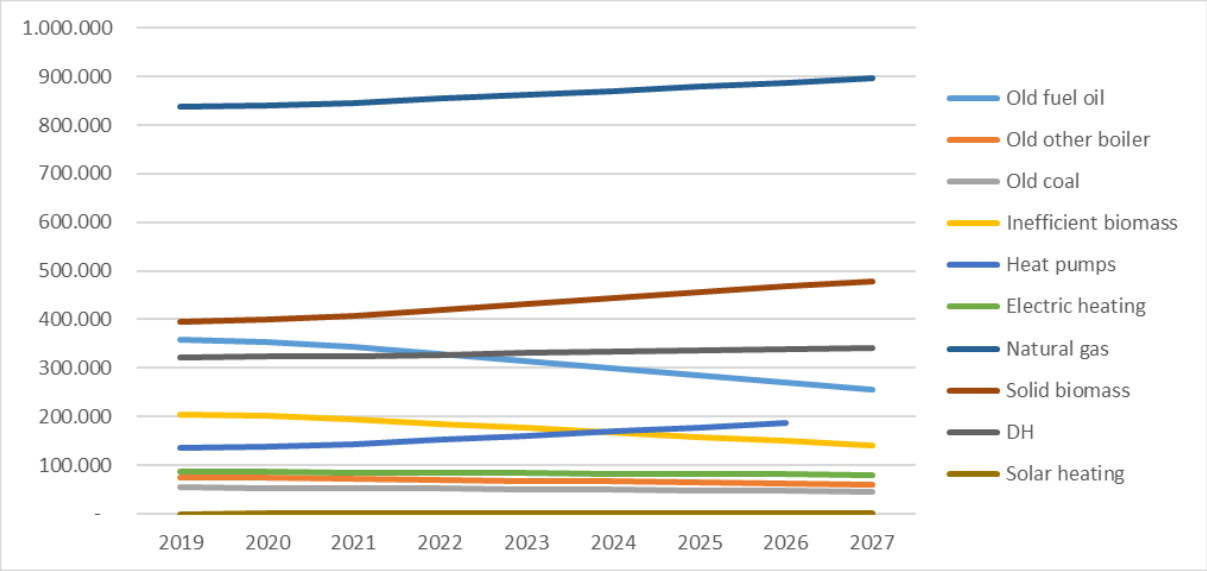

Figure 4. Evolution of home heating systems stock per year (Baseline) all regions.

RS OP Homes		Austria Salzburg	Bosnia Canton Sarajevo	Bulgaria Rhodope	Croatia PG County	Croatia Zagreb	Germany Oberland	Macedonia Skopje	Serbia Sabac	Slovenia Slovenia	Spain Castilla y León	TOTAL
Old fuel oil	Replacements	- 1.930	-	-	-	- 143	- 1.189	- 140	-	- 5.928	- 10.458	- 19.788
	Stock 2019	51.422	-	-	-	10.423	49.431	645	-	90.796	154.467	357.184
Old other boiler	Replacements	-	- 97	-	- 800	- 30	-	- 441	- 1.000	-	- 740	- 3.108
	Stock 2019	-	3.995	-	11.776	306	931	8.000	23.620	-	26.066	74.694
Natural gas	Replacements	- 537	679	30	300	52	717	140	200	- 2.000	6.560	6.141
	Stock 2019	16.900	61.599	2.700	7.945	186.980	27.789	954	10.430	37.496	484.622	837.415
Electric heating	Replacements	- 695	-	- 120	100	15	-	-	-	- 475	-	- 1.175
	Stock 2019	25.418	-	3.700	33.741	11.232	9.313	-	-	2.529	-	85.933
Solid biomass	Replacements	1.217	410	1.220	2.000	52	396	120	500	10.186	2.138	18.239
	Stock 2019	45.812	38.722	27.500	50.744	113.305	11.938	6.800	350	90.605	9.420	395.196
Old coal	Replacements	-	- 945	- 480	-	-	-	-	- 180	- 13	-	- 1.618
	Stock 2020	-	43.751	6.900	-	-	-	-	3.300	31	-	53.982
Inefficient biomasss	Replacements	-	-	- 1.550	-	-	-	-	-	- 9.000	-	- 10.550
	Stock 2019	-	-	101.500	-	-	-	-	-	102.270	-	203.770
Heat pumps	Replacements	3.502	15	370	20	-	198	420	150	6.404	1.000	12.079
	Stock 2019	23.521	100	7.600	3	-	1.710	-	300	50.486	51.478	135.198
DH	Replacements	453	-	-	200	30	177	20	375	2.300	1.800	5.355
	Stock 2020	74.464	1.600	-	8.638	84.584	5.163	-	-	144.335	3.525	322.309
Solar heating	Replacements	-	-	-	20	-	-	-	-	-	-	20
	Stock 2021	-	-	-	76	-	-	-	-	-	-	76

Table 9. Number of home heating systems replaced per year (Optimistic) all regions.

	Optimistic Replace-Scenario Homes (Overachieving REPLACE target region objectives)									
	Old fuel oil	Old other boiler	Old coal	Inefficient biomass	Heat pumps	Electric heating	Natural gas	Solid biomass	DH	Solar heating
Replacements	- 19.788	- 3.108	- 1.618	- 10.550	12.079	- 1.175	6.141	18.239	5.355	20
2019	357.184	74.694	53.982	203.770	135.198	85.933	837.415	395.196	322.309	76
2020	350.654	73.668	53.448	200.289	139.184	85.545	839.442	401.215	324.076	83
2021	337.594	71.617	52.380	193.326	147.156	84.770	843.495	413.252	327.610	96
2022	317.806	68.509	50.762	182.776	159.235	83.596	849.636	431.491	332.965	116
2023	298.018	65.401	49.144	172.226	171.314	82.421	855.777	449.729	338.320	136
2024	278.230	62.293	47.526	161.676	183.392	81.247	861.918	467.968	343.675	156
2025	258.442	59.185	45.908	151.126	195.471	80.072	868.059	486.206	349.030	176
2026	238.654	56.077	44.290	140.576	207.550	78.898	874.200	504.445	354.385	196
2027	218.866	52.969	42.672	130.026	219.629	77.723	880.341	522.683	359.740	216

Table 10. Evolution of home heating systems stock per year (Optimistic) all regions.

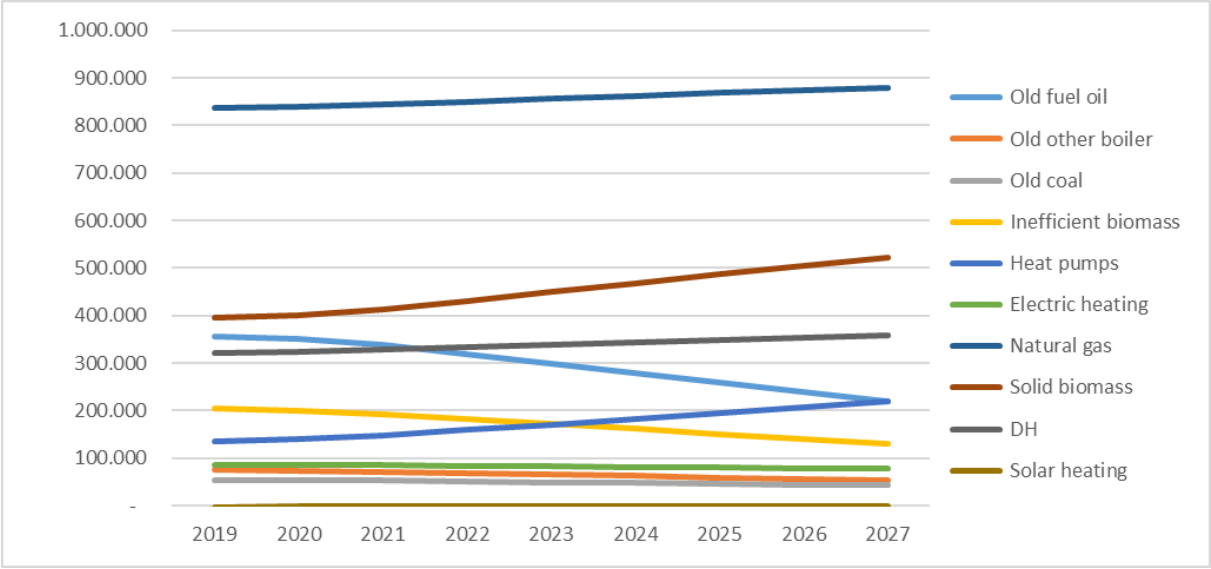

Figure 5. Evolution of home heating systems stock per year (Optimistic) all regions.

RS PE Homes		Austria Salzburg	Bosnia Canton Sarajevo	Bulgaria Rhodope	Croatia PG County	Croatia Zagreb	Germany Oberland	Macedonia Skopje	Serbia Sabac	Slovenia Slovenia	Spain Castilla y León	TOTAL
Old fuel oil	Replacements	- 1.709	-	-	-	- 128	- 1.189	- 100	-	- 5.244	- 9.093	- 17.463
	Stock 2019	51.422	-	-	-	10.423	49.431	645	-	90.796	154.467	357.184
Old other boiler	Replacements	-	- 59	-	- 550	- 26	-	- 350	- 860	-	- 740	- 2.585
	Stock 2019	-	3.995	-	11.776	306	931	8.000	23.620	-	26.066	74.694
Natural gas	Replacements	- 14	589	40	150	46	750	110	250	- 1.500	6.560	6.981
	Stock 2019	16.900	61.599	2.700	7.945	186.980	27.789	954	10.430	37.496	484.622	837.415
Electric heating	Replacements	- 604	-	- 85	70	12	-	-	-	- 420	-	- 1.027
	Stock 2019	25.418	-	3.700	33.741	11.232	9.313	-	-	2.529	-	85.933
Solid biomass	Replacements	1.070	314	880	1.700	46	350	100	400	9.010	1.373	15.243
	Stock 2019	45.812	38.722	27.500	50.744	113.305	11.938	6.800	350	90.605	9.420	395.196
Old coal	Replacements	-	- 797	- 355	-	-	-	-	- 120	- 12	-	- 1.284
	Stock 2020	-	43.751	6.900	-	-	-	-	3.300	31	-	53.982
Inefficient biomasss	Replacements	-	-	- 1.275	-	-	-	-	-	- 8.500	-	- 9.775
	Stock 2019	-	-	101.500	-	-	-	-	-	102.270	-	203.770
Heat pumps	Replacements	2.918	12	265	10	-	161	300	100	5.665	1.000	10.431
	Stock 2019	23.521	100	7.600	3	-	1.710	-	300	50.486	51.478	135.198
DH	Replacements	378	-	-	50	20	149	-	120	2.000	1.200	3.917
	Stock 2020	74.464	1.600	-	8.638	84.584	5.163	-	-	144.335	3.525	322.309
Solar heating	Replacements	-	-	-	15	-	-	-	-	-	-	15
	Stock 2021	-	-	-	76	-	-	-	-	-	-	76

Table 11. Number of home heating systems replaced per year (Pessimistic) all regions.

	Pessimistic Replace-Scenario Homes (Underachieving REPLACE target region objectives)									
	Old fuel oil	Old other boiler	Old coal	Inefficient biomass	Heat pumps	Electric heating	Natural gas	Solid biomass	DH	Solar heating
Replacements	- 17.463	- 2.585	- 1.284	- 9.775	10.431	- 1.027	6.981	15.243	3.917	15
2019	357.184	74.694	53.982	203.770	135.198	85.933	837.415	395.196	322.309	76
2020	351.421	73.841	53.558	200.544	138.640	85.594	839.719	400.226	323.602	81
2021	339.896	72.135	52.711	194.093	145.525	84.917	844.326	410.287	326.187	91
2022	322.433	69.550	51.428	184.318	155.955	83.890	851.307	425.530	330.104	106
2023	304.970	66.965	50.144	174.543	166.386	82.863	858.288	440.773	334.021	121
2024	287.507	64.380	48.861	164.768	176.817	81.836	865.269	456.017	337.938	136
2025	270.044	61.795	47.577	154.993	187.248	80.810	872.250	471.260	341.855	151
2026	252.581	59.210	46.294	145.218	197.679	79.783	879.231	486.503	345.772	166
2027	235.118	56.625	45.010	135.443	208.110	78.756	886.212	501.746	349.689	181

Table 12. Evolution of home heating systems stock per year (Pessimistic) all regions.

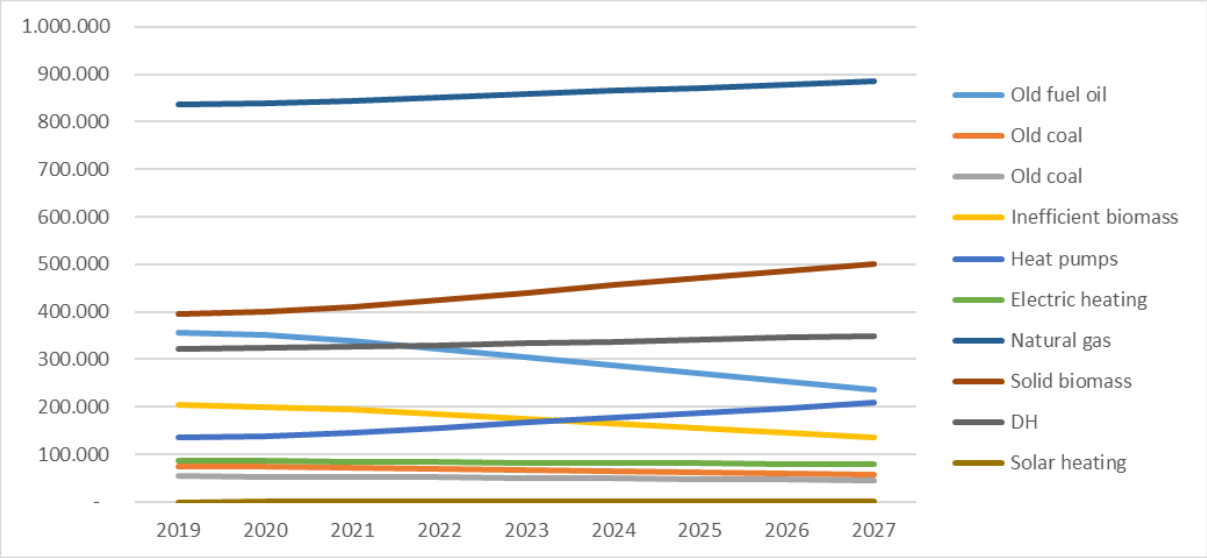

Figure 6. Evolution of home heating systems stock per year (Pessimistic) all regions.

2.2 Boiler evolution

In the following tables, the stock for the different types of boilers in the European regions of the Replace project is estimated. A number of replacements is expected every year, although it has not been considered until the year 2022 which is the year the project is expected to be finished and all the actions and measures implemented, i.e. 2022 is the year where those measures start showing relevant impacts. The boilers are organised in three different categories, individual boilers, collective boilers, and district heating. Since there are many differences in the conditions and lifestyle of the European regions of the project, these differences also translate into the boilers used in each of the regions. The same three scenarios that have been studied for the home evolution are applied here:

- Baseline scenario (Grey): shows the evolution for the boiler stock if the Replace project did not exist. In this scenario, the number of replacements is a fixed value for each of the partners regions and type of heating system. These values have been estimated by each of the partners with the help of historical data of heating systems replacements.
- Optimistic Replace Scenario (Green): shows the evolution for the boiler stock if the Replace project overachieves its targets. In this scenario the number of replacements consider a

percentage increase in respect to the original estimated impact of the Replace project in the Grant Agreement.

- Pessimistic Replace Scenario (Red): shows the evolution for the boiler stock if the Replace project underachieves its targets. In this scenario, the number of replacements consider a percentage decrease in respect the original estimated impact of the Replace project in the Grant Agreement.

The results for a sample of target technologies in the Replace project, biomass, biomass district heating, and heat pumps, are shown for the three scenarios for all the partner's regions in the following table and graphs regarding the evolution of the total stock for individual and collective boilers, and district heating:

	Total biomass boilers evolution								
	Individual boilers			Collective boilers			District Heating		
Scenario	BS	OP	PS	BS	OP	PS	BS	OP	PS
Replacements	8.984	10.647	9.211	208	509	356	17	46	29
2019	312.694	312.694	312.694	46.409	46.409	46.409	925	925	925
2020	315.659	316.208	315.734	46.478	46.577	46.526	931	940	935
2021	321.588	323.235	321.813	46.615	46.913	46.761	942	971	954
2022	330.572	333.882	331.024	46.823	47.422	47.117	959	1.017	983
2023	339.556	344.529	340.235	47.031	47.931	47.473	976	1.064	1.013
2024	348.540	355.176	349.446	47.239	48.440	47.829	994	1.110	1.042
2025	357.524	365.823	358.657	47.447	48.949	48.185	1.011	1.156	1.071
2026	366.508	376.470	367.868	47.655	49.458	48.541	1.028	1.203	1.100
2027	375.492	387.117	377.079	47.863	49.967	48.897	1.045	1.249	1.130

Table 13. Total biomass boilers' evolution, 3 scenarios.

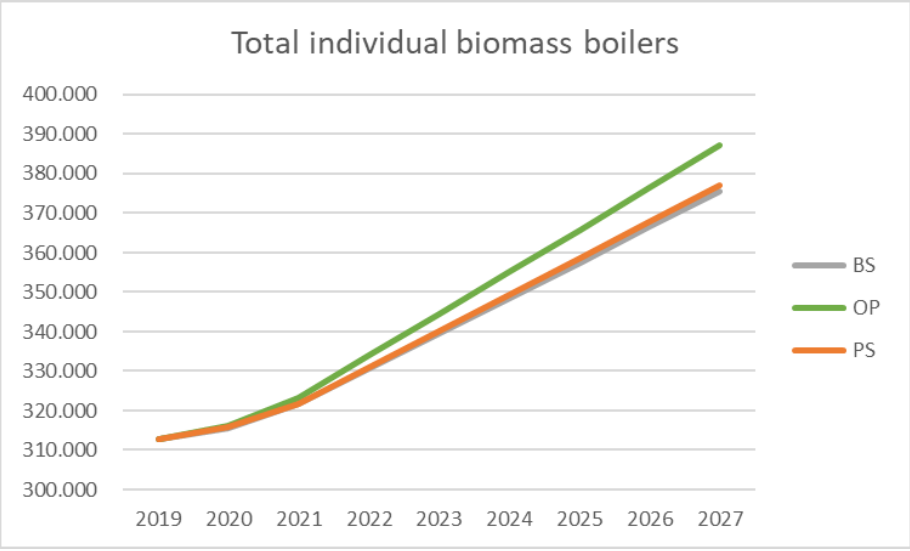

Figure 7. Total individual biomass boilers evolution, 3 scenarios.

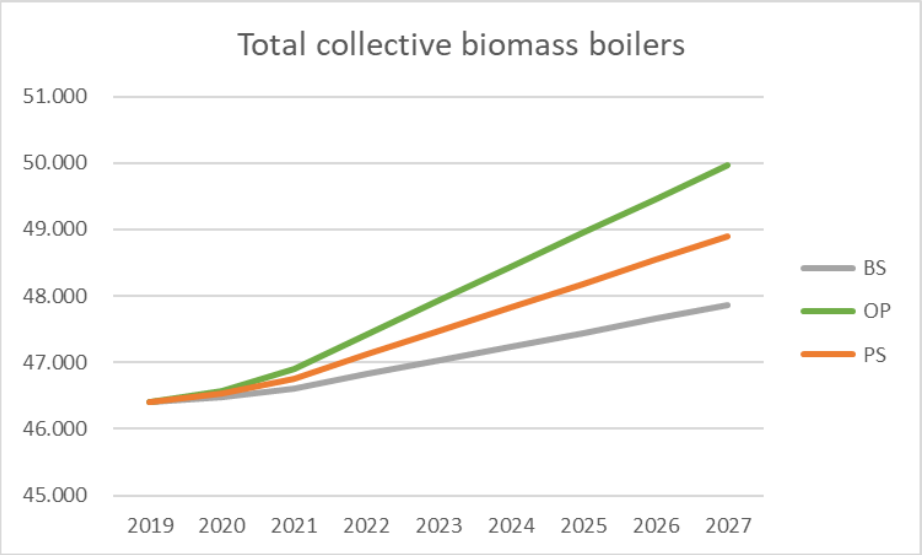

Figure 8. Total collective biomass boilers evolution, 3 scenarios.

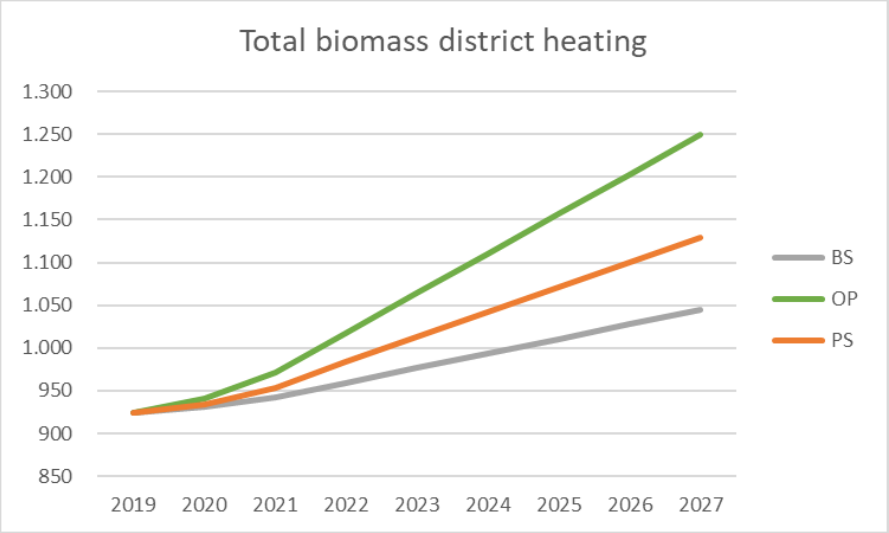

Figure 9. Total biomass district heating evolution, 3 scenarios.

	Total heat pumps boilers evolution					
	Individual boilers			Collective boilers		
Scenario	BS	OP	PS	BS	OP	PS
Replacements	6.825	11.414	8.942	101	203	159
2019	95.689	95.689	95.689	-	-	-
2020	97.941	99.456	98.640	33	67	52
2021	102.446	106.989	104.542	100	201	157
2022	109.271	118.403	113.484	201	404	316
2023	116.096	129.817	122.426	302	607	475
2024	122.921	141.231	131.368	403	810	634
2025	129.746	152.645	140.310	504	1.013	793
2026	136.571	164.059	149.252	605	1.216	952
2027	143.396	175.473	158.194	706	1.419	1.111

Table 14. Total heat pump boilers' evolution, 3 scenarios.

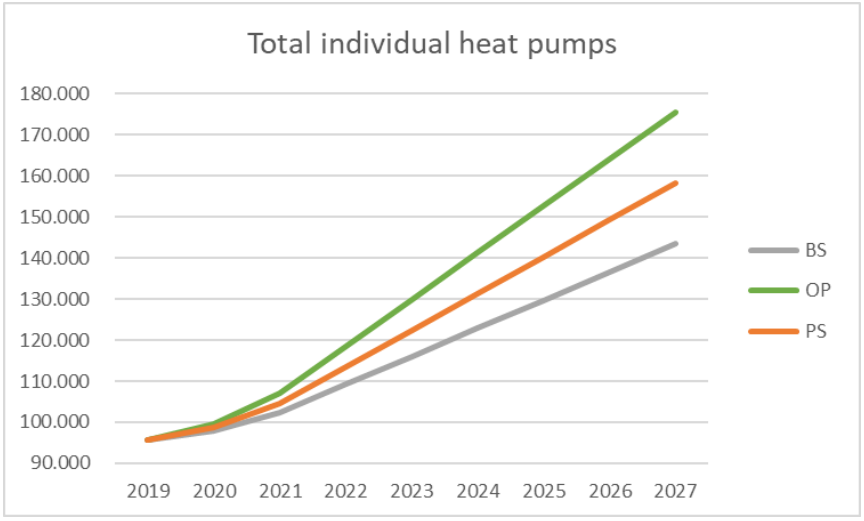

Figure 10. Total individual heat pumps evolution, 3 scenarios.

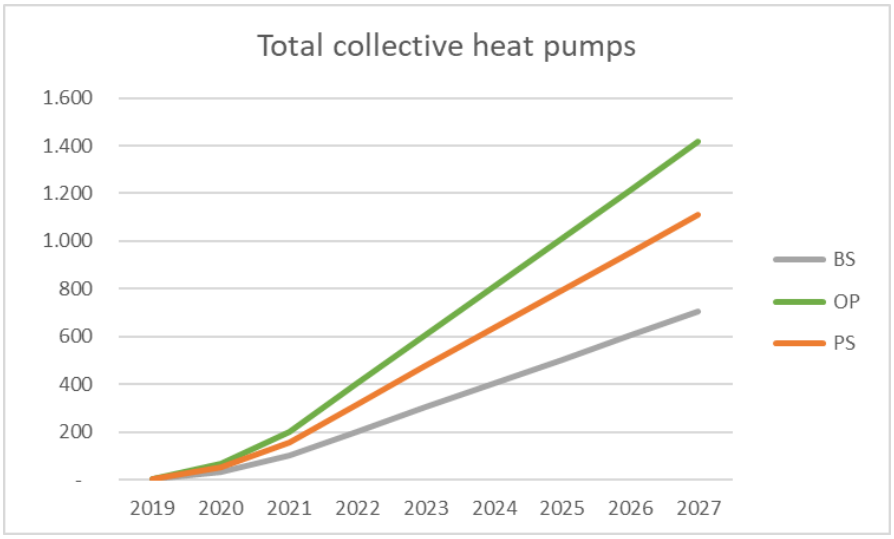

Figure 11. Total collective heat pumps evolution, 3 scenarios.

The study has been made using trustworthy sources for each region and a linear estimation over the following years in terms of the number of replacements considered. This means that the number of replacements is not subjected to variations due to subsidy funds or other variables which are difficult to predict. The replacement for each of the three scenarios in the following tables show the average replacement numbers for the period 2019 to 2027. As stated before, a positive number of replacements in each of the scenarios refers to an increase of installed boilers and a negative one to a decrease. On another hand, while the optimistic and pessimistic Replace scenarios show an increase in the absolute number of replacements for each type of technology, the optimistic scenario increases a larger number of replacements. Both scenarios aim to show the upper and lower limit of the Replace impact in Europe.

The main outcomes regarding heating system boilers are:

Individual BS		Austria Salzburg	Bosnia Canton Sarajevo	Bulgaria Rhodope	Croatia PG County	Croatia Zagreb	Germany Oberland	Macedonia Skopje	Serbia Sabac	Slovenia Slovenia	Spain Castilla y León	TOTAL
Old fuel oil	Replacements	- 1.035	-	-	-	- 12	- 925	- 40	-	- 3.454	- 5.500	- 10.966
	Stock 2019	40.500	-	-	-	1.032	39.454	545	-	70.474	110.331	262.336
Old other boiler	Replacements	-	- 30	-	- 20	- 9	-	- 157	- 600	-	- 500	- 1.316
	Stock 2019	-	1.082	-	439	99	931	7.000	23.620	-	18.618	51.789
Natural gas	Replacements	205	493	38	30	45	764	18	250	2.475	4.800	9.118
	Stock 2019	31.900	66.225	2.025	1.441	186.980	27.789	800	2.930	102.457	346.158	768.705
Electric heating	Replacements	- 321	10	- 153	50	15	-	21	-	- 566	1.000	56
	Stock 2019	17.200	100	11.285	30.026	11.232	9.313	4.200	-	4.483	51.478	139.317
Solid biomass	Replacements	476	287	405	100	33	230	35	330	7.155	160	9.211
	Stock 2019	21.600	41.649	20.625	43.036	83.043	11.938	5.000	350	83.585	1.868	312.694
Old coal	Replacements	-	- 700	- 702	-	-	-	-	- 180	- 6	-	- 1.588
	Stock 2019	-	47.058	21.045	-	-	-	-	3.300	22	-	71.425
Inefficient biomasss	Replacements	-	-	- 3.050	-	-	-	-	-	- 7.931	-	- 10.981
	Stock 2019	-	-	309.575	-	-	-	-	-	132.785	-	442.360
Heat pumps	Replacements	1.298	-	416	1	-	76	-	80	4.954	-	6.825
	Stock 2019	23.500	-	19.760	3	-	1.710	-	105	50.611	-	95.689
Solar heating	Replacements	-	-	-	10	-	-	-	-	-	-	10
	Stock 2020	-	-	-	20	-	-	-	-	-	-	20

Table 15. Number of individual boilers replaced per year (Baseline) all regions.

	Baseline Individual Boilers (expected evolution without REPLACE)								
	Old fuel oil	Old other boiler	Old coal	Inefficient biomass	Heat pumps	Electric heating	Natural gas	Solid biomass	Solar heating
Replacements	- 10.966	- 1.316	- 1.588	- 10.981	6.825	56	9.118	9.211	10
2019	262.336	51.789	71.425	442.360	95.689	139.317	768.705	312.694	20
2020	258.717	51.355	70.901	438.736	97.941	139.335	771.714	315.734	23
2021	251.480	50.486	69.853	431.489	102.446	139.372	777.732	321.813	30
2022	240.514	49.170	68.265	420.508	109.271	139.428	786.850	331.024	40
2023	229.548	47.854	66.677	409.527	116.096	139.484	795.968	340.235	50
2024	218.582	46.538	65.089	398.546	122.921	139.540	805.086	349.446	60
2025	207.616	45.222	63.501	387.565	129.746	139.596	814.204	358.657	70
2026	196.650	43.906	61.913	376.584	136.571	139.652	823.322	367.868	80
2027	185.684	42.590	60.325	365.603	143.396	139.708	832.440	377.079	90

Table 16. Evolution of individual boilers stock per year (Baseline) all regions.

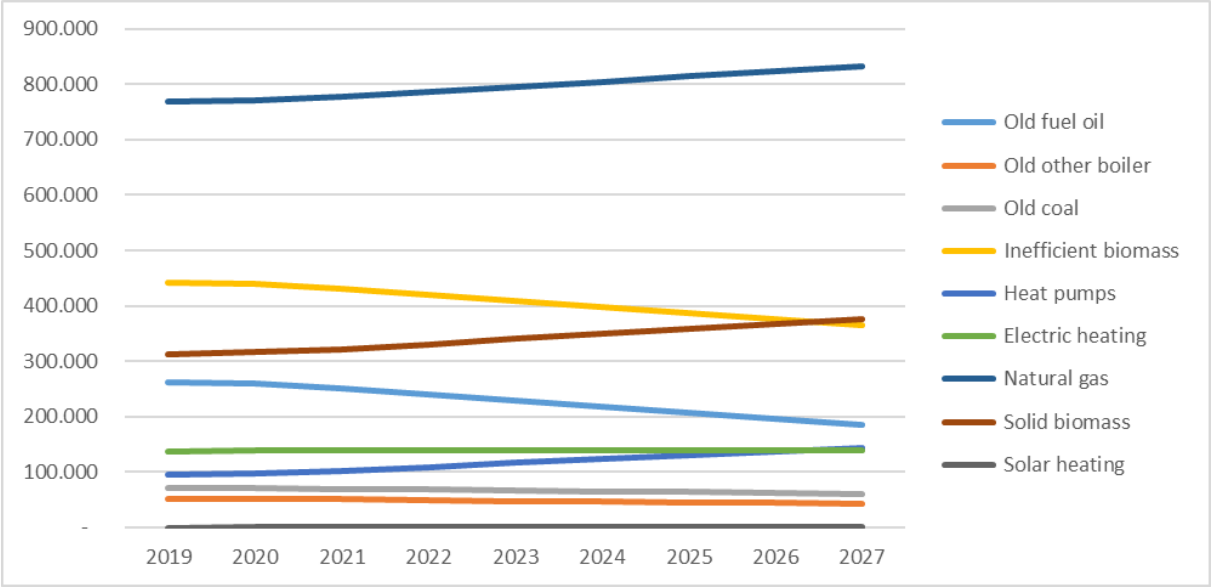

Figure 12. Evolution of individual boilers stock per year (Baseline) all regions.

Individual RS OP		Austria Salzburg	Bosnia Canton Sarajevo	Bulgaria Rhodope	Croatia PG County	Croatia Zagreb	Germany Oberland	Macedonia Skopje	Serbia Sabac	Slovenia Slovenia	Spain Castilla y León	TOTAL
Old fuel oil	Replacements	- 1.520	-	-	-	- 13	- 1.189	- 140	-	- 3.828	- 5.832	- 12.522
	Stock 2019	40.500	-	-	-	1.032	39.454	545	-	70.474	110.331	262.336
Old other boiler	Replacements	-	- 100	-	- 50	- 11	-	- 441	- 950	-	- 500	- 2.052
	Stock 2019	-	1.082	-	439	99	931	7.000	23.620	-	18.618	51.789
Natural gas	Replacements	- 1.013	683	38	50	52	717	140	200	941	4.800	6.608
	Stock 2019	31.900	66.225	2.025	1.441	186.980	27.789	800	2.930	102.457	346.158	768.705
Electric heating	Replacements	- 471	15	- 366	100	17	-	- 50	-	- 568	1.000	- 323
	Stock 2019	17.200	100	11.285	30.026	11.232	9.313	4.200	-	4.483	51.478	139.317
Solid biomass	Replacements	814	412	915	300	38	396	120	500	6.660	492	10.647
	Stock 2019	21.600	41.649	20.625	43.036	83.043	11.938	5.000	350	83.585	1.868	312.694
Old coal	Replacements	-	- 950	- 1.464	-	-	-	-	- 225	- 6	-	- 2.645
	Stock 2020	-	47.058	21.045	-	-	-	-	3.300	22	-	71.425
Inefficient biomasss	Replacements	-	-	- 4.728	-	-	-	-	-	- 7.935	-	- 12.663
	Stock 2019	-	-	309.575	-	-	-	-	-	132.785	-	442.360
Heat pumps	Replacements	2.352	-	962	20	-	198	-	150	7.732	-	11.414
	Stock 2019	23.500	-	19.760	3	-	1.710	-	105	50.611	-	95.689
Solar heating	Replacements	-	-	-	50	-	-	-	-	-	-	50
	Stock 2020	-	-	-	20	-	-	-	-	-	-	20

Table 17. Number of individual boilers replaced per year (Optimistic) all regions.

	Optimistic Replace-Scenario Individual Boilers								
	Old fuel oil	Old other boiler	Old coal	Inefficient biomass	Heat pumps	Electric heating	Natural gas	Solid biomass	Solar heating
Replacements	- 12.522	- 2.052	- 2.645	- 12.663	11.414	- 323	6.608	10.647	50
2019	262.336	51.789	71.425	442.360	95.689	139.317	768.705	312.694	20
2020	258.204	51.112	70.552	438.181	99.456	139.210	770.886	316.208	37
2021	249.939	49.758	68.806	429.824	106.989	138.997	775.247	323.235	70
2022	237.417	47.706	66.161	417.161	118.403	138.674	781.855	333.882	120
2023	224.895	45.654	63.516	404.498	129.817	138.351	788.463	344.529	170
2024	212.373	43.602	60.871	391.835	141.231	138.028	795.071	355.176	220
2025	199.851	41.550	58.226	379.172	152.645	137.705	801.679	365.823	270
2026	187.329	39.498	55.581	366.509	164.059	137.382	808.287	376.470	320
2027	174.807	37.446	52.936	353.846	175.473	137.059	814.895	387.117	370

Table 18. Evolution of individual boilers stock per year (Optimistic) all regions.

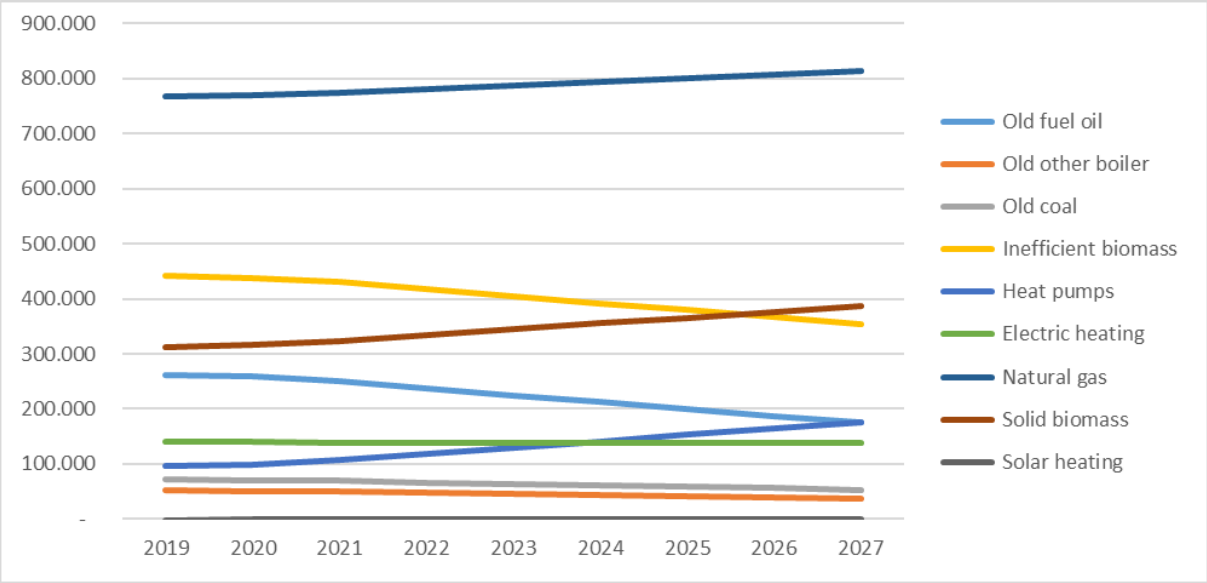

Figure 13. Evolution of individual boilers stock per year (Optimistic) all regions.

Individual RS PE		Austria	Bosnia	Bulgaria	Croatia	Croatia	Germany	Macedonia	Serbia	Slovenia	Spain	TOTAL
		Salzburg	Canton Sarajevo	Rhodope	PG County	Zagreb	Oberland	Skopje	Sabac	Slovenia	Castilla y León	
Old fuel oil	Replacements	- 1.346	-	-	-	- 12	- 1.189	- 100	-	- 3.434	- 5.679	- 11.760
	Stock 2019	40.500	-	-	-	1.032	39.454	545	-	70.474	110.331	262.336
Old other boiler	Replacements	-	- 60	-	- 30	- 9	-	- 350	- 860	-	- 500	- 1.809
	Stock 2019	-	1.082	-	439	99	931	7.000	23.620	-	18.618	51.789
Natural gas	Replacements	- 404	593	38	35	46	750	110	350	2.320	4.800	8.638
	Stock 2019	31.900	66.225	2.025	1.441	186.980	27.789	800	2.930	102.457	346.158	768.705
Electric heating	Replacements	- 409	12	- 259	65	16	-	- 20	-	- 564	1.000	- 159
	Stock 2019	17.200	100	11.285	30.026	11.232	9.313	4.200	-	4.483	51.478	139.317
Solid biomass	Replacements	703	315	660	200	34	350	100	400	5.883	339	8.984
	Stock 2019	21.600	41.649	20.625	43.036	83.043	11.938	5.000	350	83.585	1.868	312.694
Old coal	Replacements	-	- 800	- 1.083	-	-	-	-	- 120	- 6	-	- 2.009
	Stock 2020	-	47.058	21.045	-	-	-	-	3.300	22	-	71.425
Inefficient biomasss	Replacements	-	-	- 3.889	-	-	-	-	-	- 7.927	-	- 11.816
	Stock 2019	-	-	309.575	-	-	-	-	-	132.785	-	442.360
Heat pumps	Replacements	1.917	-	689	10	-	161	-	100	6.065	-	8.942
	Stock 2019	23.500	-	19.760	3	-	1.710	-	105	50.611	-	95.689
Solar heating	Replacements	-	-	-	15	-	-	-	-	-	-	15
	Stock 2020	-	-	-	20	-	-	-	-	-	-	20

Table 19. Number of individual boilers replaced per year (Pessimistic) all regions.

	Pessimistic Replace-Scenario Individual Boilers								
	Old fuel oil	Old other boiler	Old coal	Inefficient biomass	Heat pumps	Electric heating	Natural gas	Solid biomass	Solar heating
Replacements	- 11.760	- 1.809	- 2.009	- 11.816	8.942	- 159	8.638	8.984	15
2019	262.336	51.789	71.425	442.360	95.689	139.317	768.705	312.694	20
2020	258.455	51.192	70.762	438.461	98.640	139.265	771.556	315.659	25
2021	250.694	49.998	69.436	430.662	104.542	139.160	777.257	321.588	35
2022	238.934	48.189	67.427	418.846	113.484	139.001	785.895	330.572	50
2023	227.174	46.380	65.418	407.030	122.426	138.842	794.533	339.556	60
2024	215.414	44.571	63.409	395.214	131.368	138.683	803.171	348.540	70
2025	203.654	42.762	61.400	383.398	140.310	138.524	811.809	357.524	80
2026	191.894	40.953	59.391	371.582	149.252	138.365	820.447	366.508	90
2027	180.134	39.144	57.382	359.766	158.194	138.206	829.085	375.492	100

Table 20. Evolution of individual boilers stock per year (Pessimistic) all regions.

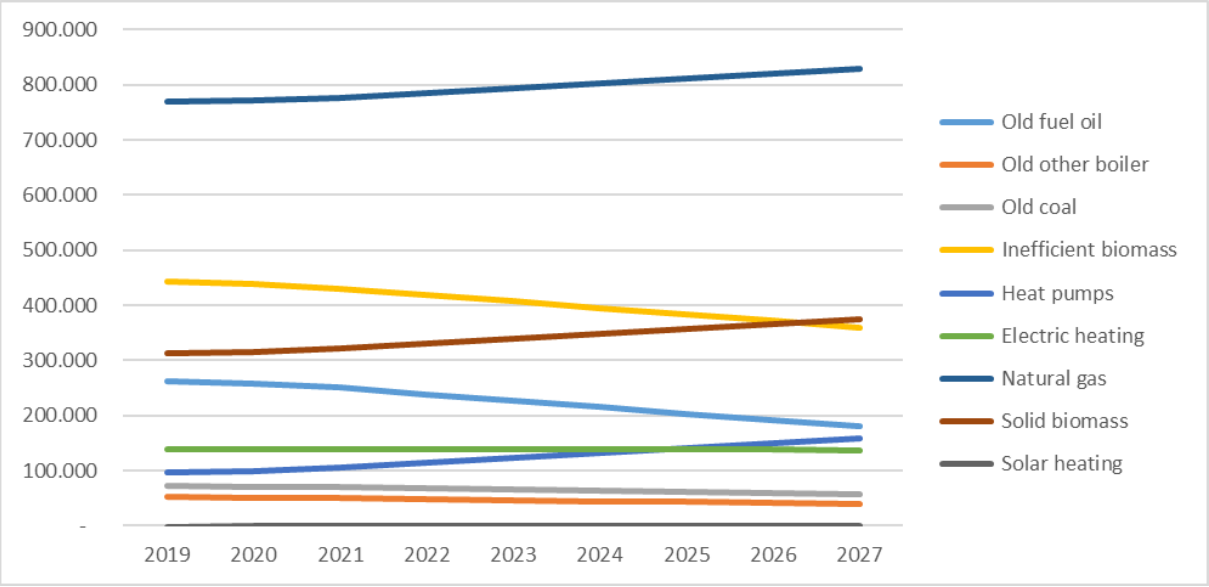

Figure 14. Pessimistic Replace scenario individual boiler evolution, all regions.

Collective BS		Austria Salzburg	Bosnia Canton Sarajevo	Bulgaria Rhodope	Croatia PG County	Croatia Zagreb	Germany Oberland	Macedonia Skopje	Serbia Sabac	Slovenia Slovenia	Spain Castilla y León	TOTAL
Old fuel oil	Replacements	- 116	-	-	-	- 113	- 231	- 10	-	-	- 250	- 720
	Stock 2019	4.550	-	-	-	9.391	9.886	100	-	-	5.517	29.444
Old other boiler	Replacements	-	-	-	- 100	- 16	-	- 90	-	-	- 30	- 236
	Stock 2019	-	-	-	11.337	207	-	1.000	-	-	931	13.475
Natural gas	Replacements	16	-	5	50	-	150	12	1	-	220	454
	Stock 2019	4.640	-	270	6.504	-	5.558	154	-	-	17.308	34.434
Solid biomass	Replacements	37	-	54	50	12	-	15	-	-	40	208
	Stock 2019	2.940	-	2.750	7.708	30.262	-	1.800	5	-	944	46.409
Heat pumps	Replacements	101	-	-	-	-	-	-	-	-	-	101
	Stock 2019	-	-	-	-	-	-	-	-	-	-	-
Electric heating	Replacements	-	-	-	30	-	-	-	-	-	-	30
	Stock 2020	-	-	-	3.715	-	-	-	-	-	-	3.715

Table 21. Number of collective boilers replaced per year (Baseline) all regions.

	Baseline Collective Boilers					
	Old fuel oil	Old other boiler	Natural gas	Solid biomass	Heat pumps	Electric heating
Replacements	- 720	- 236	454	208	101	30
2019	29.444	13.475	34.434	46.409	-	3.715
2020	29.206	13.397	34.584	46.478	33	3.725
2021	28.731	13.241	34.883	46.615	100	3.745
2022	28.011	13.005	35.337	46.823	201	3.775
2023	27.291	12.769	35.791	47.031	302	3.805
2024	26.571	12.533	36.245	47.239	403	3.835
2025	25.851	12.297	36.699	47.447	504	3.865
2026	25.131	12.061	37.153	47.655	605	3.895
2027	24.411	11.825	37.607	47.863	706	3.925

Table 22. Evolution of collective boilers stock per year (Baseline) all regions.

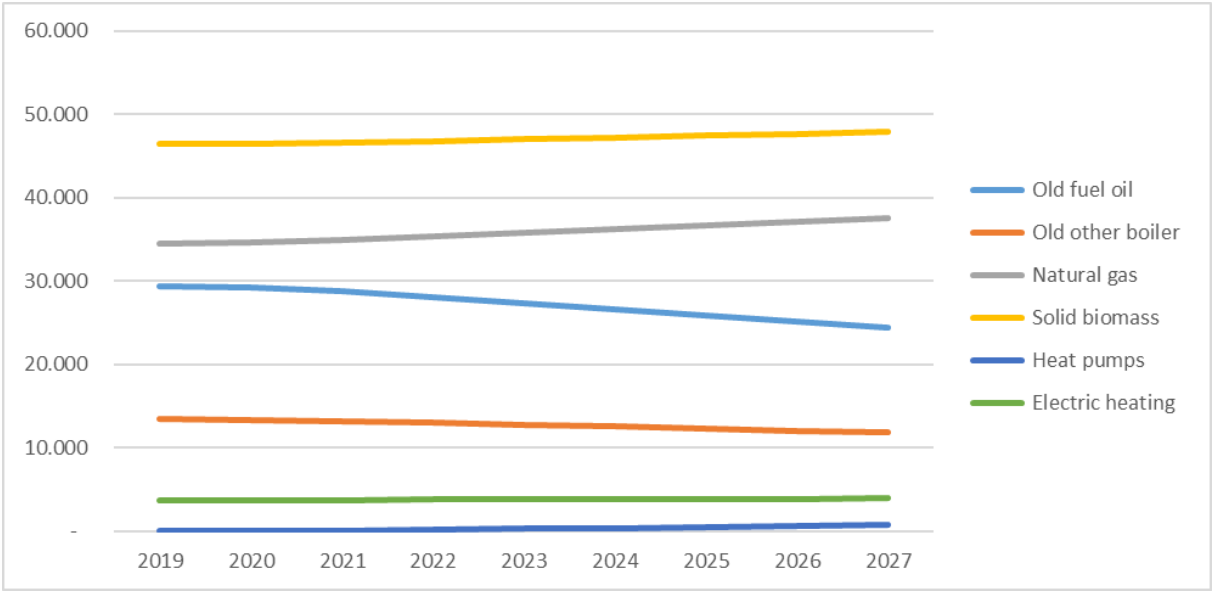

Figure 15. Evolution of collective boilers stock per year (Baseline) all regions.

Collective RS OP		Austria Salzburg	Bosnia Canton Sarajevo	Bulgaria Rhodope	Croatia PG County	Croatia Zagreb	Germany Oberland	Macedonia Skopje	Serbia Sabac	Slovenia Slovenia	Spain Castilla y León	TOTAL
Old fuel oil	Replacements	- 171	-	-	-	- 130	- 298	- 30	-	-	- 416	- 1.045
	Stock 2019	4.550	-	-	-	9.391	9.886	100	-	-	5.517	29.444
Old other boiler	Replacements	-	-	-	- 150	- 19	-	- 110	-	-	- 30	- 309
	Stock 2019	-	-	-	11.337	207	-	1.000	-	-	931	13.475
Natural gas	Replacements	- 147	-	3	80	-	191	20	1	-	220	368
	Stock 2019	4.640	-	270	6.504	-	5.558	154	-	-	17.308	34.434
Solid biomass	Replacements	74	-	122	70	14	-	22	1	-	206	509
	Stock 2019	2.940	-	2.750	7.708	30.262	-	1.800	5	-	944	46.409
Heat pumps	Replacements	203	-	-	-	-	-	-	-	-	-	203
	Stock 2019	-	-	-	-	-	-	-	-	-	-	-
Electric heating	Replacements	-	-	-	50	-	-	-	-	-	-	50
	Stock 2020	-	-	-	3.715	-	-	-	-	-	-	3.715

Table 23. Number of collective boilers replaced per year (Optimistic) all regions.

	Optimistic Replace-Scenario Collective Boilers					
	Old fuel oil	Old other boiler	Natural gas	Solid biomass	Heat pumps	Electric heating
Replacements	- 1.045	- 309	368	509	203	50
2019	29.444	13.475	34.434	46.409	-	3.715
2020	29.099	13.373	34.555	46.577	67	3.732
2021	28.409	13.169	34.798	46.913	201	3.765
2022	27.364	12.860	35.166	47.422	404	3.815
2023	26.319	12.551	35.534	47.931	607	3.865
2024	25.274	12.242	35.902	48.440	810	3.915
2025	24.229	11.933	36.270	48.949	1.013	3.965
2026	23.184	11.624	36.638	49.458	1.216	4.015
2027	22.139	11.315	37.006	49.967	1.419	4.065

Table 24. Evolution of collective boilers stock per year (Optimistic) all regions.

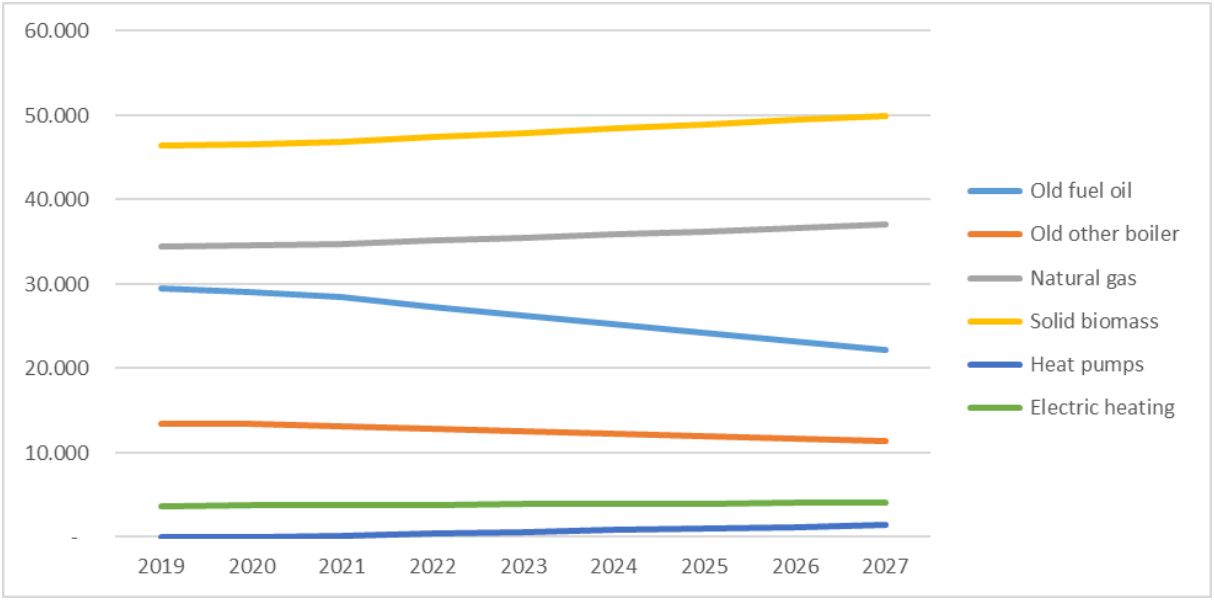

Figure 16. Evolution of collective boilers stock per year (Optimistic) all regions.

Collective RS PE		Austria	Bosnia	Bulgaria	Croatia	Croatia	Germany	Macedonia	Serbia	Slovenia	Spain	TOTAL
		Salzburg	Canton Sarajevo	Rhodope	PG County	Zagreb	Oberland	Skopje	Sabac	Slovenia	Castilla y León	
Old fuel oil	Replacements	- 151	-	-	-	- 117	- 282	- 20	-	-	- 339	- 909
	Stock 2019	4.550	-	-	-	9.391	9.886	100	-	-	5.517	29.444
Old other boiler	Replacements	-	-	-	- 100	- 17	-	- 100	-	-	- 30	- 247
	Stock 2019	-	-	-	11.337	207	-	1.000	-	-	931	13.475
Natural gas	Replacements	- 73	-	4	50	-	153	15	2	-	220	371
	Stock 2019	4.640	-	270	6.504	-	5.558	154	-	-	17.308	34.434
Solid biomass	Replacements	58	-	88	50	13	-	18	-	-	129	356
	Stock 2019	2.940	-	2.750	7.708	30.262	-	1.800	5	-	944	46.409
Heat pumps	Replacements	159	-	-	-	-	-	-	-	-	-	159
	Stock 2019	-	-	-	-	-	-	-	-	-	-	-
Electric heating	Replacements	-	-	-	25	-	-	-	-	-	-	25
	Stock 2020	-	-	-	3.715	-	-	-	-	-	-	3.715

Table 25. Number of collective boilers replaced per year (Pessimistic) all regions.

	Pessimistic Replace-Scenario Collective Boilers					
	Old fuel oil	Old other boiler	Natural gas	Solid biomass	Heat pumps	Electric heating
Replacements	- 909	- 247	371	356	159	25
2019	29.444	13.475	34.434	46.409	-	3.715
2020	29.144	13.393	34.556	46.526	52	3.723
2021	28.544	13.230	34.801	46.761	157	3.740
2022	27.635	12.983	35.172	47.117	316	3.765
2023	26.726	12.736	35.543	47.473	475	3.790
2024	25.817	12.489	35.914	47.829	634	3.815
2025	24.908	12.242	36.285	48.185	793	3.840
2026	23.999	11.995	36.656	48.541	952	3.865
2027	23.090	11.748	37.027	48.897	1.111	3.890

Table 26. Evolution of collective boilers stock per year (Pessimistic)all regions.

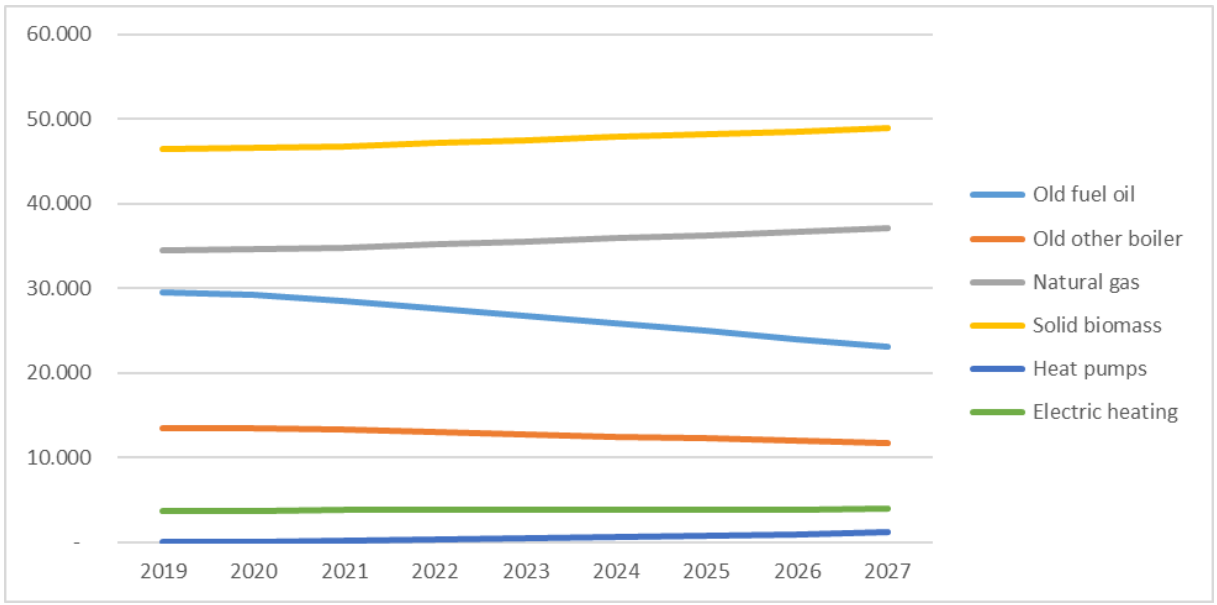

Figure 17. Evolution of collective boilers stock per year (Pessimistic)all regions.

District heating BS		Austria Salzburg	Bosnia Canton Sarajevo	Bulgaria Rhodope	Croatia PG County	Croatia Zagreb	Germany Oberland	Macedonia Skopje	Serbia Sabac	Slovenia Slovenia	Spain Castilla y León	TOTAL
Biomass DH	Replacements	13	0	-	-	-	0	2	-	0	2	17
	Stock 2019	900	2	-	-	-	3	-	1	4	14	925
Natural gas DH	Replacements	-	-	-	2	0	-	-	-	1	-	3
	Stock 2019	-	142	-	11	56	-	-	8	74	-	291
Diesel DH	Replacements	-	-	-	-	-	-	-	-	-	-	-
	Stock 2019	-	2	-	-	-	-	-	-	-	-	2
Other DH	Replacements	-	-	-	- 1	-	-	-	-	0	-	- 1
	Stock 2019	-	-	-	4	-	-	-	-	18	-	22

Table 27. Number of district heating systems replaced per year (Baseline) all regions.

	Baseline District Heating			
	Other DH	Diesel DH	Natural gas	Biomass DH
Replacements	- 1	-	3	17
2019	22	2	291	925
2020	21	2	292	931
2021	21	2	294	942
2022	20	2	297	959
2023	19	2	299	976
2024	19	2	302	994
2025	18	2	305	1.011
2026	17	2	308	1.028
2027	16	2	311	1.045

Table 28. Evolution of district heating systems stock per year (Baseline) all regions.

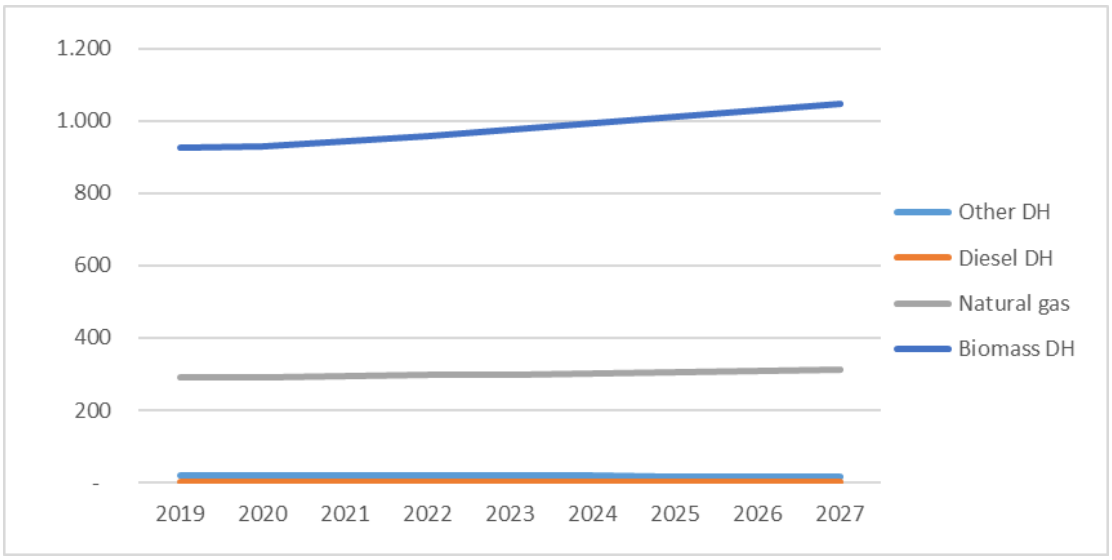

Figure 18. Evolution of district heating systems stock per year (Baseline) all regions.

District heating RS OP		Austria	Bosnia	Bulgaria	Croatia	Croatia	Germany	Macedonia	Serbia	Slovenia	Spain	TOTAL
		Salzburg	Canton Sarajevo	Rhodope	PG County	Zagreb	Oberland	Skopje	Sabac	Slovenia	Castilla y León	
Biomass DH	Replacements	26	0	-	-	-	0	10	3	0	7	46
	Stock 2019	900	2	-	-	-	3	-	1	4	14	925
Natural gas DH	Replacements	-	-	-	4	0	-	-	-	1	-	5
	Stock 2019	-	142	-	11	56	-	-	8	74	-	291
Diesel DH	Replacements	-	-	-	-	-	-	-	-	-	-	-
	Stock 2019	-	2	-	-	-	-	-	-	-	-	2
Other DH	Replacements	-	-	-	- 2	-	-	-	-	0	-	- 2
	Stock 2019	-	-	-	4	-	-	-	-	18	-	22

Table 29. Number of district heating systems replaced per year (Optimistic) all regions.

	Optimistic Replace-Scenario District Heating Boilers			
	Other DH	Diesel DH	Natural gas	Biomass DH
Replacements	- 2	-	5	46
2019	22	2	291	925
2020	21	2	293	940
2021	20	2	296	971
2022	18	2	301	1.017
2023	17	2	306	1.064
2024	15	2	312	1.110
2025	13	2	317	1.156
2026	11	2	322	1.203
2027	10	2	327	1.249

Table 30. Evolution of district heating systems stock per year (Optimistic) all regions.

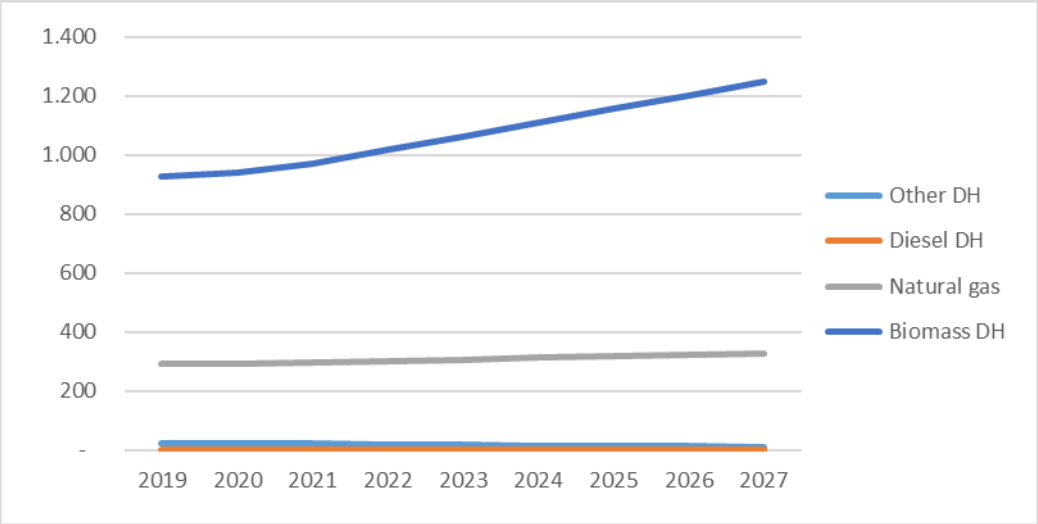

Figure 19. Evolution of district heating systems stock per year (Optimistic) all regions.

District heating RS PE		Austria Salzburg	Bosnia Canton Sarajevo	Bulgaria Rhodope	Croatia PG County	Croatia Zagreb	Germany Oberland	Macedonia Skopje	Serbia Sabac	Slovenia Slovenia	Spain Castilla y León	TOTAL
Biomass DH	Replacements	21	0	-	-	-	0	2	1	0	5	29
	Stock 2019	900	2	-	-	-	3	-	1	4	14	925
Natural gas DH	Replacements	-	-	-	2	0	-	-	-	1	-	3
	Stock 2019	-	142	-	11	56	-	-	8	74	-	291
Diesel DH	Replacements	-	-	-	-	-	-	-	-	-	-	-
	Stock 2019	-	2	-	-	-	-	-	-	-	-	2
Other DH	Replacements	-	-	-	-	-	-	-	-	0	-	0
	Stock 2019	-	-	-	4	-	-	-	-	18	-	22

Table 31. Number of district heating systems replaced per year (Pessimistic) all regions.

	Pessimistic Replace-Scenario District Heating Boilers			
	Other DH	Diesel DH	Natural gas	Biomass DH
Replacements	0	-	3	29
2019	22	2	291	925
2020	22	2	292	935
2021	22	2	294	954
2022	22	2	297	983
2023	22	2	300	1.013
2024	23	2	303	1.042
2025	23	2	306	1.071
2026	23	2	309	1.100
2027	23	2	312	1.130

Table 32. Evolution of district heating systems stock per year (Pessimistic) all regions.

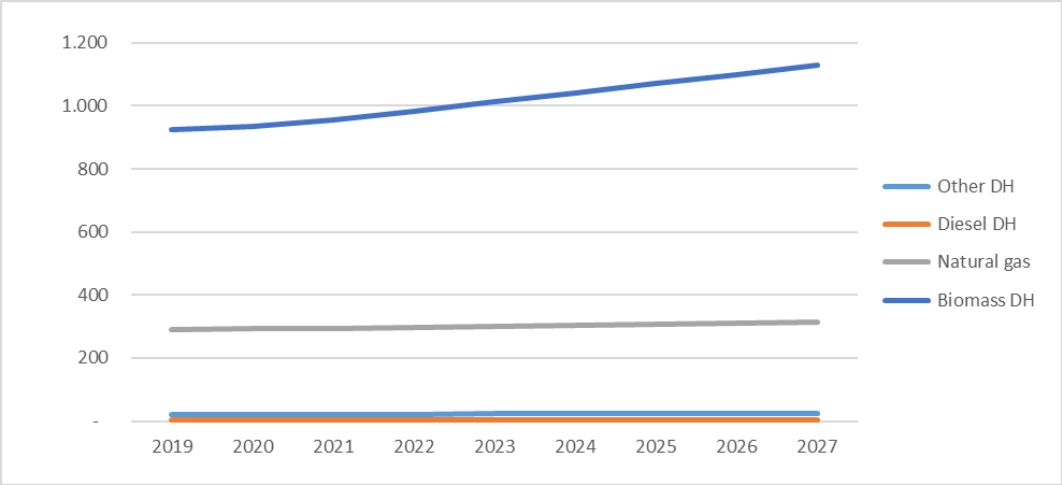

Figure 20. Evolution of district heating systems stock per year (Pessimistic) all regions.

In the European regions, the most common fuel for individual boilers is natural gas. This fuel shows an upward tendency in the baseline scenario for the following years due to the nature of the market and not because of any support by the REPLACE project and the second type of boiler most common in Europe, inefficient biomass. Although, these types of boilers are being replaced by new and more efficient biomass boilers. This type of boilers is one of the main objectives of the Replace project and not only because of the improved efficiency in the new, more comfortable models, but because of the reduction in the environmental impact since biomass, given a sustainable forest management or as – for wood pellets by-products of sawmill industry is used, is CO_2-neutral and can substitute CO_2-- intensive heating fuels (coal, oil, natural gas). By the year 2026 the number of new biomass boilers will almost surpass the inefficient biomass boilers in the optimistic Replace scenario; if not, this tendency will continue for a few more years. In the optimistic scenario, the replacement of inefficient individual biomass boilers is not compensated by new biomass individual boilers, so it might seem that biomass consumption might decrease which is not expected since there also new biomass collective boilers being installed and also district heating fuelled by biomass that can heat the homes of many Europeans. Another significant upward trend for individual boilers is the installation of heat pumps, while fuel oil and diesel show the opposite, as those oil boilers are estimated to decrease by an average rate of 11,000 every year in the ten regions studied.

For collective boilers, the trends are similar to the individual boilers. The most common type of collective boiler in the regions is biomass, followed by natural gas and like for the individual boilers they both show an upward trend over the following years. Old boilers and fuel oil show a downward trend as expected while the novelty in the next years are heat pumps as collective boilers (or heating systems, respectively). There are not any heat pumps or very few installed in the regions at the moment, but by the year 2026 around 1,000 of these heating systems are expected to be installed in the optimistic scenario. Lastly for district heating systems, all types are showing an upward trend, but the most widespread boilers are the ones functioning with biomass.

2.3 Final energy savings and emissions reduction

The Replace project will positively affect the energy demand by improving the efficiency of the new heating systems being installed, thus saving more energy by reducing energy consumption. The following tables indicate the hypothetical final energy savings that could be generated in both Replace

scenarios previously mentioned, the optimistic and pessimistic scenario. Additionally, an estimate has been calculated for the reduction of CO_2 emissions using the data from the final energy savings.

This data was based on the primary target of fuel replacement in the region. The differences in the performance of the old boiler and the new more efficient ones with differences in the energy and emissions of the type of fuel altogether allow to calculate the amount of energy that can be saved depending on the number of replacements that take place in that region. Additionally, considering the annual average home heat consumption for each fuel, an estimation of the CO2 not emitted to the atmosphere was also calculated. Since many regions could not find different data for the heat consumption for each fuel, instead an average for every residence and whatever type of fuel is consumed was used. In the case for Slovenia, their main replacement target is heat pumps, which their performance is higher than for the rest of technologies. This is why we can observe higher final energy savings for this region. Since heat pumps work with electricity, to calculate the final energy savings, the generation of the electricity from the power plant had to be considered up to the consumption at home.

Final energy savings (GWh)

	Austria	Bosnia	Bulgaria	Croatia	Croatia	Germany	Macedonia	Serbia	Slovenia	Spain	Total (GWh)
OP	Salzburg	Canton Sarajevo	Rhodope	PG County	Zagreb	Oberland	Skopje	Sabac	Slovenia	Castilla y León	
2019	1,39	-	-	-	-	-	-	-	-	-	1
2020	2,88	0,20	5,64	0,56	0,01	0,27	0,09	5,74	12,97	5,79	34
2021	5,76	0,20	11,28	1,12	0,01	0,54	0,09	11,48	28,46	8,33	67
2022	7,61	0,40	16,91	1,68	0,03	0,81	0,19	17,21	46,40	14,11	105
2023	9,66	0,60	22,55	2,24	0,04	1,08	0,28	22,95	66,93	19,90	146
2024	11,93	0,80	28,19	2,80	0,05	1,35	0,37	28,69	90,20	25,69	190
2025	14,45	1,00	33,83	3,36	0,07	1,62	0,47	34,43	116,29	31,47	237
2026	17,24	1,20	39,46	3,92	0,08	1,90	0,57	40,16	142,99	37,26	285
2027	20,31	1,40	45,10	4,48	0,10	2,17	0,68	45,90	169,69	43,04	333
PE											
2019	0,61	-	-	-	-	-	-	-	-	-	1
2020	1,21	0,05	2,82	0,22	0,00	0,19	0,07	1,08	9,67	3,12	18
2021	1,85	0,09	5,64	0,45	0,00	0,38	0,13	2,16	19,45	6,23	36
2022	2,56	0,14	8,46	0,67	0,01	0,58	0,20	3,24	29,75	9,35	55
2023	3,33	0,19	11,28	0,90	0,01	0,77	0,27	4,32	40,62	12,46	74
2024	4,18	0,23	14,09	1,12	0,01	0,96	0,33	5,40	52,07	15,58	94
2025	5,11	0,28	16,91	1,34	0,01	1,15	0,40	6,48	64,09	18,69	114
2026	6,13	0,32	19,73	1,57	0,01	1,34	0,45	7,56	76,80	21,81	136
2027	7,26	0,37	22,55	1,79	0,02	1,54	0,51	8,64	89,64	24,92	157

Table 33. Final energy savings for all regions

Emissions reduction (tCO2)

OP	Austria Salzburg	Bosnia Canton Sarajevo	Bulgaria Rhodope	Croatia PG County	Croatia Zagreb	Germany Oberland	Macedonia Skopje	Serbia Sabac	Slovenia Slovenia	Spain Castilla y León	Total (tCO2)
2019	416	-	-	-	-	-	-	-	-	-	416
2020	863	60	1.691	168	4	81	28	1.721	6.225	1.736	12.578
2021	1.728	60	3.383	336	4	162	28	3.443	13.661	2.499	25.302
2022	2.282	120	5.074	504	8	244	56	5.164	22.272	4.234	39.957
2023	2.897	180	6.765	672	12	325	84	6.885	32.128	5.970	55.918
2024	3.580	240	8.456	840	16	406	112	8.606	43.294	7.706	73.256
2025	4.336	299	10.148	1.008	21	487	140	10.328	55.820	9.441	92.027
2026	5.172	359	11.839	1.176	25	569	172	12.049	68.635	11.177	111.172
2027	6.094	419	13.530	1.344	29	650	203	13.770	81.451	12.913	130.403
PE											
2019	182	-	-	-	-	-	-	-	-	-	182
2020	362	14	846	67	1	58	20	324	4.639	935	7.264
2021	556	28	1.691	134	1	115	40	648	9.335	1.869	14.418
2022	768	42	2.537	202	2	173	60	972	14.282	2.804	21.841
2023	1.000	56	3.383	269	2	230	80	1.296	19.499	3.738	29.553
2024	1.255	70	4.228	336	3	288	100	1.620	24.994	4.673	37.566
2025	1.534	83	5.074	403	4	345	120	1.944	30.766	5.608	45.880
2026	1.840	97	5.919	470	4	403	136	2.268	36.863	6.542	54.543
2027	2.177	111	6.765	538	5	461	152	2.592	43.025	7.477	63.302

Table 34. Emission reduction for all regions.

