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Cost-benefit Analyses of Investments in the Energy Saving Measures of the Residential Sector in Central and Eastern Europe

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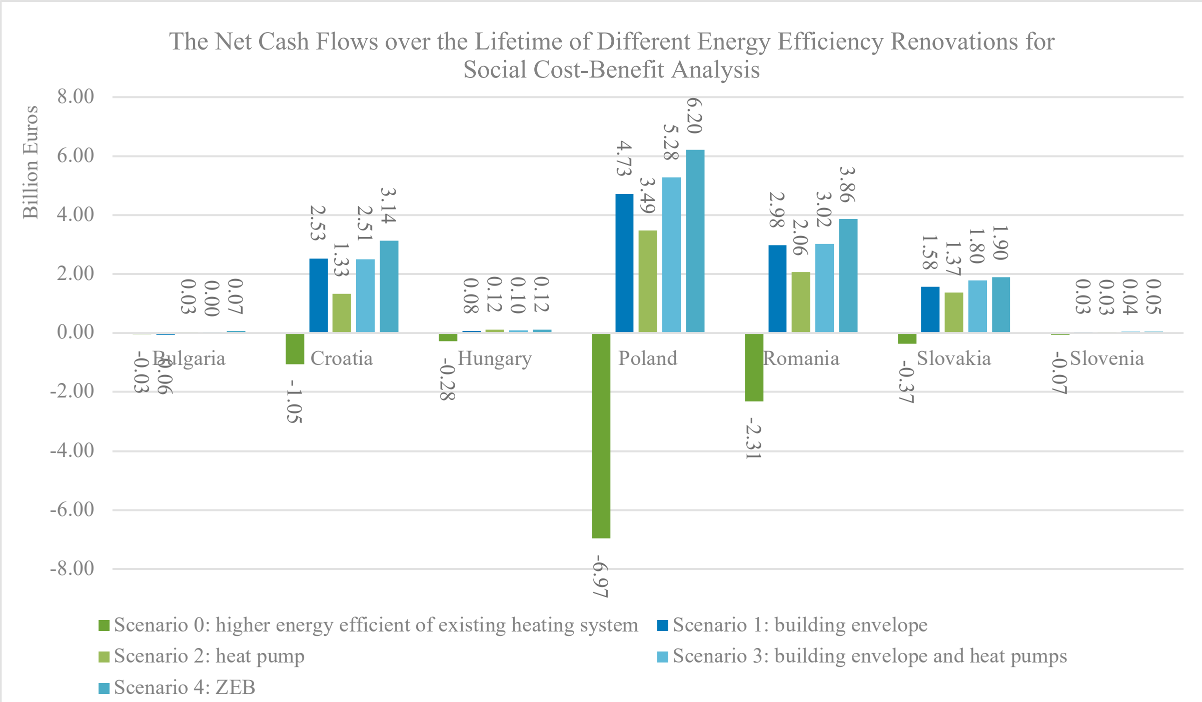
EXECUTIVE SUMMARY

The forthcoming Energy Efficiency Directive has set in Article 3 the implementation of the Energy Efficiency First principle, which is a cornerstone in the current and future energy investment decisions. The purpose of this study is to examine, through simulating different policy measures, the implementation of the Energy Efficiency First principle in practice when comparing supply side to demand side energy investments in fossil fuels, with a particular focus on fossil gas investments. Commissioned by Greenpeace Central and Eastern Europe, the study demonstrates how the budgets devoted to fossil fuel-related infrastructures and supply in different countries (Bulgaria, Croatia, Hungary, Poland, Romania, Slovakia and Slovenia) could be utilised to achieve energy efficiency improvements through the implementation of different policy measures, including ones suggesting the utilisation of renewable energy sources, specifically focused on space heating. Therefore, four scenarios on demand side energy investments (mainly energy retrofitting) were delineated, in addition to the baseline scenario where an improvement of existing fossil fuel boilers was considered. The first scenario was the energy retrofitting of the building envelope, the second the installation of heat pumps, the third the combination of the first two scenarios (energy retrofit and heat pumps), whereas the final was the combination of the first two plus the implementation of solar photovoltaics as to obtain zero-energy buildings. These scenarios were thereafter confronted and compared by performing a purely economic and a social cost-benefit analysis (through Net Present Value, Internal Rate of Return and Benefit to Cost indicators). This was done to ensure that all the multiple benefits related to the practical application of the Energy Efficiency Frist principle were considered. The decision criterion for allocating public funding was that an investment that might result unfavourable by only considering strictly economic indicators at a national level, on the other hand would result highly beneficial to society when considering multiple benefits non-related to a strictly economic perspective.

From an economic perspective the support in fossil fuel infrastructure (Scenario 0 in the Figure below) has the lowest cost-benefit ratio in all CEE countries. This means that among all scenarios investigated, gas investments bring the lowest benefit and greatest losses to the national economy. In contrast, the zero-energy buildings are everywhere the most cost-efficient option (Scenario 4).

When incorporating the multiple benefits of energy efficiency in the debate and carrying out a social cost-benefit analysis, the energy efficiency upgrades together with all heating decarbonisation measures are positive in terms of cost-benefit ratio, where the most efficient one is the zero-energy buildings. The substitution of fossil-fuel boilers with more efficient ones and the general support in fossil fuel infrastructures performs also negatively from a social cost benefit analysis in all countries.

In brief, the most socially and economically profitable solutions are the renovation of the building stock while concurrently promoting the installation of both heat pumps and photovoltaics. Renovation is in all cases considered more economically viable than public spending on fossil fuel networks. Therefore, grants for the renovation of the building envelope and zero-consumption buildings should be at the heart of the revised National Energy and Climate Plans' policies, coupled with the evaluation of alternative means for financing the required investments. Based on the decision criterion of the economic and socio-economic performance, public spending should not be targeted at fossil fuel boilers further but rather shift towards energy efficiency upgrades and zero-energy buildings in most countries.


The Net Cash Flows over the Lifetime of Different Energy Efficiency Renovations for Social Cost-Benefit Analysis
Billion Euros
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
Bulgaria
Croatia
Hungary
Poland
Romania
Slovakia
Slovenia
-0.03
-0.06
0.03
0.00
0.07
-1.05
2.53
1.33
2.51
3.14
-0.28
0.08
0.12
0.10
0.12
-6.97
4.73
3.49
5.28
6.20
-2.31
2.98
2.06
3.02
3.86
-0.37
1.58
1.37
1.80
1.90
-0.07
0.03
0.03
0.04
0.05
Scenario 0: higher energy efficient of existing heating system
Scenario 1: building envelope
Scenario 2: heat pump
Scenario 3: building envelope and heat pumps
Scenario 4: ZEB

1. INTRODUCTION

1.1 Background - Energy Policy Framework at European Level

Europe's most important and threatening crisis is climate change and the related environmental crisis affecting different sectors in different ways, posing uncertainties regarding the continent's future. As a response, on December 11th, 2019, the European Commission presented to the European Union (EU) institutions the European Green Deal[1]. The latter is a policy strategy at European level aiming to "transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use" (p.2)[1]. Perhaps the most important package containing different policy measures and directives is the "Fit for 55" package adopted and presented by the European Commission on July 14th, 2021. The name derives from the set objective of achieving a reduction of net greenhouse gas (GHG) emissions by 55% compared to 1990 levels by 2030.

The reduction of GHG emissions simultaneously requires an increase in the use of renewable energy sources (RES) and an improvement in energy efficiency. Buildings account for more than 40% of final energy consumption and at least 36% of energy related GHG emissions. Therefore, there is a need for renewable and less polluting energy systems for domestic and public buildings. This will result not only in the reduction of GHG emissions but also in the promotion of energy saving, tackling energy poverty, improving health and well-being as well as creating new opportunities for growth and work. The countries analysed in the present study present low levels of energy efficiency in the residential sector. This is due to the ageing of the buildings in the sector and lack of renovation strategies in the last years. Hence, measures promoting the energy efficiency of dwellings in the residential sector must be advanced. In the suggested framework for the delineation of National Energy and Climate Plans (NECPs) for Member States, the improvement of energy efficiency in all final consumption sectors is an important challenge and the application of an optimal combination of both regulatory and legislative interventions, as well as financial tools, is envisaged.

More specifically, the Minimum Energy Performance Standards (MEPS) target existing buildings, aiming to reduce energy poverty and improving the energy efficiency of the residential sector. The Directive on the energy performance of buildings provides for the renovation of the buildings with the worst performance, i.e., the buildings that belong to categories G or F of the Energy Performance Certificates. It is pointed out that in the energy category G the 15% of buildings with the worst performance in each country are ranked, while the rest of the buildings in the country are distributed proportionally between the other categories between G and A which corresponds to zero emission buildings. Another important factor to consider related to the general refurbishment of the building envelope is the installation of photovoltaics. These have the potential to reduce energy consumption while at the same time providing citizens with electricity generated from renewable sources.

An additional measure to reduce carbon emissions (decarbonisation) in residential heating and cooling envisages phasing out the installation or sale of new fossil fuel burners by 2030 by prohibiting member States to subsidise fossil-fuel boilers as of 2027 (Articles 8, 10, and 15 of the EPBD proposal). Hence, these would be substituted by heat pumps. There is,

[1] European Commission, (2019). *Communication from the commission to the European parliament, the European council, the council, the European economic and social committee and the committee of the regions: The European green deal*

however, the potential to lock poor households into using outdated technologies, as heat pumps are more expensive in terms of initial investment although their running costs are likely to be lower than fossil fuel burners due to higher efficiency. The only way to ensure the limitation of this phenomenon is to implement a stable and clear policy framework, which can enable energy poor households to switch to heating systems from renewable energy sources.

Finally, all the above legislative developments are also affected by the current energy crisis, which highlighted the need to implement long-term measures both to protect consumers from future increases in energy prices, and to achieve the ambitious energy and climate goals. Following the start of the war in Ukraine, the EU decided to fasten its process of independence from Russian fossil fuels and thus, on May 18th 2022, presented the *REPower EU Plan*[2]. As such, a fastening of the green energy transition is envisioned, updating some of the objectives present in the European Green Deal. This includes: an increase in the target for the renewable energy share in 2030 from the previous 40% to 45%; doubling the rate of deployment of heat pumps, including the implementation of the latter in modern district heating together with solar thermal energy[2]; and, as part of the dedicated *EU Solar Strategy*, doubling the solar photovoltaic capacity by 2025 (bringing online over 320 GW) and installing a total of 600 GW by 2030[3]. As part of the *European Solar Rooftops Initiative,* the EU will make the installation of rooftop photovoltaics compulsory for: every residential building by 2029; all new commercial and public buildings with an area larger than 250 m^2 by 2026; and all existing commercial and public buildings with an area larger than 250 m^2 by 2027[3]. In general, the plan promotes fiscal measures, such as reduced VAT rates, for energy efficient building insulation, appliances, products, and heating systems.

1.2 Energy Efficiency First Principle

The Energy Efficiency First (EE1st) principle is part of the Article 3 of the new Energy Efficiency Directive recast proposal adopted in July 2021, and it "means taking utmost account of cost-efficient energy efficiency measures in shaping energy policy and making relevant investment decisions"[4]. In practice, the EE1st principle balances demand and supply options in order to prioritize the least-expensive investments for the energy system from a societal perspective. Article 3 obliges Member States to ensure that energy efficiency is included in policy and investment decisions. It requires EU countries to: ensure that wider societal benefits are considered when developing energy efficiency solutions, delineating an entity responsible for the monitoring of the application of such principle and reporting to the Commission how the application of the principle is proceeding.

[2] European Commission, (2022). *Repowereu: A plan to rapidly reduce dependence on Russian fossil fuels and fast forward the green transition, retrieved from:* https://ec.europa.eu/commission/presscorner/detail/en/IP_22_3131
[3] European Commission, (2022). *Communication from the commission to the European parliament, the European council, the council, the European economic and social committee and the committee of the regions: EU Solar Energy Strategy*
[4] https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficiency-targets-directive-and-rules/energy-efficiency-first-principle_en#:~:text=The%20%E2%80%9Cenergy%20efficiency%20first%20principle,and%20making%20relevant%20investment%20decisions.

1.3 Considered Policy Scenarios

Every Member State is required to delineate its climate objectives in the National Energy and Climate Plans (NECPs). In the latter, renewable energy share objectives are described but also projected investments in fossil fuel infrastructures such as fossil gas for example. The present study aims to understand the devoted share of investments in fossil fuel infrastructures, with a focus on fossil gas, and assess the economic and societal benefits that would result from a shift of these investments to more energy efficient and sustainable policy measures. The specific results will come from the combined use of both cost-benefit analysis and social cost-benefit analysis, in order to evaluate the economic performance of the considered Scenarios with the maximization of social welfare.
The following Scenarios will be considered:

- Scenario 0: Country specific baseline Scenario
- Scenario 1: Energy upgrade of the building envelopes
- Scenario 2: Installation of heat pumps
- Scenario 3: Integrated energy retrofitting including the energy upgrade of the building envelopes and installations of heat pumps
- Scenario 4: Promotion of zero-energy buildings by combining all investments

The simulation of these scenarios taking into account national budgets devoted to fossil fuel investments will be performed by utilising a static MS Excel simulation tool for seven different EU countries, namely: Bulgaria, Croatia, Hungary, Poland, Romania, Slovakia, and Slovenia. The main parameters that will be compared per scenario are the Net Present Value, Internal Rate of Return, and Benefit to Cost Ratio. These will give an overview and understanding of how the different scenarios performed.

2. METHODOLOGY

2.1. *Evaluation methods: cost-benefit analysis (CBA) and social cost-benefit analysis (SCBA)*

The Cost Benefit Analysis (CBA) is a practical way of evaluating the desirability of projects. CBA is applicable when two aspects are important: (a) evaluating from long-term perspectives to consider the consequences in near and future, (b) a wide view to consider different side-effects on various target groups, including the citizens and private parties. In a nutshell, CBA is a decision support tool, which is applied to enumerate and evaluate all the relevant costs and benefits for the investment plans, policies, or other actions planned by public or private entities.

The overall objectives of CBA for the economy and society are to:

- Evaluate the impacts of the investment,
- Justify the feasibility of implementing a specific investment (yes/no decision), and
- Select the suitable choice, maximise the net benefits, among different Scenarios.

The following steps are usually conducted for CBA[5]:

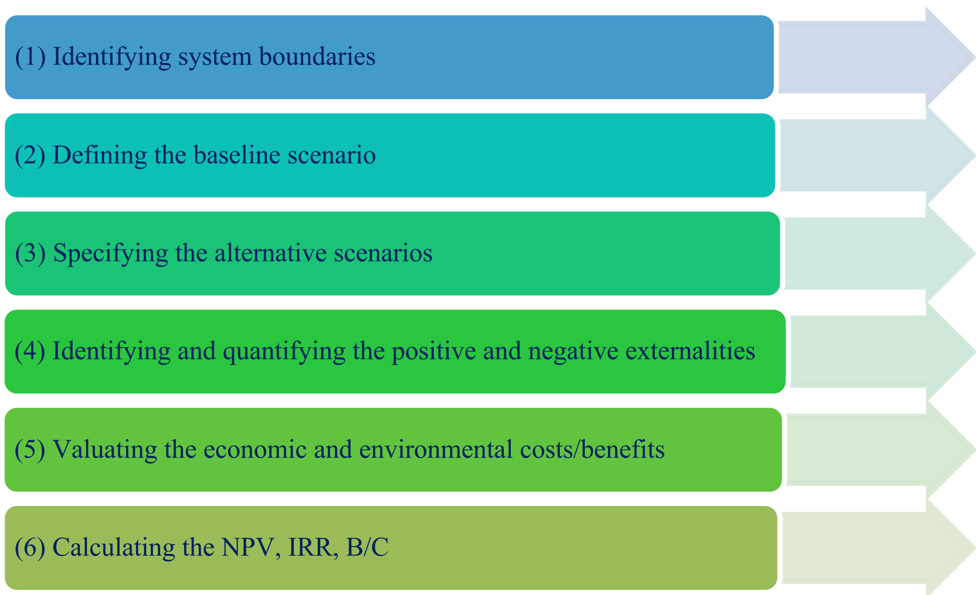


Figure 1 - Six steps for performing a CBA

Two different types of Cost-Benefit Analyses can be conducted, namely:

Table 1: Types of CBAs and their definitions

Types of CBA	Definition
Original CBA	A cost-benefit analysis (CBA) is conducted to measure the benefits of a decision or taking action minus the costs associated with taking that action. CBA includes measurable financial metrics such as revenue or costs due to the decision to pursue

[5] The basic principles for conducting a CBA as described in the "Methodology development for comprehensive Assessment" report of the JRC were incorporated into the presented methodology in Figure 1.

	a project. In this research, the term economically feasible or not feasible are also used to explain the results of the CBA analysis. The economic impacts are identified, and the evaluation is performed taking into consideration the impacts on the national economy. The analysis is based on changes in the market prices.
Social CBA	SCBA includes all the factors of CBA analysis. In addition to this, the environmental and social impacts are identified, and the evaluation is performed taking into consideration the impacts on the whole society. The analysis includes both the market prices and the external cost and benefits triggered by the examined investments.

2.2. *CBA methodology*[6]

The CBA aims to examine the social profitability of the examined energy efficiency projects, justifying the potential utilization of specific financial schemes (such as subsidies) in relation with the results of the financial analysis. The conduction of the financial analysis and the social CBA leads to the calculation of two different indicators, namely the financial NPV (or the financial IRR) and the social NPV (or the social IRR respectively).

Table 2 – The results of financial and social NPVs and the decisions to move forward/to stop

Potential result of calculations	Financial NPV	Social NPV	Conclusions	Next steps
1st	≥ 0	≥ 0	Economically and socially beneficial to invest/implement projects/interventions.	Promoting these types of investments/interventions
2nd	≤ 0	≥ 0	Economically is not beneficial. However, socially is important to invest/implement the project/intervention.	Providing financial supports, e.g., subsidies, increasing municipality's equity share in the investment
3rd	≥ 0	≤ 0	Economically is beneficial to invest on a project and not socially beneficial.	Penalty for the investors and imposing the incentives that distribute the economic benefits among different groups, such as tax.
4rth	≤ 0	≤ 0	Economically and socially is not beneficial.	Stop the investments/interventions

The proposed steps (Figure 1) are explained below for the application of CBA and social CBA on comparing the supply investments to the demand side energy efficiency investments investments of improving the energy efficiency of the buildings.

[6] It should be highlighted that the proposed methodology was developed within the framework of PRODESA project to assess the energy efficiency interventions in public buildings.

Step 1: define the system boundaries

In the current study, the CBA boundaries are set at national level for households to depict the effect of the proposed interventions to the society and economy.

Step 2: define the baseline Scenario

The baseline Scenario is the energy investment on the supply side for the expansion of the fossil gas and the current energy efficient technologies in the buildings.

Step 3: specify the alternative Scenarios

The Scenarios 1 to 4 are the alternative Scenarios. The energy efficient equipment/technologies are assessed within the alternative Scenario and the existing equipment/technology within the baseline Scenario.

Step 4: Identify and quantify the positive and negative externalities

To this context the quantification of either positive/negative externalities is performed to integrate into the analysis various social and environmental criteria, which affect the social welfare.

External costs and benefits

External costs/negative externality. A cost that a transaction or activity imposes on a party, who is not part of the transaction or activity. Specifically, it is the cost or benefit that affects a party, who did not choose to incur that cost or benefit. For instance, electricity generation creates pollution that imposes costs on citizens, or the energy consumed in a building or in a car creates pollution that imposes costs on citizens. This cost is not included in the price of energy; thus, it is an external cost that should be taken into consideration when examining the social effectiveness of an investment.

External benefits. Energy efficiency investments aim first at reducing energy consumption, but they have impact also to other challenges such as energy supply security, climate change, employment. In addition, the implementation of energy efficiency interventions can have other "non-energy", socio-economic and environmental effects such as effects on social welfare or reduced pollution levels (Appendix I). Four different types of externalities were assessed within the framework of the current study (Figure 2).

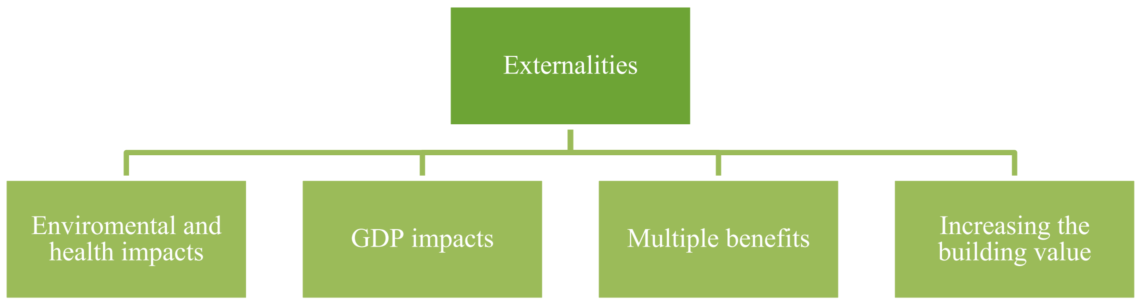


Figure 2 - Selected types of externalities within the context of the CBA

The methodological approach, which was utilized for each type of externality separately, is described briefly in Table 3.

*Table 3 – Types of externalities and their descriptions (References: Alberici et al. [7] and 2014**,** Russell et al., 2015[8])*

Categories	Description
Environmental and health externalities	The environmental and health externalities are differentiated for the various forms of energy carriers and technologies according to the pollutants emitted within the whole life cycle. Various studies attempted to estimate the environmental and health externalities of the RES and energy efficiency technologies. The calculation of the environmental and health costs and benefits was carried out considering the technical characteristics of the implemented interventions, such as, final energy consumption, insulation levels for each building separately. The data per country is provided in Table 4.
Macroeconomic effects	The quantification of the macroeconomic effects was performed considering the results of a study, which was conducted by Cambridge Econometrics to provide estimates of the multiple benefits of energy savings for the European citizens and the economy that are associated with different levels of the 2030 EU energy efficiency target. Coefficients were estimated linking the reduction in energy consumption (in Mtoe) to each of the delivered benefits. It should be noted that the coefficients represent average coefficients across the Scenarios and assume of linear relationship between energy consumption and benefits. The unitary estimation for the resulted increase of the GDP due to the realized energy efficiency interventions was considered equal to 0.93 billion EUR/Mtoe.
Improved comfort level	Previous studies indicated that the energy efficiency investments considerably improve the households' comfort levels and as the main motivations for the households. Other multiple benefits consist indicatively of the increased home durability, less maintenance, reduce noise levels, improved safety, such as fewer fires, reduced CO_2 poisoning. A percentage of the cost savings is considered as the most effective metric, which can reach to 25% of energy savings in the case that all multiple benefits will be quantified. The respective value for the current study was considered equal up to 10% of the achieved cost savings indicating a rather conservative estimate. The cost savings are resulted by the reduction of the operating and maintenance and fuel expenses.
Increased the building value	The increasing building value is considered also as another one essential impact. Specifically, the increased value of the renovated buildings can be estimated as the ratio of the cost savings due to the reduction of the operating and maintenance and fuel expenses to the capital rate of the building. The cost savings was calculated for each building separately, while the capital rate was considered equal to 3% for the case of the households taking into consideration that the current analysis is performed within the framework of the Social CBA. *Note: The triggered impact by the increased value of the renovated buildings was considered only in the Scenarios, which foresee the implementation of energy efficiency interventions in the building envelope, while the improved conform levels were assessed in the case of the individual installation of heat pumps to avoid overlaps between the two types of externalities.*

[7] Alberici et al., 2014. Subsidies and costs of EU energy. Ecofys by order European Commission.
[8] Russell et al., 2015. Recognizing the Value of Energy Efficiency's Multiple Benefits. Report IE1502.

Table 5 shows the types of external benefits and costs for each Scenario. For the external costs and benefits, the data is extracted from a report by Ecofys. Ecofys investigated the external costs (euro/MWH) per type of technology and the report is published by EU commission. These external costs are presented below[9].

Table 4 – external costs of using different types of energy efficient technologies

Data	Oil boiler-existing	Oil boiler-new	NG boiler-existing	NG boiler-new	Coal boiler-existing	Biomass boiler-existing	Biomass boiler-new	HP-existing	HP-new	Electricity-current	PV-new	Solar-new
External cost (EUR/MWh)	32	27.2	20	17.9	27.2	20	11.2	23.5	14.2	48.5	14.1	9.6

Table 5: Summary of the external costs and benefits for all the Scenarios

Scenarios	External costs	External benefits
Scenario 0 – higher energy efficient gas boiler	○ Environmental costs triggered by the utilisation of the fossil gas boiler	○ Avoided environmental costs due to substitution of the existing heating system by the fossil gas boiler ○ Multiple benefits of improving thermal comfort and reducing energy poverty
Scenario 1 – building envelope improvement	○ Energy security costs triggered by the utilisation of the existing heating system despite the occurred reduction due to the building envelope improvement	○ Reduced energy consumption due to improved building envelope ○ Increasing the house value
Scenario 2 – heat pump installations	○ Environmental costs triggered by the utilisation of the heat pump	○ Avoided environmental costs due to substitution of the existing heating systems by the heat pump ○ Multiple benefits of improving thermal comfort and reducing energy poverty ○ Macroeconomic impacts
Scenario 3 – Integrated retrofit package including the improvement of the building envelope and heat pump installation	○ Environmental costs triggered by the utilisation of heat pump	○ Avoided environmental costs due to reduced use of the existing heating systems and the operation of the heat pump ○ Increased house value ○ Macroeconomic impacts
Scenario 4– zero energy buildings	○ Environmental costs triggered by the utilisation of heat pump ○ Environmental costs triggered by the operation of photovoltaic systems	○ Avoided environmental costs due to reduced use of the existing heating systems and the operation of the heat pump ○ Increased house value ○ Reduced environmental costs due to reduction of electricity used from the grid ○ Macroeconomic impacts

[9] https://ec.europa.eu/energy/content/final-report-ecofys_da

Step 5: quantify the CBA and SCBA components

The data for the monetary costs is extracted from the Greenpeace study which was entitled "Cost-benefit analysis of RES and energy efficiency interventions in residential buildings" and published in 2022. The selected cost data within the context of the Greek study were verified by external experts. Then, the selected data were modified for the examined countries considering also data both from other available studies (e.g., IRENA, 2022, Renewable solutions in end-uses: Heat pump costs and markets) and from ECF study (IEECP, 2022, Study on the impacts of policies to decarbonize residential buildings on energy poverty in CEE/SEE and mitigation strategies). It should be noted that the selected data within ECF study were verified by the involved country experts, who facilitated the specification of representative values.) and in case different references are used per country these will be added as foot notes. Table 6 summarizes the main categories of costs and benefits, which were quantified in the conducted CBA for all the examined buildings.

Regarding the fuel benefits and cost savings, A uniform and conservation estimation was decided for the delivered cost savings by the application of the net-metering schemes in the examined countries (assuming 30% - 50% cost reduction customised per country) since it was possible to model all the implemented schemes so as to receive more accurate results within the framework of the current contract.

Table 6: Quantified categories of costs and benefits in the CBA

Cost	Description
Operational and maintenance costs	● Operational and maintenance cost of the new energy efficient equipment/technology
Operational and maintenance benefits	● Avoided operational and maintenance cost of the existing technology for the average-income group of households
Fuel costs	● Fuel cost of the new energy efficient equipment/technology
Fuel benefits	● Avoided fuel cost of the existing equipment/technology
External costs	● Environmental and health cost of the new energy efficient equipment/technology
External benefits	● Avoided environmental and health cost of the existing equipment/technology ● Macroeconomic effects due to the new energy efficient equipment/technology ● Effects due to the improved comfort levels due to the new energy efficient equipment/technology ● Increased market value of the renovated buildings
Capital costs	● Capital cost of the new energy efficient equipment/technology

Step 6: Calculate the evaluation indicators

Using the above-mentioned assumptions and collected data the differences in costs and benefits between baseline and the alternative Scenario are assessed according to the following equations:

$$Cost_t = [Cost_t]_{alternative} - [Cost_t]_{baseline} \quad (1)$$

$$Benefit_t = [Benefit_t]_{alternative} - [Benefit_t]_{baseline} \quad (2)$$

The following inputs are used in the calculations of the CBA:

- The energy efficient equipment/technology for average-income group of households is assessed within the alternative Scenario and the existing equipment/technology within the baseline Scenario
- The total cost and benefits of each year is the result of adding the value of all categories of costs and benefits, while the time frame of the analysis depicts the lifetime of the longest living asset.
- The discount rate is the parameter to estimate the value of future costs and benefits compared to present ones incorporating the social perspective on how future benefits and costs should be valued against present ones. A common discount factor equal to 3% has been selected to assess the economic and social effectiveness of the examined scenarios. The specification of the discount factor was done considering the opportunity cost of the households, which is lower than the selected value.
- The Net Present Value is calculated subtracting the expected benefits from the incurred costs discounted with a proper discount rate according to the following equation:

$$NPV = \frac{Benefit_t - Costs_t}{(1+r)^t}$$

The results of the CBA are given using three different indicators (NPV, IRR, B/C).

Regarding the indicators of the analysis based on which the comparison is made

a) Net Present Value (NPV): Expresses the net value (benefit or cost) resulting from discounting to the present the annual net cash flows (i.e., the cash balance) over the lifetime of an investment. If the KPA is positive (>0) the investment is approved, otherwise it is rejected.

b) Internal Rate of Return (IRR): It expresses the discount rate at which the NPV breaks down and thus the profitability of the investment is evaluated by comparing the IRR with the discount rate. If the IRR is greater than the discount rate, the investment is approved, otherwise it is rejected.

c) Benefit to cost ratio (B/C): B/C summarizes the overall relationship between the relative costs and benefits of a proposed project. If a project has a B/C greater than 1.0, the project is expected to deliver a positive net present value to its investors.

2.3. Data collection

The data utilised in this study was mainly collected from the Eurostat repository and national Household Budget Surveys (HBSs). When gathering VAT rates, these were taken from national institutions or journal articles. To understand the budget devoted to the improvement and extension of gas networks per country, different governmental documents were analysed, such as National Energy and Climate Plans (NECPs) for example. The heating oil prices per country were gathered from *globalpetrolprices.com.*

2.4. Brief explanations of different Scenarios

In the following sub-section, the different analysed scenarios will be portrayed and briefly explained. All the scenarios were already tackled in the previous study performed by IEECP for Greenpeace analysing Greece specifically[10]. In this new report, the same Scenarios will be applied to various countries in Central and Eastern Europe as previously explained. The subsidy rate is assumed to be zero for all Scenarios.

2.4.1 Scenario 0: Country specific baseline Scenario

Firstly, a baseline scenario is performed per country to understand what the current proposed policies and directed investments regarding the energy investment on the supply side that differ per country would result in. Apart from the expected investments for improving the heating system, no new additional upgrades of the residential sector are foreseen in this Scenario. The type of heating systems differs per country and based on the availability of types of energy sources. For example, in Bulgaria, biomass is the main heating source, and Scenario 0 compares the installation of higher energy efficient biomass boilers to the current one used by most of the population.

2.4.2 Scenario 1: Energy upgrade of the building envelopes

The following scenario analyses a situation in which the available national budgets are devoted to the energy investments on the supply side for both space heating and cooling purposes and replacing existing building envelopes including window frames, door, wall, roof, and floor area of the buildings with more energy efficient ones. This would result in reduced energy costs for the households due to the better energy performance of the buildings. Additionally, due to the latter, it was assumed that no instalment costs related to the replacement of the existing heating systems would be foreseen, as this would not be needed given the improved general energy efficiency. For each country, the share of fuels used per end-use (i.e., space heating and cooling, domestic hot water, cooking and lighting appliances) and the price per fuel were considered to calculate the economic benefit related to such policy measures. Finally, the decreasing energy security of gas was considered by including an externality factor in the calculations.

2.4.3 Scenario 2: Heat pump installations

In this Scenario, it is considered that the available national budgets for the development and expansion of the supply side energy investments would be used to install heat pumps in the residential buildings. This would result in reduced energy costs for space heating and thus energy expenses in general. Similar to Scenario 1, it was assumed that there would be no need to replace existing fossil gas boilers with higher energy efficient boilers since the old gas boilers will be replaced by the heat pump. Additionally, the same principle for calculating the economic benefits per country was employed.

2.4.4 Scenario 3: Integrated energy retrofitting including the energy upgrade of the building envelopes and installations of heat pumps

Scenario 3 evaluates the situations that the improvement of the building envelopes is conducted together with the installations of the heat pump. The logic behind the integrated renovations lies on the technical aspects of renovations. Highly insulated building is the requirement for the installation of heat pump especially for depending on the type of heat pump and the cold climate countries. The reason is that the heat pumps may provide lower temperature compared

[10] https://ieecp.org/greenpeace-greece-why-investing-in-new-gas-infrastructure-is-the-wrong-choice/

to the gas boilers or biomass boilers and therefore reducing the comfort level for the occupants. Therefore, it is highly recommended to improve the insulation of the buildings before installation of the heat pump and Scenario 3 tests whether this retrofit package provides higher economic and social values for the households.

2.4.5 Scenario 4: Performance of zero-energy buildings by combining all investments

The present scenario analyses a situation in which the available budget for the supply side energy investments would be employed to promote zero-energy buildings by combining a set of different investments. Namely, thermally insulating the exterior masonry, improving the cavity wall and solid insulation on wall/roof insulation and floor, façade, replacing existing window frames with more energy efficient ones, installing heat pumps in residential buildings, and installations of the photovoltaic solar panels. This would result in a great reduction of energy consumption and expenses due to the improved efficiency. Once again, it was considered that no investment costs would be incurred related to the replacement of existing fossil gas boilers, as there would be no need for this. Additionally, the same principle for calculating the economic benefit per country resulting from the application of these measures was applied.

3. COUNTRY FINDINGS

3.1 Country Descriptions

3.1.1 Bulgaria

General economic and energy poverty status

Before the COVID-19 pandemic, Bulgaria saw its lowest unemployment levels, a steady GDP and a growing average income, with structural reforms being implemented to boost productivity, address societal challenges and increase average income. However, following a slight rebound from the pandemic, growth weakened in 2022 and is envisioned to reach 1.7% in 2023 and thereafter 3.1% in 2024[11]. Following the effects of the war in Ukraine and the energy crisis, exports are envisioned to be badly affected, with lower consumption due to the energy crisis. Additionally, the Bulgarian tertiary sector was also affected by the war, as well as its construction sector.

Figure 3: Business confidence - Source OECD Economic Outlook

During the first half of 2022, GDP growth was robust, however high inflation has been affecting all sectors. Indeed, recovery is expected to be weak following inflation due to this resulting lower disposable income of households.[12] Additionally, income inequality is among the highest in Europe. The GDP situation was abruptly changed with COVID, with the government setting fiscal stimulus estimated at 3% of GDP.[13]

Figure 4: Inflation trend - Source: OECD Economic Outlook

Status of the energy system of the country

Energy prices

The energy prices for the first semester of 2022 were published by Eurostat in October 2022.

In the first quarter of 2022, electricity prices in Bulgaria for small household consumers were 11.0 eurocents/kWh.[14] In the first semester of 2022, electricity prices stood at 10.9 eurocents/kWh according to the Eurostat repository, representing a 6.79% increase compared to the previous year[15].

[11] OECD Economic Outlook, Volume 2022 Issue 2
[12] OECD Economic Outlook, Volume 2022 Issue 1: Preliminary Version © OECD 2022
[13] OECD Economic Surveys Bulgaria economic assessment, January 2021
[14] https://energy.ec.europa.eu/system/files/2022-01/Quarterly%20Report%20on%20European%20Electricity%20markets%20Q3%202021_v1.2_1.pdf
[15] https://ec.europa.eu/Eurostat/web/products-Eurostat-news/-/ddn-20221031-1

The market price of gas changed in Bulgaria from 68 EUR/MWh in January[16] to 72 EUR/MWh in June[17] and 152 EUR/MWh in August 2022[18]. However, the prices for the household sector were frozen until March followed by (based on Household Energy price index) a 45% rise in household gas prices (considering only Sofia).[19] On average, throughout the first semester of 2022, according to Eurostat, the gas price stood at 76.4 EUR/MWh, representing an increase of 107.65% compared to the previous year.