When the proposal for the REPLACE project was written, in 2018, the project team estimated the minimum impact, which the REPLACE project could deliver by the end of the project, to be 2.7 GWh of energy savings and 1,700 t CO_2 equivalent avoided.

Originally estimated short-term project impact (by project end, 2022)												
Project Performance Indicator	**AT**	**DE**	**ES**	**HR Zagreb**	**HR PGZ**	**BA**	**BG**	**RS**	**SI**	**MK**	Total	.. / year
Energy savings triggered	0,3	0,2	0,0	0,0	0,0	0,9	0,2	0,3	0,6	0,1	**2,7**	GWh
Reduction of GHG emissions	276	158	187	85	143	482	203	19	74	54	**1 682**	t CO_2-eq

Table 35. Binding, originally estimated short-term project impact (by project end, 2022)

The overall minimum impact of the project 5 years after project end, i.e. 2027, was expected to amount to 157 GWh of energy savings and 72,350 t CO_2 equivalent avoided.

Originally estimated long-term project impact (5 years after project end, 2027)												
Project Performance Indicator	**AT**	**DE**	**ES**	**HR Zagreb**	**HR PGZ**	**BA**	**BG**	**RS**	**SI**	**MK**	Total	.. / year
Energy savings triggered	22,1	22,9	21,4	0,5	-0,1	3,2	42,8	8,0	23,5	12,9	**157,3**	GWh
Reduction of GHG emissions	6 503	10 180	37 542	230	160	521	5 652	798	6 312	4 450	**72 348**	t CO_2-eq

Table 36. Binding, originally estimated long-term project impact (5 years after project end, 2027)

Those are the estimated figures that (are binding for) the project team, or the team is aiming to proof that they will at least actually be triggered by REPLACE activities by 2022 (end of project) and 2027 (5 years after project end), respectively.

The difference of the former (at proposal stage, in 2018) and the actual scenarios relates to changed framework conditions and to the aspect that the new scenarios were aligned closer with the members of the local working groups of the ten pilot regions. At the same time, as it was mentioned above, the impact reduction calculated in this report only considers the primary target of fuel replacement in the region (biomass) and not all inefficient boilers being replaced. In the proposal stage in 2018, the impact estimated also considered other variables such as the impact from collective actions regarding refurbishment of the uppermost ceiling, or the reduction of the useful heat demand instead of just a reduction of impact by the increased heating system performance.

In some cases, in more recent meetings of the Local Working Groups was argued that the market conditions have worsened compared to 2018 due to the global pandemic. This would cause a reduction in the original reduction estimated in the regions most affected by it. Hence, it is possible to reduce emissions against set targets from technological aspect, but with high financial efforts and significant changes in the energy sector, which must be preceded by changes in energy efficiency - the thermal efficiency of housing has the greatest impact on CO2-reduction.

2.4 Investments triggered

The Replace project will positively impact the regional economy of each of the partner's regions due to an increasing demand of renewable heating systems. To estimate the investment triggered, the average boiler power for individual (P<50 kW), collective (P>50 kW) and district heating, and the price per unit of power of each of the categories was used for each of the different regions of the project. This data was determined by each of the partners with their own experience, knowledge, and sources on heating systems.

The same way that the number of replacements for the optimistic and pessimistic scenarios have set the upper and lower limits of the total of boilers replaced estimated by the Replace project, the investment triggered by all of those replacements can be calculated. The results show the limits of what to expect in monetary terms regarding how well the project does. The total annual investment triggered for turnkey projects and the total up to the year 2027 is shown in the next table:

		Total investment (M€)										
		AEA	ENOVA	BSERC	EIHP	REGEA	EWO	SDEWES	SABAC	JSI	EREN/ESCAN	Total (M€)
		Austria	Bosnia	Bulgaria	Croatia	Croatia	Germany	Macedonia	Serbia	Slovenia	Spain	
		Salzburg	Canton Sarajevo	Rhodope	Primosko	Zagreb	Oberland	Skopje	Sabac	Slovenia	Castilla y León	
Annual REPLACE (M€) turnkey project investment	Optimistic	28	1	7	9	1	117	11	2	13	52	242
	Pessimistic	17	0	3	1	0	75	3	1	6	29	136
REPLACE (M€) turnkey project investment up to 2027	Optimistic	196	7	48	66	10	821	79	12	88	367	1.694
	Pessimistic	119	2	24	8	2	528	23	4	43	200	954

Table 37. Total investment triggered by Replace, values in Million €.

3 | Country-region Analysis

3.1 Bosnia-Herzegovina – Sarajevo Canton

3.1.1 Methodology and information sources

The data used for the region of Canton of Sarajevo was obtained from several sources. Number of boilers, energy consumption and delivered thermal energy, along with information on heated living space represent the baseline for home and boiler evolution, obtained from *Feasibility study on expansion and improvement of district heating system in Sarajevo Canton (2019)* and *Cantonal Environmental Action Plan of Sarajevo Canton (KEAP) for the period 2017 – 2022.* The feasibility study addressed the priority measures identified in the key Cantonal strategic documents and mapped bankable solutions for improvements and the expansion of service areas by analysing opportunities along the entire heat supply chain from generation to distribution to final utilization. However, the most important assessments were made based on empirical data from energy certification of over 200 individual housing facilities – internal source.

When it comes to the assessment in the Economics sheet, the main data source was Cost/Benefit Analysis in the Biomass Sector in Bosnia and Herzegovina, the publication was done in the partnership with UNDP and Global Environment Facility (GEF). The data obtained from the publication are unit costs for boilers and boilers' installation for different types of biomass (wood pellets, wood chips and firewood). The prices used in the estimation represent the mean value.

Sources:

1 - Feasibility study on expansion and improvement of district heating system in Sarajevo Canton

2 - Cantonal Environmental Action Plan of Sarajevo Canton (KEAP)
http://extwprlegs1.fao.org/docs/pdf/bih179863annex.pdf

3 - Internal sources: Data from energy certification of over 200 individual housing facilities

4 - Cost / Benefit Analysis in the Biomass Sector in BiH
https://www.ba.undp.org/content/bosnia_and_herzegovina/bs/home/library/environment_energy/cost-benefit-analysis-of-the-bosnia-and-herzegovina-biomass-ener.html

3.1.2 Home evolution

	Baseline Homes Heating (expected evolution without REPLACE)						
	Old coal	Old other boiler	Natural gas	Solid biomass	Heat pumps	Biomass DH	Biomass total
Replaced/ year	-680	-28	482	285	10	0	285
2019	43.751	3.995	61.599	38.722	100	1.600	40.322
2020	43.071	3.967	62.081	39.007	110	1.600	40.607
2021	42.391	3.939	62.563	39.292	120	1.600	40.892
2022	41.711	3.911	63.045	39.577	130	1.600	41.177
2023	41.031	3.883	63.527	39.862	140	1.600	41.462
2024	40.351	3.855	64.009	40.147	150	1.601	41.748
2025	39.671	3.827	64.491	40.432	160	1.601	42.033
2026	38.991	3.799	64.973	40.717	170	1.601	42.318
2027	38.311	3.771	65.455	41.002	180	1.601	42.603
2028	37.631	3.743	65.937	41.287	190	1.601	42.888
2029	36.951	3.715	66.419	41.572	200	1.601	43.173
2030	36.271	3.687	66.901	41.857	210	1.601	43.458
2031	35.591	3.659	67.383	42.142	220	1.601	43.743
2032	34.911	3.631	67.865	42.427	230	1.601	44.028
2033	34.231	3.603	68.347	42.712	240	1.601	44.313

Table 35. Evolution of home heating systems stock per year (Baseline) Sarajevo Canton

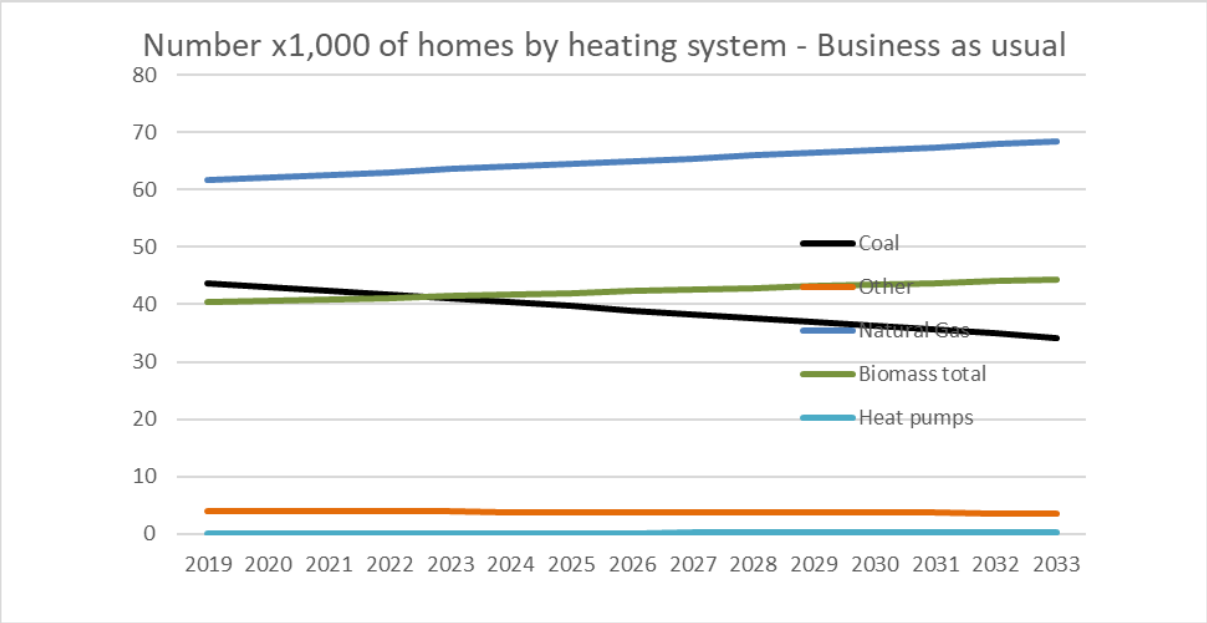

Figure 21. Evolution of home heating systems stock per year (Baseline) Sarajevo Canton

Optimistic Replace-Scenario Homes (Overachieving REPLACE target region objectives)							
	Old coal	Old other boiler	Natural gas	Solid biomass	Heat pumps	Biomass DH	Biomass total
Replaced/ year	-945	-97	679	410	15	0	410
2019	43.751	3.995	61.599	38.722	100	1.600	40.322
2020	42.806	3.898	62.278	39.132	110	1.600	40.732
2021	41.861	3.801	62.957	39.417	120	1.600	41.017
2022	40.916	3.704	63.636	39.827	130	1.601	41.428
2023	39.971	3.607	64.315	40.237	140	1.601	41.838
2024	39.026	3.510	64.994	40.647	150	1.601	42.248
2025	38.081	3.413	65.673	41.057	160	1.601	42.658
2026	37.136	3.316	66.352	41.467	170	1.601	43.068
2027	36.191	3.219	67.031	41.877	180	1.602	43.479
2028	35.246	3.122	67.710	42.287	190	1.602	43.889
2029	34.301	3.025	68.389	42.697	200	1.602	44.299
2030	33.356	2.928	69.068	43.107	210	1.602	44.709
2031	32.411	2.831	69.747	43.517	220	1.602	45.119
2032	31.466	2.734	70.426	43.927	230	1.603	45.530
2033	30.521	2.637	71.105	44.337	240	1.603	45.940

Table 38. Evolution of home heating systems stock per year (Optimistic) Sarajevo Canton

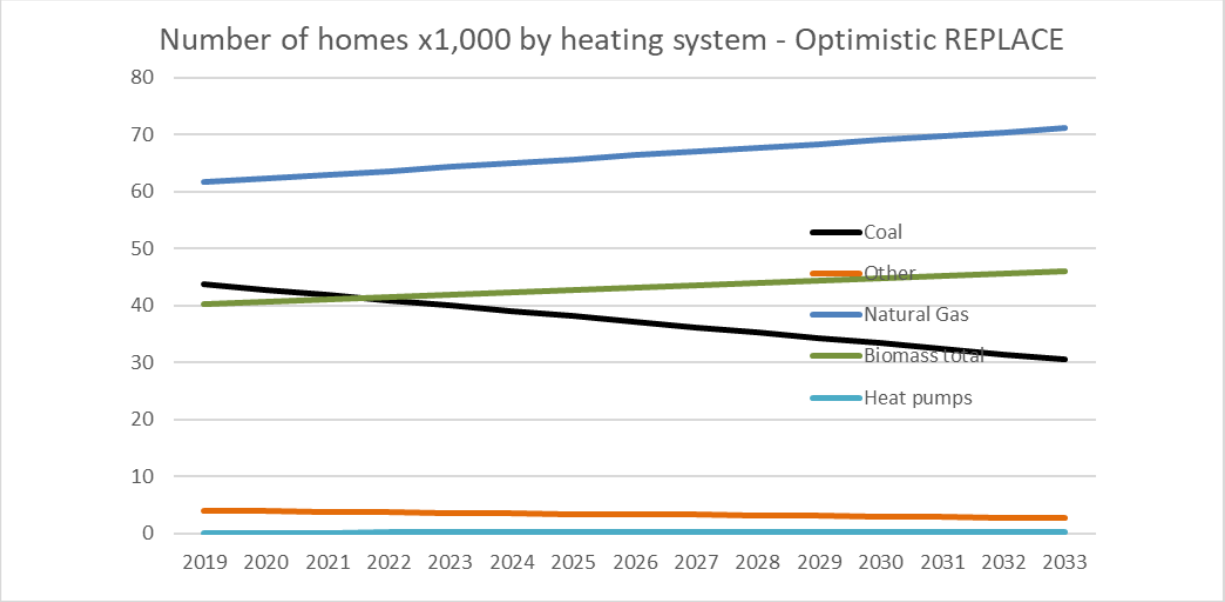

Figure 22. Evolution of home heating systems stock per year (Optimistic) Sarajevo Canton

Pessimistic Replace-Scenario Homes (Underachieving REPLACE target region objectives)							
	Old coal	Old other boiler	Natural gas	Solid biomass	Heat pumps	Biomass DH	Biomass total
Replaced/ year	-797	-59	589	314	12	0	314
2019	43.751	3.995	61.599	38.722	100	1.600	40.322
2020	42.954	3.936	62.188	39.036	112	1.600	40.636
2021	42.157	3.877	62.777	39.350	124	1.600	40.950
2022	41.360	3.818	63.366	39.664	136	1.600	41.264
2023	40.563	3.759	63.955	39.978	148	1.601	41.579
2024	39.766	3.700	64.544	40.292	160	1.601	41.893
2025	38.969	3.641	65.133	40.606	172	1.601	42.207
2026	38.172	3.582	65.722	40.920	184	1.601	42.521
2027	37.375	3.523	66.311	41.234	196	1.601	42.835
2028	36.578	3.464	66.900	41.548	208	1.601	43.149
2029	35.781	3.405	67.489	41.862	220	1.602	43.464
2030	34.984	3.346	68.078	42.176	232	1.602	43.778
2031	34.187	3.287	68.667	42.490	244	1.602	44.092
2032	33.390	3.228	69.256	42.804	256	1.602	44.406
2033	32.593	3.169	69.845	43.118	268	1.602	44.720

Table 39. Evolution of home heating systems stock per year (Pessimistic) Sarajevo Canton

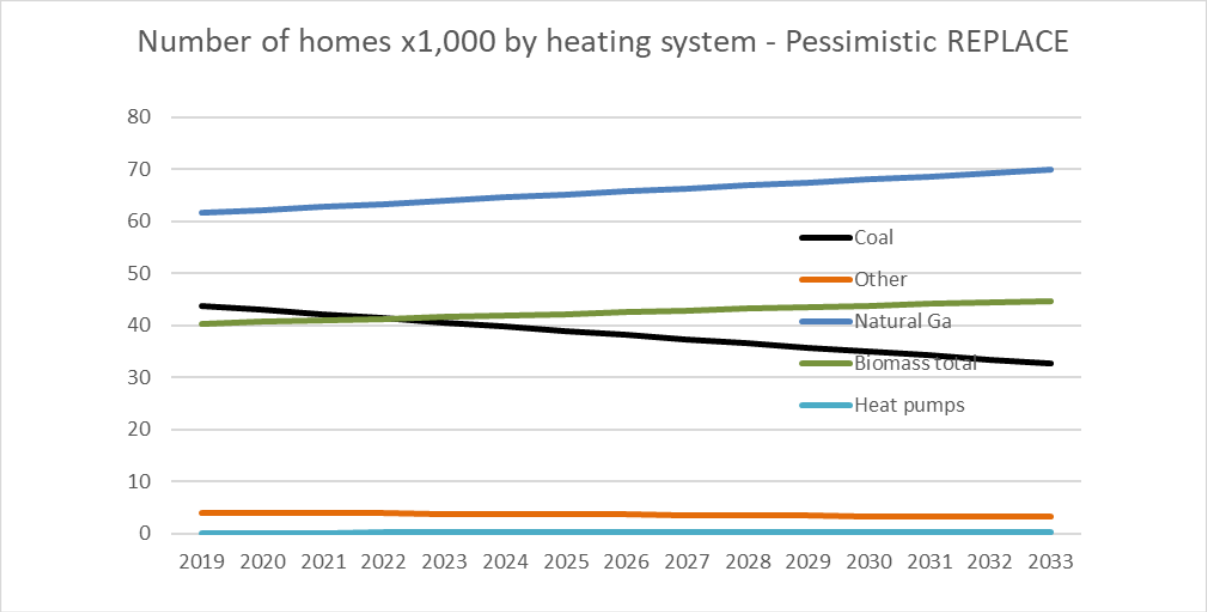

Figure 23. Evolution of home heating systems stock per year (Pessimistic) Sarajevo Canton

The main source for heating homes in the region of Sarajevo Canton is Natural gas. Heating systems using this type of fuel are predicted to continue rising in the next decade. It is observed that the opposite happens with the old coal heating systems, which is the main fuel objective to be replaced by the project in the pilot region. The project estimates between 800 and 900 of the region's homes heated with this fuel being replaced by natural gas, followed by biomass. The inventory estimates that around 400 biomass heating installations will be installed for homes in this region every year in the best scenario, and around 300 in the worst one.

Energy source	Annual average home heat consumption (kWh)
	kWh/home
Diesel oil	6.804,000
GLP	6.804,000
Natural gas	6.804,000
Electricity	6.804,000
Biomass	6.804,000

Table 40. Annual average home heat consumption, Sarajevo Canton

Old boiler performance	75%
New biomass boiler performance	91%

	Final energy savings (GWh)	
	Opptimistic Replace vs Business as usual	Pessimistic Replace vs Business as usual
2019	0,0	0,0
2020	0,2	0,0
2021	0,2	0,1
2022	0,4	0,1
2023	0,6	0,2
2024	0,8	0,2
2025	1,0	0,3
2026	1,2	0,3
2027	1,4	0,4
2028	1,6	0,4
2029	1,8	0,5
2030	2,0	0,5
2031	2,2	0,6
2032	2,4	0,6
2033	2,6	0,6

Table 41. Final energy savings, Sarajevo Canton

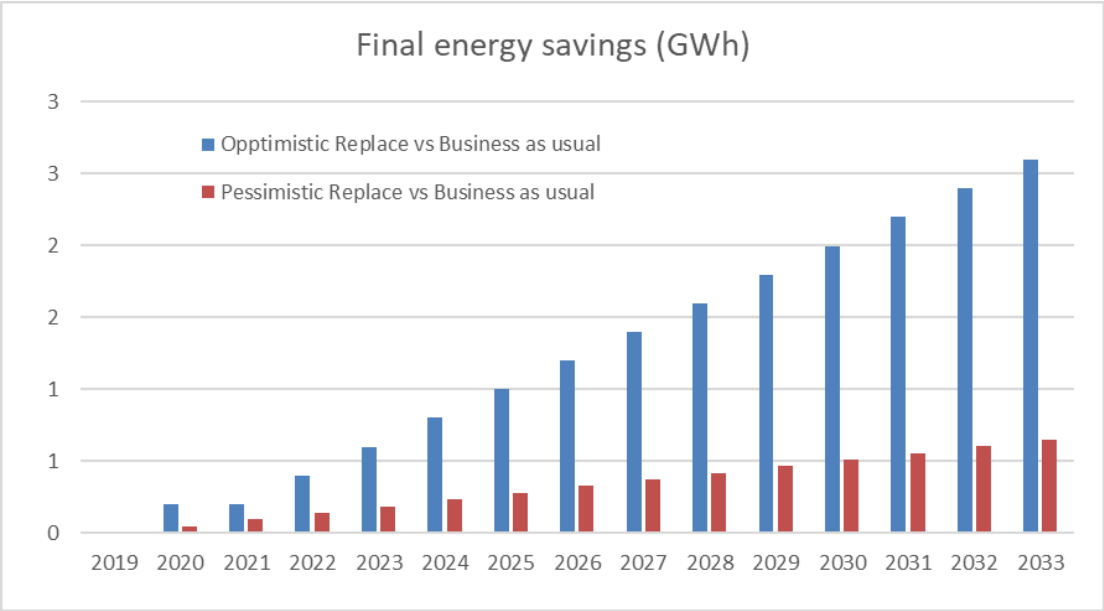

Figure 24. Final energy savings, Sarajevo Canton

	Additional emissions reduction (tCO2)	
	Opptimistic Replace vs Business as usual	Pessimistic Replace vs Business as usual
2019	0	0
2020	60	14
2021	60	28
2022	120	42
2023	180	56
2024	240	70
2025	299	83
2026	359	97
2027	419	111
2028	479	125
2029	539	139
2030	599	153
2031	659	167
2032	718	181
2033	778	195

Table 42. Additional emissions reduction, Sarajevo Canton

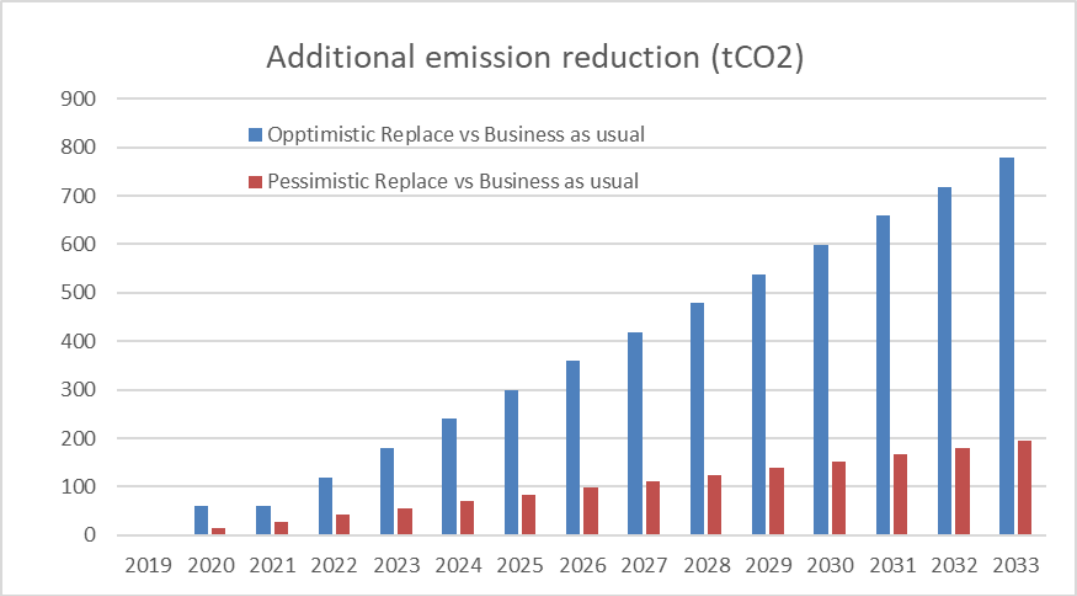

Figure 25. Additional emissions reduction, Sarajevo Canton

The final energy savings for the optimistic and pessimistic scenarios were calculated considering the number of replacements for homes, the annual average home heat consumption, and the different performance values for the old and new heating systems. By the year 2033, with the assistance of the replace project, Sarajevo Canton could save between 9 and 3.5 GWh of energy. This in turn translates to a reduction of emissions in between 2700 and 1000 tons of CO2 by the year 2033.

3.1.3 Boiler evolution

	Baseline Individual Boilers (expected evolution without REPLACE)				
	number of individual boilers		number of individual boilers		
	Stock	Stock	Stock of boilers (number, cumulated)		
	Old coal	Old other boiler	Natural gas	Biomass	Electric heating
Replaced/ year	-700	-30	493	287	10
2019	47.058	1.082	66.225	41.649	100
2020	46.358	1.052	66.718	41.936	110
2021	45.658	1.022	67.211	42.223	120
2022	44.958	992	67.704	42.510	130
2023	44.258	962	68.197	42.797	140
2024	43.558	932	68.690	43.084	150
2025	42.858	902	69.183	43.371	160
2026	42.158	872	69.676	43.658	170
2027	41.458	842	70.169	43.945	180
2028	40.758	812	70.662	44.232	190
2029	40.058	782	71.155	44.519	200
2030	39.358	752	71.648	44.806	210
2031	38.658	722	72.141	45.093	220
2032	37.958	692	72.634	45.380	230
2033	37.258	662	73.127	45.667	240

Table 43. Evolution of individual boilers stock per year (Baseline) Sarajevo Canton

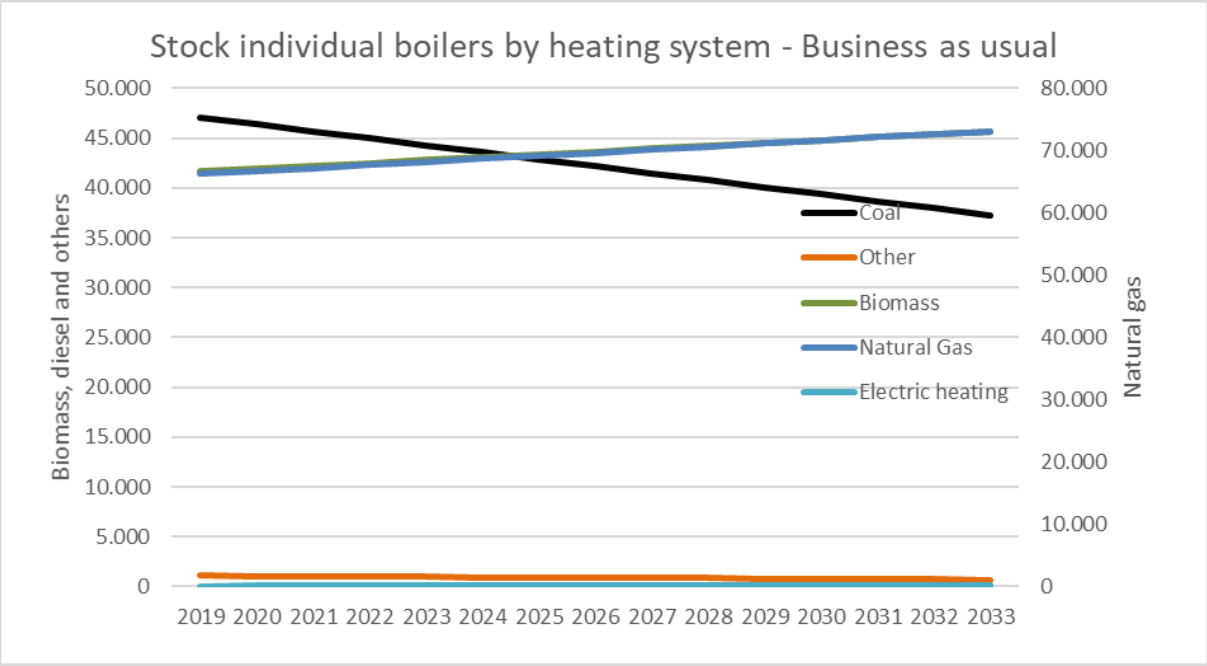

Figure 26. Evolution of individual boilers stock per year (Baseline) Sarajevo Canton

Optimistic Replace-Scenario Individual Boilers					
	number of individual boilers		number of individual boilers		
	Stock	Stock	Stock of boilers (number, cumulated)		
	Old coal	Old other boiler	Natural gas	Biomass	Electric heating
Replaced/ year	-950	-100	683	412	15
2019	47.058	1.082	66.225	41.649	100
2020	46.358	1.052	66.718	42.061	115
2021	45.658	1.022	67.211	42.473	125
2022	44.708	922	67.894	42.885	140
2023	43.758	822	68.577	43.297	155
2024	42.808	722	69.260	43.709	170
2025	41.858	622	69.943	44.121	185
2026	40.908	522	70.626	44.533	200
2027	39.958	422	71.309	44.945	215
2028	39.008	322	71.992	45.357	230
2029	38.058	222	72.675	45.769	245
2030	37.108	122	73.358	46.181	260
2031	36.158	22	74.041	46.593	275
2032	35.208	-78	74.724	47.005	290
2033	34.258	-178	75.407	47.417	305

Table 44. Evolution of individual boilers stock per year (Optimistic) Sarajevo Canton

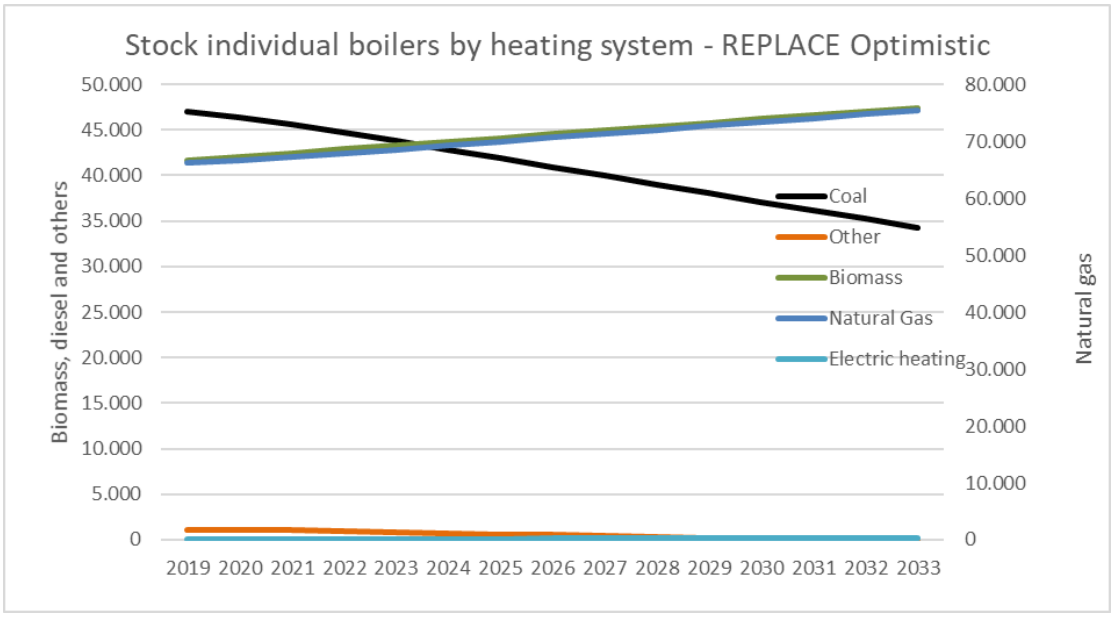

Figure 27. Evolution of individual boilers stock per year (Optimistic) Sarajevo Canton

Pessimistic Replace-Scenario Individual Boilers					
	number of individual boilers		number of individual boilers		
	Stock	Stock	Stock of boilers (number, cumulated)		
	Old coal	Old other boiler	Natural gas	Biomass	Electric heating
Replaced/ year	-800	-60	593	315	12
2019	47.058	1.082	66.225	41.649	100
2020	46.258	1.022	66.818	41.964	112
2021	45.458	962	67.411	42.279	124
2022	44.658	902	68.004	42.594	136
2023	43.858	842	68.597	42.909	148
2024	43.058	782	69.190	43.224	160
2025	42.258	722	69.783	43.539	172
2026	41.458	662	70.376	43.854	184
2027	40.658	602	70.969	44.169	196
2028	39.858	542	71.562	44.484	208
2029	39.058	482	72.155	44.799	220
2030	38.258	422	72.748	45.114	232
2031	37.458	362	73.341	45.429	244
2032	36.658	302	73.934	45.744	256
2033	35.858	242	74.527	46.059	268

Table 45. Evolution of individual boilers stock per year (Pessimistic) Sarajevo Canton

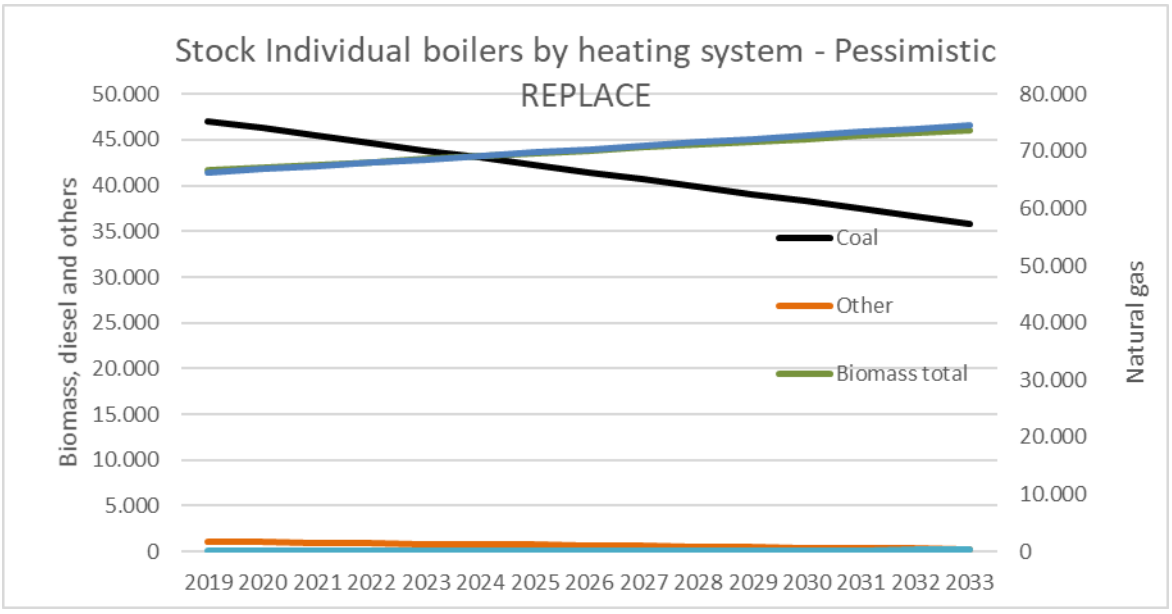

Figure 28. Evolution of individual boilers stock per year (Pessimistic) Sarajevo Canton

For individual boilers we can see a similar scenario to the home evolution situation. Mainly, old coal boilers are being replaced by natural gas, followed by biomass and very few electric heating. Collective boilers are not common in the region, instead district heating systems are used, increasing its numbers quite slowly and working with natural gas as fuel instead of biomass.

Baseline District Heating (expected evolution without REPLACE)					
	number of DH boilers		**number of DH boilers**		
	Old coal	Old other boiler	Natural gas	Solid biomass	Diesel
Replaced/ year	0	0	0	0	0
2019	2		142	2	2
2020	2	0	142	2	2
2021	2	0	142	2	2
2022	2	0	142	2	2
2023	2	0	142	2	2
2024	2	0	142	3	2
2025	2	0	142	3	2
2026	2	0	142	3	2
2027	2	0	142	3	2
2028	2	0	142	3	2
2029	2	0	142	3	2
2030	2	0	142	3	2
2031	2	0	142	3	2
2032	2	0	142	3	2
2033	2	0	142	3	2

Table 46. Evolution of district heating stock per year (Baseline) Sarajevo Canton

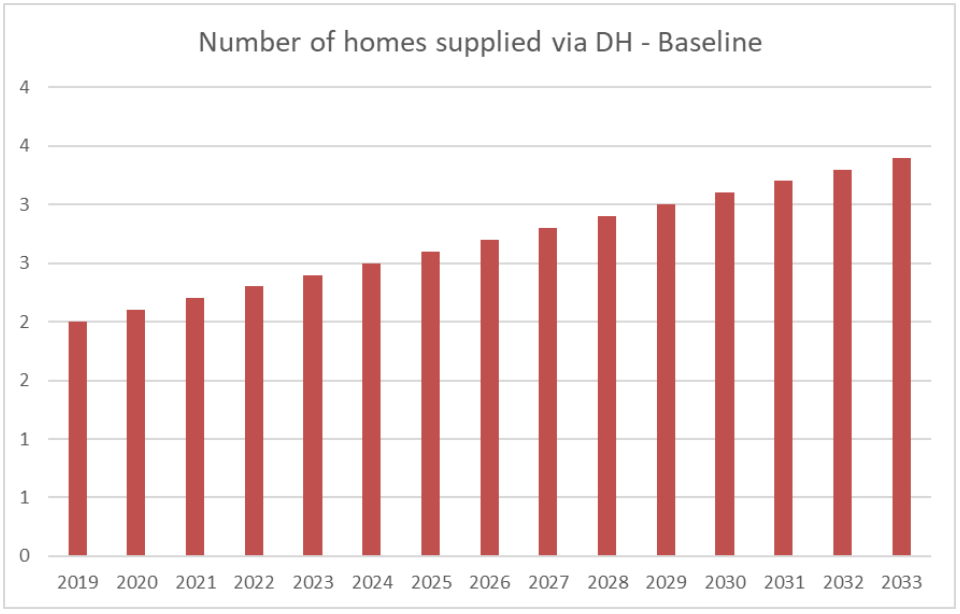

Figure 29. Evolution of district heating stock per year (Baseline) Sarajevo Canton

Optimistic Replace-Scenario DH Boilers (Overachieving REPLACE target region objectives)					
	number of individual boilers		number of individual boilers		
	Old coal	Old other boiler	Natural gas	Solid biomass	Diesel
Replaced/ year	0	0	0	0	0
2019	0	0	142	2	2
2020	0	0	142	2	2
2021	0	0	142	2	2
2022	0	0	142	3	2
2023	0	0	142	3	2
2024	0	0	142	3	2
2025	0	0	142	3	2
2026	0	0	142	3	2
2027	0	0	142	4	2
2028	0	0	142	4	2
2029	0	0	142	4	2
2030	0	0	142	4	2
2031	0	0	142	4	2
2032	0	0	142	5	2
2033	0	0	142	5	2

Table 47. Evolution of district heating stock per year (Optimistic) Sarajevo Canton

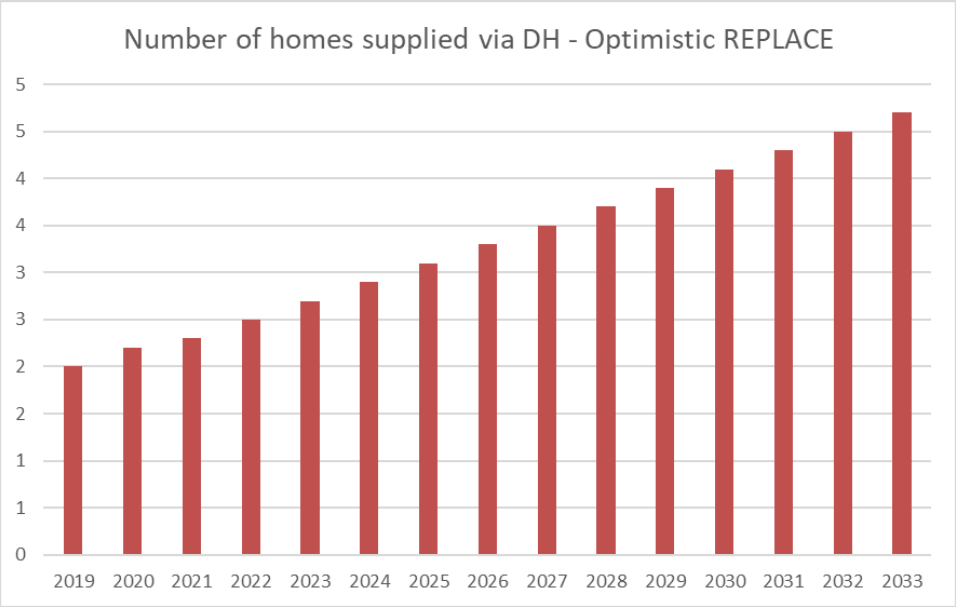

Figure 30. Evolution of district heating stock per year (Optimistic) Sarajevo Canton

Pessimistic Replace-Scenario DH Boilers (Underachieving REPLACE target region objectives)					
	number of individual boilers		number of individual boilers		
	Old coal	Old other boiler	Natural gas	Solid biomass	Diesel
Replaced/ year	0	0	0	0	0
2019	0	0	142	2	2
2020	0	0	142	2	2
2021	0	0	142	2	2
2022	0	0	142	2	2
2023	0	0	143	3	2
2024	0	0	143	3	2
2025	0	0	143	3	2
2026	0	0	143	3	2
2027	0	0	143	3	2
2028	0	0	143	3	2
2029	0	0	144	4	2
2030	0	0	144	4	2
2031	0	0	144	4	2
2032	0	0	144	4	2
2033	0	0	144	4	2

Table 48. Evolution of district heating stock per year (Pessimistic) Sarajevo Canton

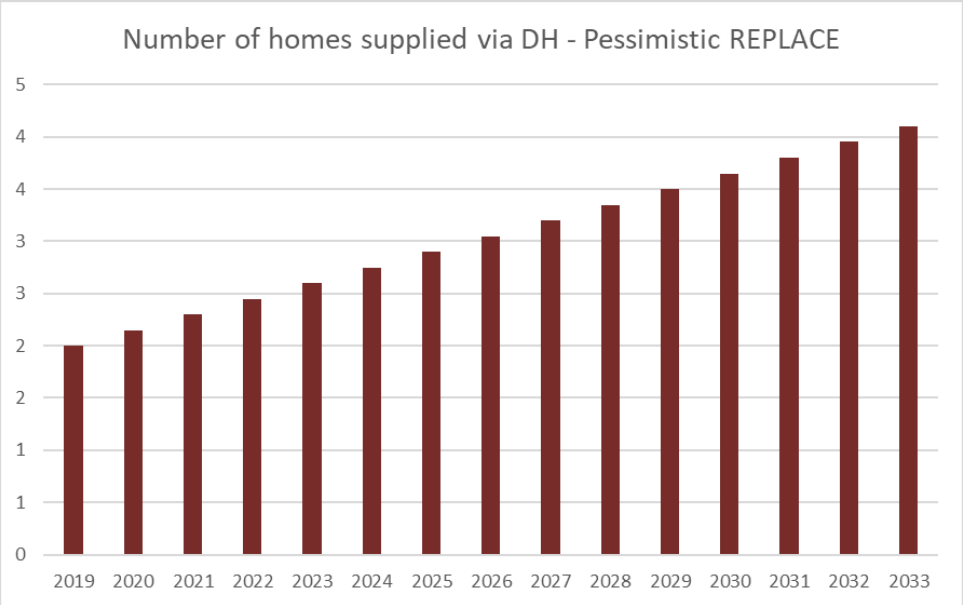

Figure 31. Evolution of district heating stock per year (Pessimistic) Sarajevo Canton

3.1.4 Investments/Economics

	Average boiler power	Price (€/kW) only boiler	Price (€/kW) biomass turnkey system
Individual boilers (P<50kW)	24	100	320
Colective boilers (P>50kW)			
Distrcit Heating boilers	4.000	90	220

Table 49. Average boiler prices, Sarajevo Canton

	Number of boilers increased by REPLACE		Annual REPLACE (€) investment only in boilers		Annual REPLACE (€) turnkey project investment	
	Optimist	Pessimist	Optimist	Pessimist	Optimist	Pessimist
Individual boilers (P<50kW)	125	28	300.000	67.200	960.000	215.040
Colective boilers (P>50kW)	0	0	-	-	-	-
Distrcit Heating boilers	0	0	36.000	18.000	88.000	44.000
Total investment Mio€			0,3	0,1	1,0	0,3

Table 50. Annual Replace investment triggered, Sarajevo Canton

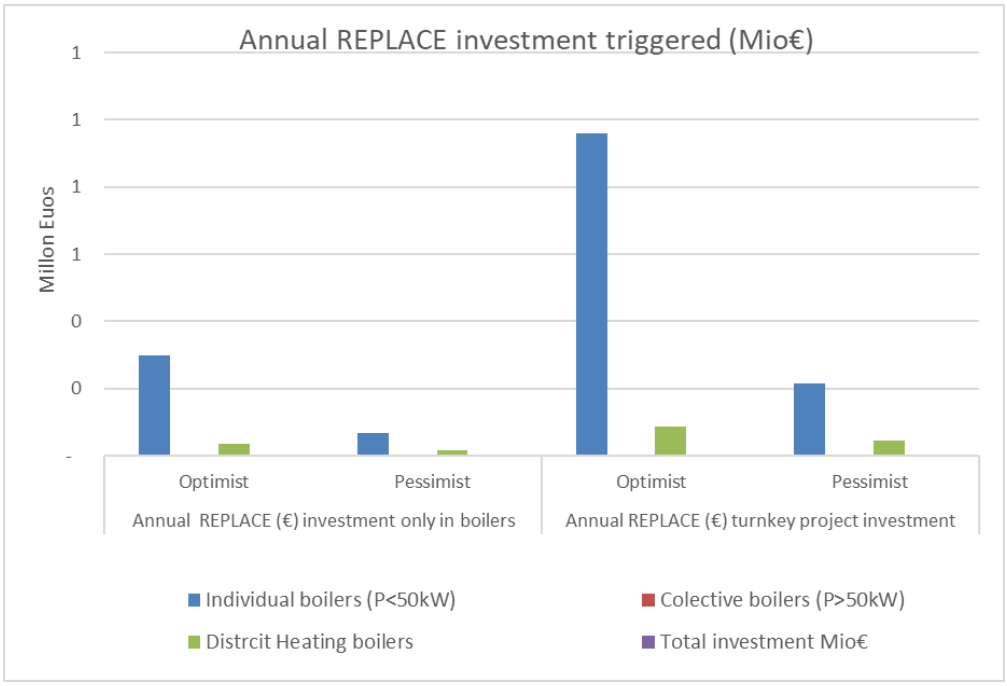

Figure 32. Annual Replace investment triggered, Sarajevo Canton

The average power for individual boilers in the region of Sarajevo is 24 kW and depending on if it includes a turnkey system, the price per kW of power can reach 3000 Euros.

The average power for district heating systems is 4000 kW. The price for the turnkey systems can reach 760000 Euros per kW installed.

3.1.5 Main conclusions

Citizens of Sarajevo Canton mainly use coal and natural gas as a heat source. Coal, due to its low price, is often the option of choice in individual housing facilities. Its use adversely affects air quality, so Sarajevo is among the most polluted cities in Europe every winter.

The population is beginning to recognize the negative consequences of coal heating, hence the reduction of coal-fired boilers and households that use them is predicted. Combined with the planned campaign within the REPLACE project, this number is expected to be significantly higher in comparison with the current trend (without the project). In the optimistic scenario, the reduction in the number of boilers will be higher by 35%, and in the pessimistic one by 15%, than it is the case right now.

On the other hand, the number of biomass boilers is expected to increase due to the popularization of pellets, but also the favourable prices of biomass technologies that are not high in Bosnia and Herzegovina, given that it is a low-income country. The percentage increase with the REPLACE project, compared to the current situation without any replacement campaigns, is 44% and 10%, according to the optimistic and pessimistic scenario, respectively. Therefore, in an optimistic estimation, the annual investment in boilers only will be around 300,000 €, and in the turnkey systems 960,000 €. The pessimistic scenario envisages investments of 67,200 € in boilers and 215,040 € in turnkey projects.

Replacement of collective boilers is not foreseen.

3.2 Bulgaria – Rhodope and rest of the country

3.2.1 Methodology and information sources

In Bulgaria, the last statistical data about the heating technologies used in homes was collected during the 2011 Census (NSI, 2011). These data are available for each municipality. During the period 2011-2020, substantial changes occurred in Rhodope region, but no statistical data are available.

The 2020 shares of each heating technology in the residential sector were calculated, based on the estimations of the administrations of the Rhodope municipalities covered by the project - Smolyan, Chepelare, Devin, Dospat, Kardzhali, Rhodope, Bratsigovo, and Ardino. These estimations were made during the visit of REPLACE team to these municipalities in August - September 2020.

By comparing the 2011 (statistical) data and the 2020 (estimated) data, the annual historical rates of heating replacement have been calculated. These rates have been considered also for the future years in the Baseline scenario.

Information about the number and surface of dwellings in the pilot region is available annually (NSI, 2020). The historical dynamics has been extrapolated in the scenario years (identical in all scenarios).

The specific energy consumption per square meter, the efficiency of heating technologies, the technology costs, and technology capacities for single-family and multi-family buildings are available in the heating calculation tool for the Rhodope region, developed by BSERC within the IEE project RES H/C SPREAD (BSERC, 2015).

The emission factors of energy carriers for Bulgaria are available in Regulation 7 on energy efficiency of buildings (Regulation 7, 2017).

The optimistic scenario assumes that REPLACE campaign in Rhodope region would be very effective. The pessimistic scenario is based on moderate campaign effectiveness, estimated at 50% of the one in the optimistic scenario.

3.2.2 Home evolution

	Baseline Homes Heating (expected evolution without REPLACE)							
	Electric heaters*	Inefficient biomass	Coal fired stoves	Natural gas	Efficient biomass	Heat pumps	Biomass DH	Biomass total
Replaced/ year	-50	-1.000	-230	50	540	160	0	-460
2019	3.700	101.500	6.900	2.700	27.500	7600	0	129.000
2020	3.650	100.500	6.670	2.750	28.040	7.760	0	128.540
2021	3.600	99.500	6.440	2.800	28.580	7.920	0	128.080
2022	3.550	98.500	6.210	2.850	29.120	8.080	0	127.620
2023	3.500	97.500	5.980	2.900	29.660	8.240	0	127.160
2024	3.450	96.500	5.750	2.950	30.200	8.400	0	126.700
2025	3.400	95.500	5.520	3.000	30.740	8.560	0	126.240
2026	3.350	94.500	5.290	3.050	31.280	8.720	0	125.780
2027	3.300	93.500	5.060	3.100	31.820	8.880	0	125.320
2028	3.250	92.500	4.830	3.150	32.360	9.040	0	124.860
2029	3.200	91.500	4.600	3.200	32.900	9.200	0	124.400
2030	3.150	90.500	4.370	3.250	33.440	9.360	0	123.940
2031	3.100	89.500	4.140	3.300	33.980	9.520	0	123.480
2032	3.050	88.500	3.910	3.350	34.520	9.680	0	123.020
2033	3.000	87.500	3.680	3.400	35.060	9.840	0	122.560

Table 51. Evolution of home heating systems stock per year (Baseline) Rhodope

*Electric heaters include devices using electricity directly (radiant quartz heaters, radiators, etc.).

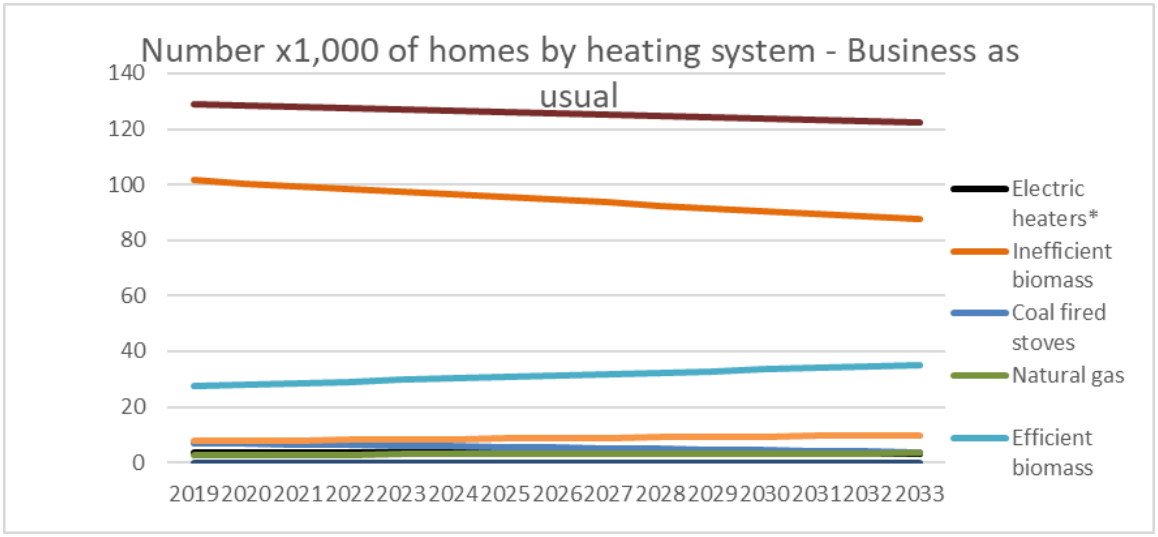

Figure 33. Evolution of home heating systems stock per year (Baseline) Rhodope

Optimistic Replace-Scenario Homes (Overachieving REPLACE target region objectives)								
	Electric heaters	Inefficient biomass	Coal fired stoves	Natural gas	Efficient biomass	Heat pumps	Biomass DH	Biomass total
Replaced/ year	-120	-1.550	-480	30	1.220	370	0	500
2019	3.700	101.500	6.900	2.700	27.500	7600	0	129.000
2020	3.580	99.950	6.420	2.730	28.720	7.970	0	128.670
2021	3.460	98.400	5.940	2.760	29.940	8.340	0	128.340
2022	3.340	96.850	5.460	2.790	31.160	8.710	0	128.010
2023	3.220	95.300	4.980	2.820	32.380	9.080	0	127.680
2024	3.100	93.750	4.500	2.850	33.600	9.450	0	127.350
2025	2.980	92.200	4.020	2.880	34.820	9.820	0	127.020
2026	2.860	90.650	3.540	2.910	36.040	10.190	0	126.690
2027	2.740	89.100	3.060	2.940	37.260	10.560	0	126.360
2028	2.620	87.550	2.580	2.970	38.480	10.930	0	126.030
2029	2.500	86.000	2.100	3.000	39.700	11.300	0	125.700
2030	2.380	84.450	1.620	3.030	40.920	11.670	0	125.370
2031	2.260	82.900	1.140	3.060	42.140	12.040	0	125.040
2032	2.140	81.350	660	3.090	43.360	12.410	0	124.710
2033	2.020	79.800	180	3.120	44.580	12.780	0	124.380

Table 52. Evolution of home heating systems stock per year (Optimistic) Rhodope

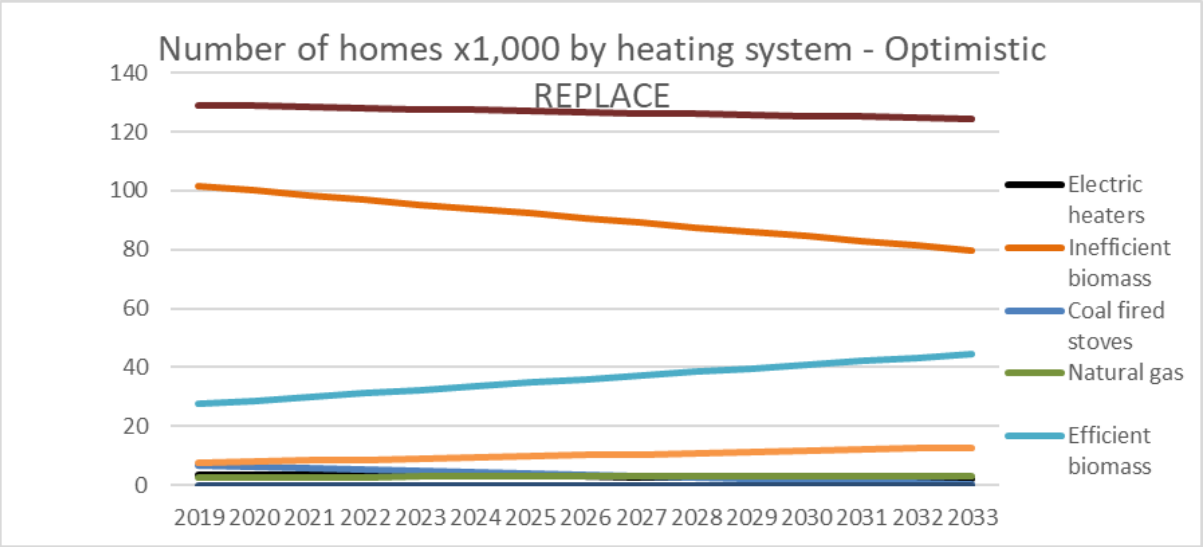

Figure 34. Evolution of home heating systems stock per year (Optimistic) Rhodope

Pessimistic Replace-Scenario Homes (Underachieving REPLACE target region objectives)								
	Electric heaters	Inefficient biomass	Coal fired stoves	Natural gas	Efficient biomass	Heat pumps	Biomass DH	Biomass total
Replaced/ year	-85	-1.275	-355	40	880	265	0	20
2019	3.700	101.500	6.900	2.700	27.500	7.600	0	129.000
2020	3.615	100.225	6.545	2.740	28.380	7.865	0	128.605
2021	3.530	98.950	6.190	2.780	29.260	8.130	0	128.210
2022	3.445	97.675	5.835	2.820	30.140	8.395	0	127.815
2023	3.360	96.400	5.480	2.860	31.020	8.660	0	127.420
2024	3.275	95.125	5.125	2.900	31.900	8.925	0	127.025
2025	3.190	93.850	4.770	2.940	32.780	9.190	0	126.630
2026	3.105	92.575	4.415	2.980	33.660	9.455	0	126.235
2027	3.020	91.300	4.060	3.020	34.540	9.720	0	125.840
2028	2.935	90.025	3.705	3.060	35.420	9.985	0	125.445
2029	2.850	88.750	3.350	3.100	36.300	10.250	0	125.050
2030	2.765	87.475	2.995	3.140	37.180	10.515	0	124.655
2031	2.680	86.200	2.640	3.180	38.060	10.780	0	124.260
2032	2.595	84.925	2.285	3.220	38.940	11.045	0	123.865
2033	2.510	83.650	1.930	3.260	39.820	11.310	0	123.470

Table 53. Evolution of home heating systems stock per year (Pessimistic) Rhodope

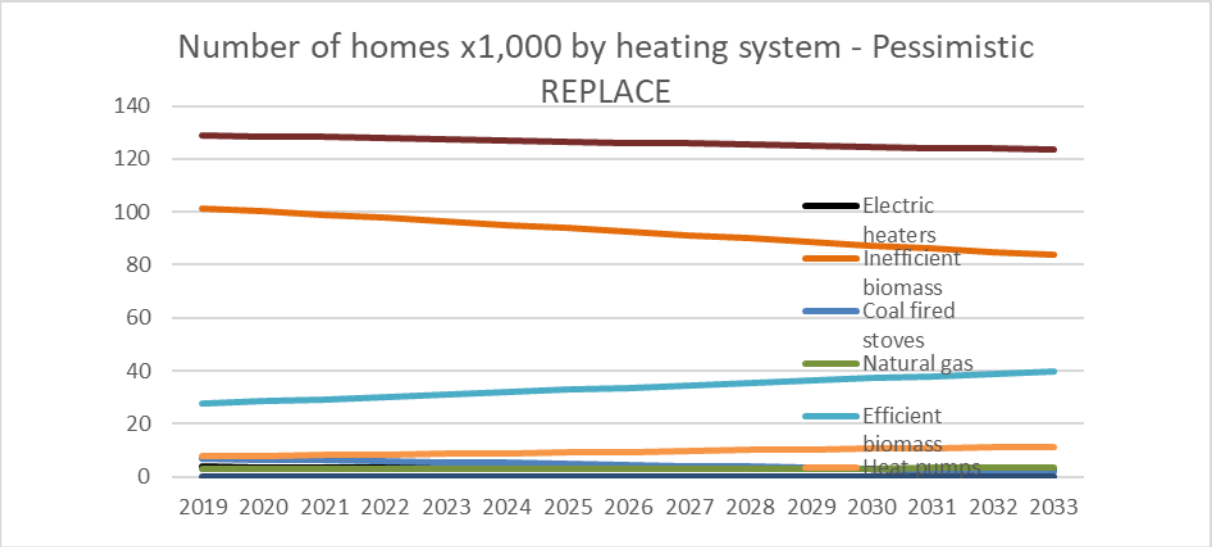

Figure 35. Evolution of home heating systems stock per year (Pessimistic) Rhodope

The main source for heating homes in the region of Rhodope is old inefficient biomass systems. Heating systems using this type of fuel are predicted to fall in the next decade. The same happens with the coal stoves and technologies that use electricity directly, such as electric radiators. Altogether, the homes relying on these three technologies would decrease annually by 1280 in the baseline scenario up to 2150 in the optimistic one. While these inefficiently heated homes are 74.8% of all homes in 2019, their share in 2033 falls to 66.1% (8.7% difference) in baseline and 57.6% (17.2% difference) in optimistic scenario.

On the other hand, the cleaner and more advanced technologies, such as efficient biomass systems and heat pumps would increase by 700 in the baseline scenario up to 1590 in the optimistic one.

Energy source	Annual average home heat consumption (kWh)
	kWh/home
Diesel oil	6.400
GLP	6.400
Natural gas	6.400
Electric heater	6.400
Heat pump	6.400
Coal	6.400
Biomass inefficient	6.400
Biomass efficient	6.400

Table 54. Annual average home heat consumption, Rhodope

coal	52%
inefficient biomass	52%
efficient biomass	82%
natural gas	85%

	Final energy savings (GWh)	
	Optimistic Replace vs Business as usual	Pessimistic Replace vs Business as usual
2019	0,0	0,0
2020	5,6	2,8
2021	11,3	5,6
2022	16,9	8,5
2023	22,6	11,3
2024	28,2	14,1
2025	33,8	16,9
2026	39,5	19,7
2027	45,1	22,6
2028	50,7	25,4
2029	56,4	28,2
2030	62,0	31,0
2031	67,7	33,8
2032	73,3	36,6
2033	78,9	39,5

Table 55. Final energy savings, Rhodope

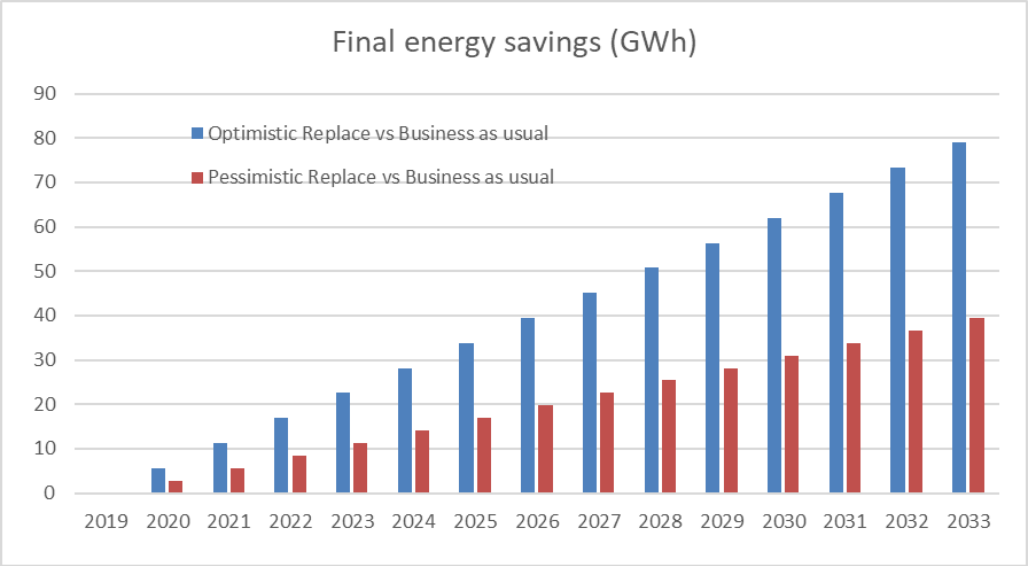

Figure 36. Final energy savings, Rhodope

	Additional emissions reduction (tCO2)	
	Opptimistic Replace vs Business as usual	Pessimistic Replace vs Business as usual
2019	0	0
2020	1.691	846
2021	3.383	1.691
2022	5.074	2.537
2023	6.765	3.383
2024	8.456	4.228
2025	10.148	5.074
2026	11.839	5.919
2027	13.530	6.765
2028	15.221	7.611
2029	16.913	8.456
2030	18.604	9.302
2031	20.295	10.148
2032	21.987	10.993
2033	23.678	11.839

Table 56. Additional emissions reduction, Rhodope

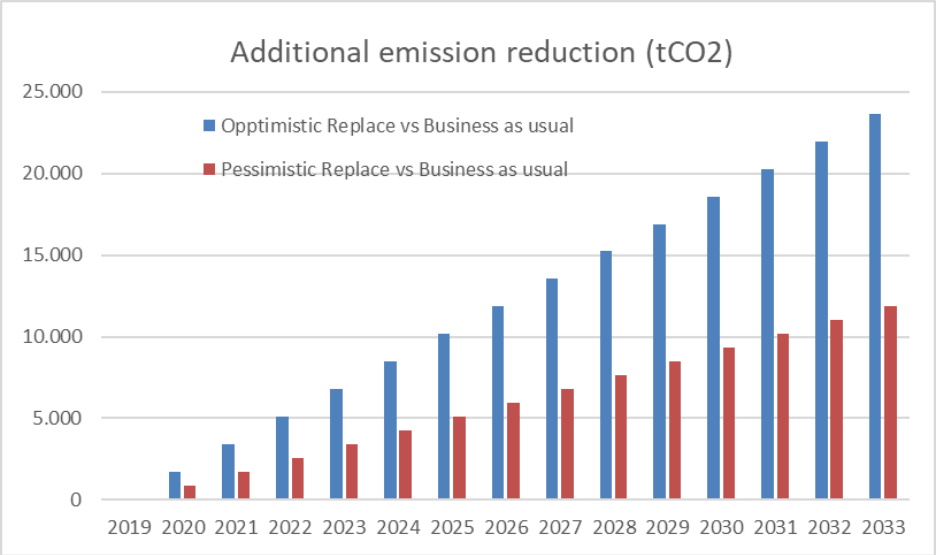

Figure 57. Additional emissions reduction, Rhodope

The final energy savings for the optimistic and pessimistic scenarios were calculated considering the number of replacements for homes, the annual average home heat consumption, and the different performance values for the old and new heating systems. By the year 2033, with the assistance of the REPLACE project, the region of Rhodope could save between 90 and 45 GWh of energy. This in turn translates to a reduction of emissions in between 17,600 and 8,800 tons of CO2 by the year 2033.

The effect of REPLACE on the rest of Bulgaria (outside the pilot region Rhodope) has also been considered, because:

- REPLACE is expected to trigger national-level policy and financial measures; as Bulgaria has relatively centralized decision-making structure, the collaboration with national institutions is crucial to achieve impact.
- REPLAC would achieve replication effect in other regions, e.g., through dissemination.

It is assumed that in the rest of the country the effect per person is 15% of the regional one.

	Final energy savings (GWh) *	
	Optimistic Replace vs Business as usual	Pessimistic Replace vs Business as usual
2019	0,0	0,0
2020	29,6	14,8
2021	59,3	29,6
2022	88,9	44,5
2023	118,5	59,3
2024	148,2	74,1
2025	177,8	88,9
2026	207,5	103,7
2027	237,1	118,5
2028	266,7	133,4
2029	296,4	148,2
2030	326,0	163,0
2031	355,6	177,8
2032	385,3	192,6
2033	414,9	207,5

Table 58. Final energy savings, whole Bulgaria

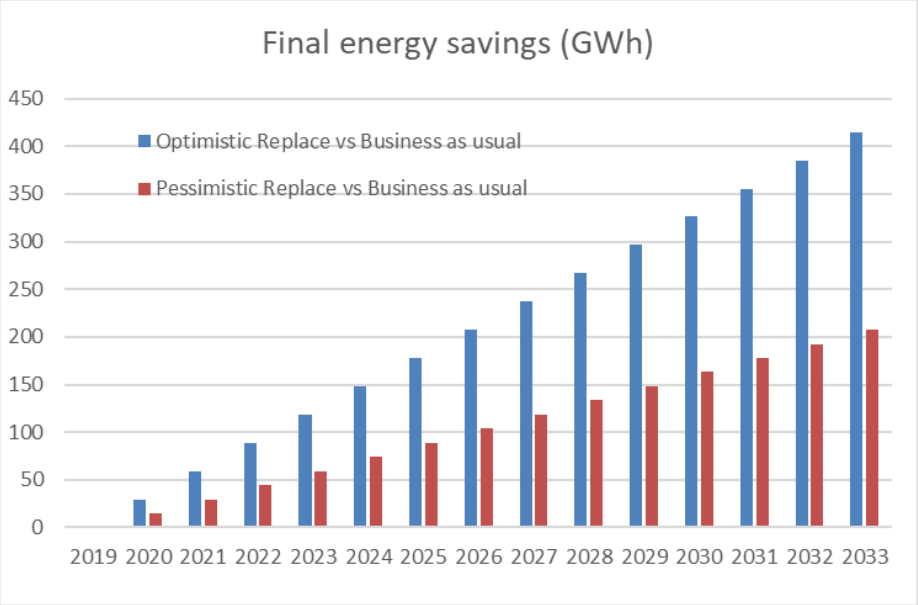

Figure 37. Final energy savings, whole Bulgaria

	Additional emissions reduction (tCO2) *	
	Opptimistic Replace vs Business as usual	Pessimistic Replace vs Business as usual
2019	0	0
2020	5.795	2.898
2021	11.591	5.795
2022	17.386	8.693
2023	23.182	11.591
2024	28.977	14.489
2025	34.773	17.386
2026	40.568	20.284
2027	46.364	23.182
2028	52.159	26.080
2029	57.954	28.977
2030	63.750	31.875
2031	69.545	34.773
2032	75.341	37.670
2033	81.136	40.568

Table 59. Additional emissions reduction, whole Bulgaria

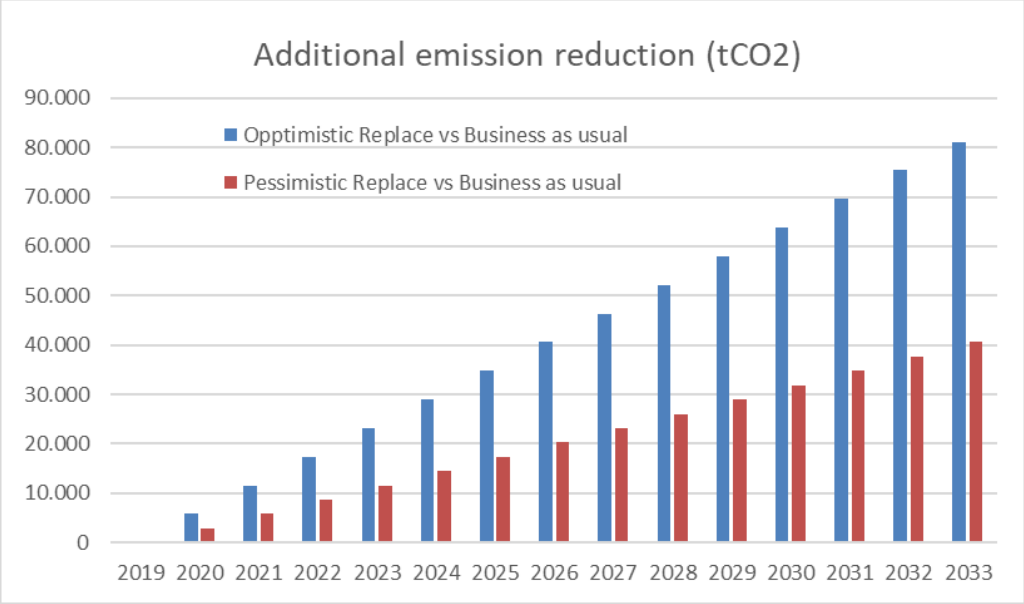

Figure 38. Additional emissions reduction, whole Bulgaria

3.2.3 Boiler evolution

	Baseline Individual Boilers (expected evolution without REPLACE)					
	number of individual boilers			**number of individual boilers**		
	Stock Electric heaters*	Stock Inefficient biomass	Stock Coal fired stoves	Stock of boilers (number, cumulated)		
				Natural gas	Efficient biomass	Heat pumps
Replaced/year	-153	-3.050	-702	38	405	416
2019	11.285	309.575	21.045	2.025	20.625	19.760
2020	11.133	306.525	20.344	2.063	21.030	20.176
2021	10.980	303.475	19.642	2.100	21.435	20.592
2022	10.828	300.425	18.941	2.138	21.840	21.008
2023	10.675	297.375	18.239	2.175	22.245	21.424
2024	10.523	294.325	17.538	2.213	22.650	21.840
2025	10.370	291.275	16.836	2.250	23.055	22.256
2026	10.218	288.225	16.135	2.288	23.460	22.672
2027	10.065	285.175	15.433	2.325	23.865	23.088
2028	9.913	282.125	14.732	2.363	24.270	23.504
2029	9.760	279.075	14.030	2.400	24.675	23.920
2030	9.608	276.025	13.329	2.438	25.080	24.336
2031	9.455	272.975	12.627	2.475	25.485	24.752
2032	9.303	269.925	11.926	2.513	25.890	25.168
2033	9.150	266.875	11.224	2.550	26.295	25.584

Table 60. Evolution of individual boilers stock per year (Baseline) Rhodope

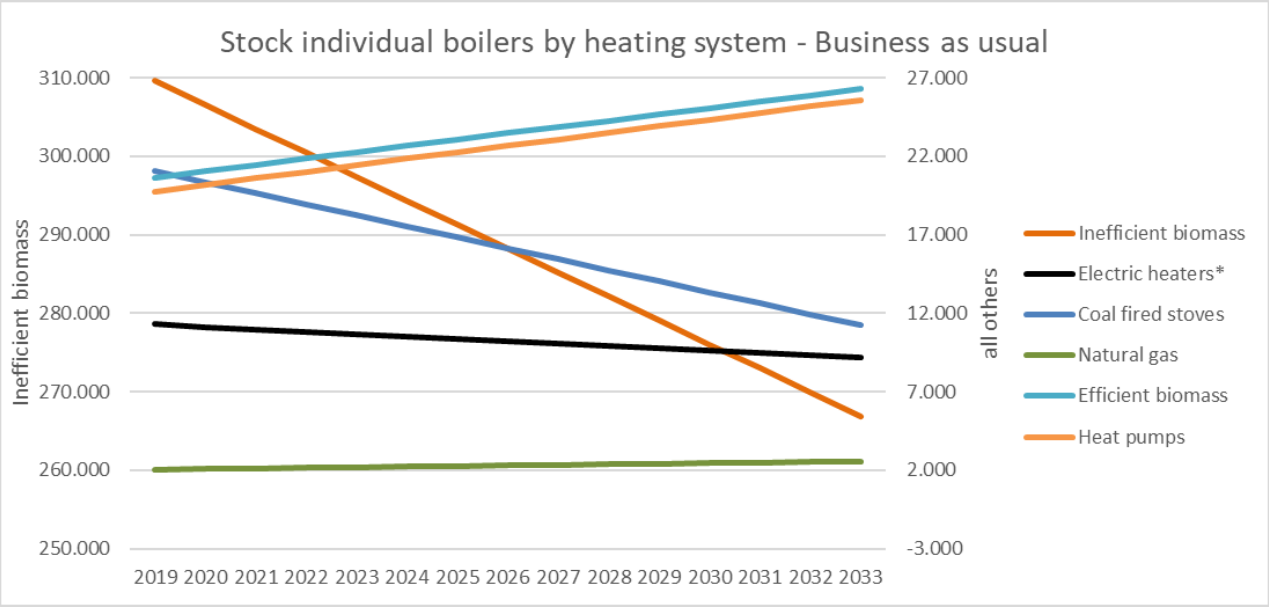

Figure 39. Evolution of individual boilers stock per year (Baseline) Rhodope

Optimistic Replace-Scenario Individual Boilers						
	number of individual boilers			number of individual boilers		
	Stock Electric heaters*	Stock Inefficient biomass	Stock Coal fired stoves	Stock of boilers (number, cumulated)		
				Natural gas	Efficient biomass	Heat pumps
Replaced/year	-366	-4.728	-1.464	38	915	962
2019	11.285	309.575	21.045	2.025	20.625	19.760
2020	10.919	304.848	19.581	2.063	21.540	20.722
2021	10.553	300.120	18.117	2.100	22.455	21.684
2022	10.187	295.393	16.653	2.138	23.370	22.646
2023	9.821	290.665	15.189	2.175	24.285	23.608
2024	9.455	285.938	13.725	2.213	25.200	24.570
2025	9.089	281.210	12.261	2.250	26.115	25.532
2026	8.723	276.483	10.797	2.288	27.030	26.494
2027	8.357	271.755	9.333	2.325	27.945	27.456
2028	7.991	267.028	7.869	2.363	28.860	28.418
2029	7.625	262.300	6.405	2.400	29.775	29.380
2030	7.259	257.573	4.941	2.438	30.690	30.342
2031	6.893	252.845	3.477	2.475	31.605	31.304
2032	6.527	248.118	2.013	2.513	32.520	32.266
2033	6.161	243.390	549	2.550	33.435	33.228

Table 61. Evolution of individual boilers stock per year (Optimistic) Rhodope

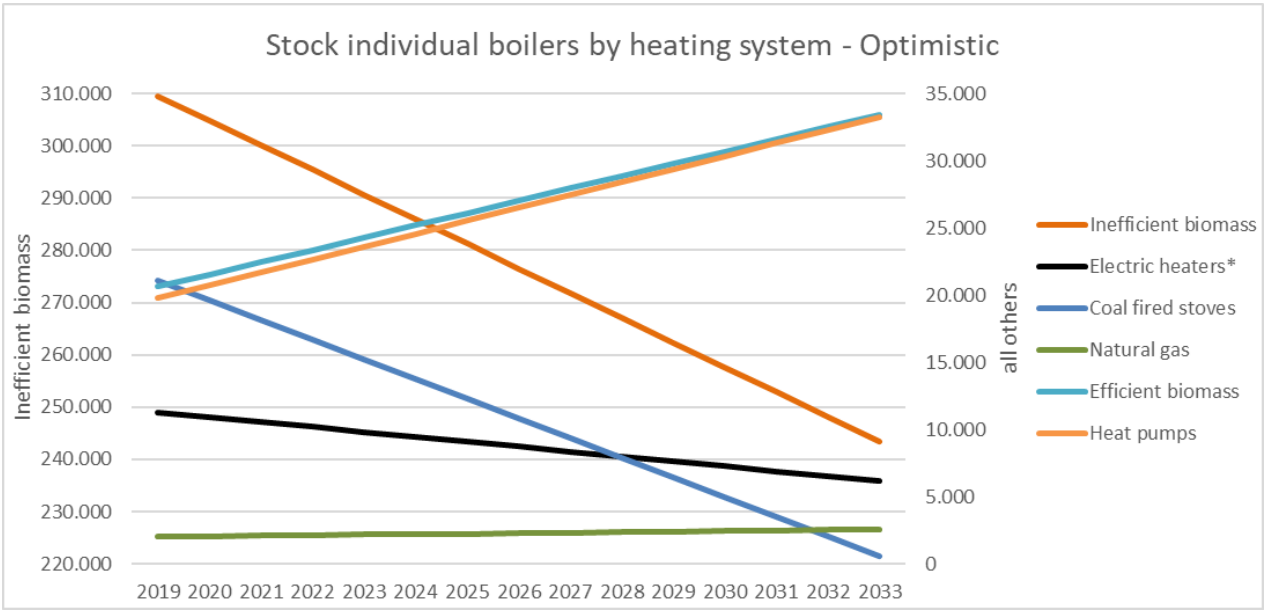

Figure 40. Evolution of individual boilers stock per year (Optimistic) Rhodope

	Pessimistic Replace-Scenario Individual Boilers					
	number of individual boilers			number of individual boilers		
	Stock Electric heaters*	Stock Inefficient biomass	Stock Coal fired stoves	Stock of boilers (number, cumulated)		
				Natural gas	Efficient biomass	Heat pumps
Replaced/year	-259	-3.889	-1.083	38	660	689
2019	11.285	309.575	21.045	2.025	20.625	19.760
2020	11.026	305.686	19.962	2.063	21.285	20.449
2021	10.767	301.798	18.880	2.100	21.945	21.138
2022	10.507	297.909	17.797	2.138	22.605	21.827
2023	10.248	294.020	16.714	2.175	23.265	22.516
2024	9.989	290.131	15.631	2.213	23.925	23.205
2025	9.730	286.243	14.549	2.250	24.585	23.894
2026	9.470	282.354	13.466	2.288	25.245	24.583
2027	9.211	278.465	12.383	2.325	25.905	25.272
2028	8.952	274.576	11.300	2.363	26.565	25.961
2029	8.693	270.688	10.218	2.400	27.225	26.650
2030	8.433	266.799	9.135	2.438	27.885	27.339
2031	8.174	262.910	8.052	2.475	28.545	28.028
2032	7.915	259.021	6.969	2.513	29.205	28.717
2033	7.656	255.133	5.887	2.550	29.865	29.406

Table 62. Evolution of individual boilers stock per year (Pessimistic) Rhodope

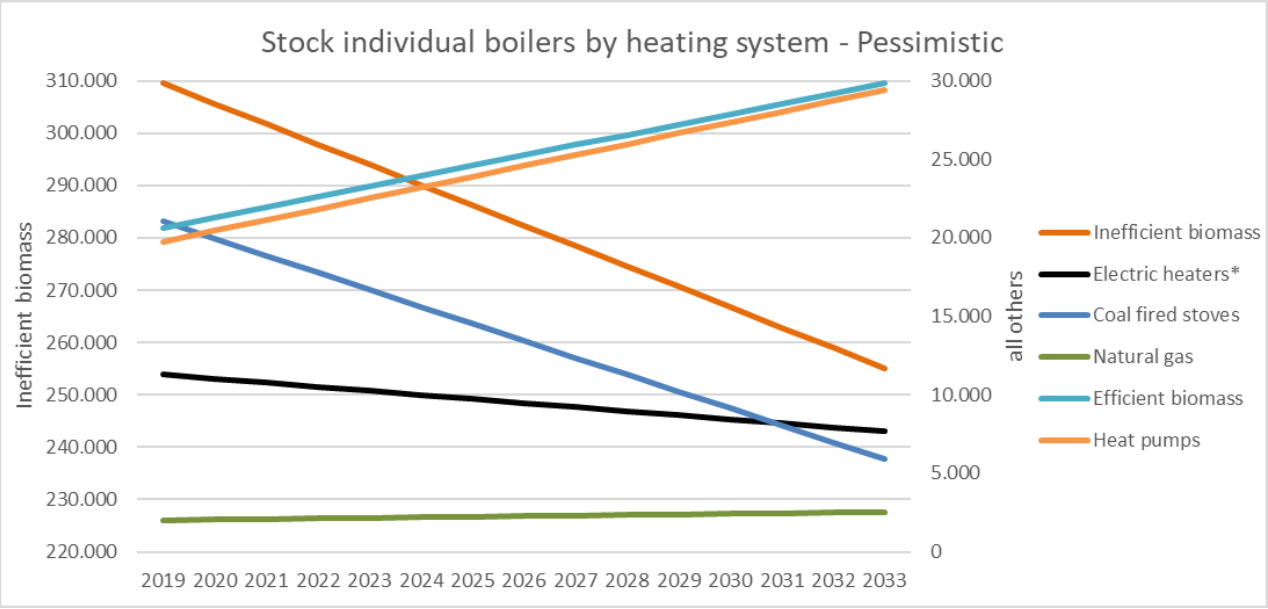

Figure 41. Evolution of individual boilers stock per year (Pessimistic) Rhodope

Baseline Colective Boilers and DH (expected evolution without REPLACE)		
number of colective boilers		
	Stock	Stock
	Natural gas	Efficient biomass
Replaced/ year	5	54
2019	270	2.750
2020	275	2.804
2021	280	2.858
2022	285	2.912
2023	290	2.966
2024	295	3.020
2025	300	3.074
2026	305	3.128
2027	310	3.182
2028	315	3.236
2029	320	3.290
2030	325	3.344
2031	330	3.398
2032	335	3.452
2033	340	3.506

Table 63. Evolution of collective boilers stock per year (Baseline) Rhodope

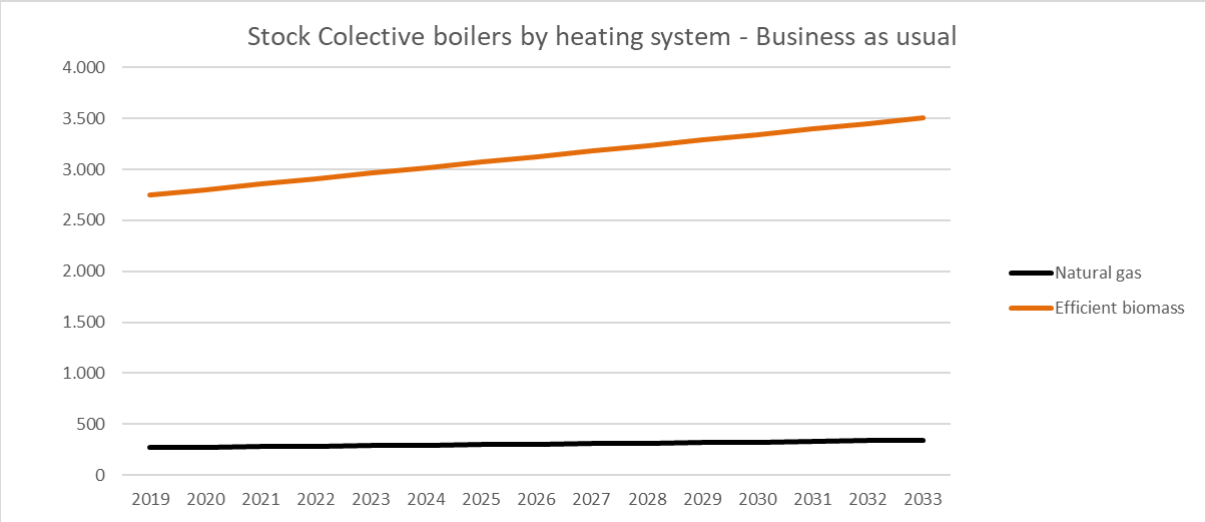

Figure 42. Evolution of collective boilers stock per year (Baseline) Rhodope

	Optimistic Replace-Scenario Colective Boilers (Overachieving REPLACE target region objectives) number of colective boilers	
	Stock	Stock
	Natural gas	Efficient biomass
Replaced/yea	3	122
2019	270	2.750
2020	273	2.872
2021	276	2.994
2022	279	3.116
2023	282	3.238
2024	285	3.360
2025	288	3.482
2026	291	3.604
2027	294	3.726
2028	297	3.848
2029	300	3.970
2030	303	4.092
2031	306	4.214
2032	309	4.336
2033	312	4.458

Table 64. Evolution of collective boilers stock per year (Optimistic) Rhodope

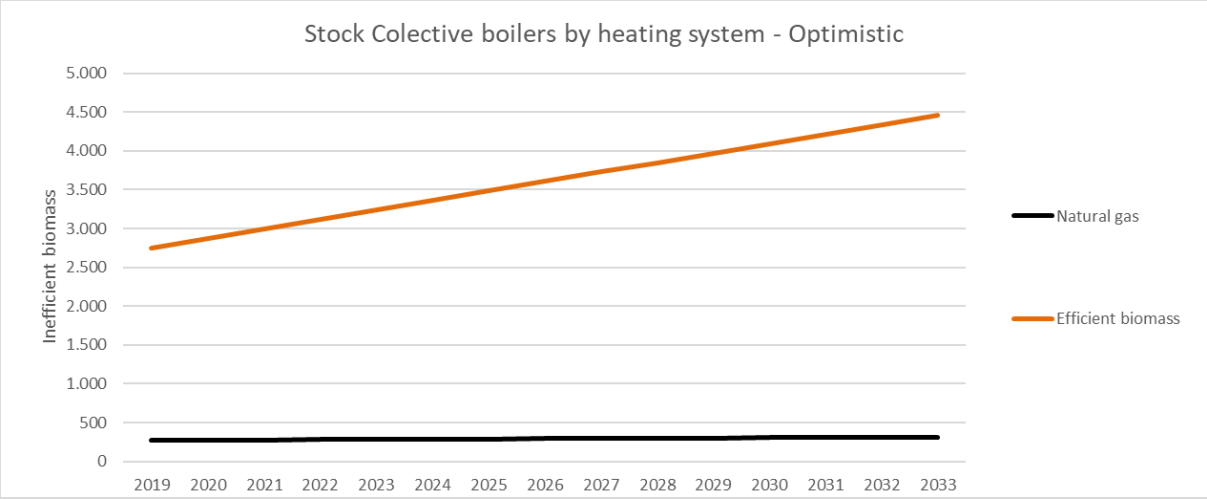

Figure 43. Evolution of collective boilers stock per year (Optimistic) Rhodope

	Pessimistic Replace-Scenario Colective Boilers (Underachieving REPLACE target region objectives)	
	number of colective boilers	
	Stock	Stock
	Natural gas	Efficient biomass
Replaced/year	4	88
2019	270	2.750
2020	274	2.838
2021	278	2.926
2022	282	3.014
2023	286	3.102
2024	290	3.190
2025	294	3.278
2026	298	3.366
2027	302	3.454
2028	306	3.542
2029	310	3.630
2030	314	3.718
2031	318	3.806
2032	322	3.894
2033	326	3.982

Table 65. Evolution of collective boilers stock per year (Pessimistic)Rhodope

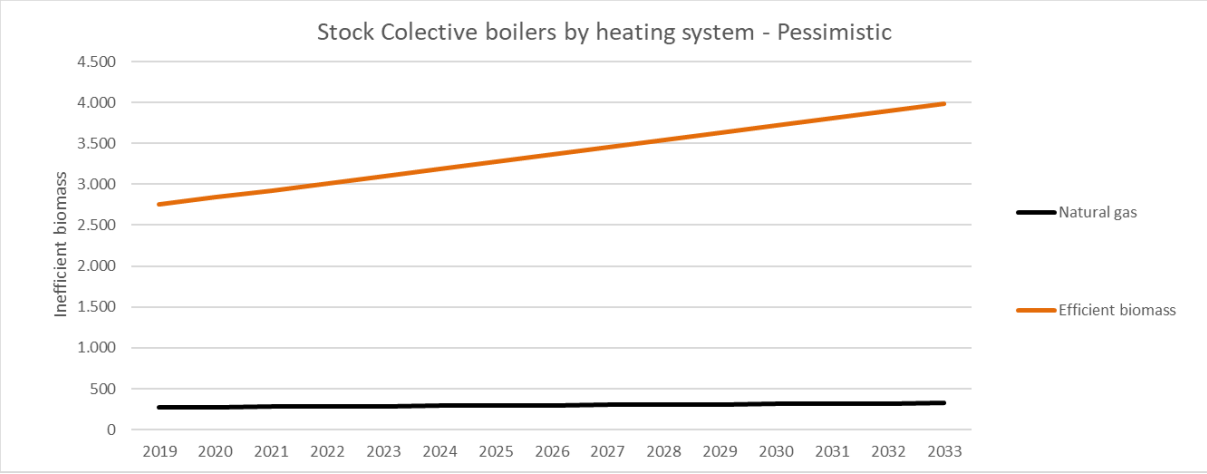

Figure 44. Evolution of collective boilers stock per year (Optimistic) Rhodope

For individual boilers we can see a similar scenario to the home evolution situation. Mainly, inefficient biomass boilers and old coal boilers are being replaced by efficient biomass ones, followed by heat pumps and very few natural gas boilers.

There are not district heating systems in the region but all the big size boilers for several homes are fuelled by biomass, followed by natural gas.

3.2.4 Investments/Economics

	Average boiler power	Price (€/kW) only boiler	Price (€/kW) biomass turnkey system
Individual boilers (P<50kW)	35	190	290
Colective boilers (P>50kW)	87	145	225
Heat pumps (individual)	1	650	650

Table 66. Average boiler prices, Rhodope

	Number of boilers increased by REPLACE		Annual REPLACE (€) investment only in boilers		Annual REPLACE (€) turnkey project investment	
	Optimist	Pessimist	Optimist	Pessimist	Optimist	Pessimist
Individual boilers (P<50kW)	510	255	3.391.500	1.695.750	5.176.500	2.588.250
Colective boilers (P>50kW)	68	34	857.820	428.910	1.331.100	665.550
Heat pumps (individual)	546	273	354.900	177.450	354.900	177.450
Total investment Mio€			4,6	2,3	6,9	3,4

Table 67. Annual Replace investment triggered, Rhodope

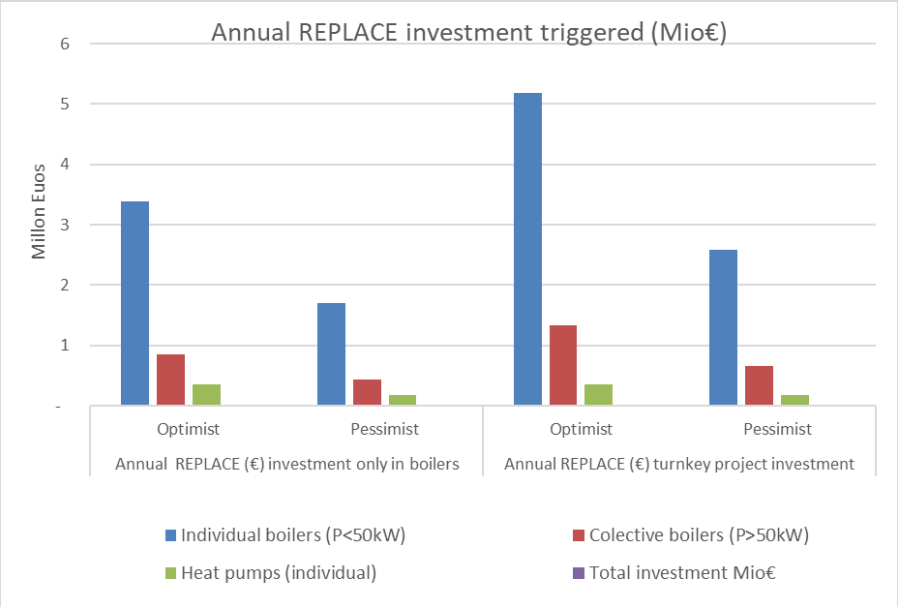

Figure 45. Annual Replace investment triggered, Rhodope

The average power for individual boilers in the region of Rhodope is 35 kW and depending on if it includes a turnkey system, the price per kW of power can reach up to 290 Euros.

The average power for collective boilers is 87 kW. The price for the turnkey systems can reach up to 225 Euros per kW installed.

The average power for heat pumps is 1 kW. The price for the turnkey systems can reach up to 650 Euros per kW installed.

The numbers for the whole Bulgaria, including both Rhodope region and the rest of the country are presented below.

	Average boiler power	Price (€/kW) only boiler	Price (€/kW) biomass turnkey system
Individual boilers (P<50kW)	35	190	290
Colective boilers (P>50kW)	87	145	225
Heat pumps (individual)	1	650	650

Table 68. Average boiler prices, whole Bulgaria

	Number of boilers increased by REPLACE *		Annual REPLACE (€) investment only in boilers		Annual REPLACE (€) turnkey project investment	
	Optimist	Pessimist	Optimist	Pessimist	Optimist	Pessimist
Individual boilers (P<50kW)	2.346	1.173	15.600.900	7.800.450	23.811.900	11.905.950
Colective boilers (P>50kW)	313	156	3.945.972	1.972.986	6.123.060	3.061.530
Heat pumps (individual)	2.512	1.256	1.632.540	816.270	1.632.540	816.270
Total investment Mio€			21,2	10,6	31,6	15,8

Table 69. Annual Replace investment triggered, whole Bulgaria

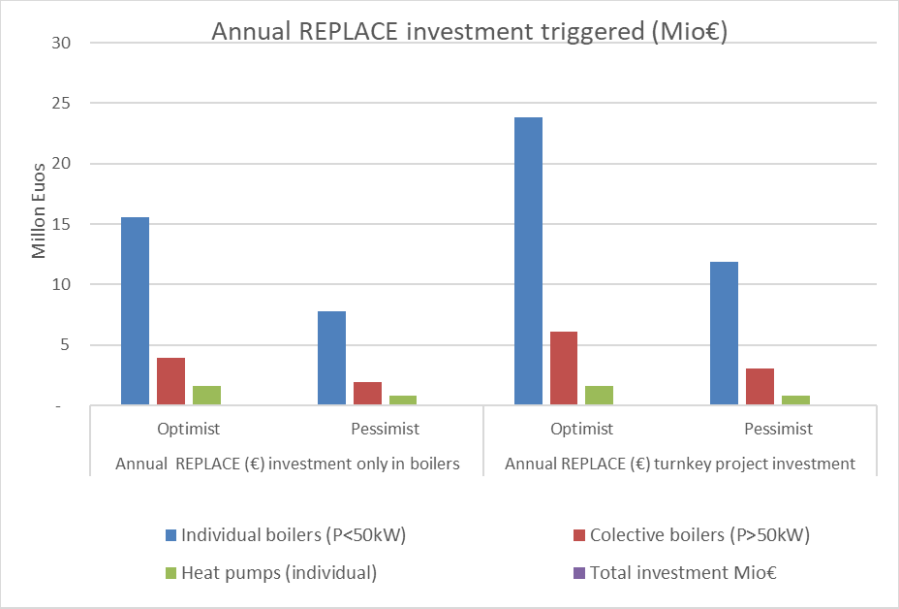

Figure 46. Annual Replace investment triggered, whole Bulgaria

3.2.5 Main conclusions

Two main conclusions can be drawn:

1. **Importance of securing the long-term impact**. As mentioned above, while the inefficiently heated homes in Rhodope region are 74.8% of all homes in 2019, their share in 2033 is projected to fall to 66.1% (8.7% difference) in baseline and 57.6% (17.2% difference) in optimistic scenario. The doubling of the replacement rate in the optimistic compared to baseline scenario until 2033, is a very ambitious target that requires long-term measures from REPLACE to sustain the high replacement rate. It is important, therefore, to make sure that public authorities and market players would continue the large-scale promotion of advanced heating and cooling beyond the project.

2. **Country-wide measures are key to achieve high impact.** Despite the ambitious targets set for Rhodope region in the optimistic scenario, the impact is relatively low, due to the limited population in the region. The impact, in terms of energy and emission savings, investments, etc., is 4.6 times higher in Bulgaria as a whole compared to Rhodope region, despite the assumption that the impact per person outside Rhodope would be only 15% of the one in Rhodope. To maximize the impact of REPLACE, therefore, efforts should be put on the introduction of information campaign, regulations, and incentives at national level, as well on the replication of the Rhodope campaign in other regions.

3.3 Croatia – Primorsko-Goranska County

3.3.1 Methodology and information sources

Data sources are:

1. Census 2011 used for the data on the number of households (https://www.dzs.hr/eng/censuses/census2011/results/censustabsxls.htm)
2. Data obtained by EIHP that have been collected for the purpose of other project on heating systems. This data originated from 2011.

Data from this sources have been adjusted to current numbers in line with EIHP research and inputs from LWG members.

3.3.2 Home evolution

	Baseline Homes Heating (expected evolution without REPLACE)								
	Old Diesel	Old other boiler	Natural gas	Solid biomass	DH	Heat pumps	Electric heating	Solar heating	Biomass total
Replaced/ year		-500	100	1.500	100	1	50	15	
2019		11.776	7.945	50.744	8.638	3	33.741	76	50.744
2020	0	11.276	8.045	52.244	8.738	4	33.791	91	52.244
2021	0	10.776	8.145	53.744	8.838	5	33.841	106	53.744
2022	0	10.276	8.245	55.244	8.938	6	33.891	121	55.244
2023	0	9.776	8.345	56.744	9.038	7	33.941	136	56.744
2024	0	9.276	8.445	58.244	9.138	8	33.991	151	58.244
2025	0	8.776	8.545	59.744	9.238	9	34.041	166	59.744
2026	0	8.276	8.645	61.244	9.338	10	34.091	181	61.244
2027	0	7.776	8.745	62.744	9.438	11	34.141	196	62.744
2028	0	7.276	8.845	64.244	9.538	12	34.191	211	64.244
2029	0	6.776	8.945	65.744	9.638	13	34.241	226	65.744
2030	0	6.276	9.045	67.244	9.738	14	34.291	241	67.244
2031	0	5.776	9.145	68.744	9.838	15	34.341	256	68.744
2032	0	5.276	9.245	70.244	9.938	16	34.391	271	70.244
2033	0	4.776	9.345	71.744	10.038	17	34.441	286	71.744

Table 70. Evolution of home heating systems stock per year (Baseline) Primorsko-Goranska County

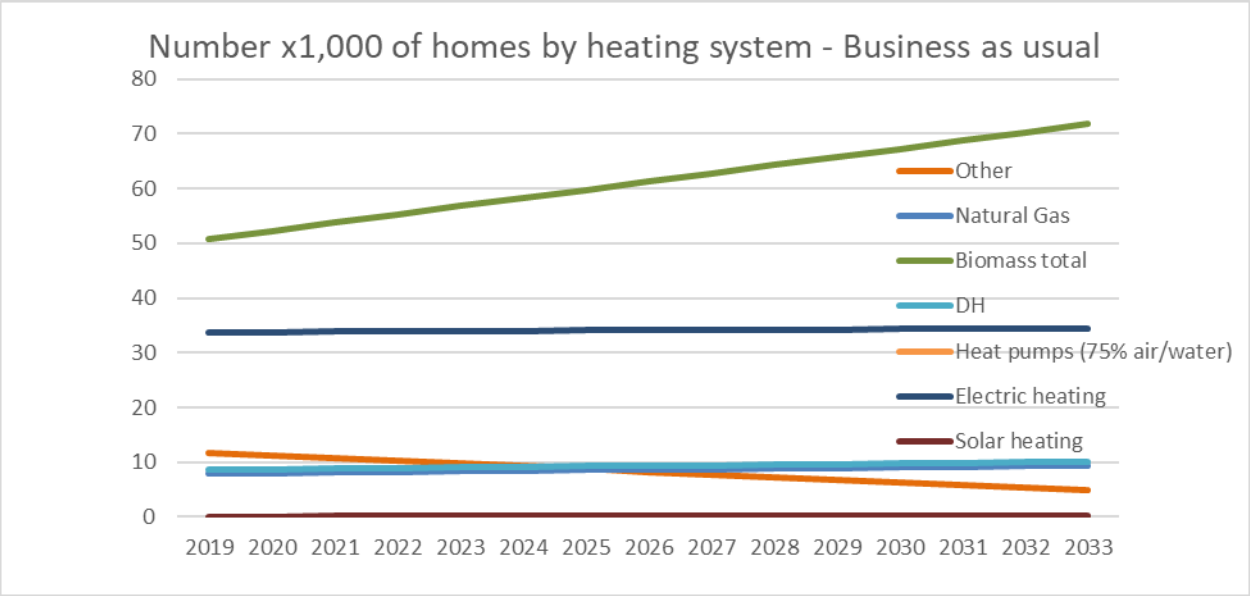

Figure 47. Evolution of home heating systems stock per year (Baseline) Primorsko-Goranska County

Optimistic Replace-Scenario Homes (Overachieving REPLACE target region objectives)

	Old Diesel	Old other boiler	Natural gas	Solid biomass	DH	Heat pumps	Electric heatin	Solar heating	Biomass total
Replaced/ year		-800	300	2.000	200	20	100	20	
2019		11.776	7.945	50.744	8.638	3	33741	76	50.744
2020	0	10.976	8.245	52.744	8.838	23	33.841	96	52.744
2021	0	10.176	8.545	54.744	9.038	43	33.891	111	54.744
2022	0	9.376	8.845	56.744	9.238	63	33.941	126	56.744
2023	0	8.576	9.145	58.744	9.438	83	33.991	141	58.744
2024	0	7.776	9.445	60.744	9.638	103	34.041	156	60.744
2025	0	6.976	9.745	62.744	9.838	123	34.091	171	62.744
2026	0	6.176	10.045	64.744	10.038	143	34.141	186	64.744
2027	0	5.376	10.345	66.744	10.238	163	34.191	201	66.744
2028	0	4.576	10.645	68.744	10.438	183	34.241	216	68.744
2029	0	3.776	10.945	70.744	10.638	203	34.291	231	70.744
2030	0	2.976	11.245	72.744	10.838	223	34.341	246	72.744
2031	0	2.176	11.545	74.744	11.038	243	34.391	261	74.744
2032	0	1.376	11.845	76.744	11.238	263	34.441	276	76.744
2033	0	576	12.145	78.744	11.438	283	34.491	291	78.744

Table 71. Evolution of home heating systems stock per year (Optimistic) Primorsko-Goranska County

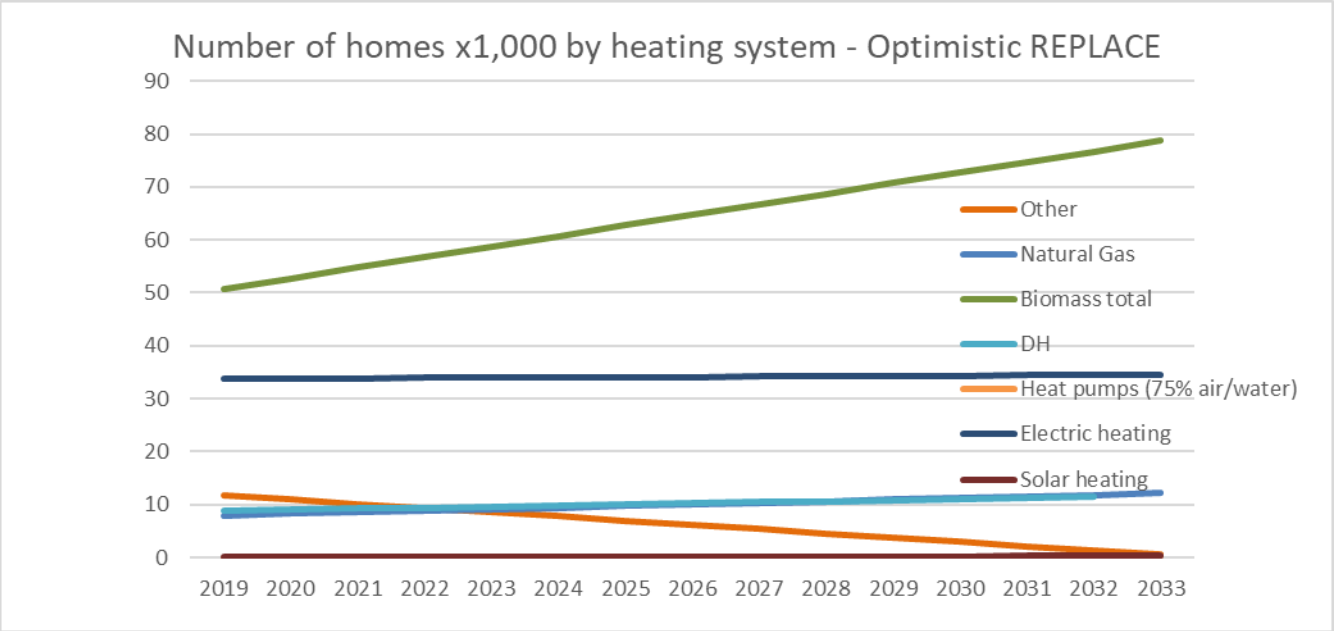

Figure 48. Evolution of home heating systems stock per year (Optimistic) Primorsko-Goranska County

Pessimistic Replace-Scenario Homes (Underachieving REPLACE target region objectives)

	Old Diesel	Old other boiler	Natural gas	Solid biomass	DH	Heat pumps	Electric heating	Solar heating	Biomass total
Replaced/ year		-550	150	1.700	50	10	70	15	
2019		11.776	7.945	50.744	8.638	3	33.741	76	50.744
2020	0	11.226	8.095	52.444	8.688	13	33.811	96	52.444
2021	0	10.676	8.245	54.144	8.738	23	33.861	111	54.144
2022	0	10.126	8.395	55.844	8.788	33	33.911	126	55.844
2023	0	9.576	8.545	57.544	8.838	43	33.961	141	57.544
2024	0	9.026	8.695	59.244	8.888	53	34.011	156	59.244
2025	0	8.476	8.845	60.944	8.938	63	34.061	171	60.944
2026	0	7.926	8.995	62.644	8.988	73	34.111	186	62.644
2027	0	7.376	9.145	64.344	9.038	83	34.161	201	64.344
2028	0	6.826	9.295	66.044	9.088	93	34.211	216	66.044
2029	0	6.276	9.445	67.744	9.138	103	34.261	231	67.744
2030	0	5.726	9.595	69.444	9.188	113	34.311	246	69.444
2031	0	5.176	9.745	71.144	9.238	123	34.361	261	71.144
2032	0	4.626	9.895	72.844	9.288	133	34.411	276	72.844
2033	0	4.076	10.045	74.544	9.338	143	34.461	291	74.544

Table 72. Evolution of home heating systems stock per year (Pessimistic) Primor-Goranska Countysko

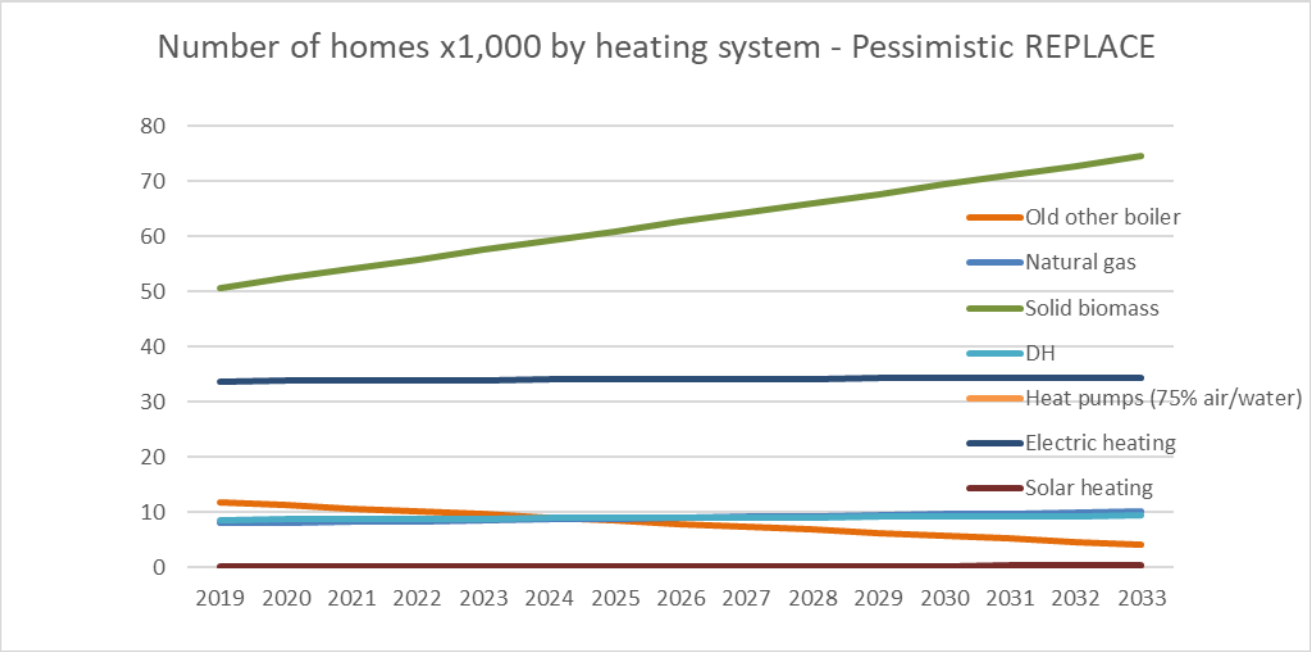

Figure 49. Evolution of home heating systems stock per year (Pessimistic) Primorsko-Goranska County

The main source for heating homes in the region of Primorsko-Goranska County is biomass. Heating systems using this type of fuel are predicted to continue rising in the next decade. It is observed that the opposite happens with the other old inefficient heating systems, which is the main fuel objective to be replaced by the project in the pilot region. The project estimates between 550 and 800 of the region's homes heated with this fuel being replaced by biomass, followed by natural gas. The inventory estimates that around 2,000 biomass heating installations will be installed for homes in this region every year in the best scenario, and around 1,700 in the worst one.

Energy source	Annual average home heat consumption (kWh)
	kWh/home
Diesel oil	
GLP	63,159
Natural gas	170,864
Electricity	294,508
Biomass	6.272,126

Table 73. Annual average home heat consumption, Primosko

Old boiler performan	70%	
New biomass boiler p	80%	
Final energy savings (GWh)		
	Opptimistic Replace vs Business as usual	Pessimistic Replace vs Business as usual
2019	0,0	0,0
2020	0,6	0,2
2021	1,1	0,4
2022	1,7	0,7
2023	2,2	0,9
2024	2,8	1,1
2025	3,4	1,3
2026	3,9	1,6
2027	4,5	1,8
2028	5,0	2,0
2029	5,6	2,2
2030	6,2	2,5
2031	6,7	2,7
2032	7,3	2,9
2033	7,8	3,1

Table 74. Final energy savings, Primorsko-Goranska County

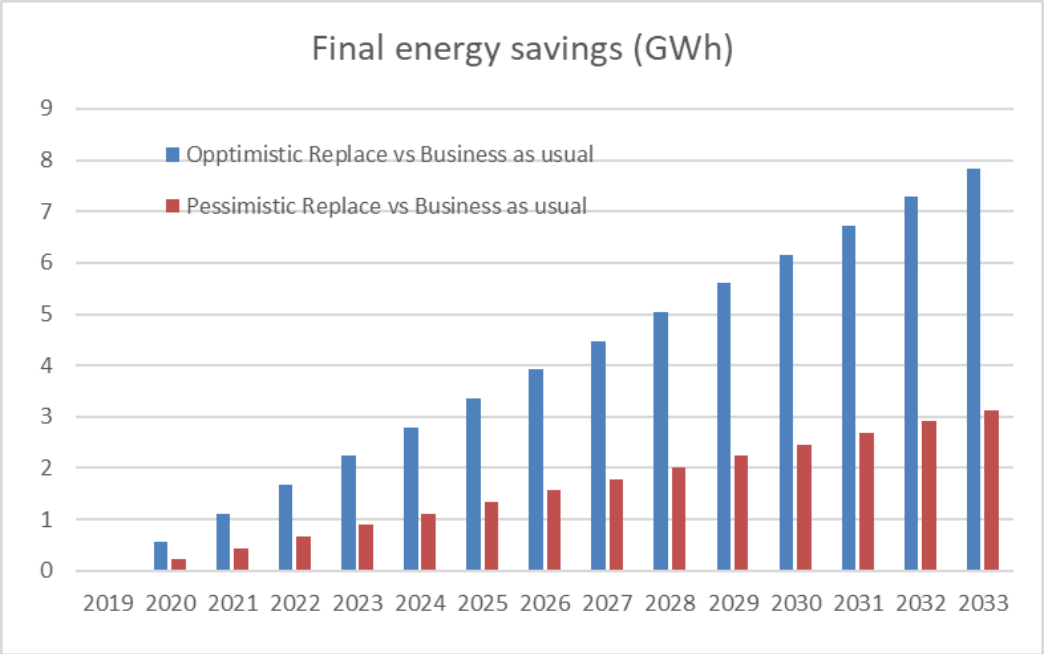

Figure 50. Final energy savings, Primorsko-Goranska County

	Additional emissions reduction (tCO2)	
	Opptimistic Replace vs Business as usual	Pessimistic Replace vs Business as usual
2019	0	0
2020	168	67
2021	336	134
2022	504	202
2023	672	269
2024	840	336
2025	1.008	403
2026	1.176	470
2027	1.344	538
2028	1.512	605
2029	1.680	672
2030	1.848	739
2031	2.016	806
2032	2.184	874
2033	2.352	941

Table 75. Additional emissions reduction, Primorsko-Goranska County

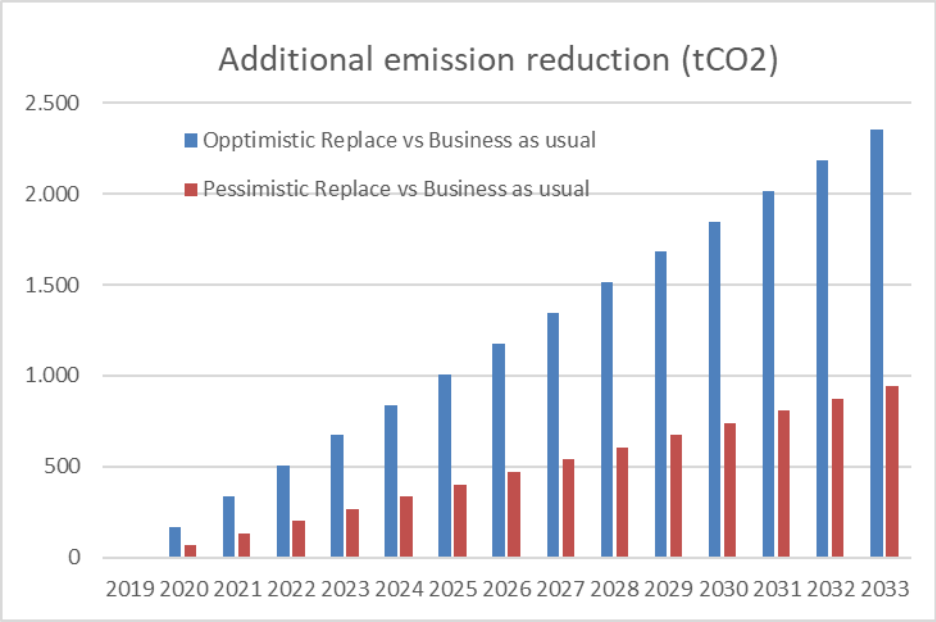

Figure 51. Additional emissions reduction, Primorsko-Goranska County

The final energy savings for the optimistic and pessimistic scenarios were calculated considering the number of replacements for homes, the annual average home heat consumption, and the different performance values for the old and new heating systems. By the year 2033, with the assistance of the replace project, the region of Primorsko-Goranska County could save between 20 and 35 GWh of energy. This in turn translates to a reduction of emissions in between 6,000 and 10,000 tons of CO2 by the year 2033.

3.3.3 Boiler evolution

	Baseline Individual Boilers (expected evolution without REPLACE)						
	number of individual boilers		number of individual boilers				
	Stock	Stock	Stock of boilers (number, cumulated)				
	Old Diesel	Old other boiler	Natural gas	Solid biomass	Electric heating	Heat pumps	Solar heating
Replaced/ year		-20	30	100	50	1	10
2019		439	1.441	43.036	30.026	3	20
2020	0	419	1.471	43.136	30.076	4	30
2021	0	399	1.501	43.236	30.126	5	40
2022	0	379	1.531	43.336	30.176	6	50
2023	0	359	1.561	43.436	30.226	7	60
2024	0	339	1.591	43.536	30.276	8	70
2025	0	319	1.621	43.636	30.326	9	80
2026	0	299	1.651	43.736	30.376	10	90
2027	0	279	1.681	43.836	30.426	11	100
2028	0	259	1.711	43.936	30.476	12	110
2029	0	239	1.741	44.036	30.526	13	120
2030	0	219	1.771	44.136	30.576	14	130
2031	0	199	1.801	44.236	30.626	15	140
2032	0	179	1.831	44.336	30.676	16	150
2033	0	159	1.861	44.436	30.726	17	160

Table 76. Evolution of individual boilers stock per year (Baseline) Primorsko-Goranska County

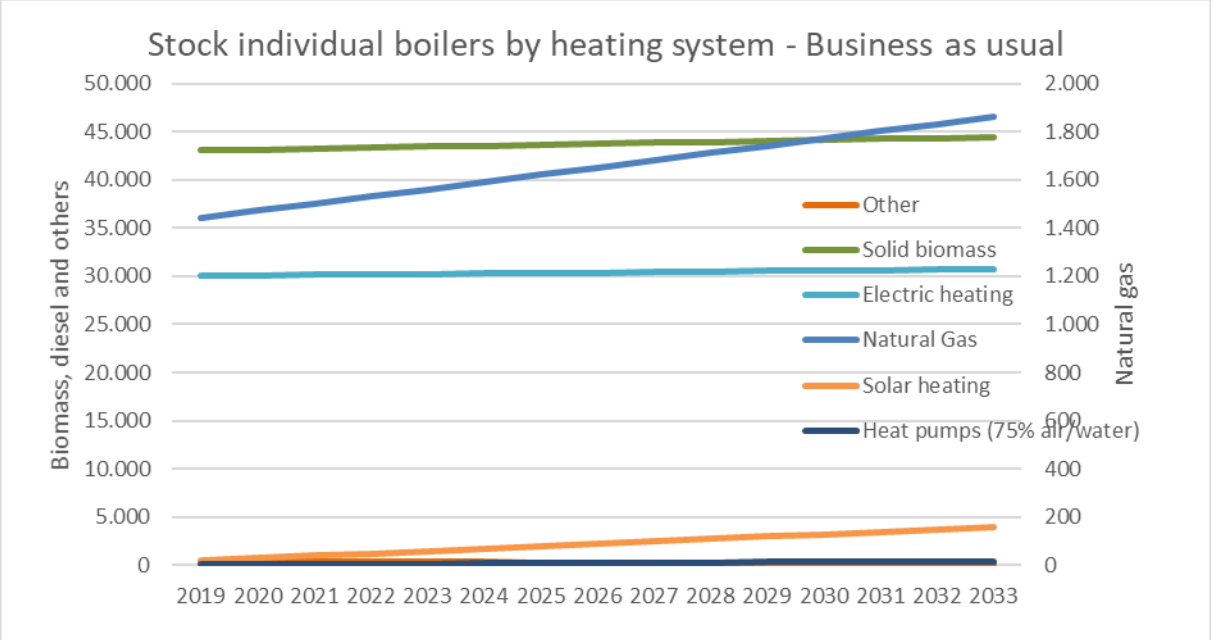

Figure 52. Evolution of individual boilers stock per year (Baseline) Primorsko-Goranska County

	Optimistic Replace-Scenario Individual Boilers						
	number of individual boilers		number of individual boilers				
	Stock	Stock	Stock of boilers (number, cumulated)				
	Old Diesel	Old other boiler	Natural gas	Solid biomass	Electric heating	Heat pumps	Solar heating
Replaced/ year		-50	50	300	100	20	50
2019		439	1.441	43.036	30.026	3	20
2020	0	419	1.471	43.336	30.076	23	70
2021	0	399	1.501	43.636	30.126	43	120
2022	0	349	1.551	43.936	30.226	63	170
2023	0	299	1.601	44.236	30.326	83	220
2024	0	249	1.651	44.536	30.426	103	270
2025	0	199	1.701	44.836	30.526	123	320
2026	0	149	1.751	45.136	30.626	143	370
2027	0	99	1.801	45.436	30.726	163	420
2028	0	49	1.851	45.736	30.826	183	470
2029	0	-1	1.901	46.036	30.926	203	520
2030	0	-51	1.951	46.336	31.026	223	570
2031	0	-101	2.001	46.636	31.126	243	620
2032	0	-151	2.051	46.936	31.226	263	670
2033	0	-201	2.101	47.236	31.326	283	720

Table 77. Evolution of individual boilers stock per year (Optimistic) Primorsko-Goranska County

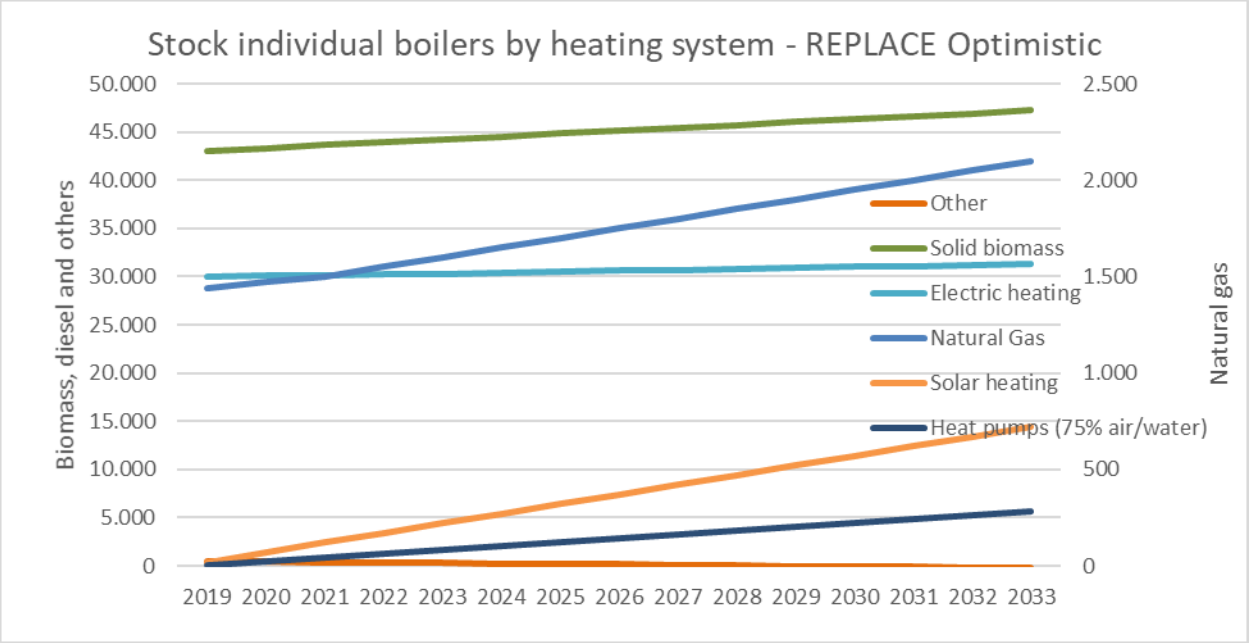

Figure 53. Evolution of individual boilers stock per year (Optimistic) Primorsko-Goranska County

	Pessimistic Replace-Scenario Individual Boilers						
	number of individual boilers		number of individual boilers				
	Stock	Stock	Stock of boilers (number, cumulated)				
	Old Diesel	Old other boiler	Natural gas	Solid biomass	Electric heating	Heat pumps	Solar heating
Replaced/ year		-30	35	200	65	10	15
2019		439	1.441	43.036	30.026	3	20
2020	0	409	1.476	43.236	30.091	13	35
2021	0	379	1.511	43.436	30.156	23	50
2022	0	349	1.546	43.636	30.221	33	65
2023	0	319	1.581	43.836	30.286	43	80
2024	0	289	1.616	44.036	30.351	53	95
2025	0	259	1.651	44.236	30.416	63	110
2026	0	229	1.686	44.436	30.481	73	125
2027	0	199	1.721	44.636	30.546	83	140
2028	0	169	1.756	44.836	30.611	93	155
2029	0	139	1.791	45.036	30.676	103	170
2030	0	109	1.826	45.236	30.741	113	185
2031	0	79	1.861	45.436	30.806	123	200
2032	0	49	1.896	45.636	30.871	133	215
2033	0	19	1.931	45.836	30.936	143	230

Table 78. Evolution of individual boilers stock per year (Pessimistic) Primorsko-Goranska County

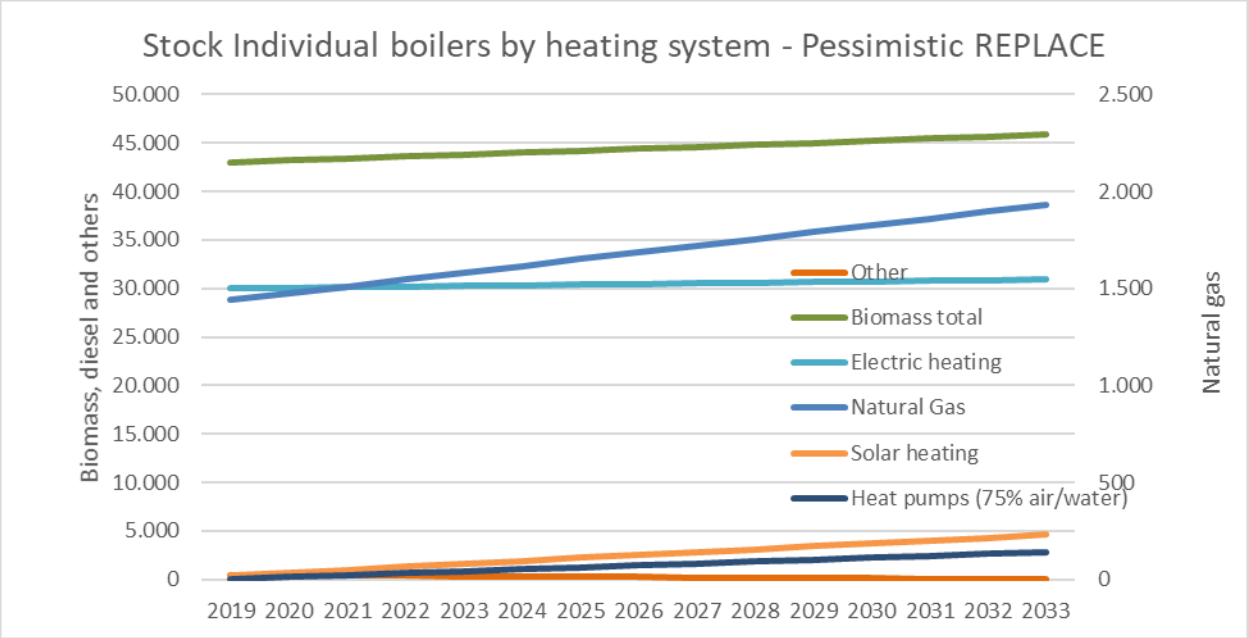

Figure 54. Evolution of individual boilers stock per year (Pessimistic) Primorsko-Goranska County

Baseline Colectivel Boilers and DH (expected evolution without REPLACE)							
	number of colective boilers		number of colective boilers				
	Old Diesel	Old other boiler	Natural gas	Solid biomass	Electric heating	Solar heating	Biomass total
Replaced/		-100	50	50	30	15	
2019		11.337	6.504	7.708	3.715	56	11.423
2020	0	11.237	6.554	7.758	3.745	71	11.423
2021	0	11.137	6.604	7.808	3.775	86	11.423
2022	0	11.037	6.654	7.858	3.805	101	11.423
2023	0	10.937	6.704	7.908	3.835	116	11.423
2024	0	10.837	6.754	7.958	3.865	131	11.423
2025	0	10.737	6.804	8.008	3.895	146	11.423
2026	0	10.637	6.854	8.058	3.925	161	11.423
2027	0	10.537	6.904	8.108	3.955	176	11.423
2028	0	10.437	6.954	8.158	3.985	191	11.423
2029	0	10.337	7.004	8.208	4.015	206	11.423
2030	0	10.237	7.054	8.258	4.045	221	11.423
2031	0	10.137	7.104	8.308	4.075	236	11.423
2032	0	10.037	7.154	8.358	4.105	251	11.423
2033	0	9.937	7.204	8.408	4.135	266	11.423

Table 79. Evolution of collective boilers stock per year (Baseline) Primorsko-Goranska County

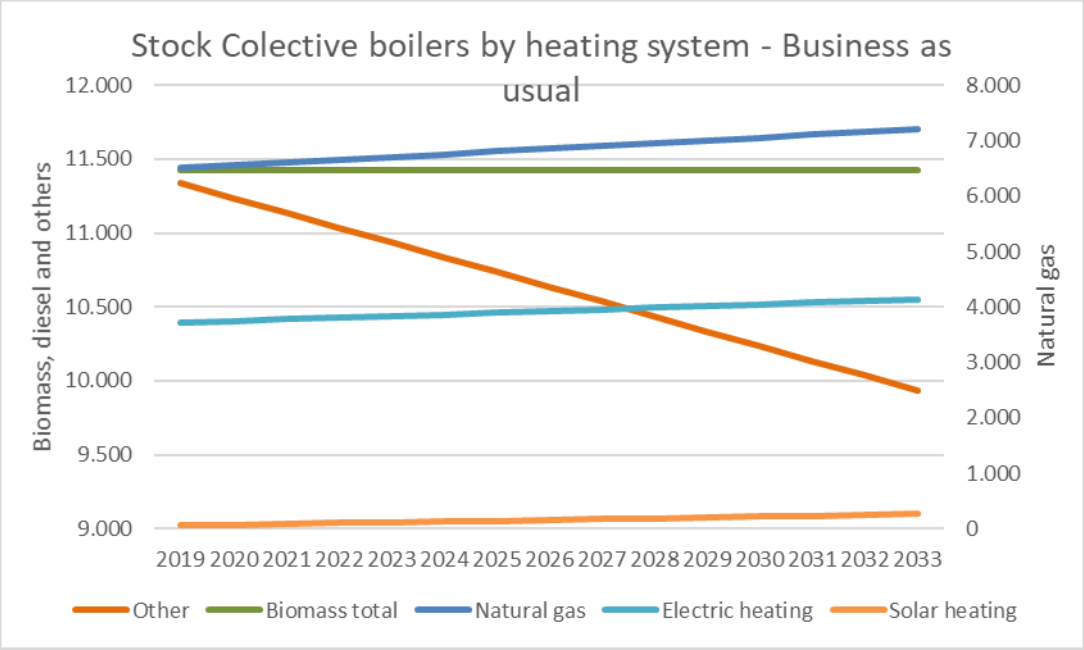

Figure 55. Evolution of collective boilers stock per year (Baseline) Primorsko-Goranska County

	Optimistic Replace-Scenario Colective Boilers (Overachieving REPLACE target region objectives)						
	number of colective boilers	number of colective boilers					
	Old Diesel	Old other boiler	Natural gas	Solid biomass	Electric heating	Solar heating	Biomass total
Replaced/ year		-150	80	70	50	25	
2019		11.337	6.504	7.708	3.715	56	7.708
2020	0	11.237	6.554	7.778	3.765	81	7.778
2021	0	11.087	6.604	7.848	3.795	96	7.848
2022	0	10.937	6.684	7.918	3.825	111	7.918
2023	0	10.787	6.764	7.988	3.855	126	7.988
2024	0	10.637	6.844	8.058	3.885	141	8.058
2025	0	10.487	6.924	8.128	3.915	156	8.128
2026	0	10.337	7.004	8.198	3.945	171	8.198
2027	0	10.187	7.084	8.268	3.975	186	8.268
2028	0	10.037	7.164	8.338	4.005	201	8.338
2029	0	9.887	7.244	8.408	4.035	216	8.408
2030	0	9.737	7.324	8.478	4.065	231	8.478
2031	0	9.587	7.404	8.548	4.095	246	8.548
2032	0	9.437	7.484	8.618	4.125	261	8.618
2033	0	9.287	7.564	8.688	4.155	276	8.688

Table 80. Evolution of collective boilers stock per year (Optimistic) Primorsko-Goranska County

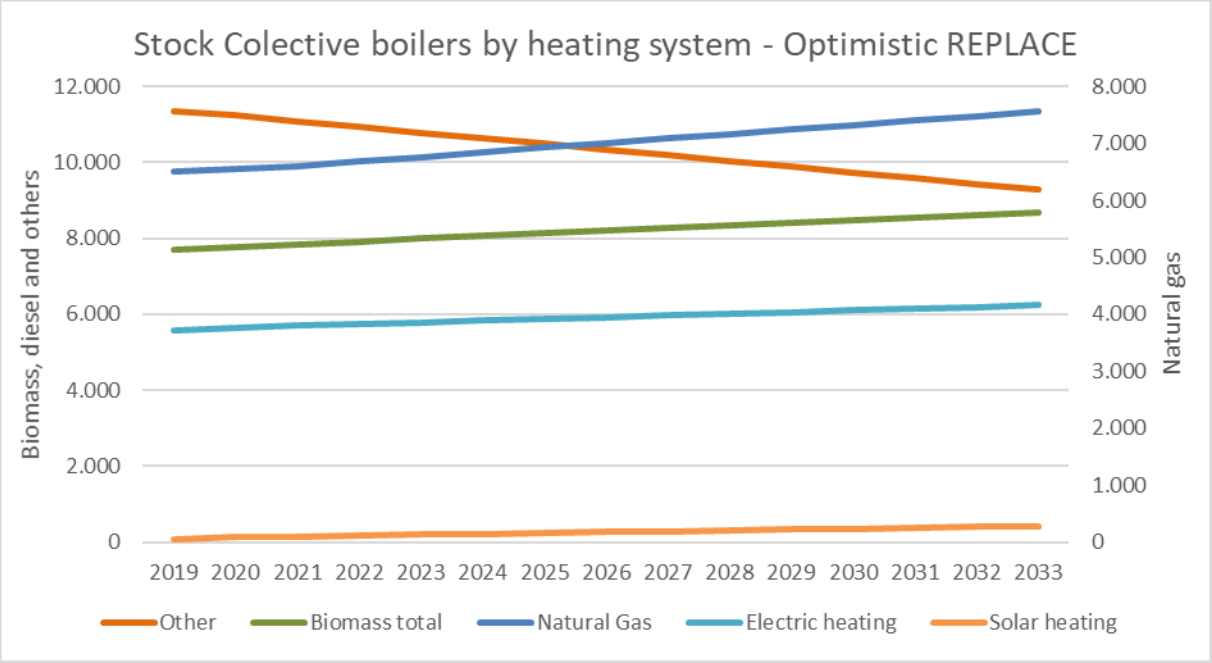

Figure 56. Evolution of collective boilers stock per year (Optimistic) Primorsko-Goranska County

	Pessimistic Replace-Scenario Colective Boilers (Underachieving REPLACE target region objectives)						
	number of colective boilers	number of colective boilers					
	Old Diesel	Old other boiler	Natural gas	Solid biomass	Electric heating	Solar heating	Biomass total
Replaced/ year		-100	50	50	25	20	
2019		11.337	6.504	7.708	3.715	56	
2020	0	11.237	6.554	7.758	3.740	76	7.758
2021	0	11.137	6.604	7.808	3.770	96	7.808
2022	0	11.037	6.654	7.858	3.800	116	7.858
2023	0	10.937	6.704	7.908	3.830	136	7.908
2024	0	10.837	6.754	7.958	3.860	156	7.958
2025	0	10.737	6.804	8.008	3.890	176	8.008
2026	0	10.637	6.854	8.058	3.920	196	8.058
2027	0	10.537	6.904	8.108	3.950	216	8.108
2028	0	10.437	6.954	8.158	3.980	236	8.158
2029	0	10.337	7.004	8.208	4.010	256	8.208
2030	0	10.237	7.054	8.258	4.040	276	8.258
2031	0	10.137	7.104	8.308	4.070	296	8.308
2032	0	10.037	7.154	8.358	4.100	316	8.358
2033	0	9.937	7.204	8.408	4.130	336	8.408

Table 81. Evolution of collective boilers stock per year (Pessimistic) Primorsko-Goranska County

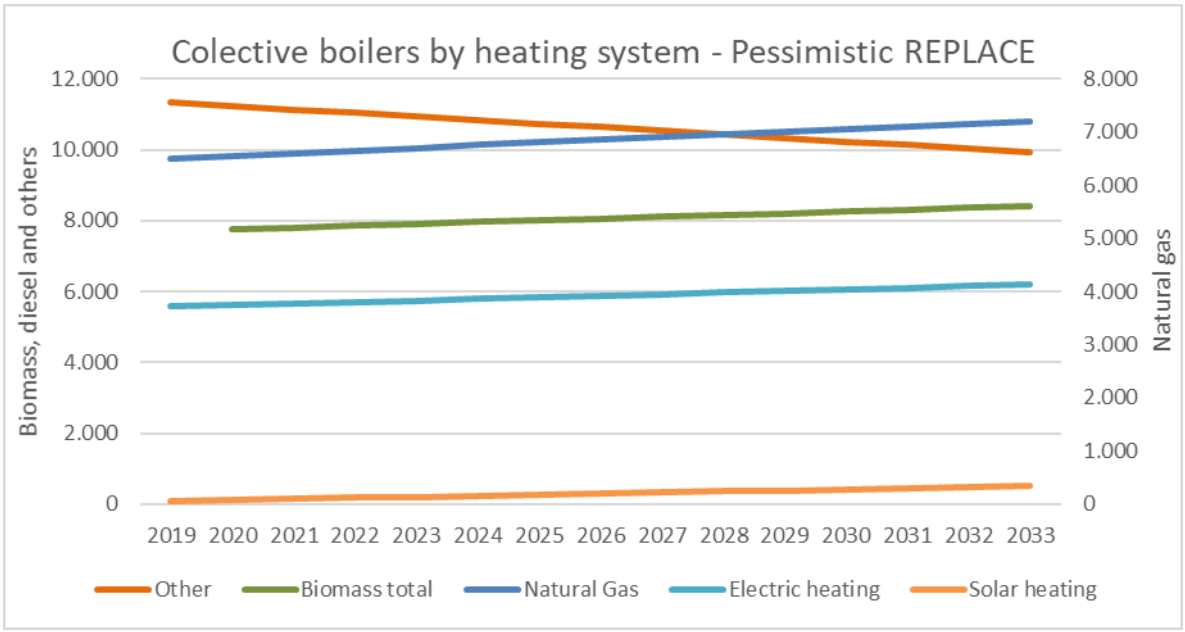

Figure 57. Evolution of collective boilers stock per year (Pessimistic) Primorsko-Goranska County

Baseline District Heating (expected evolution without REPLACE)				
	number of DH boilers		number of DH boilers	
	Old Diesel	Old other boiler	Natural gas	Solid biomass
Replaced/year		-1	2	
2019		4	11	
2020	0	3	13	
2021	0	2	15	
2022	0	1	17	
2023	0	0	19	
2024	0	-1	21	
2025	0	-2	23	
2026	0	-3	25	
2027	0	-4	27	
2028	0	-5	29	
2029	0	-6	31	
2030	0	-7	33	
2031	0	-8	35	
2032	0	-9	37	
2033	0	-10	39	

Table 82. Evolution of district heating stock per year (Baseline) Primorsko-Goranska County

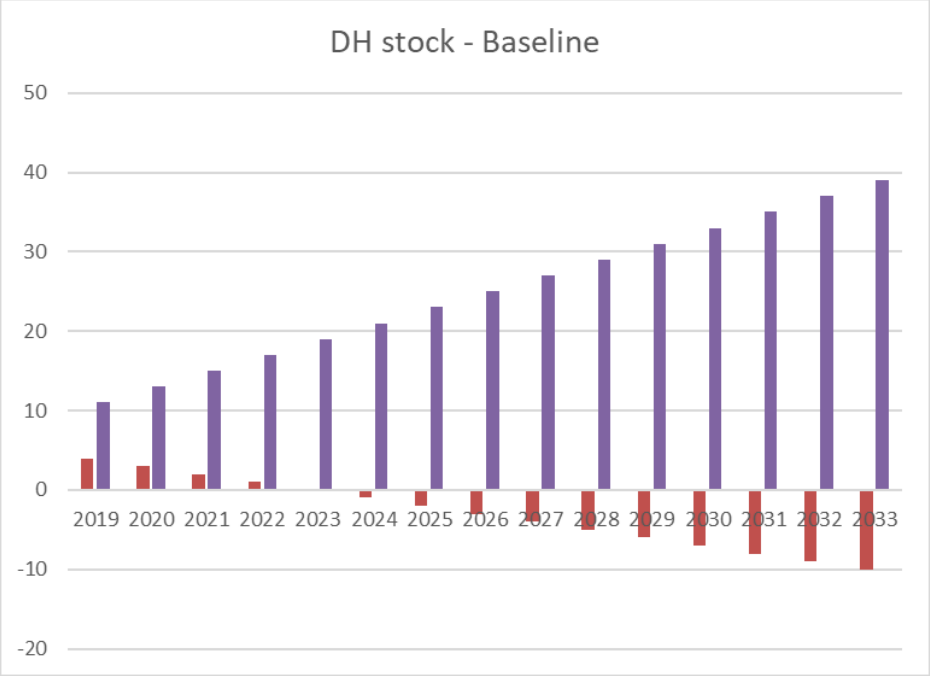

Figure 58. Evolution of district heating stock per year (Baseline) Primorsko-Goranska County

Optimistic Replace-Scenario DH Boilers (Overachieving REPLACE target region objectives				
	number of individual boilers		number of individual boilers	
	Old Diesel	Old other boiler	Natural gas	Solid biomass
Replaced/year		-2	4	
2019		4	11	
2020	0	3	13	0
2021	0	2	15	0
2022	0	0	19	0
2023	0	-2	23	0
2024	0	-4	27	0
2025	0	-6	31	0
2026	0	-8	35	0
2027	0	-10	39	0
2028	0	-12	43	0
2029	0	-14	47	0
2030	0	-16	51	0
2031	0	-18	55	0
2032	0	-20	59	0
2033	0	-22	63	0

Table 83. Evolution of district heating stock per year (Optimistic) Primorsko-Goranska County

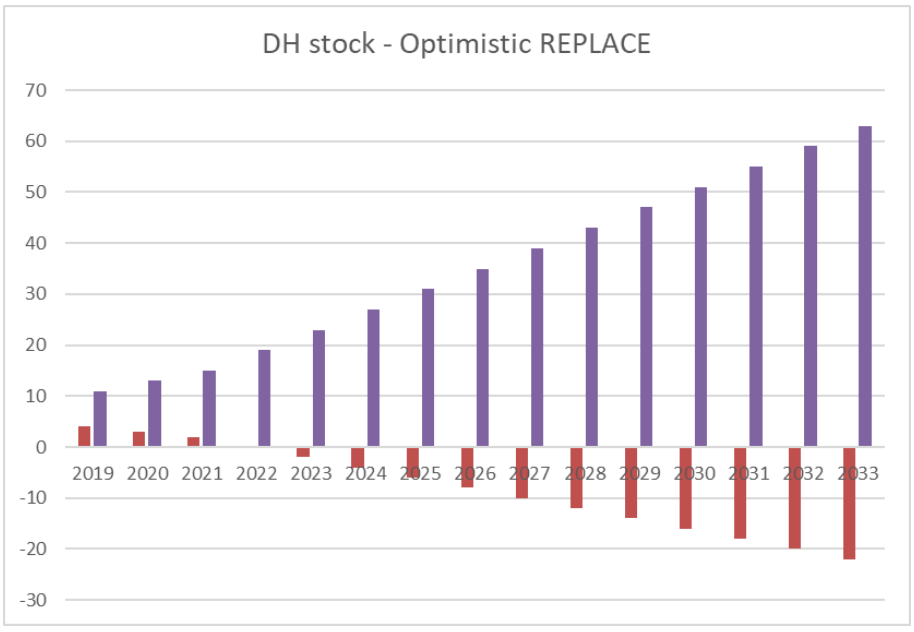

Figure 59. Evolution of district heating stock per year (Optimistic) Primorsko-Goranska County

Pessimistic Replace-Scenario DH Boilers (Underachieving REPLACE target region objectives)				
	number of individual boilers		number of individual boilers	
	Old Diesel	Old other boiler	Natural gas	Solid biomass
Replaced/year		0	2	
2019		4	11	
2020	0	4	13	
2021	0	4	15	
2022	0	4	17	
2023	0	4	19	
2024	0	4	21	
2025	0	4	23	
2026	0	4	25	
2027	0	4	27	
2028	0	4	29	
2029	0	4	31	
2030	0	4	33	
2031	0	4	35	
2032	0	4	37	
2033	0	4	39	

Table 84. Evolution of district heating stock per year (Pessimistic) Primorsko-Goranska County

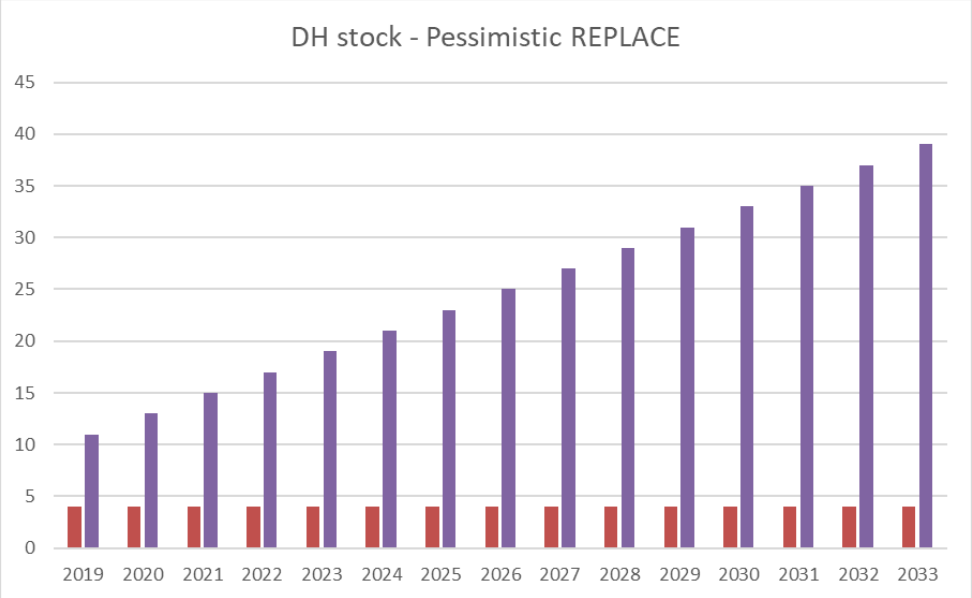

Figure 60. Evolution of district heating stock per year (Pessimistic) Primorsko-Goranska County

For individual boilers we can see a similar scenario to the home evolution situation. Mainly, old inefficient boilers are being replaced by biomass, followed by electric heaters and very few natural gas boilers.