Electricity production and energy consumption

Bulgaria is still rather dependent on fossil fuels however not heavily dependent on gas. The latter represents a fuel share of 15.17% of final energy consumption in the country (Figure 5). Additionally, gas only accounts for 5.75% of fuel share when considering electricity generation (Figure 6). Nonetheless, Bulgaria is one of the EU countries that is most dependent on Russian gas by 90%, with 3 bcm/year of imports. After Gazprom stopped their supply in May 2022, prices rose, as portrayed in the previous subsection[20]. Bulgaria is also involved in the renewable energy sector, with the share of PV in electricity production having risen in the last decade (Figure 7). Nonetheless, PV electricity production saw a slight decrease in 2021 compared to 2020. As of 2021, this represented 1.79% of the energy consumption and 3.12% of the electricity production, as can be seen in Figures 3 and 4. It should also be noted that the share of coal both in the energy consumption and electricity production rose in 2021 when compared to 2020.

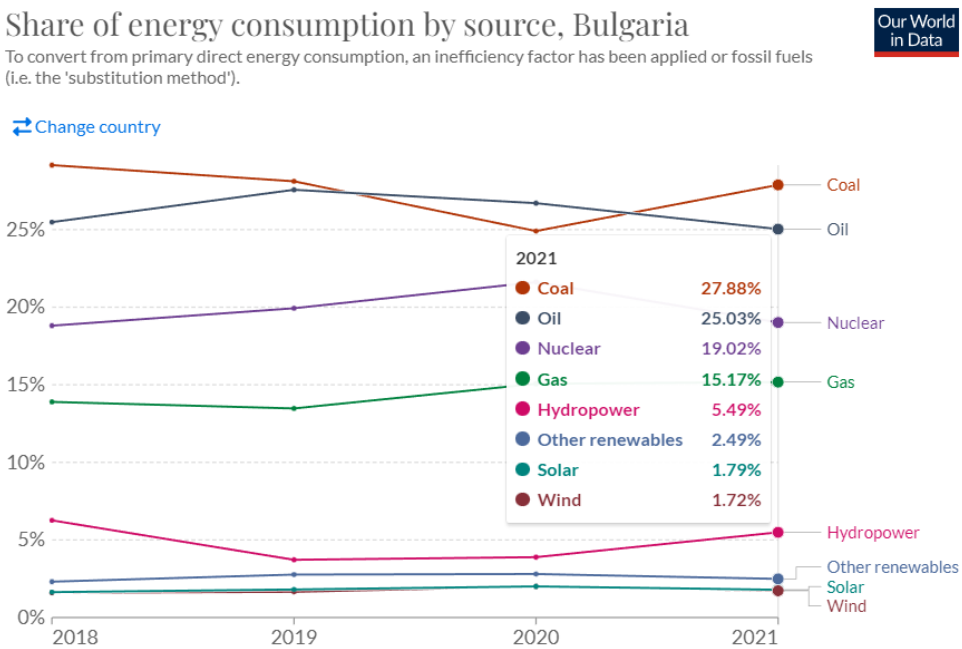


Figure 5: Share of energy consumption by fuel – Source: Our World in Data

[16] https://www.reuters.com/business/energy/bulgaria-hikes-natural-gas-price-by-304-2022-01-01/
[17] https://sofiaglobe.com/2022/06/10/bulgaria-utilities-regulator-cuts-gas-prices-by-13-for-june-2022/).
[18] https://sofiaglobe.com/2022/08/12/bulgaria-utilities-regulator-raises-gas-prices-by-60-for-august-2022/#
[19] Household energy price index for Europe: https://publuu.com/flip-book/6678/121883/page/1
[20] https://www.enerdata.net/publications/daily-energy-news/bulgaria-approves-new-measures-cope-rising-energy-prices.html

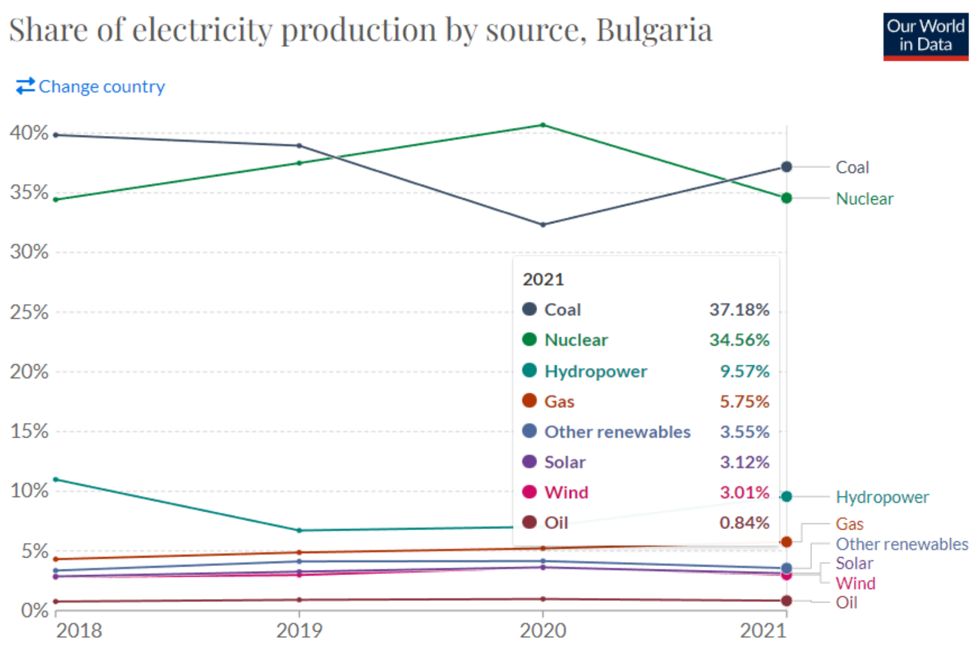


Figure 6: Share of electricity production by fuel - Source: Our World in Data

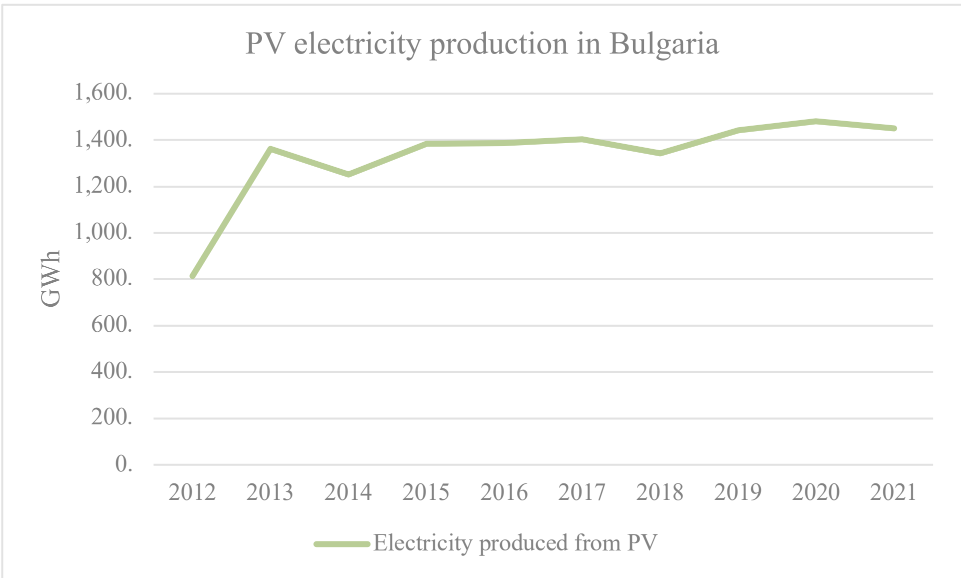


Figure 7: Trend of electricity produced from PV - Source: Eurostat

Policies implemented to decrease the adverse effects of price hikes

Several policies have been implemented to decrease the effects of price hikes, including price regulation and social measures. Heating and power prices were frozen from December 16th, 2021 to March 2022 (followed by an increase in heating prices up to 40%), and for electricity, the regulator (EWRC, Energy and Water Regulatory Commission) only approved a 3.4% increase in prices for households. Other policies included the removal of a *"social*

commitment" fee levied on distribution companies, as well as the price premiums paid to *"a significant part"* of renewable energy producers. [21]
Aside from the plans for gas diversification, other measures were also introduced with a total budget of 476 million EUR. These included a program to compensate businesses due to electricity prices, putting a ceiling at 128 EUR for end users until end September 2022. [22]
On May 16th, 2022, the Bulgarian government passed a series of aid packages totalling 1.1 billion EUR aimed at lowering the energy (and food) prices for companies and average-income consumers[23]. Electricity prices for households were frozen utilising July 2021 as threshold, petrol prices were discounted by 13 eurocents/litre from July 2022 until the end of the year, and excise duties on fossil gas, methane and electricity were scrapped[24].

[21] https://sofiaglobe.com/2022/07/01/bulgaria-regulator-approves-3-4-hike-in-electricity-prices-for-household-consumers/
[22] https://www.bruegel.org/dataset/national-policies-shield-consumers-rising-energy-prices
[23] https://www.reuters.com/business/energy/europes-efforts-shield-households-energy-cost-spike-2022-03-21/
[24] https://www.reuters.com/business/energy/bulgarian-government-approves-plan-offset-high-energy-prices-2022-05-16/

3.1.2 Croatia

General economic and energy poverty status

Croatia's growth in GDP has been stable and substantial in the two years following the COVID-19 pandemic, presenting a growth of 13.1% in 2021 and a growth of 6.4% in 2022. Nonetheless, this number is projected to decrease to 0.8% in 2023 following heavy energy and price shocks[25]. Additionally, the country's economy is heavily dependent on tourism, which gives another reason for the drop in GDP growth to -8.6% in 2020 (Figure 8) given the effect of the COVID-19 pandemic on travel. Tourist receipts in 2022 were record high, surpassing the previous all-time high achieved in 2019. Tourism together with rising exports, employment and wages are foreseen to stabilise energy prices resulting in an output growth of 1.5% in 2024[25].

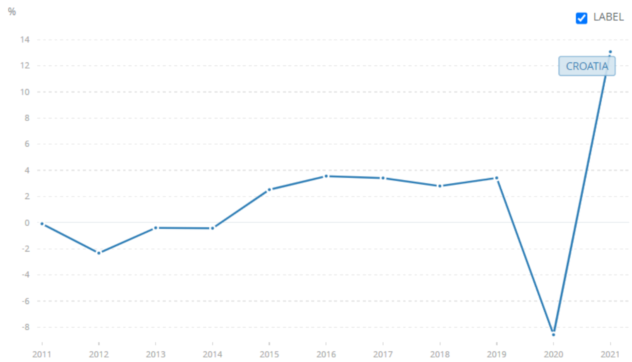


Figure 8: GDP growth in percentage Source: World Bank

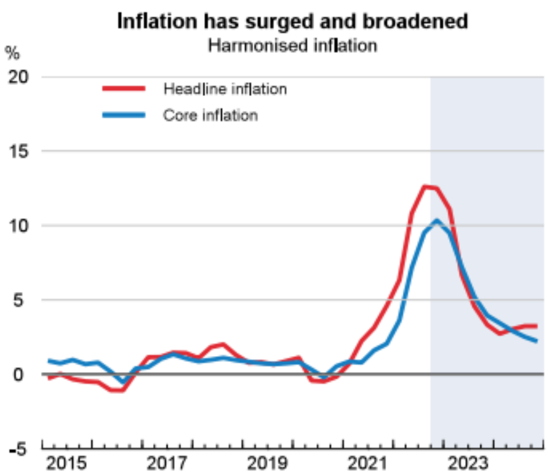


Figure 9: Inflation trends in Croatia, Source: OECD

Inflation reached 12.6% in September 2022 and thereafter 13.1% in December 2022[26]. The unemployment rate has remained fairly stable since 2020 at 7.5%, projected to increase to 7.8% in 2023 and then decrease back to 7.4% in 2024. However, Croatia has been presenting a negative migration rate steadily in the past years, however with a decline of 26.79% in 2022 compared to 2021 (migration rate of -0.779 per 1000 people) and a foreseen 36.59% decline in 2023 from 2022 (migration rate of -0.494 per 1000 people) of people emigrating from the country[27]. Whereas there are positive improvements, the numbers are still negative indicating an efflux of the population.

[25] OECD Economic Surveys Croatia economic assessment, November 2022
[26] https://tradingeconomics.com/croatia/inflation-cpi
[27] https://www.macrotrends.net/countries/HRV/croatia/net-migration

Status of the energy system of the country

Energy prices

In January 2023 the electricity end-user price in Croatia stood at 14.4 eurocents/kWh, showing a decrease of 0.7% compared to the previous month. The price of fossil gas for end-user stood at 5.2 eurocents/kWh, showing a small increase of 0.24% compared to the previous month[28].

Electricity production and energy consumption

Croatia is not heavily dependent on Russian gas, with the main fossil fuel consumed for energy purposes being oil. Gas is still the second most utilised source of fuel, with more than 28% of share. Whereas Croatia is one of the few European countries heavily dependent on oil, it has also a high share of hydropower energy consumption, making it one of the countries with the highest share of such renewable source (Figure 10). Solar represents only a 0.26% of share of energy consumption in the country. When considering the electricity mix and more specifically the electricity production, hydropower is the most utilised source of fuel (46.11%), followed by gas with a bit more than 20% (Figure 11). Interestingly, oil represents a share of only 0.2%, even though this is the most consumed type of fuel. Electricity production from solar has been increasing steadily in the country since 2018 (Figure 12). Nonetheless, solar has only a share of 0.54% in the electricity mix, with Croatia remaining at the bottom of solar production in the EU. In fact, the EU-average of electricity production from PVs is around 5%, placing it at the 23rd place in the EU, preceding only Estonia, Lithuania, Latvia and Ireland; all northern countries with a lower number of yearly sunlight hours, compared to Croatia's 2300 hours of sunlight per year on average[29]. In February 2022, 3,334 solar panels with a total power of 124 MW were connected to the grid, representing an actual consumption of 1% of the total potential in the country.

[28] https://www.energypriceindex.com/price-data
[29] https://nasuncanojstrani.hr/solarna-pismenost/solarna-energija-za-kucanstva/#/lessons/lCFoqKjX_HnCvp6pwurc6TFSCSY95BSz

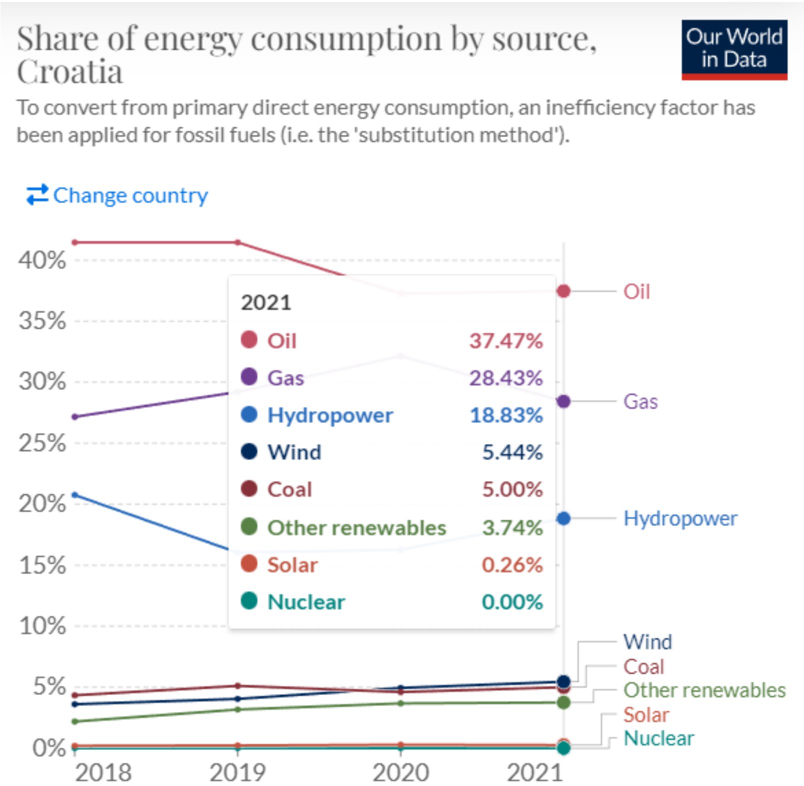


Figure 10: Share of fuels in energy consumption, Source: Our World in Data

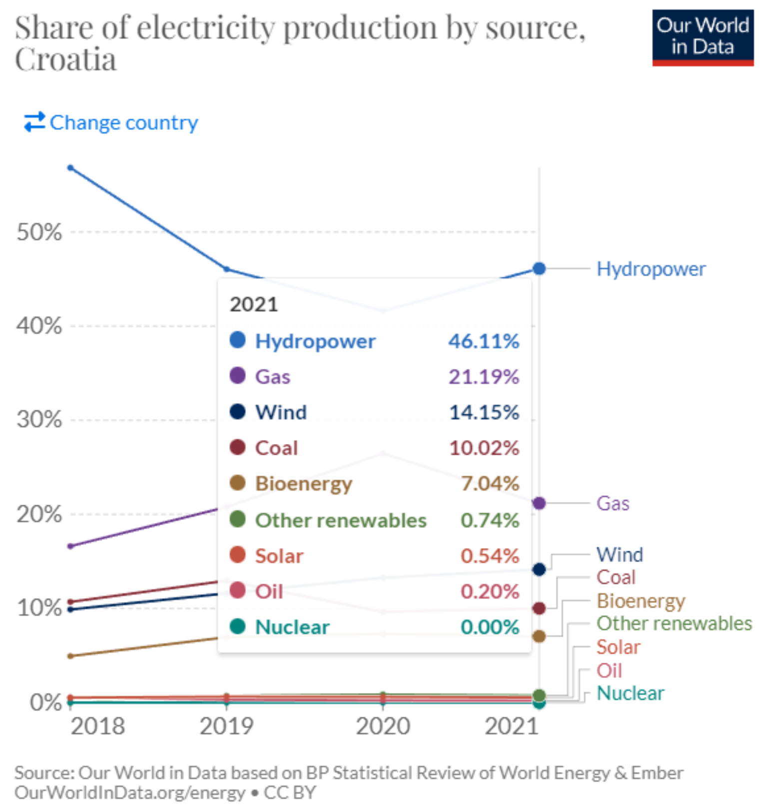


Figure 11: Share of type of fuels in electricity production, Source: Our World in Data

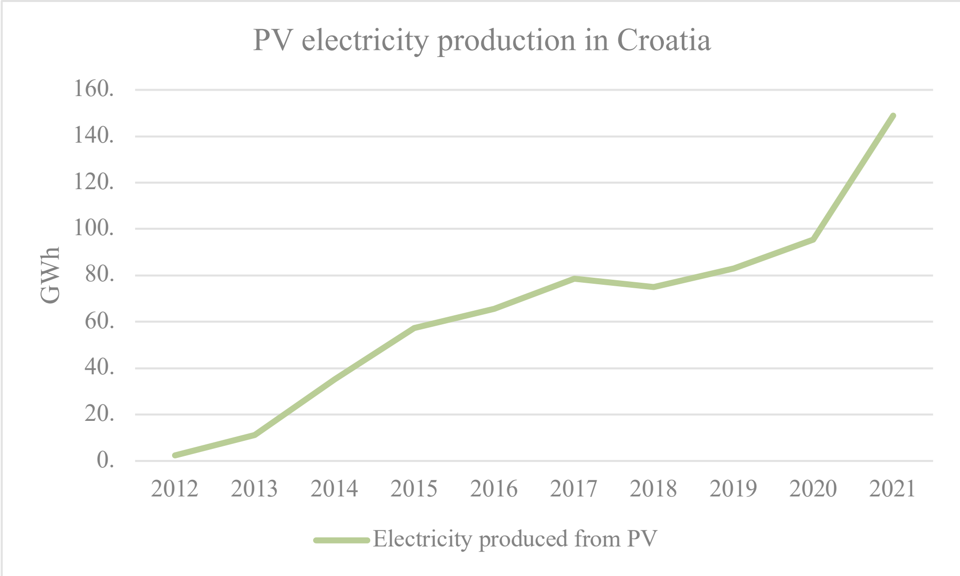


Figure 12: Solar-produced electricity in Croatia

Policies implemented to decrease the adverse effects of price hikes

Several policies were implemented in Croatia to combat the energy crisis. A first package of measures was introduced in February 2022 worth 636 million EUR[30]. These measures included also a limit on electricity price increases of 9.6% and on gas price increases of 20%, addressing the most vulnerable consumers (estimated to be over 90,000)[31]. Additionally, the VAT was lowered to 5% from beginning of April 2022 to the end of March 2023, with all households utilising gas for heating being eligible for subsidies[32]. Such economic support on the energy bill accounted for 20% of the projected energy price.

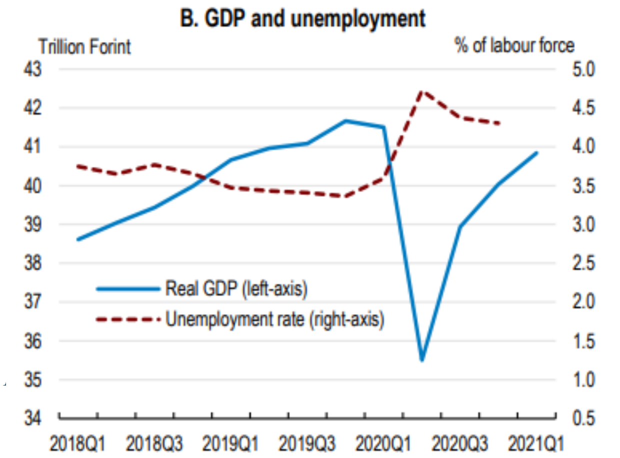
On August 8th, 2022, a new aid package worth 2 billion EUR was announced targeting energy consumers[33], followed by another package exactly another month later worth 2.8 billion EUR (21 billion HRK), introducing caps on energy prices[34]. In fact, households will pay 59 EUR/MWh, increasing to 88 EUR/MWh when consuming more than 2500 kW.

3.1.3 Hungary

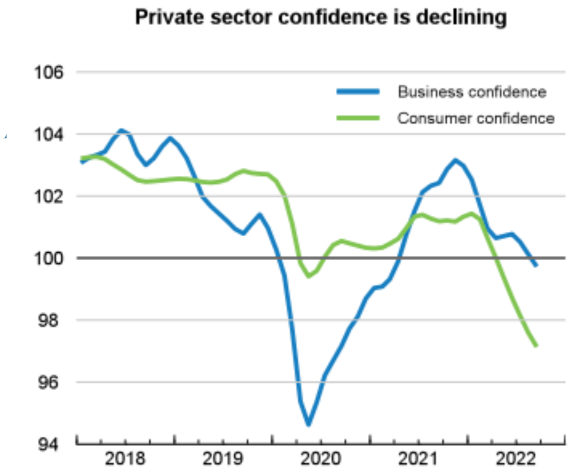
General economic and energy poverty status

[30] https://ceenergynews.com/finance/croatia-adopts-636-million-euros-package-to-mitigate-the-growth-of-energy-prices/
[31] https://oenergetice.cz/komoditni-trhy/vlady-proti-cenam-energii-bojuji-snizenim-dph-zastropovanim-cen-nebo-prispevky
[32] https://vlada.gov.hr/vijesti/predstavljen-paket-mjera-za-ublazavanje-rasta-cijena-energenata-vrijedan-4-8-milijardi-kuna/33907
[33] https://vlada.gov.hr/vijesti/vladin-paket-ukljucuje-mjere-pomoci-za-sve-segmente-drustva/36022
[34] https://www.euractiv.com/section/energy-environment/news/croatia-unveils-plan-to-cap-energy-and-food-prices/

Preceding the pandemic, Hungary presented a strong economic growth performance, with low unemployment rates and high real incomes. However, GDP growth is foreseen to decline to 1.5% in 2023 (from the 6% value obtained in 2022) and thereafter recover to 2.1% in 2024[35]. On the other hand, the unemployment rate is not envisioned to stop growing in the next two years, with projections seeing it reach 4.7% in 2023 and 5.2% in 2024 from the 3.5% rate in 2022. This reflects the persistently high inflation in the country and the economic consequences of Russia's war in Ukraine. In fact, the year-to-year inflation rate reached 25.7% in January 2023, from 24.5% in the previous month and 20.1% in September 2022[36].



The population at risk of poverty has been steadily declining in the past years, with 2022 being the exception. In fact, it increased to 11.9% from the previous year's value of 11.4%[37]. On another note, the consumer and business confidence has also been declining in the previous year (Figure 14). Due to the war in Ukraine, Hungary received an influx of almost 2.1 million refugees, which led to temporary spending pressures on different sectors in the country. Nonetheless, only 33,603 Ukrainian citizens have applied for asylum in Hungary[38].



Status of the energy system of the country

Energy prices

Energy prices have been increasing in Hungary as in the rest of Europe due to the energy crisis spiked by the war in Ukraine. In August 2022, the average wholesale electricity price surpassed 495 EUR/MWh in Hungary, representing a year-to-year increase of a factor of 4[39]. In January 2023, the electricity end-user price stood at 9 eurocents/kWh, signalling no increase compared to the previous month. The fossil gas price stood at 2.5 eurocents/kWh, again signalling no increase compared to the previous month[40].

Average electricity prices for end-users provide a good overview of the energy prices. Nonetheless, there are several kinds of tariffs present in the energy market, with the main objective being to maintain residential energy prices artificially low, affecting any energy-

[35] OECD ECONOMIC OUTLOOK, VOLUME 2022 ISSUE 2, HUNGARY
[36] https://tradingeconomics.com/hungary/inflation-cpi#:~:text=Fresh%201996%2DHigh-,The%20annual%20inflation%20rate%20in%20Hungary%20increased%20to%2025.7%25%20in,above%20market%20expectations%20of%2025.2%25.
[37] https://tradingeconomics.com/hungary/at-risk-of-poverty-rate-owner-Eurostat-data.html
[38] https://telex.hu/ellenorzo/2023/02/03/ellenorzo-j-d-vance-inflacio-magyarorszag-ukrajna-menekultek
[39] https://www.statista.com/statistics/1314534/hungary-monthly-wholesale-electricity-price/
[40] https://www.energypriceindex.com/price-data

related investment in the residential sector as well as the macroeconomics of the country. In July 2022, modifications to the energy pricing system were published, setting a discounted gas price of 102 HUF/m^3 (roughly 27 eurocents/m^3) for households consuming up to 1,729 m^3 per year, and 747 HUF/m^3 (roughly 1.95 EUR/m^3) for households exceeding such value, while setting the competitive market price at 1,020 HUF/m^3 (roughly 2.7 EUR/m^3)[41]. In August 2022, the decree was modified to include also the calorific value of gas, stating that the 1,729 m^3 of gas per year correspond to 63,645 MJ per year[42].

Electricity production and energy consumption

Hungary presents a rather higher dependence on gas, as this is the most consumed type of fuel for energy end-uses (Figure 15). Hungary signed a 15-year deal with Russian Gazprom during summer 2021, receiving 3.5 bcm of gas per year through Serbia and Bulgaria and an additional 1 bcm through pipelines in Austria[43]. Additionally, Russia accounted for 64% and 95% of crude oil and gas imports respectively, with an import dependence of 87% in 2020[44].

On the other hand, the main source of fuel for electricity generation is nuclear (45.99%) followed by gas (27.66%) (Figure 16). The Paks Nuclear Power Plant saw a sudden interest following the declaration of state of emergency in July 2022 by the Hungarian government, with plans of increasing its lifetime, seeing the country's reliance on this form of energy for its electricity production. In August 2022, approval was given by the Hungarian Atomic Energy Authority for the construction of two new blocks at the Paks II Nuclear Power Plant, with a capacity of 2.4 GW. The project will be financed by Russia, providing a 10 billion EUR loan to finance 80% of the plant[45]. The project plan was approved by the European Commission in March 2017. Nonetheless, concerns about the feasibility of such project were expressed by different exponents both in- and outside Hungary[46]. On the other hand, photovoltaics saw a great increase in their share of electricity being produced since 2018 (Figure 17). In fact, in 2021 PV presented a share of 7.21% of electricity produced and 3.52% of energy consumed.

[41] https://telex.hu/gazdasag/2022/07/21/megjelent-a-rezsirendelet-63-70-forint-lesz-a-villany-21-22-forint-a-gaz-nem-tamogatott-ara
[42] https://24.hu/belfold/2022/08/24/kozlony-gazar-rezsicsokkentes-futoertek-szamla/
[43] https://www.reuters.com/world/europe/hungarys-orban-convenes-cabinet-meeting-european-energy-supply-2022-07-13/
[44] https://www.iea.org/reports/hungary-2022/executive-summary
[45] https://balkangreenenergynews.com/hungary-to-build-paks-ii-nuclear-power-plant-with-russia/
[46] https://telex.hu/english/2023/01/31/orban-seems-committed-towards-the-russians-but-the-fate-of-hungarys-nuclear-plant-expansion-is-a-growing-question-mark

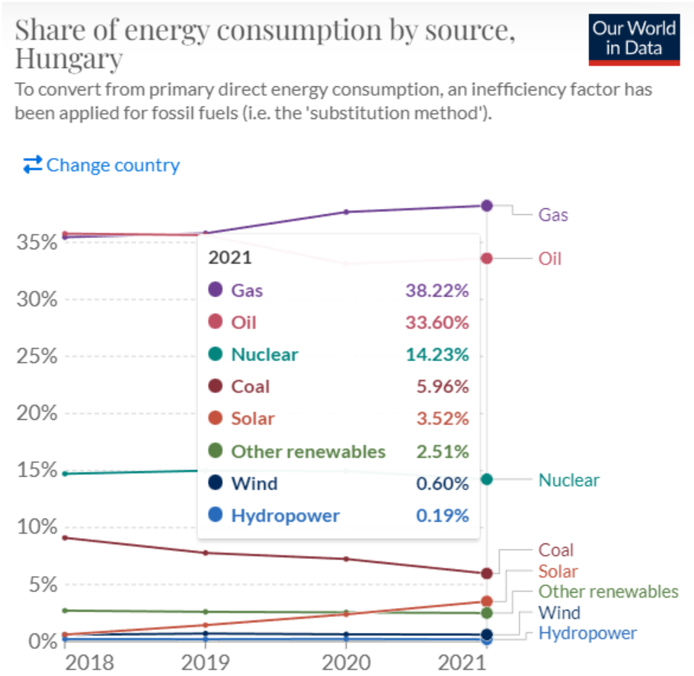


Figure 15: Share of energy consumption by fuel – Source: Our World in Data

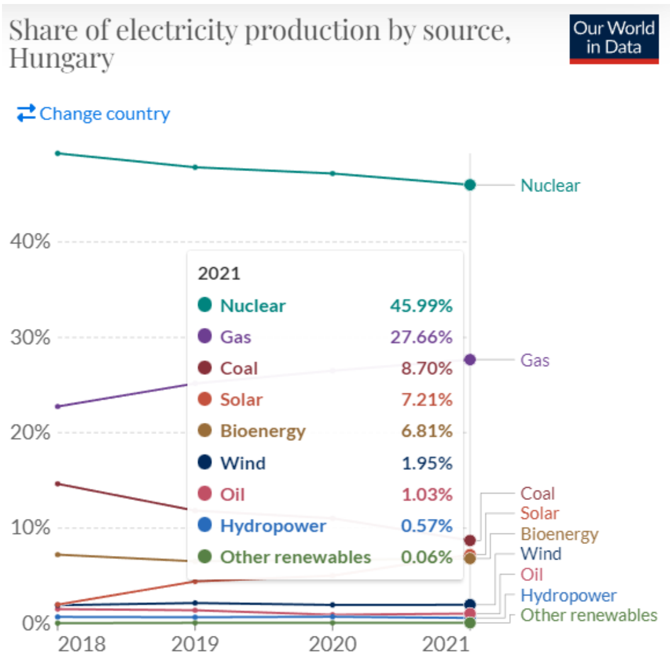


Figure 16: Share of electricity production by fuel - Source: Our World in Data

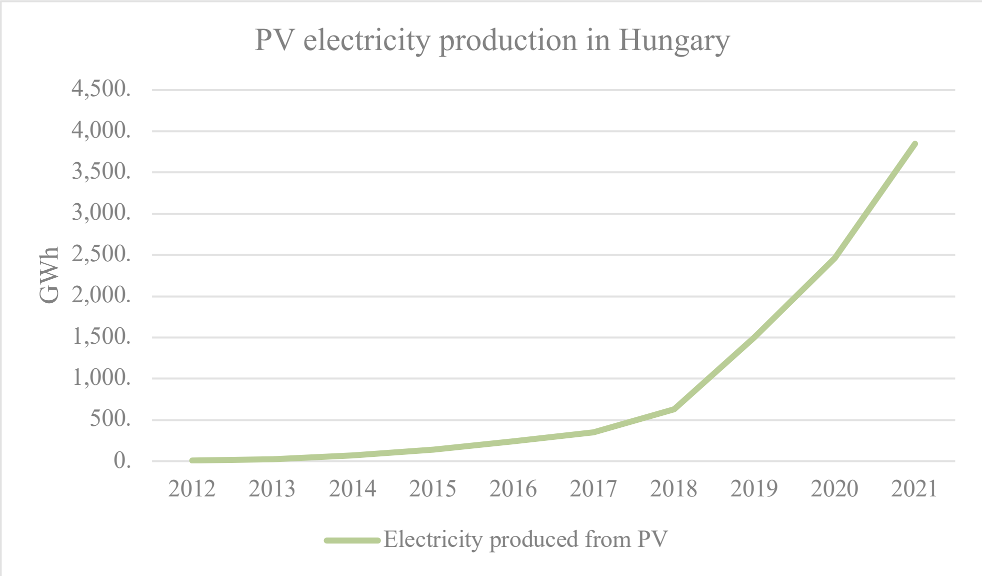


Figure 17: Trend of electricity produced from PV - Source: Eurostat

Policies implemented to decrease the adverse effects of price hikes

Several policies were implemented in Hungary to face the energy crisis. Price caps on motor fuels for private vehicles were in place until the end of 2022. Starting from September 1st, 2022, the price caps on electricity and gas were reduced to cover only those households consuming below or average levels[47]. On the other hand, the government assisted energy-intensive small businesses by covering half of the increase in their bills when compared with previous year's levels[48]. Additionally, the government mandated a gas consumption cut of 25% for all public and state-owned companies[49].

[47] https://www.reuters.com/business/energy/hungary-scrap-energy-price-caps-high-usage-households-2022-07-21/
[48] https://www.euronews.com/next/2022/09/18/hungary-economy-price-caps
[49] dailynewshungary.com https://dailynewshungary.com/cultural-and-innovation-ministry-preparing-energy-conservation-plan

3.1.4 Poland

General economic and energy poverty status

Poland had a steady and stable growth throughout the whole last decade (Figure 18), which however was slowed down by the COVID-19 pandemic first and then the energy crisis. Poland had recovered well in 2021, showing a 6.8% GDP growth increase compared to the previous year, which was followed by a 4.5% increase in 2022. Nonetheless, GDP growth is foreseen to increase only by 0.9% in 2023 and thereafter by 2.4% in 2024[50]. Due to fiscal policy, consumption and investment is expected to slow down considerably. Such policy is needed, as Poland has experienced a consumer price inflation of 15.7% in September 2022 and core inflation of 11.5% (Figure 19). Whereas inflation is expected to peak in the beginning of 2023, it will likely remain high until the end of 2024.