For collective boilers there is a similar trend but without the electric heaters. On the other hand the only district heating that is estimated to be installed are the ones that work with natural gas instead of biomass.

3.3.4 Investments/Economics

	Average boiler power	Price (€/kW) only boiler	Price (€/kW) biomass turnkey system
Individual boilers (P<50kW)	15	350	620
Colective boilers (P>50kW)	100	370	370
Distrcit Heating boilers	20000	130	169

Table 85. Average boiler prices, Primorsko-Goranska County

	Number of boilers increased by REPLACE		Annual REPLACE (€) investment only in boilers		Annual REPLACE (€) turnkey project investment	
	Optimist	Pessimist	Optimist	Pessimist	Optimist	Pessimist
Individual boilers (P<50kW)	200	100	1.050.000	525.000	1.860.000	930.000
Colective boilers (P>50kW)	20	5	740.000	185.000	740.000	185.000
Distrcit Heating boilers	2	0	5.200.000	-	6.760.000	-
Total investment Mio€			7,0	0,7	9,4	1,1

Table 86. Annual Replace investment triggered, Primorsko-Goranska County

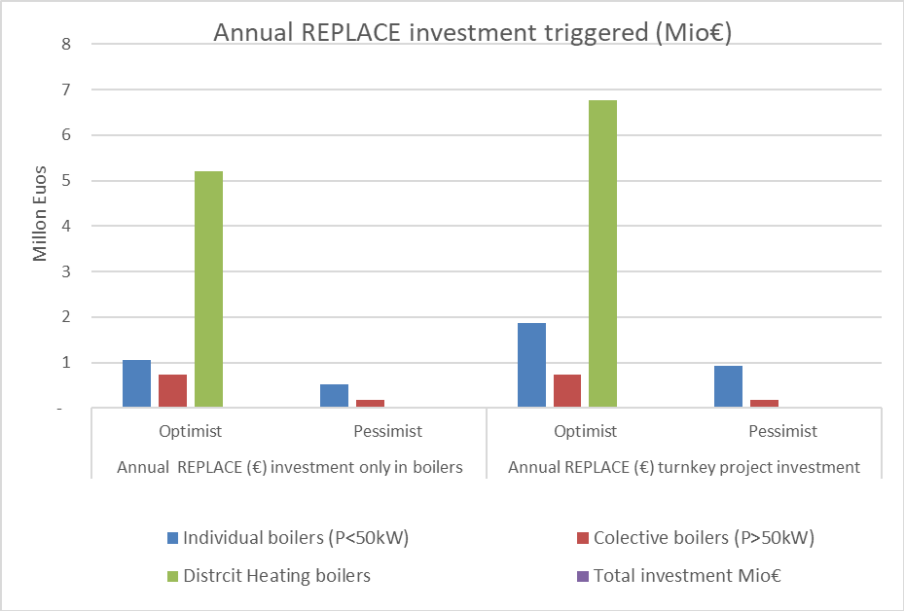

Figure 61. Annual Replace investment triggered, Primorsko-Goranska County

The average power for individual boilers in the region of Primorsko-Goranska County is 15 kW and depending if it includes a turnkey system, the price per kW of power can reach up to 620 Euros.

The average power for collective boilers is 100 kW. The price for the turnkey systems can reach up to 370 Euros per kW installed.

The average power for district heating systems is 2000 kW. The price for the turnkey systems can reach up to 169 Euros per kW installed.

3.3.5 Main conclusions

The main source of heating in the Primorsko-Goranska County is solid biomass followed by natural gas and DH system. The area of the City of Rijeka has district heating facilities using natural gas in most of the heating plants. Electric heating and solar heating systems have a rising role in County's space heating. The replacement of old and inefficient furnaces is growing. Promotion of replacement and transfer of knowledge on different heating options through REPLACE project activities should benefit the replacement tendency. The government co-finances the replacement of old heating systems with solar heating systems, woodchip/pellet boilers or heat pumps. Most of the households made the decision to replace their systems with pellet boilers due to the easy procurement of fuel (pellets) that can be purchased in supermarkets. The current situation makes it difficult for people to make a decision and that is because of the price of pellets that has exceeded the cost of fuel oil. However, this could be the chance for some other renewable system to take the lead such as solar systems or heating pumps.

3.4 Croatia – Zagreb

3.4.1 Methodology and information sources

Sources:

1.) Census 2011 - data on the number of households, fuel used and way of using it, https://www.dzs.hr/eng/censuses/census2011/results/censustabsxls.htm
2.) Long-term Strategy for Mobilising Investment in the Renovation of the National Building Stock until 2050

3.4.2 Home evolution

Baseline Homes Heating (expected evolution without REPLACE)

	Fuel oil	Old other boiler	Natural gas	Solid biomass	Electrical Heating	DH
Replaced/ year	-125	-26	45	45	10	30
2019	10.423	306	186.980	113.305	11.232	84.584
2020	10.298	280	187.025	113.350	11.242	84.614
2021	10.173	254	187.070	113.395	11.252	84.644
2022	10.048	228	187.115	113.440	11.262	84.674
2023	9.923	202	187.160	113.485	11.272	84.704
2024	9.798	176	187.205	113.530	11.282	84.734
2025	9.673	150	187.250	113.575	11.292	84.764
2026	9.548	124	187.295	113.620	11.302	84.794
2027	9.423	98	187.340	113.665	11.312	84.824
2028	9.298	72	187.385	113.710	11.322	84.854
2029	9.173	46	187.430	113.755	11.332	84.884
2030	9.048	20	187.475	113.800	11.342	84.914
2031	8.923	-6	187.520	113.845	11.352	84.944
2032	8.798	-32	187.565	113.890	11.362	84.974
2033	8.673	-58	187.610	113.935	11.372	85.004

Table 87. Evolution of home heating systems stock per year (Baseline) Zagreb

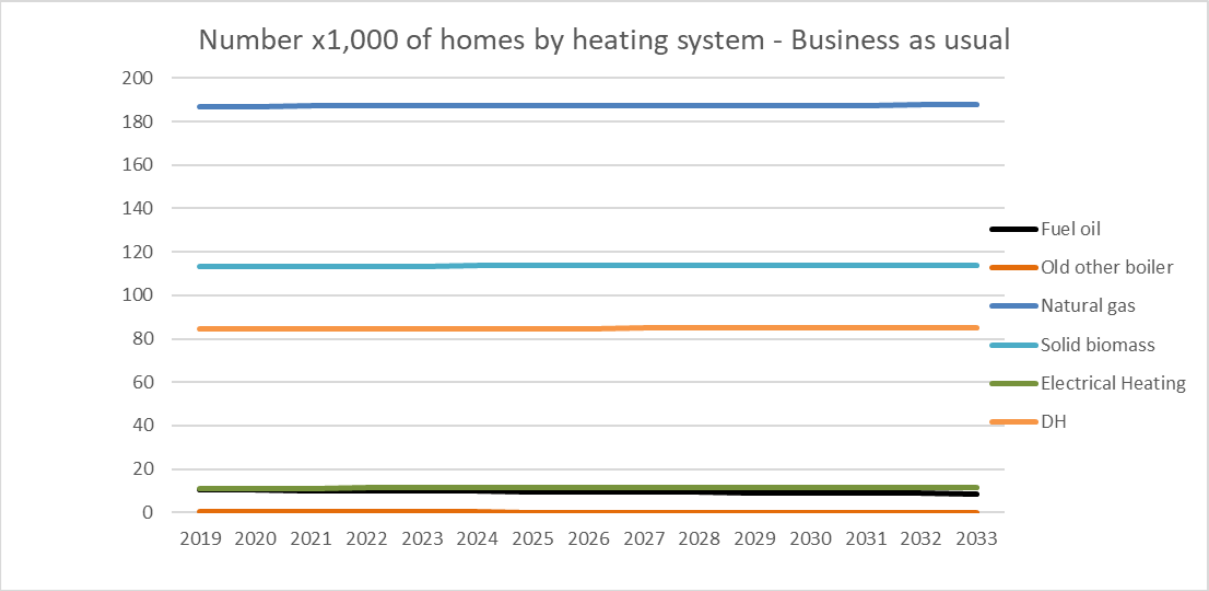

Figure 62. Evolution of home heating systems stock per year (Baseline) Zagreb

Optimistic Replace-Scenario Homes (Overachieving REPLACE target region objectives)

	Fuel oil	ld other boile	Natural gas	Solid biomass	Electrical Hea	DH
Replaced/ year	-143	-30	52	52	15	0
2019	10.423	306	186.980	113.305	11.232	84.584
2020	10.280	276	187.032	113.357	11.247	84.584
2021	10.137	246	187.084	113.402	11.257	84.584
2022	9.994	216	187.136	113.454	11.267	84.584
2023	9.851	186	187.188	113.506	11.277	84.584
2024	9.708	156	187.240	113.558	11.287	84.584
2025	9.565	126	187.292	113.610	11.297	84.584
2026	9.422	96	187.344	113.662	11.307	84.584
2027	9.279	66	187.396	113.714	11.317	84.584
2028	9.136	36	187.448	113.766	11.327	84.584
2029	8.993	6	187.500	113.818	11.337	84.584
2030	8.850	-24	187.552	113.870	11.347	84.584
2031	8.707	-54	187.604	113.922	11.357	84.584
2032	8.564	-84	187.656	113.974	11.367	84.584
2033	8.421	-114	187.708	114.026	11.377	84.584

Table 88. Evolution of home heating systems stock per year (Optimistic) Zagreb

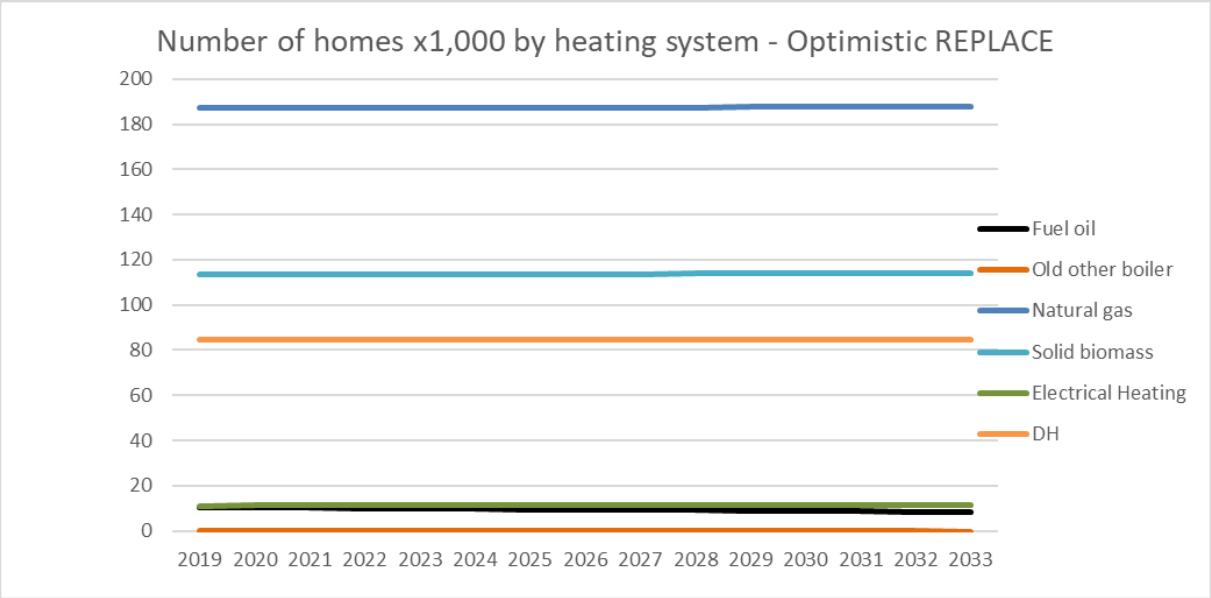

Figure 63. Evolution of home heating systems stock per year (Optimistic) Zagreb

Pessimistic Replace-Scenario Homes (Underachieving REPLACE target region objectives)

	Fuel oil	ld other boile	Natural gas	Solid biomass	Electrical Hea	DH
Replaced/ year	-128	-26	46	46	12	
2019	10.423	306	186.980	113.305	11.232	84.584
2020	10.295	280	187.026	113.351	11.244	84.584
2021	10.167	254	187.072	113.397	11.256	84.584
2022	10.039	228	187.118	113.443	11.268	84.584
2023	9.911	202	187.164	113.489	11.280	84.584
2024	9.783	176	187.210	113.535	11.292	84.584
2025	9.655	150	187.256	113.581	11.304	84.584
2026	9.527	124	187.302	113.627	11.316	84.584
2027	9.399	98	187.348	113.673	11.328	84.584
2028	9.271	72	187.394	113.719	11.340	84.584
2029	9.143	46	187.440	113.765	11.352	84.584
2030	9.015	20	187.486	113.811	11.364	84.584
2031	8.887	-6	187.532	113.857	11.376	84.584
2032	8.759	-32	187.578	113.903	11.388	84.584
2033	8.631	-58	187.624	113.949	11.400	84.584

Table 89. Evolution of home heating systems stock per year (Pessimistic) Zagreb

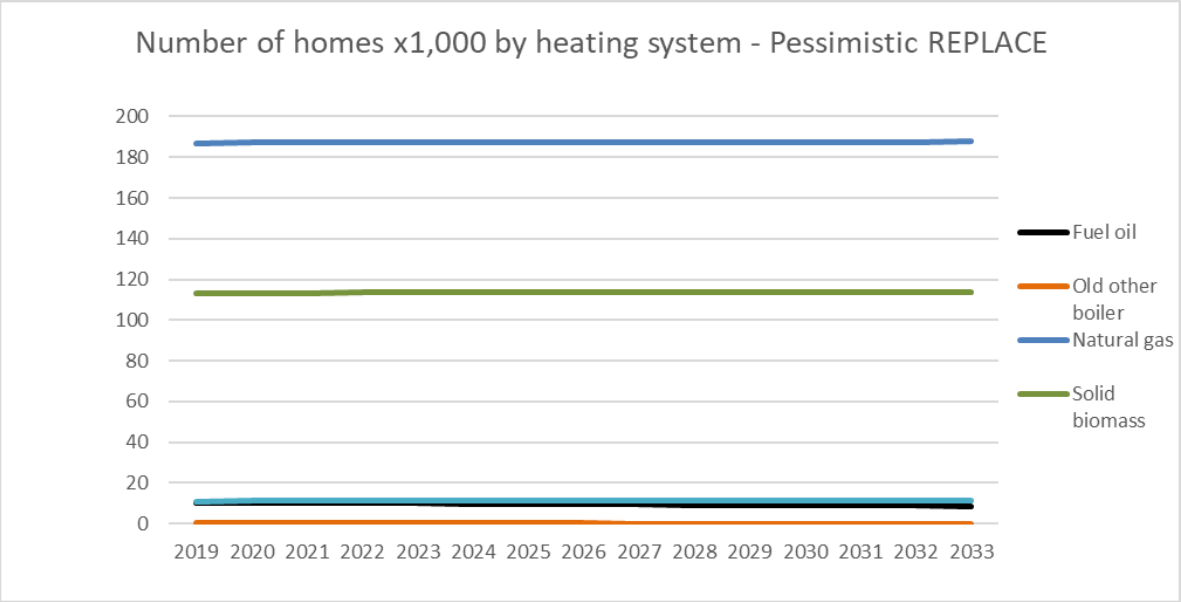

Figure 64. Evolution of home heating systems stock per year (Pessimistic) Zagreb

The main source for heating homes in the region of Zagreb is Natural gas. Heating systems using this type of fuel are predicted to continue rising in the next decade. It is observed that the opposite happens with the fuel oil heating systems, which is the main fuel objective to be replaced by the project in the pilot region. The project estimates between 128 and 143 of the region's homes heated with this fuel being replaced by natural gas and biomass. The inventory estimates that around 52 biomass and natural gas heating installations will be installed for homes in this region every year in the best scenario, and around 46 in the worst one.

Energy source	Annual average home heat consumption (kWh)
	kWh/home
Diesel oil	9.536,6
GLP	9.536,6
Natural gas	9.536,6
Electricity	9.536,6
Biomass	9.536,6

Table 90. Annual average home heat consumption, Zagreb

Old boiler performance	65%
New biomass boiler performance	75%

	Final energy savings (GWh)	
	Opptimistic Replace vs Business as usual	Pessimistic Replace vs Business as usual
2019	0,000	0,000
2020	0,014	0,002
2021	0,014	0,004
2022	0,027	0,006
2023	0,041	0,008
2024	0,055	0,010
2025	0,068	0,012
2026	0,082	0,014
2027	0,096	0,016
2028	0,110	0,018
2029	0,123	0,020
2030	0,137	0,022
2031	0,151	0,023
2032	0,164	0,025
2033	0,178	0,027

Table 91. Final energy savings, Zagreb

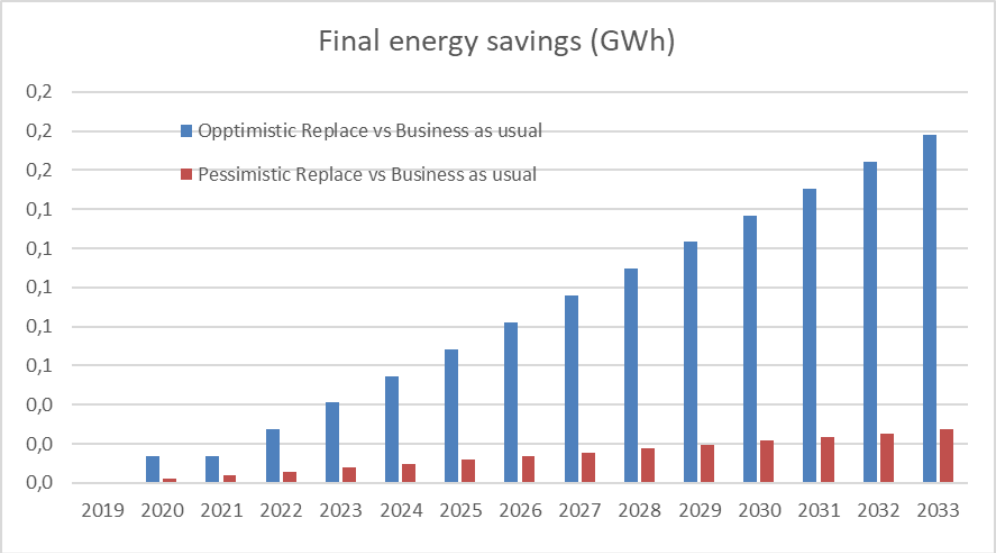

Figure 65. Final energy savings, Zagreb

	Additional emissions reduction (tCO2)	
	Opptimistic Replace vs Business as usual	Pessimistic Replace vs Business as usual
2019	0	0
2020	4	1
2021	4	1
2022	8	2
2023	12	2
2024	16	3
2025	21	4
2026	25	4
2027	29	5
2028	33	5
2029	37	6
2030	41	6
2031	45	7
2032	49	8
2033	53	8

Table 92. Additional emissions reduction, Zagreb

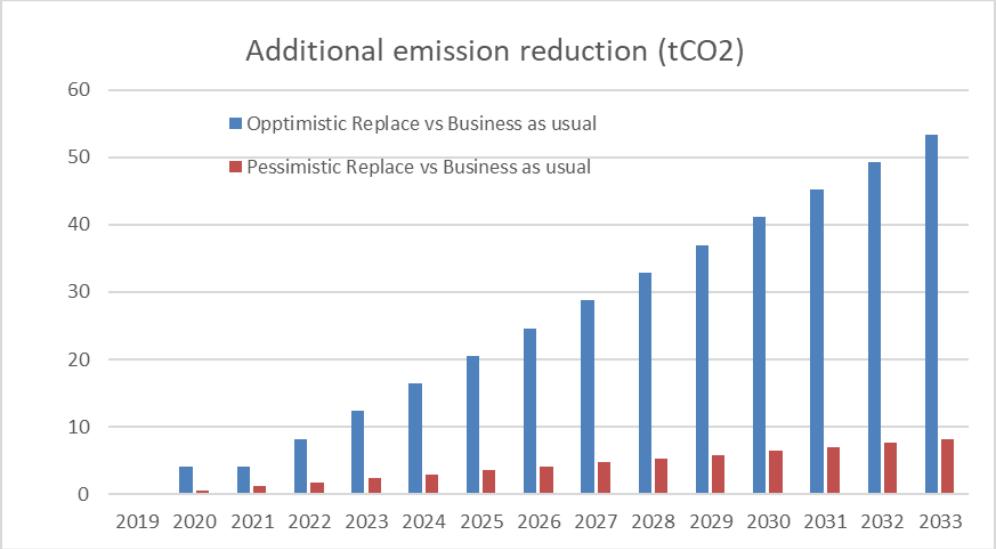

Figure 66. Additional emissions reduction, Zagreb

The final energy savings for the optimistic and pessimistic scenarios were calculated considering the number of replacements for homes, the annual average home heat consumption, and the different performance values for the old and new heating systems. By the year 2033, with the assistance of the replace project, the region of Zagreb could save between 0.2 and 1 GWh of energy. This in turn translates to a reduction of emissions in between 36 and 300 tons of CO2 by the year 2033.

3.4.3 Boiler evolution

	Baseline Individual Boilers (expected evolution without REPLACE)				
	number of individual boilers		number of individual boilers		
	Stock	Stock	Stock of boilers (number, cumulated)		
	Fuel Oil	Old other boiler	Natural gas	Solid biomass	Electric heating
Replaced/year	-12	-9	45	33	15
2019	1.032	99	186.980	83.043	11.232
2020	1.020	90	187.025	83.076	11.247
2021	1.008	81	187.070	83.109	11.262
2022	996	72	187.115	83.142	11.277
2023	984	63	187.160	83.175	11.292
2024	972	54	187.205	83.208	11.307
2025	960	45	187.250	83.241	11.322
2026	948	36	187.295	83.274	11.337
2027	936	27	187.340	83.307	11.352
2028	924	18	187.385	83.340	11.367
2029	912	9	187.430	83.373	11.382
2030	900	0	187.475	83.406	11.397
2031	888	-9	187.520	83.439	11.412
2032	876	-18	187.565	83.472	11.427
2033	864	-27	187.610	83.505	11.442

Table 93. Evolution of individual boilers stock per year (Baseline) Zagreb

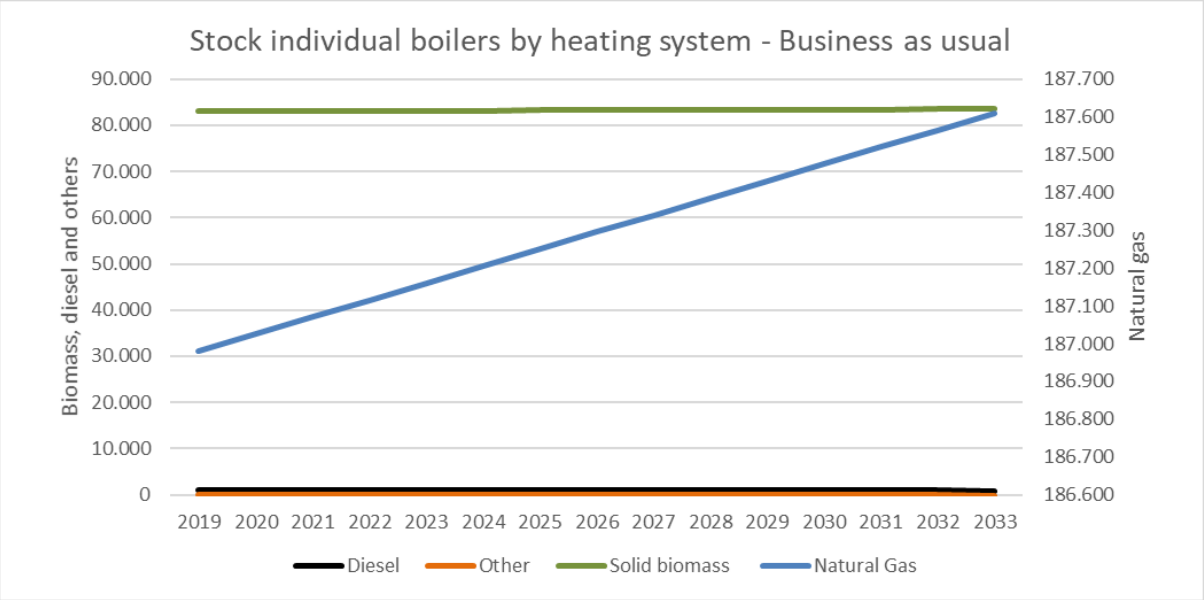

Figure 67. Evolution of individual boilers stock per year (Baseline) Zagreb

	Optimistic Replace-Scenario Individual Boilers				
	number of individual boilers		number of individual boilers		
	Stock	Stock	Stock of boilers (number, cumulated)		
	Fuel Oil	Old other boiler	Natural gas	Solid biomass	Electric heating
Replaced/year	-13	-11	52	38	17
2019	1.032	99	186.980	83.043	11.232
2020	1.019	88	187.032	83.081	11.249
2021	1.007	79	187.077	83.119	11.264
2022	994	68	187.129	83.157	11.281
2023	981	57	187.181	83.195	11.298
2024	968	46	187.233	83.233	11.315
2025	955	35	187.285	83.271	11.332
2026	942	24	187.337	83.309	11.349
2027	929	13	187.389	83.347	11.366
2028	916	2	187.441	83.385	11.383
2029	903	-9	187.493	83.423	11.400
2030	890	-20	187.545	83.461	11.417
2031	877	-31	187.597	83.499	11.434
2032	864	-42	187.649	83.537	11.451
2033	851	-53	187.701	83.575	11.468

Table 94. Evolution of individual boilers stock per year (Optimistic) Zagreb

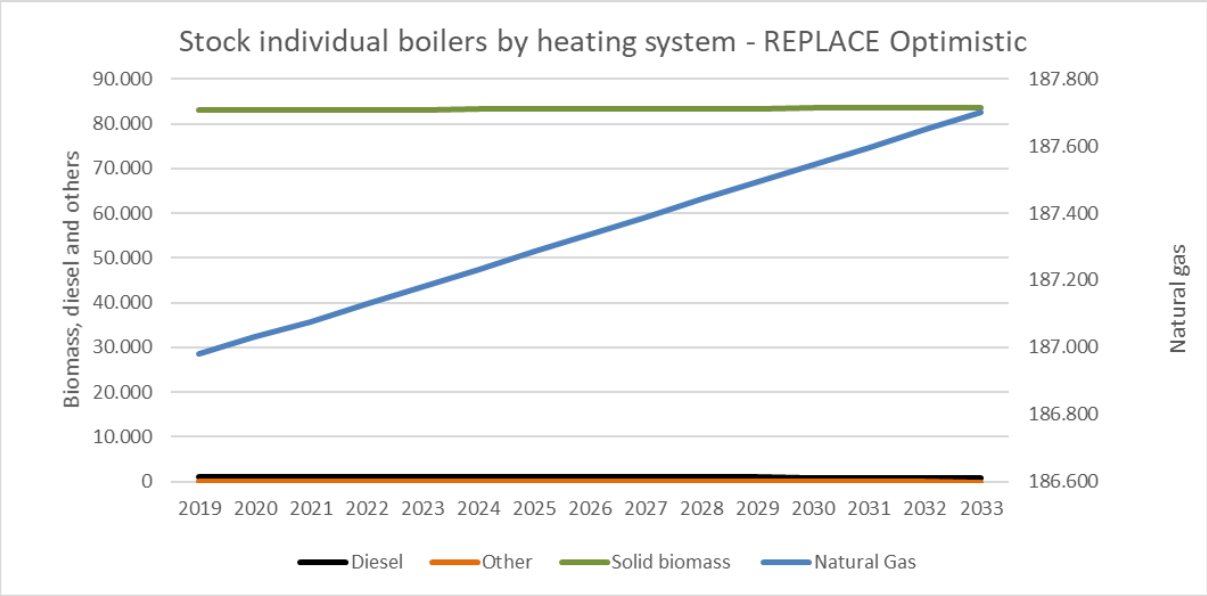

Figure 68. Evolution of individual boilers stock per year (Optimistic) Zagreb

	Pessimistic Replace-Scenario Individual Boilers				
	number of individual boilers		number of individual boilers		
	Stock	Stock	Stock of boilers (number, cumulated)		
	Fuel Oil	Old other boiler	Natural gas	Solid biomass	Electric heating
Replaced/year	-12	-9	46	34	16
2019	1.032	99	186.980	83.043	11.232
2020	1.020	90	187.026	83.077	11.248
2021	1.008	81	187.072	83.111	11.264
2022	996	72	187.118	83.145	11.280
2023	984	63	187.164	83.179	11.296
2024	972	54	187.210	83.213	11.312
2025	960	45	187.256	83.247	11.328
2026	948	36	187.302	83.281	11.344
2027	936	27	187.348	83.315	11.360
2028	924	18	187.394	83.349	11.376
2029	912	9	187.440	83.383	11.392
2030	900	0	187.486	83.417	11.408
2031	888	-9	187.532	83.451	11.424
2032	876	-18	187.578	83.485	11.440
2033	864	-27	187.624	83.519	11.456

Table 95. Evolution of individual boilers stock per year (Pessimistic) Zagreb

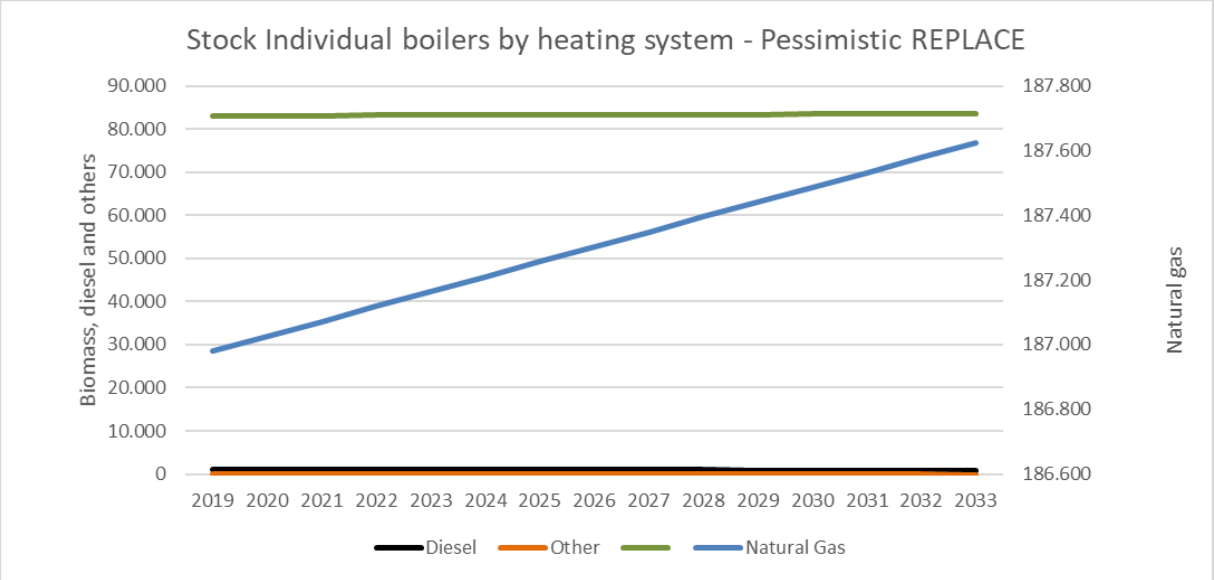

Figure 69. Evolution of individual boilers stock per year (Pessimistic) Zagreb

Baseline Colectivel Boilers and DH (expected evolution without REPLACE)					
	number of colective boilers		number of colective boilers		
	Fuel Oil	Old other boiler	Natural gas	Solid biomass	Biomass DH
Replaced/year	-113	-16		12	
2019	9.391	207		30.262	
2020	9.278	191	0	30.274	0
2021	9.165	175	0	30.286	0
2022	9.052	159	0	30.298	0
2023	8.939	143	0	30.310	0
2024	8.826	127	0	30.322	0
2025	8.713	111	0	30.334	0
2026	8.600	95	0	30.346	0
2027	8.487	79	0	30.358	0
2028	8.374	63	0	30.370	0
2029	8.261	47	0	30.382	0
2030	8.148	31	0	30.394	0
2031	8.035	15	0	30.406	0
2032	7.922	-1	0	30.418	0
2033	7.809	-17	0	30.430	0

Table 96. Evolution of collective boilers stock per year (Baseline) Zagreb

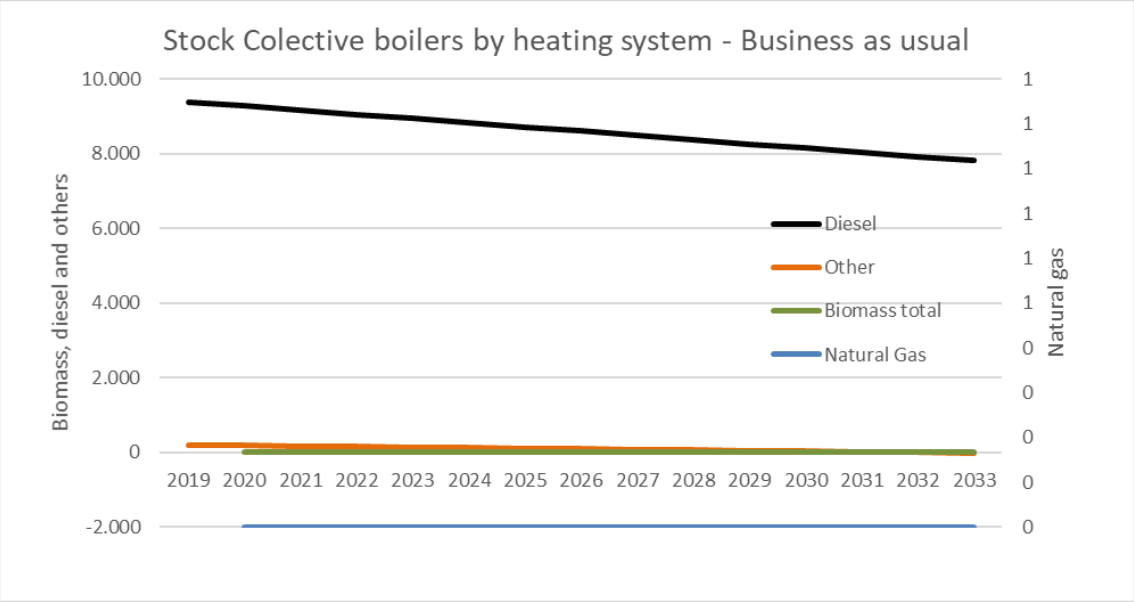

Figure 70. Evolution of collective boilers stock per year (Baseline) Zagreb

Optimistic Replace-Scenario Colective Boilers (Overachieving REPLACE target region objectives)					
	number of colective boilers		number of colective boilers		
	Old Diesel	Old other boiler	Natural gas	Solid biomass	Biomass DH
Replaced/year	-130	-19		14	
2019	9.391	207		30.262	
2020	9.261	191	0	30.276	0
2021	9.131	172	0	30.290	0
2022	9.001	153	0	30.304	0
2023	8.871	134	0	30.318	0
2024	8.741	115	0	30.332	0
2025	8.611	96	0	30.346	0
2026	8.481	77	0	30.360	0
2027	8.351	58	0	30.374	0
2028	8.221	39	0	30.388	0
2029	8.091	20	0	30.402	0
2030	7.961	1	0	30.416	0
2031	7.831	-18	0	30.430	0
2032	7.701	-37	0	30.444	0
2033	7.571	-56	0	30.458	0

Table 97. Evolution of collective boilers stock per year (Optimistic) Zagreb

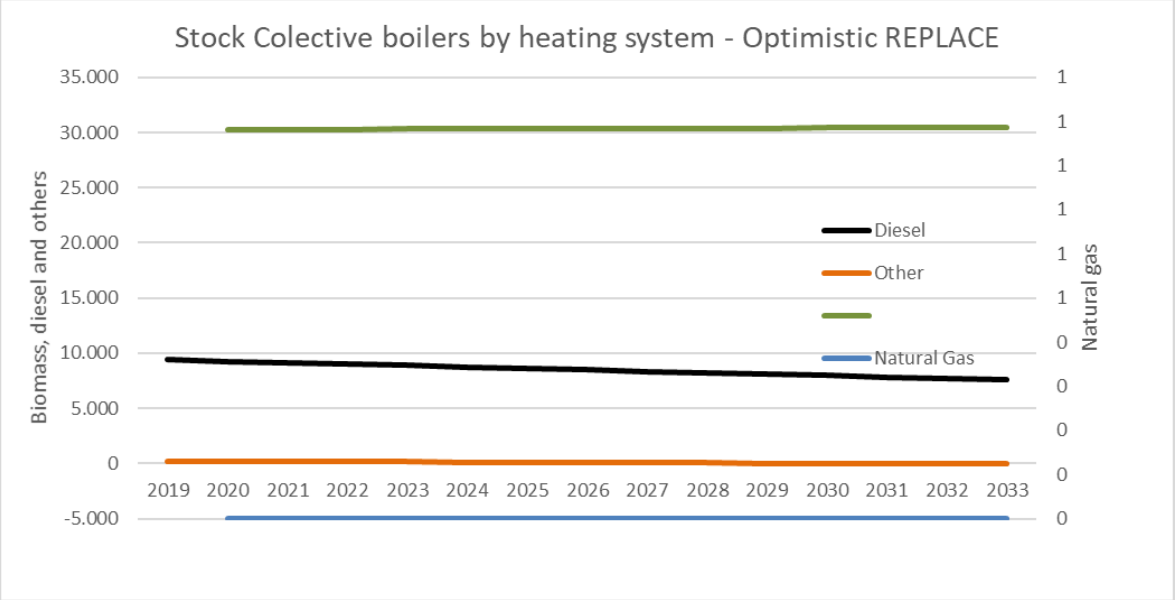

Figure 71. Evolution of collective boilers stock per year (Optimistic) Zagreb

Pessimistic Replace-Scenario Colective Boilers (Underachieving REPLACE target region objectives)					
	number of colective boilers		number of colective boilers		
	Old Diesel	Old other boiler	Natural gas	Solid biomass	Biomass DH
Replaced/year	-117	-17		13	
2019	9.391	207		30.262	
2020	9.274	190	0	30.275	0
2021	9.157	173	0	30.288	0
2022	9.040	156	0	30.301	0
2023	8.923	139	0	30.314	0
2024	8.806	122	0	30.327	0
2025	8.689	105	0	30.340	0
2026	8.572	88	0	30.353	0
2027	8.455	71	0	30.366	0
2028	8.338	54	0	30.379	0
2029	8.221	37	0	30.392	0
2030	8.104	20	0	30.405	0
2031	7.987	3	0	30.418	0
2032	7.870	-14	0	30.431	0
2033	7.753	-31	0	30.444	0

Table 98. Evolution of collective boilers stock per year (Pessimistic) Zagreb

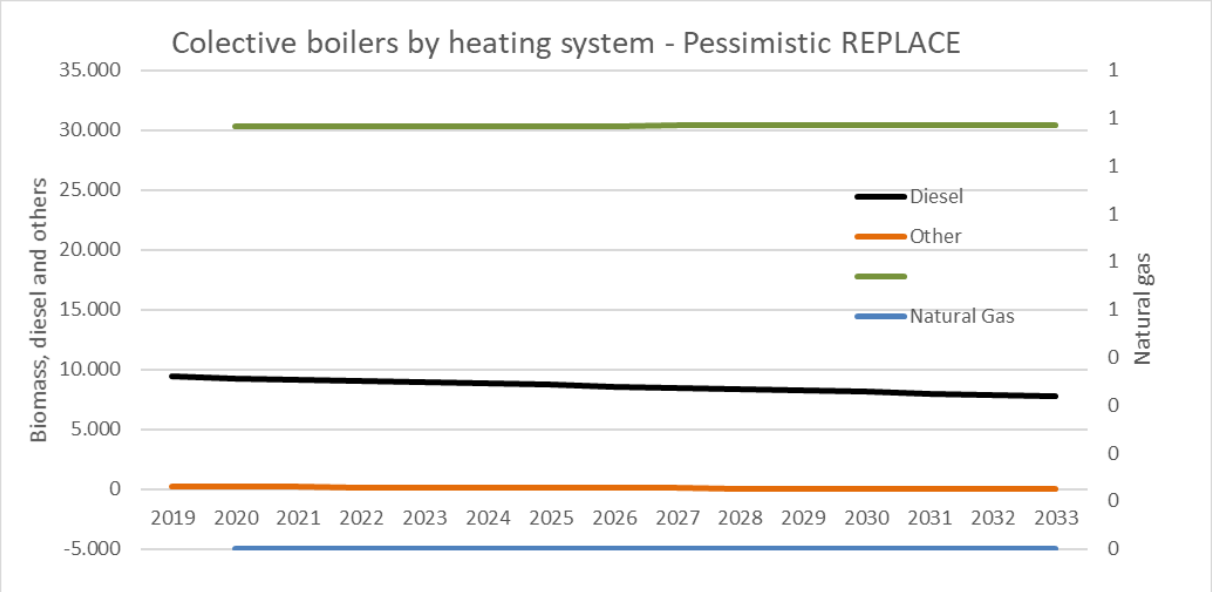

Figure 72. Evolution of collective boilers stock per year (Pessimistic) Zagreb

Baseline District Heating (expected evolution without REPLACE)				
	number of DH boilers		**number of DH boilers**	
	Old Diesel	Old other boiler	Natural gas	Solid biomass
Replaced/year		0	0	
2019			56	
2020	0	0	56	0
2021	0	0	56	0
2022	0	0	56	0
2023	0	0	56	0
2024	0	0	56	0
2025	0	0	57	0
2026	0	0	57	0
2027	0	0	57	0
2028	0	0	57	0
2029	0	0	57	0
2030	0	0	57	0
2031	0	0	57	0
2032	0	0	57	0
2033	0	0	57	0

Table 99. Evolution of district heating stock per year (Baseline) Zagreb

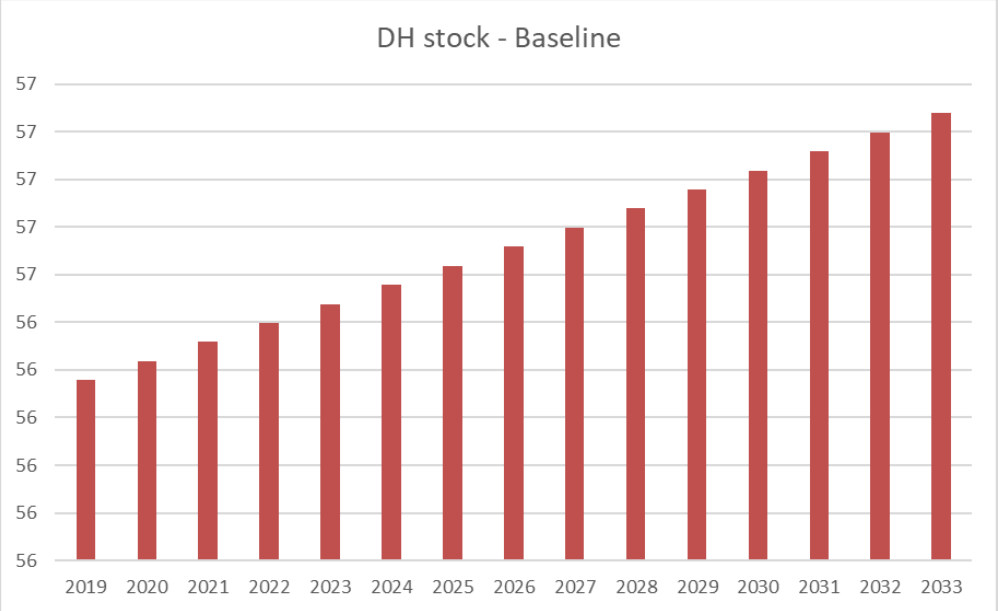

Figure 73. Evolution of district heating stock per year (Baseline) Zagreb

Optimistic Replace-Scenario DH Boilers (Overachieving REPLACE target region objectives)				
	number of DH boilers		number of DH boilers	
	Old Diesel	Old other boiler	Natural gas	Solid biomass
Replaced/year			0	
2019			56	
2020	0	0	56	0
2021	0	0	56	0
2022	0	0	56	0
2023	0	0	56	0
2024	0	0	57	0
2025	0	0	57	0
2026	0	0	57	0
2027	0	0	57	0
2028	0	0	57	0
2029	0	0	57	0
2030	0	0	57	0
2031	0	0	57	0
2032	0	0	57	0
2033	0	0	57	0

Table 100. Evolution of district heating stock per year (Optimistic) Zagreb

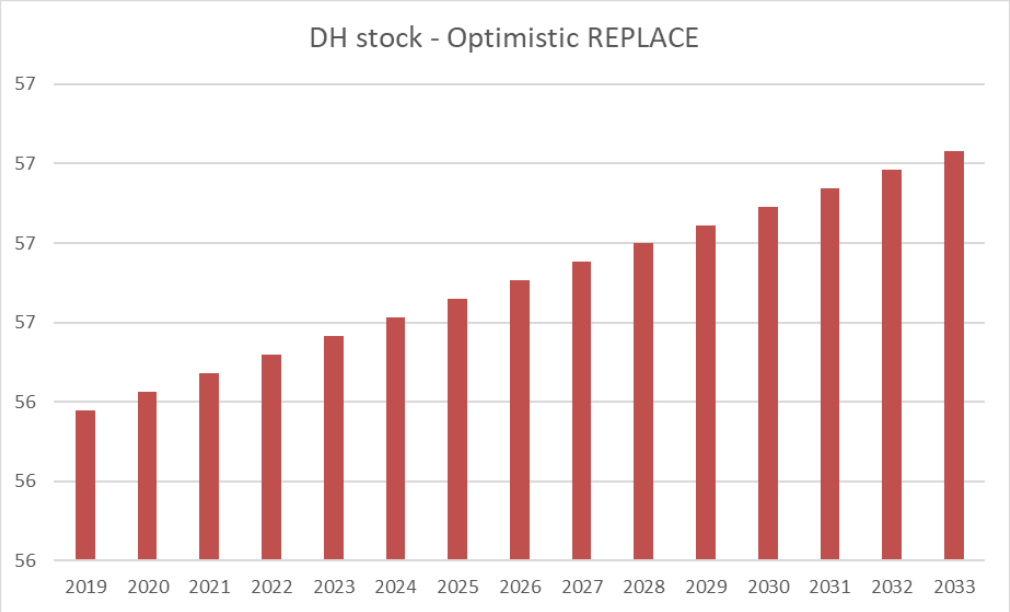

Figure 74. Evolution of district heating stock per year (Optimistic) Zagreb

Pessimistic Replace-Scenario DH Boilers (Underachieving REPLACE target region objectives)				
	number of DH boilers		number of DH boilers	
	Old Diesel	Old other boiler	Natural gas	Solid biomass
Replaced/year			0	
2019			56	
2020	0	0	56	0
2021	0	0	56	0
2022	0	0	56	0
2023	0	0	56	0
2024	0	0	56	0
2025	0	0	57	0
2026	0	0	57	0
2027	0	0	57	0
2028	0	0	57	0
2029	0	0	57	0
2030	0	0	57	0
2031	0	0	57	0
2032	0	0	57	0
2033	0	0	57	0

Table 101. Evolution of district heating stock per year (Pessimistic) Zagreb

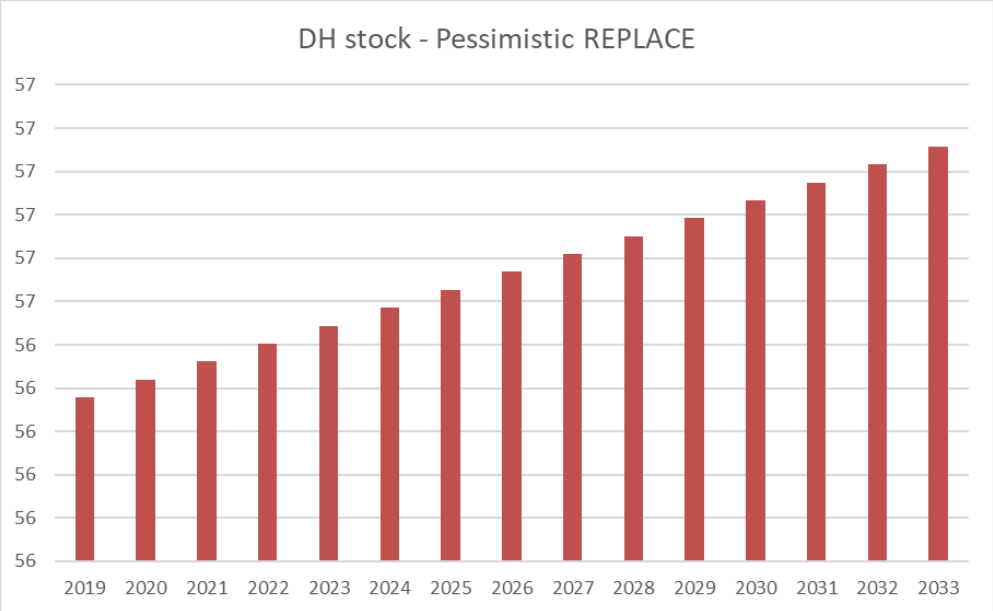

Figure 75. Evolution of district heating stock per year (Pessimistic) Zagreb

For individual boilers we can see a similar scenario to the home evolution situation. Mainly, fuel oil boilers are being replaced by natural gas, followed by biomass and very few electric heaters.

Collective diesel boilers are being replaced by biomass collective boilers and for district heating, we find a rising estimate of these systems fuelled by natural gas.

3.4.4 Investment/Economics

	Average boiler power	Price (€/kW) only boiler	Price (€/kW) biomass turnkey system
Individual boilers (P<50kW)	45	69,82	69,82
Colective boilers (P>50kW)	140	192,86	192,86
District Heating boilers	800	330,42	330,42

Table 102. Average boiler prices, Zagreb

	Number of boilers increased by REPLACE		Annual REPLACE (€) investment only in boilers		Annual REPLACE (€) turnkey project investment	
	Optimist	Pessimist	Optimist	Pessimist	Optimist	Pessimist
Individual boilers (P<50kW)	5	1	15.710	3.142	15.710	3.142
Colective boilers (P>50kW)	2	1	54.000	27.000	54.000	27.000
District Heating boilers	5	1	1.321.689	264.338	1.321.689	264.338
Total investment Mio€			1,4	0,3	1,4	0,3

Table 103. Annual Replace investment triggered, Zagreb

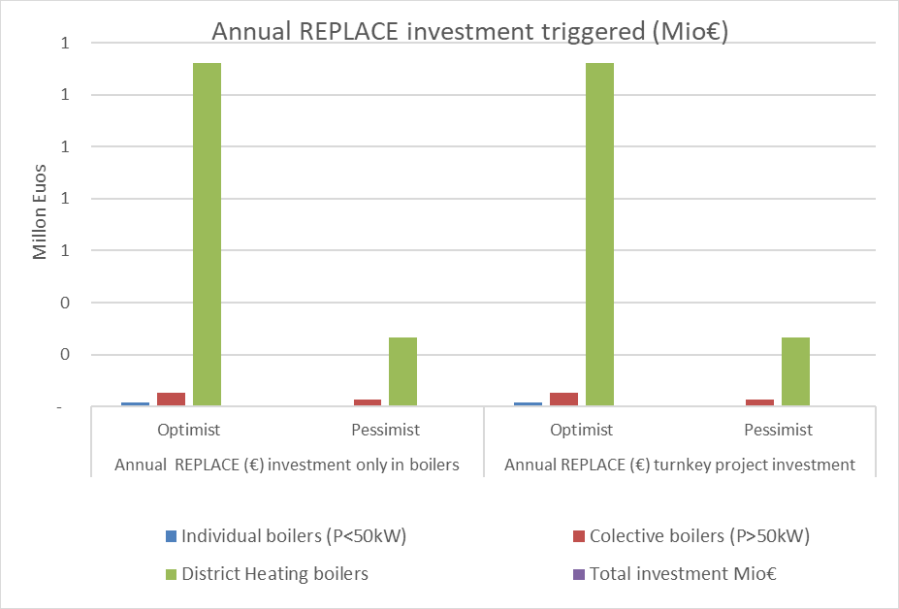

Figure 76. Annual Replace investment triggered, Zagreb

The average power for individual boilers in the region of Zagreb is 45 kW and depending if it includes a turnkey system, the price per kW of power can reach up to 70 Euros.

The average power for collective boilers is 140 kW. The price for the turnkey systems can reach up to 193 Euros per kW installed.

The average power for district heating systems is 800 kW. The price for the turnkey systems can reach up to 330 Euros per kW installed.

3.4.5 Main conclusions

REGEA has prepared a statistical inventory of the heating systems market for the region of North-west Croatia, focusing on the city of Zagreb to identify a realistic activation potential for replacement activities. Data has been collected from two main sources:

- Census 2011 - data on the number of households, fuel used and way of using it, https://www.dzs.hr/eng/censuses/census2011/results/censustabsxls.htm

- Long-term Strategy for Mobilising Investment in the Renovation of the National Building Stock until 2050

According to the analyze of home Evolution, North-west Croatia, region Zagreb has a great potential with the support of the Replace project, for saving between 0.2 and 1 GWh of energy by replacing the heating systems, which will result in a reduction in emissions between 36 and 300 tons of CO2 by the year 2033. Home Evolution shows the progress from 2020 to 2030, for or individual boilers we can see a similar scenario to the home evolution situation. Mainly, fuel oil boilers are being replaced by natural gas, followed by biomass and very few electric heaters.

The citizens of the Zagreb region are mostly heated by natural gas. The analysis shows, heating systems using this type of fuel are predicted to continue rising in the next decade. It is observed that the opposite happens with the fuel oil heating systems, which is the main fuel objective to be replaced by the project in the pilot region. The project estimates between 128 and 143 of the region's homes heated with this fuel being replaced by natural gas and biomass. This inventory determined that there will be around 52 biomass and natural gas heating installations installed for homes in this region every year in the best scenario, and around 46 in the worst one. However, such major transitions are not expected soon, due to the non-Governmental support for renewable heating systems. Current subsidy levels are considered insufficient for the present demand, which is reflected in the rapid allocation of available funds from annual public calls for the co-funding of the renewable heating systems in residential buildings.

With regard to the project investment and technical solutions, for the individual boilers the average power is 45 kW and depending on if it includes a turnkey system, the price per kW of power can reach up to 70 Euros. Further, the average power for collective boilers is 140 kW. The price for the turnkey systems can reach up to 193 Euros per kW installed. The average power for district heating systems is 800 kW. The price for the turnkey systems can reach up to 330 Euros per kW installed.

Collective diesel boilers are being replaced by biomass collective boilers and for district heating, we find a rising estimate of these systems fuelled by natural gas. It can be concluded, there are still like-for-like replacements in the field of oil and especially natural gas. Those end consumers made good experiences with their fossil-based heating systems, supplying them over many years reliably with heat. Importance of renewable heating and cooling for the future sustainable development of this target region has been recognized. The marketing campaign would be crucial in delivering the benefits of the implemented activities. However, they should include two-way communication and provide end consumers with additional information on the possibilities and benefits of renewable heating and how to include it in their household. In long term, these campaigns should educate users and be interactive so end consumers can appreciate the benefits of investing in a new heating system, to achieve replacement scenarios by 2030.

3.5 Germany – Bayerisches Oberland

3.5.1 Methodology and information sources

For the input data EWO could fall back on data calculated for the project INOLA, where EWO acted as co-project leader. Within the project INOLA, the distribution of energy sources for three of four districts within the Bavarian Oberland were calculated. By also including statistical data about the development of number of homes for the four districts, we can produce reliable data for the replace calculations.

- **Total homes**
  - "Gebäude- und Wohnungsbestand: Gemeinden, Wohngebäude, Wohnungen, Wohnfläche, Zahl der Wohnungen, Stichtag", Fortschreibung d.Wohngebäude- u.Wohnungsbestandes , **Source: GENESIS Online:** https://www.statistikdaten.bayern.de/genesis/online/data?operation=abruftabelleBearbeiten&levelindex=2&levelid=1582809615874&auswahloperation=abruftabelleAuspraegungAuswaehlen&auswahlverzeichnis=ordnungsstruktur&auswahlziel=werteabruf&selectionname=31231-003r&auswahltext=&werteabruf=starten&nummer=9&variable=9&name=GEMEIN
- **Development of homes 2015-2045:**
  - Project INOLA, Report No. 10: Source: https://inola-region.de/download/a4gs9u1mm0veeq58n7u0578ni7f/INOLA_Arbeitsbericht_Nr10.pdf
- **Distribution of energy sources in Bavarian Oberland (four districts):**
  - Input data of calculation model of project INOLA (2015), (for three districts). Model calculations without district of GAP.
  - Project INOLA, Report No. 01: https://inola-region.de/download/a2s2qgq5dl5a06qu16vbhssovao/INOLA_Arbeitsbericht_Nr1_2018-01-30neu.pdf
  - Project INOLA, Report No. 02: https://inola-region.de/download/av4ce9r81s8d8tkene729vjr0nt/INOLA_Arbeitsbericht_Nr2_2018-01-30neu.pdf
  - Project INOLA, Report No. 09: https://inola-region.de/download/a1n6jnauum7hqdokuddinno4ub0/Sanierungsbericht_final_mitcover_.pdf
  - Extrapolation of the calculated data to four districts with numbers of homes (Source: https://www.statistikdaten.bayern.de/genesis/online/data?operation=abruftabelleBearbeiten&levelindex=2&levelid=1582809615874&auswahloperation=abruftabelleAuspraegungAuswaehlen&auswahlverzeichnis=ordnungsstruktur&auswahlziel=werteabruf&selectionname=31231-003r&auswahltext=&werteabruf=starten&nummer=9&variable=9&name=GEMEIN
- **Heat consumption**
  - Born/Diefenbach/Lola, Institut Wohnen und Umwelt GmbH (IUW): Energieeinsparung durch Verbesserung des Wärmeschutzes und Modernisierun der Heizungsanlage für 31 Musterhäuser der Gebäudetypologie, Studie im Auftrag des ImpulsprogrammsHessen, Endbericht, Darmstadt 2003, URL: http://www.iuw.de/fileadmin/user_upload/dateien/energie/klima_altbau/GebTyp_Impulsogramm_Hessen_22_01_2003.pdf [Stand 27.10.2009]
  - Neuffer/Witterhold: Strategien und Technologien in einer pluralistischen Fern- und Nahwärmeversorgung in einem liberalisierten Energiemarkt unter besonderer Berücksichtigung der Kraft-Wärme-Kopplung und erneuerbarer Energien, AGFW-Hauptstudie - erster Bearbeitungsabschnitt, Band 2: Wärmeversorgung des Gebäudebestandes +

Technologieentwicklung und -Bewetung, Frankfurt/M. 2001, URL: http://www.agfw.de/86.0.html [Stand:28.10.2009]

- Project INOLA, Report No. 10:
  Source: https://inola-region.de/download/a4gs9u1mm0veeq58n7u0578ni7f/INOLA_Arbeitsbericht_Nr10.pdf

- **Boiler Prices:** Verbraucherzentrale Bayern (assoc. PP of replace). Numbers are estimations, and not published, but are empirical values which are used in energy advices within the Bavarian Oberland.
- **Acceptance of Renewable Energies:** Project INOLA, Report No. 6: https://inola-region.de/download/akna5v9ba5kp0e41nc6oba37dtk/INOLA_Arbeitsbericht_Nr6_2018-01-30neu.pdf

3.5.2 Home evolution

Baseline Homes Heating (expected evolution without REPLACE)

	Oil	Electricity	Natural gas	Solid biomass	Heat pumps (7	DH	ST	Others
New/year	817,9964152	0	764,2772476	230,7482425	76,30563574	87,90409237	0	0
Replaced/ year	-1.977	0				0		
2019	49.431	9.313	27.789	11.938	1710	5.163	965	931
2020	48.272	9.313	28.553	12.169	1.786	5.251	965	931
2021	47.113	9.313	29.318	12.399	1.863	5.339	965	931
2022	45.954	9.313	30.082	12.630	1.939	5.427	965	931
2023	44.795	9.313	30.846	12.861	2.015	5.515	965	931
2024	43.636	9.313	31.610	13.092	2.092	5.603	965	931
2025	42.477	9.313	32.375	13.322	2.168	5.690	965	931
2026	41.318	9.313	33.139	13.553	2.244	5.778	965	931
2027	40.159	9.313	33.903	13.784	2.320	5.866	965	931
2028	39.000	9.313	34.667	14.015	2.397	5.954	965	931
2029	37.841	9.313	35.432	14.245	2.473	6.042	965	931
2030	36.682	9.313	36.196	14.476	2.549	6.130	965	931
2031	35.523	9.313	36.960	14.707	2.626	6.218	965	931
2032	34.364	9.313	37.725	14.938	2.702	6.306	965	931
2033	33.205	9.313	38.489	15.168	2.778	6.394	965	931

Table 104. Evolution of home heating systems stock per year (Baseline) Oberland

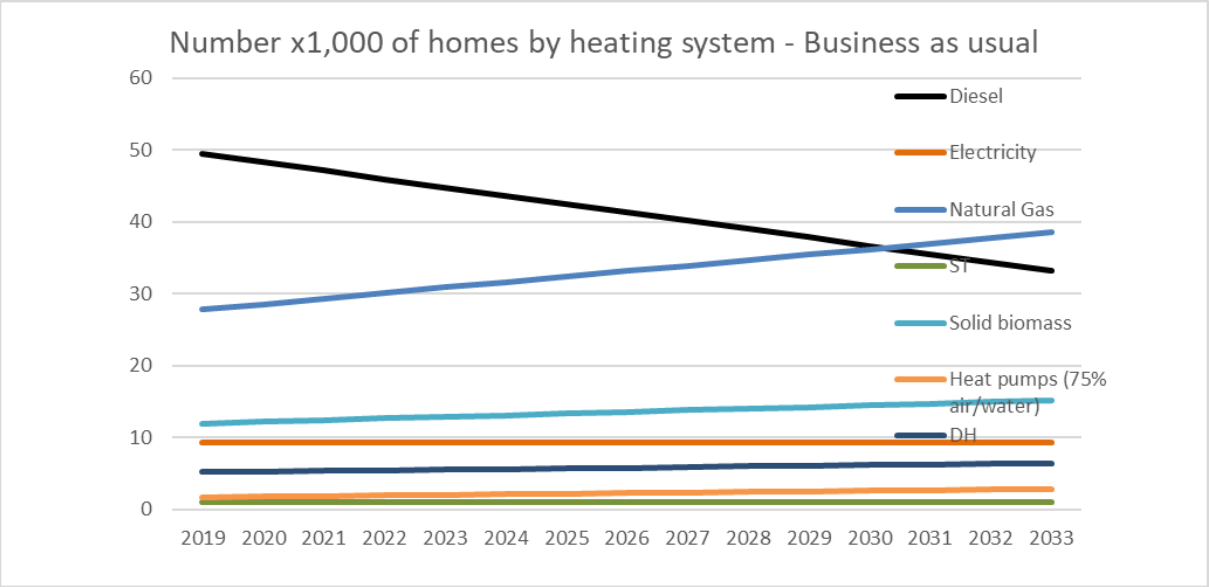

Figure 77. Evolution of home heating systems stock per year (Baseline) Oberland

Total Replace-Scenario Homes (NEW) - Replacement of all fossil fuels

	Oil	Electricity	Natural gas	Solid biomass	Heat pumps (7	DH	ST	Others
New/year	0	0	0	1211,459344	865,3281027	1038,393723	346,1312411	0
Replaced/ year	-1.977	-373	-1.112					
2019	49.431	9.313	27.789	11.938	1710	5.163	965	931
2020	47.454	8.940	26.677	13.149	2.575	6.201	1.311	931
2021	45.477	8.568	25.565	14.361	3.441	7.240	1.657	931
2022	43.500	8.195	24.453	15.572	4.306	8.278	2.003	931
2023	41.523	7.823	23.341	16.784	5.171	9.317	2.350	931
2024	39.546	7.450	22.229	17.995	6.037	10.355	2.696	931
2025	37.569	7.078	21.117	19.207	6.902	11.393	3.042	931
2026	35.592	6.705	20.005	20.418	7.767	12.432	3.388	931
2027	33.615	6.333	18.893	21.630	8.633	13.470	3.734	931
2028	31.638	5.960	17.781	22.841	9.498	14.509	4.080	931
2029	29.661	5.588	16.669	24.053	10.363	15.547	4.426	931
2030	27.684	5.215	15.557	25.264	11.229	16.585	4.772	931
2031	25.707	4.843	14.445	26.476	12.094	17.624	5.119	931
2032	23.730	4.470	13.333	27.687	12.959	18.662	5.465	931
2033	21.753	4.098	12.221	28.898	13.825	19.701	5.811	931

Table 105. Evolution of home heating systems stock per year (Optimistic) Oberland

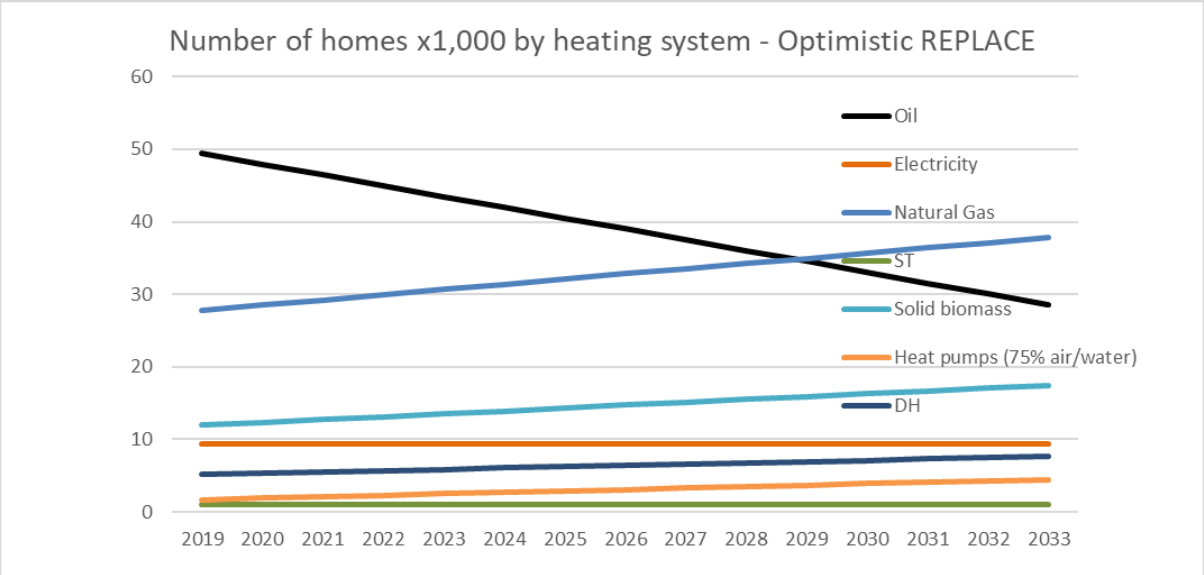

Figure 78. Evolution of home heating systems stock per year (Optimistic) Oberland

Pessimistic Replace-Scenario Homes (Underachieving REPLACE target region objectives)

	Oil	Electricity	Natural gas	Solid biomass	Heat pumps (	DH	ST	Others
New/year	778,2694284	0	750,8010956	350,984252	161,7579596	149,5498117	0	0
Replaced/ year	-2.191							
2019	49.431	9.313	27.789	11.938	1710	5.163	965	931
2020	48.018	9.313	28.540	12.289	1.872	5.313	965	931
2021	46.606	9.313	29.291	12.640	2.034	5.462	965	931
2022	45.193	9.313	30.041	12.991	2.195	5.612	965	931
2023	43.780	9.313	30.792	13.342	2.357	5.761	965	931
2024	42.367	9.313	31.543	13.693	2.519	5.911	965	931
2025	40.955	9.313	32.294	14.044	2.681	6.060	965	931
2026	39.542	9.313	33.045	14.395	2.842	6.210	965	931
2027	38.129	9.313	33.795	14.746	3.004	6.359	965	931
2028	36.716	9.313	34.546	15.097	3.166	6.509	965	931
2029	35.304	9.313	35.297	15.448	3.328	6.658	965	931
2030	33.891	9.313	36.048	15.799	3.489	6.808	965	931
2031	32.478	9.313	36.799	16.150	3.651	6.958	965	931
2032	31.066	9.313	37.549	16.501	3.813	7.107	965	931
2033	29.653	9.313	38.300	16.852	3.975	7.257	965	931

Table 106. Evolution of home heating systems stock per year (Pessimistic) Oberland

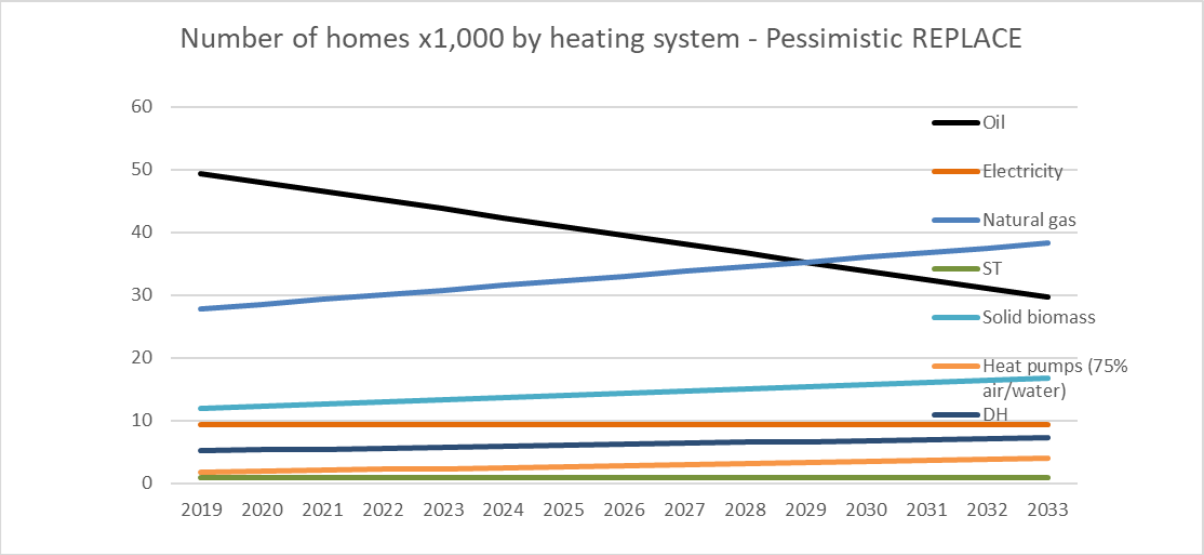

Figure 79. Evolution of home heating systems stock per year (Pessimistic) Oberland

The main source for heating homes in the region of Oberland is fuel oil. Heating systems using this type of fuel are predicted to continue falling in the next decade, which is the main fuel objective to be replaced by the project in the pilot region. It is observed that the opposite happens with the natural gas heating systems. The project estimates between 1977 and 2191 of the region's homes heated with fuel oil will be replaced every year by natural gas, followed by biomass. The inventory estimates that around 1211 biomass heating installations will be installed for homes in this region every year in the best scenario, and around 350 in the worst one.