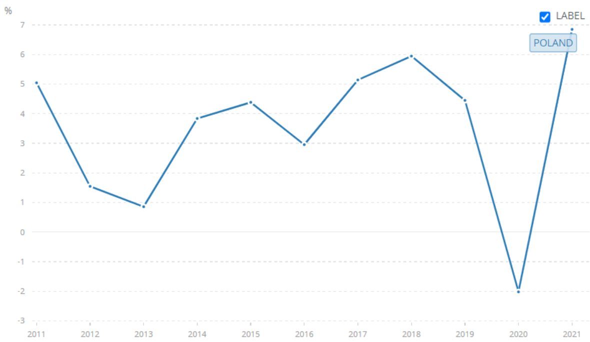


Figure 18: Poland annual GDP growth in percentage, Source: World Bank

The unemployment rate is expected to remain fairly stable, with a slight increase from 3.4% of the workforce in 2021 to 3.8% in 2024. Nonetheless, inequality in Poland is fairly lower that in most advanced economies; with the poorest 20% of households earning 8.5% of total income[51]. Lastly, direct trade with Belarus, Russia and Ukraine represented 3-5% of GDP before 2022, which now has lowered due to the sanctions.

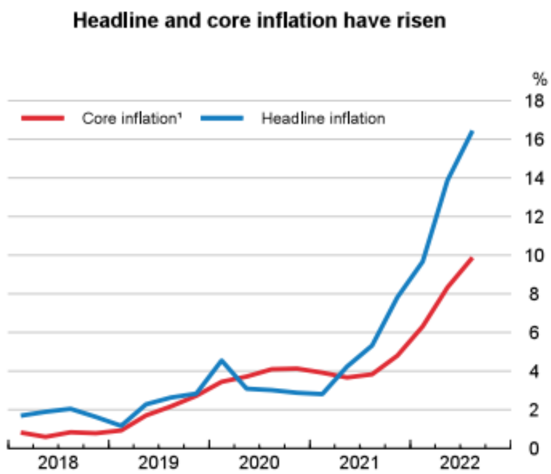


Figure 19: Inflation trend, Source: OECD

Status of the energy system of the country

Energy prices

In January 2018, the average wholesale electricity market price stood at 163.95 zloty/MWh; in June 2022 it stood at 884.6 zloty/MWh (approximately 142.53 EUR/MWh)[52]. The cost of energy prices amounted to around 50 billion zlotys (approximately 10.5 billion EUR) to be financed largely by taxpayers and energy firms[53]. Poland relies heavily on coal, and despite being the biggest producer of it in the EU, it still imported more than 8 million tonnes from Russia in 2021. Due to a declining coal production, Poland faced a shortfall of 11 million tonnes of coal in 2022[54]. Subsidy programmes were introduced for coal purchases and other fossil fuels for heating, but the market shortage was not resolved. In January 2023,

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[50] OECD Economic Surveys Poland economic assessment, November 2022
[51] Economic Policy Reforms 2021: Going for Growth, OECD Poland
[52] https://www.statista.com/statistics/1066654/poland-wholesale-electricity-prices/#:~:text=In%20the%20observed%20period%2C%20weighted%20average%20monthly%20electricity,You%20need%20a%20Single%20Account%20for%20unlimited%20access
[53] https://www.reuters.com/business/energy/curbing-energy-prices-poland-will-cost-50-billion-zlotys-pm-2022-08-02/
[54] https://www.reuters.com/business/energy/poland-boost-coal-imports-subsidies-amid-russia-sanctions-2022-07-18/

electricity price in Poland stood at 22.5 eurocents/kWh; whereas the price of fossil gas stood at 6.98 eurocents/kWh[55].

Electricity production and energy consumption

Poland is a country highly dependent on fossil fuels. More than 70% of its consumed energy comes from coal and oil, with the former being the most utilised source of fuel with a share of over 42% (Figure 20). In this context, solar energy represents a minimal contribution to the energy consumption mix with a share of 0.84%. When considering electricity production, coal has the vast majority of type of fuel share, with over 70% (Figure 21). Solar represents only 2.21% of the electricity produced in Poland. Nonetheless, the amount of electricity produced from photovoltaics has been constantly growing since 2018 (Figure 22).

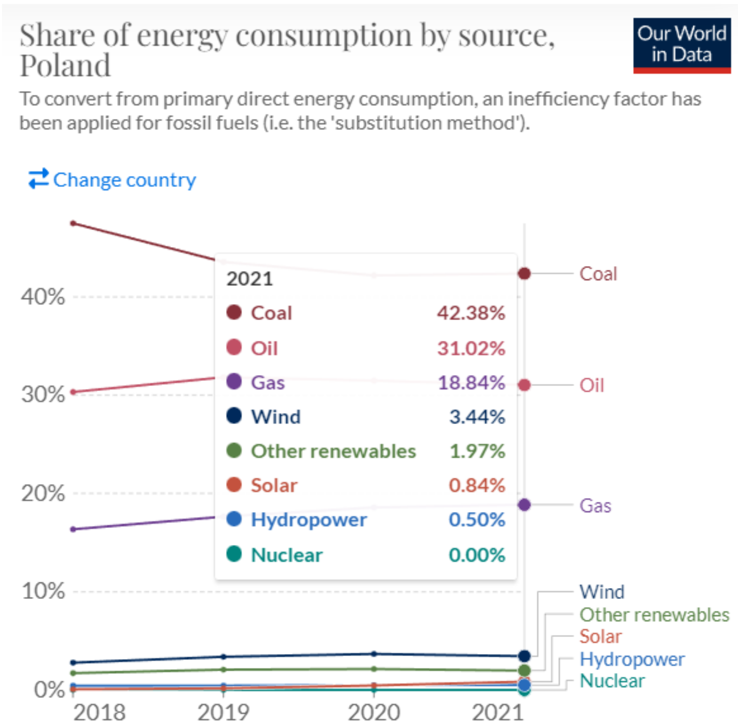

Figure 20: Share of energy consumption by fuel – Source: Our World in Data

[55] https://www.energypriceindex.com/price-data

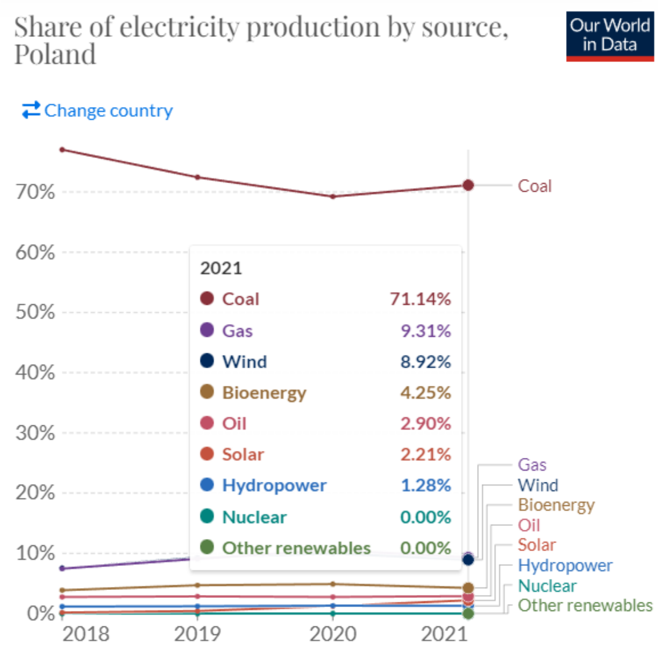

Figure 21: Share of electricity production by fuel – Source: Our World in Data

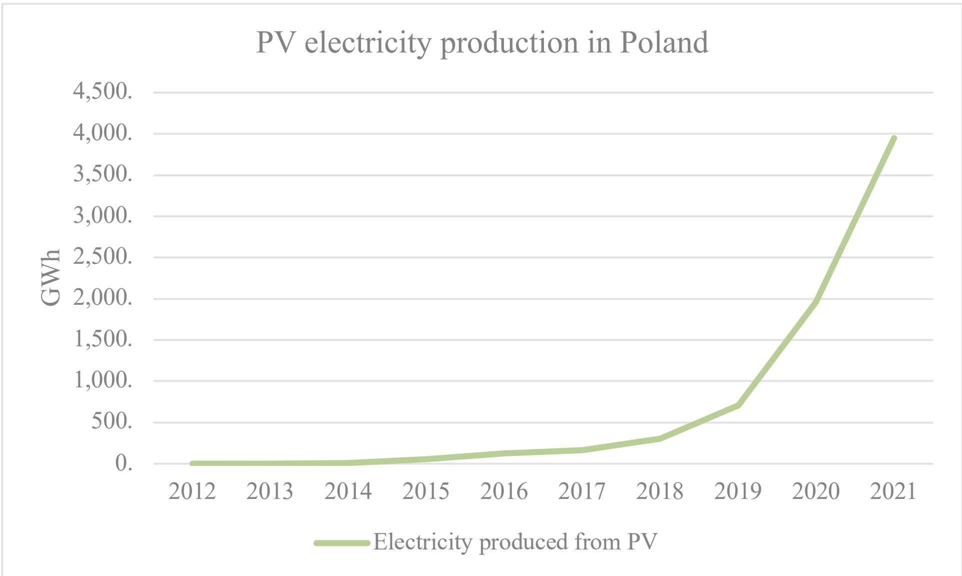

Figure 22: Trend of electricity produced from PV - Source: Eurostat

Policies implemented to decrease the adverse effects of price hikes

Poland is still in the process of liberalising its fossil gas market, where the state-owned PGNiG gas and oil company (recently acquired by PKN Orlen – major company in Poland) has a dominant position. Whereas most regulation of gas prices ended in 2017, the regulation of prices for end-users was set to finish in December 2023 but was further prolonged until 2027 over concerns of price volatility[56].

As a response to the war in Ukraine, Poland banned imports of Russian coal in April 2022 and offered a one-off payment to households of 3,000 zlotys (632 EUR) to aid with the rising energy and coal prices[57]. Electricity prices were capped at 2022 prices for the first 2,000 kWh consumed by households in 2023[58]. In fact, on October 11th, prices were confirmed to be capped at 785 PLN/MWh (16 eurocents/kWh) for small and medium-sized enterprises and public buildings, whereas for households the cap was set at 699 PLN/MWh (14 eurocents/kWh)[59]. In addition, allowances ranging from 1000 PLN (208 EUR) to 1500 PLN (312 EUR) were also announced[60]. These measures costed approximately 23 billion PLN (4.8 billion EUR). Lastly, in case households reduced their electricity consumption by at least 10% in the period from October 1st 2022 to December 31st 2023 compared to the same period one year before, these will get a 10% discount on their electricity bill in 2024 as part of a new measure[61]. The government introduced also the cap for gas prices for households in 2023 in the amount of 200 PLN net/MWh[62].

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[56] http://swaid.stat.gov.pl/EN/Ceny_dashboards/Raporty_predefiniowane/RAP_DBD_CEN_9.aspx
[57] https://www.reuters.com/business/energy/poland-boost-coal-imports-subsidies-amid-russia-sanctions-2022-07-18/
[58] https://www.reuters.com/world/europe/poland-freeze-electricity-prices-households-2023-2022-09-13/
[59] https://businessinsider.com.pl/twoje-pieniadze/maksymalna-cena-pradu-dla-firm-morawiecki-oglosil-szczegoly/tkdjx61
[60] https://dignitynews.eu/en/government-adopted-a-bill-to-freeze-electricity-prices/
[61] https://china-cee.eu/2022/10/26/poland-social-briefing-the-actions-of-the-polish-government-in-the-face-of-the-energy-crisis/
[62] https://www.gov.pl/web/klimat/rzad-wspiera-obywateli-w-zakresie-cen-gazu-i-energii

3.1.5 Romania

General economic and energy poverty status

Romania presented an impressive economic performance preceding the COVID-19 pandemic. In fact, the Eastern European country saw its gap in GDP per capita to the OECD average be reduced from 70% to 35% in less than 20 years[63]. Output growth is foreseen to reach 6.5% in 2022[64]. Nonetheless, following a steep 5.9% rebound in 2021, GDP growth rates are expected to deflate to 1.4% in 2023 and 2.8% in 2024. Whereas business confidence has not been affected by the war in Ukraine, supply chain disruptions and increasing commodity prices have affected economic activity.

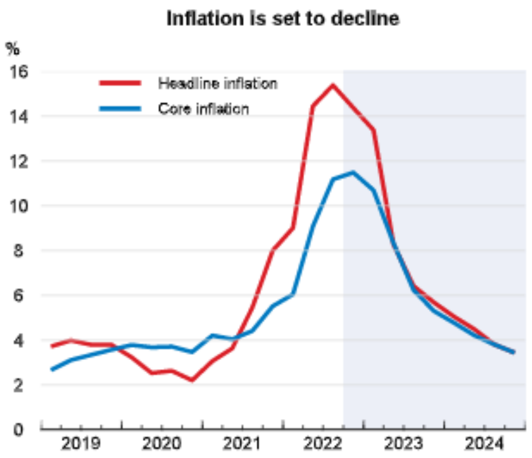

Figure 23: Inflation trend in Romania - Source: OECD Economic Outlook

Romania presents the highest percentage of people at risk of poverty or social exclusion within the EU[65]. Poverty remains widespread and unfortunately increasing in rural areas. This contributes also to a high-income inequality[66]. Inflation has been at rather high levels in the last years. Indeed, headline consumer price inflation is foreseen to reach 13.3% in 2022, notwithstanding tight monetary policies implemented within the country. Similarly, year-on-year inflation reached 15.3% in October 2022 and thereafter increased to 16.37% in December 2022[67]. On the other hand, Romania presents a low unemployment rate, which has been steadily decreasing since 2015 up to the COVID-19 pandemic. Nonetheless, in 2022 unemployment rate was lowered once again, declining to 5.2% in September 2022.

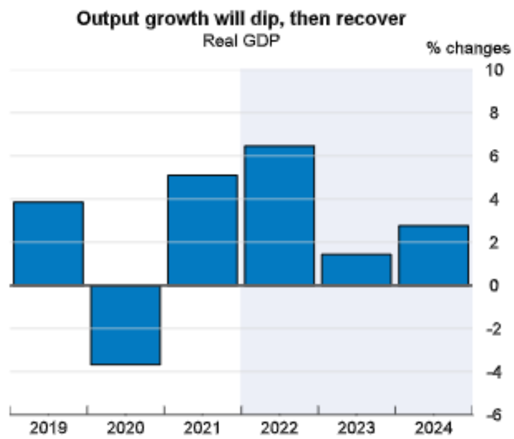

Figure 24: Output Growth in Romania - Source: OECD Economic Outlook

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[63] Romania 2020, Economic Survey Overview, OECD
[64] OECD Economic Outlook, Volume 2022 Issue 2
[65] https://ec.europa.eu/Eurostat/statistics-explained/index.php?title=Living_conditions_in_Europe_-_poverty_and_social_exclusion#Key_findings
[66] Economic Policy Reforms 2021: Going for growth, Romania, OECD
[67] https://tradingeconomics.com/romania/inflation-cpi

Status of the energy system in the country

Energy prices

In the first quarter of 2022, average household electricity prices stood at 14.2 eurocents/kWh[14]. As of August 1st, 2022, these increased to 16.18 eurocents/kWh (including taxes). However, when adjusted for purchasing power standards (PPS), the price increases to 30.6[14]. According to Eurostat, average electricity prices in the first quarter of 2022 were of 17.8 eurocents/kWh, representing a 55.13% increase compared to the previous year.

Gas prices in Romania amounted to 6.3 eurocents/kWh as of August 1st, 2022; well below the EU average[14]. Once again, when adjusted to PPS, these almost double, standing at 11.9[14]. Nonetheless, this is still below the EU average. According to Eurostat, average gas prices in the first quarter of 2022 stood at 6.1 eurocents/kWh, representing a 94.53% increase compared to the previous year.

Electricity production and energy consumption

Romania is still dependent on fossil fuels for energy consumption, however at lowering numbers, especially for electricity generation. Romania is amongst the least dependent European countries on Russian gas. With the start of new gas production in the Romanian Black Sea in June 28th 2022, Romania has already filled 80% its gas storage facilities, with an objective of 90% gas self-sufficiency envisioned by the Prime Minister for November 2022 This represents 29.34% of the total energy consumption (Figure 25). Additionally, gas represents a 17.13% share of the electricity produced (Figure 26). On the other hand, electricity production from PV has greatly increased in the country since the start of the decade, when it was virtually zero (Figure 27). In 2021, PV production represented 2.87% of the electricity produced and 1.14% of the energy consumed.

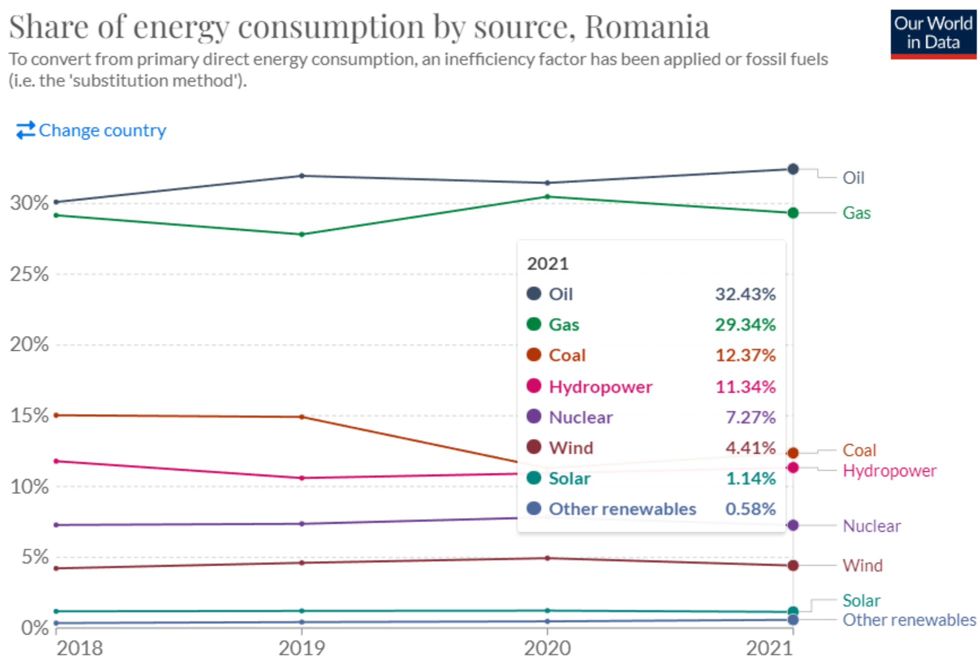

Figure 25: Energy consumption by source - Our World in Data

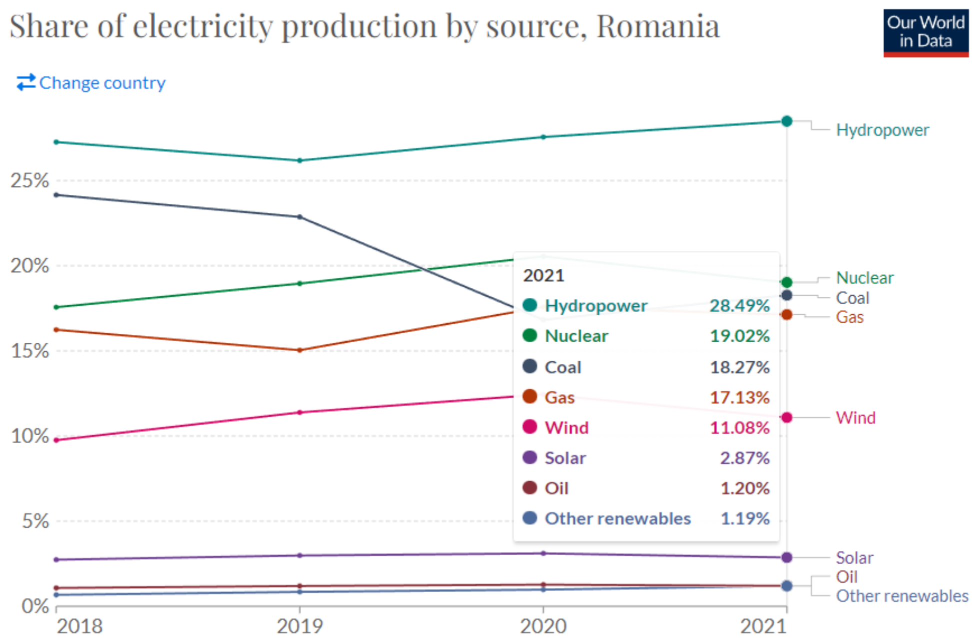

Figure 26: Electricity production by source - Our World in Data

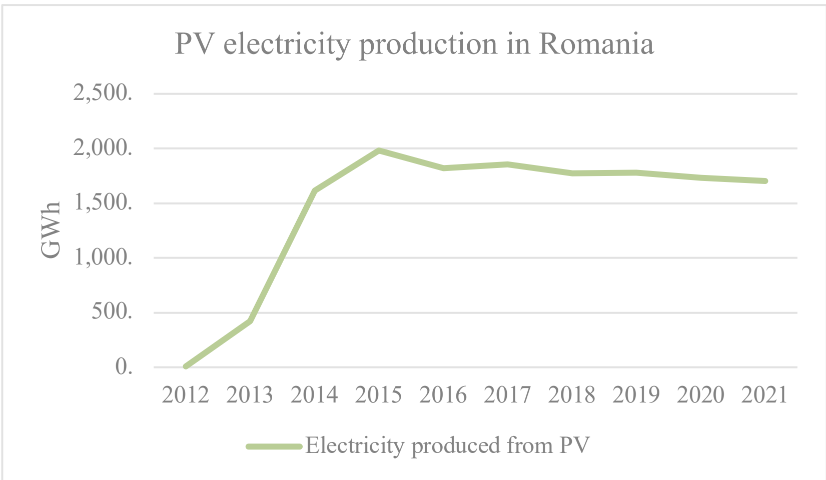

Figure 27: Electricity produced from PV - Source: Eurostat

Policies implemented to decrease the adverse effects of price hikes

Compensations for both electricity and gas bills were announced on October 4th, 2021 by the Romanian government. These measures lasted from November 1st 2021 to March 31st 2022, affecting approximately 85% of the Romanian population[68]. A price ceiling on electricity and gas prices was implemented on March 20th 2022. Initially planned to last for 1 year, this was extended on September 1st 2022 to last until the end of August 2023, costing 1 billion LEI (202

[68] https://www.libertatea.ro/stiri/guvernul-a-aprobat-compensarea-facturilor-la-energie-si-gaze-pentru-consumatorii-casnici-care-sunt-sumele-suportate-de-stat-3767484

million EUR) per month[69]. Electricity prices were capped according to the following scheme: 13.7 eurocents/kWh for households consuming up to 100 kWh/month; 16.1 eurocents/kWh for households consuming 100-300 kWh/month; 20 eurocents/kWh for households consuming more[70]. Concerning gas prices: 6.3 eurocents/kWh for households consuming up to 1200 m^3. The measure is expected to cost around 2.9 billion EUR, of which 1.9 billion only for the cap on electricity prices. Additionally, on April 11th 2022, the Romanian government announced a series of grants and vouchers worth 3.5 billion EUR to help vulnerable households and industries. Half of this fund will be covered by EU funds[71].

[69] https://www.euractiv.com/section/energy-environment/news/romania-extends-energy-price-caps-by-a-year/
[70] https://www.enerdata.net/publications/daily-energy-news/romania-extends-cap-electricity-and-gas-prices-end-2022.html
[71] https://www.euronews.com/next/2022/04/11/romania-government-economy

3.1.6 Slovakia

General economic and energy poverty status

Constant economic growth has characterised Slovakia throughout the last decade (Figure 28). The national GDP is foreseen to grow by 1.6% in 2022, followed by an increase of 0.5% and 2.1% in 2023 and 2024 respectively[72]. The unemployment rate has been relatively stable since 2020 and is foreseen to reach 6.7% and 6.5% of the labour force in 2023 and 2024 respectively. The country has additionally seen high increases in food and energy prices since the start of the war in Ukraine, calling for a need for fiscal support policy measures.

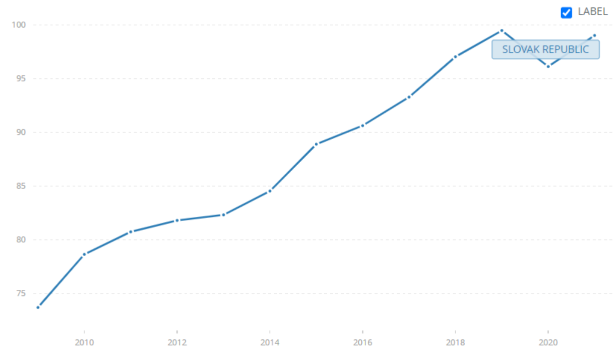

Figure 28: Annual GDP growth rate Slovakia, Source: World Bank

The Central European country presents a rather low inequality, with the poorest 20% of households earning 9.4% of total income[73]. Consumer price inflation reached 14.5% in October 2022 due to rises in food and energy prices and a disruption of supply. Similarly, core inflation reached 9.3% in October 2022. As a result of the war, 100,000 Ukrainian refugees have applied for residence permits, which is expected to boost the labour force by around 1%.

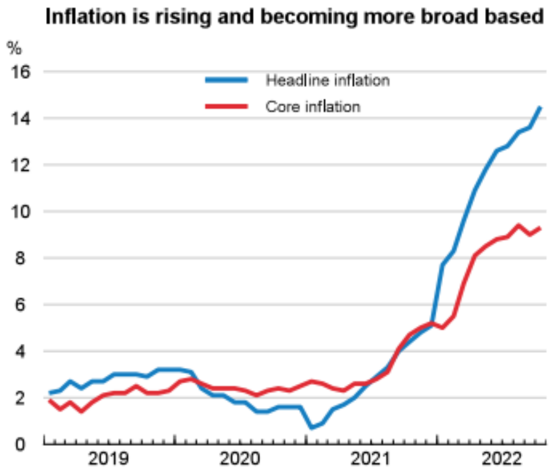

Figure 29: Inflation trend in Slovakia, Source: OECD

Status of the energy system in the country

Energy prices

The average household electricity prices in Slovakia stood at 18.2 eurocents/kWh in the first quarter of 2022[14]. These increased further to 19.03 eurocents/kWh (including taxes) as of August 1st, 2022[14]. If corrected for purchasing power standards (PPS), there is no high variation in price, remaining at 23.51.

The price of fossil gas in Bratislava stood at 5.3 eurocents/kWh on August 1st, 2022[14], being the third lowest value in the EU. Furthermore, if adjusted to PPS, the price increased only up to 6.5 eurocents/kWh, making it the second lowest value in the EU[14].

[72] OECD Economic Surveys Slovak Republic economic assessment, November 2022
[73] Economic Policy Reforms 2021: Going for Growth, OECD Slovak Republic

Electricity production and energy consumption

The two main types of fuels consumed in Slovakia for energy purposes are gas and oil, with shares of 26.99% and 24.89% respectively (Figure 30). The usage of gas has been increasing since 2018. Interestingly, since 2020 the utilisation of nuclear has reduced while that of coal has increased. Solar represents a share of only 0.89%. With regards to electricity production, this is predominantly nuclear based, with a share of over 53% (Figure 31). Solar has share of only 1.93%. Nonetheless, the production of electricity from photovoltaics has been steadily increasing in Slovakia since 2017 (Figure 32).

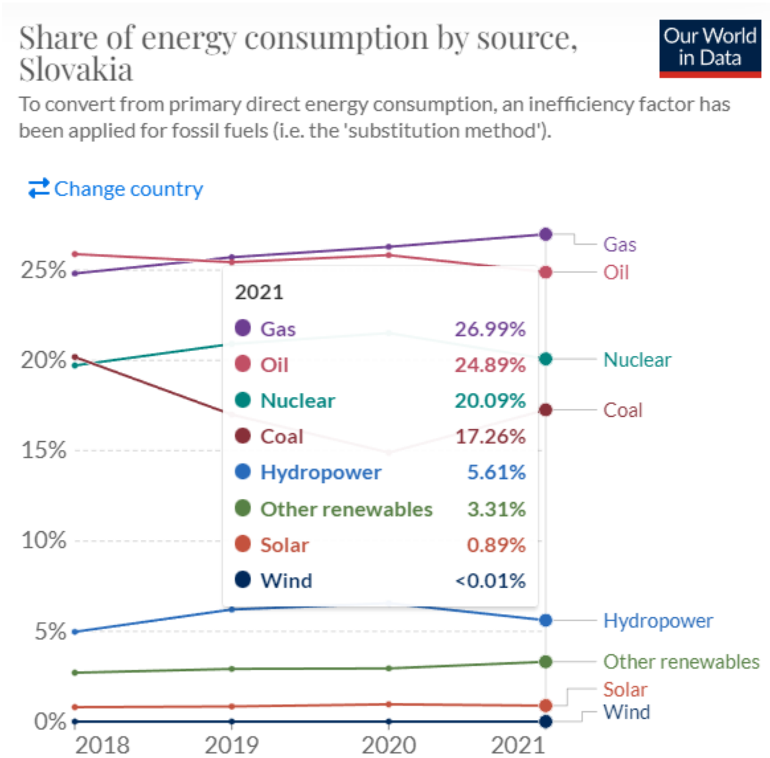

Figure 30: Energy consumption by type of fuel, Source: Our World in Data

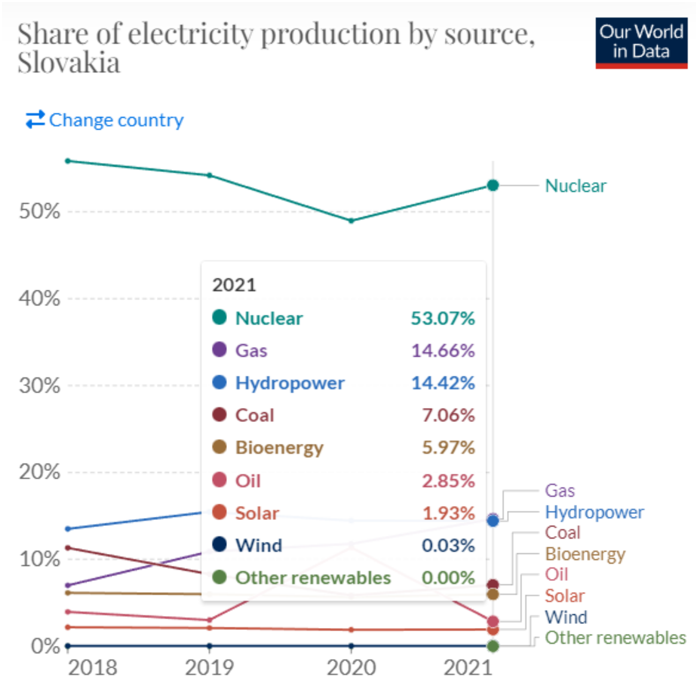

Figure 31: Share of electricity production by type of fuel, Source: Our World in Data

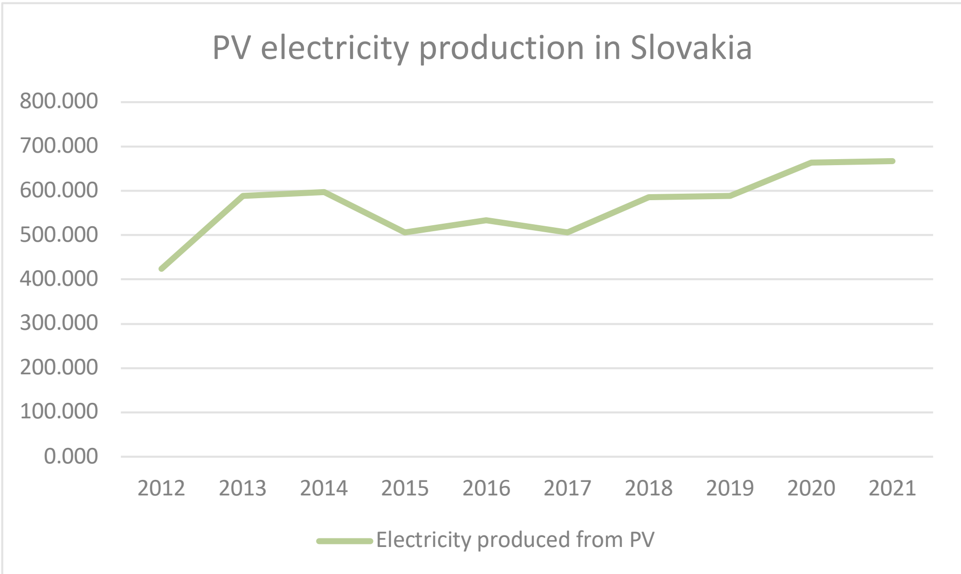

Figure 32: Electricity produced from PV - Source: Eurostat

Policies implemented to decrease the adverse effects of price hikes

In February 2022, an agreement was reached between the government and power utility Slovenské elektrárne to guarantee a stable electricity price of 61.2 EUR/MWh (excluding VAT) for a total volume of 6.2 TWh/year until 2024, covering the yearly consumption of households. Additionally, a bill proposing extra taxes on electricity produced by nuclear power was withdrew by the government[74]. The bilateral deal is considered to be worth around

[74] https://www.enerdata.net/publications/daily-energy-news/slovakias-se-agrees-cap-electricity-prices-households-until-2024.html

850 million EUR[75]. The expected savings are of 500 EUR per household, which would amount to 1 billion EUR, excluding taxes[76]. On October 25th, 2022, an energy price cap was announced for companies and businesses starting from November 2022 and lasting until March 2023; with prices fixed at 199 EUR/MWh for electricity and 99 EUR/MWh for gas[77]. This measure is envisioned to cost around half a billion EUR.

[75] https://world-nuclear-news.org/Articles/Slovak-agreement-reached-on-measures-to-limit-ener
[76] https://e.dennikn.sk/minuta/2723356
[77] https://www.euractiv.com/section/energy-environment/news/slovak-government-to-cap-energy-prices-for-businesses/

3.1.7 Slovenia

General economic and energy poverty status

Slovenia has had a positive GDP growth rate throughout majority of the last decade preceding the COVID-19 pandemic (Figure 33). Nonetheless, the GDP growth is foreseen to slow down from its value of 5% in 2022 to 0.5% in 2023[78]. Currently, due to the energy crisis and the disruption of supply chains due to the war in Ukraine, the economy needs more fiscal policies, also to combat the surging energy prices. The economy continued to grow despite higher inflation. Core inflation reached 6.6% in September 2022, whereas headline inflation reached 10.3% in October 2022.

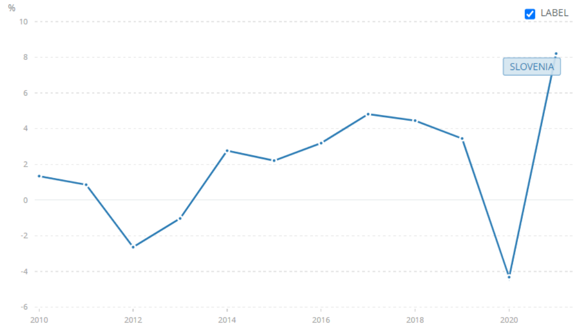

Figure 33: Annual GDP growth rate in Slovenia, Source: World Bank

Unemployment levels in the country have remained fairly stable. In fact, in 2021 about 4.8% of the working force were unemployed, and this number is foreseen to increase up to 4.9% in 2024[78]. The Central European country presented low inequality levels compared with the most advanced economies, with the poorest 20% of households earning 9.6% of total income[79].

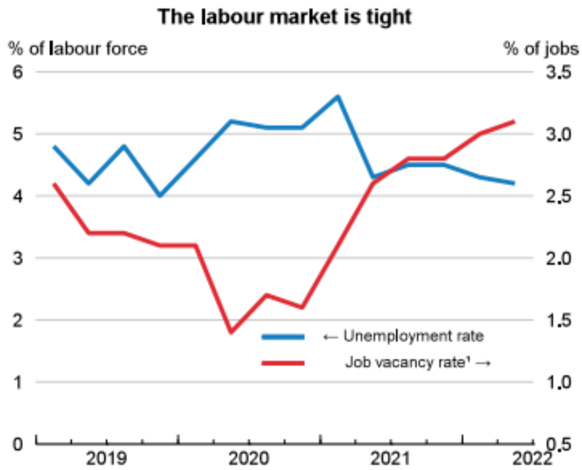

Figure 34: Unemployment trend in Slovenia, Source: OECD

Status of the energy system in the country

Energy prices

In January 2023, the electricity price for end-user stood at 17.4 eurocents/kWh, representing a reduction of 1.93% compared to the previous month[80]. On the other hand, the price of fossil gas for the end-user stood at 10.5 eurocents/kWh, representing a slight reduction of 0.12 percentage points compared to the previous month.

Electricity production and energy consumption

The most utilised source of fuel in Slovenia for energy end-uses is oil (Figure 35), similarly to its neighbouring country Croatia. This fuel has a share of over 35%, with the second most utilised being nuclear with a share of less than 20%. Solar corresponds to 1.05% of the total

[78] OECD Economic Surveys Slovenia economic assessment, November 2022
[79] Economic Policy Reforms 2021: Going for Growth, OECD Slovenia
[80] https://www.energypriceindex.com/price-data

consumed energy. On the other hand, nuclear is the most utilised form of fuel when it comes to electricity production, with a share of over 43% (Figure 36). Hydropower is a close second, with around 27% of the electricity produced. Solar energy has a share of around 2% of total electricity produced. Nonetheless, the amount of electricity produced from photovoltaics has been increasing steadily since 2018 (Figure 37).

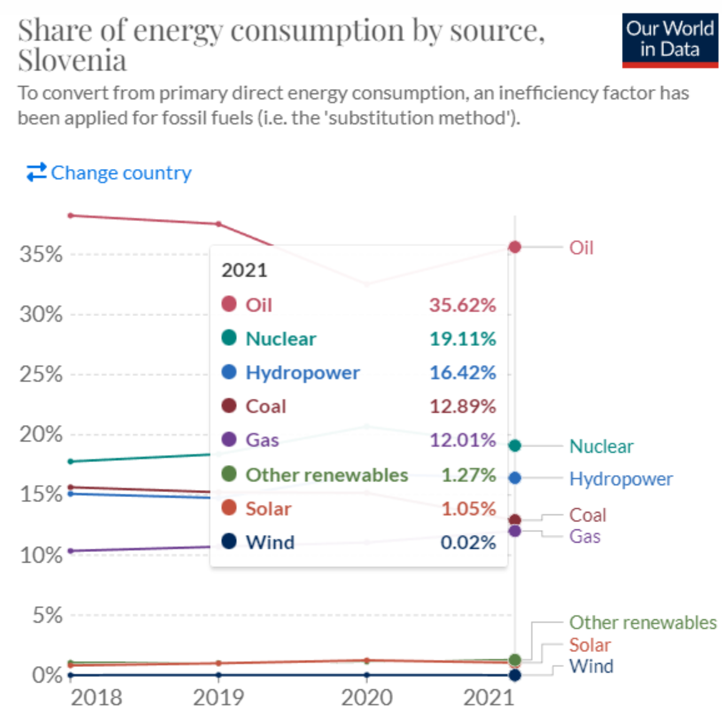

Figure 35: Share of energy consumption by type of fuel, Source: Our World in Data

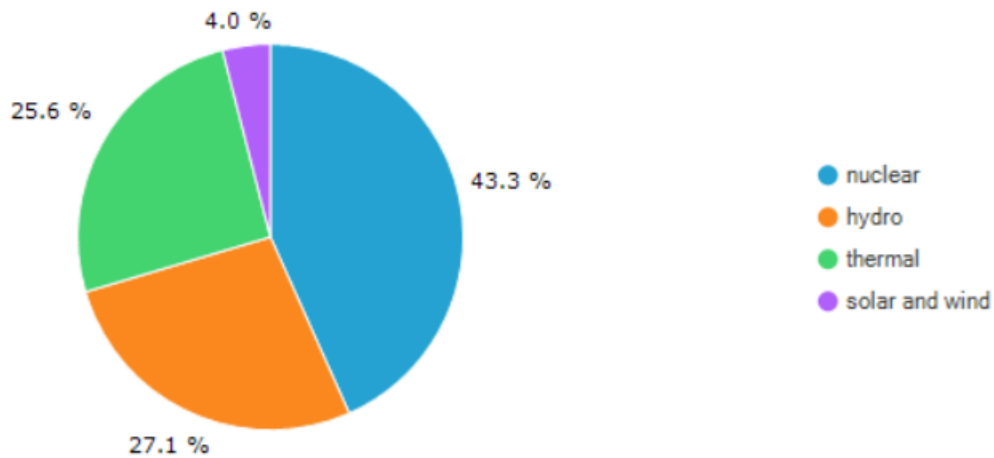

Figure 36: Share of electricity production by type of fuel in June 2022, Source: Statistical Office of the Republic of Slovenia

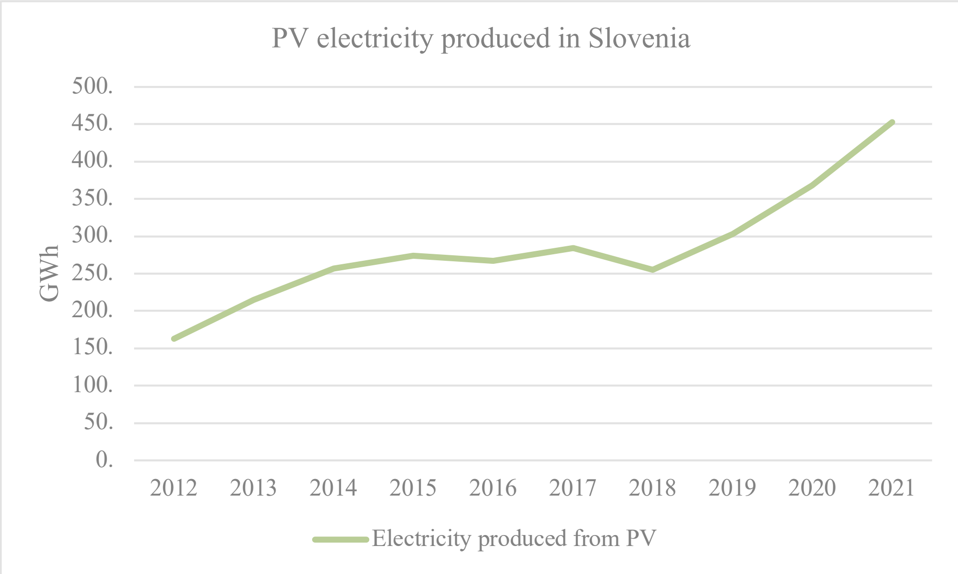

Figure 37: Yearly production of electricity from PV, Source: Eurostat

Policies implemented to decrease the adverse effects of price hikes

Several policies were implemented in Slovenia to counter the energy crisis. In January 2022, a budget of 106 million EUR was allocated for providing low-income citizens with a one-off energy voucher of 150 EUR (around 621,000 people) and a voucher of 200 EUR for large families[81;82;83]. Furthermore, households were exempt from paying electricity bills and had a reduction on electricity excise duties from February to April 2022. In September 2022, the government capped the price of electricity and gas for households for one year[84]. Lastly, a reduced VAT rate of 9.5% will apply until May 2023 to the supply of fossil gas, electricity, district heating and firewood[85].

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[81] https://www.delo.si/novice/slovenija/danes-in-v-cetrtek-nakazilo-po-150-evrov/
[82] https://www.sueddeutsche.de/wirtschaft/energie-so-gehen-europaeische-laender-gegen-hohe-energiepreise-vor-dpa.urn-newsml-dpa-com-20090101-220425-99-31784
[83] https://www.primorske.si/slovenija/vlada-najranljivejsim-namenja-energetski-solidarno
[84] https://www.gov.si/en/news/2022-07-14-8th-government-session/
[85] https://www.euractiv.com/section/energy-environment/news/slovenia-to-reduce-vat-on-energy/

4. RESULTS

4.1 The input data on the supply side energy investments

4.1.1 Bulgaria

The main assumptions from the supply side were gathered from the National Resilience and Recovery Plan (NRRP) of Bulgaria, but also other EU and nationally funded projects. Three main investments and two reforms were considered for this study. Firstly, as part also of the NECP, the liberalisation of the energy market was greatly enforced, with what is essentially a legislative measure balancing market reforms and promoting electricity market integration. The main objective of the Bulgarian government is, by the end of 2025, to eliminate regulated electricity prices and fully transition to market conditions, thus promoting market competition[86]. This will also contribute to integrate the Bulgarian energy market with the European market, presenting advantages such as real-time access to supply offers and purchasing from EU market members. The second considered reform, or legislative measure, is the national roadmap for improving conditions for deploying the potential for the development of hydrogen technologies and mechanisms for the production and supply of hydrogen. Green hydrogen was already an integral part of the policy measures included in the *Integrated Energy and Climate Plan of the Republic of Bulgaria 2021-2030* (IECP). In fact, the surplus generated from solar and wind power, in this plan, was expected to be used for green hydrogen production in Bulgaria, foreseeing a pilot hydrogen plant with an expected total capacity of 20 MW to be developed by 2030[87]. More specifically, in the NRRP, in the "Green Bulgaria" section, it is said that the NRRP aims to approve a "*National Roadmap to improve the conditions for unleashing the potential of hydrogen technologies and mechanisms for producing and supplying hydrogen*". Related to green hydrogen is the first investment, namely a scheme to support pilot projects for the production of green hydrogen and biogas. Namely, 69 million EUR will be invested, aiming to have a capacity of 65 MW for green hydrogen production by 2026, 9000 t/year of green hydrogen produced, and 7 ktoe/year of biogas produced. The second considered investment is the EU-co-funded Bulgarian section of the Serbian-Bulgarian gas interconnector funded with 27.6 million EUR under the Connecting Europe Facility Energy programme and 6 million EUR from structural funds[88]. The third investment considered is the expansion of the gas interconnector between Greece and Bulgaria, which will transport gas from Komotini (EL) to Stara Zagora (BG), supported by the European Commission and with a value of 240 million EUR[89]. Therefore, by summing these three investments, the total budget considered for Bulgaria was of 342.6 million EUR.

[86] https://ceelegalmatters.com/bulgaria/18210-liberalization-of-the-bulgarian-energy-market-at-the-end-of-the-long-road
[87] https://ceelegalmatters.com/briefings/21162-the-future-of-green-hydrogen-in-bulgaria
[88] https://energy.ec.europa.eu/news/start-construction-works-launched-bulgarian-section-gas-interconnector-bulgaria-serbia-2023-02-01_en
[89] https://www.reuters.com/business/energy/greece-bulgaria-pipeline-starts-operations-boost-non-russian-gas-flows-2022-10-01/

Table 7: Summary of considered investments in Bulgaria

Investment	Amount
Scheme to support pilot projects for the production of green hydrogen and biogas	69 million EUR
Serbian-Bulgarian gas interconnector	33.6 million EUR
Expansion of gas interconnection between Greece and Bulgaria (IGB)	240 million EUR
Total considered funds for Bulgaria	**342.6 million EUR**

4.1.2 Croatia

Two main investments were considered for Croatia. On August 18th, 2022, the Croatian government adopted a decision to increase the security of gas supply by constructing the gas pipeline Zlobin-Bosiljevo and increasing the capacity of the LNG terminal to 6.1 bcm of gas per year[90]. The total cost of the investment is 180 million EUR, out of which 25 million EUR is planned to be invested in the expansion of the LNG terminal and the remaining 155 million EUR in the construction of the gas transmission pipeline. This will ensure the security of gas supply in Croatia; nonetheless, the development of the 58 Km-long pipeline will not increase the transport capacities towards neighbouring countries. The other investment considered is the budget devoted to the fossil gas transportation and distribution in the NECP. Namely, for the period 2021-2030 around 1.4 billion EUR will be devoted to it and for the period 2030-2050 around 371.7 million EUR. These were the main investments found related to the gas infrastructure improvement in Croatia and thus a total budget of 1.972 billion EUR was considered for this study.

Table 8: Summary of considered investments in Croatia

Investment	Amount
Expansion of the LNG terminal	25 million EUR
Construction of the gas transmission pipeline, section Zlobin-Bosiljevo	155 million EUR
NECP**:** Fossil gas transportation and distribution Period 2021-2030: 10.7 billion HRK Period 2030-2050: 2.8 billion HRK	 1.4 billion EUR 371.7 million EUR
Total considered funds for Croatia	**1.97 billion EUR**

4.1.3 Hungary

One main investment was considered for Hungary in this study. Namely, the replacement of the coal based Mátrai power plant to a 500 MW gas turbine plant. The price tag is foreseen to be around 500 million EUR (200 billion HUF)[91], with a substantial share of the fund stemming from the support mechanism under point 10c of the directive 2003/87/EC. The total budget considered in this study was thus of 500 million EUR for Hungary.

[90] https://www.vecernji.hr/vijesti/plenkovic-nehammer-i-soder-objavili-izjavu-o-energetsko-politickoj-suradnji-1636392
[91] https://kormany.hu/hirek/elkezdodott-a-matrai-eromu-atalakitasa-a-munkahelyek-nincsenek-veszelyben

Table 9: Summary of considered investments in Hungary

Investment	Amount
500 MW gas turbine power plant	200 billion HUF 500 million EUR
Total considered funds for Hungary	**200 billion HUF** **500 million EUR**

4.1.4 Poland

Several gas-related investments were considered for Poland for this study when delineating the final supply side investments budget. Firstly, it was looked into new investments delineated regarding gas powerplants. The amount of capital invested/foreseen to be invested per gas powerplant was provided by experts from the Polish Greenpeace team. Seven gas powerplants used for electricity generation only were considered across the country[92]. The power plants and related investments can be found in Table 9. The next investment considered is the Floating Storage and Regasification Unit (FSRU) in Gdańsk where the (state-owned) gas grid operator *Gaz-System* plans to have a 6 to 12 billion m^3 gas capacity by 2027/2028 costing 3 billion PLN[93]. The other investment considered is the LNG terminal in Świnoujście, also sponsored by *Gaz-System*, being upgraded to increase capacity by 2024 with an estimated investment cost of 2.3 billion PLN[94]. The next tranche of money that will flow to various gas powerplants starting from 2026 will be capacity market payments, completely paid by Polish tax-money, and worth 18 billion PLN[95][96]. The last investment considered are the various gas pipelines and other gas infrastructure elements, to be built or upgraded by *Gaz-System* by 2030, with a value of 14 billion PLN[97]. By summing all these investments, a total budget of 59.1 billion PLN is obtained, corresponding to roughly 12.6 billion EUR. More details can be found in the table below.

Table 10: Summary of considered investments in Poland

Investment	Amount
600 MW Gas power plant in Adamów (Investor: ZE PAK)	1.9 billion PLN 0.4 billion EUR
745 MW Gas power plant in Ostrołęka (Investor: Energa (PKN Orlen))	2.5 billion PLN 0.5 billion EUR
1400 MW Gas power plant in Dolna Odra (Investor: PGE)	3.7 billion PLN 0.8 billion EUR
563 MW Gas power plant in Grudziądz (Investor: Energa (PKN Orlen)	2 billion PLN 0.4 billion EUR
2100-2200 MW Gas power plant in Kozienice (Investor: Enea)	6.94 billion PLN 1.5 billion EUR
400-500 MW Gas power plant in Łagisza (Investor: Tauron)	1.5 billion PLN

[92] https://wysokienapiecie.pl/79857-z-czym-do-rynku-mocy-beda-kolejne-bloki-gazowe/
[93] https://www.money.pl/gospodarka/polska-bedzie-miala-plywajacy-terminal-lng-za-piec-lat-niemcy-zbudowali-go-w-200-dni-6844555230644800a.html
[94] https://samorzad.pap.pl/kategoria/polityka-spojnosci-w-regionach/fundusze-europejskie-wspieraja-bezpieczenstwo-dostaw-gazu
[95] https://www.teraz-srodowisko.pl/aktualnosci/elektrownie-gazowe-Polska-komentarze-11499.html
[96] https://carbontracker.org/reports/polands-energy-dilemma/
[97] https://www.cire.pl/artykuly/serwis-informacyjny-cire-24/156155-naimski-20-mld-zl-w-10-lat-na-infrastrukture-przesylowa,-60-mld-zl-w-20-lat-na-energetyka-nuklearna

	0.3 billion EUR
800-900 MW Gas power plant in Rybillionik (Investor: PGE)	3.3 billion PLN 0.7 billion EUR
FSRU in Gdańsk (Investor: Gaz-System)	3 billion PLN 0.6 billion EUR
Upgrade of the LNG terminal in Świnoujście (Investor: Gaz-System)	2.3 billion PLN 0.5 billion EUR
Capacity market payments for various gas power plants (Investor: taxpayer/State)	18 billion PLN 3.8 billion EUR
Gas pipelines and other gas infrastructure elements (grid) (Investor: Gaz-System)	14 billion PLN 2.9 billion EUR
Total considered funds for Poland	**59.1 billion PLN** **12.6 billion EUR**

4.1.5 Romania

The main assumption from the supply side is collected from the National Investment Program of Romania. Starting with April 26, 2022, local authorities were expected to submit funding applications, through the "Anghel Saligny" National Investment Program (NLDP or NIP), for projects aimed at fossil gas distribution systems, including branches, as well as the connection to the fossil gas transport system. Other programs and plans include: the Large Infrastructure Operational Program (LIOP), the National Recovery and Resilience Plan (NRPP), the Sustainable Development Operational Program (SDOP), and the Modernisation Fund (*Fondul de modernizare*). The Joint order of the Minister of Development, Public Works, and Administration, as well as the Minister of Energy regarding the approval of the Methodological Norms was published in the Official Gazette of Romania, Part I. Hence, local authorities can request funding for the projects through which will provide financing for 2,500 km of gas pipelines and connect 196,000 households to the fossil gas distribution network. The goal is to provide this basic service for citizens who are not connected to the fossil gas network, namely through the modernisation of the existing infrastructure. Through the "Anghel Saligny" National Investment Program, the Government provides financing worth 1.5 billion EUR for the rehabilitation and expansion of fossil gas networks. The selection of investment objectives will be carried out, after the period of submission of funding applications, based on the criteria provided by the legislation in force, contained in the Methodological Norms. The program allows the financing of the establishment of new fossil gas distribution systems, their expansion, as well as their modernization, by transforming the existing ones into intelligent fossil gas distribution systems. However, according to Nuțu and "Expert Forum" (2022)[98], 17.7 billion LEI were devoted for the grid and 3.6 billion LEI to the gas-fired electricity generation. This would total around 4.4 billion EUR allocated for gas projects in Romania.

Table 11: Summary of considered investments in Romania

Investment	Amount
NLDP total allocation	13 billion LEI 2.6 billion EUR
LIOP total allocation	1,2 billion LEI 243.8 million EUR

[98] https://www.energynomics.ro/wp-content/uploads/2022/10/5-mituri-despre-gaz.pdf

NRRP Gas grid – extension	1.98 billion LEI 402.2 million EUR
NRRP Electrolysers for H2	569.3 million LEI 115.6 million EUR
SDOP 437 Km T&D gas grid	1,6 billion LEI 329.96 million EUR
Total allocations (grid only)	**17.8 billion LEI 3.6 billion EUR**
Gas-fired electricity generation	
Modernisation Fund – Oltenia EC – 1,325 MW CCGT	2.1 billion LEI 426.4 million EUR
NRRP – 300 MW gas-fired heating and power plant	1.5 billion LEI 301.5 million EUR
SDOP Motru cogeneration capacity	50 million LEI 10.2 million EUR
Total allocations – gas grant	**3.6 billion LEI 738.1 million EUR**
Total allocations for gas projects	**21.4 billion LEI 4.4 billion EUR**

4.1.6 Slovakia

Several supply side investments were considered in this study for Slovakia. The first investment considered is part of the *Renewable energy sources and energy infrastructure* component of the Slovak recovery plan (Plán Obnovy, article 3.2.2) 62 million EUR directed at the modernisation of biogas plants. The second investment is the modernisation fund until 2030, where as part of a state aid scheme for the district heating sector, 1 billion EUR are devoted to targeting energy efficiency improvements, modernisation of energy systems, including heat distribution systems for district heating or cooling, energy storage and smart solutions for heat distribution, and increasing the share of electricity and heat produced by high-efficiency combined heat and power plants (CHP)[99][100]. The third proposed investment is the building of a new LNG terminal in the port of Bratislava by the state-owned Port authority, worth 40 million EUR[101]. Thereafter, two investments part of the SFC2021 programme supported by the "ERDF Investing in employment and growth" in biomass and biomass for less developed regions were considered, respectively of 4 and 16 million EUR[102]. In total, the considered supply side energy investments budget for Slovakia is of 321 million EUR.

Table 12: Summary of considered investments in Slovakia

Investment	**Amount**
Modernisation of biogas plants	62 million EUR
Modernisation Fund: State aid scheme to support investments to modernise energy systems	1 billion EUR
LNG terminal plans on the Danube	40 million EUR

[99] https://obchodnyvestnik.justice.gov.sk/Handlers/StiahnutPrilohu.ashx?IdPriloha=380945&csrt=17050381321799905652
[100] https://www.minzp.sk/klima/modernizacny-fond/
[101] https://www.euractiv.com/section/politics/short_news/bratislava-port-to-get-its-own-e40-million-lng-terminal/
[102] https://drive.google.com/file/d/1lBGM9P_sDyunohdYskpuHaZcLYRU0Ke0/view

SCF2021 programme supported by the ERDF Investing in employment and growth: biomass	4 million EUR
SCF2021 programme supported by the ERDF Investing in employment and growth: biomass for less developed regions	16 million EUR
Total considered funds for Slovakia	**1.122 billion EUR**

4.1.7 Slovenia

For Slovenia, two investments from the ten year development program developed by ENTSO gas were considered. Namely, the development of a gas interconnector in Rogatec[103][104][105] with an investment worth 12.4 million EUR and the establishment of a gas interconnector in Kidričevo[106][107][108] with an investment worth 91 million EUR[109]. Thus, totalling a budget of 103.4 million EUR.

Table 13: Summary of considered investments in Slovenia

Investment	Amount
Gas interconnector at Rogatec	12.4 million EUR
Gas interconnector at Kidričevo	91 million EUR
Total considered funds for Slovenia	**103.4 million EUR**

[103] https://ec.europa.eu/energy/maps/pci_fiches/PciFiche_6.26.1.pdf
[104] https://ec.europa.eu/energy/maps/pci_fiches/PciImplementationPlan_6.26.1.pdf
[105] https://www.plinovodi.si/media/5280/pci-information-leaflet-626.pdf
[106] https://ec.europa.eu/energy/maps/pci_fiches/PciFiche_6.23.pdf
[107] https://ec.europa.eu/energy/maps/pci_fiches/PciImplementationPlan_6.23.pdf
[108] https://www.plinovodi.si/media/5279/pci-information-leaflet-623.pdf
[109] https://www.entsog.eu/sites/default/files/2022-10/PR0279_221021_ENTSOG%20publishes%20an%20updated%20list%20of%20projects%20for%20TYNDP%202022.pdf

5. RESULTS OF THE SCENARIO ANALYSES

5.1 Scenario analyses for the case study of Bulgaria

Scenario 1 – energy upgrade of the building envelopes for Bulgaria

Scenario 1 evaluates the utilisation of the available budget to improve the insulation level of buildings in the residential sector and replace the windows with more energy efficient ones. Households' benefits will be energy saving for space heating and cooling and consequently reducing the energy costs. The economic benefits of improving the building envelopes are calculated using the Eurostat data of the average costs of energy for space heating. Table 14 presents the price of energy sources, the share of fuels used for space heating, and the amount devoted to space heating when considering the type of fuel individually. The sum of all the values in the second column will amount to 100, as it shows the share of each type of fuel in the total energy consumption for space heating. On the other hand, the third column will not as it illustrates the percentage devoted to space heating when considering the total consumption of the single type of fuel. This is useful to understand the role that space heating plays in the utilisation of one particular type of fuel. For example, in Bulgaria, biomass is almost exclusively tied to space heating as a main fuel without using fossil gas.

Table 14: Overview of energy prices, share of fuels in space heating and shares devoted to space heating per type of fuel in Bulgaria

Source of energy	Price (EUR/MWh)	Fuel share in space heating (%)	Share devoted to space heating (%)
Electricity	109	10.02	11.42
Heating oil	177	0.03	39.00
LPG		0.05	2.81
Fossil gas	79	0	-
Solar thermal		0	0
Ambient heat	NA	NA	NA
Biomass		81.35	94.84
District heating		3.40	59.68
Other		5.15	96.96

(a) Social cost-benefit analysis

Table 15 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 1. The methodological approach is based on the European Horizon 2020 project PRODESA[110]. Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 342.6 million) is divided by unitary investment cost (EUR 16,000) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 342.6 million}}{\text{EUR 16,000}} = 21{,}413$ (0.7%).

[110] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

- It is also assumed that the households do not need to install a new energy efficient boiler due to reduction of energy consumption for space heating. Therefore, the required investment costs are reduced for the households. Since this Scenario considers the upgrade of the building envelope without changing the heating system, no avoided costs result since the households continue to operate the existing heating system.
- The energy saving rates for space heating and cooling are assumed to be 50% due to improving the building envelopes (Balaras, 2007).
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime of building envelope is on average 25 years. It is also considered that 10% of the value of the investment will be remained in the year 25.

Table 15: The variables and their values for calculating SCBA in Scenario 1 for Bulgaria

Variables	Values	Units
Available budget for the production of hydrogen and biogas	342,600,000	EUR
Unitary investment cost	16,000	EUR
Avoided cost from new fossil fuel boiler	0	EUR
Number of influenced households	21,413	number of households
Energy consumption for space cooling	41	kWh
Energy consumption for space heating	4,466	kWh
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	22	kWh
Energy savings in space heating	2,233	kWh
Electricity price	0.10	EUR/kWh
Existing fuel price for space heating	0.05	EUR/kWh
Remaining value	10%	% of capital cost
Discount rate	3%	%

The SCBA considers all the expenditures and benefits from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is 0.10 $\frac{\text{EUR}}{kwh}$, while the price for space heating is equal to 0.05 $\frac{\text{EUR}}{kwh}$. In particular, Table 16 presents external costs and benefit components which are considered to assess Scenario 1 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 16 - external costs and benefit components for SCBA for Bulgaria

External costs and benefits	Description

Environmental costs from the implementations of the energy saving measure	The unit external-cost prices include both the effects on human health, agricultural production, and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit cost for the existing heating system (coal stove or boiler) was considered to be equal to 27.2 EUR/MWh, while the unit cost for the existing cooling system (air conditioning unit) was estimated at 23.5 EUR/MWh.
Increasing the house value due to the improvement of the building envelope	The increase in the value of residential buildings is determined by calculating the cost savings due to improving the energy performance of the building envelope. A capital recovery coefficient is used, and the value is considered equal to 3%. The component needs to consider the year of implementation of the investment.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The SCBA also results in a negative NPV, with IRR<3%, and B/C lower than 1. This indicates that a refurbishment of the building envelope by itself brings lower benefits than other scenarios examined in the specific case of Bulgaria. This indicated that the allocated budget could be better spent by combining the measure with other measures such as solar PV or heat pump installation.

Table 17: Results of social cost-benefit analysis in Scenario 1 for Bulgaria

SCBA	**NPV**	**IRR**	**B/C**
Scenario 1	-64,707,939	0.30%	0.83

Table 18 shows the main components including the fuel costs and benefits for Scenario 1 without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 18: Cash flows for social cost-benefit analysis in Scenario 1 for Bulgaria (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						75,152,318	285,500,000		-210,347,682
1	0.00	0.00	0.00	2,254,570	0.00	5,169,532			7,424,102
2	0.00	0.00	0.00	2,254,570	0.00	5,169,532			7,424,102
3	0.00	0.00	0.00	2,254,570	0.00	5,169,532			7,424,102
4	0.00	0.00	0.00	2,254,570	0.00	5,169,532			7,424,102
5	0.00	0.00	0.00	2,254,570	0.00	5,169,532			7,424,102
6	0.00	0.00	0.00	2,254,570	0.00	5,169,532			7,424,102
7	0.00	0.00	0.00	2,254,570	0.00	5,169,532			7,424,102
8	0.00	0.00	0.00	2,254,570	0.00	5,169,532			7,424,102
9	0.00	0.00	0.00	2,254,570	0.00	5,169,532			7,424,102
10	0.00	0.00	0.00	2,254,570	0.00	5,169,532			7,424,102
11	0.00	0.00	0.00	2,254,570	0.00	5,169,532			7,424,102
12	0.00	0.00	0.00	2,254,570	0.00	5,169,532			7,424,102
13	0.00	0.00	0.00	2,254,570	0.00	5,169,532			7,424,102

14	0.00	0.00	0.00	2,254,570	0.00	5,169,532			7,424,102
15	0.00	0.00	0.00	2,254,570	0.00	5,169,532			7,424,102
16	0.00	0.00	0.00	2,254,570	0.00	5,169,532			7,424,102
17	0.00	0.00	0.00	2,254,570	0.00	5,169,532			7,424,102
18	0.00	0.00	0.00	2,254,570	0.00	5,169,532			7,424,102
19	0.00	0.00	0.00	2,254,570	0.00	5,169,532			7,424,102
20	0.00	0.00	0.00	2,254,570	0.00	5,169,532			7,424,102
21	0.00	0.00	0.00	2,254,570	0.00	5,169,532			7,424,102
22	0.00	0.00	0.00	2,254,570	0.00	5,169,532			7,424,102
23	0.00	0.00	0.00	2,254,570	0.00	5,169,532			7,424,102
24	0.00	0.00	0.00	2,254,570	0.00	5,169,532			7,424,102
25	0.00	0.00	0.00	2,254,570	0.00	5,169,532		34,260,000	41,684,102
Total	0.00	0.00	0.00	39,259,152	0.00	165,170,142	285,500,000	33,262,136	-64,707,939

Scenario 2 – Heat pump installations for Bulgaria

Scenario 2 examines the allocation of the available budget for the installation of heat pumps for the average-income group of households in the residential buildings. Households benefit from the investments due to reducing the energy demands and consequently energy costs for space heating. Similar to Scenario 1, the economic benefits of heat pump installations are calculated based on the collected Eurostat data on weighted average cost of purchasing energy products for space heating in the residential sector.

(a) Social cost-benefit analysis for Scenario 2 for Bulgaria

Table 19 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 2. The methodological approach is based on the European project PRODESA[111]. Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 342.6 million) is divided by unitary investment cost (EUR 10,000) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{EUR\ 342.6\ million}{EUR\ 10{,}000} = 34{,}260$ (1.2%).
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households.
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime of heat pump is on average 12 years.

[111] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

Table 19: The variables and their values for calculating SCBA in Scenario 2 for Bulgaria

Variables	Values	Units
Available budget for the production of hydrogen and biogas	342,600,000	EUR
Unitary investment cost	10,000	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Number of influenced households	34,260	number of households
Energy consumption for space cooling	41	kWh
Energy consumption for space heating	4,466	kWh
Performance ratio existing boiler	30%	%
COP heat pump	3.0	
Electricity price	0.10	EUR/kWh
Existing fuel price for space heating	0.05	EUR/kWh
Remaining value	0%	% of capital cost
Discount rate	3%	%

The SCBA considers all the expenditures and benefits from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is $0.10\ \frac{\text{EUR}}{kwh}$, while the price for space heating is equal to $0.05\ \frac{\text{EUR}}{kwh}$.

In particular, the following external costs and benefit components (Table 20) are considered to evaluate the Scenario 2 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 20: external costs and benefits and the descriptions in Scenario 2 for Bulgaria

External costs and benefits	Description
Environmental costs from the installation of heat pumps	The unit external-cost prices include both the effects on human health, agricultural production and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit costs for the existing heating system (coal stove or boiler) were considered to be equal to 27.2 EUR/MWh, while the unit cost for the installed heat pump was estimated at 14.2 EUR/MWh.
Multiple benefits from the installation of heat pumps	Multiple benefit means for example the improvement of comfort conditions in buildings and the fight against energy poverty, the reduction of morbidity and mortality cases, etc. The calculation was carried out considering that the multiple benefits are equal to 10% of the cost savings, which results from the installation of the heat pump. This component is obtained on an annual basis after the implementation of the investment under consideration.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The results of the SCBA indicates the highly social effectiveness of Scenario 2 for the average-income group of households living in Bulgaria (Table 21). Therefore, the allocation of resources for installation of the heat pump is highly recommended instead of investments on the development and expansion of the fossil gas network. The values of the SCBA are much greater than those found when performing a SCBA for the building envelopes in Scenario 1.

Table 21: Results of social cost-benefit analysis in Scenario 2 for Bulgaria

SCBA	NPV	IRR	B/C
Scenario 2	33,921,998	6%	1.18

Table 22 shows the main components including the fuel costs and benefits for Scenario 2 without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 22: Cash flows for social cost-benefit analysis in Scenario 2 for Bulgaria (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						0	171,300,000		- 171,300,000
1	0	0	1,534,379	7,074,703	651,851	15,728,557			20,617,030
2	0	0	1,534,379	7,074,703	651,851	15,728,557			20,617,030
3	0	0	1,534,379	7,074,703	651,851	15,728,557			20,617,030
4	0	0	1,534,379	7,074,703	651,851	15,728,557			20,617,030
5	0	0	1,534,379	7,074,703	651,851	15,728,557			20,617,030
6	0	0	1,534,379	7,074,703	651,851	15,728,557			20,617,030
7	0	0	1,534,379	7,074,703	651,851	15,728,557			20,617,030
8	0	0	1,534,379	7,074,703	651,851	15,728,557			20,617,030
9	0	0	1,534,379	7,074,703	651,851	15,728,557			20,617,030
10	0	0	1,534,379	7,074,703	651,851	15,728,557			20,617,030
11	0	0	1,534,379	7,074,703	651,851	15,728,557			20,617,030
12	0	0	1,534,379	7,074,703	651,851	15,728,557		0	20,617,030
Total	0	0	15,273,213	70,421,627	6,488,531	156,562,115	171,300,000	0	33,921,998

Scenario 3 – Integrated energy retrofitting of the energy upgrade of the building envelopes and installations of the heat pump

(a) Social cost-benefit analysis in Scenario 3 for Bulgaria

Table 23 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 3. The methodological approach is based on the European project PRODESA[112]. Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 342.6 million) is divided by unitary investment cost with subsidy (EUR 26,000) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{EUR\ 342.6\ million}{EUR\ 26{,}000} = 13{,}177\ (0.4\%)$.
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households (avoided fuel cost = EUR 4,000).
- The energy saving rates for space heating and cooling are assumed to be 50% due to improving the building envelops (Balaras, 2007).
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime is on average 25 years.

Table 23: The variables and their values for calculating SCBA in Scenario 3 for Bulgaria

Variables	Values	Unit
Available budget for the production of hydrogen and biogas	342,600,000	EUR
Unitary investment cost-Building envelope	16,000	EUR
Unitary investment cost-Heat pump	10,000	EUR
Unitary investment cost-PV	0	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Number of influenced households	13,177	number of households
Installed capacity PV	0	kW
Unitary investment cost PV	0	EUR/kW
Capacity factor PV	14%	%
Energy consumption for space cooling	41	kWh
Energy consumption for space heating	4,466	kWh
Performance ratio existing boiler	30%	%
COP heat pump	3.0	
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	20	kWh
Energy savings in space heating	2,233	kWh
Electricity consumption after interventions	4,460	kWh
Electricity price	0.10	EUR/kWh
Cost reduction due to net-metering	100%	
Electricity price-net metering	0.10	EUR/kWh
Existing fuel price for space heating	0.05	EUR/kWh

[112] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

Remaining value	10%	% of capital cost
Discount rate	3%	%

The SCBA considers all the expenditures and benefits from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is $0.10\,\frac{\text{EUR}}{kwh}$, while the price for space heating and the electricity price-net metering are both equal to $0.05\,\frac{\text{EUR}}{kwh}$.