Energy source	Annual average home heat consumption (kWh)
	kWh/home
Diesel oil	3.500,000
GLP	3.500,000
Natural gas	3.500,000
Electricity	3.500,000
Biomass	3.500,000

Table 107. Annual average home heat consumption, Oberland

Old boiler performance	65%
New biomass boiler performance	75%

	Final energy savings (GWh)	
	Opptimistic Replace vs Business as usual	Pessimistic Replace vs Business as usual
2019	0,0	0,0
2020	0,3	0,2
2021	0,5	0,4
2022	0,8	0,6
2023	1,1	0,8
2024	1,4	1,0
2025	1,6	1,2
2026	1,9	1,3
2027	2,2	1,5
2028	2,4	1,7
2029	2,7	1,9
2030	3,0	2,1
2031	3,2	2,3
2032	3,5	2,5
2033	3,8	2,7

Table 108. Final energy savings, Oberland

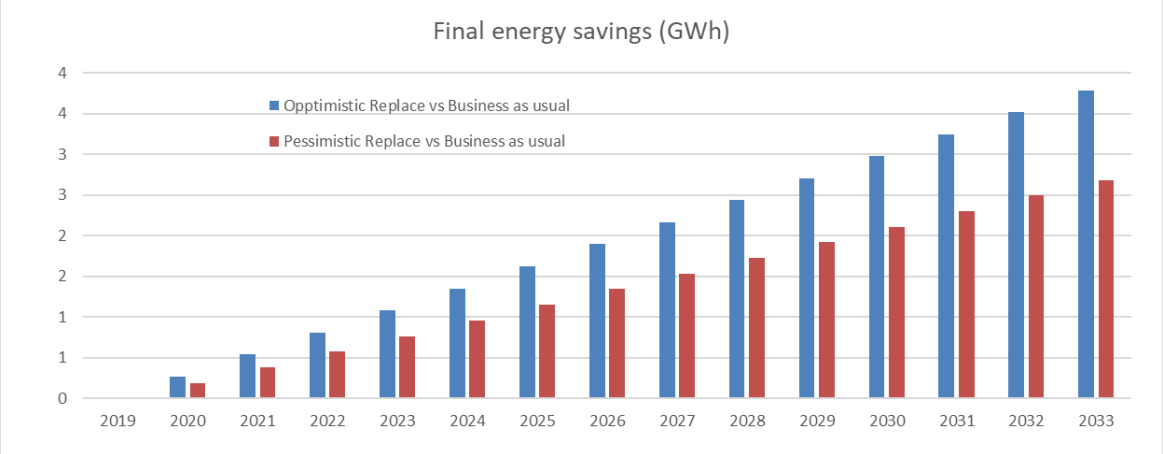

Figure 80. Final energy savings, Oberland

	Additional emissions reduction (tCO2)	
	Opptimistic Replace vs Business as usual	Pessimistic Replace vs Business as usual
2019	0	0
2020	81	58
2021	162	115
2022	244	173
2023	325	230
2024	406	288
2025	487	345
2026	569	403
2027	650	461
2028	731	518
2029	812	576
2030	894	633
2031	975	691
2032	1.056	749
2033	1.137	806

Table 109. Additional emissions reduction, Oberland

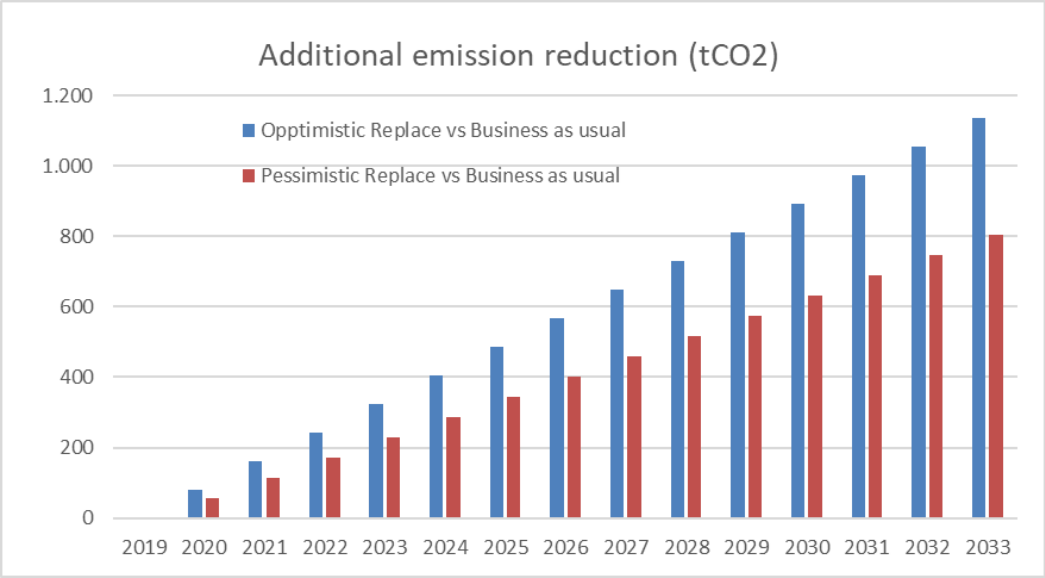

Figure 81. Additional emissions reduction, Oberland

The final energy savings for the optimistic and pessimistic scenarios were calculated considering the number of replacements for homes, the annual average home heat consumption, and the different performance values for the old and new heating systems. By the year 2033, with the assistance of the replace project, the region of Oberland could save between 15 and 21 GWh of energy. This in turn translates to a reduction of emissions in between 4,500 and 6,300 tons of CO2 by the year 2033.

3.5.3 Boiler evolution

	Baseline Individual Boilers (expected evolution without REPLACE)						
	number of individual boilers		number of individual boilers				
	Stock	Stock	Stock of boilers (number, cumulated)				
	Oil	Old other boiler	Natural gas	Solid biomass	Electric heating	HP	ST
	652,8945513		764,2772476	230,7482425		76,30563574	
Replaced/year	-1.578						
2019	39.454	931	27.789	11.938	9.313	1.710	965
2020	38.529	931	28.553	12.169	9.313	1.786	965
2021	37.604	931	29.318	12.399	9.313	1.863	965
2022	36.679	931	30.082	12.630	9.313	1.939	965
2023	35.754	931	30.846	12.861	9.313	2.015	965
2024	34.829	931	31.610	13.092	9.313	2.092	965
2025	33.904	931	32.375	13.322	9.313	2.168	965
2026	32.978	931	33.139	13.553	9.313	2.244	965
2027	32.053	931	33.903	13.784	9.313	2.320	965
2028	31.128	931	34.667	14.015	9.313	2.397	965
2029	30.203	931	35.432	14.245	9.313	2.473	965
2030	29.278	931	36.196	14.476	9.313	2.549	965
2031	28.353	931	36.960	14.707	9.313	2.626	965
2032	27.428	931	37.725	14.938	9.313	2.702	965
2033	26.503	931	38.489	15.168	9.313	2.778	965

Table 110. Evolution of individual boilers stock per year (Baseline) Oberland

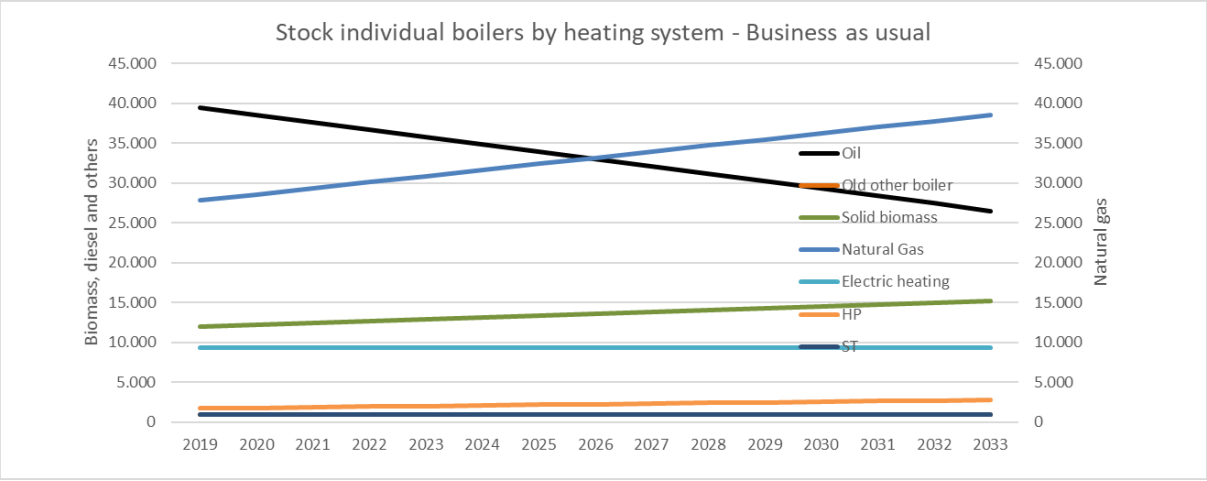

Figure 82. Evolution of individual boilers stock per year (Baseline) Oberland

	Optimistic Replace-Scenario Individual Boilers						
	number of individual boilers		number of individual boilers				
	Stock	Stock	Stock of boilers (number, cumulated)				
	Oil	Old other boiler	Natural gas	Solid biomass	Electric heating	HP	ST
	560,2853545		717,2286889	396,7648066		198,3824033	0
Replaced/year	-1.749						
2019	39.454	931	27.789	11.938	9.313	1.710	965
2020	38.265	931	28.506	12.335	9.313	1.908	965
2021	37.076	931	29.223	12.732	9.313	2.107	965
2022	35.888	931	29.941	13.128	9.313	2.305	965
2023	34.699	931	30.658	13.525	9.313	2.504	965
2024	33.510	931	31.375	13.922	9.313	2.702	965
2025	32.321	931	32.092	14.319	9.313	2.900	965
2026	31.133	931	32.810	14.715	9.313	3.099	965
2027	29.944	931	33.527	15.112	9.313	3.297	965
2028	28.755	931	34.244	15.509	9.313	3.495	965
2029	27.566	931	34.961	15.906	9.313	3.694	965
2030	26.377	931	35.679	16.302	9.313	3.892	965
2031	25.189	931	36.396	16.699	9.313	4.091	965
2032	24.000	931	37.113	17.096	9.313	4.289	965
2033	22.811	931	37.830	17.493	9.313	4.487	965

Table 111. Evolution of individual boilers stock per year (Optimistic) Oberland

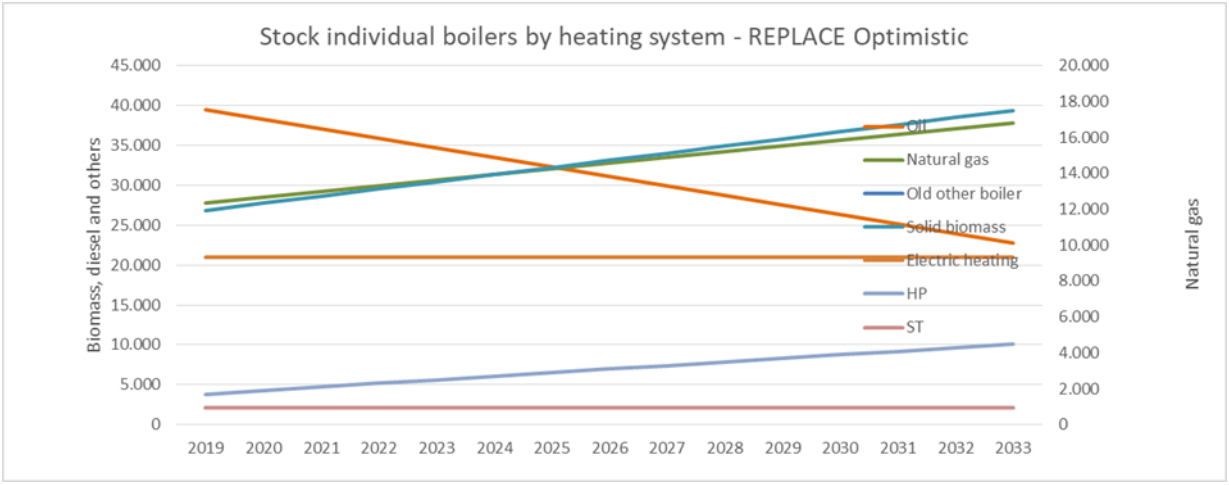

Figure 83. Evolution of individual boilers stock per year (Optimistic) Oberland

	Pessimistic Replace-Scenario Individual Boilers						
	number of individual boilers		number of individual boilers				
	Stock	Stock	Stock of boilers (number, cumulated)				
	Oil	Old other boiler	Natural gas	Solid biomass	Electric heating	HP	ST
	621,1859365		750,8010956	350,984252		161,7579596	0
Replaced/year	-1.749						
2019	39.454	931	27.789	11.938	9.313	1.710	965
2020	38.326	931	28.540	12.289	9.313	1.872	965
2021	37.199	931	29.291	12.640	9.313	2.034	965
2022	36.071	931	30.041	12.991	9.313	2.195	965
2023	34.944	931	30.792	13.342	9.313	2.357	965
2024	33.816	931	31.543	13.693	9.313	2.519	965
2025	32.688	931	32.294	14.044	9.313	2.681	965
2026	31.561	931	33.045	14.395	9.313	2.842	965
2027	30.433	931	33.795	14.746	9.313	3.004	965
2028	29.306	931	34.546	15.097	9.313	3.166	965
2029	28.178	931	35.297	15.448	9.313	3.328	965
2030	27.051	931	36.048	15.799	9.313	3.489	965
2031	25.923	931	36.799	16.150	9.313	3.651	965
2032	24.795	931	37.549	16.501	9.313	3.813	965
2033	23.668	931	38.300	16.852	9.313	3.975	965

Table 112. Evolution of individual boilers stock per year (Pessimistic) Oberland

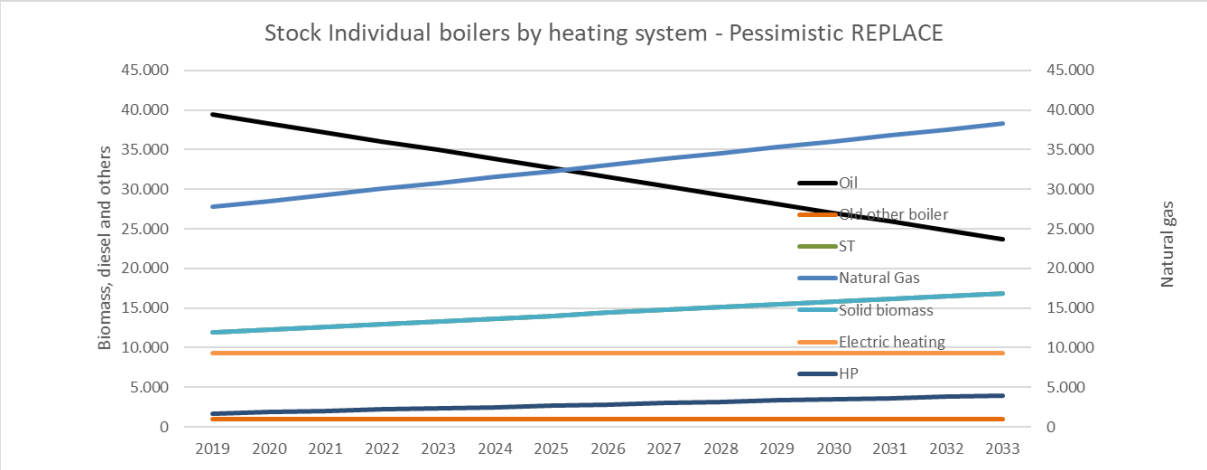

Figure 84. Evolution of individual boilers stock per year (Pessimistic) Oberland

Baseline Colectivel Boilers and DH (expected evolution without REPLACE)					
	number of colective boilers		number of colective boilers		
	Oil	Old other boiler	Natural gas	Solid biomass	Biomass DH
Replaced/year	-395				
New/Year	164	0	150	0	88
2019	9.886		5.558		5.163
2020	9.654	0	5.708	0	5.251
2021	9.422	0	5.858	0	5.339
2022	9.191	0	6.008	0	5.427
2023	8.959	0	6.158	0	5.515
2024	8.727	0	6.308	0	5.603
2025	8.495	0	6.458	0	5.690
2026	8.263	0	6.608	0	5.778
2027	8.032	0	6.758	0	5.866
2028	7.800	0	6.908	0	5.954
2029	7.568	0	7.058	0	6.042
2030	7.336	0	7.208	0	6.130
2031	7.104	0	7.358	0	6.218
2032	6.873	0	7.508	0	6.306
2033	6.641	0	7.658	0	6.394

Table 113. Evolution of collective boilers stock per year (Baseline) Oberland

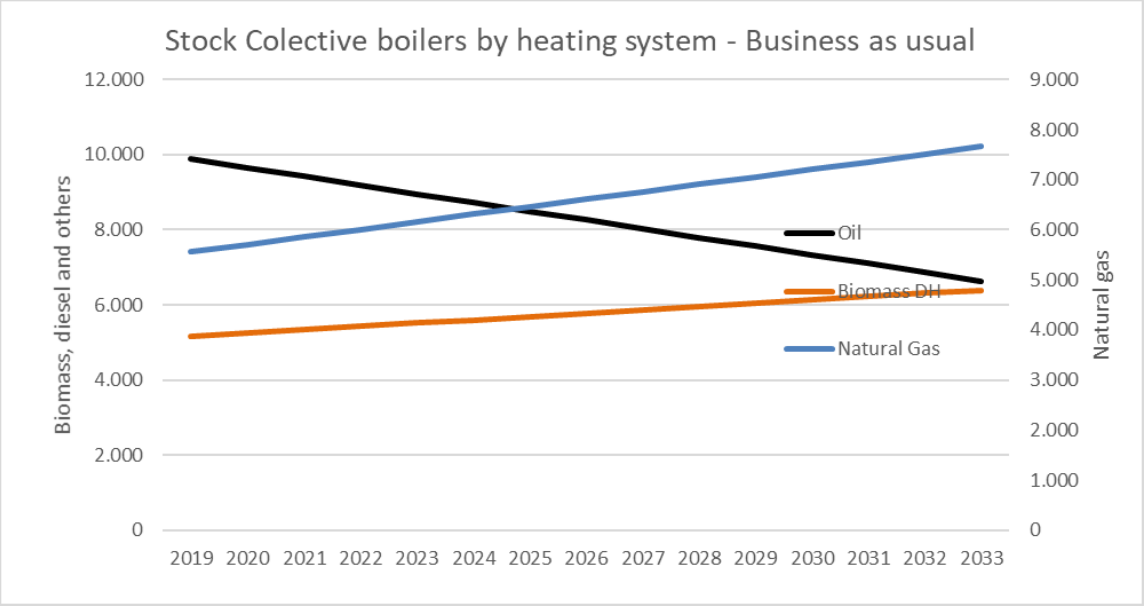

Figure 85. Evolution of collective boilers stock per year (Baseline) Oberland

Optimistic Replace-Scenario Colective Boilers (Overachieving REPLACE target region objectives)						
	number of colective boilers		number of colective boilers			
	Oil	Old other boiler	Natural gas	Solid biomass	Biomass DH	Biomass total
Replaced/year	-438					
New/Year	140	0	191	0	150	
2019	9.886		5.558		5.163	
2020	9.588	0	5.749	0	5.313	5.313
2021	9.290	0	5.940	0	5.462	5.462
2022	8.991	0	6.131	0	5.612	5.612
2023	8.693	0	6.322	0	5.761	5.761
2024	8.395	0	6.513	0	5.911	5.911
2025	8.097	0	6.704	0	6.060	6.060
2026	7.799	0	6.895	0	6.210	6.210
2027	7.500	0	7.086	0	6.359	6.359
2028	7.202	0	7.277	0	6.509	6.509
2029	6.904	0	7.468	0	6.658	6.658
2030	6.606	0	7.659	0	6.808	6.808
2031	6.308	0	7.850	0	6.958	6.958
2032	6.010	0	8.041	0	7.107	7.107
2033	5.711	0	8.232	0	7.257	7.257

Table 114. Evolution of collective boilers stock per year (Optimistic) Oberland

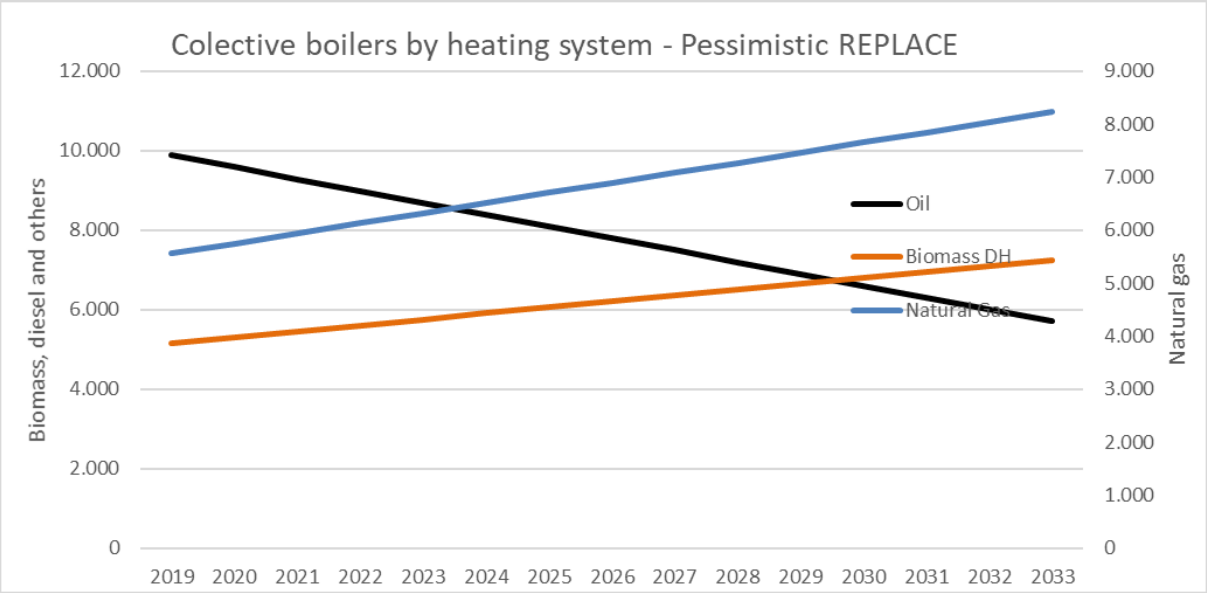

Figure 86. Evolution of collective boilers stock per year (Optimistic) Oberland

Pessimistic Replace-Scenario Colective Boilers (Underachieving REPLACE target region objectives)						
	number of colective boilers		number of colective boilers			
	Oil	Old other boiler	Natural gas	Solid biomass	Biomass DH	Biomass total
Replaced/year	-438					
New/Year	156	0	153	0	133	0
2019	9.886		5.558		5.163	
2020	9.604	0	5.711	0	5.296	5.296
2021	9.321	0	5.864	0	5.430	5.430
2022	9.039	0	6.017	0	5.563	5.563
2023	8.757	0	6.170	0	5.696	5.696
2024	8.475	0	6.323	0	5.829	5.829
2025	8.192	0	6.476	0	5.963	5.963
2026	7.910	0	6.629	0	6.096	6.096
2027	7.628	0	6.782	0	6.229	6.229
2028	7.346	0	6.935	0	6.362	6.362
2029	7.063	0	7.088	0	6.496	6.496
2030	6.781	0	7.241	0	6.629	6.629
2031	6.499	0	7.394	0	6.762	6.762
2032	6.217	0	7.547	0	6.895	6.895
2033	5.934	0	7.700	0	7.029	7.029

Table 115. Evolution of collective boilers stock per year (Pessimistic) Oberland

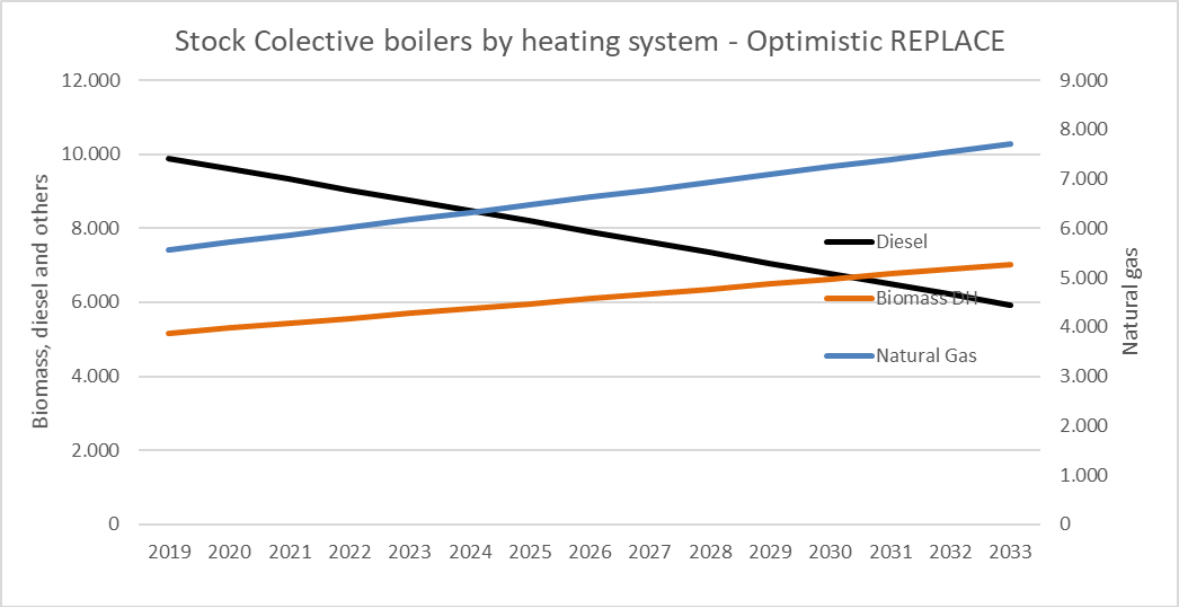

Figure 87. Evolution of collective boilers stock per year (Pessimistic) Oberland

	Baseline District Heating (expected evolution without REPLACE)			
	number of DH boilers		number of DH boilers	
	Oil	Old other boiler	Natural gas	Solid biomass
Replaced/year				68
2019				4.000
2020	0	0	0	5.251
2021	0	0	0	5.339
2022	0	0	0	5.427
2023	0	0	0	5.515
2024	0	0	0	5.603
2025	0	0	0	5.690
2026	0	0	0	5.778
2027	0	0	0	5.866
2028	0	0	0	5.954
2029	0	0	0	6.042
2030	0	0	0	6.130
2031	0	0	0	6.218
2032	0	0	0	6.306
2033	0	0	0	6.394

Table 116. Evolution of district heating stock per year (Baseline) Oberland

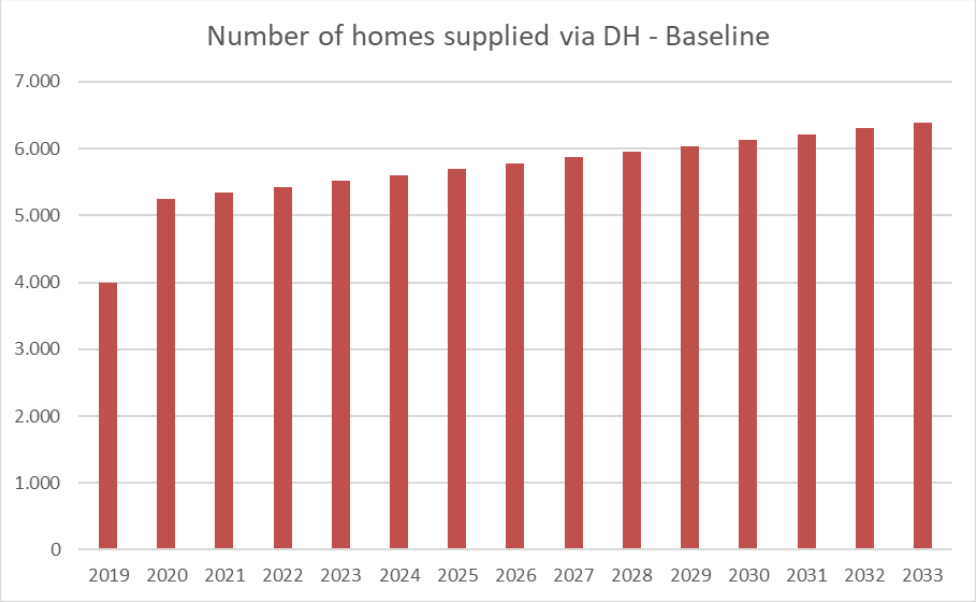

Figure 88. Evolution of district heating stock per year (Baseline) Oberland

Optimistic Replace-Scenario DH Boilers (Overachieving REPLACE target region objectives)				
	number of individual boilers		number of individual boilers	
	Oil	Old other boiler	Natural gas	Solid biomass
Replaced/year				150
2019				5.163
2020	0	0	0	5.313
2021	0	0	0	5.462
2022	0	0	0	5.612
2023	0	0	0	5.761
2024	0	0	0	5.911
2025	0	0	0	6.060
2026	0	0	0	6.210
2027	0	0	0	6.359
2028	0	0	0	6.509
2029	0	0	0	6.658
2030	0	0	0	6.808
2031	0	0	0	6.958
2032	0	0	0	7.107
2033	0	0	0	7.257

Table 117. Evolution of district heating stock per year (Optimistic) Oberland

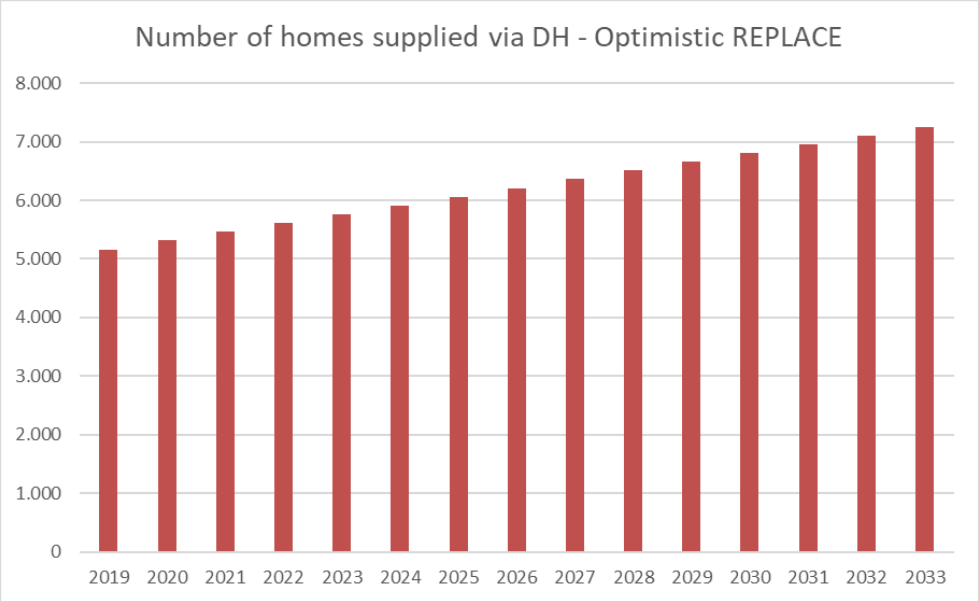

Figure 89. Evolution of district heating stock per year (Optimistic) Oberland

Pessimistic Replace-Scenario DH Boilers (Underachieving REPLACE target region objectives)				
	number of individual boilers		number of individual boilers	
	Oil	Old other boiler	Natural gas	Solid biomass
Replaced/year				
				133
2019				5.163
2020	0	0	0	5.296
2021	0	0	0	5.430
2022	0	0	0	5.563
2023	0	0	0	5.696
2024	0	0	0	5.829
2025	0	0	0	5.963
2026	0	0	0	6.096
2027	0	0	0	6.229
2028	0	0	0	6.362
2029	0	0	0	6.496
2030	0	0	0	6.629
2031	0	0	0	6.762
2032	0	0	0	6.895
2033	0	0	0	7.029

Table 118. Evolution of district heating stock per year (Pessimistic) Oberland

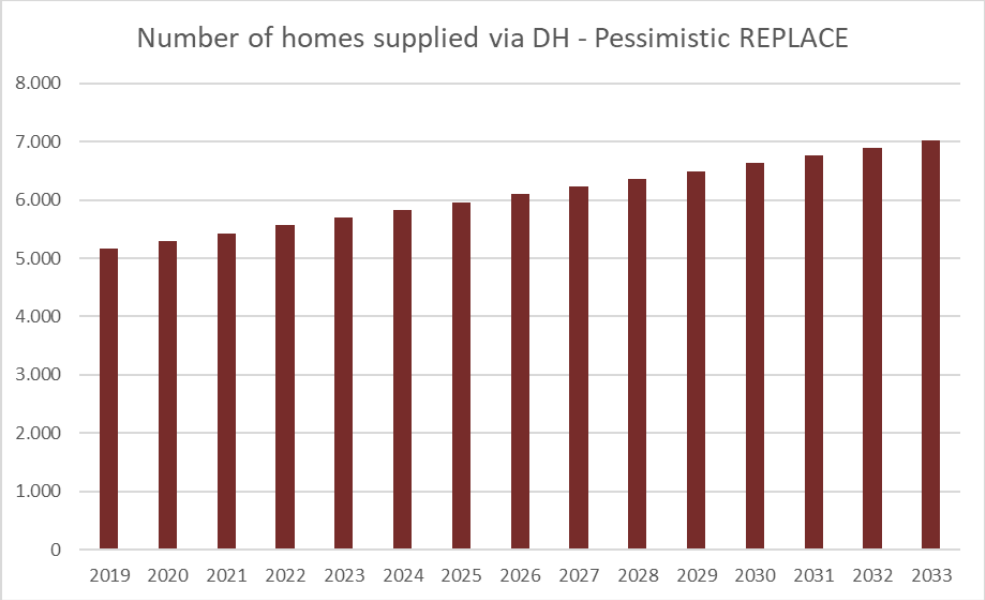

Figure 90. Evolution of district heating stock per year (Pessimistic) Oberland

For individual boilers we can see a similar scenario to the home evolution situation. Mainly, fuel oil boilers are being replaced by natural gas boilers, followed by biomass boilers and some heat pumps.

Collective boilers are not common in the region, but they follow a similar trend as the individual boilers. Old fuel oil collective boilers are being replaced by natural gas collective boilers and by biomass district heating.

3.5.4 Investment/Economics

	Average boiler power	Price (€/kWh) only boiler	Price (€/kWh) biomass turnkey system
Individual boilers (P<50kW)	40	400	900
Colective boilers (P>50kW)	500	300	800
Distrcit Heating boilers	2200	200	700

Table 119. Average boiler prices, Oberland

	Number of boilers increased by REPLACE		Annual REPLACE (€) investment only in boilers		Annual REPLACE (€) turnkey project investment	
	Optimist	Pessimist	Optimist	Pessimist	Optimist	Pessimist
Individual boilers (P<50kW)	166	120	2.656.265	1.923.776	5.976.596	4.328.496
Colective boilers (P>50kW)	41	3	6.150.000	450.000	16.400.000	1.200.000
Distrcit Heating boilers	62	45	27.124.117	19.954.851	94.934.408	69.841.979
Total investment Mio€			35,9	22,3	117,3	75,4

Table 120. Annual Replace investment triggered, Oberland

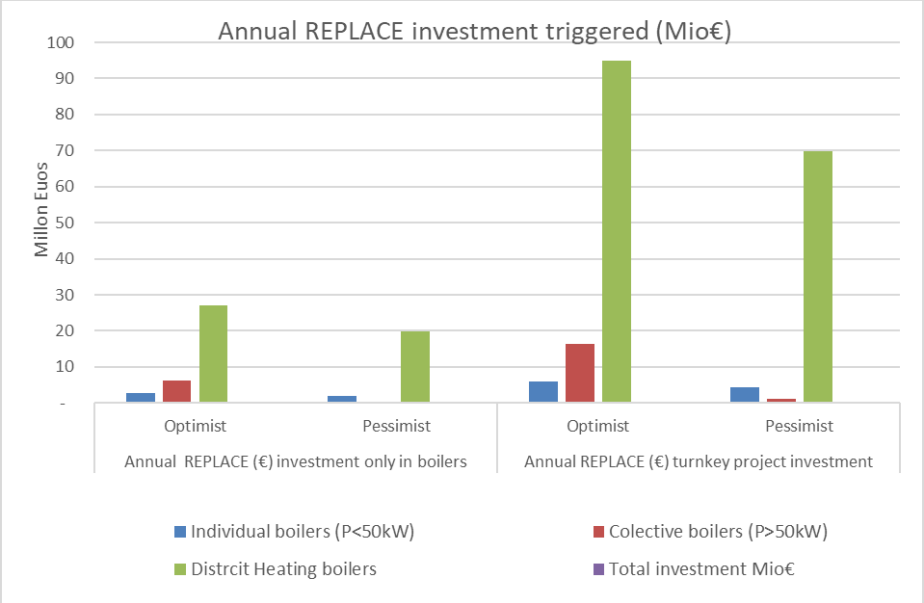

Figure 91. Annual Replace investment triggered, Oberland

The average power for individual boilers in the region of Oberland is 40 kW and depending on if it includes a turnkey system, the price per kW of power can reach up to 900 Euros.

The average power for collective boilers is 500 kW. The price for the turnkey systems can reach up to 800 Euros per kW installed.

The average power for district heating systems is 2200 kW. The price for the turnkey systems can reach up to 700 Euros per kW installed.

3.5.5 Main conclusions

In 2019, about 20% of private houses in the pilot region were heated by renewable energies. A lot of heating systems are old and inefficient and must be replaced within the next years. Climate protection is very important to the people living in the Bavarian Oberland, and renewable energies are highly accepted (see INOLA Report No. 6).

The legal basis for replacing oil boilers is quite good: According to the law, the installation of new oil heating systems will be prohibited from 2026. Nevertheless, oil heating will not have completely disappeared by 2050, as the lifetime of the plants must be counted with at least 25 years.

Challenge for a further replacement of fossil fuels is the low oil price, but the CO2 taxation will lead to increased costs for fossil fuels in the future.

At the moment, there are many programs with state subsidies that private households can apply for when switching to renewable energies. Nevertheless, people give as an obstacle for changing their existing system the financial investment for new systems and the satisfaction with their running system. If all existing funds were used, the turnaround would be easy to implement without great financial outlay.

Therefore, consumers must get independent and qualified advice for existing subsidies and systems. Through bundled advice, and field trips and open house events there can be drawn attention to the wide variety of renewable systems and financial support.

Replacing heating systems without the use of gas would be desirable but is at the moment not accepted in the pilot region.

To foster the replacement of old inefficient fossil fuel systems to renewable energy heating systems replace offers a wide range of solutions, which are implemented within the pilot region Bavarian Oberland.

3.6 Macedonia – Skopje

3.6.1 Methodology and information sources

(The data used for KAGoP region was obtained from several sources. Key studies that provide information for types and number of heating systems in the municipalities were:

- Study for techno-economic feasible and environmentally friendly structure and district heating system for heating and domestic hot water in the City of Skopje
- Study for heating systems in the city of Skopje: policy and measure analysis
- Analysis of energy requirements for heating of residential buildings in the municipalities

These studies were justified with an expert judgement. Namely each municipal representative that is part of the Local working group is involved in the Sector for Energy efficiency of the respective municipality as well. Therefore, they have better insight what is the current heating situation on local level.

3.6.2 Home evolution

	Baseline Homes Heating (expected evolution without REPLACE)						
	Old Diesel	Old other boile	Natural gas	Solid biomass	Heat pumps (7	Biomass DH	Biomass total
Replaced/year	-50	-247	30	50	240	10	60
2019	645	8,000	954	6,800	0	0	6,800
2020	595	7,753	984	6,850	240	0	6,850
2021	545	7,506	1,014	6,900	480	0	6,900
2022	495	7,259	1,044	6,950	720	0	6,950
2023	445	7,012	1,074	7,000	960	0	7,000
2024	395	6,765	1,104	7,050	1,200	0	7,050
2025	345	6,518	1,134	7,100	1,440	100	7,200
2026	295	6,271	1,164	7,150	1,680	110	7,260
2027	245	6,024	1,194	7,200	1,920	120	7,320
2028	195	5,777	1,224	7,250	2,160	130	7,380
2029	145	5,530	1,254	7,300	2,400	140	7,440
2030	95	5,283	1,284	7,350	2,640	150	7,500
2031	45	5,036	1,314	7,400	2,880	160	7,560
2032	0	4,789	1,344	7,450	3,120	170	7,620
2033	0	4,542	1,374	7,500	3,360	180	7,680

Table 121. Evolution of home heating systems stock per year (Baseline) Skopje

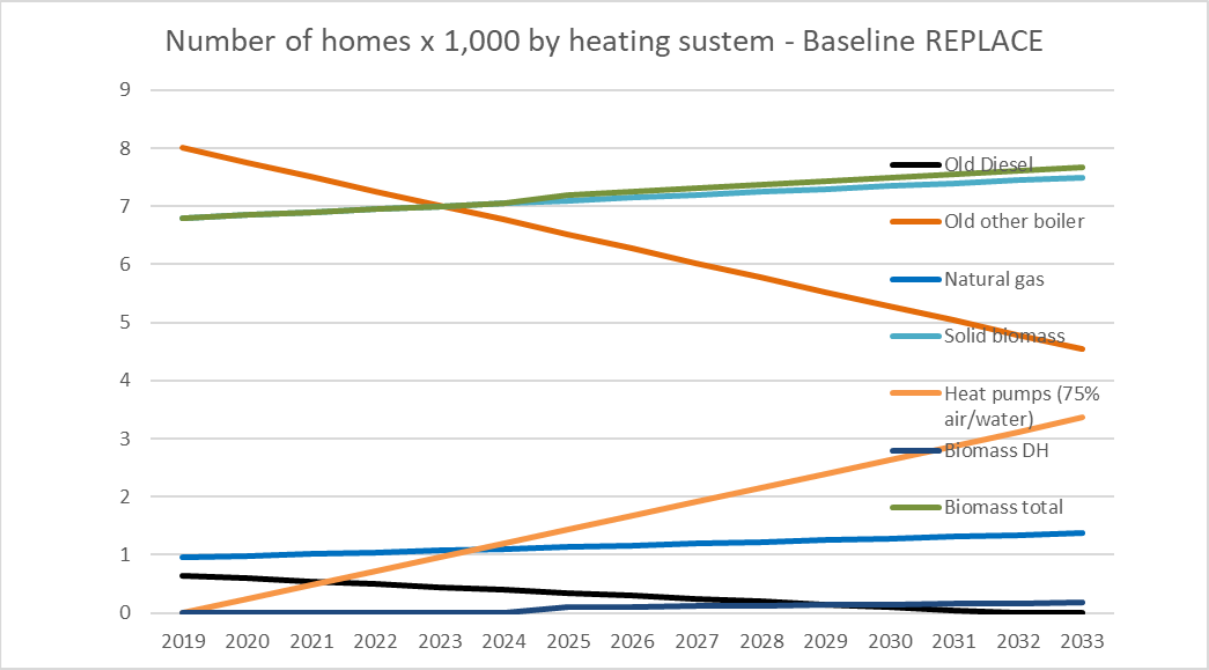

Figure 92. Evolution of home heating systems stock per year (Baseline) Skopje

Optimistic Replace-Scenario Homes (Overachieving REPLACE target region objectives)

	Old Diesel	Old other boile	Natural gas	Solid biomass	Heat pumps (7	Biomass DH	Biomass total
Replaced/year	-140	-441	140	120	420	20	140
2019	645	8,000	954	6,800	0	0	6,800
2020	505	7,559	1,094	6,920	420	0	6,920
2021	365	7,118	1,234	6,970	660	0	6,970
2022	225	6,677	1,374	7,090	900	0	7,090
2023	85	6,236	1,514	7,210	1,140	0	7,210
2024	0	5,795	1,654	7,330	1,380	0	7,330
2025	0	5,354	1,794	7,450	1,620	100	7,550
2026	0	4,913	1,934	7,570	1,860	120	7,690
2027	0	4,472	2,074	7,690	2,100	140	7,830
2028	0	4,031	2,214	7,810	2,340	160	7,970
2029	0	3,590	2,354	7,930	2,580	180	8,110
2030	0	3,149	2,494	8,050	2,820	200	8,250
2031	0	2,708	2,634	8,170	3,060	220	8,390
2032	0	2,267	2,774	8,290	3,300	240	8,530
2033	0	1,826	2,914	8,410	3,540	260	8,670

Table 122. Evolution of home heating systems stock per year (Optimistic) Skopje

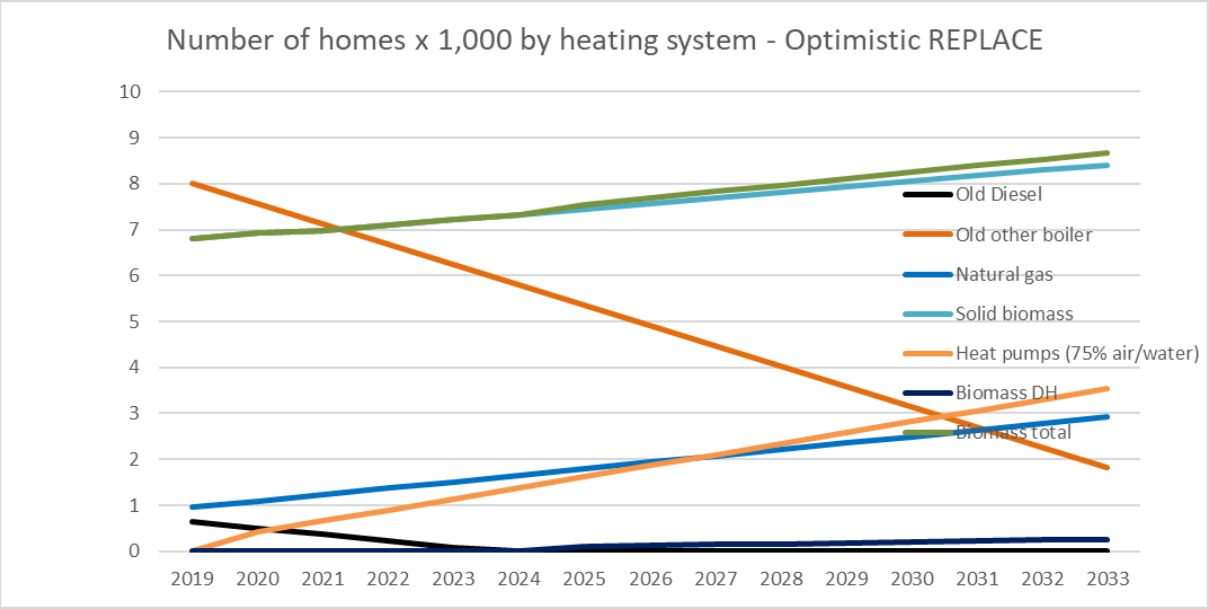

Figure 93. Evolution of home heating systems stock per year (Optimistic) Skopje

Pessimistic Replace-Scenario Homes (Underachieving REPLACE target region objectives)

	Old Diesel	Old other boile	Natural gas	Solid biomass	Heat pumps (7	Biomass DH	Biomass total
Replaced/year	-100	-350	110	100	300	0	100
2019	645	8,000	954	6,800	0	0	6,800
2020	545	7,650	1,064	6,900	300	0	6,900
2021	445	7,300	1,174	7,000	600	0	7,000
2022	345	6,950	1,284	7,100	900	0	7,100
2023	245	6,600	1,394	7,200	1,200	0	7,200
2024	145	6,250	1,504	7,300	1,500	0	7,300
2025	45	5,900	1,614	7,400	1,800	100	7,500
2026	0	5,550	1,724	7,500	2,100	100	7,600
2027	0	5,200	1,834	7,600	2,400	100	7,700
2028	0	4,850	1,944	7,700	2,700	100	7,800
2029	0	4,500	2,054	7,800	3,000	100	7,900
2030	0	4,150	2,164	7,900	3,300	100	8,000
2031	0	3,800	2,274	8,000	3,600	100	8,100
2032	0	3,450	2,384	8,100	3,900	100	8,200
2033	0	3,100	2,494	8,200	4,200	100	8,300

Table 123. Evolution of home heating systems stock per year (Pessimistic) Skopje

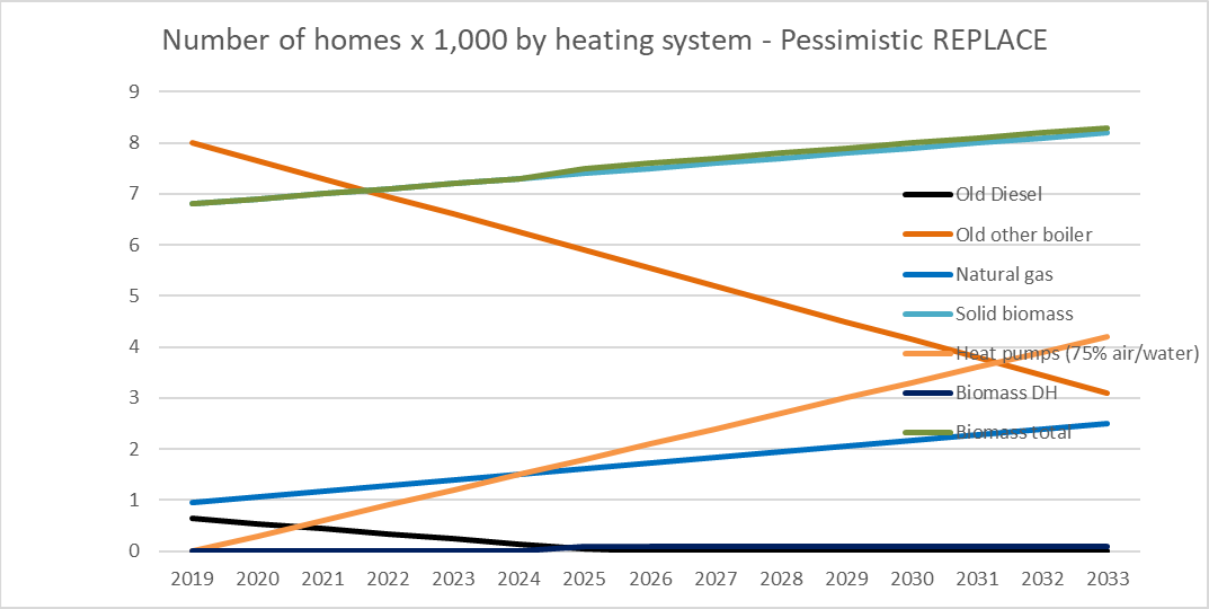

Figure 94. Evolution of home heating systems stock per year (Pessimistic) Skopje

The main source for heating homes in the region of Skopje is biomass. Heating systems using this type of fuel are predicted to continue rising in the next decade. It is observed that the opposite happens with the fuel oil and old heating systems, which is the main fuel objective to be replaced by the project in the pilot region. The project estimates between 300 and 420 of the region's homes heated with this fuel being replaced by heat pumps, followed by biomass and natural gas. The inventory estimates that around 120 biomass heating installations will be installed for homes in this region every year in the best scenario, and around 100 in the worst one.

Energy source	Annual average home heat consumption (kWh)
	kWh/home
Diesel oil	6.482,000
GLP	6.482,000
Natural gas	6.482,000
Electricity	6.482,000
Biomass	6.482,000

Table 124. Annual average home heat consumption, Skopje

Old boiler performance	65%	
New biomass boiler performance	75%	
	Final energy savings (GWh)	
	Opptimistic Replace vs Business as usual	Pessimistic Replace vs Business as usual
2019	0,0	0,0
2020	0,1	0,1
2021	0,1	0,1
2022	0,2	0,2
2023	0,3	0,3
2024	0,4	0,3
2025	0,5	0,4
2026	0,6	0,5
2027	0,7	0,5
2028	0,8	0,6
2029	0,9	0,6
2030	1,0	0,7
2031	1,1	0,7
2032	1,2	0,8
2033	1,3	0,8

Table 125. Final energy savings, Skopje

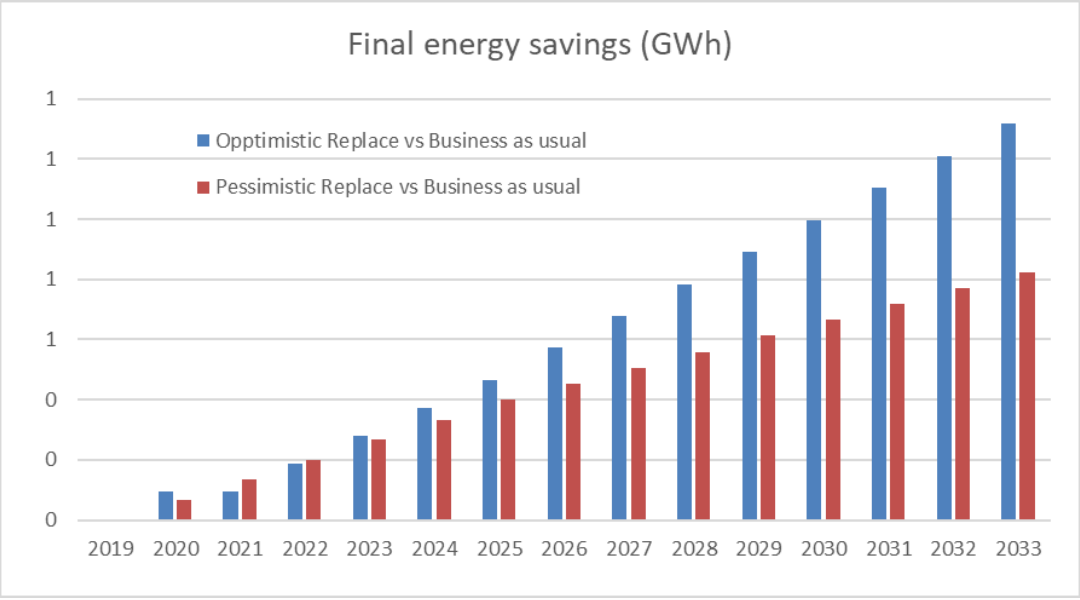

Figure 95. Final energy savings, Skopje

	Additional emissions reduction (tCO2)	
	Opptimistic Replace vs Business as usual	Pessimistic Replace vs Business as usual
2019	0	0
2020	28	20
2021	28	40
2022	56	60
2023	84	80
2024	112	100
2025	140	120
2026	172	136
2027	203	152
2028	235	168
2029	267	183
2030	299	199
2031	331	215
2032	363	231
2033	395	247

Table 126. Additional emissions reduction, Skopje

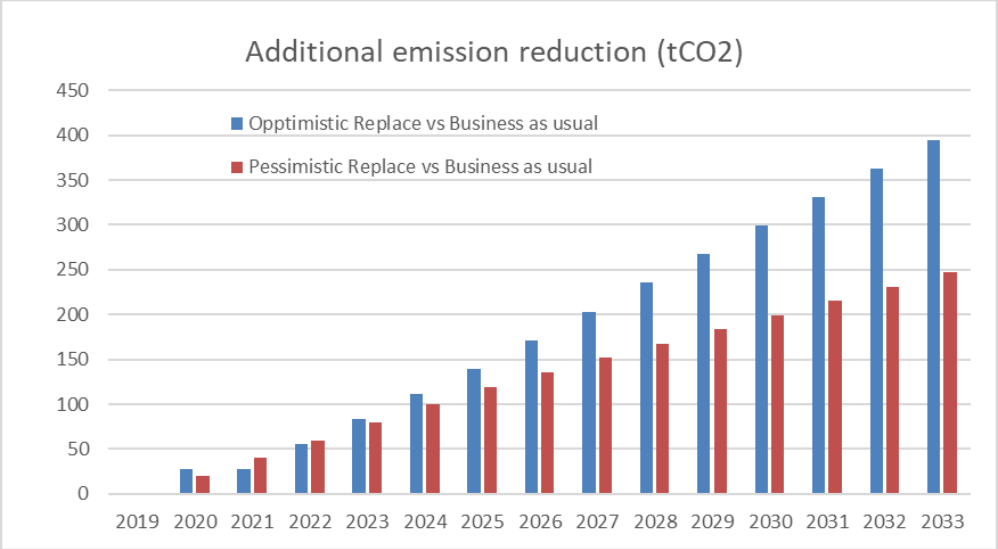

Figure 96. Additional emissions reduction, Skopje

The final energy savings for the optimistic and pessimistic scenarios were calculated considering the number of replacements for homes, the annual average home heat consumption, and the different performance values for the old and new heating systems. By the year 2033, with the assistance of the replace project, the region of Skopje could save around 5.7 GWh of energy. This in turn translates to a reduction of emissions of 1,668 tons of CO2 by the year 2033.