In particular, Table 24 presents external costs and benefit components are assessed to assess the Scenario 3 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 24: the external costs and benefits and the descriptions for Scenario 3 for Bulgaria

External costs and benefits	Description
Environmental costs from the implementations of the energy saving measure	The unit external-cost prices include both the effects on human health, agricultural production and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit costs for the existing heating system (coal stove or boiler) were considered to be equal to 27.2 EUR/MWh, while unit cost for the existing cooling system (air conditioning unit) was estimated at 23.5 EUR/MWh. Moreover, the unit cost for the installed heat pump was estimated at 14.2 EUR/MWh. Finally, the unit cost for photovoltaic systems is considered equal to 14.1 EUR/MWh, while the corresponding price for the electricity used from the grid was taken equal to 48.5 EUR/MWh.
Increasing the house value due to the improvement of the building envelope	The increase in the value of residential buildings is determined by calculating the cost savings due to improving the energy performance of the building envelope. A capital recovery coefficient is used, and the value is considered equal to 3%. The component needs to consider the year of implementation of the investment.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The results of the SCBA indicate the social effectiveness of Scenario 3 for the average-income group of households living in Bulgaria (Table 25). It should be noticed that social efficiency is significantly influenced by the double investment regarding the replacement of the heat pump (after the end of the 12-year life) with a new heat pump for the next 12 years, until the investment is repaid in the building envelope that has a lifespan of 25 years.

Table 25: Results of social cost-benefit analysis in Scenario 3 for Bulgaria

SCBA	NPV	IRR	B/C
Scenario 3	3,287,991 EUR	3%	1.08

Table 26 shows the main components including the fuel costs and benefits for Scenario 3 without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 26: Cash flows for social cost-benefit analysis in Scenario 3 for Bulgaria (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						81,762,482	241,576,923		-159,814,441
1	0	0	295,073	2,747,947	125,356	6,099,428			8,426,947
2	0	0	295,073	2,747,947	125,356	6,099,428			8,426,947
3	0	0	295,073	2,747,947	125,356	6,099,428			8,426,947
4	0	0	295,073	2,747,947	125,356	6,099,428			8,426,947
5	0	0	295,073	2,747,947	125,356	6,099,428			8,426,947
6	0	0	295,073	2,747,947	125,356	6,099,428			8,426,947
7	0	0	295,073	2,747,947	125,356	6,099,428			8,426,947
8	0	0	295,073	2,747,947	125,356	6,099,428			8,426,947
9	0	0	295,073	2,747,947	125,356	6,099,428			8,426,947
10	0	0	295,073	2,747,947	125,356	6,099,428			8,426,947
11	0	0	295,073	2,747,947	125,356	6,099,428			8,426,947
12	0	0	295,073	2,747,947	125,356	6,099,428			8,426,947
13	0	0	295,073	2,747,947	125,356	6,099,428			8,426,947
14	0	0	295,073	2,747,947	125,356	6,099,428			8,426,947
15	0	0	295,073	2,747,947	125,356	6,099,428			8,426,947
16	0	0	295,073	2,747,947	125,356	6,099,428			8,426,947
17	0	0	295,073	2,747,947	125,356	6,099,428			8,426,947
18	0	0	295,073	2,747,947	125,356	6,099,428			8,426,947
19	0	0	295,073	2,747,947	125,356	6,099,428			8,426,947
20	0	0	295,073	2,747,947	125,356	6,099,428			8,426,947
21	0	0	295,073	2,747,947	125,356	6,099,428			8,426,947
22	0	0	295,073	2,747,947	125,356	6,099,428			8,426,947
23	0	0	295,073	2,747,947	125,356	6,099,428			8,426,947
24	0	0	295,073	2,747,947	125,356	6,099,428			8,426,947
25	0	0	295,073	2,747,947	125,356	6,099,428		34,260,000	42,686,947
Total	**0**	**0**	**5,138,147**	**47,850,412**	**2,182,843**	**187,972,726**	**241,576,923**	**33,262,136**	**3,287,991**

Scenario 4 – zero energy buildings by combining various investments for Bulgaria

Scenario 4 examines the use of the available budget for the production of hydrogen and biogas to promote zero-energy buildings (ZEB) for households. ZEB can be achieved through the combination of thermal insulation of external wall, the replacement of existing window frames (not roofs and walls) with new energy efficient ones, and the installation of photovoltaic solar panel in residential buildings and the installation of a heat pump.

The benefits of households could be the reduction of energy costs due to both the reduced energy demand for space heating and cooling, as well as the operation of the heat pump. The economic benefits of heat pump installations are calculated based on the collected Eurostat data on weighted average cost of purchasing energy products for space heating in the residential sector.

(a) Social cost-benefit analysis in Scenario 4 for Bulgaria

Table 27 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 4. The methodological approach is based on the European project PRODESA[113]. Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 342.6 million) is divided by unitary investment cost with subsidy (EUR 30,680) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 342.6 million}}{\text{EUR 30,680}} = 11{,}167$ (0.4%).
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households (avoided fuel cost = EUR 4,000).
- The energy saving rates for space heating and cooling are assumed to be 50% due to improving the building envelops (Balaras, 2007).
- The operation and maintenance costs are assumed higher for the alternative Scenario compared to the baseline one.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime is on average 25 years.

Table 27: The variables and their values for calculating SCBA in Scenario 4 for Bulgaria

Variables	Values	Units
Available budget for the production of hydrogen and biogas	342,600,000	EUR
Unitary investment cost-Building envelope	16,000	EUR
Unitary investment cost-Heat pump	10,000	EUR
Unitary investment cost-PV	4,680	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Number of influenced households	11,167	number of households
Installed capacity PV	3.0	kW
Unitary investment cost PV	1,560	EUR/kW
Capacity factor PV	14%	%
Energy consumption for space cooling	41	kWh
Energy consumption for space heating	4,466	kWh
Performance ratio existing boiler	30%	%
COP heat pump	3.0	
% of energy savings in space cooling	50%	%

[113] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

% of energy savings in space heating	50%	%
Energy savings in space cooling	20	kWh
Energy savings in space heating	2,233	kWh
Electricity consumption after interventions	4,460	kWh
Electricity price	0.10	EUR/kWh
Cost reduction due to net-metering	50%	
Electricity price-net metering	0.05	EUR/kWh
Existing fuel price for space heating	0.05	EUR/kWh
Cost of operation and maintenance - Baseline Scenario	0	EUR
Cost of operation and maintenance - Alternative Scenario	100	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

The SCBA considers all the expenditures and benefits from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is 0.10 $\frac{\text{EUR}}{kwh}$, while the price for space heating and the electricity price-net metering are both equal to 0.05 $\frac{\text{EUR}}{kwh}$.

In particular, Table 28 presents external costs and benefit components are assessed to assess the Scenario 4 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 28: the external costs and benefits and the descriptions for Scenario 4 for Bulgaria

External costs and benefits	Description

Environmental costs from the implementations of the energy saving measure	The unit external-cost prices include both the effects on human health, agricultural production and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit costs for the existing heating system (coal stove or boiler) were considered to be equal to 27.2 EUR/MWh, while unit cost for the existing cooling system (air conditioning unit) was estimated at 23.5 EUR/MWh. Moreover, the unit cost for the installed heat pump was estimated at 14.2 EUR/MWh. Finally, the unit cost for photovoltaic systems is considered equal to 14.1 EUR/MWh, while the corresponding price for the electricity used from the grid was taken equal to 48.5 EUR/MWh.
Increasing the house value due to the improvement of the building envelope	The increase in the value of residential buildings is determined by calculating the cost savings due to improving the energy performance of the building envelope. A capital recovery coefficient is used, and the value is considered equal to 3%. The component needs to consider the year of implementation of the investment.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The results of the SCBA indicate the social effectiveness of Scenario 4 for the average-income group of households living in Bulgaria (Table 29). Therefore, the allocation of resources for ZEB is highly recommended instead of investments on the development and expansion of the fossil gas network. It should be noticed that social efficiency is significantly influenced by the double investment regarding the replacement of the heat pump (after the end of the 12-year life) with a new heat pump for the next 12 years, until the investment is repaid in the building envelope that has a lifespan of 25 years.

Table 29: Results of social cost-benefit analysis in Scenario 4 for Bulgaria

SCBA	NPV	IRR	B/C
Scenario 4	66,522,876	7%	1.30

Table 30 shows the main components including the fuel costs and benefits for Scenario 4 without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 30: Cash flows for social cost-benefit analysis in Scenario 4 for Bulgaria (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						122,506,235	248,277,053		-125,770,818
1	900,555	0	250,062	4,825,804	665,880	7,094,032			10,103,339
2	900,555	0	250,062	4,825,804	665,880	7,094,032			10,103,339
3	900,555	0	250,062	4,825,804	665,880	7,094,032			10,103,339
4	900,555	0	250,062	4,825,804	665,880	7,094,032			10,103,339
5	900,555	0	250,062	4,825,804	665,880	7,094,032			10,103,339
6	900,555	0	250,062	4,825,804	665,880	7,094,032			10,103,339
7	900,555	0	250,062	4,825,804	665,880	7,094,032			10,103,339
8	900,555	0	250,062	4,825,804	665,880	7,094,032			10,103,339

9	900,555	0	250,062	4,825,804	665,880	7,094,032			10,103,339
10	900,555	0	250,062	4,825,804	665,880	7,094,032			10,103,339
11	900,555	0	250,062	4,825,804	665,880	7,094,032			10,103,339
12	900,555	0	250,062	4,825,804	665,880	7,094,032			10,103,339
13	900,555	0	250,062	4,825,804	665,880	7,094,032			10,103,339
14	900,555	0	250,062	4,825,804	665,880	7,094,032			10,103,339
15	900,555	0	250,062	4,825,804	665,880	7,094,032			10,103,339
16	900,555	0	250,062	4,825,804	665,880	7,094,032			10,103,339
17	900,555	0	250,062	4,825,804	665,880	7,094,032			10,103,339
18	900,555	0	250,062	4,825,804	665,880	7,094,032			10,103,339
19	900,555	0	250,062	4,825,804	665,880	7,094,032			10,103,339
20	900,555	0	250,062	4,825,804	665,880	7,094,032			10,103,339
21	900,555	0	250,062	4,825,804	665,880	7,094,032			10,103,339
22	900,555	0	250,062	4,825,804	665,880	7,094,032			10,103,339
23	900,555	0	250,062	4,825,804	665,880	7,094,032			10,103,339
24	900,555	0	250,062	4,825,804	665,880	7,094,032			10,103,339
25	900,555	0	250,062	4,825,804	665,880	7,094,032		34,260,000	44,363,339
Total	15,681,500	0	4,354,362	84,032,437	11,595,073	246,035,661	248,277,053	33,262,136	66,522,876

Scenario 0 – The baseline Scenario for Bulgaria

The share of biomass utilisation for space heating in Bulgaria is over 80%. This illustrates not only a high consumption but also dependence on this type of fuel in the country. For this reason, Scenario 0 examines the utilization of the available budget to install higher energy efficient boilers (EUR 342.6 million). However, this entails more energy efficient biomass boilers, as a considerable share of the population still utilises boilers running on coal. The SCBA is conducted to evaluate the costs and benefits of investment on the higher energy efficient boilers by average-income groups of households. The average-income groups usually cannot afford the initial investment cost for the energy efficiency investments.

(a) Social cost-benefit analysis in Scenario 0 for Bulgaria

Table 31 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 0. The methodological approach is based on the European project PRODESA[114]. Here are the other few assumptions which are similarly used for all Scenario:

- The total budget (EUR 342.6 million) is divided by unitary investment cost (EUR 4,000) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to 85,560 (2.9%).
- It is assumed that the performance ratio of the energy efficient boilers is improved from 30% to 95% (assumption) efficiency.
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.

[114] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

- The lifetime of the new biomass boiler is equal to 15 years.

Table 31: The variables and their values for calculating SCBA in Scenario 0 for Bulgaria

Variables	Values	Units
Available budget for the production of hydrogen and biogas	342,600,000	EUR
Unitary investment cost	4,000	EUR
Number of affected households	85,650	Number of households
Unitary energy consumption for space cooling	41	kWh
Unitary energy consumption for space heating	4,466	kWh
Performance ratio of energy efficient boiler	95%	%
Performance ratio existing boiler	30%	%
Energy consumption after the interventions	1,410	kWh
Electricity price	0.11	EUR/kWh
Existing fuel price for space heating	0.05	EUR/kWh
Remaining value	10%	% of capital cost
Discount rate	3%	%

As mentioned in the methodology section, the main difference of social cost-benefit analysis is that it quantifies the external costs and benefits and to evaluate the Scenarios more comprehensively. In addition, the value added tax was deducted from the prices of energy products and the investment costs since these are costs for the individuals and not to the national economy and society. More specifically, while the NG price is equal to 0.079 $\frac{\text{EUR}}{kwh}$, the fuel price for space heating is considered to be equal to 0.0719 $\frac{\text{EUR}}{kwh}$ $(NG_{Price} \times (1 - VAT))$.

In particular, the following external costs and benefit components (Table 32) are considered to evaluate the Scenario 0 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 32: external costs and benefits and the descriptions in Scenario 0 for Bulgaria

External costs and benefits	Description

Environmental costs from the implementations of the energy saving measure	The unit external-cost prices, which were used, concern both the effects on human health, agricultural production, and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit costs for the existing heating system (coal stove or boiler) were considered to be equal to 27.2 EUR/MWh, while unit cost for the new biomass boiler was estimated at 11.2 EUR/MWh for Scenario 0 in Bulgaria.
Multiple benefits from the implementation of the energy saving measure	The multiple benefits are calculated to as a ratio of the cost saving due to the installation of the energy saving measure. The ratio is equal to 2% based on the type of multiple benefits which is considered for Bulgaria. The multiple benefits are calculated annually, and the sum of these values are equal to the total multiple benefits of installations of energy saving measures.

The results of the social cost-benefit analysis do not indicate a social effectiveness of the Scenario 0. Therefore, implementing the Scenario 0 is not recommended as the CBA and SCBA do not support it.

Table 33 - Results of cost-benefit analysis in Scenario 0 for Bulgaria

SCBA	NPV	IRR	B/C
Scenario 0	-30,080,190	1%	0.92

Table 34 shows the main components including the fuel costs and benefits without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 34: Cash flows for social cost-benefit analysis in Scenario 0 for Bulgaria (EUR)

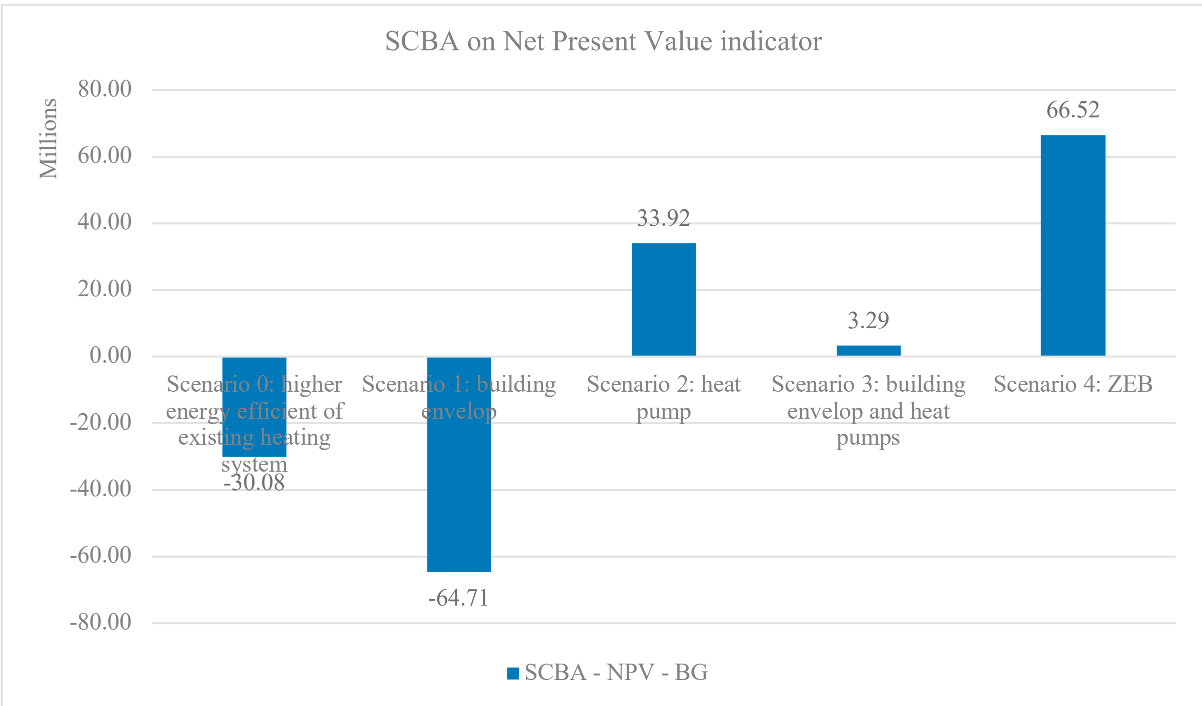
Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						0	285,500,000		- 285,500,000
1	0	0	5,585,292	17,686,759	1,352,990	10,647,168			21,395,644
2	0	0	5,585,292	17,686,759	1,352,990	10,647,168			21,395,644
3	0	0	5,585,292	17,686,759	1,352,990	10,647,168			21,395,644
4	0	0	5,585,292	17,686,759	1,352,990	10,647,168			21,395,644
5	0	0	5,585,292	17,686,759	1,352,990	10,647,168			21,395,644
6	0	0	5,585,292	17,686,759	1,352,990	10,647,168			21,395,644
7	0	0	5,585,292	17,686,759	1,352,990	10,647,168			21,395,644
8	0	0	5,585,292	17,686,759	1,352,990	10,647,168			21,395,644
9	0	0	5,585,292	17,686,759	1,352,990	10,647,168			21,395,644
10	0	0	5,585,292	17,686,759	1,352,990	10,647,168			21,395,644
11	0	0	5,585,292	17,686,759	1,352,990	10,647,168			21,395,644
12	0	0	5,585,292	17,686,759	1,352,990	10,647,168			21,395,644
13	0	0	5,585,292	17,686,759	1,352,990	10,647,168			21,395,644
14	0	0	5,585,292	17,686,759	1,352,990	10,647,168			21,395,644
15	0	0	5,585,292	17,686,759	1,352,990	10,647,168			21,395,644
Total	0	0	66,676,856	211,143,378	16,151,908	127,105,197	285,500,000	0	- 30,080,190

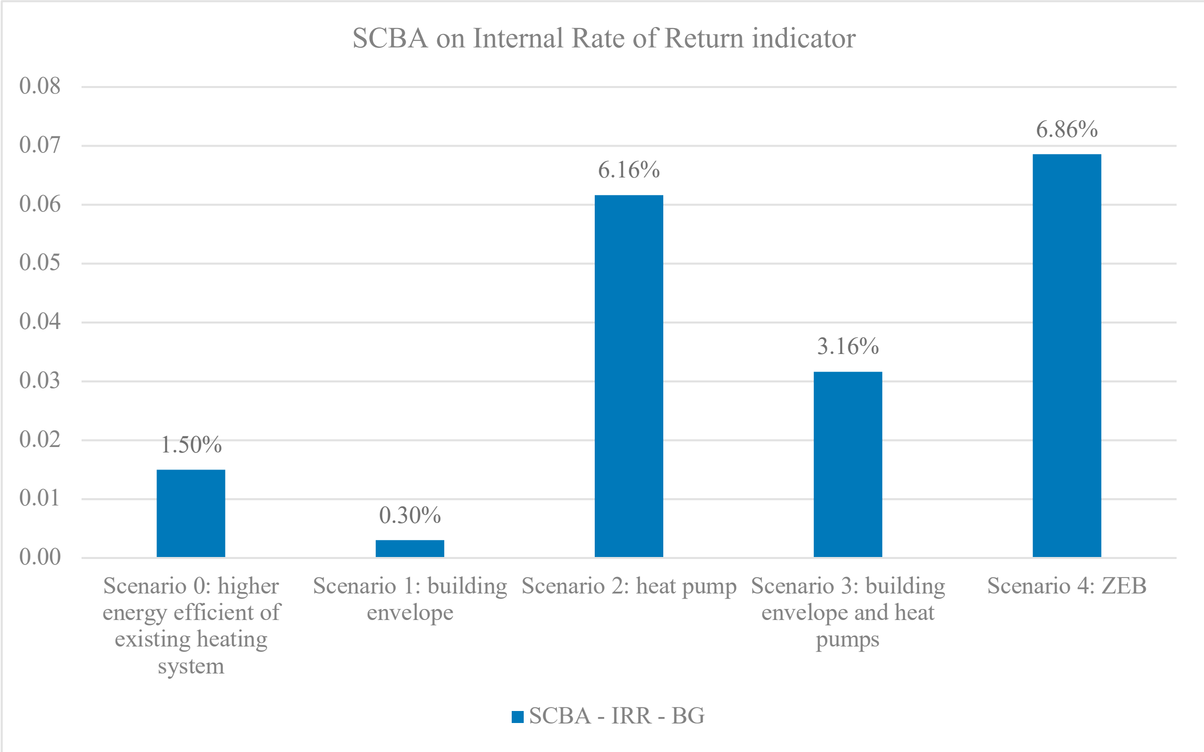
Conclusions for the case study of Bulgaria

The various considered Scenarios and their consequences for the average household have been discussed extensively in the previous subsections. Hereby a summary and overview of the main results is given. As shown in Table 14, Bulgaria is highly dependent on biomass when it comes to space heating. Additionally, fossil gas has no share in space heating (or in any energy end-use). This has consequences for the overall analysis, as the gas infrastructure is very poor, and the allocated budget is not substantial (342.6 million EUR). Indeed, the change to heat pumps from existing boilers brings great benefits to the average household, this can be seen also by the fact that all three Scenarios implementing these (Scenario 2, 3, 4) present positive NPV, IRR and B/C values when considering the SCBA. In addition, Scenarios 3 and 4 are also beneficial in terms of social cost benefit analyses and are recommended to be implemented as the third and fourth best performing Scenarios, respectively. In particular, Scenario 4, proposing a combination of heat pumps, photovoltaics and building envelope refurbishment, yields the best results with regards to all three indicators (NPV, IRR, and B/C) when performing a SCBA (Table 35). Scenario 1 performed the worst among the scenarios considered. As a final conclusion, Scenario 4 is suggested for Bulgaria, it yields high social benefits.

Table 35- Summarizing Table – All Scenarios for Bulgaria

Scenarios	Method	NPV (EUR)	IRR	B/C
Scenario 0 – higher energy efficient of existing heating system	SCB analysis	-30,080,190	1%	0.92
Scenario 1 – building envelope	SCB analysis	-64,707,939	0%	0.83
Scenario 2 – heat pump	SCB analysis	33,921,998	6%	1.18
Scenario 3 – building envelope and heat pump	SCB analysis	3,287,991	3%	1.08
Scenario 4 – ZEB	SCB analysis	66,522,876	7%	1.30





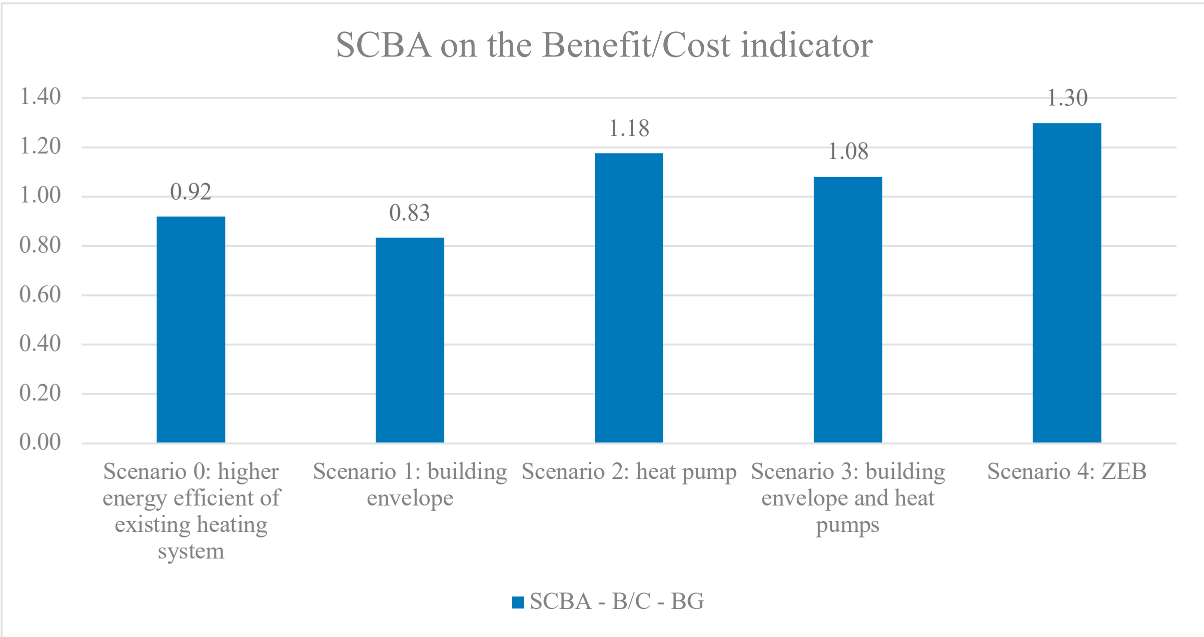


Figure 38 – summarizing figures – all Scenarios - Bulgaria

5.2 Scenario analyses for the case study of Croatia

Scenario 1 – Energy upgrade of the building envelopes for Croatia

Scenario 1 evaluates the utilisation of the available budget for "the creation of an LNG terminal and fossil gas transportation and distribution" to improve the insulation level of buildings in the residential sector and replace the windows with more energy efficient ones. Households' benefits will be energy saving for space heating and cooling and consequently reducing the energy costs. The economic benefits of improving the building envelopes are calculated using the Eurostat data of the average costs of energy for space heating. Table 36 presents the price of energy sources and the share of fuels used for space heating and cooling. The sum of all the values in the second column will amount to 100, as it shows the share of each type of fuel in the total energy consumption for space heating and cooling. As can be seen, in Croatia, biomass and fossil gas have the highest share in space heating and cooling.

Table 36: Overview of energy prices, share of fuels in space heating and shares devoted to space heating per type of fuel in Croatia[115]

Source of energy	Price (EUR/MWh)	Fuel share in space heating and cooling (%)
Electricity	106	12.04
Heating oil		2.82
LPG		0.26
Fossil gas	34.6	23.02
Solar thermal		0.59
Ambient heat		2.93
Biomass		52.38
District heating		5.97
Other		0

Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 1.972 billion) is divided by unitary investment cost (EUR 6,000) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 1.972 billion}}{\text{EUR 6,000}} = 328{,}667$ (22.5%).
- It is also assumed that the households do not need to install a new energy efficient boiler due to reduction of energy consumption for space heating. Therefore, the required investment costs are reduced for the households. Since this Scenario considers the upgrade of the building envelope without changing the heating system, no avoided costs result since the households continue to operate the existing heating system.
- From Greenpeace on field experience, it is assumed that with a 6,000 EUR investment 30% energy savings are achievable for the average household in Croatia
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.

[115] Ministarstvo prostornoga uredjenja, graditeljstva i drzavne imovine (2021), Program energetske obnove visestambenih zgrada za razdoblje do 2030. godine

- The lifetime of building envelope is on average 25 years. It is also considered that 10% of the value of the investment will be remained in the year 25.

(a) Social cost-benefit analysis

Table 37 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 1. The methodological approach is based on the European project PRODESA[116].

Table 37: The variables and their values for calculating SCBA in Scenario 1 for Croatia

Variable	Value	Unit
Available budget for the creation of an LNG terminal and fossil gas transportation and distribution	1,972,000,000	EUR
Unitary investment cost	6,000	EUR
Avoided cost from new fossil fuel boiler	0	EUR
Number of influenced households	328,667	number of households
Energy consumption for space cooling	354	kWh
Energy consumption for space heating	11,951	kWh
% of energy savings in space cooling	30%	%
% of energy savings in space heating	30%	%
Energy savings in space cooling	106	kWh
Energy savings in space heating	3,585	kWh
Electricity price	0.09	EUR/kWh
Existing fuel price for space heating	0.03	EUR/kWh
Remaining value	10%	% of capital cost
Discount rate	3%	%

The SCBA considers all the expenditures and revenues from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is $0.09\,\frac{\text{EUR}}{\text{kwh}}$, while the price for space heating is equal to $0.03\,\frac{\text{EUR}}{\text{kwh}}$. In particular, Table 38 presents external costs and benefit components which are considered to assess Scenario 1 in addition to the costs and benefits, which are quantified in the economic analysis:

[116] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

Table 38 - external costs and benefit components for SCBA for Croatia

External costs and benefits	Description
Environmental costs from the implementations of the energy saving measure	The unit external-cost prices include both the effects on human health, agricultural production, and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit cost for the existing heating system (coal stove or boiler) was considered to be equal to 27.2 EUR/MWh, while the unit cost for the existing cooling system (air conditioning unit) was estimated at 23.5 EUR/MWh.
Increasing the house value due to the improvement of the building envelope	The increase in the value of residential buildings is determined by calculating the cost savings due to improving the energy performance of the building envelope. A capital recovery coefficient is used, and the value is considered equal to 3%. The component needs to consider the year of implementation of the investment.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The SCBA results in a positive NPV, with a B/C more than 1. This indicates that a refurbishment of the building envelope leads to huge advantage to society. Thus, Scenario 1 is highly recommended in Croatia.

Table 39: Results of social cost-benefit analysis in Scenario 1 for Croatia

SCBA	NPV	IRR	B/C
Scenario 1	2,527,671,164	86%	2.44

Table 40 shows the main components including the fuel costs and benefits for Scenario 1 without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 40: Cash flows for social cost-benefit analysis in Scenario 1 for Croatia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						1,403,369,125	1,577,600,000		-174,230,875
1	0	0	0	42,101,074	13,747,197	121,401,829			149,755,706
2	0	0	0	42,101,074	13,747,197	121,401,829			149,755,706
3	0	0	0	42,101,074	13,747,197	121,401,829			149,755,706
4	0	0	0	42,101,074	13,747,197	121,401,829			149,755,706
5	0	0	0	42,101,074	13,747,197	121,401,829			149,755,706
6	0	0	0	42,101,074	13,747,197	121,401,829			149,755,706
7	0	0	0	42,101,074	13,747,197	121,401,829			149,755,706
8	0	0	0	42,101,074	13,747,197	121,401,829			149,755,706
9	0	0	0	42,101,074	13,747,197	121,401,829			149,755,706

10	0	0	0	42,101,074	13,747,197	121,401,829			149,755,706
11	0	0	0	42,101,074	13,747,197	121,401,829			149,755,706
12	0	0	0	42,101,074	13,747,197	121,401,829			149,755,706
13	0	0	0	42,101,074	13,747,197	121,401,829			149,755,706
14	0	0	0	42,101,074	13,747,197	121,401,829			149,755,706
15	0	0	0	42,101,074	13,747,197	121,401,829			149,755,706
16	0	0	0	42,101,074	13,747,197	121,401,829			149,755,706
17	0	0	0	42,101,074	13,747,197	121,401,829			149,755,706
18	0	0	0	42,101,074	13,747,197	121,401,829			149,755,706
19	0	0	0	42,101,074	13,747,197	121,401,829			149,755,706
20	0	0	0	42,101,074	13,747,197	121,401,829			149,755,706
21	0	0	0	42,101,074	13,747,197	121,401,829			149,755,706
22	0	0	0	42,101,074	13,747,197	121,401,829			149,755,706
23	0	0	0	42,101,074	13,747,197	121,401,829			149,755,706
24	0	0	0	42,101,074	13,747,197	121,401,829			149,755,706
25	0	0	0	42,101,074	13,747,197	121,401,829		197,200,000	346,955,706
Total	0	0	0	733,112,215	239,381,965	3,517,357,095	1,577,600,000	191,456,311	2,527,671,164

Scenario 2 – Heat pump installations for Croatia

Scenario 2 examines the allocation of the available budget for the installation of heat pumps for the average-income group of households in the residential buildings. Households benefit from the investments due to reducing the energy demands and consequently energy costs for space heating. Similar to Scenario 1, the economic benefits of heat pump installations are calculated based on the collected Eurostat data on weighted average cost of purchasing energy products for space heating in the residential sector.

Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 1.972 billion) is divided by unitary investment cost (EUR 8,000) to calculate the number of households that can benefit from this investment.
- The unitary investment cost (8,000 EUR) is an average between the lowest (approximately 6,600 EUR) to highest (approximately 10,600 EUR) costs found in Croatia.[117]
- The number of influenced households is equal to $\frac{\text{EUR 1.972 billion}}{\text{EUR 8,000}} = 246{,}500$ (16.9%).
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households.
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios. Therefore, no specific value is defined for this cost.

[117] https://www.emajstor.hr/cijene/toplotne_crpke_pumpe

- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime of heat pump is on average 12 years.

(a) Social cost-benefit analysis for Scenario 2 for Croatia

Table 41 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 2. The methodological approach is based on the European project PRODESA[118].

Table 41: The variables and their values for calculating SCBA in Scenario 2 for Croatia

Variable	**Value**	**Unit**
Available budget for the creation of an LNG terminal and fossil gas transportation and distribution	1,972,000,000	EUR
Unitary investment cost	8,000	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Number of influenced households	246,500	number of households
Energy consumption for space cooling	354	kWh
Energy consumption for space heating	11,951	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
Electricity price	0.09	EUR/kWh
Existing fuel price for space heating	0.03	EUR/kWh
Remaining value	0%	% of capital cost
Discount rate	3%	%

The SCBA considers all the expenditures and revenues from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is 0.09 $\frac{\text{EUR}}{\text{kwh}}$, while the price for space heating is equal to 0.03 $\frac{\text{EUR}}{\text{kwh}}$.

In particular, the following external costs and benefit components (Table 42) are considered to evaluate the Scenario 2 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 42: external costs and benefits and the descriptions in Scenario 2 for Croatia

External costs and benefits	Description

[118] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

Environmental costs from the installation of heat pumps	The unit external-cost prices include both the effects on human health, agricultural production and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit costs for the existing heating system (coal stove or boiler) were considered to be equal to 27.2 EUR/MWh, while the unit cost for the installed heat pump was estimated at 14.2 EUR/MWh.
Multiple benefits from the installation of heat pumps	Multiple benefit means for example the improvement of comfort conditions in buildings and the fight against energy poverty, the reduction of morbidity and mortality cases, etc. The calculation was carried out considering that the multiple benefits are equal to 10% of the cost savings, which results from the installation of the heat pump. This component is obtained on an annual basis after the implementation of the investment under consideration.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The results of the SCBA indicates the highly social effectiveness of Scenario 2 for the average-income group of households living in Croatia (Table 43). Therefore, the allocation of resources for installation of the heat pump is highly recommended instead of investments on the creation of an LNG terminal and fossil gas transportation and distribution.

Table 43: Results of social cost-benefit analysis in Scenario 2 for Croatia

SCBA	NPV	IRR	B/C
Scenario 2	1,329,780,252	25%	1.69

Table 44 shows the main components including the fuel costs and benefits for Scenario 2 without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 44: Cash flows for social cost-benefit analysis in Scenario 2 for Croatia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						0	788,800,000		-788,800,000
1	0	0	78,294,716	97,072,041	35,556,142	229,615,808			212,836,990
2	0	0	78,294,716	97,072,041	35,556,142	229,615,808			212,836,990
3	0	0	78,294,716	97,072,041	35,556,142	229,615,808			212,836,990
4	0	0	78,294,716	97,072,041	35,556,142	229,615,808			212,836,990
5	0	0	78,294,716	97,072,041	35,556,142	229,615,808			212,836,990
6	0	0	78,294,716	97,072,041	35,556,142	229,615,808			212,836,990
7	0	0	78,294,716	97,072,041	35,556,142	229,615,808			212,836,990
8	0	0	78,294,716	97,072,041	35,556,142	229,615,808			212,836,990
9	0	0	78,294,716	97,072,041	35,556,142	229,615,808			212,836,990
10	0	0	78,294,716	97,072,041	35,556,142	229,615,808			212,836,990
11	0	0	78,294,716	97,072,041	35,556,142	229,615,808			212,836,990
12	0	0	78,294,716	97,072,041	35,556,142	229,615,808		0	212,836,990

Total	0	0	779,345,920	966,255,487	353,925,980	2,285,596,666	788,800,000	0	1,329,780,252

Scenario 3 – Integrated energy retrofitting of the energy upgrade of the building envelopes and installations of the heat pump

Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 1.972 billion) is divided by unitary investment cost with subsidy (EUR 14,000) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 1.972 billion}}{\text{EUR 14,000}}$ = 140,857 (9.6%).
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households (avoided fuel cost = EUR 4,000).
- The energy saving rates for space heating and cooling are assumed to be 30% due to improving the building envelops (Balaras, 2007).
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime is on average 25 years.