3.6.3 Boiler evolution

	Baseline Individual Boilers (expected evolution without REPLACE)				
	number of individual boilers		number of individual boilers		
	Stock	Stock	Stock of boilers (number, cumulated)		
	Old Diesel	Old other boiler	Natural gas	Solid biomass	Electric heating
Replaced/year	-40	-157	18	35	21
2019	545	7.000	800	5.000	4.200
2020	505	6.843	818	5.035	4.221
2021	465	6.686	836	5.070	4.242
2022	425	6.529	854	5.105	4.263
2023	385	6.372	872	5.140	4.284
2024	345	6.215	890	5.175	4.305
2025	305	6.058	908	5.210	4.326
2026	265	5.901	926	5.245	4.347
2027	225	5.744	944	5.280	4.368
2028	185	5.587	962	5.315	4.389
2029	145	5.430	980	5.350	4.410
2030	105	5.273	998	5.385	4.431
2031	65	5.116	1.016	5.420	4.452
2032	25	4.959	1.034	5.455	4.473
2033	-15	4.802	1.052	5.490	4.494

Table 127. Evolution of individual boilers stock per year (Baseline) Skopje

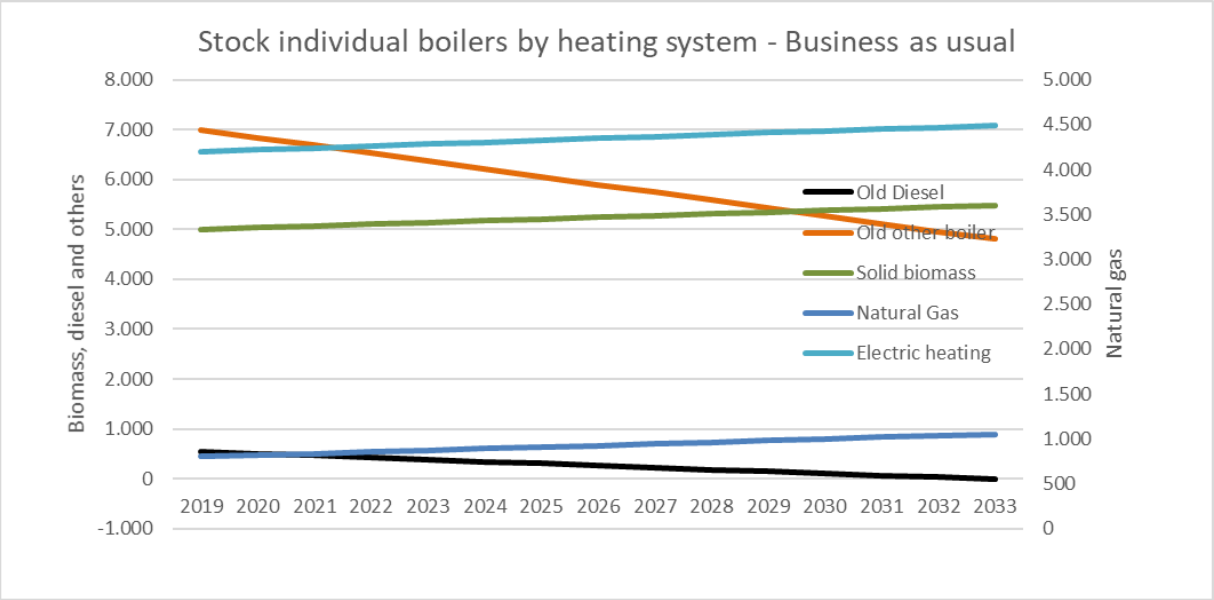

Figure 97. Evolution of individual boilers stock per year (Baseline) Skopje

	Optimistic Replace-Scenario Individual Boilers				
	number of individual boilers		number of individual boilers		
	Stock	Stock	Stock of boilers (number, cumulated)		
	Old Diesel	Old other boiler	Natural gas	Solid biomass	Electric heating
Replaced/year	-140	-441	140	120	-50
2019	545	7.000	800	5.000	4.200
2020	505	6.843	818	5.120	4.221
2021	465	6.686	836	5.240	4.242
2022	325	6.245	976	5.360	4.192
2023	185	5.804	1.116	5.480	4.142
2024	45	5.363	1.256	5.600	4.092
2025	-95	4.922	1.396	5.720	4.042
2026	-235	4.481	1.536	5.840	3.992
2027	-375	4.040	1.676	5.960	3.942
2028	-515	3.599	1.816	6.080	3.892
2029	-655	3.158	1.956	6.200	3.842
2030	-795	2.717	2.096	6.320	3.792
2031	-935	2.276	2.236	6.440	3.742
2032	-1.075	1.835	2.376	6.560	3.692
2033	-1.215	1.394	2.516	6.680	3.642

Table 128. Evolution of individual boilers stock per year (Optimistic) Skopje

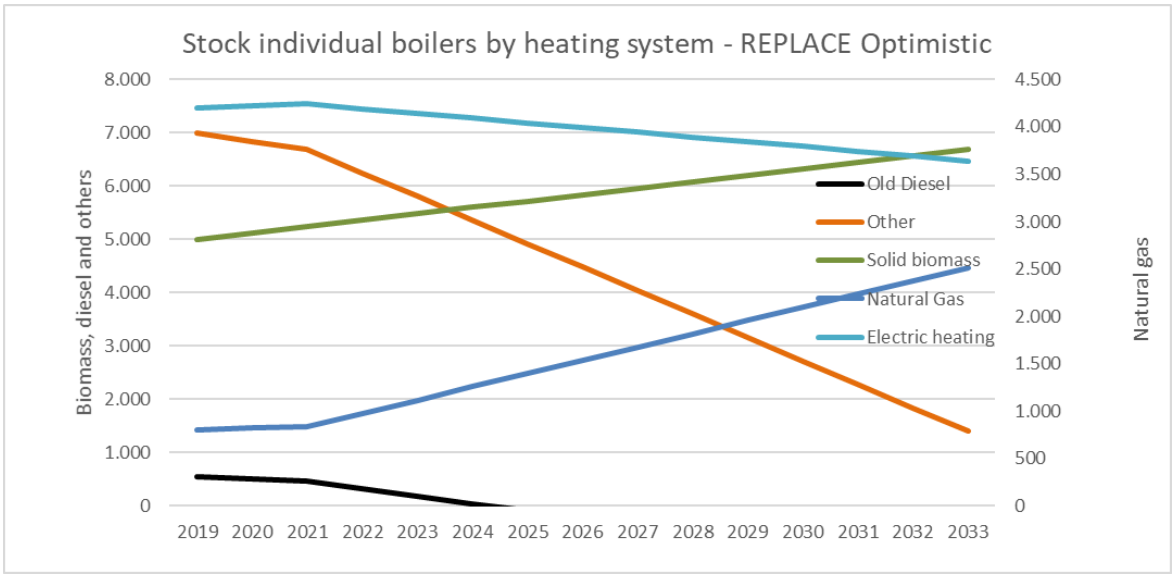

Figure 98. Evolution of individual boilers stock per year (Optimistic) Skopje

	Pessimistic Replace-Scenario Individual Boilers				
	number of individual boilers		number of individual boilers		
	Stock	Stock	Stock of boilers (number, cumulated)		
	Old Diesel	Old other boiler	Natural gas	Solid biomass	Electric heating
Replaced/year	-100	-350	110	100	-20
2019	545	7.000	800	5.000	4.200
2020	445	6.650	910	5.100	4.180
2021	345	6.300	1.020	5.200	4.160
2022	245	5.950	1.130	5.300	4.140
2023	145	5.600	1.240	5.400	4.120
2024	45	5.250	1.350	5.500	4.100
2025	-55	4.900	1.460	5.600	4.080
2026	-155	4.550	1.570	5.700	4.060
2027	-255	4.200	1.680	5.800	4.040
2028	-355	3.850	1.790	5.900	4.020
2029	-455	3.500	1.900	6.000	4.000
2030	-555	3.150	2.010	6.100	3.980
2031	-655	2.800	2.120	6.200	3.960
2032	-755	2.450	2.230	6.300	3.940
2033	-855	2.100	2.340	6.400	3.920

Table 129. Evolution of individual boilers stock per year (Pessimistic) Skopje

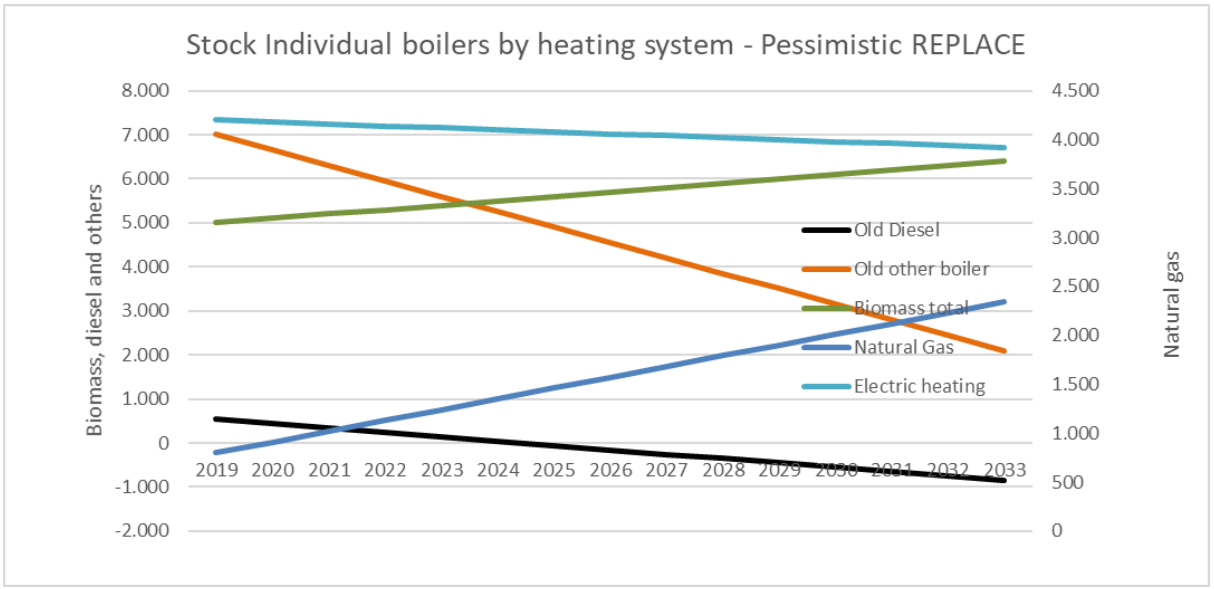

Figure 99. Evolution of individual boilers stock per year (Pessimistic) Skopje

	Baseline Colectivel Boilers and DH (expected evolution without REPLACE)					
	number of colective boilers		number of colective boilers			
	Old Diesel	Old other boiler	Natural gas	Solid biomass	Biomass DH	Biomass total
Replaced/year	-10	-90	12	15	2	17
2019	100	1.000	154	1.800	0	1.800
2020	90	910	166	1.815	2	1.817
2021	80	820	178	1.830	4	1.834
2022	70	730	190	1.845	6	1.851
2023	60	640	202	1.860	8	1.868
2024	50	550	214	1.875	10	1.885
2025	40	460	226	1.890	12	1.902
2026	30	370	238	1.905	14	1.919
2027	20	280	250	1.920	16	1.936
2028	10	190	262	1.935	18	1.953
2029	0	100	274	1.950	20	1.970
2030	-10	10	286	1.965	22	1.987
2031	-20	-80	298	1.980	24	2.004
2032	-30	-170	310	1.995	26	2.021
2033	-40	-260	322	2.010	28	2.038

Table 130. Evolution of collective boilers stock per year (Baseline) Skopje

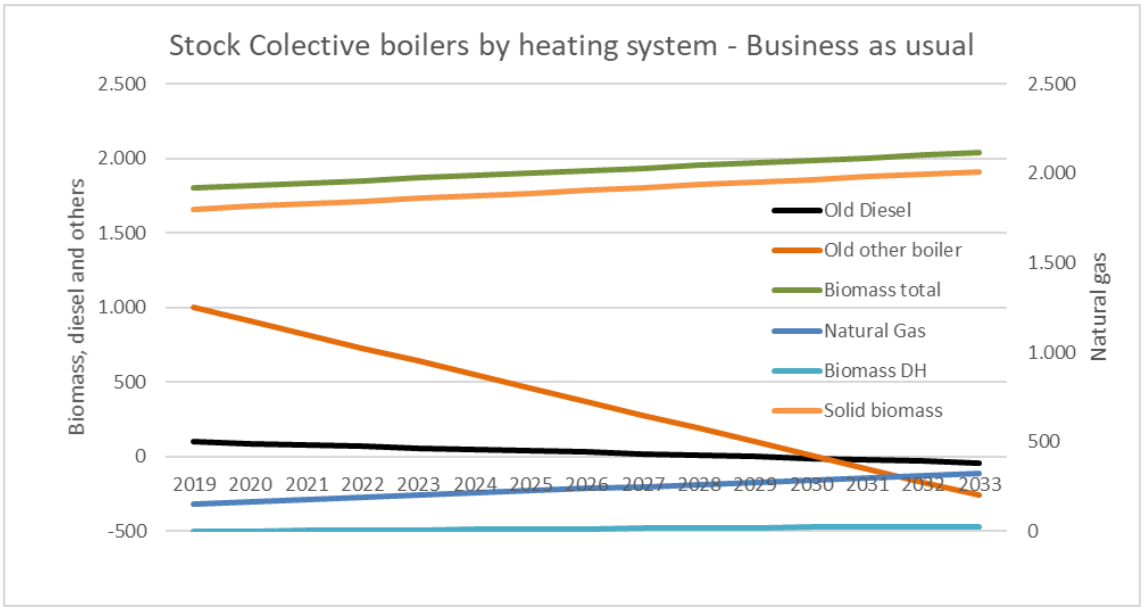

Figure 100. Evolution of collective boilers stock per year (Baseline) Skopje

	Optimistic Replace-Scenario Colective Boilers (Overachieving REPLACE target region objectives)					
	number of colective boilers		number of colective boilers			
	Old Diesel	Old other boiler	Natural gas	Solid biomass	Biomass DH	Biomass total
Replaced/year	-30	-110	20	22	10	32
2019	100	1.000	154	1.800	0	1.800
2020	70	910	166	1.822	10	1.832
2021	40	800	178	1.844	20	1.864
2022	10	690	198	1.866	30	1.896
2023	-20	580	218	1.888	40	1.928
2024	-50	470	238	1.910	50	1.960
2025	-80	360	258	1.932	60	1.992
2026	-110	250	278	1.954	70	2.024
2027	-140	140	298	1.976	80	2.056
2028	-170	30	318	1.998	90	2.088
2029	-200	-80	338	2.020	100	2.120
2030	-230	-190	358	2.042	110	2.152
2031	-260	-300	378	2.064	120	2.184
2032	-290	-410	398	2.086	130	2.216
2033	-320	-520	418	2.108	140	2.248

Table 131. Evolution of collective boilers stock per year (Optimistic) Skopje

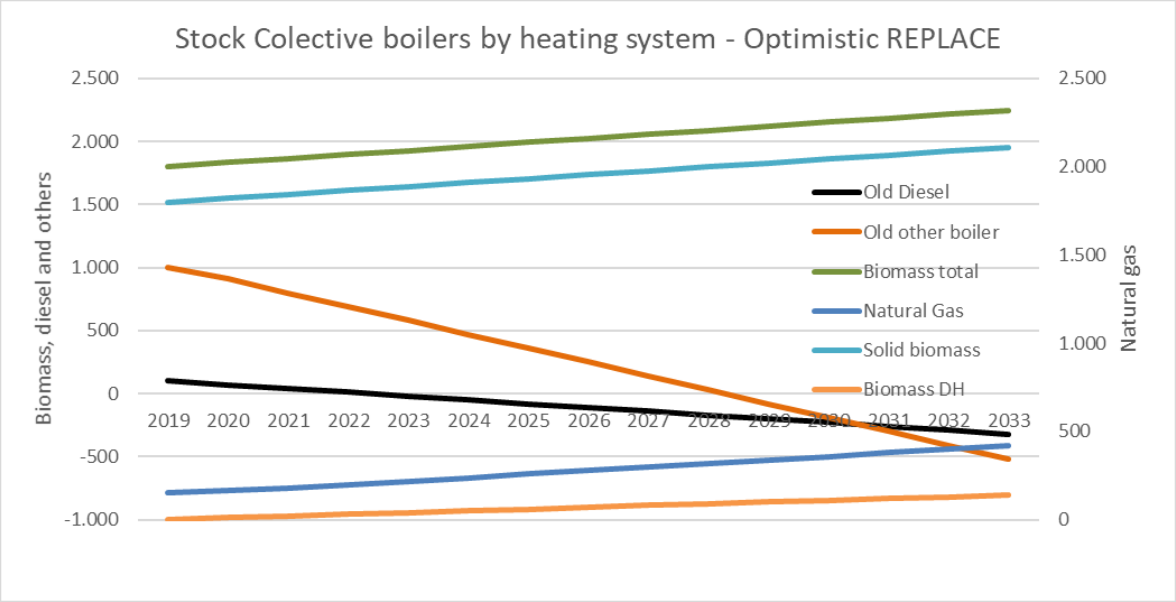

Figure 101. Evolution of collective boilers stock per year (Optimistic) Skopje

	Pessimistic Replace-Scenario Colective Boilers (Underachieving REPLACE target region objectives)					
	number of colective boilers		number of colective boilers			
	Old Diesel	Old other boiler	Natural gas	Solid biomass	Biomass DH	Biomass total
Replaced/year	-20	-100	15	18	6	24
2019	100	1.000	154	1.800	0	1.800
2020	80	900	169	1.818	6	1.824
2021	60	800	184	1.836	12	1.848
2022	40	700	199	1.854	18	1.872
2023	20	600	214	1.872	24	1.896
2024	0	500	229	1.890	30	1.920
2025	-20	400	244	1.908	36	1.944
2026	-40	300	259	1.926	42	1.968
2027	-60	200	274	1.944	48	1.992
2028	-80	100	289	1.962	54	2.016
2029	-100	0	304	1.980	60	2.040
2030	-120	-100	319	1.998	66	2.064
2031	-140	-200	334	2.016	72	2.088
2032	-160	-300	349	2.034	78	2.112
2033	-180	-400	364	2.052	84	2.136

Table 132. Evolution of collective boilers stock per year (Pessimistic) Skopje

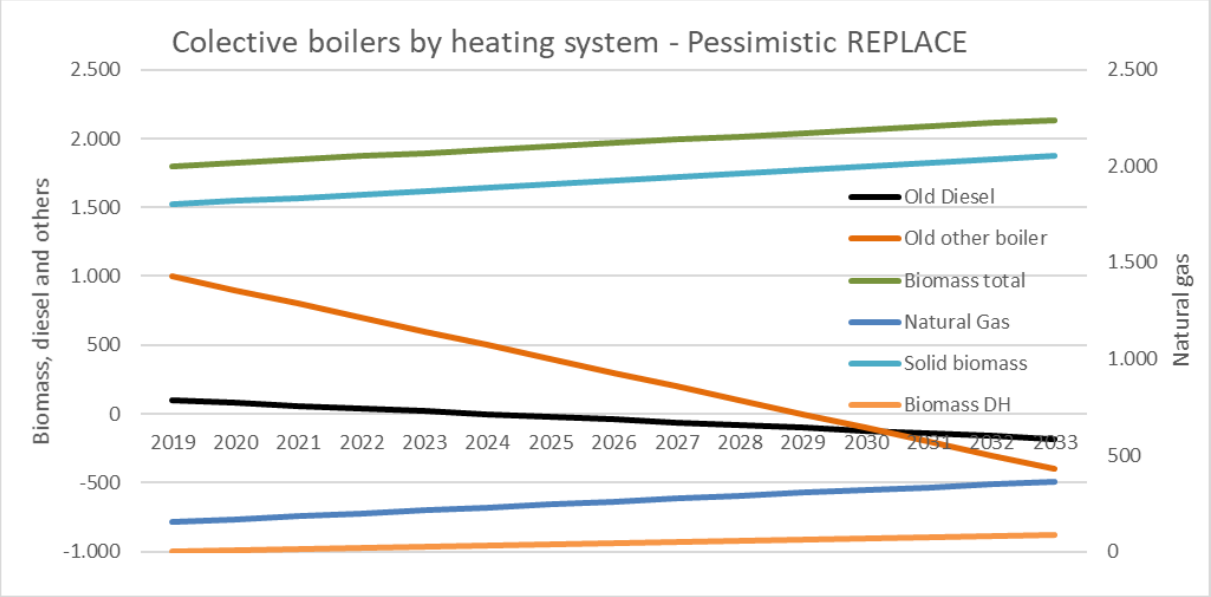

Figure 102. Evolution of collective boilers stock per year (Pessimistic) Skopje

Baseline District Heating (expected evolution without REPLACE)				
	number of DH boilers		**number of DH boilers**	
	Old Diesel	Old other boiler	Natural gas	Solid biomass
Replaced/year				2
2019				0
2020	0	0	0	0
2021	0	0	0	0
2022	0	0	0	0
2023	0	0	0	0
2024	0	0	0	0
2025	0	0	0	2
2026	0	0	0	4
2027	0	0	0	6
2028	0	0	0	8
2029	0	0	0	10
2030	0	0	0	12
2031	0	0	0	14
2032	0	0	0	16
2033	0	0	0	18

Table 133. Evolution of district heating stock per year (Baseline) Skopje

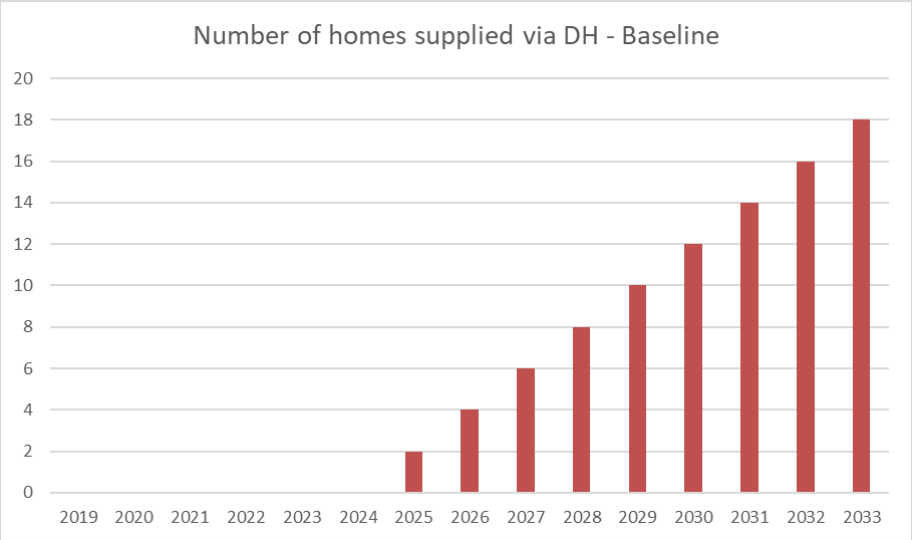

Figure 103. Evolution of district heating stock per year (Baseline) Skopje

Optimistic Replace-Scenario DH Boilers (Overachieving REPLACE target region objectives)				
	number of individual boilers		number of individual boilers	
	Old Diesel	Old other boiler	Natural gas	Solid biomass
Replaced/year				10
2019				0
2020	0	0	0	0
2021	0	0	0	0
2022	0	0	0	0
2023	0	0	0	0
2024	0	0	0	0
2025	0	0	0	2
2026	0	0	0	12
2027	0	0	0	22
2028	0	0	0	32
2029	0	0	0	42
2030	0	0	0	52
2031	0	0	0	62
2032	0	0	0	72
2033	0	0	0	82

Table 134. Evolution of district heating stock per year (Optimistic) Skopje

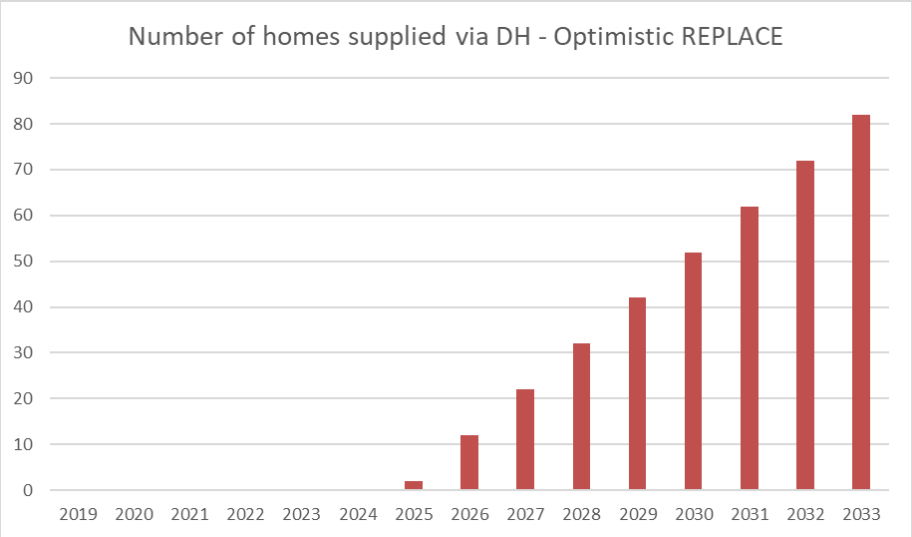

Figure 104. Evolution of district heating stock per year (Optimistic) Skopje

Pessimistic Replace-Scenario DH Boilers (Underachieving REPLACE target region objectives)				
	number of individual boilers		number of individual boilers	
	Old Diesel	Old other boiler	Natural gas	Solid biomass
Replaced/year				2
2019				0
2020	0	0	0	0
2021	0	0	0	0
2022	0	0	0	0
2023	0	0	0	0
2024	0	0	0	0
2025	0	0	0	2
2026	0	0	0	8
2027	0	0	0	14
2028	0	0	0	20
2029	0	0	0	26
2030	0	0	0	32
2031	0	0	0	38
2032	0	0	0	44
2033	0	0	0	50

Table 135. Evolution of district heating stock per year (Pessimistic) Skopje

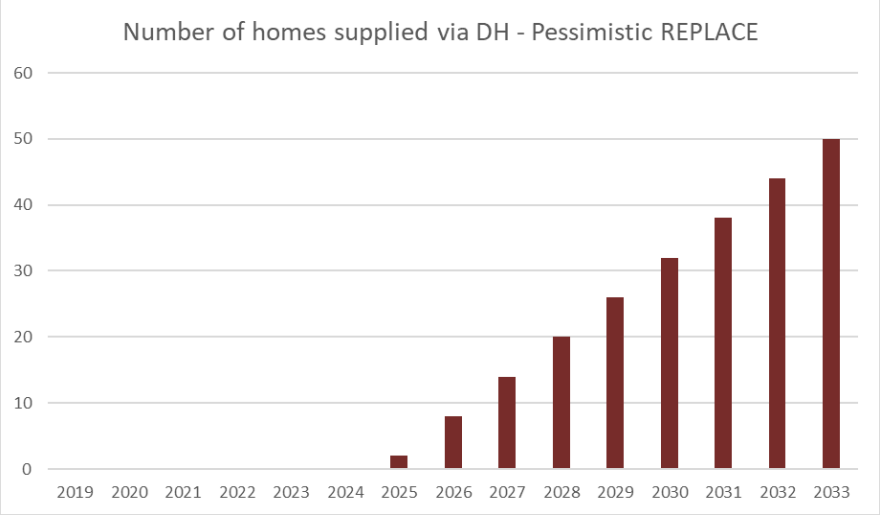

Figure 105. Evolution of district heating stock per year (Pessimistic) Skopje

For individual boilers we can see a similar scenario to the home evolution situation. Mainly, fuel oil boilers and other types of old boilers are being replaced by natural gas and biomass boilers. The evolution for collective boilers follows a similar trend and a few district heating systems will be installed in the coming years.

3.6.4 Investment/Economics

	Average boiler power	Price (€/kW) only boiler	Price (€/kW) biomass turnkey system
Individual boilers (P<50kW)	30	956	1060
Colective boilers (P>50kW)	500	790	850
Distrcit Heating boilers	2000	300	350

Table 136. Average boiler prices, Skopje

	Number of boilers increased by REPLACE		Annual REPLACE (€) investment only in boilers		Annual REPLACE (€) turnkey project investment	
	Optimist	Pessimist	Optimist	Pessimist	Optimist	Pessimist
Individual boilers (P<50kW)	85	65	2.437.800	1.864.200	2.703.000	2.067.000
Colective boilers (P>50kW)	7	3	2.765.000	1.185.000	2.975.000	1.275.000
Distrcit Heating boilers	8	4	4.800.000	2.400.000	5.600.000	2.800.000
Total investment Mio€			10,0	5,4	11,3	6,1

Table 137. Annual Replace investment triggered, Skopje

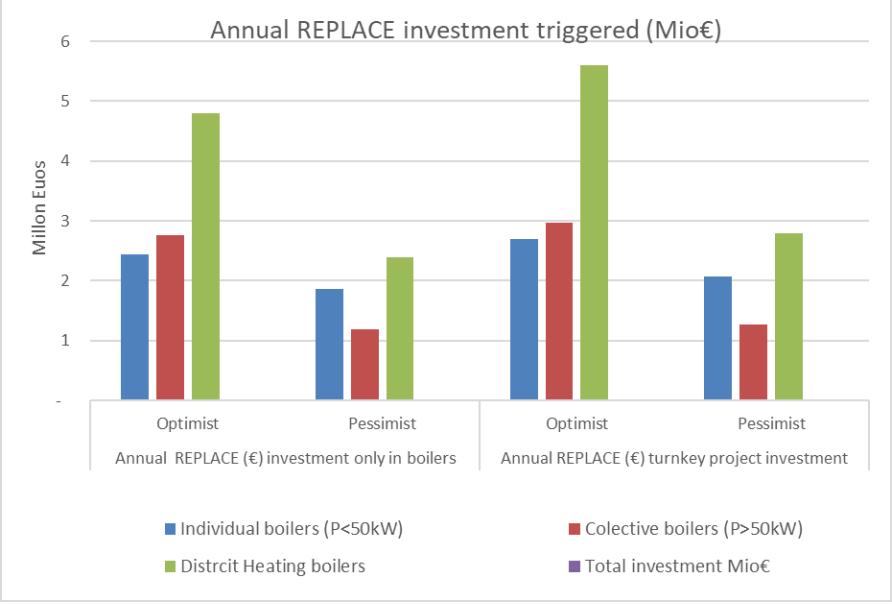

Figure 106. Annual Replace investment triggered, Skopje

The average power for individual boilers in the region of Skopje is 30 kW and depending if it includes a turnkey system, the price per kW of power can reach up to 1060 Euros.

The average power for collective boilers is 500 kW. The price for the turnkey systems can reach up to 850 Euros per kW installed.

The average power for district heating systems is 2000 kW. The price for the turnkey systems can reach up to 350 Euros per kW installed.

3.6.5 Main conclusions

A general overview of heating conditions in KAGoP region was performed with the most recent data. The study is using reliable sources for the region and a linear estimation over the upcoming years in regards of the number of replacements considered. Moreover, it gives a summary of the 2019 stock for different boiler categories and the number of homes heated with a certain type of fuel for three scenarios (Baseline, Optimistic and Pessimistic).

The main source for heating homes in the region of Skopje is biomass (firewood stoves). Heating systems using this type of fuel will be increasing in the next decade transiting towards pellet boilers. However, a decreasing trend is expected with the fuel oil and old heating systems, which is the main fuel objective to be replaced by the project in this and other pilot regions. In general, the REPLACE scenarios will contribute to a larger impact (even with the pessimistic scenario) in the evolution of boilers used over the years, dominating with the optimistic scenario to be the optimistic one. A number of replacements are expected each year beyond 2022 after all the actions and measures will be implemented. The boilers are divided in several categories such: individual boilers, collective boilers, and district heating. A similar scenario to the home evolution situation is expected for individual boilers. Mainly, fuel oil boilers and other types of old boilers are being replaced by natural gas and biomass boilers. The evolution for collective boilers follows a similar trend and a few district heating systems will be installed in the coming years. The replacements will impact the energy demand by improving the efficiency of the new heating systems, thus it will contribute to energy saving by reducing energy consumption. By the year 2033, with the assistance of the REPLACE project, KAGoP region could save around 5.67 GWh of energy. This in turn translates to a reduction of emissions of 1,668 tons of CO_2 by the year 2033.

Overall, KAGoP region estimates a decent percentage of the region's homes heated with fuel oil and traditional biomass to be replaced with heat pumps, followed by biomass (pellets) and natural gas.

3.7 Spain – Castilla y León

3.7.1 Methodology and information sources

The data used for the region of Castilla y León was obtained from several sources. Firstly, a statistical summary for the weekly energy consumption was used to see the fuel demand of natural gas, LPG, diesel and electricity and its annual evolution. The information was acquired from the region's council. The most recent data, such as for the year 2018 had to be obtained from other sources since the region's council database takes longer to update and do not show the most recent years. A study from the corporation of strategic reserves of petroleum products of 2018 was used to explore the tendencies of fuel use in Castilla y León.

Biomass information for the region was provided by AVEBIOM, in its webpage. Here, one can find the number of biomass installations over the years, the power installed, the energy consumed, the reduction of CO2 emissions and the reduction in fuel use for 3 categories of boilers: stoves, >50kW boilers and <50kW boilers. For other important types of fuel in the region, like natural gas, a study made by IDAE (Institute for Diversification and Saving of Energy) was consulted. The main objective of this study has been to determine the gas consumption of the homes in the region and its distribution according to the thermal services available, considering the types of homes and climate zones that are representative at the national level. Another study from IDAE was consulted, in which it shows data for the electricity consumption per service in homes. It was used to estimate the percentage consumption for heating and air conditioning and domestic hot water.

Information sources:

1- Resumen Estadística Energética en Castilla y León (varios años para ver demandas y evolución)

https://energia.jcyl.es/web/es/biblioteca/boletin-estadisticas-energeticas.html

Datos del sector residencial: demanda eléctrica, gas natural, GLP y gasóleo, y su evolución anual

2- Dato GO-C CCyLL año 2018
https://www.cores.es/sites/default/files/archivos/publicaciones/informe-estadistico-anual-2018.pdf

3 - Datos del observatorio de la biomasa AVEBIOM-número de calderas de biomasa (<50 kW, >50 kW) y de ADHAC (DH con biomasa sector residencial)

https://observatoriobiomasa.es/

Consumo de biomasa en el sector residencial y su evolución anual

4- Proyecto IDAE SPAHOUSEC

https://www.idae.es/publicaciones/spahousec-ii-analisis-estadistico-del-consumo-de-gas-natural-en-las-viviendas

Consumo medio (kWh/hogar) de gas natural por usos según tipo de viviendas: para asignar el % del gas residencial a calefacción y ACS (eliminando uso en cocina)

5- Informe IDAE

https://www.idae.es/uploads/documentos/documentos_Documentacion_Basica_Residencial_Unido_c93da537.pdf

Consumo de electricidad por servicio en viviendas (para estimar % consumo en calefacción y A/C y ACS)

3.7.2 Home evolution

Baseline Homes Heating (expected evolution without REPLACE)

	Old Diesel	Old other boiler	Natural gas	Solid biomass	Heat pumps (	Biomass DH	Biomass total
Replaced/ year	-7.500	-740	6.560	480	1.000	500	980
2019	154.467	26.066	484.622	9.420	51478	3.525	12.945
2020	146.967	25.326	491.182	9.900	52.478	4.025	13.925
2021	139.467	24.586	497.742	10.380	53.478	4.525	14.905
2022	131.967	23.846	504.302	10.860	54.478	5.025	15.885
2023	124.467	23.106	510.862	11.340	55.478	5.525	16.865
2024	116.967	22.366	517.422	11.820	56.478	6.025	17.845
2025	109.467	21.626	523.982	12.300	57.478	6.525	18.825
2026	101.967	20.886	530.542	12.780	58.478	7.025	19.805
2027	94.467	20.146	537.102	13.260	59.478	7.525	20.785
2028	86.967	19.406	543.662	13.740	60.478	8.025	21.765
2029	79.467	18.666	550.222	14.220	61.478	8.525	22.745
2030	71.967	17.926	556.782	14.700	62.478	9.025	23.725
2031	64.467	17.186	563.342	15.180	63.478	9.525	24.705
2032	56.967	16.446	569.902	15.660	64.478	10.025	25.685
2033	49.467	15.706	576.462	16.140	65.478	10.525	26.665

Table 138. Evolution of home heating systems stock per year (Baseline) Castilla y León

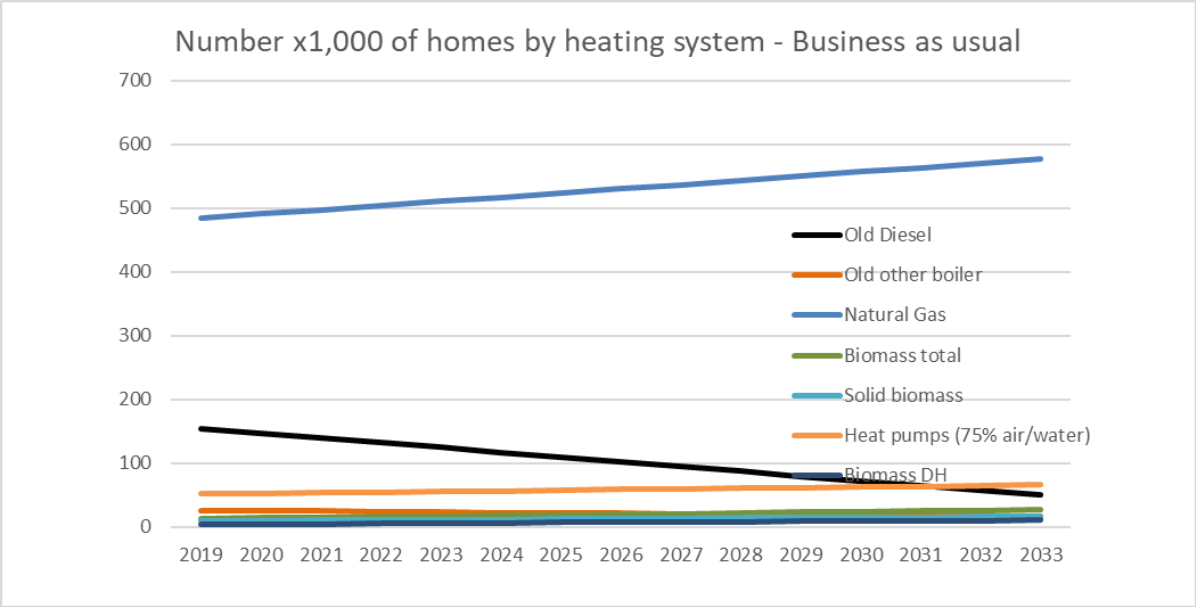

Figure 107. Evolution of home heating systems stock per year (Baseline) Castilla y León

Optimistic Replace-Scenario Homes (Overachieving REPLACE target region objectives)

	Old Diesel	Old other boiler	Natural gas	Solid biomass	Heat pumps (	Biomass DH	Biomass total
Replaced/ year	-10.458	-740	6.560	2.138	1.000	1.800	3.938
2019	154.467	26.066	484.622	9.420	51478	3.525	12.945
2020	144.010	25.326	491.182	11.558	52.478	5.325	16.883
2021	133.552	24.586	497.742	12.038	53.478	7.125	19.163
2022	123.095	23.846	504.302	14.175	54.478	8.925	23.100
2023	112.637	23.106	510.862	16.313	55.478	10.725	27.038
2024	102.180	22.366	517.422	18.450	56.478	12.525	30.975
2025	91.722	21.626	523.982	20.588	57.478	14.325	34.913
2026	81.265	20.886	530.542	22.725	58.478	16.125	38.850
2027	70.807	20.146	537.102	24.863	59.478	17.925	42.788
2028	60.350	19.406	543.662	27.000	60.478	19.725	46.725
2029	49.892	18.666	550.222	29.138	61.478	21.525	50.663
2030	39.435	17.926	556.782	31.275	62.478	23.325	54.600
2031	28.977	17.186	563.342	33.413	63.478	25.125	58.538
2032	18.520	16.446	569.902	35.550	64.478	26.925	62.475
2033	8.062	15.706	576.462	37.688	65.478	28.725	66.413

Table 139. Evolution of home heating systems stock per year (Optimistic) Castilla y León

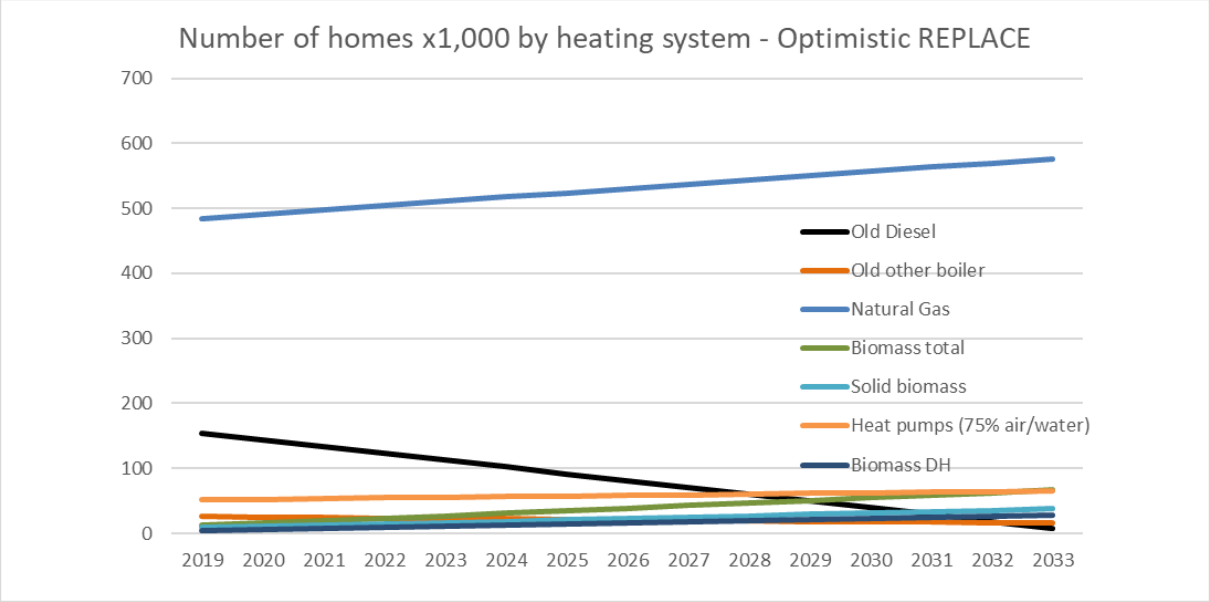

Figure 108. Evolution of home heating systems stock per year (Optimistic) Castilla y León

Pessimistic Replace-Scenario Homes (Underachieving REPLACE target region objectives)

	Old Diesel	Old other boiler	Natural gas	Solid biomass	Heat pumps (	Biomass DH	Biomass total
Replaced/ year	-9.093	-740	6.560	1.373	1.000	1.200	2.573
2019	154.467	26.066	484.622	9.420	51.478	3.525	12.945
2020	145.375	25.326	491.182	10.793	52.478	4.725	15.518
2021	136.282	24.586	497.742	12.165	53.478	5.925	18.090
2022	127.190	23.846	504.302	13.538	54.478	7.125	20.663
2023	118.097	23.106	510.862	14.910	55.478	8.325	23.235
2024	109.005	22.366	517.422	16.283	56.478	9.525	25.808
2025	99.912	21.626	523.982	17.655	57.478	10.725	28.380
2026	90.820	20.886	530.542	19.028	58.478	11.925	30.953
2027	81.727	20.146	537.102	20.400	59.478	13.125	33.525
2028	72.635	19.406	543.662	21.773	60.478	14.325	36.098
2029	63.542	18.666	550.222	23.145	61.478	15.525	38.670
2030	54.450	17.926	556.782	24.518	62.478	16.725	41.243
2031	45.357	17.186	563.342	25.890	63.478	17.925	43.815
2032	36.265	16.446	569.902	27.263	64.478	19.125	46.388
2033	27.172	15.706	576.462	28.635	65.478	20.325	48.960

Table 140. Evolution of home heating systems stock per year (Pessimistic) Castilla y León

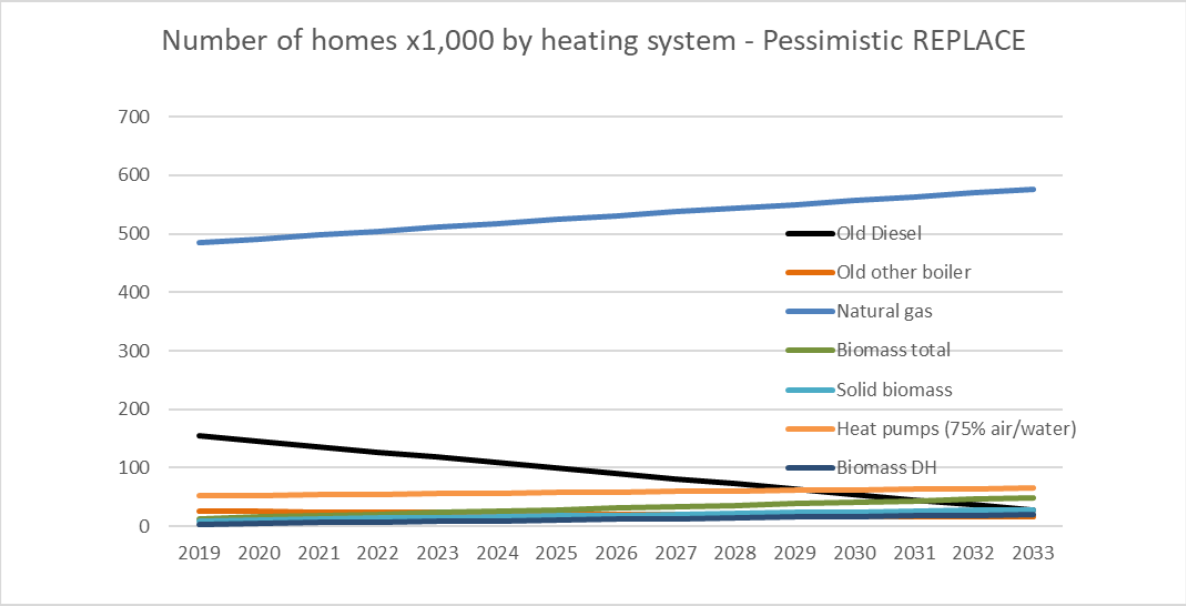

Figure 109. Evolution of home heating systems stock per year (Pessimistic) Castilla y León

The main source for heating homes in the region of Castilla y León is Natural gas. Heating systems using this type of fuel are predicted to continue rising in the next decade, but also biomass. It is observed that the opposite happens with the diesel heating systems, which is the main fuel objective to be replaced by biomass for the project in the pilot region. The project estimates between 9,000 and 10,500 of the region's homes heated with diesel will be replaced every year by biomass, and natural gas. The inventory estimates that around 2,100 biomass heating installations will be installed for homes in this region every year in the best scenario, and around 1,300 in the worst one.

Energy source	Annual average home heat consumption (kWh)
	kWh/hogar
Diesel oil	9.536,600
GLP	9.536,600
Natural gas	9.536,600
Electricity	9.536,600
Biomass	9.536,600

Table 141. Annual average home heat consumption

Old boiler performance	65%
New biomass boiler performance	75%

	Final energy savings (GWh)	
	Opptimistic Replace vs Business as usual	Pessimistic Replace vs Business as usual
2019	0,0	0,0
2020	5,8	3,1
2021	8,3	6,2
2022	14,1	9,3
2023	19,9	12,5
2024	25,7	15,6
2025	31,5	18,7
2026	37,3	21,8
2027	43,0	24,9
2028	48,8	28,0
2029	54,6	31,2
2030	60,4	34,3
2031	66,2	37,4
2032	72,0	40,5
2033	77,8	43,6

Table 142. Final energy savings, Castilla y León

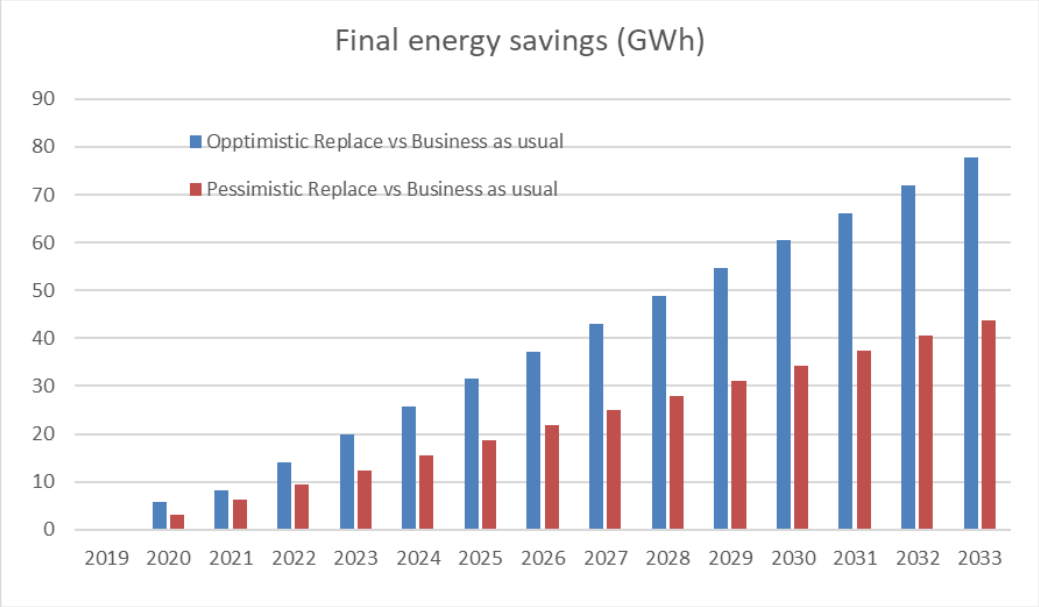

Figure 110. Final energy savings, Castilla y León

	Additional emissions reduction (tCO2)	
	Opptimistic Replace vs Business as usual	Pessimistic Replace vs Business as usual
2019	0	0
2020	1.736	935
2021	2.499	1.869
2022	4.234	2.804
2023	5.970	3.738
2024	7.706	4.673
2025	9.441	5.608
2026	11.177	6.542
2027	12.913	7.477
2028	14.648	8.411
2029	16.384	9.346
2030	18.120	10.280
2031	19.855	11.215
2032	21.591	12.150
2033	23.327	13.084

Table 143. Additional emission reduction, Castilla y León

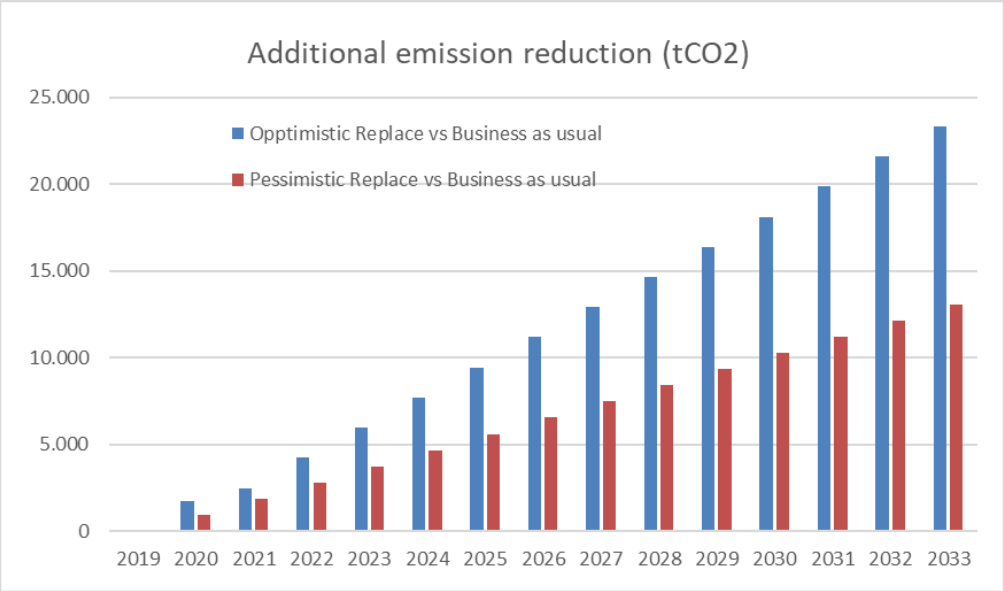

Figure 111. Additional emission reduction, Castilla y León

The final energy savings for the optimistic and pessimistic scenarios were calculated considering the number of replacements for homes, the annual average home heat consumption, and the different performance values for the old and new heating systems. By the year 2033, with the assistance of the replace project, the region of Castilla y León could save between 245 and 328 GWh of energy. This in turn translates to a reduction of emissions in between 73,600 and 98,500 tons of CO2 by the year 2033.

3.7.3 Boiler evolution

	Baseline Individual Boilers (expected evolution without REPLACE)				
	number of individual boilers		**number of individual boilers**		
	Stock	Stock	Stock of boilers (number, cumulated)		
	Old Diesel	Old other boiler	Natural gas	Solid biomass	Electric heating
Replaced/year	-5.500	-500	4.800	160	1.000
2019	110.331	18.618	346.158	1.868	51.478
2020	104.831	18.118	350.958	2.028	52.478
2021	99.331	17.618	355.758	2.188	53.478
2022	93.831	17.118	360.558	2.348	54.478
2023	88.331	16.618	365.358	2.508	55.478
2024	82.831	16.118	370.158	2.668	56.478
2025	77.331	15.618	374.958	2.828	57.478
2026	71.831	15.118	379.758	2.988	58.478
2027	66.331	14.618	384.558	3.148	59.478
2028	60.831	14.118	389.358	3.308	60.478
2029	55.331	13.618	394.158	3.468	61.478
2030	49.831	13.118	398.958	3.628	62.478
2031	44.331	12.618	403.758	3.788	63.478
2032	38.831	12.118	408.558	3.948	64.478
2033	33.331	11.618	413.358	4.108	65.478

Table 144. Evolution of individual boilers stock per year (Baseline) Castilla y León

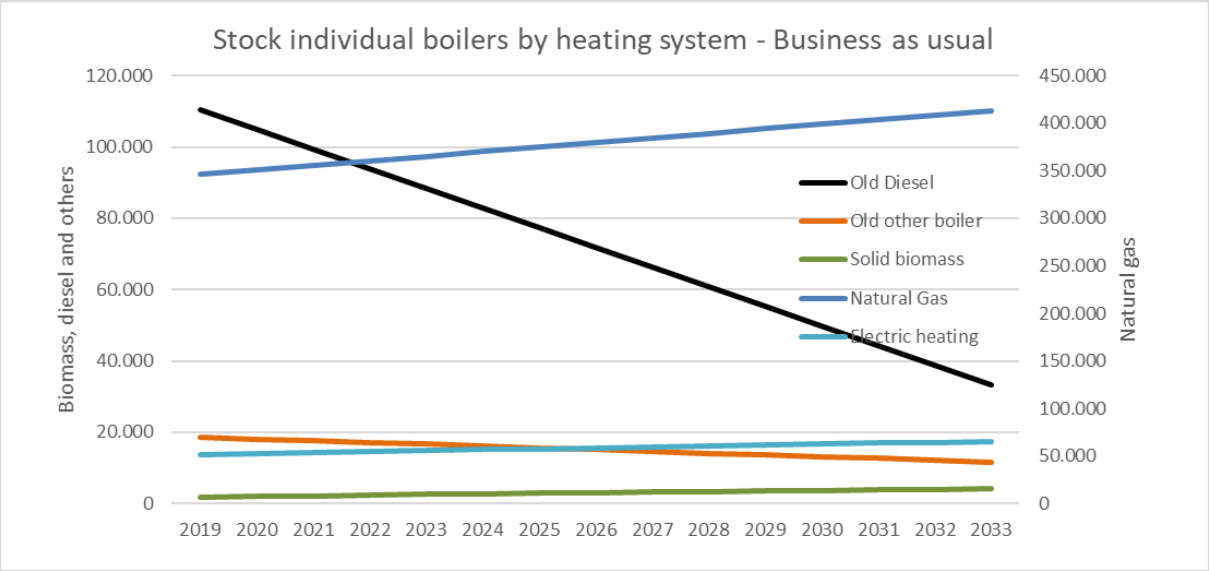

Figure 112. Evolution of individual boilers stock per year (Baseline) Castilla y León

	Optimistic Replace-Scenario Individual Boilers				
	number of individual boilers		number of individual boilers		
	Stock	Stock	Stock of boilers (number, cumulated)		
	Old Diesel	Old other boiler	Natural gas	Solid biomass	Electric heating
Replaced/year	-5.832	-500	4.800	492	1.000
2019	110.331	18.618	346.158	1.868	51.478
2020	104.831	18.118	350.958	2.360	52.478
2021	99.331	17.618	355.758	2.851	53.478
2022	93.500	17.118	360.558	3.343	54.478
2023	87.668	16.618	365.358	3.834	55.478
2024	81.837	16.118	370.158	4.326	56.478
2025	76.005	15.618	374.958	4.817	57.478
2026	70.174	15.118	379.758	5.309	58.478
2027	64.342	14.618	384.558	5.800	59.478
2028	58.511	14.118	389.358	6.292	60.478
2029	52.679	13.618	394.158	6.783	61.478
2030	46.848	13.118	398.958	7.275	62.478
2031	41.016	12.618	403.758	7.766	63.478
2032	35.185	12.118	408.558	8.258	64.478
2033	29.353	11.618	413.358	8.749	65.478

Table 145. Evolution of individual boilers stock per year (Optimistic) Castilla y León

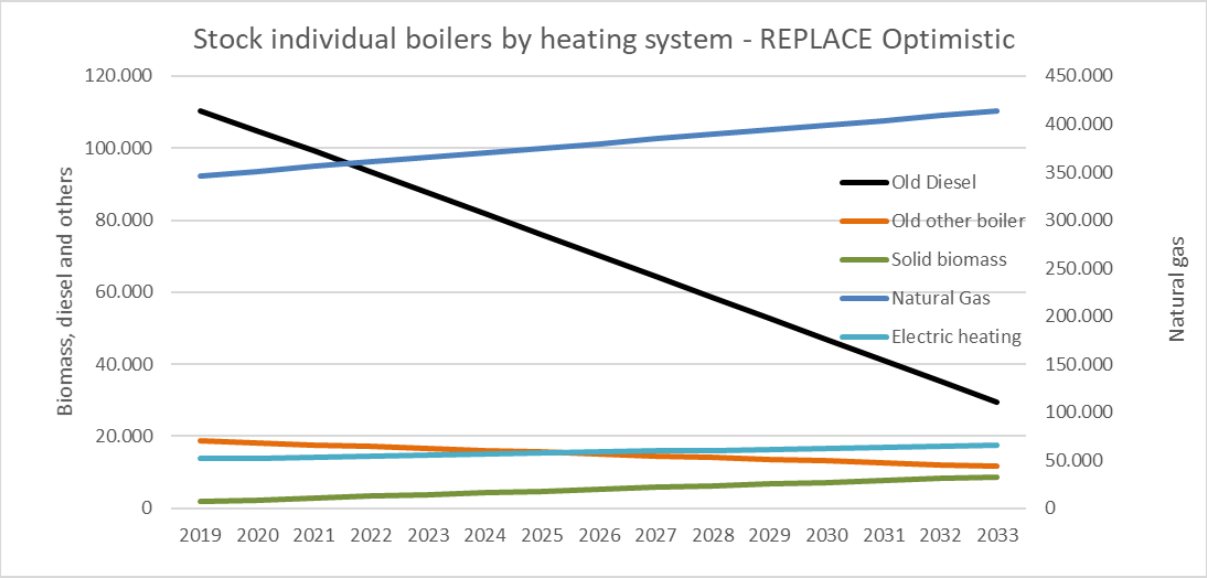

Figure 113. Evolution of individual boilers stock per year (Optimistic) Castilla y León

	Pessimistic Replace-Scenario Individual Boilers				
	number of individual boilers		number of individual boilers		
	Stock	Stock	Stock of boilers (number, cumulated)		
	Old Diesel	Old other boiler	Natural gas	Solid biomass	Electric heating
Replaced/year	-5.679	-500	4.800	339	1.000
2019	110.331	18.618	346.158	1.868	51.478
2020	104.653	18.118	350.958	2.207	52.478
2021	98.974	17.618	355.758	2.545	53.478
2022	93.296	17.118	360.558	2.884	54.478
2023	87.617	16.618	365.358	3.222	55.478
2024	81.939	16.118	370.158	3.561	56.478
2025	76.260	15.618	374.958	3.899	57.478
2026	70.582	15.118	379.758	4.238	58.478
2027	64.903	14.618	384.558	4.576	59.478
2028	59.225	14.118	389.358	4.915	60.478
2029	53.546	13.618	394.158	5.253	61.478
2030	47.868	13.118	398.958	5.592	62.478
2031	42.189	12.618	403.758	5.930	63.478
2032	36.511	12.118	408.558	6.269	64.478
2033	30.832	11.618	413.358	6.607	65.478

Table 146. Evolution of individual boilers stock per year (Pessimistic) Castilla y León

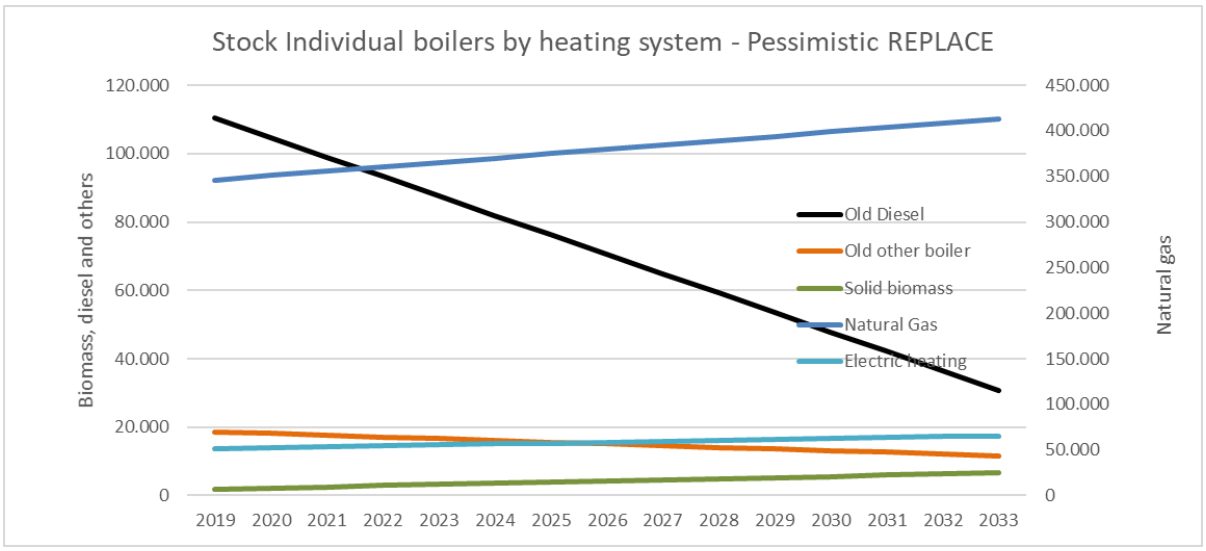

Figure 114. Evolution of individual boilers stock per year (Pessimistic) Castilla y León

	Baseline Colectivel Boilers and DH (expected evolution without REPLACE)					
	number of colective boilers		**number of colective boilers**			
	Old Diesel	Old other boiler	Natural gas	Solid biomass	Biomass DH	Biomass total
Replaced/year	-250	-30	220	40	2	42
2019	5.517	931	17.308	944	14	958
2020	5.267	901	17.528	984	16	1.000
2021	5.017	871	17.748	1.024	18	1.042
2022	4.767	841	17.968	1.064	20	1.084
2023	4.517	811	18.188	1.104	22	1.126
2024	4.267	781	18.408	1.144	24	1.168
2025	4.017	751	18.628	1.184	26	1.210
2026	3.767	721	18.848	1.224	28	1.252
2027	3.517	691	19.068	1.264	30	1.294
2028	3.267	661	19.288	1.304	32	1.336
2029	3.017	631	19.508	1.344	34	1.378
2030	2.767	601	19.728	1.384	36	1.420
2031	2.517	571	19.948	1.424	38	1.462
2032	2.267	541	20.168	1.464	40	1.504
2033	2.017	511	20.388	1.504	42	1.546

Table 147. Evolution of collective boilers stock per year (Baseline) Castilla y León

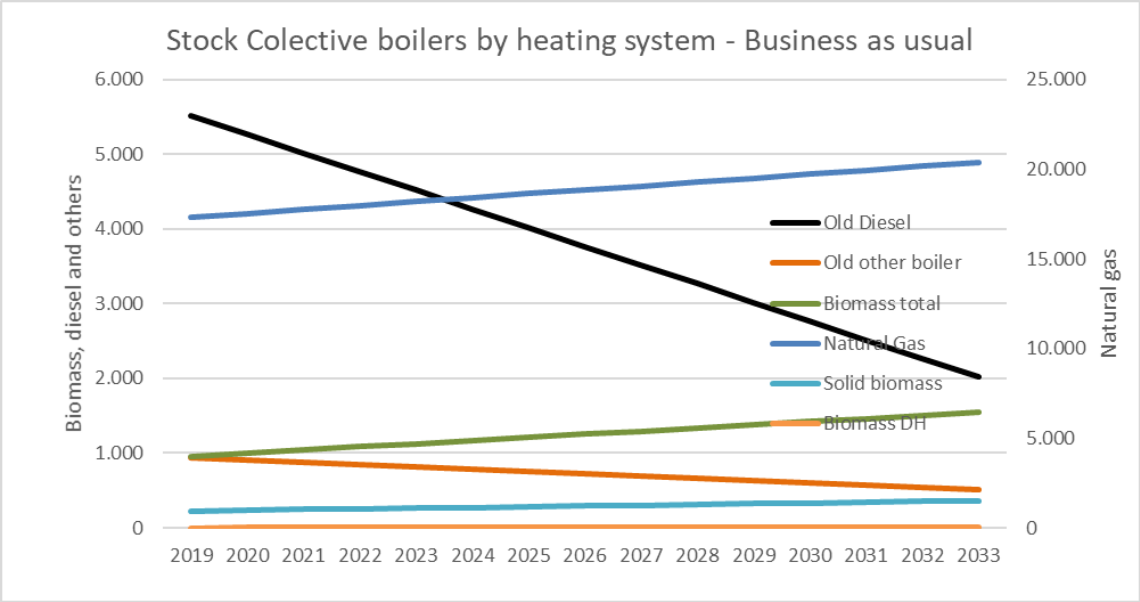

Figure 115. Evolution of collective boilers stock per year (Baseline) Castilla y León

	Optimistic Replace-Scenario Colective Boilers (Overachieving REPLACE target region objectives)					
	number of colective boilers		number of colective boilers			
	Old Diesel	Old other boiler	Natural gas	Solid biomass	Biomass DH	Biomass total
Replaced/year	-416	-30	220	206	7	213
2019	5.517	931	17.308	944	14	958
2020	5.101	901	17.528	1.150	21	1.171
2021	4.686	871	17.748	1.356	28	1.384
2022	4.270	841	17.968	1.561	35	1.596
2023	3.854	811	18.188	1.767	42	1.809
2024	3.438	781	18.408	1.973	49	2.022
2025	3.023	751	18.628	2.179	56	2.235
2026	2.607	721	18.848	2.384	63	2.447
2027	2.191	691	19.068	2.590	70	2.660
2028	1.775	661	19.288	2.796	77	2.873
2029	1.360	631	19.508	3.002	84	3.086
2030	944	601	19.728	3.207	91	3.298
2031	528	571	19.948	3.413	98	3.511
2032	112	541	20.168	3.619	105	3.724
2033	-304	511	20.388	3.825	112	3.937

Table 148. Evolution of collective boilers stock per year (Optimistic) Castilla y León

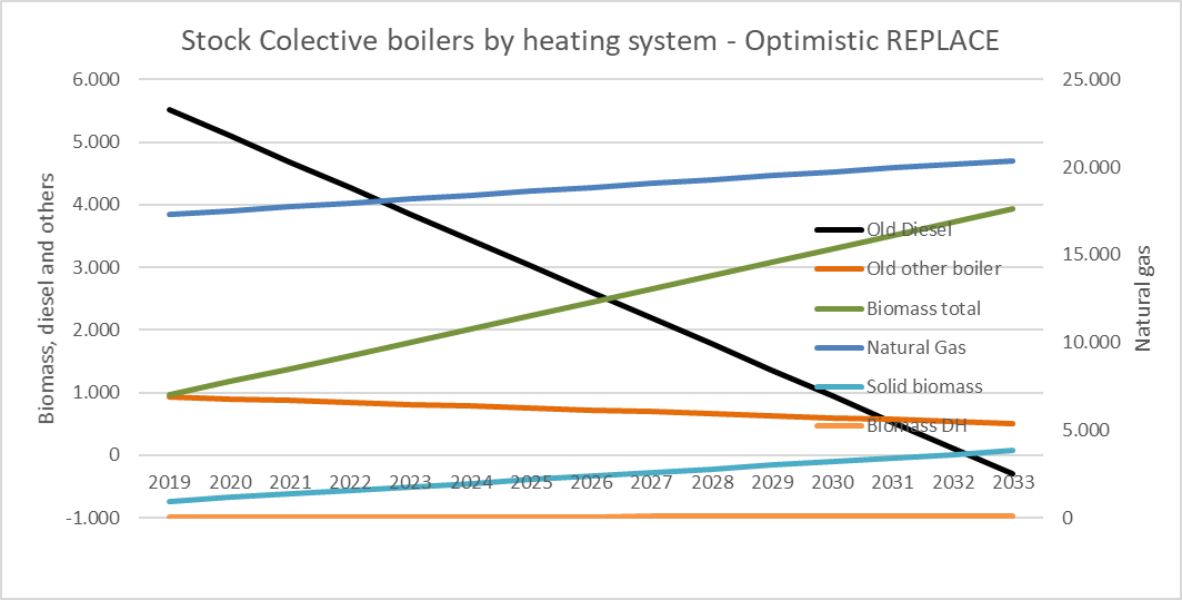

Figure 116. Evolution of collective boilers stock per year (Optimistic) Castilla y León

	Pessimistic Replace-Scenario Colective Boilers (Underachieving REPLACE target region objectives)					
	number of colective boilers		number of colective boilers			
	Old Diesel	Old other boiler	Natural gas	Solid biomass	Biomass DH	Biomass total
Replaced/year	-339	-30	220	129	5	134
2019	5.517	931	17.308	944	14	958
2020	5.178	901	17.528	1.073	19	1.092
2021	4.839	871	17.748	1.203	24	1.227
2022	4.499	841	17.968	1.332	29	1.361
2023	4.160	811	18.188	1.461	34	1.495
2024	3.821	781	18.408	1.590	39	1.629
2025	3.482	751	18.628	1.720	44	1.764
2026	3.142	721	18.848	1.849	49	1.898
2027	2.803	691	19.068	1.978	54	2.032
2028	2.464	661	19.288	2.107	59	2.166
2029	2.125	631	19.508	2.237	64	2.301
2030	1.785	601	19.728	2.366	69	2.435
2031	1.446	571	19.948	2.495	74	2.569
2032	1.107	541	20.168	2.624	79	2.703
2033	768	511	20.388	2.754	84	2.838

Table 149. Evolution of collective boilers stock per year (Pessimistic) Castilla y León

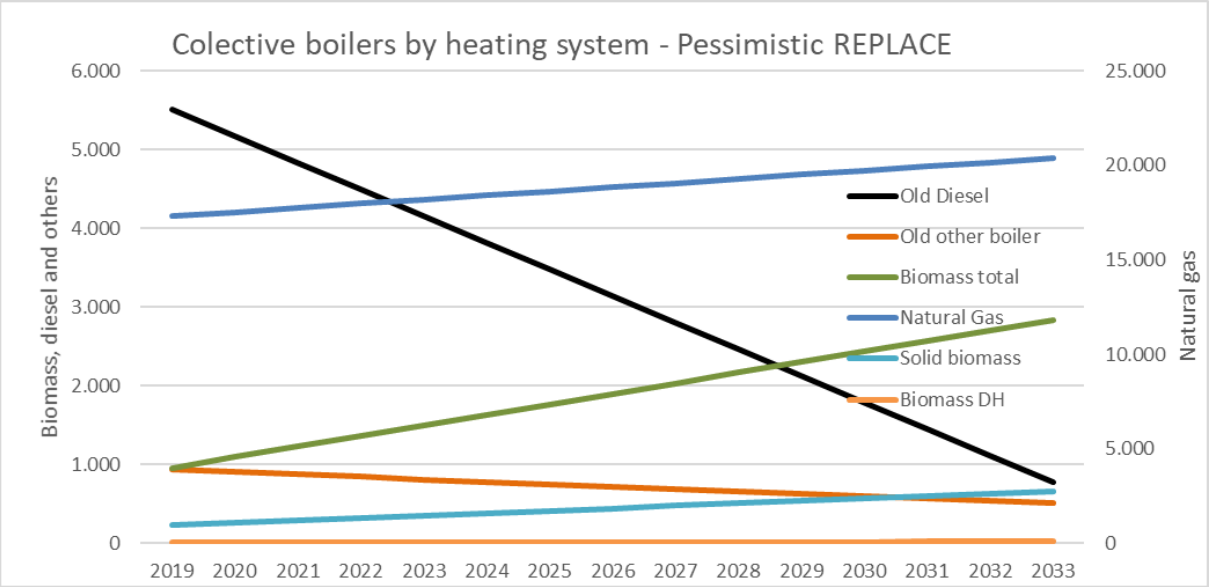

Figure 117. Evolution of collective boilers stock per year (Pessimistic) Castilla y León

	Baseline District Heating (expected evolution without REPLACE)			
	number of DH boilers		**number of DH boilers**	
	Old Diesel	Old other boiler	Natural gas	Solid biomass
Replaced/year	0	0	0	2
2019	0	0	0	14
2020	0	0	0	16
2021	0	0	0	18
2022	0	0	0	20
2023	0	0	0	22
2024	0	0	0	24
2025	0	0	0	26
2026	0	0	0	28
2027	0	0	0	30
2028	0	0	0	32
2029	0	0	0	34
2030	0	0	0	36
2031	0	0	0	38
2032	0	0	0	40
2033	0	0	0	42

Table 150. Evolution of district heating stock per year (Baseline) Castilla y León

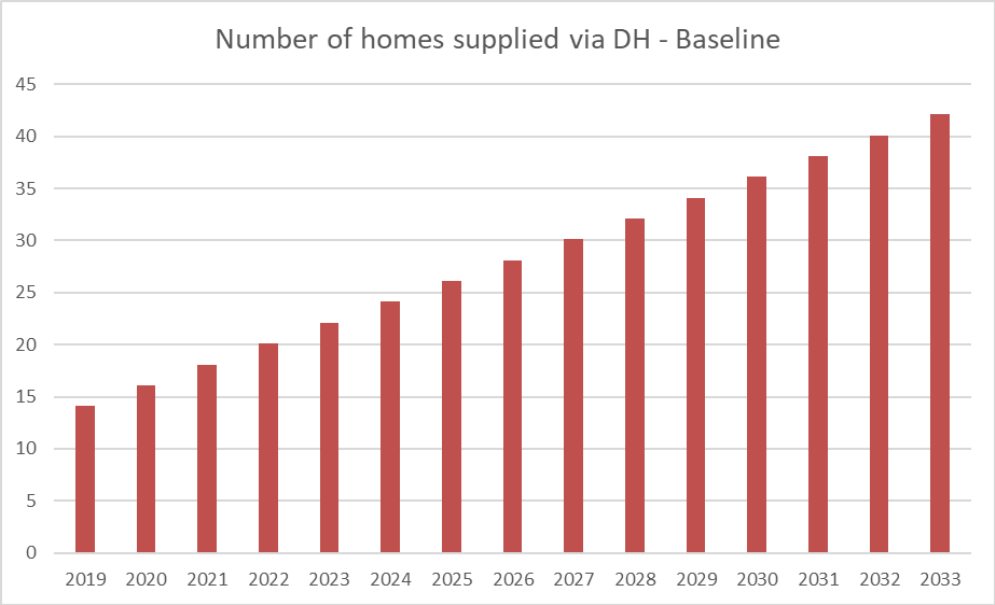

Figure 118. Evolution of district heating stock per year (Baseline) Castilla y León

Optimistic Replace-Scenario DH Boilers (Overachieving REPLACE target region objectives)				
	number of DH boilers		**number of DH boilers**	
	Old Diesel	Old other boiler	Natural gas	Solid biomass
Replaced/year	0	0	0	7
2019	0	0	0	17
2020	0	0	0	24
2021	0	0	0	26
2022	0	0	0	33
2023	0	0	0	40
2024	0	0	0	47
2025	0	0	0	54
2026	0	0	0	61
2027	0	0	0	68
2028	0	0	0	75
2029	0	0	0	82
2030	0	0	0	89
2031	0	0	0	96
2032	0	0	0	103
2033	0	0	0	110

Table 151. Evolution of district heating stock per year (Optimistic) Castilla y León

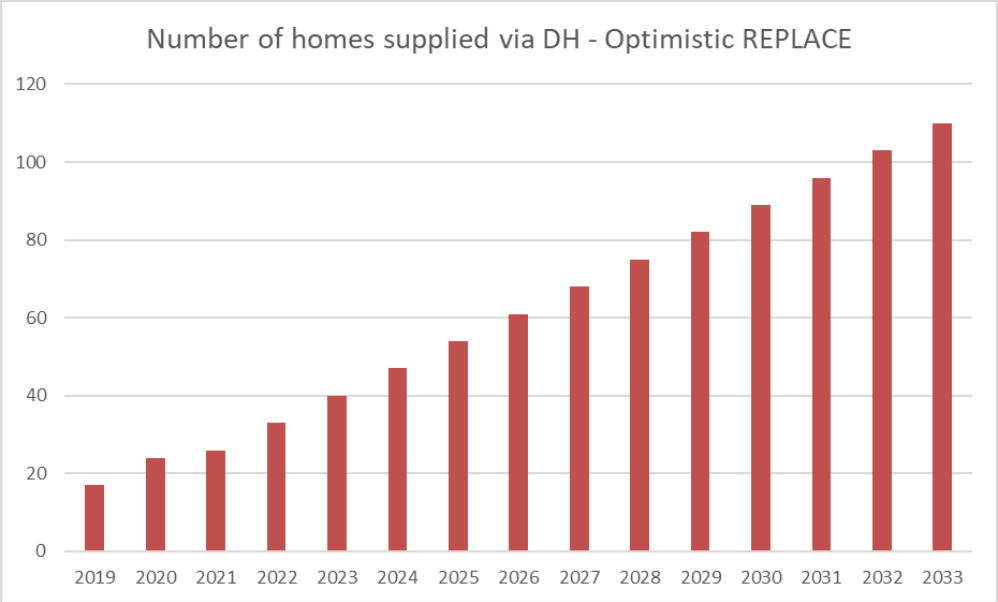

Figure 119. Evolution of district heating stock per year (Optimistic) Castilla y León

Pessimistic Replace-Scenario DH Boilers (Underachieving REPLACE target region objectives)				
	number of DH boilers		number of DH boilers	
	Old Diesel	Old other boiler	Natural gas	Solid biomass
Replaced/year	0	0	0	5
2019	0	0	0	14
2020	0	0	0	19
2021	0	0	0	24
2022	0	0	0	29
2023	0	0	0	34
2024	0	0	0	39
2025	0	0	0	44
2026	0	0	0	49
2027	0	0	0	54
2028	0	0	0	59
2029	0	0	0	64
2030	0	0	0	69
2031	0	0	0	74
2032	0	0	0	79
2033	0	0	0	84

Table 152. Evolution of district heating stock per year (Pessimistic) Castilla y León

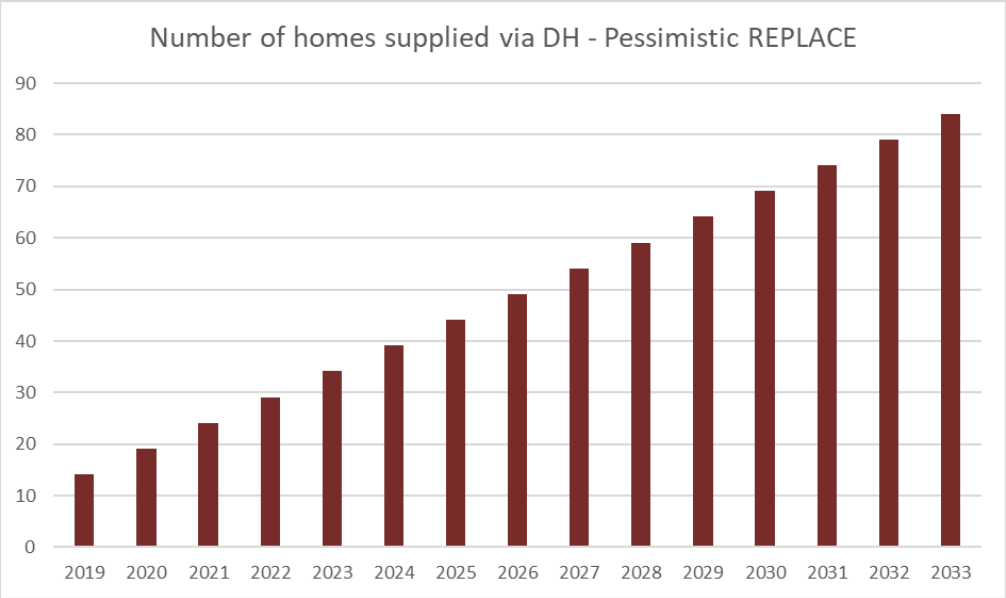

Figure 120. Evolution of district heating stock per year (Pessimistic) Castilla y León

For individual boilers we can see a similar scenario to the home evolution situation. Mainly, diesel is being replaced by natural gas, biomass boilers and electric heating. Collective boilers follow a similar pattern, but without the electric heating. It can also be observed an upward trend of installing biomass district heating which is not as common as in other European regions.

3.7.4 Investment/Economics

	Average boiler power	Price (€/kW) only boiler	Price (€/kW) biomass turnkey system
Individual boilers (P<50kW)	33	500	825
Colective boilers (P>50kW)	500	300	450
Distrcit Heating boilers	2220	300	550

Table 153. Average boiler price, Castilla y León

	Number of boilers increased by REPLACE		Annual REPLACE (€) investment only in boilers		Annual REPLACE (€) turnkey project investment	
	Optimist	Pessimist	Optimist	Pessimist	Optimist	Pessimist
Individual boilers (P<50kW)	332	179	5.469.750	2.945.250	9.025.088	4.859.663
Colective boilers (P>50kW)	166	89	24.862.500	13.387.500	37.293.750	20.081.250
Distrcit Heating boilers	5	3	3.330.000	1.998.000	6.105.000	3.663.000
Total investment Mio€			33,7	18,3	52,4	28,6

Table 154. Annual Replace investment triggered, Castilla y León

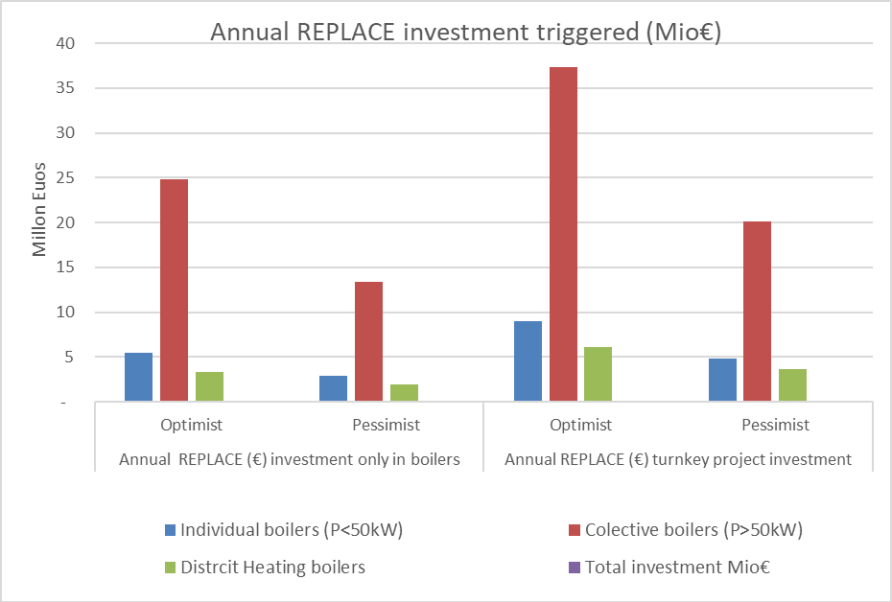

Figure 121. Annual Replace investment triggered, Castilla y León

The average power for individual boilers in the region of Castilla y León is 33 kW and depending on if it includes a turnkey system, the price per kW of power can reach up to 825 Euros.

The average power for collective boilers is 500 kW. The price for the turnkey systems can reach up to 450 Euros per kW installed.

The average power for district heating systems is 2220 kW. The price for the turnkey systems can reach up to 550 Euros per kW installed.

3.7.5 Main conclusions

In the region of Castilla y León in Spain, the main fuel consumed for heating systems is fuel oil and diesel followed by natural gas closely. Since they are contaminant technologies due to the use of fossil fuels, the diesel boilers are the main target for the REPLACE project in this region. On the other hand, natural gas boilers are expected to continue raising and while it's not the primary target, it is expected to slow down its expansion due to the project. There are around 136.000 inefficient boilers in the region and for the year 2030 it is expected that 65.000 will be replaced for more efficient ones, especially biomass boilers.

The main challenge for a further replacement of fossil fuels is the low oil price, but the CO2 taxation will lead to increased costs for fossil fuels in the future. This taxation will turn the average costumer towards newer and cleaner technologies which due to the CO2 taxation will also be cheaper. The project expects to make an impact of around 200 GWh of final energy saved by the year 2030 which can be translated to 60.000 tCO2eq. This numbers do not consider the number of replacements that would take place in the normal market without the impact from REPLACE.

At the moment, there are many programs with state subsidies that private households can apply for when switching to renewable energies. Nevertheless, people give as an obstacle for changing their existing system the financial investment for new systems and the satisfaction with their running system. If all existing funds were used, the turnaround would be easy to implement without great

financial outlay. Additional benefits are also to be expected, like the generation of new jobs thanks to an estimated investment of around 66,5 M€ every year.

Therefore, consumers must get independent and qualified advice for existing subsidies and systems. Through bundled advice, and field trips and open house events there can be drawn attention to the wide variety of renewable systems and financial support.

3.8 Austria – Salzburg

3.8.1 Methodology and information sources

The stock of residential homes, the distribution of homes heated with different heating systems in the pilot region Province of Salzburg, respectively, was taken from micro census data from Statistic Austria for the latest year of data available, 2018.[1] The data cover all main residences in the pilot region (independent of building type).

For the baseline scenario the replacement rates were extrapolated linearly based on the average changes of the bi-annual micro census data back to 2010 (average increments over five data surveys).

The optimistic (and pessimistic) scenarios stated in this sector do not only address the impact associated directly with REPLACE activities but are scenarios that are in line or show the "energy carrier" replacement rates needed to fulfill the energy policy goals set for the pilot region, the Province of Salzburg. In chapter 3.8.4 only the contribution of the share of "energy carrier" replacement rates related to REPLACE activities is stated. Given the REPLACE activities planned for the pilot region (e.g. introduction and promotion of all-round care free boiler replacement packages, the boiler replacement campaign, information evenings etc.) it is estimated that the contribution of REPLACE is about 12% of the overall changes needed related to the existing stock of heating systems for energy and climate policy target achievement.

For the optimistic scenario, the replacement rates of the different energy carriers used in homes was changed dynamically to achieve the overall energy and climate policy targets set for the pilot region. One aim was to phase-out heating oil and liquid petroleum gas used in homes by 50% until 2030 and completely around 2035. A similar development was taken for the phase-out natural gas and (direct) electricity heating systems, which should be achieved around 2040. To compensate for the estimated increased number of homes and for the phase out of oil and gas energy carriers and direct electricity used in homes were increasingly switched towards individual solid biomass, heat pump and district heating systems by 2040. The contributions of the different renewable heating systems and of district heat[2] was based on a study that was made for the core local working group member, the Department 4/04 of the Office of the Salzburg Provincial Government.[3]

As the boiler replacement rates are dynamically the tables below show average replacements for the period of 2019 (project start) to 2027 (five years after project end).

The pessimistic scenario lies exactly between the baseline and the optimistic scenario (averages of the replacement rates of the optimistic and baseline scenario).

[1] Source: STATISTIK AUSTRIA, Energiestatistik: MZ Energieeinsatz der Haushalte 2017/2018. Erstellt am 11.06.2019.

[2] Biomass district heat (DH) and district heat based on natural gas and waste heat sources, while natural gas used in DH should phase out too, around 2050.

[3] Support the process of developing the "Climate + Energy 2030" master plan. Austrian Energy Agency and Umweltbundesamt. 2019

As the scenarios related to number of homes, the same scenarios were calculated related to the number and development of stock of boilers. The boiler stock data were received from the Department 4/04 of the Office of the Salzburg Provincial Government.

The annual average home heat consumption was calculated based on the final energy consumption statistics by usage category of Statistic Austria[4] and the stock of homes by energy carriers data of 2018. The different performance values for the old and new heating systems was based on AEA data.

3.8.2 Home evolution

	Baseline Homes Heating (expected evolution without REPLACE)					
	Fuel oil + LPG	Electricity	Natural gas	Solid biomass	Heat pumps	District heat
Replaced/ year	-1.315	-474	323	749	2.042	253
2018	51.422	25.418	16.890	45.812	23.521	74.464
2019	50.107	24.944	17.197	46.561	26.788	74.731
2020	48.792	24.470	17.488	47.309	28.829	75.013
2021	47.477	23.996	17.765	48.058	30.871	75.310
2022	46.162	23.522	18.028	48.806	32.912	75.623
2023	44.847	23.048	18.278	49.555	34.954	75.954
2024	43.532	22.574	18.516	50.304	36.996	76.303
2025	42.217	22.100	18.741	51.052	39.037	76.671
2026	40.902	21.626	18.956	51.801	41.079	77.059
2027	39.587	21.152	19.159	52.549	43.120	77.468
2028	38.272	20.678	19.353	53.298	45.162	77.901
2029	36.957	20.204	19.536	54.046	47.204	78.357
2030	35.642	19.730	19.711	54.795	49.245	78.838
2031	34.327	19.256	19.877	55.544	51.287	79.345
2032	33.012	18.782	20.034	56.292	53.328	79.880
2033	31.697	18.308	20.184	57.041	55.370	80.445

Table 155. Evolution of home heating systems stock per year (Baseline) Salzburg

[4] Nutzenergieanalyse nach Nutzenergiekategorien Salzburg 1993 bis 2019 (Detailinformation), Statistik Austria, Letzte Änderung am 11.12.2020.

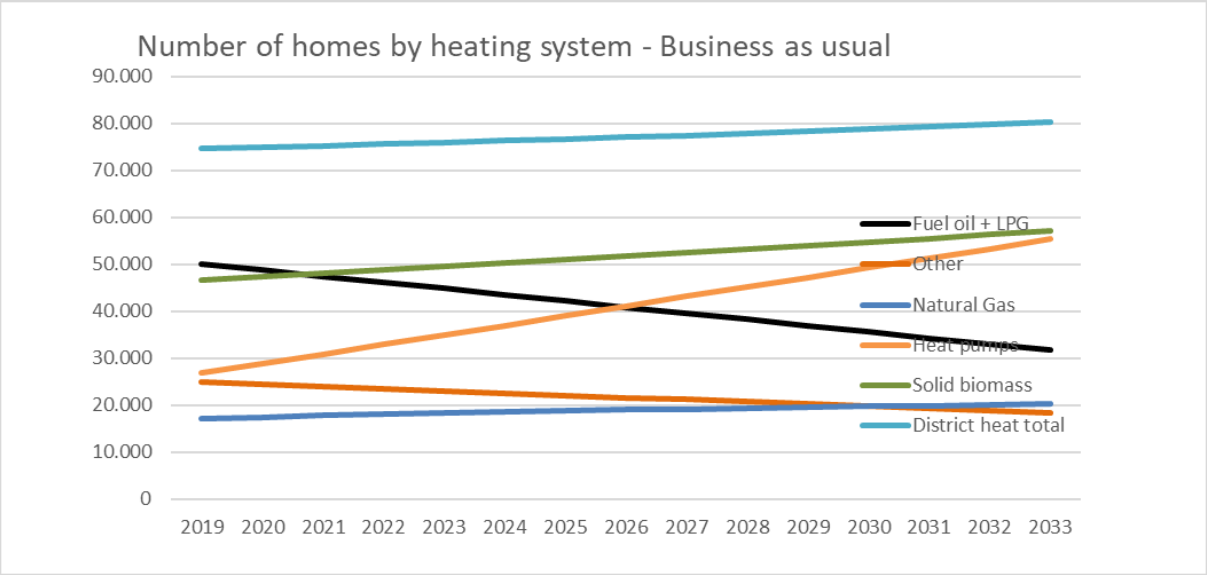

Figure 122. Evolution of home heating systems stock per year (Baseline) Salzburg

Optimistic Replace-Scenario Homes (Overachieving REPLACE target region objectives)						
	Fuel oil + LPG	Electricity	Natural gas	Solid biomass	Heat pumps	District heat
Replaced/ year	-1.930	-695	-537	1.217	3.502	453
2018	51.422	25.418	16.890	45.812	23.521	74.464
2019	49.357	24.674	16.326	47.029	27.023	74.945
2020	47.147	23.879	15.734	48.246	30.525	75.457
2021	44.783	23.027	15.112	48.995	34.027	76.001
2022	42.253	22.116	14.460	50.212	37.529	76.579
2023	39.546	21.141	13.774	51.429	41.031	77.194
2024	36.650	20.098	13.055	52.646	44.533	77.847
2025	33.551	18.982	12.299	53.863	48.035	78.541
2026	30.234	17.788	11.506	55.080	51.537	79.279
2027	26.686	16.511	10.673	56.297	55.039	80.063
2028	22.890	15.143	9.798	57.514	58.541	80.896
2029	18.827	13.681	8.880	58.731	62.043	81.782
2030	14.481	12.115	7.915	59.948	65.545	82.723
2031	9.830	10.440	6.903	61.165	69.047	83.724
2032	4.853	8.648	5.839	62.382	72.549	84.787
2033	0	6.731	4.723	63.599	76.051	85.918

Table 156. Evolution of home heating systems stock per year (Optimistic) Salzburg

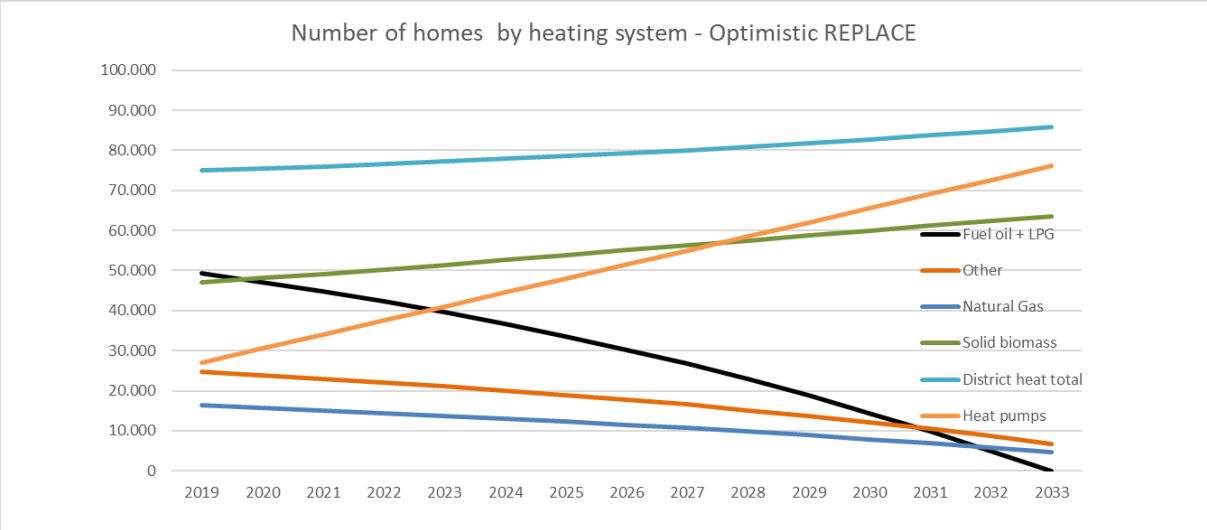

Figure 123. Evolution of home heating systems stock per year (Optimistic) Salzburg

Pessimistic Replace-Scenario Homes (Underachieving REPLACE target region objectives)						
	Fuel oil + LPG	Electricity	Natural gas	Solid biomas:	Heat pumps	District heat
Replaced/ year	-1.709	-604	-14	1.070	2.918	378
2018	51.422	25.418	16.890	45.812	23.521	74.464
2019	49.614	24.779	16.875	46.882	26.439	74.866
2020	47.455	24.103	16.858	47.952	29.357	75.293
2021	45.171	23.389	16.840	49.022	32.275	75.747
2022	42.756	22.633	16.821	50.092	35.193	76.229
2023	40.201	21.833	16.799	51.162	38.111	76.742
2024	37.498	20.987	16.776	52.232	41.029	77.287
2025	34.639	20.093	16.751	53.302	43.947	77.866
2026	31.616	19.147	16.724	54.372	46.865	78.481
2027	28.418	18.146	16.694	55.442	49.783	79.136
2028	25.035	17.087	16.661	56.512	52.701	79.831
2029	21.457	15.968	16.626	57.582	55.619	80.570
2030	17.673	14.783	16.588	58.652	58.537	81.356
2031	13.670	13.531	16.546	59.722	61.455	82.191
2032	9.436	12.206	16.501	60.792	64.373	83.078
2033	4.958	10.804	16.452	61.862	67.291	84.021

Table 157. Evolution of home heating systems stock per year (Pessimistic) Salzburg

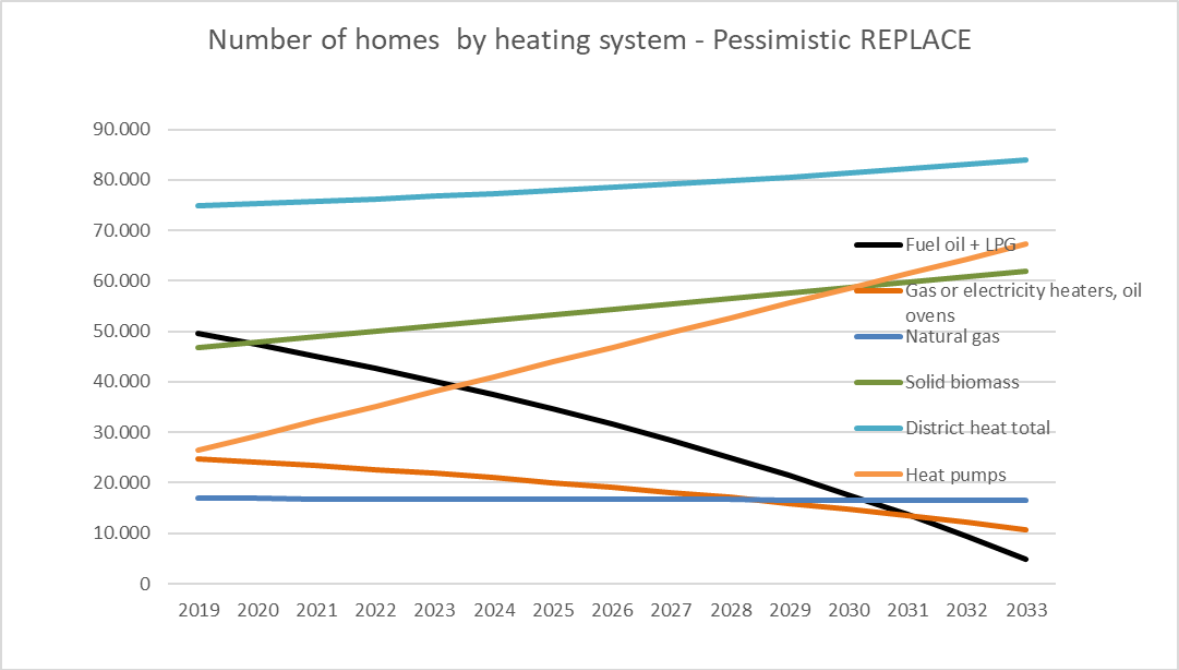

Figure 124. Evolution of home heating systems stock per year (Pessimistic) Salzburg

The main source for heating homes in the region of Salzburg is district heating, fuel oil and LPG. Heating systems using this type of fuel are predicted to continue falling in the next decade. It is observed that the opposite happens with the biomass heating systems and heat pumps. The project estimates that around 2,000 of the region's homes heated with fuel oil and LPG will be replaced every year by heat pumps and biomass. The inventory estimates that around 3500 heat pumps will be installed for homes in this region every year in the best scenario, and around 2900 in the worst one.

Energy source	Annual average home heat consumption (kWh)

	kWh/home
Fuel oil + LPG	16.903
Gas or electricity heaters, oil ovens	6.760
Natural gas	33.896
Solid biomass	23.387
Heat pumps	11.142
District heat	10.456

Table 158. Annual average home heat consumption, Salzburg

	Optimistic Replace vs Business as usual	Pessimistic Replace vs Business as usual
2018	0,00	0,00
2019	1,39	0,61
2020	2,88	1,21
2021	5,76	1,85
2022	7,61	2,56
2023	9,66	3,33
2024	11,93	4,18
2025	14,45	5,11
2026	17,24	6,13
2027	20,31	7,26
2028	23,70	8,49
2029	27,41	9,84
2030	31,50	11,32
2031	35,97	12,94
2032	40,85	14,71
2033	46,19	16,63

Table 159. Final energy savings, Salzburg

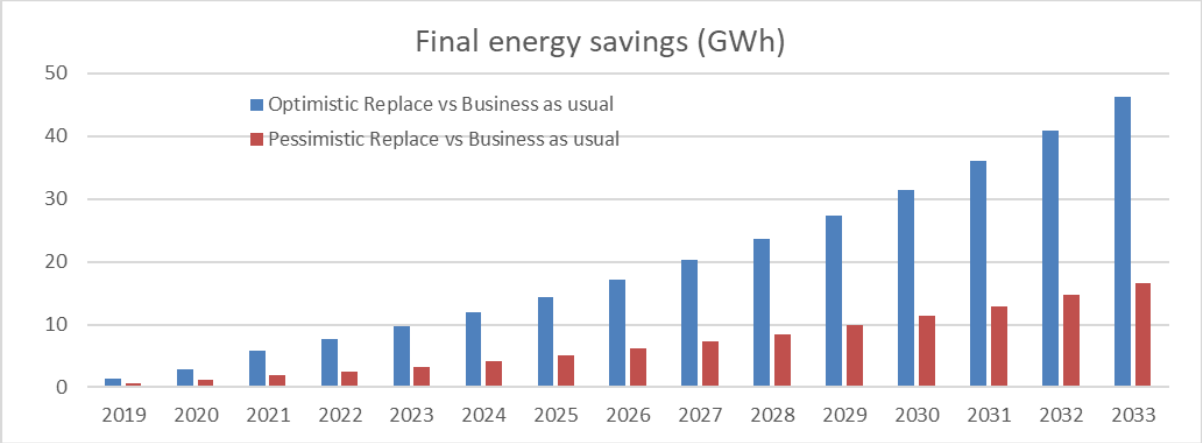

Figure 125. Final energy savings, Salzburg

	Optimistic Replace vs Business as usual	Pessimistic Replace vs Business as usual
2018	0	0
2019	416	182
2020	863	362
2021	1.728	556
2022	2.282	768
2023	2.897	1.000
2024	3.580	1.255
2025	4.336	1.534
2026	5.172	1.840
2027	6.094	2.177
2028	7.109	2.547
2029	8.224	2.952
2030	9.449	3.396
2031	10.790	3.882
2032	12.256	4.412
2033	13.858	4.989

Table 160. Additional emissions reduction, Salzburg

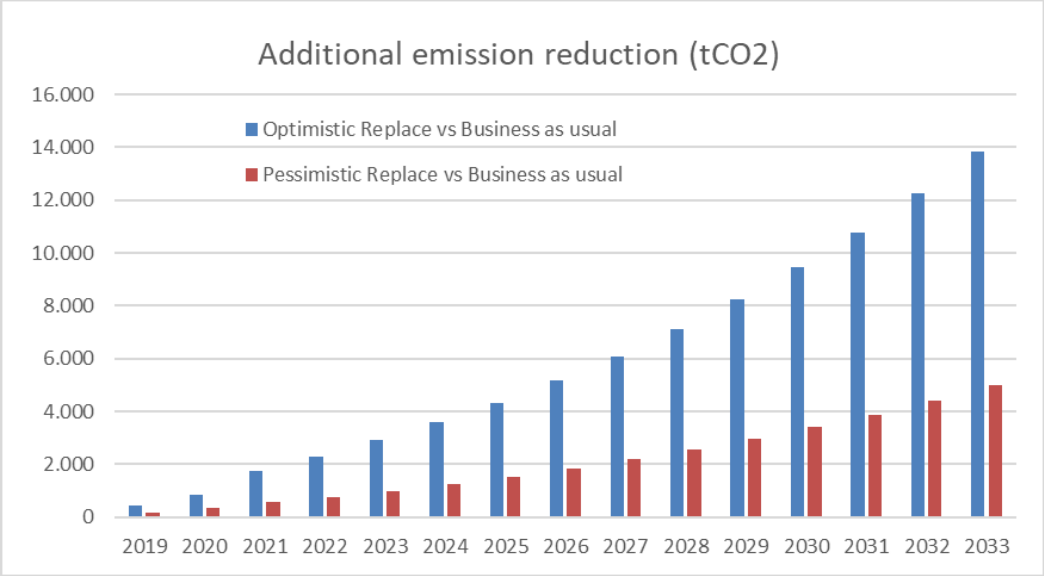

Figure 126. Additional emissions reduction, Salzburg

The final energy savings for the optimistic and pessimistic scenarios were calculated considering the number of replacements for homes, the annual average home heat consumption, and the different performance values for the old and new heating systems. By the year 2033, with the assistance of the replace project, the region of Salzburg could save between 70 and 320 GWh of energy. This in turn translates to a reduction of emissions in between 61,100 and 140,400 tons of CO2 by the year 2033.

3.8.3 Boiler evolution

	Baseline Individual Boilers (expected evolution without REPLACE)				
	Fuel oil + LPG	Electric heaters	Natural gas	Solid biomass	Heat pumps
Replaced/year	-1.035	-321	205	476	1.298
2018	40.484	17.212	31.872	21.568	23.521
2019	39.449	16.891	32.067	22.044	24.819
2020	38.414	16.570	32.252	22.520	26.116
2021	37.378	16.249	32.428	22.996	27.414
2022	36.343	15.928	32.595	23.472	28.712
2023	35.308	15.607	32.753	23.948	30.010
2024	34.272	15.286	32.904	24.423	31.307
2025	33.237	14.965	33.047	24.899	32.605
2026	32.202	14.644	33.183	25.375	33.903
2027	31.167	14.323	33.312	25.851	35.201
2028	30.131	14.002	33.435	26.327	36.498
2029	29.096	13.681	33.552	26.803	37.796
2030	28.061	13.360	33.663	27.278	39.094
2031	27.025	13.039	33.768	27.754	40.392
2032	25.990	12.718	33.868	28.230	41.689
2033	24.955	12.397	33.963	28.706	42.987

Table 161. Evolution of individual boilers stock per year (Baseline) Salzburg

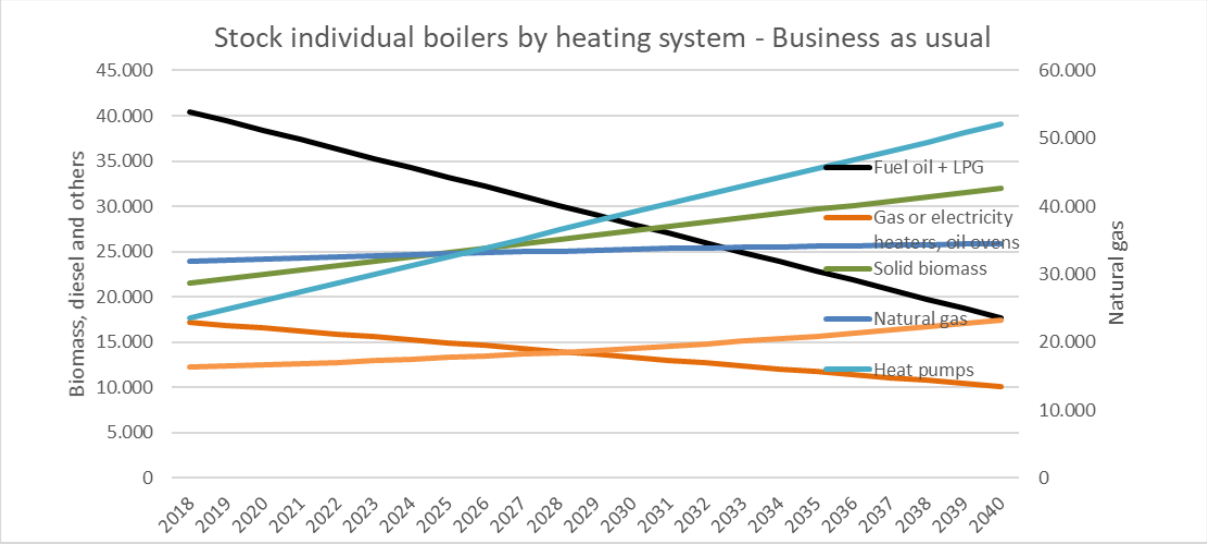

Figure 127. Evolution of individual boilers stock per year (Baseline) Salzburg

	Optimistic Replace-Scenario Individual Boilers				
	Fuel oil + LPG	Electric heaters	Natural gas	Solid biomass	Heat pumps
Replaced/year	-1.520	-471	-1.013	814	2.352
2018	40.484	17.212	31.872	21.568	23.521
2019	38.858	16.708	30.809	22.382	25.873
2020	37.118	16.169	29.692	23.196	28.225
2021	35.255	15.592	28.519	23.672	30.577
2022	33.263	14.974	27.288	24.486	32.929
2023	31.131	14.314	25.995	25.300	35.281
2024	28.850	13.607	24.637	26.114	37.633
2025	26.409	12.851	23.212	26.928	39.985
2026	23.798	12.041	21.715	27.742	42.337
2027	21.003	11.175	20.144	28.556	44.689
2028	18.013	10.249	18.494	29.370	47.041
2029	14.814	9.257	16.761	30.184	49.393
2030	11.390	8.197	14.942	30.998	51.745
2031	7.727	7.062	13.032	31.812	54.097
2032	3.808	5.847	11.026	32.626	56.449
2033	0	4.548	8.920	33.440	58.801

Table 162. Evolution of individual boilers stock per year (Optimistic) Salzburg

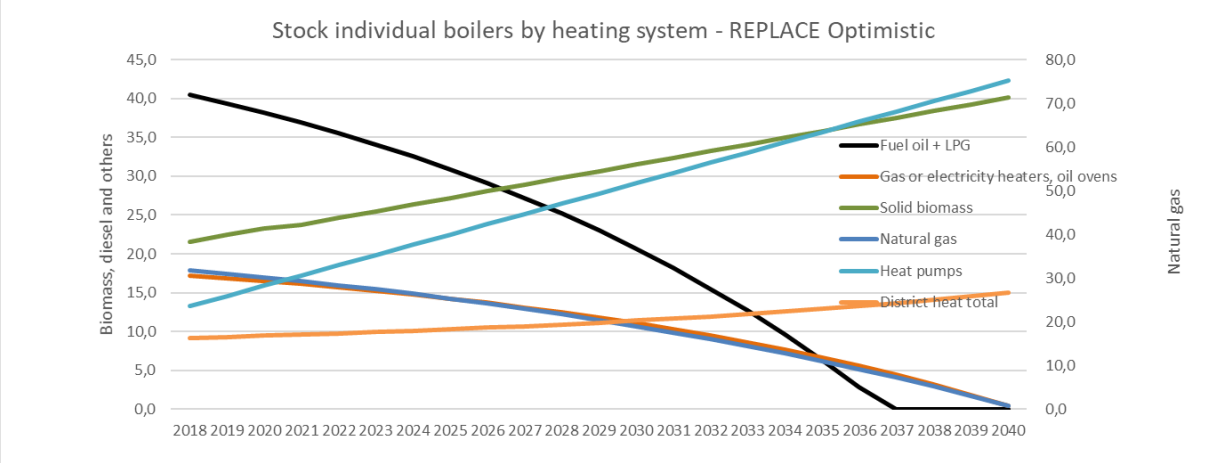

Figure 128. Evolution of individual boilers stock per year (Optimistic) Salzburg

	Pessimistic Replace-Scenario Individual Boilers				
	Fuel oil + LPG	Electric heaters	Natural gas	Solid biomass	Heat pumps
Replaced/year	-1.346	-409	-404	703	1.917
2018	40.484	17.212	31.872	21.568	23.521
2019	39.061	16.779	31.433	22.271	25.438
2020	37.360	16.322	30.955	22.974	27.355
2021	35.561	15.838	30.436	23.677	29.272
2022	33.659	15.326	29.871	24.380	31.189
2023	31.647	14.784	29.256	25.083	33.106
2024	29.518	14.212	28.588	25.786	35.023
2025	27.267	13.606	27.861	26.489	36.940
2026	24.886	12.965	27.071	27.192	38.857
2027	22.367	12.287	26.211	27.895	40.774
2028	19.703	11.571	25.276	28.598	42.691
2029	16.885	10.812	24.260	29.301	44.608
2030	13.905	10.011	23.155	30.004	46.525
2031	10.752	9.162	21.952	30.707	48.442
2032	7.418	8.265	20.645	31.410	50.359
2033	3.891	7.316	19.223	32.113	52.276

Table 163. Evolution of individual boilers stock per year (Pessimistic) Salzburg

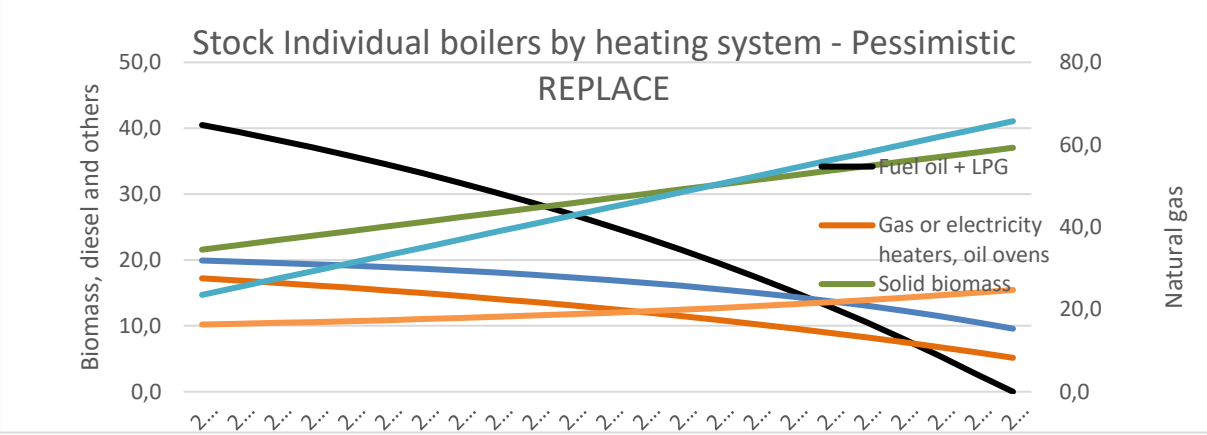

Figure 129. Evolution of individual boilers stock per year (Pessimistic) Salzburg

	Baseline Collective Boilers and DH (expected evolution without REPLACE)					
	Fuel oil + LPG	Electric heaters	Natural gas	Solid biomass	Heat pumps	District heat
Replaced/year	-116	0	16	37	101	13
2018	4.554	0	4.637	2.938	0	896
2019	4.438	0	4.652	2.975	101	910
2020	4.321	0	4.666	3.012	202	925
2021	4.205	0	4.680	3.049	303	940
2022	4.088	0	4.693	3.086	404	956
2023	3.972	0	4.706	3.123	505	973
2024	3.855	0	4.717	3.160	606	991
2025	3.739	0	4.728	3.197	707	1.010
2026	3.623	0	4.739	3.234	808	1.030
2027	3.506	0	4.749	3.271	909	1.051
2028	3.390	0	4.759	3.308	1.010	1.073
2029	3.273	0	4.768	3.345	1.111	1.096
2030	3.157	0	4.777	3.382	1.212	1.121
2031	3.040	0	4.785	3.419	1.313	1.147
2032	2.924	0	4.793	3.456	1.414	1.175
2033	2.807	0	4.800	3.493	1.515	1.204

Table 164. Evolution of collective boilers stock per year (Baseline) Salzburg

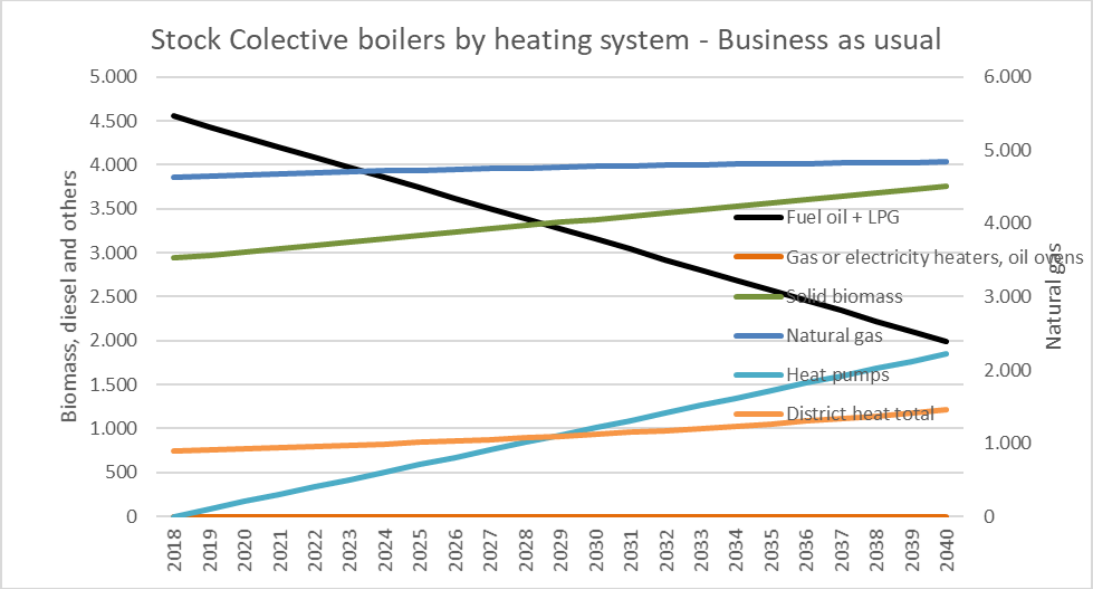

Figure 130. Evolution of collective boilers stock per year (Baseline) Salzburg

	Optimistic Replace-Scenario Collective Boilers (Overachieving REPLACE target region objectives)					
	Fuel oil + LPG	Electric heaters	Natural gas	Solid biomass	Heat pumps	District heat
Replaced/year	-171	0	-147	74	203	26
2018	4.554	0	4.637	2.938	0	896
2019	4.371	0	4.482	3.012	203	924
2020	4.175	0	4.320	3.086	406	953
2021	3.966	0	4.150	3.160	609	985
2022	3.742	0	3.972	3.234	812	1.018
2023	3.502	0	3.784	3.308	1.015	1.053
2024	3.245	0	3.587	3.382	1.218	1.091
2025	2.971	0	3.380	3.456	1.421	1.130
2026	2.677	0	3.163	3.530	1.624	1.173
2027	2.363	0	2.935	3.604	1.827	1.218
2028	2.026	0	2.695	3.678	2.030	1.266
2029	1.666	0	2.444	3.752	2.233	1.316
2030	1.281	0	2.180	3.826	2.436	1.370
2031	869	0	1.903	3.900	2.639	1.428
2032	428	0	1.612	3.974	2.842	1.489
2033	0	0	1.306	4.048	3.045	1.554

Table 165. Evolution of collective boilers stock per year (Optimistic) Salzburg

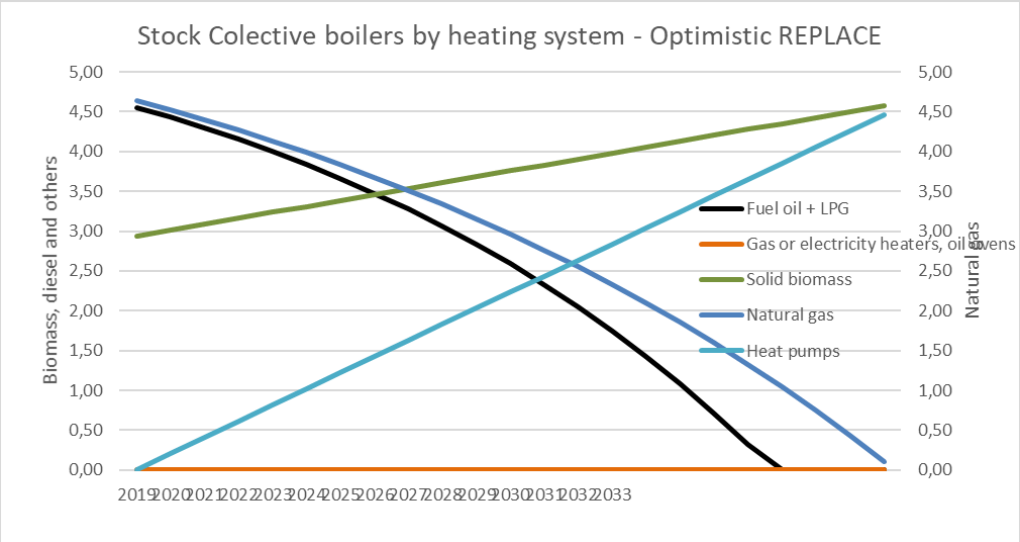

Figure 131. Evolution of collective boilers stock per year (Optimistic) Salzburg

	Pessimistic Replace-Scenario Collective Boilers (Underachieving REPLACE target region objectives)					
	Fuel oil + LPG	Electric heaters	Natural gas	Solid biomass	Heat pumps	District heat
Replaced/year	-151	0	-73	58	159	21
2018	4.554	0	4.637	2.938	0	896
2019	4.395	0	4.557	2.996	159	919
2020	4.226	0	4.471	3.054	318	942
2021	4.047	0	4.377	3.112	477	968
2022	3.858	0	4.275	3.170	636	994
2023	3.658	0	4.164	3.228	795	1.023
2024	3.447	0	4.043	3.286	954	1.053
2025	3.223	0	3.912	3.344	1.113	1.085
2026	2.986	0	3.769	3.402	1.272	1.120
2027	2.736	0	3.614	3.460	1.431	1.156
2028	2.471	0	3.445	3.518	1.590	1.195
2029	2.192	0	3.261	3.576	1.749	1.236
2030	1.895	0	3.062	3.634	1.908	1.279
2031	1.582	0	2.844	3.692	2.067	1.326
2032	1.251	0	2.608	3.750	2.226	1.375
2033	901	0	2.351	3.808	2.385	1.427

Table 166. Evolution of collective boilers stock per year (Pessimistic) Salzburg

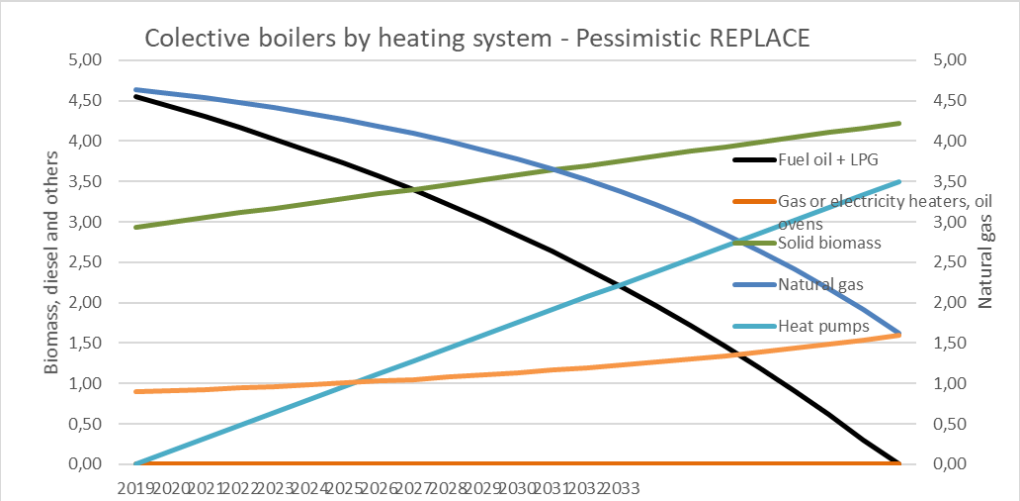

Figure 132. Evolution of collective boilers stock per year (Pessimistic) Salzburg

For individual boilers we can see a similar scenario to the home evolution situation. Mainly, fuel oil and LPG boilers are being replaced by heat pumps and biomass boilers. For the collective boilers, a similar trend can be observed, plus some installations for biomass district heating.

3.8.4 Investment/Economics

	Average boiler power	Price (€/kW) turnkey system	Number of boilers increased by REPLACE		Annual REPLACE (€) investment turnkey systems	
			Optimist	Pessimist	Optimist	Pessimist
Individual boilers (P<50kW)						
Fuel oil	12		-474,0	-304,1	0	0
Gas or electricity heaters, oil ovens	6		-146,9	-86,5	0	0
Natural gas	17		-1 297,6	-647,9	0	0
Solid biomass	15	1485	371,0	245,4	8 298 182	5 488 660
Heat pumps	8	1627	1 138,4	669,3	14 529 143	8 542 221
District heat	8	1274	150,2	91,2	1 501 742	911 372
Total investments individual boilers					**24 329 067**	**14 942 252**

Table 167. Economic investment individual boilers, Salzburg

	Average boiler power	Price (€/kW) turnkey system	Number of boilers increased by REPLACE		Annual REPLACE (€) investment turnkey systems	
			Optimist	Pessimist	Optimist	Pessimist
Collective boilers (P>=50kW)						
Fuel oil + LPG	15		-53,3	-34,2	0	0
Gas or electricity heaters, oil ovens			0,0	0,0	0	0
Natural gas	75		-173,4	-94,2	0	0
Solid biomass	35	1337	40,3	23,0	1 878 928	1 072 579
Heat pumps	10	1545	110,0	62,8	1 632 145	931 703
District heat	10	1210	14,4	8,4	167 163	98 105
Total investments collective boilers					**3 678 236**	**2 102 387**

Table 168. Economic investment collective boilers, Salzburg

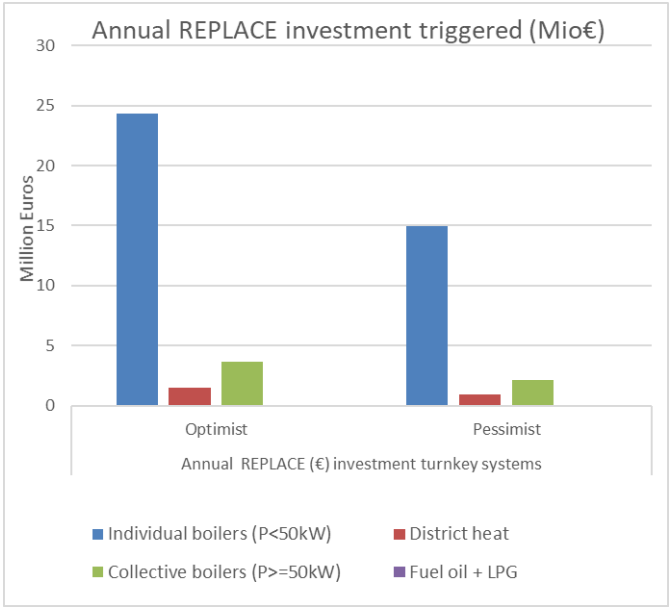

Figure 133. Annual Replace investment triggered, Salzburg

The average power for individual boilers in the region of Salzburg is between 6 and 17 kW and depending on if it includes a turnkey system, the price per kW of power can reach up to 1600 Euros.

The average power for collective boilers is between 10 and 75 kW. The price for the turnkey systems can reach up to 1545 Euros per kW installed.

3.8.5 Main conclusions

Based on the analyses and some recently gained statistics the following conclusions can be drawn:

- The optimistic scenario drawn in this chapter for the pilot region of the province Salzburg reflects a scenario where the energy and climate policy targets can be achieved. Core targets are -50% of current fuel oil and LPG boiler stock by 2030 (starting from ~50,000 homes or 40,000 boilers) and a complete phase out of oil and LPG by 2035. Individual natural gas shall completely phase out around 2040.
- Given the REPLACE activities planned for the pilot region of Salzburg (e.g. introduction and promotion of supply side all-round care free boiler replacement packages, the boiler replacement campaign, information evenings etc.) it is estimated that the contribution of REPLACE is about 12% of the overall changes needed related to the existing stock of heating systems for energy and climate policy target achievement.
- Related to the main scope of REPLACE, the replacement of fuel oil and LPG boilers, by 2030 an average of more than 2,000 oil and LPG boilers (2,500 homes) would have to be replaced by heating systems based on renewable energy sources and district heat. Recent figures show however that, despite large scale "out of oil" investment subsidy funds (100 Mio. Euro nationwide) and a relatively high funding share[5] (~30-40% of total investment) only 659 (thereof 20 collective) oil and LPG boilers were replaced, supported with subsidies in 2020. That means that efforts need to more than triple.[6]
- In the optimistic scenario a progressive boiler replacement rate was set. REPLACE set itself a target to achieve a certain impact five years after project end, in 2027. The average fuel oil and LPG replacement rate from 2019 to 2027 in the optimistic scenario is 1,500 boilers per year. A contribution of 12% of that development translates into an effort of REPLACE to help switching 180 fuel oil and LPG boilers per year. This is quite ambitious, as it corresponds to more than a quarter of the boiler exchange rate that was achieved in total in 2020. [7]
- Salzburg some years ago already has achieved fuel oil and LPG replacement rates that were beyond 2,000 fuel oil and LPG boilers per year. That was a time when district heat infrastructure was extended massively and DH operators went from house to house (door handle cleaning). DH infrastructure by now nearly has exploited its economic viable potential, however. All good sites have been made accessible, some extensions and densifications as well as micro grids to supply some blocks are still possible, fortunately.
- The fact that the "out of fuel oil" funds will double for the next two years, compared to 2020 (200 Mio. Euro p.a.) gives rise that REPLACE activities in Salzburg fall on fertile ground. A higher fuel oil price, compared to that in 2020 of course would help too. The availability of installers is a limiting factor that needs to be addressed, however. The approach to help installers to potentially have more "on-site time" for actual replacements, by introducing all-round free

[55] Funding shares in Germany currently are at a level of 45%, which help the replacement market to flourish.

[6] Preliminary data of the federal "out of fuel oil" campaigns' funding settlement office Kommunalkredit Austria. February 2021.

[7] The short-term impact of REPLACE in Salzburg should be about 5% of the 2027 target, i.e. 9 fuel and LPG boilers replaced.

replacement packages on the supply side, where installers are assisted by heating system manufacturers, wholesalers or joint effort sharing of installers, should help to partly overcome that limiting factor (and contribute to the 12% overall change contribution of REPLACE). If REPLACE succeeds, based on the activities planned, it will be beneficial to adapt the activities for other regions and to replicate them.

3.9 Serbia – Sabac

3.9.1 Methodology and information sources

1 . Census 2011 - Report which contents the basic data on households' structure,

2. Surveys conducted within executed projects in period 2016-2019.,

3. Data collected from the local energy company PUC "Toplana-Sabac".

3.9.2 Home evolution

	Baseline Homes Heating (expected evolution without REPLACE)						
	Old Coal	Old other boiler	Natural gas	Solid biomass	Heat pumps	Biomass DH	Biomass total
Replaced/ year	-180	-600	250	330	80	120	450
2019	3.300	23.620	10.430	350	300	0	350
2020	3.120	23.020	10.680	680	380	120	800
2021	2.940	22.420	10.930	1.010	460	240	1.250
2022	2.760	21.820	11.180	1.340	540	360	1.700
2023	2.580	21.220	11.430	1.670	620	480	2.150
2024	2.400	20.620	11.680	2.000	700	600	2.600
2025	2.220	20.020	11.930	2.330	780	720	3.050
2026	2.040	19.420	12.180	2.660	860	840	3.500
2027	1.860	18.820	12.430	2.990	940	960	3.950
2028	1.680	18.220	12.680	3.320	1.020	1.080	4.400
2029	1.500	17.620	12.930	3.650	1.100	1.200	4.850
2030	1.320	17.020	13.180	3.980	1.180	1.320	5.300
2031	1.140	16.420	13.430	4.310	1.260	1.440	5.750
2032	960	15.820	13.680	4.640	1.340	1.560	6.200
2033	780	15.220	13.930	4.970	1.420	1.680	6.650

Table 169. Evolution of home heating systems stock per year (Baseline) Sabac

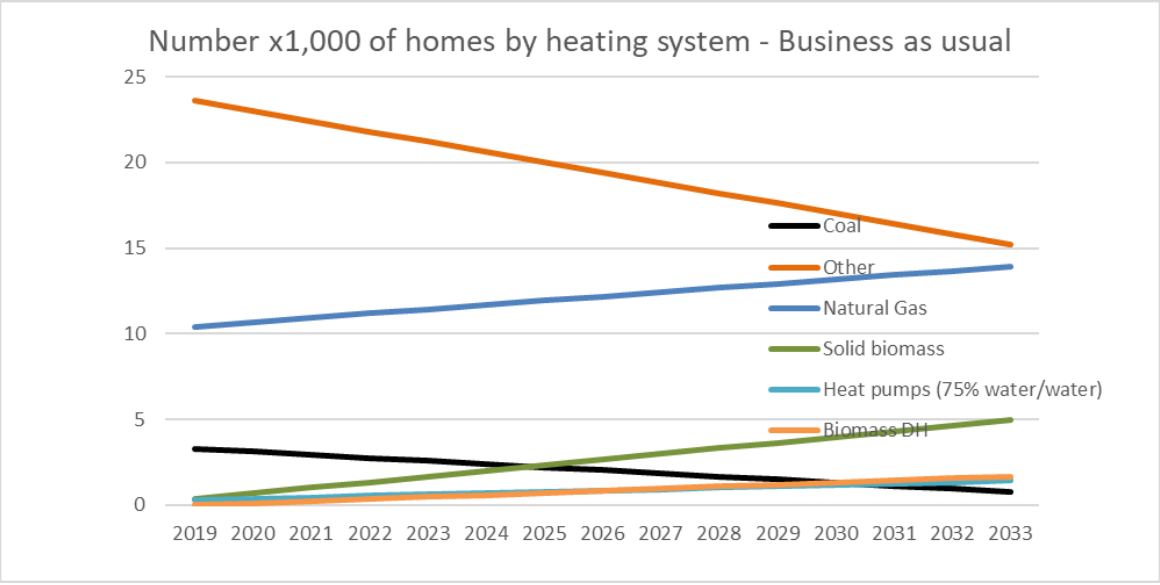

Figure 134. Evolution of home heating systems stock per year (Baseline) Sabac

	Optimistic Replace-Scenario Homes (Overachieving REPLACE target region objectives)						
	Old Coal	Old other boiler	Natural gas	Solid biomass	Heat pumps	Biomass DH	Biomass total
Replaced/ year	-225	-1.000	200	500	150	375	875
2019	3.300	23.620	10.430	350	300	0	350
2020	3.075	22.620	10.630	850	450	375	1.225
2021	2.850	21.620	10.830	1.350	600	750	2.100
2022	2.625	20.620	11.030	1.850	750	1.125	2.975
2023	2.400	19.620	11.230	2.350	900	1.500	3.850
2024	2.175	18.620	11.430	2.850	1.050	1.875	4.725
2025	1.950	17.620	11.630	3.350	1.200	2.250	5.600
2026	1.725	16.620	11.830	3.850	1.350	2.625	6.475
2027	1.500	15.620	12.030	4.350	1.500	3.000	7.350
2028	1.275	14.620	12.230	4.850	1.650	3.375	8.225
2029	1.050	13.620	12.430	5.350	1.800	3.750	9.100
2030	825	12.620	12.630	5.850	1.950	4.125	9.975
2031	600	11.620	12.830	6.350	2.100	4.500	10.850
2032	375	10.620	13.030	6.850	2.250	4.875	11.725
2033	150	9.620	13.230	7.350	2.400	5.250	12.600

Table 170. Evolution of home heating systems stock per year (Optimistic) Sabac

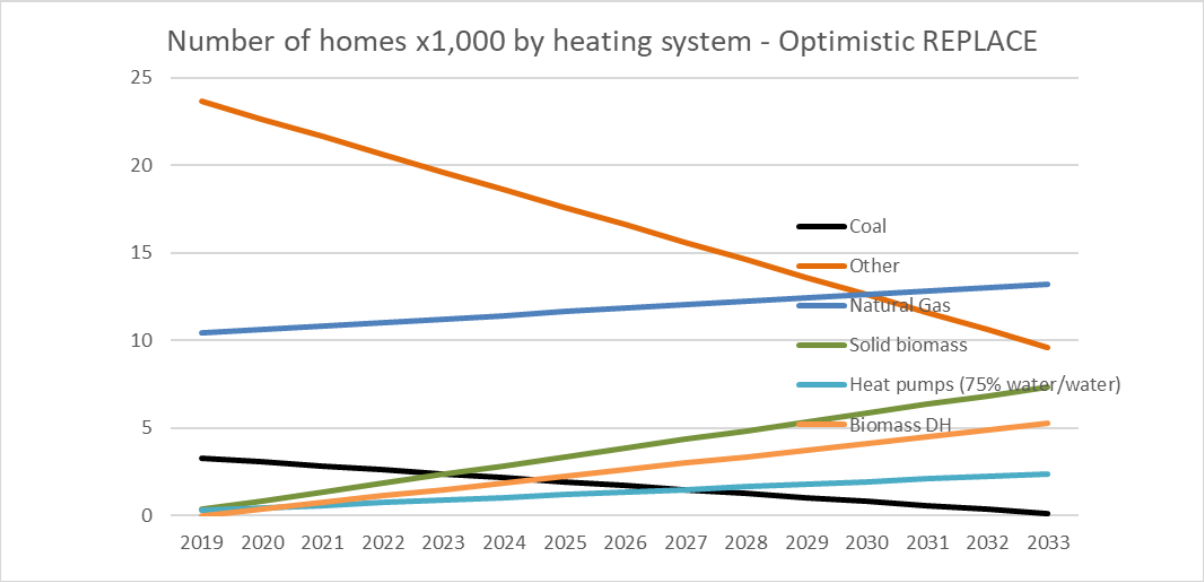

Figure 135. Evolution of home heating systems stock per year (Optimistic) Sabac

	Pessimistic Replace-Scenario Homes (Underachieving REPLACE target region objectives)						
	Old Coal	Old other boiler	Natural gas	Solid biomass	Heat pumps (	Biomass DH	Biomass total
Replaced/ year	-120	-860	350	400	100	130	530
2019	3.300	23.620	10.430	350	300	0	350
2020	3.180	22.760	10.780	750	400	130	880
2021	3.060	21.900	11.130	1.150	500	260	1.410
2022	2.940	21.040	11.480	1.550	600	390	1.940
2023	2.820	20.180	11.830	1.950	700	520	2.470
2024	2.700	19.320	12.180	2.350	800	650	3.000
2025	2.580	18.460	12.530	2.750	900	780	3.530
2026	2.460	17.600	12.880	3.150	1.000	910	4.060
2027	2.340	16.740	13.230	3.550	1.100	1.040	4.590
2028	2.220	15.880	13.580	3.950	1.200	1.170	5.120
2029	2.100	15.020	13.930	4.350	1.300	1.300	5.650
2030	1.980	14.160	14.280	4.750	1.400	1.430	6.180
2031	1.860	13.300	14.630	5.150	1.500	1.560	6.710
2032	1.740	12.440	14.980	5.550	1.600	1.690	7.240
2033	1.620	11.580	15.330	5.950	1.700	1.820	7.770

Table 171. Evolution of home heating systems stock per year (Pessimistic) Sabac

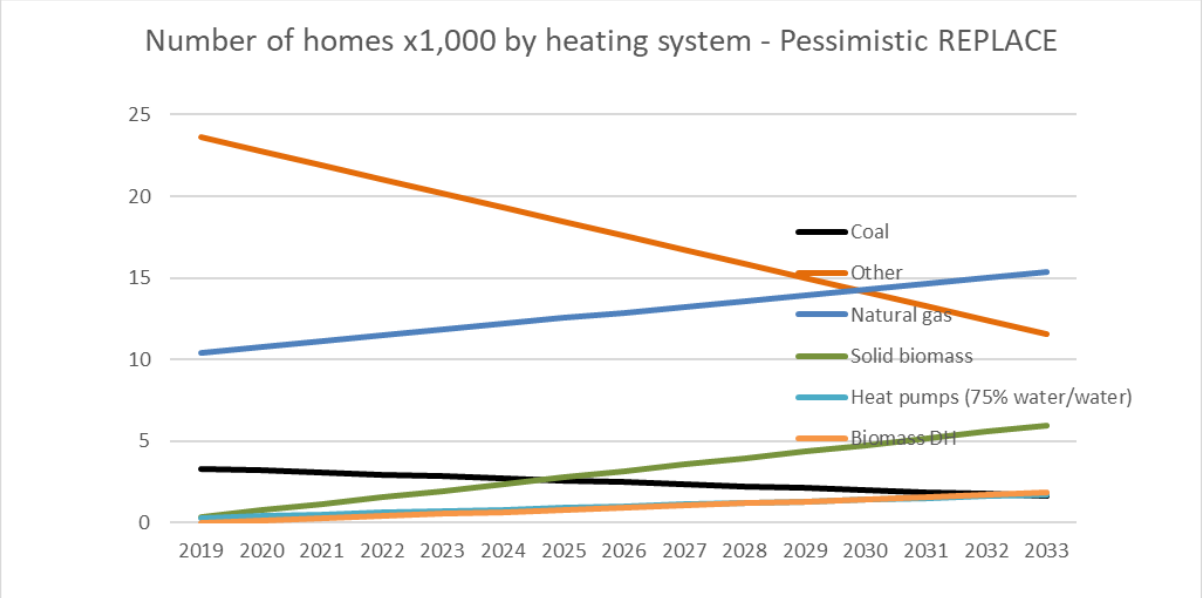

Figure 136. Evolution of home heating systems stock per year (Pessimistic) Sabac

The main source for heating homes in the region of Sabac are inefficient fuels for old boilers. Heating systems using this type of fuel are predicted to continue falling in the next decade. It is observed that the opposite happens with the natural gas and biomass heating systems. The project estimates between 860 and 1000 of the region's homes heated with inefficient types of fuel being replaced by biomass, followed by natural gas. The inventory estimates that around 500 biomass heating installations will be installed for homes in this region every year in the best scenario, and around 400 in the worst one.

Energy source	Annual average home heat consumption (kWh)
	kWh/home
Coal	10.800,000
GLP	0,000
Natural gas	10.800,000
Electricity	10.800,000
Biomass	10.800,000

Table 172. Annual average home heat consumption, Sabac

Old boiler performance	40,00%
New biomass boiler performance	80,00%

	Final energy savings (GWh)	
	Opptimistic Replace vs Business as usual	Pessimistic Replace vs Business as usual
2019	0,0	0,0
2020	5,7	1,1
2021	11,5	2,2
2022	17,2	3,2
2023	23,0	4,3
2024	28,7	5,4
2025	34,4	6,5
2026	40,2	7,6
2027	45,9	8,6
2028	51,6	9,7
2029	57,4	10,8
2030	63,1	11,9
2031	68,9	13,0
2032	74,6	14,0
2033	80,3	15,1

Table 173. Final energy savings, Sabac

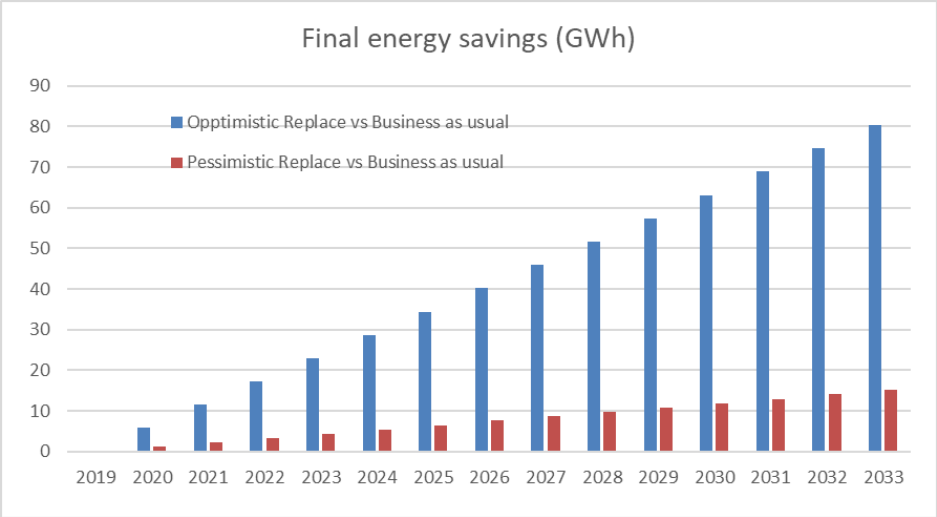

Figure 137. Final energy savings, Sabac

	Additional emissions reduction (tCO2)	
	Opptimistic Replace vs Business as usual	Pessimistic Replace vs Business as usual
2019	0	0
2020	1.721	324
2021	3.443	648
2022	5.164	972
2023	6.885	1.296
2024	8.606	1.620
2025	10.328	1.944
2026	12.049	2.268
2027	13.770	2.592
2028	15.491	2.916
2029	17.213	3.240
2030	18.934	3.564
2031	20.655	3.888
2032	22.376	4.212
2033	24.098	4.536

Table 174. Additional emissions reduction, Sabac

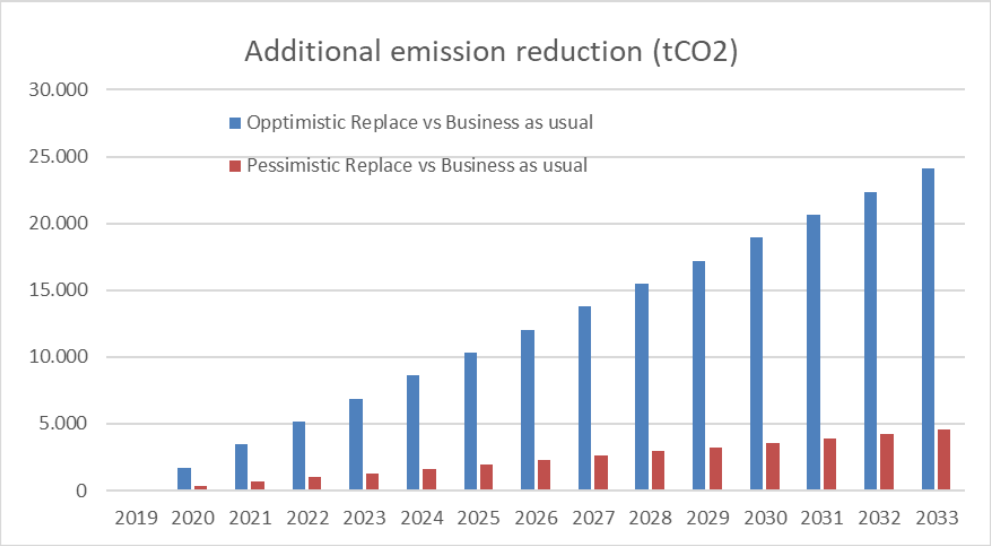

Figure 138. Additional emissions reduction, Sabac

The final energy savings for the optimistic and pessimistic scenarios were calculated considering the number of replacements for homes, the annual average home heat consumption, and the different performance values for the old and new heating systems. By the year 2033, with the assistance of the replace project, the region of Sabac could save between 24 and 32 GWh of energy. This in turn translates to a reduction of emissions in between 7,200 and 9,639 tons of CO2 by the year 2033.