(a) Social cost-benefit analysis in Scenario 3 for Croatia

Table 45 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 3. The methodological approach is based on the European project PRODESA[119].

Table 45: The variables and their values for calculating SCBA in Scenario 3 for Croatia

Variable	Value	Unit
Available budget for the creation of an LNG terminal and fossil gas transportation and distribution	1,972,000,000	EUR
Unitary investment cost-Building envelope	6,000	EUR
Unitary investment cost-Heat pump	8,000	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Number of influenced households	140,857	number of households
Capacity factor PV	15%	%
Energy consumption for space cooling	354	kWh
Energy consumption for space heating	11,951	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
% of energy savings in space cooling	30%	%

[119] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

% of energy savings in space heating	30%	%
Energy savings in space cooling	106	kWh
Energy savings in space heating	3,585	kWh
Electricity consumption after interventions	7,284	kWh
Electricity price	0.09	EUR/kWh
Cost reduction due to net-metering	100%	
Electricity price-net metering	0.09	EUR/kWh
Existing fuel price for space heating	0.03	EUR/kWh
Remaining value	10%	% of capital cost
Discount rate	3%	%

The SCBA considers all the expenditures and revenues from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is $0.09\,\frac{\text{EUR}}{\text{kwh}}$, while the price for space heating and the electricity price-net metering are equal to $0.03\,\frac{\text{EUR}}{\text{kwh}}$.

In particular, Table 46 presents external costs and benefit components are assessed to assess the Scenario 3 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 46: the external costs and benefits and the descriptions for Scenario 3 for Croatia

External costs and benefits	Description
Environmental costs from the implementations of the energy saving measure	The unit external-cost prices include both the effects on human health, agricultural production and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit costs for the existing heating system (coal stove or boiler) were considered to be equal to 27.2 EUR/MWh, while unit cost for the existing cooling system (air conditioning unit) was estimated at 23.5 EUR/MWh. Moreover, the unit cost for the installed heat pump was estimated at 14.2 EUR/MWh. Finally, the unit cost for photovoltaic systems is considered equal to 14.1 EUR/MWh, while the corresponding price for the electricity used from the grid was taken equal to 48.5 EUR/MWh.
Increasing the house value due to the improvement of the building envelope	The increase in the value of residential buildings is determined by calculating the cost savings due to improving the energy performance of the building envelope. A capital recovery coefficient is used, and the value is considered equal to 3%. The component needs to consider the year of implementation of the investment.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The results of the SCBA indicate the social effectiveness of Scenario 3 for the average-income group of households living in Croatia (Table 47). It should be noticed that social efficiency is significantly influenced by the double investment regarding the replacement of the heat pump (after the end of the 12-year life) with a new heat pump for the next 12 years, until the investment is repaid in the building envelope that has a lifespan of 25 years.

Table 47: Results of social cost-benefit analysis in Scenario 3 for Croatia

SCBA	NPV	IRR	B/C
Scenario 3	2,508,706,598 EUR	56%	2.36

Table 48 shows the main components including the fuel costs and benefits for Scenario 3 without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 48: Cash flows for social cost-benefit analysis in Scenario 3 for Croatia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						851,808,242	1,126,857,143		-275,048,901
1	0	0	31,317,887	56,872,134	14,222,457	143,124,585			154,456,376
2	0	0	31,317,887	56,872,134	14,222,457	143,124,585			154,456,376
3	0	0	31,317,887	56,872,134	14,222,457	143,124,585			154,456,376
4	0	0	31,317,887	56,872,134	14,222,457	143,124,585			154,456,376
5	0	0	31,317,887	56,872,134	14,222,457	143,124,585			154,456,376
6	0	0	31,317,887	56,872,134	14,222,457	143,124,585			154,456,376
7	0	0	31,317,887	56,872,134	14,222,457	143,124,585			154,456,376
8	0	0	31,317,887	56,872,134	14,222,457	143,124,585			154,456,376
9	0	0	31,317,887	56,872,134	14,222,457	143,124,585			154,456,376
10	0	0	31,317,887	56,872,134	14,222,457	143,124,585			154,456,376
11	0	0	31,317,887	56,872,134	14,222,457	143,124,585			154,456,376
12	0	0	31,317,887	56,872,134	14,222,457	143,124,585			154,456,376
13	0	0	31,317,887	56,872,134	14,222,457	143,124,585			154,456,376
14	0	0	31,317,887	56,872,134	14,222,457	143,124,585			154,456,376
15	0	0	31,317,887	56,872,134	14,222,457	143,124,585			154,456,376
16	0	0	31,317,887	56,872,134	14,222,457	143,124,585			154,456,376
17	0	0	31,317,887	56,872,134	14,222,457	143,124,585			154,456,376
18	0	0	31,317,887	56,872,134	14,222,457	143,124,585			154,456,376
19	0	0	31,317,887	56,872,134	14,222,457	143,124,585			154,456,376
20	0	0	31,317,887	56,872,134	14,222,457	143,124,585			154,456,376
21	0	0	31,317,887	56,872,134	14,222,457	143,124,585			154,456,376
22	0	0	31,317,887	56,872,134	14,222,457	143,124,585			154,456,376
23	0	0	31,317,887	56,872,134	14,222,457	143,124,585			154,456,376
24	0	0	31,317,887	56,872,134	14,222,457	143,124,585			154,456,376
25	0	0	31,317,887	56,872,134	14,222,457	143,124,585		197,200,000	351,656,376

Total	0	0	545,342,984	990,322,866	247,657,741	3,344,057,781	1,126,857,143	191,456,311	2,508,706,598

Scenario 4 – zero energy buildings by combining various investments for Croatia

Scenario 4 examines the use of the available budget for the production of hydrogen and biogas to promote zero-energy buildings (ZEB) for households. ZEB can be achieved through the combination of thermal insulation of external wall, the replacement of existing window frames (not roofs and walls) with new energy efficient ones, and the installation of photovoltaic solar panel in residential buildings and the installation of a heat pump.

The benefits of households could be the reduction of energy costs due to both the reduced energy demand for space heating and cooling, as well as the operation of the heat pump. The economic benefits of heat pump installations are calculated based on the collected Eurostat data on weighted average cost of purchasing energy products for space heating in the residential sector.

Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 1.972 billion) is divided by unitary investment cost with subsidy (EUR 22,546) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 1.972 billion}}{\text{EUR 22,546}} = 87{,}467$ (6.0%).
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households (avoided fuel cost = EUR 4,000).
- The energy saving rates for space heating and cooling are assumed to be 30% due to improving the building envelops (Balaras, 2007).
- The operation and maintenance costs are assumed higher for the alternative Scenario compared to the baseline one.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime is on average 25 years.

(a) Social cost-benefit analysis in Scenario 4 for Croatia

Table 49 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 4. The methodological approach is based on the European project PRODESA[120].

Table 49: The variables and their values for calculating SCBA in Scenario 4 for Croatia

Variable	Value	Unit
Available budget for the creation of an LNG terminal and fossil gas transportation and distribution	1,972,000,000	EUR
Unitary investment cost-Building envelope	6,000	EUR

[120] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

Unitary investment cost-Heat pump	8,000	EUR
Unitary investment cost-PV	8,546	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Number of influenced households	87,467	Number of households
Installed capacity PV	5.6	kW
Unitary investment cost PV	1,526	EUR/kW
Capacity factor PV	15%	%
Energy consumption for space cooling	354	kWh
Energy consumption for space heating	11,951	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
% of energy savings in space cooling	30%	%
% of energy savings in space heating	30%	%
Energy savings in space cooling	106	kWh
Energy savings in space heating	3,585	kWh
Electricity consumption after interventions	7,284	kWh
Electricity price	0.09	EUR/kWh
Cost reduction due to net-metering	30%	
Electricity price-net metering	0.03	EUR/kWh
Existing fuel price for space heating	0.03	EUR/kWh
Cost of operation and maintenance - Baseline scenario	0	EUR
Cost of operation and maintenance - Alternative scenario	100	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

The SCBA considers all the expenditures and revenues from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is 0.09 $\frac{\text{EUR}}{\text{kwh}}$, while the price for space heating and the electricity price-net metering are both equal to 0.03 $\frac{\text{EUR}}{\text{kwh}}$.

In particular, Table 50 presents external costs and benefit components are assessed to assess the Scenario 4 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 50: the external costs and benefits and the descriptions for Scenario 4 for Croatia

External costs and benefits	Description

Environmental costs from the implementations of the energy saving measure	The unit external-cost prices include both the effects on human health, agricultural production and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit costs for the existing heating system (coal stove or boiler) were considered to be equal to 27.2 EUR/MWh, while unit cost for the existing cooling system (air conditioning unit) was estimated at 23.5 EUR/MWh. Moreover, the unit cost for the installed heat pump was estimated at 14.2 EUR/MWh. Finally, the unit cost for photovoltaic systems is considered equal to 14.1 EUR/MWh, while the corresponding price for the electricity used from the grid was taken equal to 48.5 EUR/MWh.
Increasing the house value due to the improvement of the building envelope	The increase in the value of residential buildings is determined by calculating the cost savings due to improving the energy performance of the building envelope. A capital recovery coefficient is used, and the value is considered equal to 3%. The component needs to consider the year of implementation of the investment.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The results of the SCBA indicate the social effectiveness of Scenario 4 for the average-income group of households living in Croatia (Table 51). Therefore, the allocation of resources for ZEB is highly recommended instead of investments on creation of an LNG terminal and fossil gas transportation and distribution. It should be noticed that social efficiency is significantly influenced by the double investment regarding the replacement of the heat pump (after the end of the 12-year life) with a new heat pump for the next 12 years, until the investment is repaid in the building envelope that has a lifespan of 25 years.

Table 51: Results of social cost-benefit analysis in Scenario 4 for Croatia

SCBA	NPV	IRR	B/C
Scenario 4	3,142,039,002	--	2.57

Table 52 shows the main components including the fuel costs and benefits for Scenario 4 without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 52: Cash flows for social cost-benefit analysis in Scenario 4 for Croatia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						1,688,341,973	1,297,705,032		390,636,941
1	7,053,805	0	19,447,272	77,151,336	17,809,961	119,758,088			152,598,387
2	7,053,805	0	19,447,272	77,151,336	17,809,961	119,758,088			152,598,387
3	7,053,805	0	19,447,272	77,151,336	17,809,961	119,758,088			152,598,387
4	7,053,805	0	19,447,272	77,151,336	17,809,961	119,758,088			152,598,387
5	7,053,805	0	19,447,272	77,151,336	17,809,961	119,758,088			152,598,387
6	7,053,805	0	19,447,272	77,151,336	17,809,961	119,758,088			152,598,387
7	7,053,805	0	19,447,272	77,151,336	17,809,961	119,758,088			152,598,387
8	7,053,805	0	19,447,272	77,151,336	17,809,961	119,758,088			152,598,387

9	7,053,805	0	19,447,272	77,151,336	17,809,961	119,758,088			152,598,387
10	7,053,805	0	19,447,272	77,151,336	17,809,961	119,758,088			152,598,387
11	7,053,805	0	19,447,272	77,151,336	17,809,961	119,758,088			152,598,387
12	7,053,805	0	19,447,272	77,151,336	17,809,961	119,758,088			152,598,387
13	7,053,805	0	19,447,272	77,151,336	17,809,961	119,758,088			152,598,387
14	7,053,805	0	19,447,272	77,151,336	17,809,961	119,758,088			152,598,387
15	7,053,805	0	19,447,272	77,151,336	17,809,961	119,758,088			152,598,387
16	7,053,805	0	19,447,272	77,151,336	17,809,961	119,758,088			152,598,387
17	7,053,805	0	19,447,272	77,151,336	17,809,961	119,758,088			152,598,387
18	7,053,805	0	19,447,272	77,151,336	17,809,961	119,758,088			152,598,387
19	7,053,805	0	19,447,272	77,151,336	17,809,961	119,758,088			152,598,387
20	7,053,805	0	19,447,272	77,151,336	17,809,961	119,758,088			152,598,387
21	7,053,805	0	19,447,272	77,151,336	17,809,961	119,758,088			152,598,387
22	7,053,805	0	19,447,272	77,151,336	17,809,961	119,758,088			152,598,387
23	7,053,805	0	19,447,272	77,151,336	17,809,961	119,758,088			152,598,387
24	7,053,805	0	19,447,272	77,151,336	17,809,961	119,758,088			152,598,387
25	7,053,805	0	19,447,272	77,151,336	17,809,961	119,758,088		197,200,000	349,798,387
Total	122,828,942	0	338,638,217	1,343,447,603	310,127,477	3,773,707,249	1,297,705,032	191,456,311	3,142,039,002

Scenario 0 – The baseline Scenario for Croatia

Biomass and fossil gas are the first and second main sources of space heating in Croatia. Scenario 0 examines the utilization of the available budget to install higher energy efficient boilers (EUR 1.972 billion). The CBA and SCBA are conducted to evaluate the costs and benefits of investing on the higher energy efficient boilers by average-income groups of households.

Here are the other few assumptions which are similarly used for all Scenario:

- The total budget (EUR 1.972 billion) is divided by unitary investment cost (EUR 4,000) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to 493,000 (33.7%).
- It is assumed that the performance ratio of the energy efficient boilers is improved from 85% to 95% (assumption) efficiency.
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime of the new energy efficient boilers is equal to 15 years.

(a) Social cost-benefit analysis in Scenario 0 for Croatia

Table 53 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 0. The methodological approach is based on the European project PRODESA[121].

Table 53: The variables and their values for calculating SCBA in Scenario 0 for Croatia

Variable	Value	Unit
Available budget for creation of an LNG terminal and fossil gas transportation and distribution	1,972,000,000	EUR
Unitary investment cost	4,000	EUR
Avoided cost from fossil gas boilers	0	EUR
Number of affected households	493,000	number of households
Unitary energy consumption for space cooling	354	kWh
Unitary energy consumption for space heating	11,951	kWh
Performance ratio of energy efficient boiler	95%	%
Performance ratio existing boiler	85%	%
Energy consumption after the interventions	10,693	kWh
Electricity price	0.09	EUR/kWh
Existing fuel price for space heating	0.03	EUR/kWh
Cost of operation and maintenance - Baseline Scenario	0	EUR
Cost of operation and maintenance - Alternative Scenario	0	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

As mentioned in the methodology section, the SCBA considers all the expenditures and revenues from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition, the value added tax was deducted from the prices of energy products and the investment costs since these are costs for the individuals and not to the national economy and society. More specifically, while the NG price is equal to 0.079 $\frac{\text{EUR}}{\text{kwh}}$, the fuel price for space heating is considered to be equal to 0.0719 $\frac{\text{EUR}}{\text{kwh}}$ $(\text{NG}_{\text{Price}} \times (1 - \text{VAT}))$.

In particular, the following external costs and benefit components (Table 54) are considered to evaluate the Scenario 0 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 54: external costs and benefits and the descriptions in Scenario 0 for Croatia

External costs and benefits	Description

[121] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

Environmental costs from the implementations of the energy saving measure	The unit external-cost prices, which were used, concern both the effects on human health, agricultural production, and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit costs for the existing heating system (coal stove or boiler) were considered to be equal to 27.2 EUR/MWh, while unit cost for the new biomass boiler was estimated at 11.2 EUR/MWh for Scenario 0 in Croatia.
Multiple benefits from the implementation of the energy saving measure	The multiple benefits are calculated to as a ratio of the cost saving due to the installation of the energy saving measure. The ratio is equal to 2% based on the type of multiple benefits which is considered for Croatia. The multiple benefits are calculated annually, and the sum of these values are equal to the total multiple benefits of installations of energy saving measures.

The results of the social cost-benefit analysis do not indicate a social effectiveness of the Scenario 0. Therefore, implementing Scenario 0 is not recommended as the CBA and SCBA do not support it.

Table 55- Results of social cost-benefit analysis in Scenario 0 for Croatia

SCBA	NPV	IRR	B/C
Scenario 0	-1,048,528,144 EUR	-9%	0.78

Table 56 shows the main components including the fuel costs and benefits without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 56: Cash flows for social cost-benefit analysis in Scenario 0 for Croatia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						0	1,577,600,000		-1,577,600,000
1	0	0	173,707,863	194,144,083	94,359,517	118,241,838			44,318,540
2	0	0	173,707,863	194,144,083	94,359,517	118,241,838			44,318,540
3	0	0	173,707,863	194,144,083	94,359,517	118,241,838			44,318,540
4	0	0	173,707,863	194,144,083	94,359,517	118,241,838			44,318,540
5	0	0	173,707,863	194,144,083	94,359,517	118,241,838			44,318,540
6	0	0	173,707,863	194,144,083	94,359,517	118,241,838			44,318,540
7	0	0	173,707,863	194,144,083	94,359,517	118,241,838			44,318,540
8	0	0	173,707,863	194,144,083	94,359,517	118,241,838			44,318,540
9	0	0	173,707,863	194,144,083	94,359,517	118,241,838			44,318,540
10	0	0	173,707,863	194,144,083	94,359,517	118,241,838			44,318,540
11	0	0	173,707,863	194,144,083	94,359,517	118,241,838			44,318,540
12	0	0	173,707,863	194,144,083	94,359,517	118,241,838			44,318,540

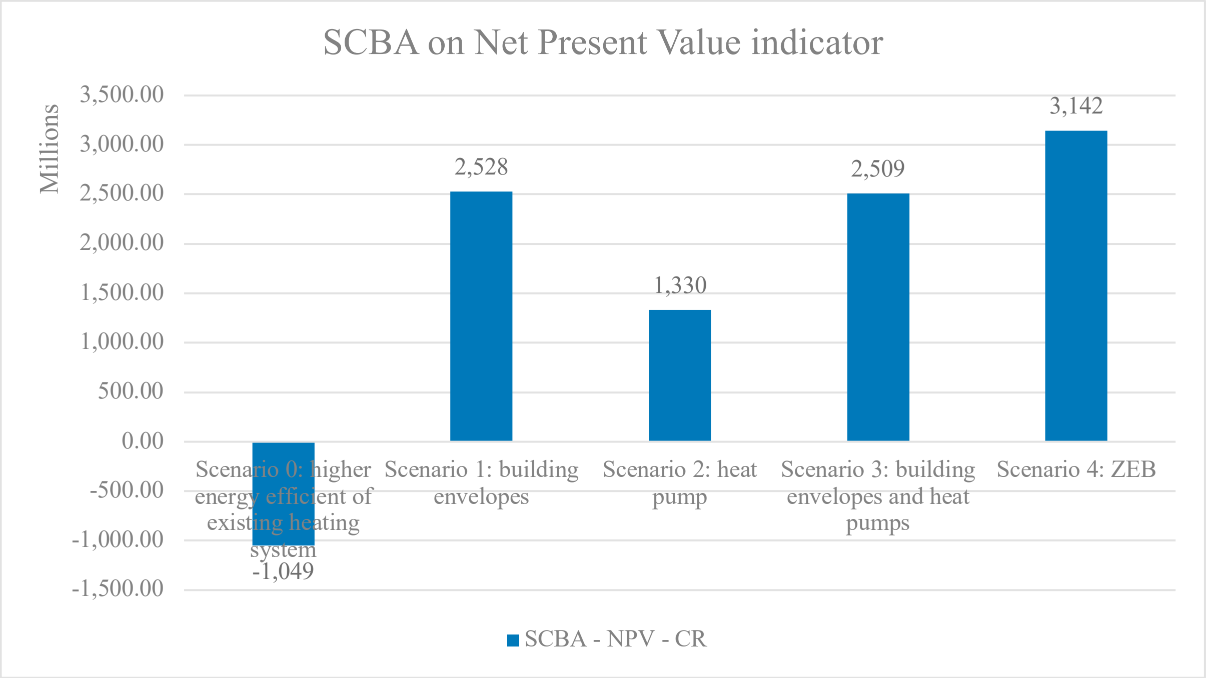
13	0	0	173,707,863	194,144,083	94,359,517	118,241,838			44,318,540
14	0	0	173,707,863	194,144,083	94,359,517	118,241,838			44,318,540
15	0	0	173,707,863	194,144,083	94,359,517	118,241,838			44,318,540
Total	0	0	2,073,713,197	2,317,679,455	1,126,457,790	1,411,563,388	1,577,600,000	0	-1,048,528,144

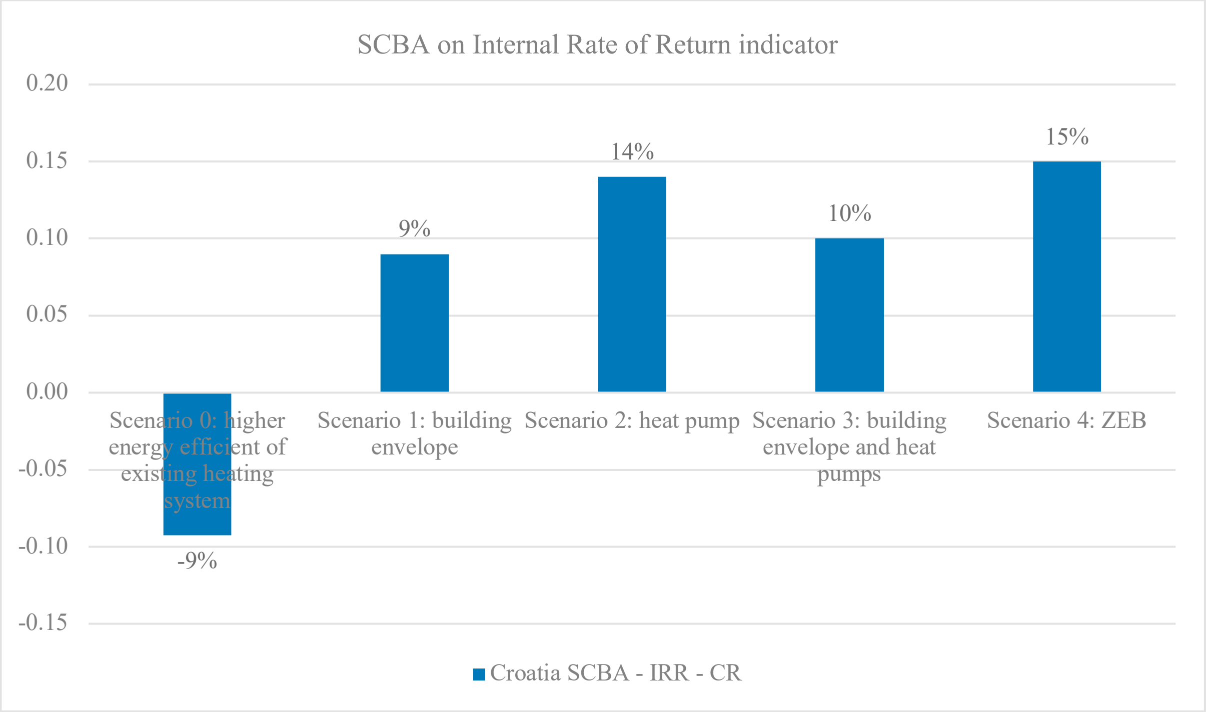
Conclusions for the case study of Croatia

As expected, the first thing that was noticed for Croatia's case is that Scenario 0, namely the replacement of boilers with more efficient fossil-fuel ones is not beneficial neither from an economic nor societal perspective. From a purely economic perspective, the only positive insight found was that Scenario 2 holds a B/C ratio slightly higher than one, suggesting a possible positive return on investment resulting from the implementation of heat pumps. On the other hand, when analysing all scenarios from a societal perspective, it can be seen that all hold positive parameters. The best performing one is Scenario 4, presenting the highest parameters. Additionally, it was found that the latter would need a subsidy rate of 31% to achieve an IRR of 3% when performing a purely economic analysis. Interestingly, Scenario 1 performs better than Scenario 3. This suggests that it is more advisable to target refurbishments of the building envelope as a standalone measure rather than coupling it with the installation of heat pumps. This is due to the rather low costs found in Croatia for the refurbishment of the building envelope. In fact, these were lower than those found for the installation of a heat pump. Nonetheless, when a combination of all measures, is considered, hence adding the installation of photovoltaics, this results in the best parameters and thus in the most advised policy measure, namely Scenario 4. All scenarios, including Scenario 4 with a subsidy rate of 31%, are summarised in the Table and Figure below.

Table 57- Summarizing Table – All Scenarios for Croatia

Scenario Croatia	Indicators	SCBA
Scenario 1	NPV	2,527,671,164
	IRR	86%
	B/C	**2.44**
Scenario 2	NPV	1,329,780,252
	IRR	25%
	B/C	**1.69**
Scenario 3	NPV	2,508,706,598
	IRR	56%
	B/C	**2.36**
Scenario 4	NPV	3,142,039,002
	IRR	–
	B/C	**2.57**
Scenario 0	NPV	-1,048,528,144
	IRR	-9%
	B/C	**0.78**


SCBA on Net Present Value indicator
Millions
3,500.00
3,000.00
2,500.00
2,000.00
1,500.00
1,000.00
500.00
0.00
-500.00
-1,000.00
-1,500.00
-1,049
2,528
1,330
2,509
3,142
Scenario 0: higher energy efficient of existing heating system
Scenario 1: building envelopes
Scenario 2: heat pump
Scenario 3: building envelopes and heat pumps
Scenario 4: ZEB
SCBA - NPV - CR


SCBA on Internal Rate of Return indicator
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
-9%
9%
14%
10%
15%
Scenario 0: higher energy efficient of existing heating system
Scenario 1: building envelope
Scenario 2: heat pump
Scenario 3: building envelope and heat pumps
Scenario 4: ZEB
Croatia SCBA - IRR - CR

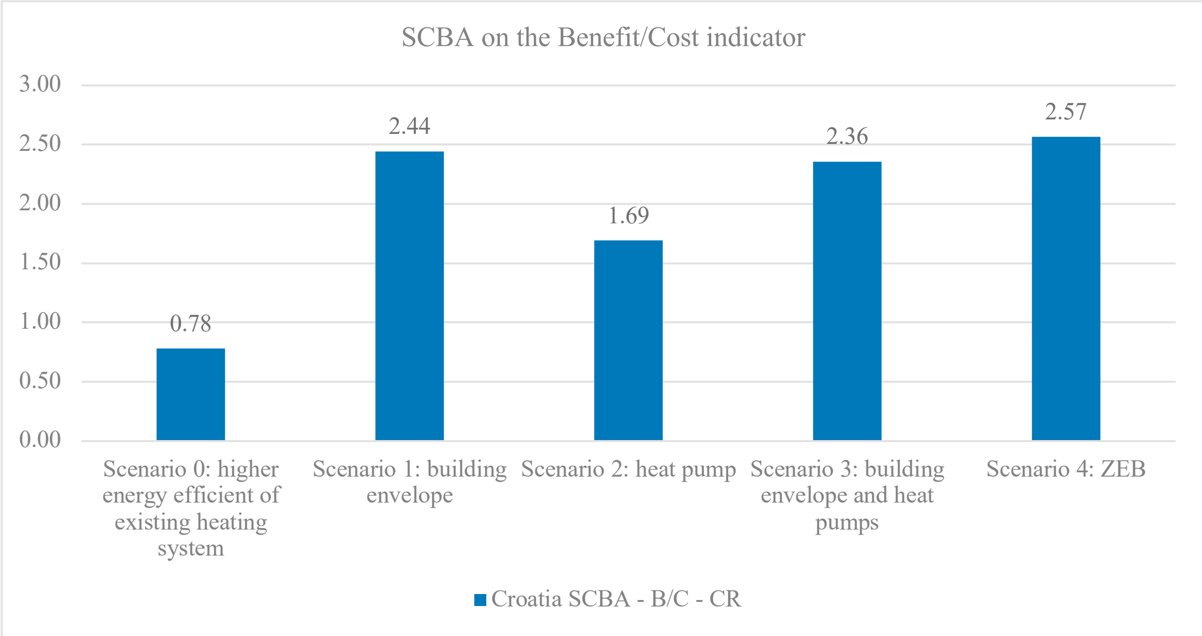


Figure 39 – summarizing figures – all Scenarios – Croatia

5.3 Scenario analyses for the case study of Hungary

Scenario 1 – energy upgrade of the building envelopes for Hungary

Scenario 1 evaluates the utilisation of the available budget to improve the insulation level of the buildings and replace the windows with more energy efficient ones in the residential sector. Households' benefits will be energy saving for space heating and cooling and consequently reducing the energy costs. The economic benefits of improving the building envelopes are calculated using the Eurostat data of the average costs of energy for space heating. Table 58 presents the price of energy sources, the share of fuels used for space heating, and the amount devoted to space heating when considering the type of fuel individually. The sum of all the values in the second column will amount to 100, as it shows the share of each type of fuel in the total energy consumption for space heating. On the other hand, the third column will not as it illustrates the percentage devoted to space heating when considering the total consumption of the single type of fuel. This is useful to understand the role that space heating plays in the utilisation of one particular type of fuel. For example, in Hungary, it can be seen that gas is the most utilised type of fuel for space heating with biomass being the second one. However, biomass is almost exclusively utilised for the latter end-use.

Table 58 - Overview of energy prices, share of fuels in space heating and shares devoted to space heating per type of fuel in Hungary, Source: Hungarian Energy and Public Utility Regulatory Authority[122]

Source of energy	Price (EUR/MWh)	Fuel share in space heating (%)	Share devoted to space heating (%)
Electricity	95	2.09	8.72
Heating oil	159	0	
LPG		0.05	2.91
Fossil gas	29	60.44	84.83
Solar thermal		0	
Ambient heat		0	
Biomass		28.35	97.69
District heating		8.10	75.62
Other		0.96	100

Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 500 million) is divided by unitary investment cost EUR 18,000 to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 500 million}}{\text{EUR 18,000}} = 27{,}778$ (0.7% of average income group).
- It is also assumed that the households do not need to install a new energy efficient boiler due to reduction of energy consumption for space heating. Therefore, the required investment costs are reduced for the households. Since this Scenario considers the upgrade of the building envelope without changing the heating system, no avoided costs result since the households continue to operate the existing heating system.

[122] http://www.mekh.hu/download/9/93/31000/8_1_haztartasok_felhasznalasa_eves_2015_2021.xlsx

- The energy saving rates for space heating and cooling are assumed to be 50% due to improving the building envelops (Balaras, 2007).
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs and are thus part of the unitary investment costs. Therefore, these values are assumed to be zero.
- The lifetime of building envelope is on average 25 years. It is also considered that 10% of the value of the investment will be remained in the year 25.

(a) Social cost-benefit analysis in Scenario 1 for Hungary

Table 59 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 1. The methodological approach is based on the European project PRODESA[123].

Table 59- the variables and their values for calculating SCBA in Scenario 1 for Hungary

Variable	Values	Unit
Available budget for the expansion of the electricity grid and the development of gas turbine power plant	500,000,000	EUR
Unitary investment cost	18,000	EUR
Number of influenced households	27,778	number of households
Energy consumption for space cooling	39	kWh
Energy consumption for space heating	11,388	kWh
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	19	kWh
Energy savings in space heating	5,694	kWh
Electricity price	0.07	EUR/kWh
Existing fuel price for space heating	0.02	EUR/kWh
Remaining value	10%	% of capital cost
Discount rate	3%	%

The SCBA considers all the expenditures and revenues from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is 0.07 $\frac{\text{EUR}}{kwh}$, while the price for space heating is equal to 0.02 $\frac{\text{EUR}}{kwh}$.

[123] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

In particular, Table 60 presents external costs and benefit components which are considered to assess Scenario 1 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 60 - external costs and benefits and the descriptions in Scenario 1 for Hungary

External costs and benefits	Description
Environmental costs from the implementations of the energy saving measure	The unit external-cost prices include both the effects on human health, agricultural production, and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit cost for the existing heating system (coal stove or boiler) was considered to be equal to 27.2 EUR/MWh, while the unit cost for the existing cooling system (air conditioning unit) was estimated at 23.5 EUR/MWh.
Increasing the house value due to the improvement of the building envelope	The increase in the value of residential buildings is determined by calculating the cost savings due to improving the energy performance of the building envelope. A capital recovery coefficient is used, and the value is considered equal to 3%. The component needs to consider the year of implementation of the investment.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The results of the SCBA indicates the highly social effectiveness of Scenario 1 for the average-income group of households living in Hungary. Therefore, the allocation of resources for improving the building envelope is highly recommended instead of investments on the expansion of the electricity grid and the development of gas turbine power plant.

Table 61 - Results of social cost-benefit analysis in Scenario 1 for Hungary

SCBA	NPV	IRR	B/C
Scenario 1	78,646,406	5%	1.25

Table 62 shows the main components including the fuel costs and benefits for Scenario 1 without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 62 - Cash flows for social cost-benefit analysis in Scenario 1 for Hungary (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						122,139,920	393,700,787		-271,560,867
1	0	0	0	3,664,198	790,845	15,866,912			18,740,265
2	0	0	0	3,664,198	790,845	15,866,912			18,740,265
3	0	0	0	3,664,198	790,845	15,866,912			18,740,265
4	0	0	0	3,664,198	790,845	15,866,912			18,740,265
5	0	0	0	3,664,198	790,845	15,866,912			18,740,265
6	0	0	0	3,664,198	790,845	15,866,912			18,740,265

7	0	0	0	3,664,198	790,845	15,866,912			18,740,265
8	0	0	0	3,664,198	790,845	15,866,912			18,740,265
9	0	0	0	3,664,198	790,845	15,866,912			18,740,265
10	0	0	0	3,664,198	790,845	15,866,912			18,740,265
11	0	0	0	3,664,198	790,845	15,866,912			18,740,265
12	0	0	0	3,664,198	790,845	15,866,912			18,740,265
13	0	0	0	3,664,198	790,845	15,866,912			18,740,265
14	0	0	0	3,664,198	790,845	15,866,912			18,740,265
15	0	0	0	3,664,198	790,845	15,866,912			18,740,265
16	0	0	0	3,664,198	790,845	15,866,912			18,740,265
17	0	0	0	3,664,198	790,845	15,866,912			18,740,265
18	0	0	0	3,664,198	790,845	15,866,912			18,740,265
19	0	0	0	3,664,198	790,845	15,866,912			18,740,265
20	0	0	0	3,664,198	790,845	15,866,912			18,740,265
21	0	0	0	3,664,198	790,845	15,866,912			18,740,265
22	0	0	0	3,664,198	790,845	15,866,912			18,740,265
23	0	0	0	3,664,198	790,845	15,866,912			18,740,265
24	0	0	0	3,664,198	790,845	15,866,912			18,740,265
25	0	0	0	3,664,198	790,845	15,866,912		50,000,000	68,740,265
Total	**0**	**0**	**0**	**63,805,214**	**13,771,093**	**398,432,794**	**393,700,787**	**48,543,689**	**78,646,406**

Scenario 2 – Heat pump installations for Hungary

Scenario 2 examines the allocation of the available budget for the expansion of the electricity grid and the development of gas turbine power plant for the installation of heat pumps for the average-income group of households in the residential buildings. Households benefit from the investments due to reducing the energy demands and consequently energy costs for space heating. Similar to Scenario 1, the economic benefits of heat pump installations are calculated based on the collected Eurostat data on weighted average cost of purchasing energy products for space heating in the residential sector.

Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 500 million) is divided by unitary investment cost (EUR 10,500) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 500 million}}{\text{EUR 10,500}} = 47{,}619$ (1.2%).
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households.
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime of heat pump is on average 12 years.

(a) Social cost-benefit analysis in Scenario 2 for Hungary

Table 63 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 2. The methodological approach is based on the European project PRODESA[124].

Table 63 - the variables and their values for calculating SCBA in Scenario 2 for Hungary

Variables	Values	Units
Available budget for the expansion of the electricity grid and the development of gas turbine power plant	500,000,000	EUR
Unitary investment cost	10,500	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Number of influenced households	47,619	number of households
Energy consumption for space cooling	39	kWh
Energy consumption for space heating	11,388	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
Electricity price	0.07	EUR/kWh
Existing fuel price for space heating	0.02	EUR/kWh
Remaining value	0%	% of capital cost
Discount rate	3%	%

The SCBA considers all the expenditures and revenues from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is $0.07 \frac{\text{EUR}}{kwh}$, while the price for space heating is equal to $0.02 \frac{\text{EUR}}{kwh}$.

In particular, the following external costs and benefit components (Table 64) are considered to evaluate the Scenario 2 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 64- external costs and benefits and the descriptions in Scenario 2 for Hungary

External costs and benefits	Description

[124] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

Environmental costs from the installation of heat pumps	The unit external-cost prices include both the effects on human health, agricultural production and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit costs for the existing heating system (coal stove or boiler) were considered to be equal to 27.2 EUR/MWh, while unit cost for the existing cooling system (air conditioning unit) was estimated at 23.5 EUR/MWh. Moreover, the unit cost for the installed heat pump was estimated at 14.2 EUR/MWh.
Multiple benefits from the installation of heat pumps	Multiple benefit means for example the improvement of comfort conditions in buildings and the fight against energy poverty, the reduction of morbidity and mortality cases, etc. The calculation was carried out considering that the multiple benefits are equal to 2% of the cost savings, which results from the installation of the heat pump. This component is obtained on an annual basis after the implementation of the investment under consideration.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The results of the SCBA indicates the highly social effectiveness of Scenario 2 for the average-income group of households living in Hungary (Table 65). Therefore, the allocation of resources for installation of the heat pump is highly recommended instead of investments on the expansion of the electricity grid and the development of gas turbine power plant.

Table 65 - Results of social cost-benefit analysis in Scenario 2 for Hungary

SCBA	**NPV**	**IRR**	**B/C**
Scenario 2	118,911,225	10%	1.28

Table 66 shows the main components including the fuel costs and benefits for Scenario 2 without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 66 - Cash flows for social cost-benefit analysis in Scenario 2 for Hungary (EUR)

Year	**O&M Cost**	**O&M Benefit**	**Fuel cost**	**Fuel benefit**	**External cost**	**External benefit**	**Investment cost**	**Remaining value**	**Net cash flow**
0						0	243,719,535		-243,719,535
1	0	0	11,469,292	12,425,778	6,545,481	42,019,638			36,430,642
2	0	0	11,469,292	12,425,778	6,545,481	42,019,638			36,430,642
3	0	0	11,469,292	12,425,778	6,545,481	42,019,638			36,430,642
4	0	0	11,469,292	12,425,778	6,545,481	42,019,638			36,430,642
5	0	0	11,469,292	12,425,778	6,545,481	42,019,638			36,430,642
6	0	0	11,469,292	12,425,778	6,545,481	42,019,638			36,430,642
7	0	0	11,469,292	12,425,778	6,545,481	42,019,638			36,430,642
8	0	0	11,469,292	12,425,778	6,545,481	42,019,638			36,430,642
9	0	0	11,469,292	12,425,778	6,545,481	42,019,638			36,430,642
10	0	0	11,469,292	12,425,778	6,545,481	42,019,638			36,430,642

11	0	0	11,469,292	12,425,778	6,545,481	42,019,638			36,430,642
12	0	0	11,469,292	12,425,778	6,545,481	42,019,638		0	36,430,642
Total	**0**	**0**	**114,165,377**	**123,686,242**	**65,153,747**	**418,263,641**	**243,719,535**	**0**	**118,911,225**

Scenario 3 – Integrated energy retrofitting of the energy upgrade of the building envelopes and installations of the heat pump

Scenario 3 indicates the integrated effects of the implementations of the improvement of the building envelopes together with installations of the heat pump (i.e., the combined effects of Scenarios 1 and 2).

Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 500 million) is divided by unitary investment cost with subsidy (EUR 28,500) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 500 } million}{\text{EUR 28,500}} = 17{,}544$ (0.4%).
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households (avoided fuel cost = EUR 4,000).
- The energy saving rates for space heating and cooling are assumed to be 50% due to improving the building envelops (Balaras, 2007).
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime is on average 25 years.

(a) Social cost-benefit analysis in Scenario 3 for Hungary

Table 67 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 3. The methodological approach is based on the European project PRODESA[125].

Table 67: The variables and their values for calculating SCBA in Scenario 3 for Hungary

Variable	Value	Unit
Available budget for the expansion of the electricity grid and the development of gas turbine power plant	500,000,000	EUR
Unitary investment cost-Building envelope	18,000	EUR
Unitary investment cost-Heat pump	10,500	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Number of influenced households	17,544	number of households
Capacity factor PV	14%	%

[125] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

Energy consumption for space cooling	39	kWh
Energy consumption for space heating	11,388	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	19	kWh
Energy savings in space heating	5,694	kWh
Electricity consumption after interventions	4,752	kWh
Electricity price	0.07	EUR/kWh
Cost reduction due to net-metering	100%	
Electricity price-net metering	0.07	EUR/kWh
Existing fuel price for space heating	0.02	EUR/kWh
Cost of operation and maintenance - Baseline Scenario	0	EUR
Cost of operation and maintenance - Alternative Scenario	0	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

The SCBA considers all the expenditures and revenues from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is $0.07\,\frac{\text{EUR}}{kwh}$, while the price for space heating is equal to $0.02\,\frac{\text{EUR}}{kwh}$.

In particular, presents external costs and benefit components are considered to assess the Scenario 3 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 68: the external costs and benefits and the descriptions for Scenario 3 for Hungary

External costs and benefits	Description

Environmental costs from the implementations of the energy saving measure	The unit external-cost prices include both the effects on human health, agricultural production and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit costs for the existing heating system (coal stove or boiler) were considered to be equal to 27.2 EUR/MWh, while unit cost for the existing cooling system (air conditioning unit) was estimated at 23.5 EUR/MWh. Moreover, the unit cost for the installed heat pump was estimated at 14.2 EUR/MWh.
Increasing the house value due to the improvement of the building envelope	The increase in the value of residential buildings is determined by calculating the cost savings due to improving the energy performance of the building envelope. A capital recovery coefficient is used, and the value is considered equal to 3%. The component needs to consider the year of implementation of the investment.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The results of the SCBA indicate the social effectiveness of Scenario 3 for the average-income group of households living in Hungary (Table 69). Therefore, the allocation of resources for ZEB is highly recommended instead of investments on the expansion of the electricity grid and the development of gas turbine power plant. It should be noticed that social efficiency is significantly influenced by the double investment regarding the replacement of the heat pump (after the end of the 12-year life) with a new heat pump for the next 12 years, until the investment is repaid in the building envelope that has a lifespan of 25 years.

Table 69: Results of social cost-benefit analysis in Scenario 3 for Hungary

CBA	NPV	IRR	B/C
Scenario 3	99,799,914	6%	1.31

Table 70 shows the main components including the fuel costs and benefits for Scenario 3 without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 70: Cash flows for social cost-benefit analysis in Scenario 3 for Hungary (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						83,014,162	338,444,537		-225,430,375
1	0	0	2,112,764	4,603,189	1,205,747	17,744,047			19,028,726
2	0	0	2,112,764	4,603,189	1,205,747	17,744,047			19,028,726
3	0	0	2,112,764	4,603,189	1,205,747	17,744,047			19,028,726
4	0	0	2,112,764	4,603,189	1,205,747	17,744,047			19,028,726
5	0	0	2,112,764	4,603,189	1,205,747	17,744,047			19,028,726
6	0	0	2,112,764	4,603,189	1,205,747	17,744,047			19,028,726
7	0	0	2,112,764	4,603,189	1,205,747	17,744,047			19,028,726
8	0	0	2,112,764	4,603,189	1,205,747	17,744,047			19,028,726
9	0	0	2,112,764	4,603,189	1,205,747	17,744,047			19,028,726

10	0	0	2,112,764	4,603,189	1,205,747	17,744,047			19,028,726
11	0	0	2,112,764	4,603,189	1,205,747	17,744,047			19,028,726
12	0	0	2,112,764	4,603,189	1,205,747	17,744,047			19,028,726
13	0	0	2,112,764	4,603,189	1,205,747	17,744,047			19,028,726
14	0	0	2,112,764	4,603,189	1,205,747	17,744,047			19,028,726
15	0	0	2,112,764	4,603,189	1,205,747	17,744,047			19,028,726
16	0	0	2,112,764	4,603,189	1,205,747	17,744,047			19,028,726
17	0	0	2,112,764	4,603,189	1,205,747	17,744,047			19,028,726
18	0	0	2,112,764	4,603,189	1,205,747	17,744,047			19,028,726
19	0	0	2,112,764	4,603,189	1,205,747	17,744,047			19,028,726
20	0	0	2,112,764	4,603,189	1,205,747	17,744,047			19,028,726
21	0	0	2,112,764	4,603,189	1,205,747	17,744,047			19,028,726
22	0	0	2,112,764	4,603,189	1,205,747	17,744,047			19,028,726
23	0	0	2,112,764	4,603,189	1,205,747	17,744,047			19,028,726
24	0	0	2,112,764	4,603,189	1,205,747	17,744,047			19,028,726
25	0	0	2,112,764	4,603,189	1,205,747	17,744,047		50,000,000	69,028,726
Total	**0**	**0**	**36,798,877**	**80,156,012**	**20,995,843**	**391,993,879**	**338,444,537**	**48,543,689**	**99,799,914**

Scenario 4– Zero energy buildings by combining various investments for Hungary

Scenario 4 examines the use of the available budget for the development and expansion of the gas network to promote zero-energy buildings (ZEB). ZEB can be achieved through the combination of thermal insulation of the building envelope, the installation of photovoltaic solar panels and the installation of a heat pump.

The benefits of households could be the reduction of energy costs due to both the reduced energy demand for space heating and cooling, as well as the operation of the heat pump. the economic benefits of heat pump installations are calculated based on the collected Eurostat data on weighted average cost of purchasing energy products for space heating in the residential sector.

Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 500 million) is divided by unitary investment cost with subsidy (EUR 35,104) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 500 } million}{\text{EUR 35,104}} = 14{,}243$ (0.3%).
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households (avoided fuel cost = EUR 4,000).
- The energy saving rates for space heating and cooling are assumed to be 50% due to improving the building envelops (Balaras, 2007).
- The operation and maintenance costs are assumed to be higher in the alternative Scenario compared to the baseline one.

- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime is on average 25 years.

(a) Social cost-benefit analysis in Scenario 4 for Hungary

Table 71 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 4. The methodological approach is based on the European project PRODESA[126].

Table 71 - the variables and their values for calculating SCBA in Scenario 4 for Hungary

Variable	Value	Unit
Available budget for the expansion of the electricity grid and the development of gas turbine power plant	500,000,000	EUR
Unitary investment cost-Building envelope	18,000	EUR
Unitary investment cost-Heat pump	10,500	EUR
Unitary investment cost-PV	6,604	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Number of influenced households	14,243	number of households
Installed capacity PV	4	kW
Unitary investment cost PV	1,651	EUR/kW
Capacity factor PV	14%	%
Energy consumption for space cooling	39	kWh
Energy consumption for space heating	11,388	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	19	kWh
Energy savings in space heating	5,694	kWh
Electricity consumption after interventions	4,752	kWh
Electricity price	0.07	EUR/kWh
Cost reduction due to net-metering	50%	
Electricity price-net metering	0.04	EUR/kWh
Existing fuel price for space heating	0.02	EUR/kWh
Cost of operation and maintenance - Baseline Scenario	0	EUR
Cost of operation and maintenance - Alternative Scenario	100	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

[126] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

The SCBA considers all the expenditures and revenues from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is $0.07\,\frac{\text{EUR}}{kwh}$, while the price for space heating and the electricity price-net metering are equal to $0.02\,\frac{\text{EUR}}{kwh}$ and $0.04\,\frac{\text{EUR}}{kwh}$, respectively.

In particular, Table 72 presents external costs and benefit components are assessed to assess the Scenario 4 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 72 - the external costs and benefits and the descriptions for Scenario 4 for Hungary

External costs and benefits	Description
Environmental costs from the implementations of the energy saving measure	The unit external-cost prices include both the effects on human health, agricultural production and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit costs for the existing heating system (coal stove or boiler) were considered to be equal to 27.2 EUR/MWh, while unit cost for the existing cooling system (air conditioning unit) was estimated at 23.5 EUR/MWh. Moreover, the unit cost for the installed heat pump was estimated at 14.2 EUR/MWh. Finally, the unit cost for photovoltaic systems is considered equal to 14.1 EUR/MWh, while the corresponding price for the electricity used from the grid was taken equal to 48.5 EUR/MWh.
Increasing the house value due to the improvement of the building envelope	The increase in the value of residential buildings is determined by calculating the cost savings due to improving the energy performance of the building envelope. A capital recovery coefficient is used, and the value is considered equal to 3%. The component needs to consider the year of implementation of the investment.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The results of the SCBA indicates the social effectiveness of Scenario 4 for the average-income group of households living in Hungary (Table 73). Therefore, the allocation of resources for ZEB is highly recommended instead of investments on the expansion of the electricity grid and the development of gas turbine power plant. It should be noticed that social efficiency is significantly influenced by the double investment regarding the replacement of the heat pump (after the end of the 12-year life) with a new heat pump for the next 12 years, until the investment is repaid in the building envelope that has a lifespan of 25 years.

Table 73 - Results of social cost-benefit analysis in Scenario 4 for Hungary

SCBA	NPV	IRR	B/C
Scenario 4	123,578,745	7%	1.34

Table 74 shows the main components including the fuel costs and benefits for Scenario 4 without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 74 - Cash flows for social cost-benefit analysis in Scenario 4 for Hungary (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						113,318,593	348,839,713		-235,521,120
1	1,148,661	0	1,715,297	6,263,515	1,972,629	17,824,019			19,250,947
2	1,148,661	0	1,715,297	6,263,515	1,972,629	17,824,019			19,250,947
3	1,148,661	0	1,715,297	6,263,515	1,972,629	17,824,019			19,250,947
4	1,148,661	0	1,715,297	6,263,515	1,972,629	17,824,019			19,250,947
5	1,148,661	0	1,715,297	6,263,515	1,972,629	17,824,019			19,250,947
6	1,148,661	0	1,715,297	6,263,515	1,972,629	17,824,019			19,250,947
7	1,148,661	0	1,715,297	6,263,515	1,972,629	17,824,019			19,250,947
8	1,148,661	0	1,715,297	6,263,515	1,972,629	17,824,019			19,250,947
9	1,148,661	0	1,715,297	6,263,515	1,972,629	17,824,019			19,250,947
10	1,148,661	0	1,715,297	6,263,515	1,972,629	17,824,019			19,250,947
11	1,148,661	0	1,715,297	6,263,515	1,972,629	17,824,019			19,250,947
12	1,148,661	0	1,715,297	6,263,515	1,972,629	17,824,019			19,250,947
13	1,148,661	0	1,715,297	6,263,515	1,972,629	17,824,019			19,250,947
14	1,148,661	0	1,715,297	6,263,515	1,972,629	17,824,019			19,250,947
15	1,148,661	0	1,715,297	6,263,515	1,972,629	17,824,019			19,250,947
16	1,148,661	0	1,715,297	6,263,515	1,972,629	17,824,019			19,250,947
17	1,148,661	0	1,715,297	6,263,515	1,972,629	17,824,019			19,250,947
18	1,148,661	0	1,715,297	6,263,515	1,972,629	17,824,019			19,250,947
19	1,148,661	0	1,715,297	6,263,515	1,972,629	17,824,019			19,250,947
20	1,148,661	0	1,715,297	6,263,515	1,972,629	17,824,019			19,250,947
21	1,148,661	0	1,715,297	6,263,515	1,972,629	17,824,019			19,250,947
22	1,148,661	0	1,715,297	6,263,515	1,972,629	17,824,019			19,250,947
23	1,148,661	0	1,715,297	6,263,515	1,972,629	17,824,019			19,250,947
24	1,148,661	0	1,715,297	6,263,515	1,972,629	17,824,019			19,250,947
25	1,148,661	0	1,715,297	6,263,515	1,972,629	17,824,019		50,000,000	69,250,947
Total	**20,001,796**	**0**	**29,868,718**	**109,067,516**	**34,349,684**	**423,690,862**	**348,839,713**	**48,543,689**	**123,578,745**

Scenario 0 – The baseline Scenario for Hungary

Hungary's main source of fuel for space heating is fossil gas (60.44%) followed by biomass (28.35%). For this reason, Scenario 0 examines the utilization of the available budget for the investment on the expansion of the electricity grid and the development of gas turbine power plant in order to install higher energy efficient gas boilers (EUR 500 million). The CBA and SCBA are conducted to evaluate the costs and benefits of investments on the higher energy efficient boilers by average-income group of households. The average-income group usually cannot afford the initial investment cost for the energy efficiency investments.

Here are the other few assumptions which are similarly used for all Scenario:

- The total budget (EUR 500 million) is divided by unitary investment cost (EUR 4,000) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to 125,000 (3.1%).
- It is assumed that the performance ratio of the energy efficient boilers is improved from 85% to 95% (assumption) efficiency.
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime of new gas boiler is equal to 15 years.

(a) Social cost-benefit analysis in Scenario 0 for Hungary

Table 75 presents the main variables and their values for calculation of social cost-benefit analysis. The methodological approach is based on the European project PRODESA[127].

Table 75 - the variables and their values for calculating SCBA in Scenario 0 for Hungary

Variable	Value	Unit
Available budget for the investment on the expansion of the electricity grid and the development of gas turbine power plant	500,000,000	EUR
Unitary investment cost	4,000	EUR
Avoided cost from fossil gas boilers	0	EUR
Number of affected households	125,000	number of households
Unitary energy consumption for space cooling	39	kWh
Unitary energy consumption for space heating	11,388	kWh
Performance ratio of energy efficient boiler	95%	%
Performance ratio existing boiler	85%	%
Energy consumption after the interventions	10,189	kWh
Electricity price	0.07	EUR/kWh
Existing fuel price for space heating	0.02	EUR/kWh
Cost of operation and maintenance - Baseline Scenario	0	EUR
Cost of operation and maintenance - Alternative Scenario	0	EUR
Remaining value	10%	% of capital cost

127 PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

Discount rate	3%	%

As mentioned in the methodology section, The SCBA considers all the expenditures and revenues from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition, the value added tax were deducted from the prices of energy products and the investment costs since these are costs for the individuals and not to the national economy and society. More specifically, while the NG price is equal to 0.06 $\frac{\text{EUR}}{kwh}$, the fuel price for space heating is considered to be equal to 0.058 $\frac{\text{EUR}}{kwh}$ $(NG_{Price} \times (1 - VAT))$.

In particular, the following external costs and benefit components (Table 76) are considered to evaluate the Scenario 0 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 76 – external costs and benefits and the descriptions in Scenario 0 for Hungary

External costs and benefits	**Description**
Environmental costs from the implementations of the energy saving measure	The unit external-cost prices, which were used, concern both the effects on human health, agricultural production, and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit cost for the existing heating system (fossil gas boiler) was considered to be equal to 20.0 EUR/MWh, while the unit cost for the new fossil gas boiler amounted to 17.9 EUR/MWh.
Multiple benefits from the implementation of the energy saving measure	The multiple benefits are calculated to as a ratio of the cost saving due to the installation of the energy saving measure. The ratio is equal to 2% based on the type of multiple benefits which is considered for Hungary. The multiple benefits are calculated annually, and the sum of these values are equal to the total multiple benefits of installations of energy saving measures.

The results of the social cost-benefit analysis do not indicate the social effectiveness of the Scenario 0. Therefore, implementing the Scenario 0 is not recommended as the CBA and SCBA do not support the Scenario 0 (Table 77).

Table 77 - Results of social cost-benefit analysis in Scenario 0 for Hungary

SCBA	**NPV**	**IRR**	**B/C**
Scenario 0	-284,185,616	-11%	0.72

Table 78 shows the main components including the fuel costs and benefits without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 78 - Cash flows for social cost-benefit analysis in Scenario 0 for Hungary (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						0	393,700,787		-393,700,787

1	0	0	29,184,228	32,617,667	22,798,799	28,539,072			9,173,711
2	0	0	29,184,228	32,617,667	22,798,799	28,539,072			9,173,711
3	0	0	29,184,228	32,617,667	22,798,799	28,539,072			9,173,711
4	0	0	29,184,228	32,617,667	22,798,799	28,539,072			9,173,711
5	0	0	29,184,228	32,617,667	22,798,799	28,539,072			9,173,711
6	0	0	29,184,228	32,617,667	22,798,799	28,539,072			9,173,711
7	0	0	29,184,228	32,617,667	22,798,799	28,539,072			9,173,711
8	0	0	29,184,228	32,617,667	22,798,799	28,539,072			9,173,711
9	0	0	29,184,228	32,617,667	22,798,799	28,539,072			9,173,711
10	0	0	29,184,228	32,617,667	22,798,799	28,539,072			9,173,711
11	0	0	29,184,228	32,617,667	22,798,799	28,539,072			9,173,711
12	0	0	29,184,228	32,617,667	22,798,799	28,539,072			9,173,711
13	0	0	29,184,228	32,617,667	22,798,799	28,539,072			9,173,711
14	0	0	29,184,228	32,617,667	22,798,799	28,539,072			9,173,711
15	0	0	29,184,228	32,617,667	22,798,799	28,539,072			9,173,711
Total	**0**	**0**	**348,399,422**	**389,387,589**	**272,170,586**	**340,697,590**	**393,700,787**	**0**	**-284,185,616**

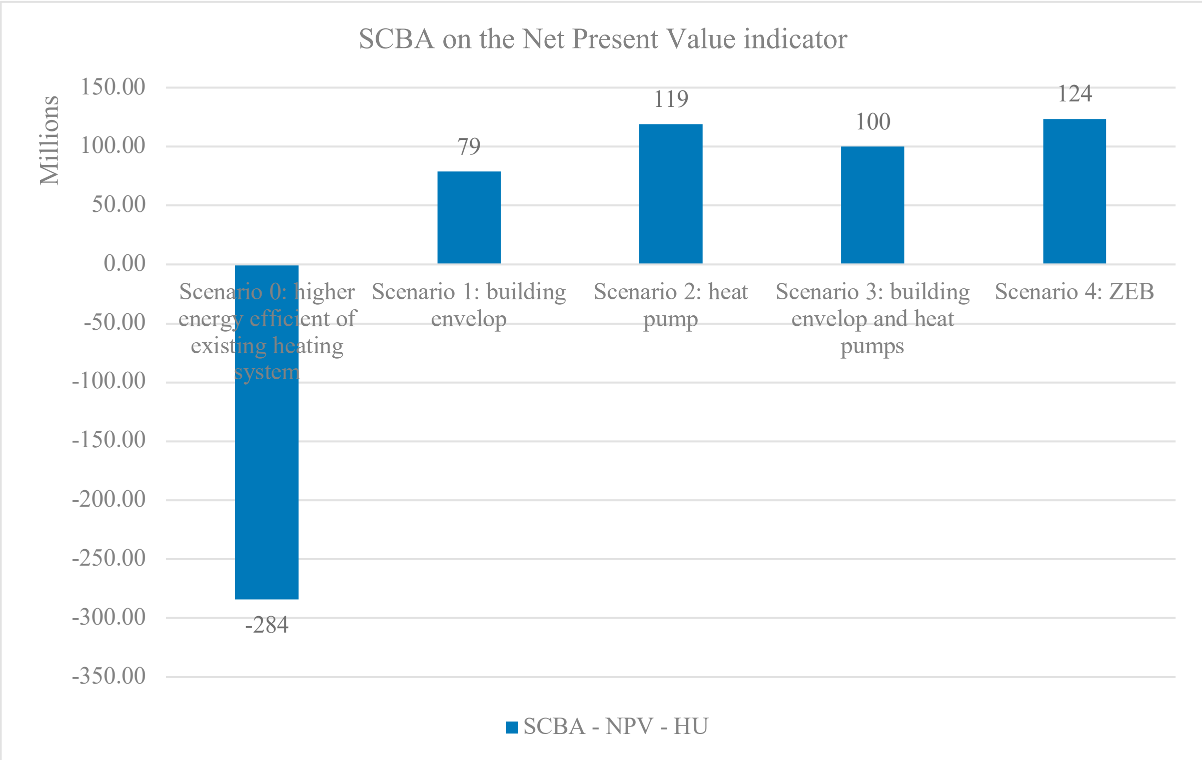
Conclusions for the case study of Hungary

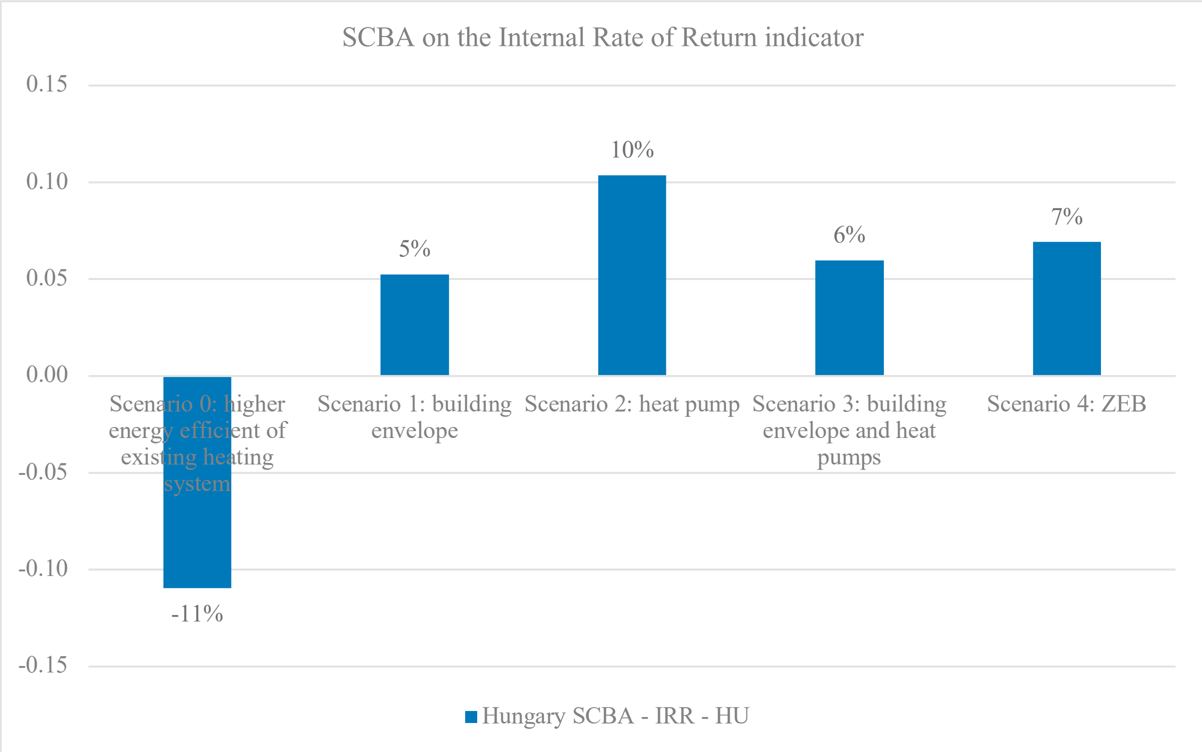
The main conclusions that can be drawn from the Scenario analysis will be summarised in the following subsection. Firstly, Scenario 0 presented negative results when performing both an economic analysis and a SCBA (Table 79). It is expected that the Scenario presenting no major energy efficiency improvements would not provide desired results (presenting the worst NPV). On the other hand, when the implementation of PVs is coupled with that of heat pumps and building envelope refurbishments (Scenario 4), it becomes highly beneficial for society. In fact, this Scenario presented both the highest NPV and C/B rate when performing a SCBA. Additionally, it also presented the best IRR throughout all Scenarios when performing a purely economic analysis. Interestingly, the highest IRR was found when performing a SCBA of Scenario 2. Since the most utilised fuel for space heating in Hungary is gas, substituting gas-fed boilers with heat pumps would entail great efficiency improvements and thus savings, justifying the high IRR. To conclude, it is suggested to implement Scenario 4 in Hungary, as such policy measure presented the greatest social benefits, but also great economic potential if coupled with subsidy measures and rates.

Table 79 - Summarising Table – All Scenarios for Hungary

Scenario	Indicators	SCBA
Scenario 1	NPV	78,646,406
	IRR	5%
	B/C	**1.25**
Scenario 2	NPV	118,911,225

	IRR	10%
	B/C	**1.28**
Scenario 3	NPV	99,799,914
	IRR	6%
	B/C	**1.31**
Scenario 4	NPV	123,578,745
	IRR	7%
	B/C	**1.34**
Scenario 0	NPV	-284,185,616
	IRR	-11%
	B/C	**0.72**





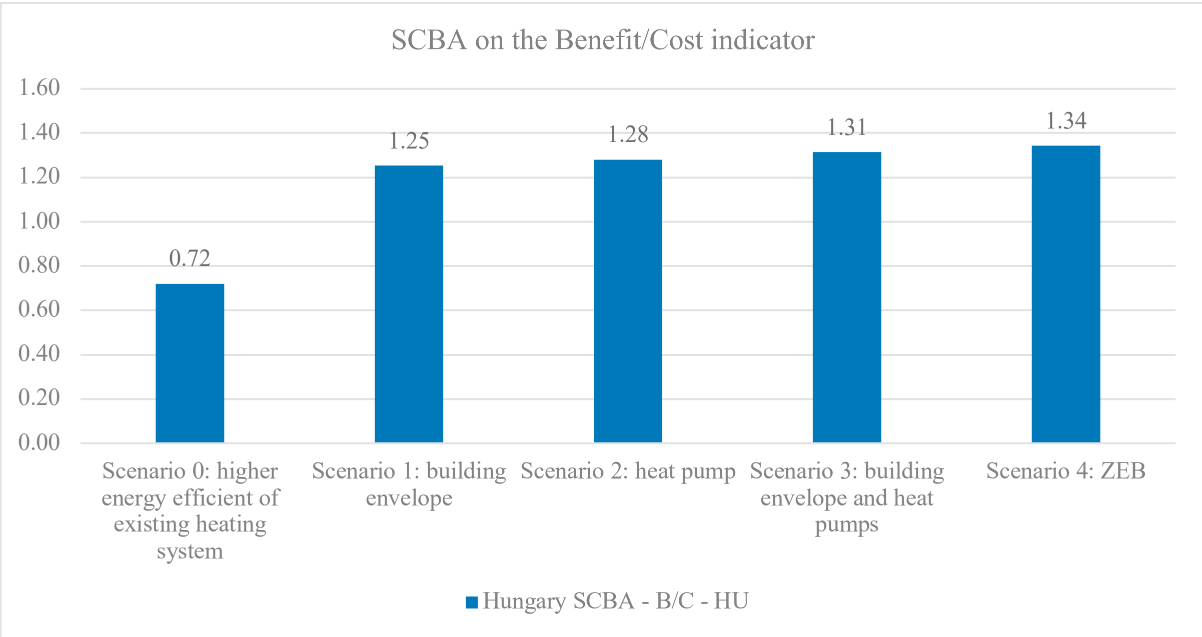


Figure 40 - Summarising figure – All Scenarios for Hungary

5.4 Scenario analyses for the case study of Poland

Scenario 1 – energy upgrade of the building envelopes for Poland

Scenario 1 evaluates the utilisation of the available budget to improve the insulation level of the buildings and replace the windows with more energy efficient ones in the residential sector. Households' benefits will be energy saving for space heating and cooling and consequently reducing the energy costs. The economic benefits of improving the building envelopes are calculated using the Eurostat data of the average costs of energy for space heating. Table 80 presents the price of energy sources, the share of fuels used for space heating, and the amount devoted to space heating when considering the type of fuel individually. The sum of all the values in the second column will amount to 100, as it shows the share of each type of fuel in the total energy consumption for space heating. On the other hand, the third column will not amount to 100 as it illustrates the percentage devoted to space heating when considering the total consumption of the single type of fuel. This is useful to understand the role that space heating plays in the utilisation of one particular type of fuel. For example, in Poland it can be seen that coal is the most utilized type of fuel for space heating, in this case represented as "Other". Additionally, we can see that heating oil is fully utilised for space heating, even though it represents a minimal share of the fuel mix. Interestingly, fossil gas is only the fourth most utilized type of fuel in Poland.

Table 80 - Overview of energy prices, share of fuels in space heating and shares devoted to space heating per type of fuel in Poland

Source of energy	Price (EUR/MWh)	Fuel share in space heating (%)	Share devoted to space heating (%)
Electricity	146	0.96	4.44
Heating oil	150	0.53	87.91
LPG		0.20	3.96
Fossil gas	60	16.72	53.44
Solar thermal		0.04	4.99
Ambient heat		1.42	70.00
Biomass		18.88	89.62
District heating		21.00	67.27
Other		40.24	89.82

Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 12.566 billion) is divided by unitary investment cost 17,000 to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 12.566 billion}}{\text{EUR 17,000}} = 739{,}176$ (5.1% of average income group).
- It is also assumed that the households do not need to install a new energy efficient boiler due to reduction of energy consumption for space heating. Therefore, the required investment costs are reduced for the households. Since this Scenario considers the

upgrade of the building envelope without changing the heating system, no avoided costs result since the households continue to operate the existing heating system.

- The energy saving rates for space heating and cooling are assumed to be 50% due to improving the building envelops (Balaras, 2007).
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime of building envelope is on average 25 years. It is also considered that 10% of the value of the investment will be remained in the year 25.

(a) Social cost-benefit analysis in Scenario 1 for Poland

Table 81 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 1. The methodological approach is based on the European project PRODESA[128].

Table 81- the variables and their values for calculating SCBA in Scenario 1 for Poland

Variable	Values	Unit
Available budget for the expansion of the gas infrastructure and gas power plants	12,566,000,000	EUR
Unitary investment cost	17,000	EUR
Avoided cost from new fossil fuel boiler	0	EUR
Number of influenced households	739,176	number of households
Energy consumption for space cooling	0	kWh
Energy consumption for space heating	9,379	kWh
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	0	kWh
Energy savings in space heating	4,690	kWh
Electricity price	0.12	EUR/kWh
Existing fuel price for space heating	0.05	EUR/kWh
Cost of operation and maintenance - Baseline Scenario	0	EUR
Cost of operation and maintenance - Alternative Scenario	0	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

The SCBA considers all the expenditures and revenues from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household

[128] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

and not for the society and the national economy. More specifically, the electricity price is $0.12\ \frac{\text{EUR}}{kwh}$, while the price for space heating is equal to $0.05\ \frac{\text{EUR}}{kwh}$.

In particular, Table 82 presents external costs and benefit components which are considered to assess Scenario 1 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 82 - external costs and benefits and the descriptions in Scenario 1 for Poland

External costs and benefits	Description
Environmental costs from the implementations of the energy saving measure	The unit external-cost prices include both the effects on human health, agricultural production, and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit cost for the existing heating system (coal stove or boiler) was considered to be equal to 27.2 EUR/MWh, while the unit cost for the existing cooling system (air conditioning unit) was estimated at 23.5 EUR/MWh.
Increasing the house value due to the improvement of the building envelope	The increase in the value of residential buildings is determined by calculating the cost savings due to improving the energy performance of the building envelope. A capital recovery coefficient is used, and the value is considered equal to 3%. The component needs to consider the year of implementation of the investment.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The results of the SCBA indicates the highly social effectiveness of Scenario 1 for the average-income group of households living in Poland. Therefore, the allocation of resources for improving the building envelope is highly recommended instead of investments on gas.