3.9.3 Boiler evolution

	Baseline Individual Boilers (expected evolution without REPLACE)				
	number of individual boilers		**number of individual boilers**		
	Stock	Stock	Stock of boilers (number, cumulated)		
	Old coal	Old other boiler	Natural gas	Solid biomass	Electric heating (heat pump)
Replaced/year	-180	-600	250	330	80
2019	3.300	23.620	2.930	350	105
2020	3.120	23.020	3.180	680	185
2021	2.940	22.420	3.430	1.010	265
2022	2.760	21.820	3.680	1.340	345
2023	2.580	21.220	3.930	1.670	425
2024	2.400	20.620	4.180	2.000	505
2025	2.220	20.020	4.430	2.330	585
2026	2.040	19.420	4.680	2.660	665
2027	1.860	18.820	4.930	2.990	745
2028	1.680	18.220	5.180	3.320	825
2029	1.500	17.620	5.430	3.650	905
2030	1.320	17.020	5.680	3.980	985
2031	1.140	16.420	5.930	4.310	1.065
2032	960	15.820	6.180	4.640	1.145
2033	780	15.220	6.430	4.970	1.225

Table 175. Evolution of individual boilers stock per year (Baseline) Sabac

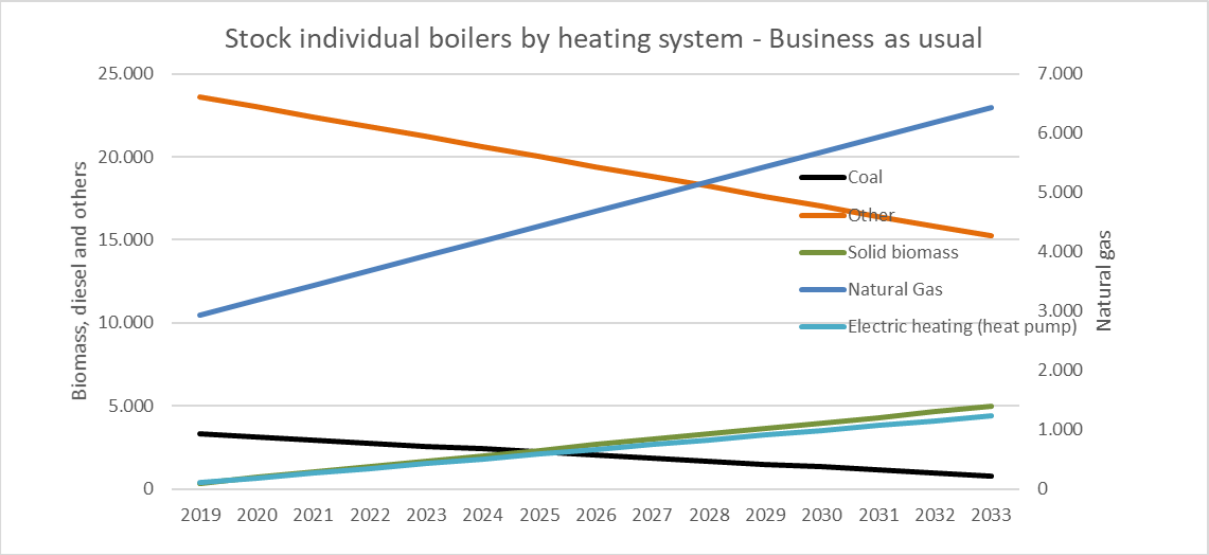

Figure 139. Evolution of individual boilers stock per year (Baseline) Sabac

	Optimistic Replace-Scenario Individual Boilers				
	number of individual boilers		number of individual boilers		
	Stock	Stock	Stock of boilers (number, cumulated)		
	Old coal	Old other boiler	Natural gas	Solid biomass	Electric heating (heat pump)
Replaced/year	-225	-950	200	500	150
2019	3.300	23.620	2.930	350	105
2020	3.120	23.020	3.180	850	185
2021	2.940	22.420	3.430	1.350	265
2022	2.715	21.470	3.630	1.850	415
2023	2.490	20.520	3.830	2.350	565
2024	2.265	19.570	4.030	2.850	715
2025	2.040	18.620	4.230	3.350	865
2026	1.815	17.670	4.430	3.850	1.015
2027	1.590	16.720	4.630	4.350	1.165
2028	1.365	15.770	4.830	4.850	1.315
2029	1.140	14.820	5.030	5.350	1.465
2030	915	13.870	5.230	5.850	1.615
2031	690	12.920	5.430	6.350	1.765
2032	465	11.970	5.630	6.850	1.915
2033	240	11.020	5.830	7.350	2.065

Table 176. Evolution of individual boilers stock per year (Optimistic) Sabac

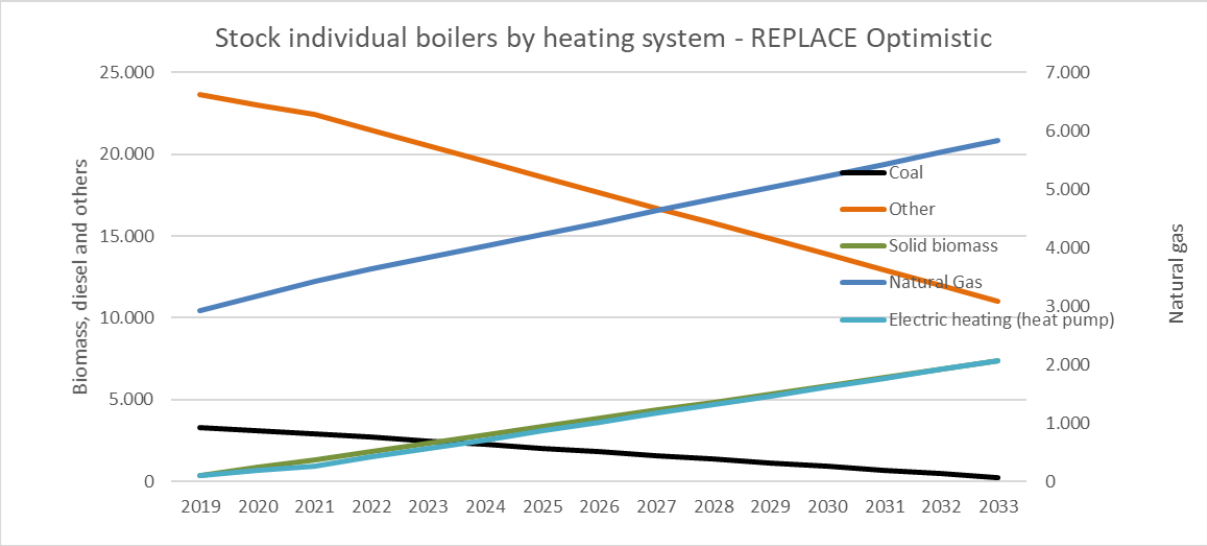

Figure 140. Evolution of individual boilers stock per year (Optimistic) Sabac

	Pessimistic Replace-Scenario Individual Boilers				
	number of individual boilers		number of individual boilers		
	Stock	Stock	Stock of boilers (number, cumulated)		
	Old coal	Old other boiler	Natural gas	Solid biomass	Electric heating (heat pump)
Replaced/year	-120	-860	350	400	100
2019	3.300	23.620	2.930	350	105
2020	3.180	22.760	3.280	750	205
2021	3.060	21.900	3.630	1.150	305
2022	2.940	21.040	3.980	1.550	405
2023	2.820	20.180	4.330	1.950	505
2024	2.700	19.320	4.680	2.350	605
2025	2.580	18.460	5.030	2.750	705
2026	2.460	17.600	5.380	3.150	805
2027	2.340	16.740	5.730	3.550	905
2028	2.220	15.880	6.080	3.950	1.005
2029	2.100	15.020	6.430	4.350	1.105
2030	1.980	14.160	6.780	4.750	1.205
2031	1.860	13.300	7.130	5.150	1.305
2032	1.740	12.440	7.480	5.550	1.405
2033	1.620	11.580	7.830	5.950	1.505

Table 177. Evolution of individual boilers stock per year (Pessimistic) Sabac

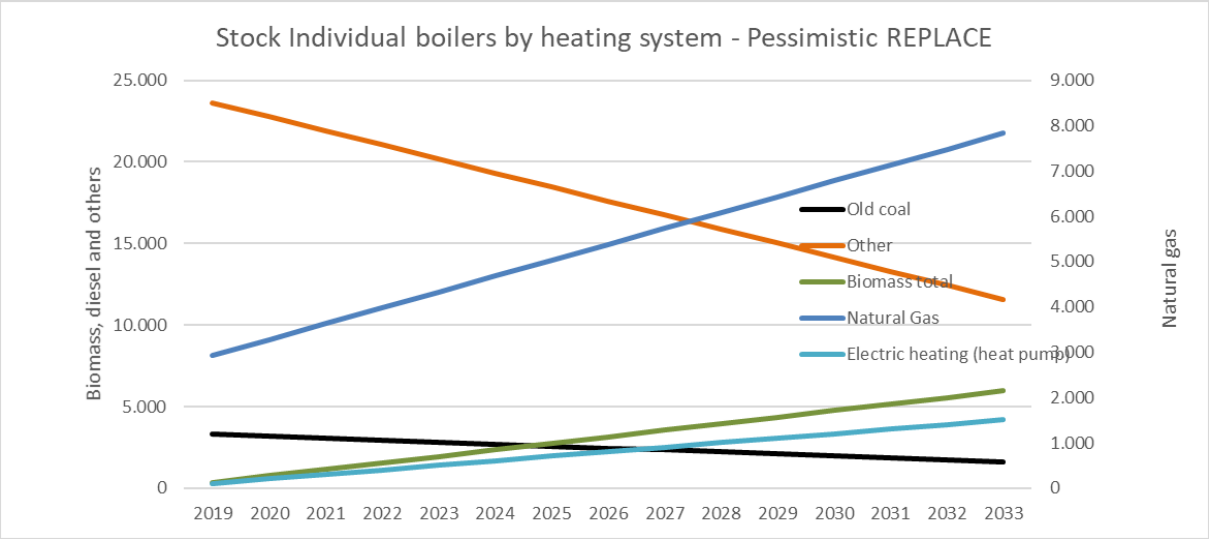

Figure 141. Evolution of individual boilers stock per year (Pessimistic) Sabac

	Baseline Colectivel Boilers and DH (expected evolution without REPLACE)					
	number of colective boilers		**number of colective boilers**			
	Old coal	Old other boiler	Natural gas	Solid biomass	Biomass DH	Biomass total
Replaced/year	0	0	1	0	1	1
2019	0	0	0	5	1	6
2020	0	0	1	5	2	7
2021	0	0	2	5	3	8
2022	0	0	3	5	4	9
2023	0	0	4	5	5	10
2024	0	0	5	5	6	11
2025	0	0	6	5	7	12
2026	0	0	7	5	8	13
2027	0	0	8	5	9	14
2028	0	0	9	5	10	15
2029	0	0	10	5	11	16
2030	0	0	11	5	12	17
2031	0	0	12	5	13	18
2032	0	0	13	5	14	19
2033	0	0	14	5	15	20

Table 178. Evolution of collective boilers stock per year (Baseline) Sabac

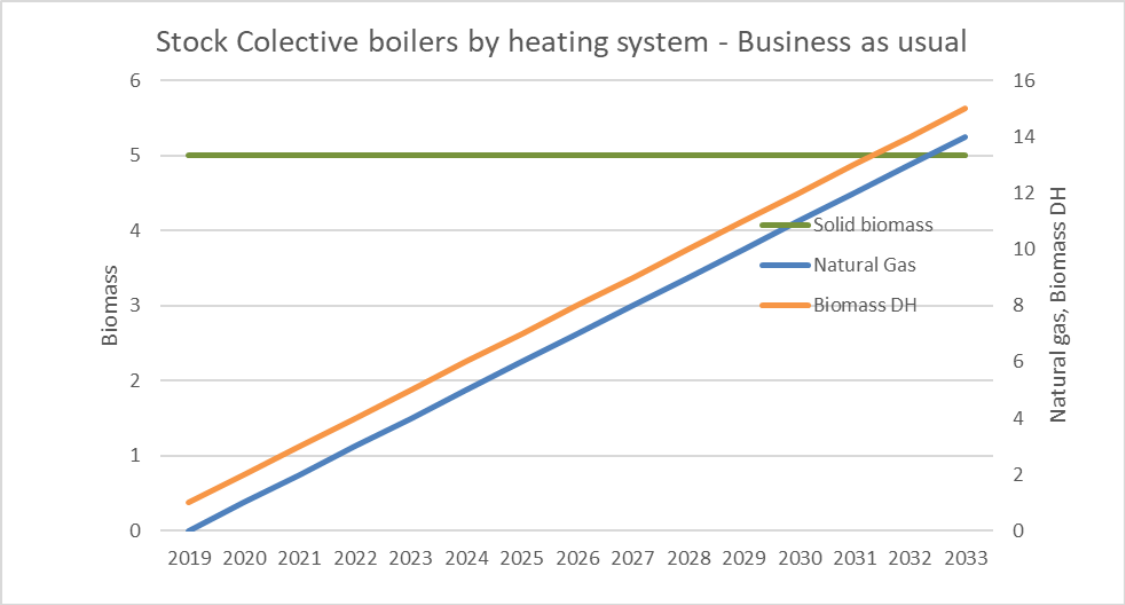

Figure 142. Evolution of collective boilers stock per year (Baseline) Sabac

	Optimistic Replace-Scenario Colective Boilers (Overachieving REPLACE target region objectives)					
	number of colective boilers		number of colective boilers			
	Old coal	Old other boiler	Natural gas	Solid biomass	Biomass DH	Biomass total
Replaced/year	0	0	1	1	2	3
2019	0	0	0	5	1	6
2020	0	0	1	6	3	9
2021	0	0	2	7	5	12
2022	0	0	3	8	7	15
2023	0	0	4	9	9	18
2024	0	0	5	10	11	21
2025	0	0	6	11	13	24
2026	0	0	7	12	15	27
2027	0	0	8	13	17	30
2028	0	0	9	14	19	33
2029	0	0	10	15	21	36
2030	0	0	11	16	23	39
2031	0	0	12	17	25	42
2032	0	0	13	18	27	45
2033	0	0	14	19	29	48

Table 179. Evolution of collective boilers stock per year (Optimistic) Sabac

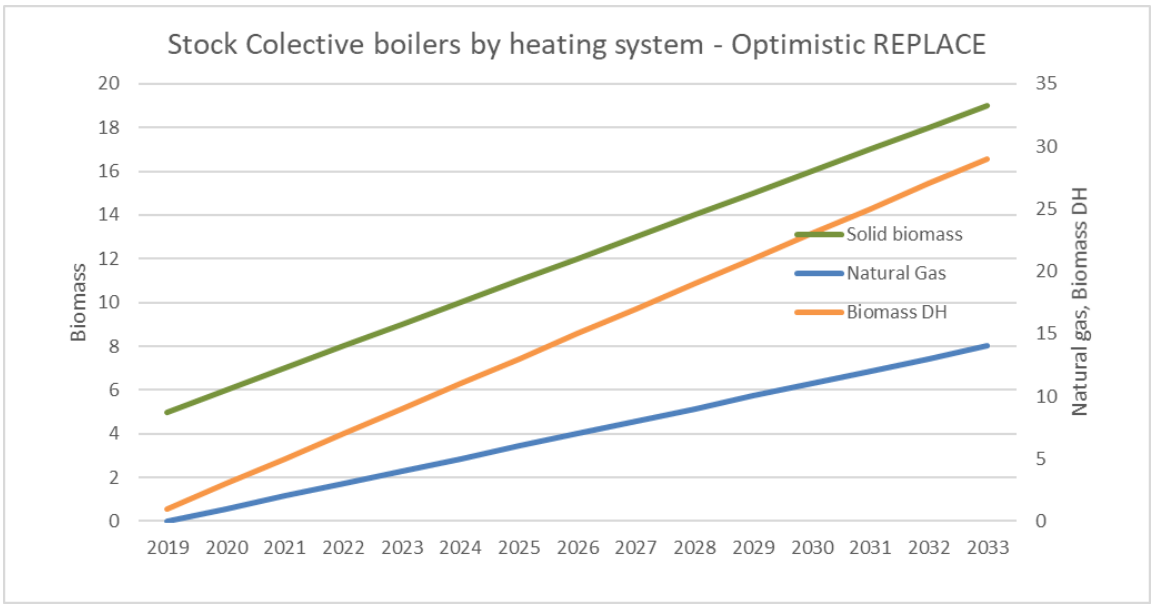

Figure 143. Evolution of collective boilers stock per year (Optimistic) Sabac

	Pessimistic Replace-Scenario Colective Boilers (Underachieving REPLACE target region objectives)					
	number of colective boilers		number of colective boilers			
	Old coal	Old other boiler	Natural gas	Solid biomass	Biomass DH	Biomass total
Replaced/year	0	0	2	0	1	1
2019	0	0	0	5	1	6
2020	0	0	2	5	2	7
2021	0	0	4	5	3	8
2022	0	0	6	5	4	9
2023	0	0	8	5	5	10
2024	0	0	10	5	6	11
2025	0	0	12	5	7	12
2026	0	0	14	5	8	13
2027	0	0	16	5	9	14
2028	0	0	18	5	10	15
2029	0	0	20	5	11	16
2030	0	0	22	5	12	17
2031	0	0	24	5	13	18
2032	0	0	26	5	14	19
2033	0	0	28	5	15	20

Table 180. Evolution of collective boilers stock per year (Pessimistic) Sabac

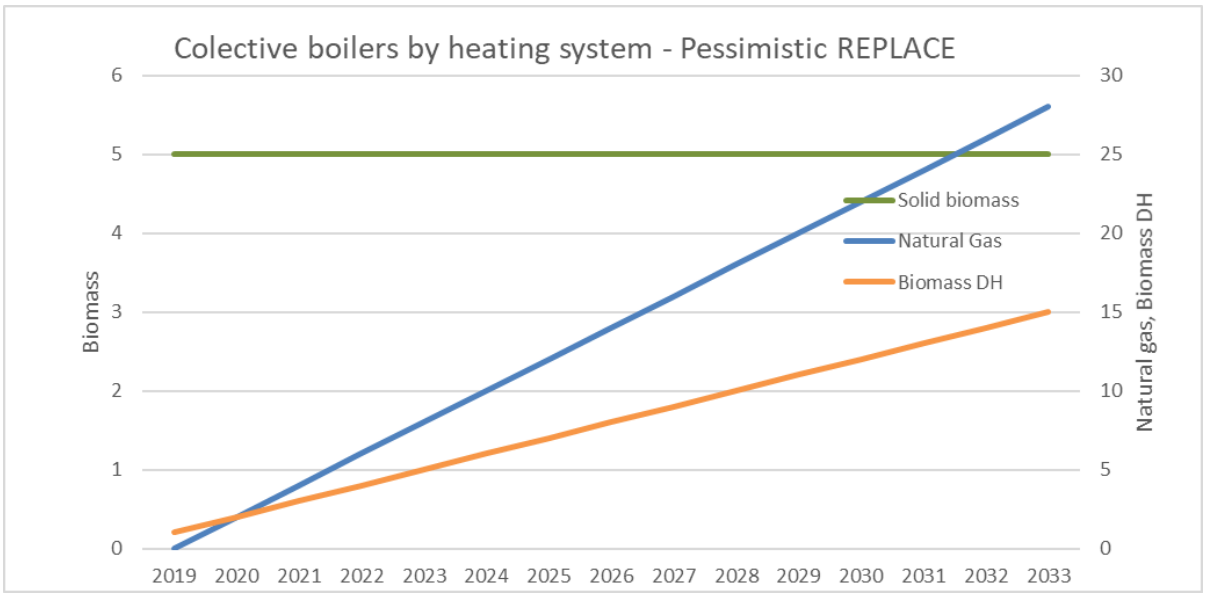

Figure 144. Evolution of collective boilers stock per year (Pessimistic) Sabac

	Baseline District Heating (expected evolution without REPLACE)			
	number of DH boilers		**number of DH boilers**	
	Old coal	Old other boiler	Natural gas	Solid biomass
Replaced/year	0	0	0	0
2019	0	0	8	1
2020	0	0	8	1
2021	0	0	8	1
2022	0	0	8	1
2023	0	0	8	1
2024	0	0	8	1
2025	0	0	8	1
2026	0	0	8	1
2027	0	0	8	1
2028	0	0	8	1
2029	0	0	8	1
2030	0	0	8	1
2031	0	0	8	1
2032	0	0	8	1
2033	0	0	8	1

Table 181. Evolution of district heating stock per year (Baseline) Sabac

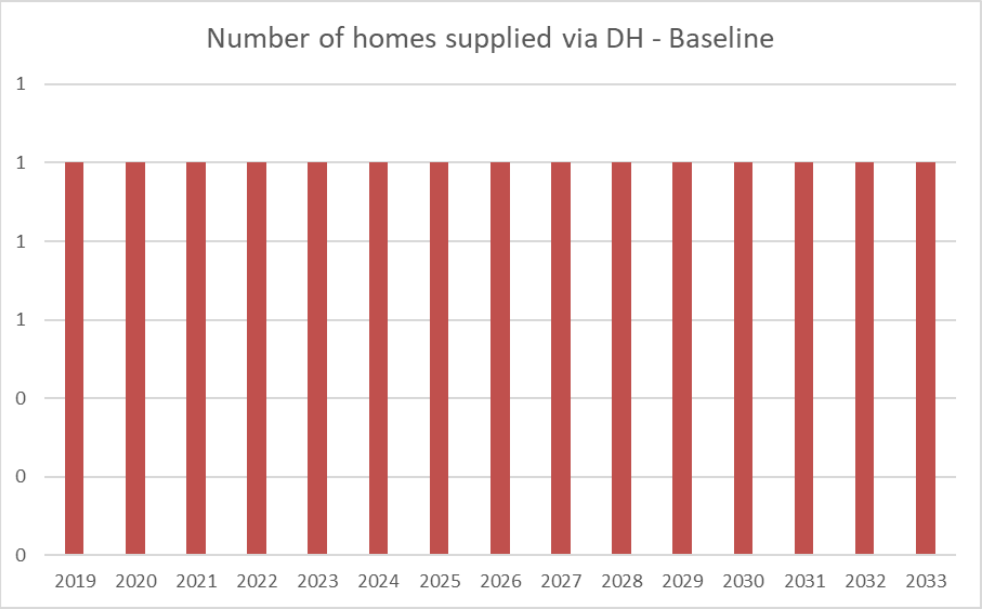

Figure 145. Evolution of district heating stock per year (Baseline) Sabac

Optimistic Replace-Scenario DH Boilers (Overachieving REPLACE target region objectives)				
	number of individual boilers		**number of individual boilers**	
	Old coal	Old other boiler	Natural gas	Solid biomass
Replaced/year	0	0	0	3
2019	0	0	8	1
2020	0	0	8	4
2021	0	0	8	7
2022	0	0	8	10
2023	0	0	8	13
2024	0	0	8	16
2025	0	0	8	19
2026	0	0	8	22
2027	0	0	8	25
2028	0	0	8	28
2029	0	0	8	31
2030	0	0	8	34
2031	0	0	8	37
2032	0	0	8	40
2033	0	0	8	43

Table 182. Evolution of district heating stock per year (Optimistic) Sabac

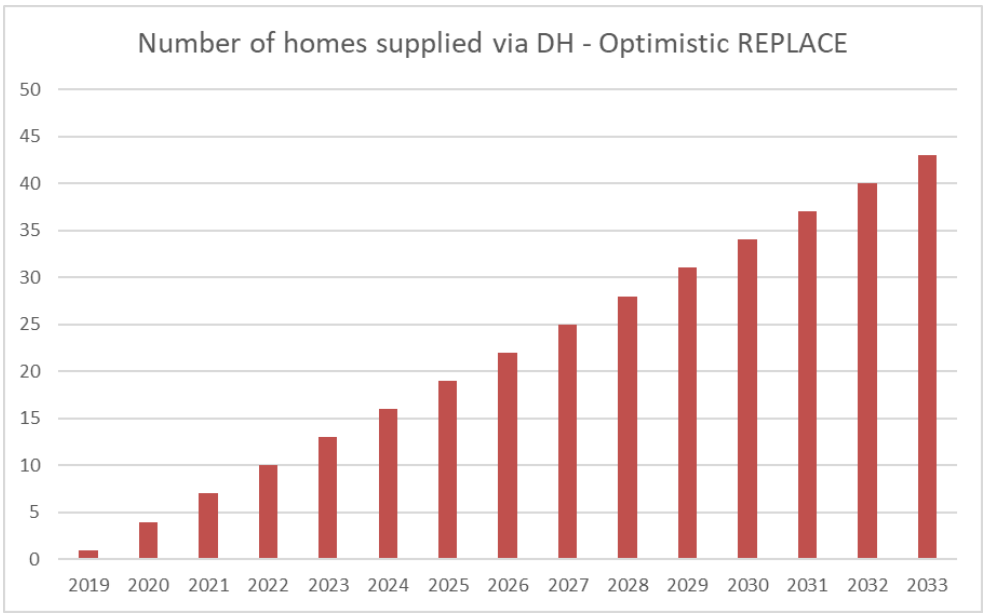

Figure 146. Evolution of district heating stock per year (Optimistic) Sabac

Pessimistic Replace-Scenario DH Boilers (Underachieving REPLACE target region objectives)				
	number of individual boilers		number of individual boilers	
	Old coal	Old other boiler	Natural gas	Solid biomass
Replaced/year	0	0	0	1
2019	0	0	8	1
2020	0	0	0	2
2021	0	0	0	3
2022	0	0	0	4
2023	0	0	0	5
2024	0	0	0	6
2025	0	0	0	7
2026	0	0	0	8
2027	0	0	0	9
2028	0	0	0	10
2029	0	0	0	11
2030	0	0	0	12
2031	0	0	0	13
2032	0	0	0	14
2033	0	0	0	15

Table 183. Evolution of district heating stock per year (Pessimistic) Sabac

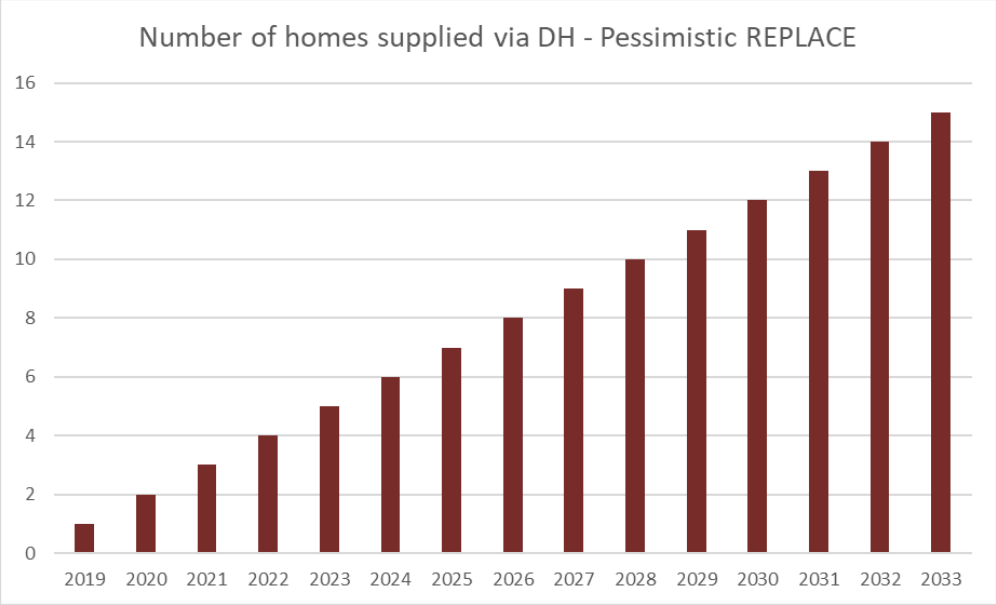

Figure 147. Evolution of district heating stock per year (Pessimistic) Sabac

For individual boilers we can see a similar scenario to the home evolution situation. Mainly, inefficient old boilers are being replaced by efficient biomass boilers, followed by natural gas boilers.

3.9.4 Investment/Economics

	Average boiler power	Price (€/kW) only boiler	Price (€/kW) biomass turnkey system
Individual boilers (P<50kW)	36	100	130
Colective boilers (P>50kW)	500	200	350
Distrcit Heating boilers	1000	180	260

Table 184. Average boiler price, Sabac

	Number of boilers increased by REPLACE		Annual REPLACE (€) investment only in boilers		Annual REPLACE (€) turnkey project investment	
	Optimist	Pessimist	Optimist	Pessimist	Optimist	Pessimist
Individual boilers (P<50kW)	170	70	612.000	252.000	795.600	327.600
Colective boilers (P>50kW)	1	0	100.000	-	175.000	-
Distrcit Heating boilers	3	1	540.000	180.000	780.000	260.000
Total investment €			1.252.000,0	432.000,0	1.750.600,0	587.600,0

Table 185. Annual Replace investment triggered, Sabac

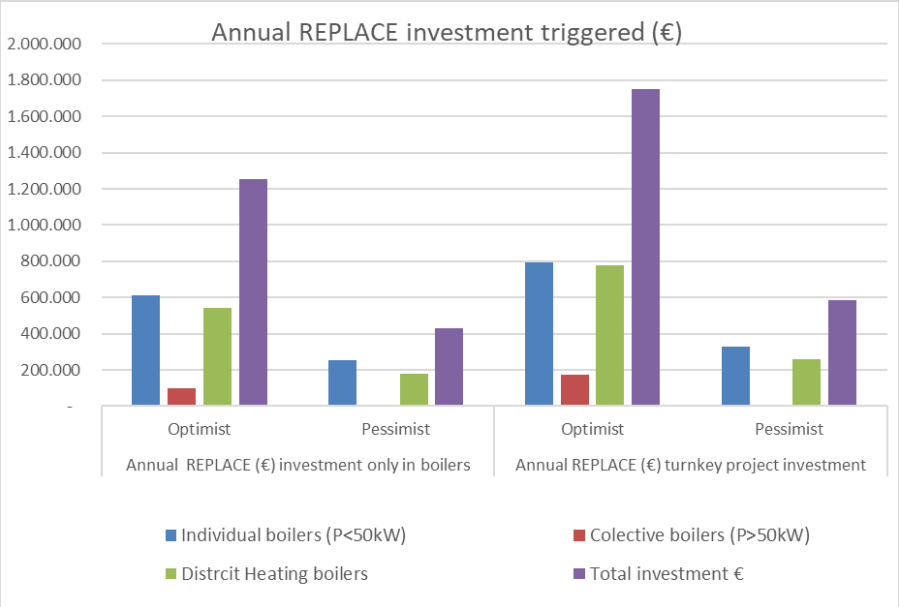

Figure 148. Annual Replace investment triggered, Sabac

3.9.5 Main conclusions

In order to better understand the report, it should be noted that the Assembly of the City of Sabac adopted a document entitled "Energy Policy of the City of Sabac" which defines the framework for local energy development and the transition from energy based on fossil fuels to increase the share of green technologies. By 2050, complete independence of the heating and cooling sector from fossil fuels is planned.

Decision makers focused on the implementation of energy efficiency measures that include thermal insulation of existing buildings (both private and commercial) as well as the construction of new heat sources that will use renewable energy. Locally available renewable energy is geothermal energy, solar energy as well as wood biomass. The use of waste heat from cogeneration plants that run on biomass from agricultural residues and the use of a large-capacity heat pump that will use water from the municipal wastewater treatment plant (before discharge into the Sava River) will play a significant role. In that sense, the strategy of the city of Sabac is to expand the district heating network in the urban part of the administrative territory of the city.

Small district heating networks that use renewable energy (wood biomass) are planned in suburban settlements and central parts of rural settlements where public buildings belonging to the local self-government are located and where the population density is high, which supports the financial sustainability of these projects.

For other households and technological producers in the food production and processing sector, as well as for smaller technological lines, the use of individual fireplaces in which pellets or wood chips are burned is envisaged.

The analysis of the pessimistic replacement scenario took into account the current situation that in the urban part of Sabac there is a 200 km long natural gas distribution network and that approximately 3,200 households are connected to it, but the projected number of connections is 10,000. With air

pollution caused by emmision from individual fireplaces (which use coal or log-wood but in an inefficient way), could motivate local authorities to activate mechanisms to promote the use of natural gas as an alternative to coal and replace old inefficient boilers.

Energy efficiency measures and the need to reduce energy consumption in the district heating sector have been promoted since 2010, when collective actions were launched with a focus on thermal insulation of existing buildings and then the installation of thermostatic valves and cost allocators. The city authorities supported this project with a subsidy mechanism, and through media campaigns, the citizens' awareness of the need to preserve the environment and the effects of efficient energy consumption was raised. The assessment of the number of households and their interest in replacement activities is based on these facts. The presented data show that the number of households that use coal in 2033 could be halved (pessimistic scenario) or even stop using coal (optimistic scenario). It should be noted that there is no information that any household in Šabac uses heating oil for heating. Other old boilers use log-wood but have a low degree of efficiency (40%), as such they are not financially viable and are a source of emissions that harm the environment. It is expected to reduce the number of households using old inefficient wood-fired boilers, to 40% but not more than 50%.

However, wood pellets have become attractive to a large number of households, so the growth in the number of households that will replace their old boilers with new and more efficient boilers could be as much as 25 times higher than it is now, but certainly not less than 15 times . The low price of electricity in Serbia additionally motivates families to use water-to-water and air-to-water heat pumps. The expected growth in the number of households using heat pumps for heating and cooling will increase 6 to 8 times compared to the current situation.

The risk for the replacement project is the unused capacity of the gas network. If there are no large disturbations in the natural gas market, growth is expected in the number of households using natural gas by 3,000 (optimistic variant) to 5,000 (pessimistic variant).

In any case, it is possible to save primary energy from 24.2 GWh to 32.1 GWh, ie a reduction of CO2 emissions in the amount of 7,258 t / a to 9,639 t / a is expected.

The traditional way of heating means that every household has its own boiler. The growth in the number of biomass and natural gas boilers corresponds to the change in the number of households that will replace coal-fired boilers and old inefficient wood-fired boilers. The optimistic scenario relies on the prediction that the installation of heat pumps and pellet boilers will be more attractive for owners of coal-fired boilers and owners of inefficient old wood-fired boilers. According to the pessimistic scenario, citizens will be more motivated to install natural gas boilers, but there will definitely be an increase in demand for pellet boilers and heat pumps. Large collective boilers used by condominiums are not traditionally represented in Sabac, although there are such examples. The number of new boilers in residential buildings is estimated at 3 (according to the pessimistic scenario) to 8 according to the optimistic scenario). There are more chances to increase the number of large wood-fired boilers in suburban and rural settlements where small district heating networks with wood-fired boilers are promoted. In the period under analysis, the construction of more than 40 small district heating networks with wood-fired boilers is expected.

In the urban part of the city there is a trend of building boiler rooms with bigger natural gas boilers. If the district heating network does not develop fast enough, citizens who own apartments in multi-family buildings will be motivated to invest in the purchase of gas boilers.

The average size of boilers in households is 36 kW, which is a consequence of the relatively high heat demand. The Rulebook on Energy Efficiency entered into force at the end of 2016, so a small number of residential buildings meet EU standards on energy consumption. The capacity of boilers in buildings

is up to 500 kW and the average size of wood-fired boilers used in small district heating networks is 1,000 kW.

Taking into account the estimate of the number of devices that will be replaced, REPLACE project is expected to launch an investment cycle in the amount of EUR 432,000 to EUR 1,252,000 related to the procurement of devices but together with the accompanying installation works the citizens of Sabac are expected to invest in REPLACE activities between € 587,000 and € 1,750,000.

3.10 Slovenia – Slovenia

3.10.1 Methodology and information sources

The data used for Slovenia were obtained from several sources. The origin database consists combined data from Register of Real Estates (consists data on buildings), Eco fund (consists data on subsidized EE and RES measures), Chimney sweeper database (consists data on all residential boilers below 50 kW) and Statistical Office of the Republic of Slovenia. The data were used for the preparation of the analysis for National Energy and Climate plan, from which derives baseline and optimistic scenario.

3.10.2 Home evolution

Baseline Homes Heating (expected evolution without REPLACE)								
	Coal boiler	Fuel oil	Natural gas	Old biomass	Modern biomass	Heat pumps	Electric heating	DH
2019	31	90.796	37.496	102.270	90605	50.486	2.529	144.335
2020	21	86.236	38.717	93.756	98.441	55.412	2.164	146.004
2021	14	81.796	39.717	85.178	106.505	60.464	1.823	147.687
2022	9	77.413	40.293	76.538	114.780	65.568	1.509	149.385
2023	6	73.076	40.419	67.855	123.278	70.713	1.227	151.099
2024	4	68.785	40.066	59.158	132.002	75.880	979	152.829
2025	2	64.553	39.199	50.486	140.936	81.050	766	154.573
2026	1	60.366	37.707	41.894	149.850	86.113	586	156.334
2027	1	56.261	35.580	33.442	158.853	91.127	439	158.109
2028	1	52.266	32.783	25.201	167.891	96.073	321	159.901
2029	0	48.414	29.296	17.245	176.905	100.936	229	161.708
2030	0	44.733	25.129	9.648	185.848	105.720	160	163.532
2031	0	41.272	20.402	2.562	193.896	109.486	108	165.024
2032	0	38.066	15.506	0	201.609	112.885	71	166.517
2033	0	35.124	10.479	0	208.965	115.913	46	168.012

Table 186. Evolution of home heating systems stock per year (Baseline) Slovenia

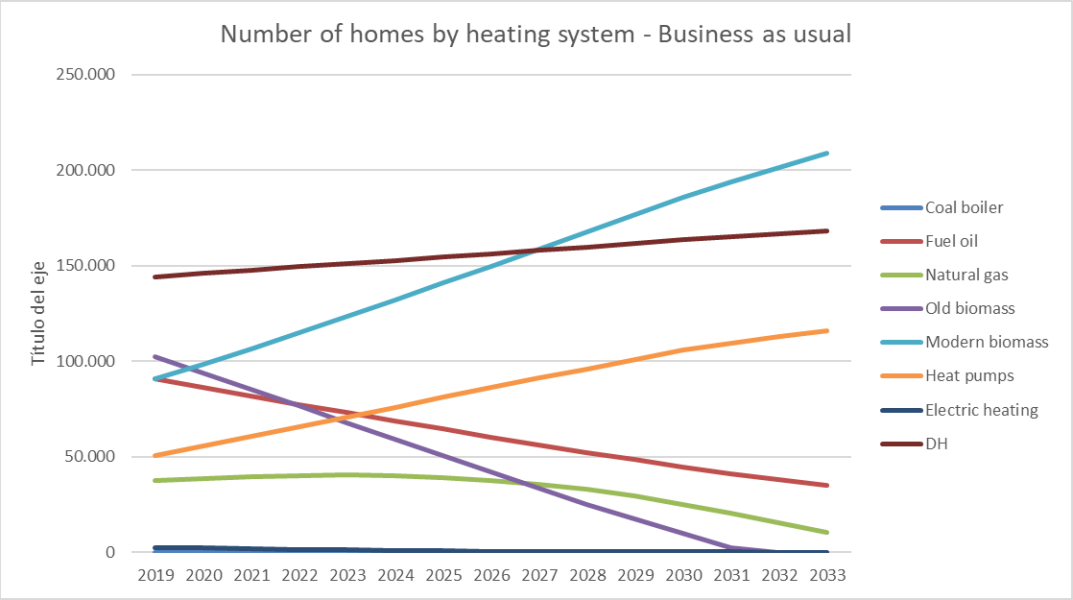

Figure 149. Evolution of home heating systems stock per year (Baseline) Slovenia

Optimistic Replace-Scenario Homes (Overachieving REPLACE target region objectives)								
	Coal boiler	Fuel oil	Natural gas	Old biomass	Modern biomass	Heat pumps	Electric heating	DH
2019	31	90.796	37.496	102.270	90605	50.486	2.529	144.335
2020	21	85.846	36.560	93.595	97.921	57.679	2.164	146.690
2021	14	80.988	35.633	84.964	105.387	65.439	1.823	148.601
2022	9	76.130	33.941	76.256	112.939	73.680	1.509	150.598
2023	6	71.256	31.440	67.488	120.586	82.415	1.227	152.684
2024	4	66.363	28.085	58.687	128.325	91.649	979	154.860
2025	2	61.459	23.827	49.895	136.140	101.381	766	157.130
2026	1	56.632	18.724	41.163	144.142	111.111	586	159.494
2027	1	51.913	12.743	32.554	152.307	120.793	439	161.956
2028	1	47.336	5.860	24.136	160.594	130.374	321	164.518
2029	0	42.936	0	15.983	168.961	139.797	229	167.182
2030	0	38.744	0	8.236	177.409	149.155	160	169.657
2031	0	34.767	0	975	184.645	156.740	108	171.907
2032	0	31.024	0	0	191.537	163.970	71	174.266
2033	0	27.527	0	0	198.047	170.791	46	176.734

Table 187. Evolution of home heating systems stock per year (Optimistic) Slovenia

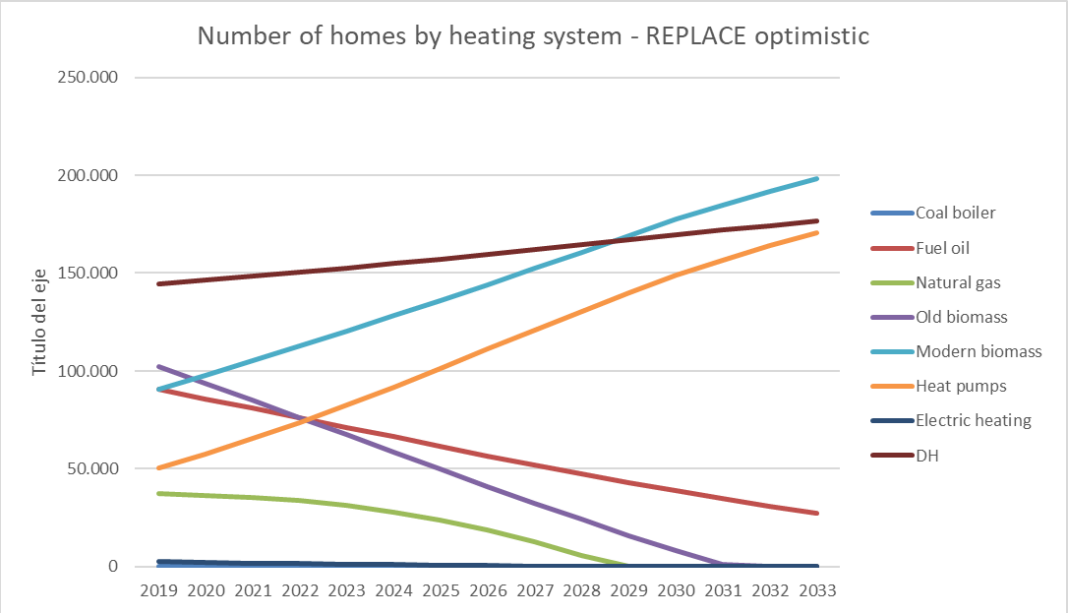

Figure 150. Evolution of home heating systems stock per year (Optimistic) Slovenia

Pessimistic Replace-Scenario Homes (Underachieving REPLACE target region objectives)								
	Coal boiler	Fuel oil	Natural gas	Old biomass	Modern biomass	Heat pumps	Electric heating	DH
2019	31	90.796	37.263	102.200	90605	50.486	2.529	144.638
2020	21	86.276	38.380	93.659	97.211	57.102	2.164	146.446
2021	14	81.837	39.151	85.041	103.848	63.863	1.823	148.300
2022	9	77.456	39.572	76.355	110.532	70.770	1.509	150.201
2023	6	73.121	39.621	67.618	117.269	77.815	1.227	152.150
2024	4	68.834	39.271	58.859	124.051	84.983	979	154.147
2025	2	64.605	38.493	50.118	130.859	92.256	766	156.195
2026	1	60.423	37.220	41.447	137.677	99.539	586	158.293
2027	1	56.313	35.428	32.909	144.473	106.797	439	160.443
2028	1	52.305	33.089	24.574	151.200	113.991	321	162.646
2029	0	48.430	30.192	16.515	157.808	121.079	229	164.903
2030	0	44.716	26.791	8.822	164.249	128.018	160	167.145
2031	0	41.167	22.786	1.629	169.751	133.567	108	169.096
2032	0	37.831	18.654	0	175.034	138.690	71	171.089
2033	0	34.717	14.427	0	180.068	143.348	46	173.124

Table 188. Evolution of home heating systems stock per year (Pessimistic) Slovenia

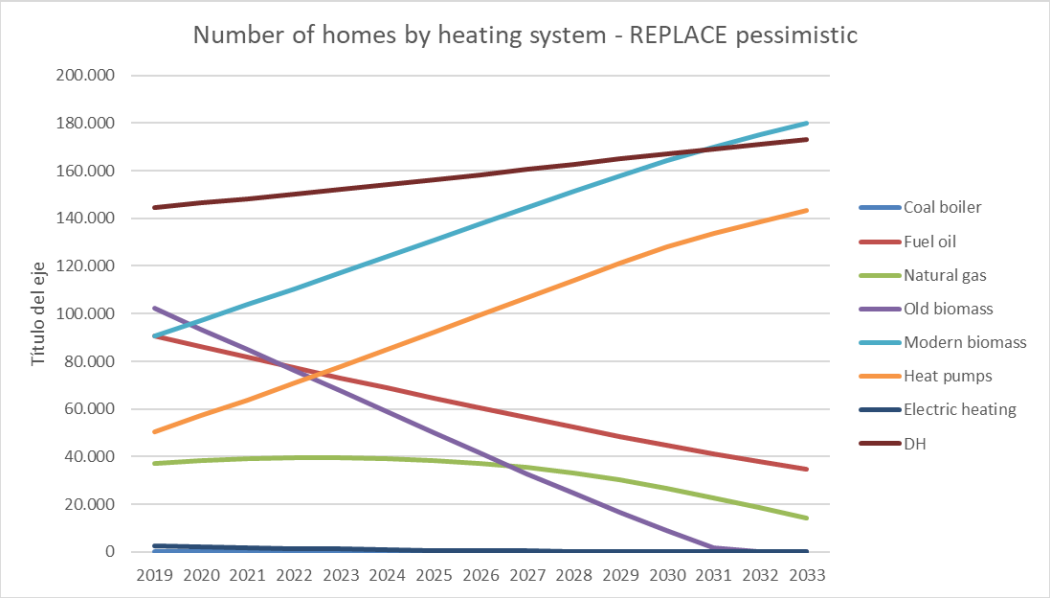

Figure 151. Evolution of home heating systems stock per year (Pessimistic) Slovenia

The main source for heating homes in Slovenia is biomass. Residential homes using natural gas are predicted to continue to use it for some time, but later on replace it with either district heating substation heat pump, since natural gas is mainly present in urban areas. Old biomass heating systems are being replaced by more efficient biomass heating systems and heat pumps.

Energy source	Annual average home heat consumption (kWh)
	kWh/home
Diesel oil	8.580,0
GLP	8.580,0
Natural gas	8.580,0
Heat Pump	8.580,0
Biomass	8.580,0

Table 189. Annual average home heat consumption, Slovenia

Old boiler performance	75%	
New heating generator (heat pump)	150%	
	Final energy savings (GWh)	
	Opptimistic Replace vs Business as usual	Pessimistic Replace vs Business as usual
2019	0,0	0,0
2020	13,0	9,7
2021	28,5	19,4
2022	46,4	29,8
2023	66,9	40,6
2024	90,2	52,1
2025	116,3	64,1
2026	143,0	76,8
2027	169,7	89,6
2028	196,2	102,5
2029	222,3	115,2
2030	248,4	127,5
2031	270,3	137,7
2032	292,2	147,6
2033	313,9	156,9

Table 190. Final energy savings, Slovenia

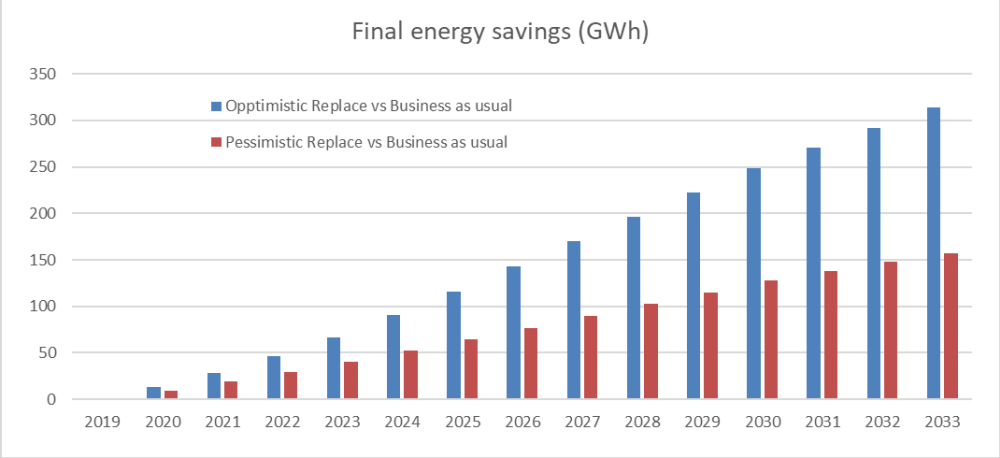

Figure 152. Final energy savings, Slovenia

	Additional emissions reduction (tCO2)	
	Opptimistic Replace vs Business as usual	Pessimistic Replace vs Business as usual
2019	0	0
2020	6.225	4.639
2021	13.661	9.335
2022	22.272	14.282
2023	32.128	19.499
2024	43.294	24.994
2025	55.820	30.766
2026	68.635	36.863
2027	81.451	43.025
2028	94.174	49.195
2029	106.697	55.306
2030	119.255	61.221
2031	129.741	66.117
2032	140.260	70.851
2033	150.674	75.325

Table 191. Additional emissions reduction, Slovenia

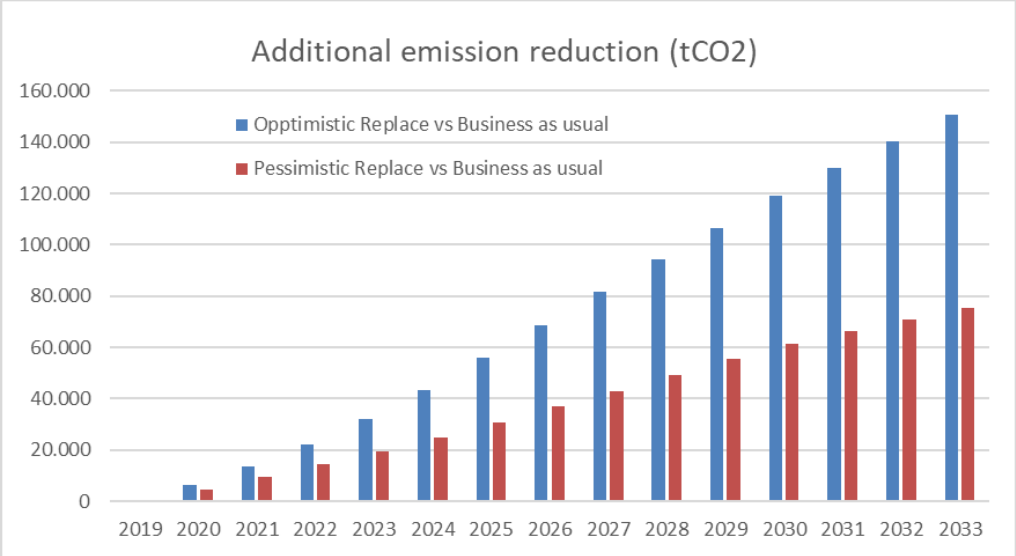

Figure 153. Additional emissions reduction, Slovenia

The final energy savings for the optimistic and pessimistic scenarios were calculated considering the number of replacements for homes, the annual average home heat consumption, and the different performance values for the old and new heating systems. By the year 2033, with the assistance of the replace project, Slovenia could save between 1,000 and 2,100 GWh of energy. This in turn translates to a reduction of emissions in between 500,000 and 1,000,000 tons of CO2 by the year 2033.

3.10.3 Boiler evolution

	Baseline Individual Boilers (expected evolution without REPLACE)						
	number of individual boilers						
	Coal boiler	Fuel oil	Natural gas	Old biomass	Modern biomass	Heat pumps	Electric heating
Replaced/year	-6	-3.454	2.475	-7.931	7.155	4.954	-566
2019	22	70.474	102.457	132.785	83.585	50.611	4.483
2020	15	67.021	104.932	124.854	90.740	55.565	3.917
2021	11	63.675	107.202	116.866	98.072	60.649	3.382
2022	8	60.396	109.168	108.824	105.580	65.789	2.880
2023	5	57.172	110.821	100.743	113.276	70.973	2.420
2024	3	53.999	112.143	92.651	121.160	76.184	2.004
2025	2	50.880	113.114	84.586	129.221	81.403	1.637
2026	1	47.804	113.727	76.597	137.215	86.526	1.318
2027	1	44.796	113.982	68.744	145.254	91.613	1.046
2028	1	41.878	113.856	61.093	153.290	96.647	820
2029	0	39.071	113.326	53.715	161.269	101.609	634
2030	0	36.395	112.388	46.683	169.149	106.507	485
2031	0	33.886	110.811	40.066	176.295	110.368	368
2032	0	31.570	109.111	33.927	183.129	113.861	276
2033	0	29.455	107.296	28.318	189.644	116.980	206

Table 192. Evolution of individual boilers stock per year (Baseline) Slovenia

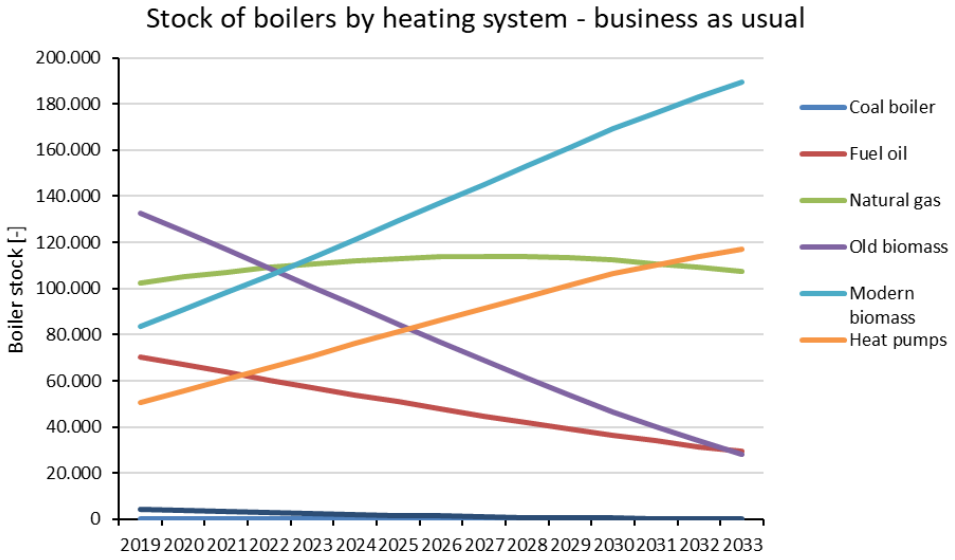

Figure 154. Evolution of individual boilers stock per year (Baseline) Slovenia

	Optimistic Replace-Scenario Individual Boilers						
	number of individual boilers						
	Coal boiler	Fuel oil	Natural gas	Old biomass	Modern biomass	Heat pumps	Electric heating
Replaced/year	-6	-3.828	941	-7.935	6.660	7.732	-568
2019	22	70.474	102.457	132.785	83.585	50.611	4.483
2020	15	66.646	103.398	124.851	90.246	58.343	3.915
2021	11	62.883	103.939	116.863	96.986	63.681	3.380
2022	8	59.130	103.904	108.820	103.783	69.079	2.878
2023	5	55.369	103.264	100.740	110.643	74.522	2.418
2024	3	51.592	101.987	92.648	117.565	79.993	2.003
2025	2	47.801	100.040	84.583	124.533	85.473	1.635
2026	1	44.085	97.675	76.594	131.658	90.852	1.316
2027	1	40.465	94.878	68.741	138.918	96.194	1.045
2028	1	36.964	91.638	61.089	146.281	101.479	818
2029	0	33.608	87.948	53.712	153.711	106.690	633
2030	0	30.422	83.810	46.679	161.189	111.832	484
2031	0	27.396	79.538	40.062	167.622	115.887	366
2032	0	24.544	75.152	33.923	173.752	119.554	275
2033	0	21.874	70.677	28.315	179.556	122.829	205

Table 193. Evolution of individual boilers stock per year (Optimistic) Slovenia

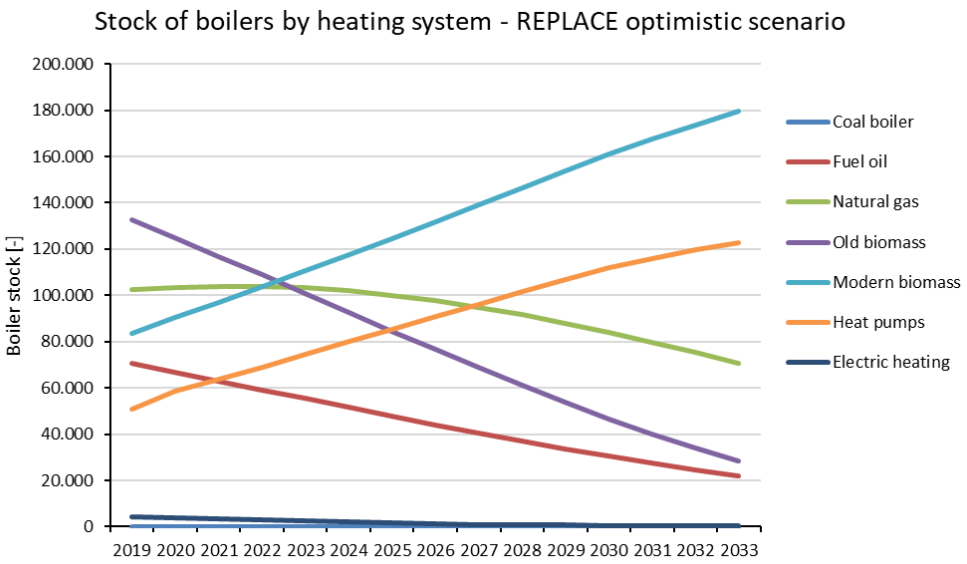

Figure 155. Evolution of individual boilers stock per year (Optimistic) Slovenia

	Pessimistic Replace-Scenario Individual Boilers						
	number of individual boilers						
	Coal boiler	Fuel oil	Natural gas	Old biomass	Modern biomass	Heat pumps	Electric heating
	-6	-3.434	2.320	-7.927	5.883	6.065	-564
2019	22	70.474	102.457	132.785	83.585	50.611	4.483
2020	15	67.040	104.777	124.859	89.468	56.676	3.920
2021	11	63.696	106.889	116.871	95.353	61.862	3.384
2022	8	60.420	108.788	108.828	101.249	67.105	2.883
2023	5	57.198	110.469	100.747	107.158	72.393	2.422
2024	3	54.027	111.920	92.655	113.071	77.708	2.007
2025	2	50.912	113.128	84.590	118.972	83.031	1.639
2026	1	47.840	114.137	76.601	124.834	88.256	1.320
2027	1	44.828	114.936	68.748	130.622	93.445	1.049
2028	1	41.897	115.514	61.097	136.297	98.580	822
2029	0	39.067	115.858	53.719	141.817	103.641	636
2030	0	36.359	115.963	46.687	147.140	108.637	487
2031	0	33.760	115.388	40.070	151.695	112.576	370
2032	0	31.315	114.734	33.931	156.064	116.138	278
2033	0	29.028	114.003	28.323	160.228	119.319	207

Table 194. Evolution of individual boilers stock per year (Pessimistic) Slovenia

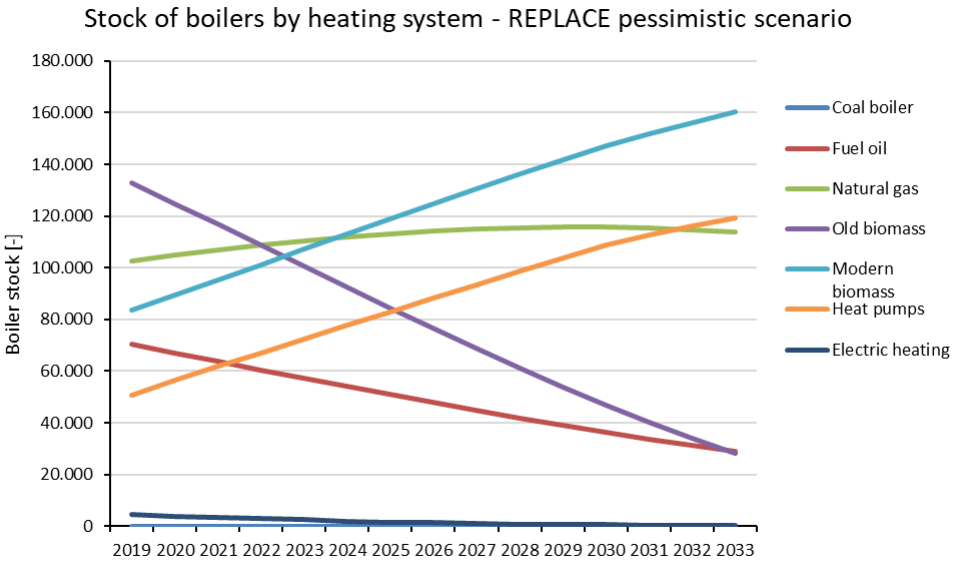

Figure 156. Evolution of individual boilers stock per year (Pessimistic) Slovenia

Baseline District Heating (expected evolution without REPLACE)							
	Fossil fuels			RES			
	0	1	0	0	0	0	0
2019	1	39	17	0	17	4	1
2020	1	40	17	0	17	4	1
2021	1	40	17	0	17	4	1
2022	1	41	18	0	18	4	1
2023	1	42	18	0	18	4	1
2024	1	42	18	0	18	4	1
2025	1	43	18	0	18	4	1
2026	1	44	18	0	18	4	1
2027	1	44	19	0	19	4	1
2028	1	45	19	0	19	4	1
2029	1	46	19	0	19	5	1
2030	1	46	19	0	19	5	1
2031	1	47	19	0	19	5	1
2032	1	48	20	0	20	5	1
2033	1	48	20	0	20	5	1

Table 195. Evolution of district heating stock per year (Baseline) Slovenia

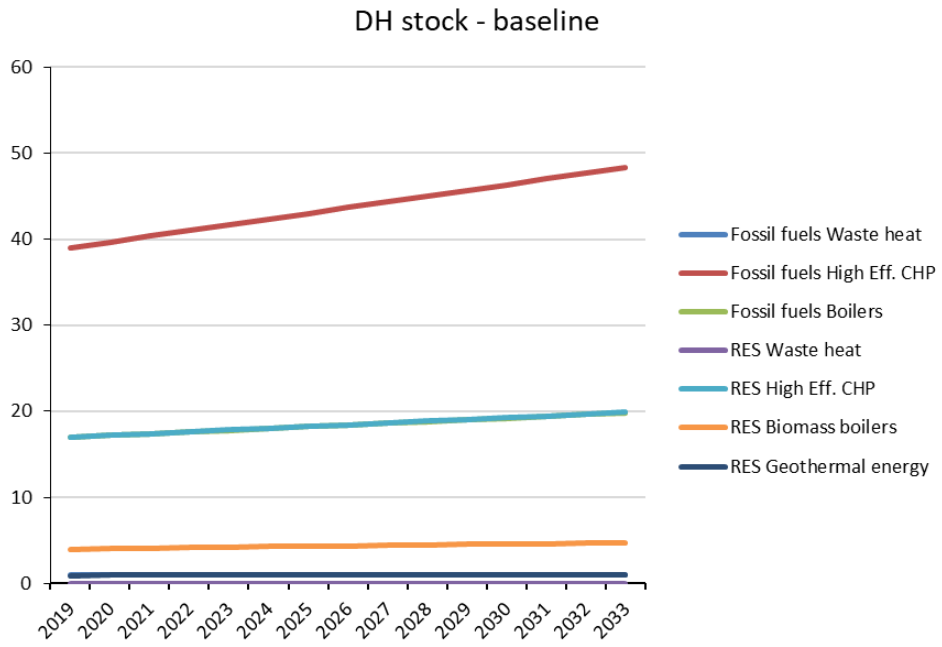

Figure 157. Evolution of district heating stock per year (Baseline) Slovenia

Optimistic Replace-Scenario DH Boilers							
	Fossil fuels				RES		
0	0	1	0	0	0	0	0
2019	1	57	17	0	17	4	1
2020	1	58	17	0	18	5	1
2021	1	59	18	0	18	5	1
2022	1	59	18	0	18	5	1
2023	1	60	18	0	19	5	1
2024	1	61	19	0	19	5	1
2025	1	62	19	0	19	5	1
2026	1	63	19	0	19	5	1
2027	1	64	19	0	20	5	1
2028	1	65	20	0	20	5	1
2029	1	66	20	0	20	5	1
2030	1	67	20	0	21	5	1
2031	1	68	20	0	21	5	1
2032	1	69	21	0	21	5	1
2033	1	69	21	0	21	5	1

Table 196. Evolution of district heating stock per year (Optimistic) Slovenia

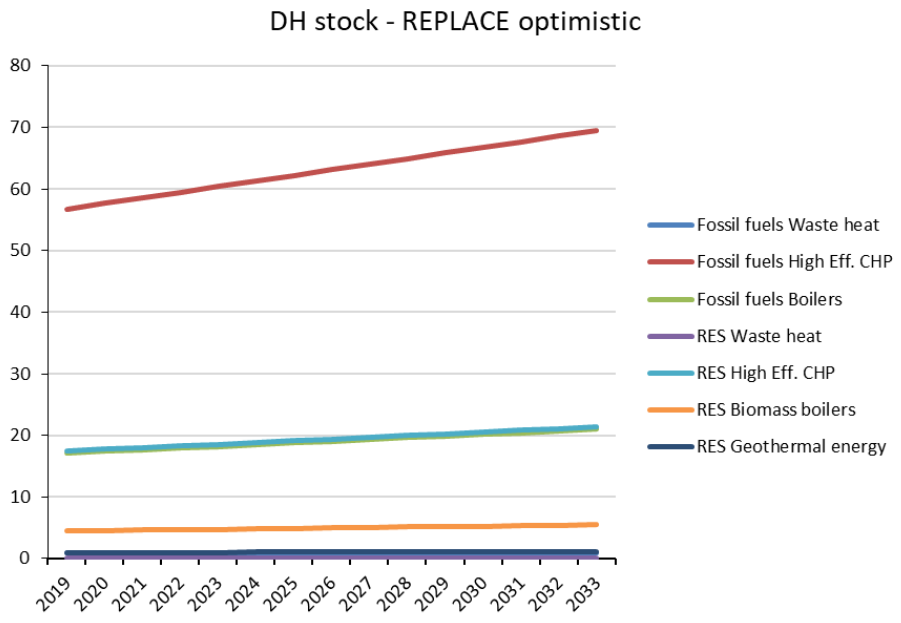

Figure 158. Evolution of district heating stock per year (Optimistic) Slovenia

Pessimistic Replace-Scenario DH Boilers							
	Fossil fuels			RES			
0	0	1	0	0	0	0	0
2019	1	57	17	0	17	4	1
2020	1	58	17	0	18	5	1
2021	1	58	18	0	18	5	1
2022	1	59	18	0	18	5	1
2023	1	60	18	0	18	5	1
2024	1	61	18	0	19	5	1
2025	1	62	19	0	19	5	1
2026	1	62	19	0	19	5	1
2027	1	63	19	0	19	5	1
2028	1	64	19	0	20	5	1
2029	1	65	20	0	20	5	1
2030	1	66	20	0	20	5	1
2031	1	66	20	0	20	5	1
2032	1	67	20	0	21	5	1
2033	1	68	21	0	21	5	1

Table 197. Evolution of district heating stock per year (Pessimistic) Slovenia

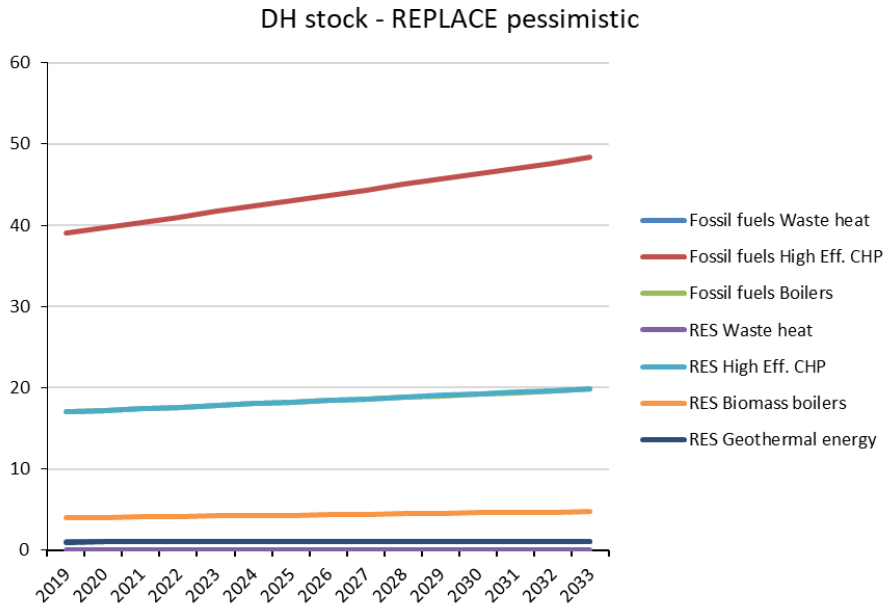

Figure 159. Evolution of district heating stock per year (Pessimistic) Slovenia

For the number of replacements per year of modern biomass individual boilers in Slovenia, the baseline scenario is much higher than the optimistic and pessimistic scenarios. Overall, baseline scenarios foresees 189.644 modern biomass boilers, while optimistic and pessimistic 179.556 and 160.228, respectively. This is due to the foreseen heating system restructure scenarios. In the optimistic scenario, less modern biomass boilers are going to be installed due to higher rate of heat pump instalment . On the other hand, pessimistic scenarios foresees lower rates of modern biomass boilers and heat pumps, while on the other hand the rate of condensing natural gas boilers will increase significantly.

3.10.4 Investment/Economics

	Average boiler power	Price (€/kW) only boiler	Price (€/kW) of the heating system
Individual HP (P<50kW)	15	500	825
Colective boilers (P>50kW)			
Distrcit Heating boilers	40	300	300

Table 198. Average boiler price, Slovenia

	Number of boilers increased by REPLACE		Annual REPLACE (€) investment only in boilers		Annual REPLACE (€) turnkey project investment	
	Optimist	Pessimist	Optimist	Pessimist	Optimist	Pessimist
Individual HP (P<50kW)	418	167	3.133.381	1.253.353	5.170.079	2.068.032
Colective boilers (P>50kW)			-	-	-	-
Distrcit Heating boilers	622	343	7.459.578	4.113.241	7.459.578	4.113.241
Total investment Mio€			10,6	5,4	12,6	6,2

Table 199. Annual Replace investment triggered

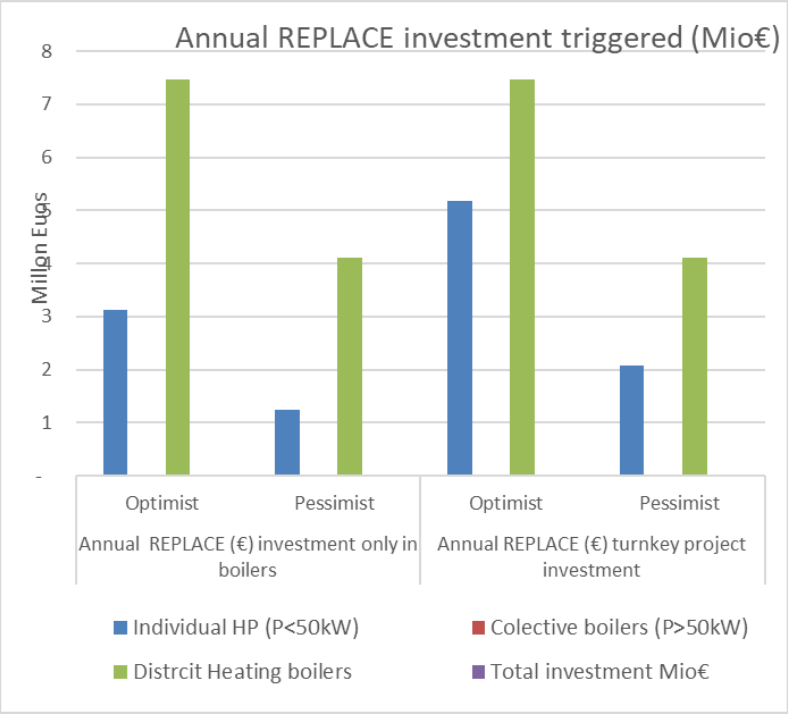

Figure 160. Annual Replace investment triggered

The average power for individual heating pumps in Slovenia is 15 kW and depending on if it includes a turnkey system, the price per kW of power can reach up to 825 Euros.

The average power for district heating systems is 40 kW. The price for the turnkey systems can reach up to 300 Euros per kW installed.

3.10.5 Main conclusions

Slovenian residential homes are mainly being heated by biomass, slightly over 216,000 such boilers were identified. As much as 61 % of those are old, inefficient, air pollutant and in need of replacement. Furthermore, Slovenian households use over 70,000 fuel oil boilers that use 1,190 GWh of final energy or 11 % of the entire final energy used for heating and domestic hot water preparation (Figure 161). Despite the fact the number of those fuel oil boilers more than halved in the past 15 years, the aggregated number is still large. Combined with old biomass boilers, over 203,000 boilers present technical potential for heating system replacement in residential homes. REPLACE project targets those through different means and aims to increase the overall replacement rates.

Many such boilers are located within urban areas, where existing district heating or natural gas network may be present. If not, installment of new biomass boilers is not advised due to regulated emission of substances into the atmosphere from small combustion plants in densely populated areas. The REPLACE scenarios (baseline and optimistic) follow scenarios from National Energy and Climate plan, where the restructure of inefficient systems in urban areas is directed towards either connection to the district heating grid or installment of heat pumps. This results in lower aggregated number of biomass boilers in optimistic scenarios at the end of the observed period than in the baseline. The pessimistic scenarios foresees higher rates of replacement such systems with connections to the natural gas network due to lower investment costs and reasonable energy price.

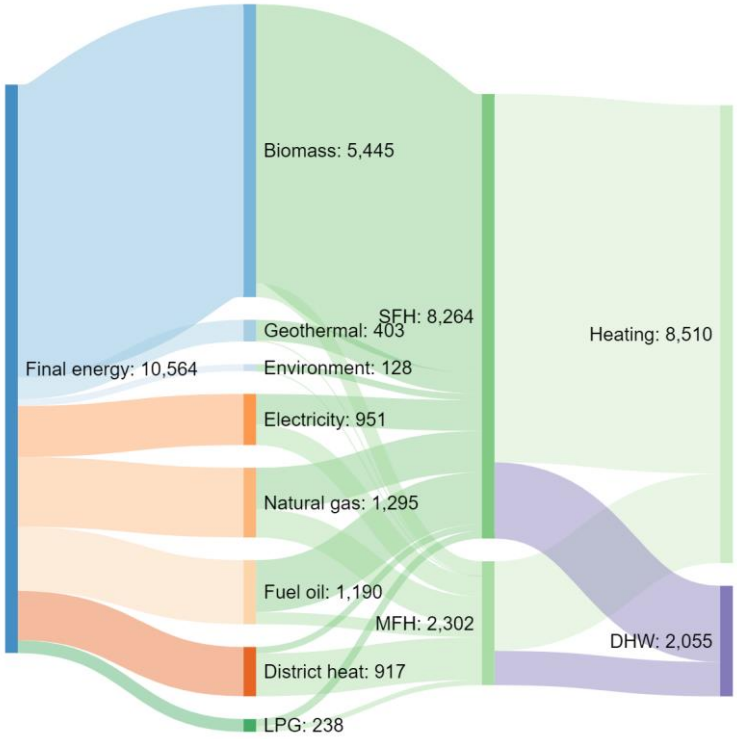

Figure 161: Sankey's diagram of energy balance for Slovenian single- (SFH) and multi-family houses (MFH) in GWh

General direction of heating system restructure in urban areas is to either connect the buildings to existing district heating network or install a heat pump. Such policy contributes to preservation of the air quality. Due to relatively short winter period in 2020, the number of exceedances od the daily PM10 limit was still high (Table 200), which clearly shows the need to increase efforts in raising awareness on heating systems replacements.

Table 200: Number of exceedances of the daily limit concentration of PM10 in 2020[8].

merilno mesto	jan	feb	mar	apr	maj	jun	jul	avg	sep	okt	no	dec	skupno
Celje	17	0	2	0	0	0	0	0	0	0	2	4	25
Celje Mariborska	22	1	2	0	0	0	0	0	0	0	4	7	36
Hrastnik	7	0	2	0	0	0	0	0	0	0	0	0	9
Iskrba	0	0	2	0	0	--	--	--	0	0	0	0	2
Koper	5	5	3	0	0	0	0	0	0	0	3	4	20
Kranj	5	0	2	0	0	0	0	0	0	0	0	3	10
LJ Celovška*	16	0	3	0	0	0	0	0	0	0	0	3	22
Ljubljana Bežigrad	15	0	3	0	0	0	0	0	0	0	0	3	21
Ljubljana BF	10	0	2	0	0	0	0	0	0	0	0	2	14
MB center	15	0	2	0	0	0	0	0	0	0	0	0	17
MB Vrbanski plato	3	0	2	0	0	0	0	0	0	0	0	0	5
MS Cankarjeva	17	1	2	0	0	0	0	0	0	0	1	0	21
Murska Sobota	11	0	2	0	0	0	0	0	0	0	0	0	13
Nova Gorica Grčna	5	6	3	0	0	0	0	0	0	0	1	2	17
Nova Gorica Vojkova	6	7	3	0	0	0	0	0	0	0	1	2	19
Novo mesto	10	0	3	0	0	0	0	0	0	0	0	0	13
Ptuj	12	0	2	0	0	0	0	0	0	0	2	0	16
Trbovlje	14	0	3	0	0	0	0	0	0	0	2	2	21
Velenje	0	0	2	0	0	0	0	0	0	0	0	0	2
Zagorje	17	0	3	0	0	0	0	0	0	0	4	3	27
Žerjav	3	0	2	0	0	0	0	0	0	0	2	0	7

Homes in rural areas will be predominantly heated by biomass boilers in all scenarios, similar as today. The optimistic scenarios foresees slightly higher rates of heat pump installments in such areas as well than in the baseline, since the trend in the past years indicate increase of this technology installment in such areas as well.

Heat pumps will be mainly targeted in the scope of REPLACE project as the system that will be used for replacement of fuel oil boilers. This is due to the fact that 1.) large number of such boilers are located within urban areas, 2.) many buildings that use fuel oil for heating were subjected to either partial or deep renovation and their energy need for heating is below 100 kWh/m2a, hence making heat pump as suitable system and 3.) heat pumps have proven to be a popular choice for heating system replacement in the past years, since many households replace inefficient biomass boiler with heat pump. With REPLACE related activities it is envisaged that additional 4,1 mio EUR of investments will be triggered or 418 heat pumps that will be used for system replacement on national scale.

[8] https://www.arso.gov.si/zrak/kakovost%20zraka/podatki/preseganja_pm10.html

4 | REFERENCES

Figures

Tables