Table 83 - Results of social cost-benefit analysis in Scenario 1 for Poland

SCBA	NPV	IRR	B/C
Scenario 1	4,725,755,860	10%	1.51

Table 84 shows the main components including the fuel costs and benefits for Scenario 1 without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 84 - Cash flows for social cost-benefit analysis in Scenario 1 for Poland (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						5,655,282,835	10,216,260,163		-4,560,977,328
1	0	0	0	169,658,485	17,332,221	346,525,189			498,851,453
2	0	0	0	169,658,485	17,332,221	346,525,189			498,851,453
3	0	0	0	169,658,485	17,332,221	346,525,189			498,851,453
4	0	0	0	169,658,485	17,332,221	346,525,189			498,851,453
5	0	0	0	169,658,485	17,332,221	346,525,189			498,851,453

6	0	0	0	169,658,485	17,332,221	346,525,189			498,851,453
7	0	0	0	169,658,485	17,332,221	346,525,189			498,851,453
8	0	0	0	169,658,485	17,332,221	346,525,189			498,851,453
9	0	0	0	169,658,485	17,332,221	346,525,189			498,851,453
10	0	0	0	169,658,485	17,332,221	346,525,189			498,851,453
11	0	0	0	169,658,485	17,332,221	346,525,189			498,851,453
12	0	0	0	169,658,485	17,332,221	346,525,189			498,851,453
13	0	0	0	169,658,485	17,332,221	346,525,189			498,851,453
14	0	0	0	169,658,485	17,332,221	346,525,189			498,851,453
15	0	0	0	169,658,485	17,332,221	346,525,189			498,851,453
16	0	0	0	169,658,485	17,332,221	346,525,189			498,851,453
17	0	0	0	169,658,485	17,332,221	346,525,189			498,851,453
18	0	0	0	169,658,485	17,332,221	346,525,189			498,851,453
19	0	0	0	169,658,485	17,332,221	346,525,189			498,851,453
20	0	0	0	169,658,485	17,332,221	346,525,189			498,851,453
21	0	0	0	169,658,485	17,332,221	346,525,189			498,851,453
22	0	0	0	169,658,485	17,332,221	346,525,189			498,851,453
23	0	0	0	169,658,485	17,332,221	346,525,189			498,851,453
24	0	0	0	169,658,485	17,332,221	346,525,189			498,851,453
25	0	0	0	169,658,485	17,332,221	346,525,189		1,256,600,000	1,755,451,453
Total	**0**	**0**	**0**	2,954,288,257	301,808,518	11,689,377,125	**10,216,260,163**	1,220,000,000	4,725,755,860

Scenario 2 – Heat pump installations for Poland

Scenario 2 examines the allocation of the available budget for the expansion of the gas infrastructure and gas power plants for the installation of heat pumps for the average-income group of households in the residential buildings. Households benefit from the investments due to reducing the energy demands and consequently energy costs for space heating. Similarly to Scenario 1, the economic benefits of heat pump installations are calculated based on the collected Eurostat data on weighted average cost of purchasing energy products for space heating in the residential sector.

Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 12.566 billion) is divided by unitary investment cost (EUR 10,000) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 12.566 billion}}{\text{EUR 10,000}} = 1{,}256{,}600$ (8.7%).
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households.
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.

- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime of heat pump is on average 12 years.

(a) Social cost-benefit analysis in Scenario 2 for Poland

Table 85 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 2. The methodological approach is based on the European project PRODESA[129].

Table 85 - the variables and their values for calculating SCBA in Scenario 2 for Poland

Variables	Values	Units
Available budget for the expansion of the gas infrastructure and gas power plants	12,566,000,000	EUR
Unitary investment cost	10,000	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Number of influenced households	1,256,600	number of households
Energy consumption for space cooling	0	kWh
Energy consumption for space heating	9,379	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
Electricity price	0.12	EUR/kWh
Existing fuel price for space heating	0.05	EUR/kWh
Remaining value	0%	% of capital cost
Discount rate	3%	%

The SCBA considers all the expenditures and revenues from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is $0.12\,\frac{\text{EUR}}{kwh}$, while the price for space heating is equal to $0.05\,\frac{\text{EUR}}{kwh}$.

In particular, the following external costs and benefit components (Table 86) are considered to evaluate the Scenario 2 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 86 - external costs and benefits and the descriptions in Scenario 2 for Poland

External costs and benefits	Description

[129] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

Environmental costs from the installation of heat pumps	The unit external-cost prices include both the effects on human health, agricultural production and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit costs for the existing heating system (coal stove or boiler) were considered to be equal to 27.2 EUR/MWh, while unit cost for the existing cooling system (air conditioning unit) was estimated at 23.5 EUR/MWh. Moreover, the unit cost for the installed heat pump was estimated at 14.2 EUR/MWh.
Multiple benefits from the installation of heat pumps	Multiple benefit means for example the improvement of comfort conditions in buildings and the fight against energy poverty, the reduction of morbidity and mortality cases, etc. The calculation was carried out considering that the multiple benefits are equal to 2% of the cost savings, which results from the installation of the heat pump. This component is obtained on an annual basis after the implementation of the investment under consideration.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The results of the SCBA indicates the highly social effectiveness of Scenario 2 for the average-income group of households living in Poland (Table 87). Therefore, the allocation of resources for installation of the heat pump is highly recommended instead of investments in gas infrastructures.

Table 87 - Results of social cost-benefit analysis in Scenario 2 for Poland

SCBA	**NPV**	**IRR**	**B/C**
Scenario 2	3,487,908,548	11%	1.30

Table 88 shows the main components including the fuel costs and benefits for Scenario 2 without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 88 - Cash flows for social cost-benefit analysis in Scenario 2 for Poland (EUR)

Year	**O&M Cost**	**O&M Benefit**	**Fuel cost**	**Fuel benefit**	**External cost**	**External benefit**	**Investment cost**	**Remaining value**	**Net cash flow**
0						0	6,129,756,098		-6,129,756,098
1	0	0	397,463,048	576,838,849	142,255,934	929,090,780			966,210,648
2	0	0	397,463,048	576,838,849	142,255,934	929,090,780			966,210,648
3	0	0	397,463,048	576,838,849	142,255,934	929,090,780			966,210,648
4	0	0	397,463,048	576,838,849	142,255,934	929,090,780			966,210,648
5	0	0	397,463,048	576,838,849	142,255,934	929,090,780			966,210,648
6	0	0	397,463,048	576,838,849	142,255,934	929,090,780			966,210,648
7	0	0	397,463,048	576,838,849	142,255,934	929,090,780			966,210,648
8	0	0	397,463,048	576,838,849	142,255,934	929,090,780			966,210,648

9	0	0	397,463,048	576,838,849	142,255,934	929,090,780			966,210,648
10	0	0	397,463,048	576,838,849	142,255,934	929,090,780			966,210,648
11	0	0	397,463,048	576,838,849	142,255,934	929,090,780			966,210,648
12	0	0	397,463,048	576,838,849	142,255,934	929,090,780		0	966,210,648
Total	**0**	**0**	**3,956,348,763**	**5,741,856,208**	**1,416,016,137**	**9,248,173,337**	**6,129,756,098**	**0**	**3,487,908,548**

Scenario 3 – Integrated energy retrofitting of the energy upgrade of the building envelopes and installations of the heat pump

Scenario 3 indicates the integrated effects of the implementations of the improvement of the building envelopes together with installations of the heat pump (i.e., the combined effects of Scenarios 1 and 2).

Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 12.566 billion) is divided by unitary investment cost with subsidy (EUR 27,000) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 12.566 billion}}{\text{EUR 27,000}} = 465{,}407$ (3.2%).
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households (avoided fuel cost = EUR 4,000).
- The energy saving rates for space heating and cooling are assumed to be 50% due to improving the building envelops (Balaras, 2007).
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime is on average 25 years.

(a) Social cost-benefit analysis in Scenario 3 for Poland

Table 89 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 3. The methodological approach is based on the European project PRODESA[130].

Table 89: The variables and their values for calculating SCBA in Scenario 3 for Poland

Variable	Value	Unit
Available budget for fossil fuels	12,566,000,000	EUR
Unitary investment cost-Building envelope	17,000	EUR
Unitary investment cost-Heat pump	10,000	EUR

[130] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

Unitary investment cost-PV	0	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Number of influenced households	465,407	number of households
Installed capacity PV	0	kW
Unitary investment cost PV	0	EUR/kW
Capacity factor PV	12%	%
Energy consumption for space cooling	0	kWh
Energy consumption for space heating	9,379	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	0	kWh
Energy savings in space heating	4,690	kWh
Electricity consumption after interventions	3,599	kWh
Electricity price	0.12	EUR/kWh
Cost reduction due to net-metering	100%	
Electricity price-net metering	0.12	EUR/kWh
Existing fuel price for space heating	0.05	EUR/kWh
Cost of operation and maintenance - Baseline scenario	0	EUR
Cost of operation and maintenance - Alternative scenario	0	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

The SCBA considers all the expenditures and revenues from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is $0.12\ \frac{\text{EUR}}{kwh}$, while the price for space heating is equal to $0.05\ \frac{\text{EUR}}{kwh}$.

In particular, presents external costs and benefit components are considered to assess the Scenario 3 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 90: the external costs and benefits and the descriptions for Scenario 3 for Poland

External costs and benefits	**Description**

Environmental costs from the implementations of the energy saving measure	The unit external-cost prices include both the effects on human health, agricultural production and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit costs for the existing heating system (coal stove or boiler) were considered to be equal to 27.2 EUR/MWh, while unit cost for the existing cooling system (air conditioning unit) was estimated at 23.5 EUR/MWh. Moreover, the unit cost for the installed heat pump was estimated at 14.2 EUR/MWh.
Increasing the house value due to the improvement of the building envelope	The increase in the value of residential buildings is determined by calculating the cost savings due to improving the energy performance of the building envelope. A capital recovery coefficient is used, and the value is considered equal to 3%. The component needs to consider the year of implementation of the investment.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The results of the SCBA indicate the social effectiveness of Scenario 3 for the average-income group of households living in Poland (Table 91). Therefore, the allocation of resources for ZEB is highly recommended instead of investments in the gas sector. It should be noticed that social efficiency is significantly influenced by the double investment regarding the replacement of the heat pump (after the end of the 12-year life) with a new heat pump for the next 12 years, until the investment is repaid in the building envelope that has a lifespan of 25 years.

Table 91: Results of social cost-benefit analysis in Scenario 3 for Poland

CBA	NPV	IRR	B/C
Scenario 3	5,282,618,031	12%	1.57

Table 92 shows the main components including the fuel costs and benefits for Scenario 3 without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 92: Cash flows for social cost-benefit analysis in Scenario 3 for Poland (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						4,667,991,671	8,702,740,139		-4,034,748,467
1	0	0	73,604,268	213,644,018	26,343,692	386,914,600			500,610,659
2	0	0	73,604,268	213,644,018	26,343,692	386,914,600			500,610,659
3	0	0	73,604,268	213,644,018	26,343,692	386,914,600			500,610,659
4	0	0	73,604,268	213,644,018	26,343,692	386,914,600			500,610,659
5	0	0	73,604,268	213,644,018	26,343,692	386,914,600			500,610,659
6	0	0	73,604,268	213,644,018	26,343,692	386,914,600			500,610,659
7	0	0	73,604,268	213,644,018	26,343,692	386,914,600			500,610,659

8	0	0	73,604,268	213,644,018	26,343,692	386,914,600			500,610,659
9	0	0	73,604,268	213,644,018	26,343,692	386,914,600			500,610,659
10	0	0	73,604,268	213,644,018	26,343,692	386,914,600			500,610,659
11	0	0	73,604,268	213,644,018	26,343,692	386,914,600			500,610,659
12	0	0	73,604,268	213,644,018	26,343,692	386,914,600			500,610,659
13	0	0	73,604,268	213,644,018	26,343,692	386,914,600			500,610,659
14	0	0	73,604,268	213,644,018	26,343,692	386,914,600			500,610,659
15	0	0	73,604,268	213,644,018	26,343,692	386,914,600			500,610,659
16	0	0	73,604,268	213,644,018	26,343,692	386,914,600			500,610,659
17	0	0	73,604,268	213,644,018	26,343,692	386,914,600			500,610,659
18	0	0	73,604,268	213,644,018	26,343,692	386,914,600			500,610,659
19	0	0	73,604,268	213,644,018	26,343,692	386,914,600			500,610,659
20	0	0	73,604,268	213,644,018	26,343,692	386,914,600			500,610,659
21	0	0	73,604,268	213,644,018	26,343,692	386,914,600			500,610,659
22	0	0	73,604,268	213,644,018	26,343,692	386,914,600			500,610,659
23	0	0	73,604,268	213,644,018	26,343,692	386,914,600			500,610,659
24	0	0	73,604,268	213,644,018	26,343,692	386,914,600			500,610,659
25	0	0	73,604,268	213,644,018	26,343,692	386,914,600		1,256,600,000	1,757,210,659
Total	**0**	**0**	**1,281,681,991**	**3,720,214,842**	**458,726,591**	**11,405,392,751**	**8,702,740,139**	**1,220,000,000**	**5,282,618,031**

Scenario 4– Zero energy buildings by combining various investments for Poland

Scenario 4 examines the use of the available budget for the development and expansion of the gas network to promote zero-energy buildings (ZEB). ZEB can be achieved through the combination of thermal insulation of external wall, the replacement of existing window frames with new energy efficient ones, and the installation of photovoltaic solar panel in residential buildings and the installation of a heat pump.

The benefits of households could be the reduction of energy costs due to both the reduced energy demand for space heating and cooling, as well as the operation of the heat pump. the economic benefits of heat pump installations are calculated based on the collected Eurostat data on weighted average cost of purchasing energy products for space heating in the residential sector.

Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 12.566 billion) is divided by unitary investment cost with subsidy (EUR 13,983) to calculate the number of households that can benefit from this investment.

- The number of influenced households is equal to $\frac{\text{EUR 12.566 billion}}{\text{EUR 13,983}} = 898{,}660$ (6.2%).
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households (avoided fuel cost = EUR 4,000).
- The energy saving rates for space heating and cooling are assumed to be 50% due to improving the building envelops (Balaras, 2007).
- The operation and maintenance costs are assumed to be higher in the alternative Scenario compared to the baseline one.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime is on average 25 years.

(a) Social cost-benefit analysis in Scenario 4 for Poland

Table 93 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 4. The methodological approach is based on the European project PRODESA[131].

Table 93 - the variables and their values for calculating SCBA in Scenario 4 for Poland

Variable	Value	Unit
Available budget for the expansion of the gas infrastructure and gas power plants	12,566,000,000	EUR
Unitary investment cost-Building envelope	17,000	EUR
Unitary investment cost-Heat pump	10,000	EUR
Unitary investment cost-PV	5,597	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Number of influenced households	385,502	number of households
Installed capacity PV	4	kW
Unitary investment cost PV	1,599	EUR/kW
Capacity factor PV	12%	%
Energy consumption for space cooling	0	kWh
Energy consumption for space heating	9,379	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	0	kWh
Energy savings in space heating	4,690	kWh
Electricity consumption after interventions	3,599	kWh
Electricity price	0.12	EUR/kWh
Cost reduction due to net-metering	50%	
Electricity price-net metering	0.06	EUR/kWh

[131] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

Existing fuel price for space heating	0.05	EUR/kWh
Cost of operation and maintenance - Baseline Scenario	0	EUR
Cost of operation and maintenance - Alternative Scenario	100	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

The SCBA considers all the expenditures and revenues from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is $0.12\,\frac{\text{EUR}}{kwh}$, while the price for space heating and the electricity price-net metering are equal to $0.05\,\frac{\text{EUR}}{kwh}$ and $0.06\,\frac{\text{EUR}}{kwh}$, respectively.

In particular, Table 94 presents external costs and benefit components are assessed to assess the Scenario 4 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 94 - the external costs and benefits and the descriptions for Scenario 4 for Poland

External costs and benefits	Description
Environmental costs from the implementations of the energy saving measure	The unit external-cost prices include both the effects on human health, agricultural production and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit costs for the existing heating system (coal stove or boiler) were considered to be equal to 27.2 EUR/MWh, while unit cost for the existing cooling system (air conditioning unit) was estimated at 23.5 EUR/MWh. Moreover, the unit cost for the installed heat pump was estimated at 14.2 EUR/MWh. Finally, the unit cost for photovoltaic systems is considered equal to 14.1 EUR/MWh, while the corresponding price for the electricity used from the grid was taken equal to 48.5 EUR/MWh.
Increasing the house value due to the improvement of the building envelope	The increase in the value of residential buildings is determined by calculating the cost savings due to improving the energy performance of the building envelope. A capital recovery coefficient is used, and the value is considered equal to 3%. The component needs to consider the year of implementation of the investment.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The results of the SCBA indicates the social effectiveness of Scenario 4 for the average-income group of households living in Poland (Table 95). Therefore, the allocation of resources for ZEB is highly recommended instead of investments in gas. It should be noticed that social efficiency is significantly influenced by the double investment regarding the replacement of the heat pump (after the end of the 12-year life) with a new heat pump for the next 12 years, until the investment is repaid in the building envelope that has a lifespan of 25 years.

Table 95 - Results of social cost-benefit analysis in Scenario 4 for Poland

SCBA	NPV	IRR	B/C
Scenario 4	6,203,911,082	15%	1.60

Table 96 shows the main components including the fuel costs and benefits for Scenario 4without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 96 - Cash flows for social cost-benefit analysis in Scenario 4 for Poland (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						5,582,816,495	8,962,596,713		-3,379,780,218
1	31,088,832	0	60,967,136	259,540,462	42,215,001	390,635,631			515,905,125
2	31,088,832	0	60,967,136	259,540,462	42,215,001	390,635,631			515,905,125
3	31,088,832	0	60,967,136	259,540,462	42,215,001	390,635,631			515,905,125
4	31,088,832	0	60,967,136	259,540,462	42,215,001	390,635,631			515,905,125
5	31,088,832	0	60,967,136	259,540,462	42,215,001	390,635,631			515,905,125
6	31,088,832	0	60,967,136	259,540,462	42,215,001	390,635,631			515,905,125
7	31,088,832	0	60,967,136	259,540,462	42,215,001	390,635,631			515,905,125
8	31,088,832	0	60,967,136	259,540,462	42,215,001	390,635,631			515,905,125
9	31,088,832	0	60,967,136	259,540,462	42,215,001	390,635,631			515,905,125
10	31,088,832	0	60,967,136	259,540,462	42,215,001	390,635,631			515,905,125
11	31,088,832	0	60,967,136	259,540,462	42,215,001	390,635,631			515,905,125
12	31,088,832	0	60,967,136	259,540,462	42,215,001	390,635,631			515,905,125
13	31,088,832	0	60,967,136	259,540,462	42,215,001	390,635,631			515,905,125
14	31,088,832	0	60,967,136	259,540,462	42,215,001	390,635,631			515,905,125
15	31,088,832	0	60,967,136	259,540,462	42,215,001	390,635,631			515,905,125
16	31,088,832	0	60,967,136	259,540,462	42,215,001	390,635,631			515,905,125
17	31,088,832	0	60,967,136	259,540,462	42,215,001	390,635,631			515,905,125
18	31,088,832	0	60,967,136	259,540,462	42,215,001	390,635,631			515,905,125
19	31,088,832	0	60,967,136	259,540,462	42,215,001	390,635,631			515,905,125
20	31,088,832	0	60,967,136	259,540,462	42,215,001	390,635,631			515,905,125
21	31,088,832	0	60,967,136	259,540,462	42,215,001	390,635,631			515,905,125
22	31,088,832	0	60,967,136	259,540,462	42,215,001	390,635,631			515,905,125
23	31,088,832	0	60,967,136	259,540,462	42,215,001	390,635,631			515,905,125
24	31,088,832	0	60,967,136	259,540,462	42,215,001	390,635,631			515,905,125
25	31,088,832	0	60,967,136	259,540,462	42,215,001	390,635,631		1,256,600,000	1,772,505,125

Tot al	541,354, 415	0	1,061,629, 738	4,519,416, 397	735,096,0 48	12,385,012, 439	8,962,596,7 13	1,220,000,00 0	6,203,911, 082

Scenario 0 – The baseline Scenario for Poland

Scenario 0 examines the utilization of the available budget for the expansion of the gas infrastructure and gas power plants to install higher energy efficient gas boilers (EUR 12.566 billion). The CBA and SCBA are conducted to evaluate the costs and benefits of investments on the higher energy efficient boilers by average-income group of households. The average-income group usually cannot afford the initial investment cost for the energy efficiency investments.

Here are the other few assumptions which are similarly used for all Scenario:

- The total budget (EUR 12.566 billion) is divided by unitary investment cost (EUR 4,000) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to 3,141,500 (21.8%).
- It is assumed that the performance ratio of the energy efficient boilers is improved from 85% to 95% (assumption) efficiency.
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime of new gas boiler is equal to 15 years.

(a) Social cost-benefit analysis in Scenario 0 for Poland

Table 97 presents the main variables and their values for calculation of social cost-benefit analysis. The methodological approach is based on the European project PRODESA[132].

Table 97 - the variables and their values for calculating SCBA in Scenario 0 for Poland

Variable	Value	Unit
Available budget for the expansion of the gas infrastructure and gas power plants	12,566,000,000	EUR
Unitary investment cost	4,000	EUR
Avoided cost from fossil gas boilers	0	EUR
Number of affected households	3,141,500	number of households
Unitary energy consumption for space heating	9,379	kWh
Performance ratio of energy efficient boiler	95%	%
Performance ratio existing boiler	85%	%
Energy consumption after the interventions	8,392	kWh
Electricity price	0.12	EUR/kWh
Existing fuel price for space heating	0.05	EUR/kWh
Remaining value	10%	% of capital cost
Discount rate	3%	%

[132] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

As mentioned in the methodology section, the main difference of social cost-benefit analysis is that it quantifies the external costs and benefits and to evaluate the Scenarios more comprehensively. In addition, the value added tax were deducted from the prices of energy products and the investment costs since these are costs for the individuals and not to the national economy and society. More specifically, while the NG price is equal to 0.06 $\frac{\text{EUR}}{kwh}$, the fuel price for space heating is considered to be equal to 0.058 $\frac{\text{EUR}}{kwh}$ $(NG_{Price} \times (1 - VAT))$.

In particular, the following external costs and benefit components (Table 98) are considered to evaluate the Scenario 0 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 98 – external costs and benefits and the descriptions in Scenario 0 for Poland

External costs and benefits	Description
Environmental costs from the implementations of the energy saving measure	The unit external-cost prices, which were used, concern both the effects on human health, agricultural production, and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit cost for the existing heating system (fossil gas boiler) was considered to be equal to 20.0 EUR/MWh, while the unit cost for the new fossil gas boiler amounted to 17.9 EUR/MWh.
Multiple benefits from the implementation of the energy saving measure	The multiple benefits are calculated to as a ratio of the cost saving due to the installation of the energy saving measure. The ratio is equal to 2% based on the type of multiple benefits which is considered for Hungary. The multiple benefits are calculated annually, and the sum of these values are equal to the total multiple benefits of installations of energy saving measures.

The results of the social cost-benefit analysis do not indicate the social effectiveness of the Scenario 0. Therefore, implementing the Scenario 0 is not recommended as the SCBA do not support the Scenario 0 (Table 99).

Table 99 - Results of social cost-benefit analysis in Scenario 0 for Poland

SCBA	NPV	IRR	B/C
Scenario 0	-6,966,401,368	-10%	0.78

Table 100 shows the main components including the fuel costs and benefits without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 100 - Cash flows for social cost-benefit analysis in Scenario 0 for Poland (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					12,566,000,000		- 12,566,000,000
1	0	0	1,587,065,834	1,773,779,461			186,713,627
2	0	0	1,587,065,834	1,773,779,461			186,713,627
3	0	0	1,587,065,834	1,773,779,461			186,713,627
4	0	0	1,587,065,834	1,773,779,461			186,713,627

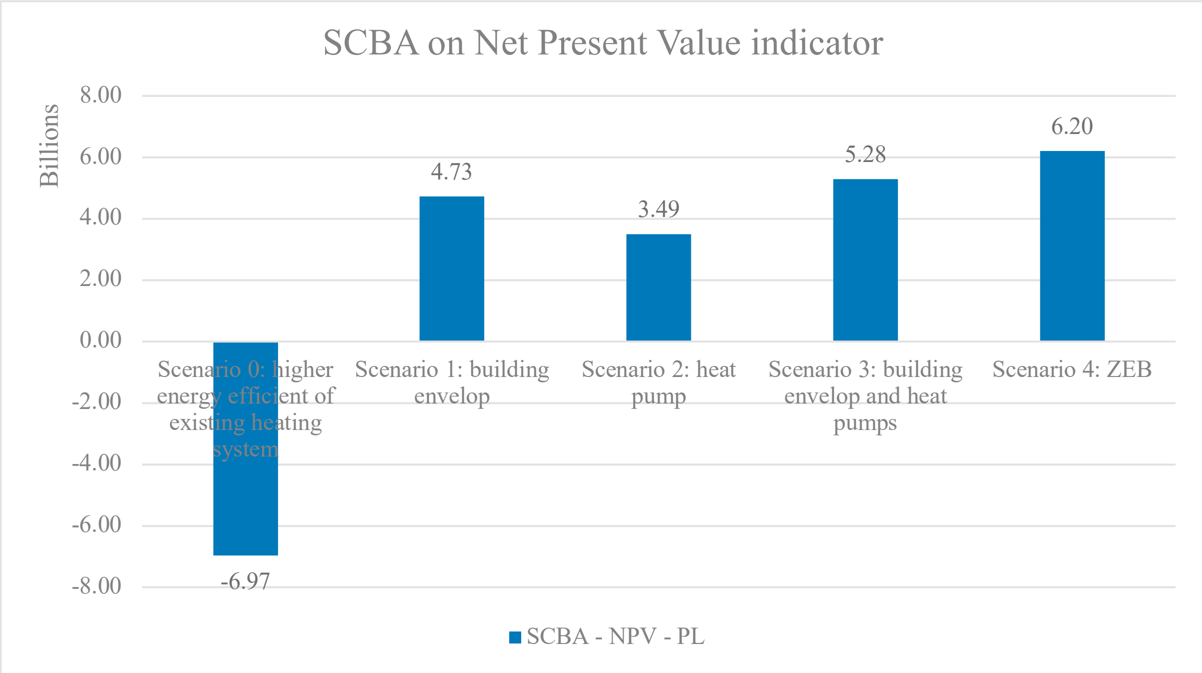
5	0	0	1,587,065,834	1,773,779,461			186,713,627
6	0	0	1,587,065,834	1,773,779,461			186,713,627
7	0	0	1,587,065,834	1,773,779,461			186,713,627
8	0	0	1,587,065,834	1,773,779,461			186,713,627
9	0	0	1,587,065,834	1,773,779,461			186,713,627
10	0	0	1,587,065,834	1,773,779,461			186,713,627
11	0	0	1,587,065,834	1,773,779,461			186,713,627
12	0	0	1,587,065,834	1,773,779,461			186,713,627
13	0	0	1,587,065,834	1,773,779,461			186,713,627
14	0	0	1,587,065,834	1,773,779,461			186,713,627
15	0	0	1,587,065,834	1,773,779,461			186,713,627
Total	**0**	**0**	**18,946,288,900**	**21,175,264,065**	**12,566,000,000**	**0**	**-10,337,024,835**

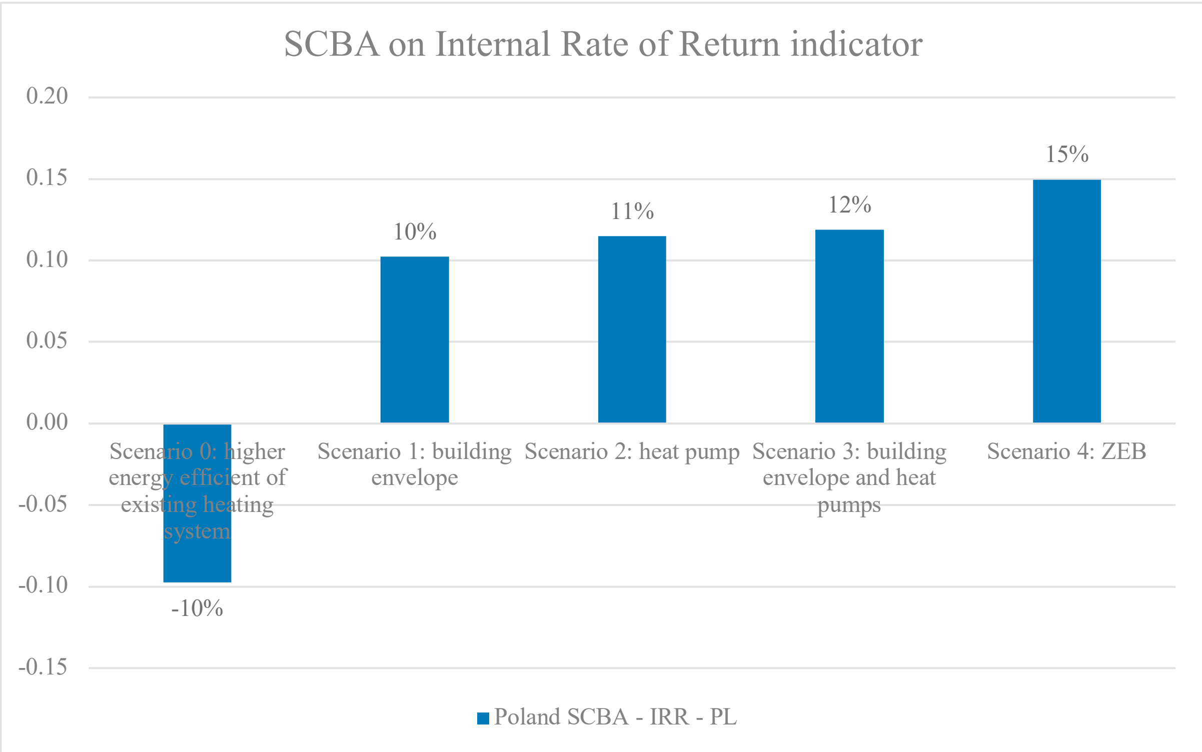
Conclusions for the case study of Poland

In the following subsection, the main conclusions from the Polish case study will be summarised. As expected, Scenario 0 is the worst-performing one, presenting the worst parameters out of all Scenarios both when performing a CBA and SCBA. Scenario 4 is the one that best performed in Poland, with the highest parameters among other Scenarios when performing a SCBA (Table 101). Additionally, Scenario 4 presented also the highest IRR when performing a purely economic analysis of all Scenarios. This all goes to show that Scenario 4 is suggested as the best policy measure in Poland, foreseeing great social, but also economic, benefits.

Table 101 - Summarising Table – All Scenarios for Poland

Scenario	Indicators	SCBA
Scenario 1: Building envelopes	NPV	4,725,755,860
	IRR	10%
	B/C	1.51
Scenario 2: Heat pumps	NPV	3,487,908,548
	IRR	11%
	B/C	1.30
Scenario 3: Building envelopes and heat pumps	NPV	5,282,618,031
	IRR	12%
	B/C	1.57
Scenario 4: ZEB	NPV	6,203,911,082
	IRR	15%
	B/C	1.60
Scenario 0: Installations of higher energy efficient heating systems	NPV	-6,966,401,368
	IRR	-10%
	B/C	0.78


SCBA on Net Present Value indicator
Billions
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
4.73
3.49
5.28
6.20
-6.97
Scenario 0: higher energy efficient of existing heating system
Scenario 1: building envelop
Scenario 2: heat pump
Scenario 3: building envelop and heat pumps
Scenario 4: ZEB
SCBA - NPV - PL


SCBA on Internal Rate of Return indicator
0.20
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
10%
11%
12%
15%
-10%
Scenario 0: higher energy efficient of existing heating system
Scenario 1: building envelope
Scenario 2: heat pump
Scenario 3: building envelope and heat pumps
Scenario 4: ZEB
Poland SCBA - IRR - PL

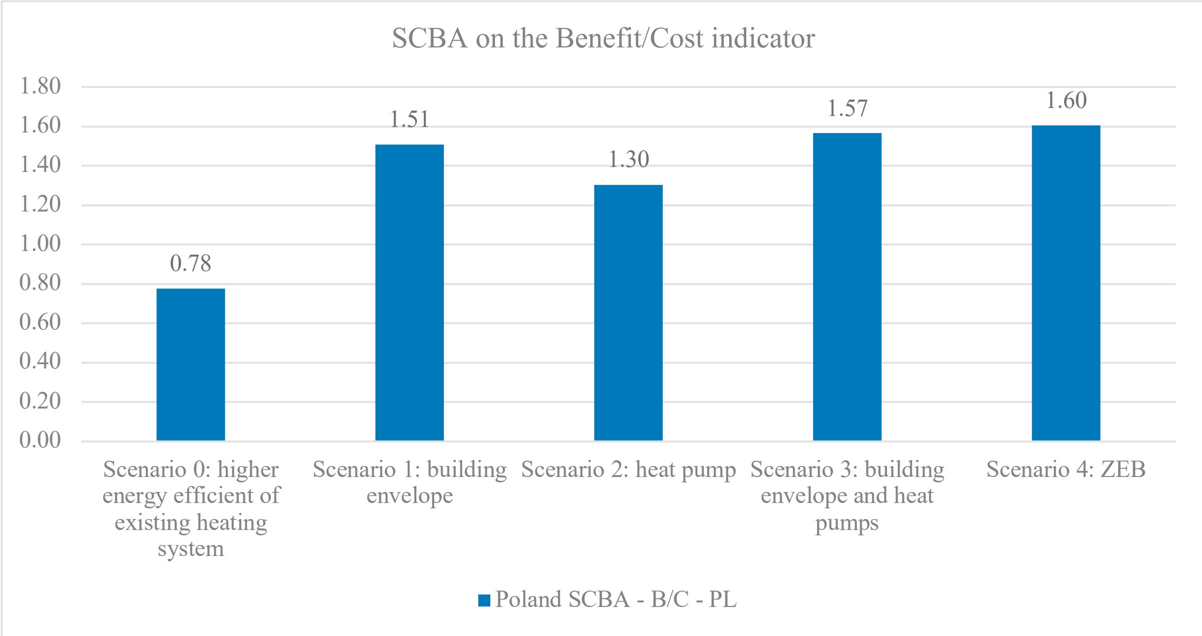


Figure 41 - summarising figure – All Scenarios for Poland

5.5 Scenario analyses for the case study of Romania

For Romania, an extra scenario analysing the implementation of photovoltaics as a stand-alone measure was added. The latter was defined as *Scenario PV*. This is due to the fact that the Romanian government has recently shown an inclination to boost solar deployment in the country. In fact, Europe's largest solar plant will be constructed in the country[133], while the government is willing to support households installing solar panels[134].

Scenario 1 – energy upgrade of the building envelopes for Romania

Scenario 1 evaluates the utilisation of the available budget for the investment on the fossil gas for the improvement of the insulation level of the buildings and replacing the windows with more energy efficient ones in the residential sector. Households' benefits will be energy saving for space heating and cooling and consequently reducing the energy costs. The economic benefits of improving the building envelopes are calculated using the Eurostat data of the average costs of energy for space heating. Table 102 presents the price of energy sources, the share of fuels used for space heating, and the amount devoted to space heating when considering the type of fuel individually. The sum of all the values in the second column will amount to 100, as it shows the share of each type of fuel in the total energy consumption for space heating. On the other hand, the third column will not as it illustrates the percentage devoted to space heating when considering the total consumption of the single type of fuel. This is useful to understand the role that space heating plays in the utilisation of one particular type of fuel. For example, in Romania, it can be seen that district heating is exclusively used for space heating, even though this being only the third most utilised type of fuel for space heating.

Table 102: Overview of energy prices, share of fuels in space heating and shares devoted to space heating per type of fuel in Romania

Source of energy	Price (EUR/MWh)	Fuel share in space heating (%)	Share devoted to space heating (%)
Electricity	169	0.20	0.86
Heating oil	188	0.001	0.14
LPG		0.008	0.14
Fossil gas	62	29.86	58.54
Solar thermal		0	-
Ambient heat		0	-
Biomass		54.59	85.64
District heating		14.75	100
Other		0.59	68.92

[133] https://tvpworld.com/66415454/romania-to-construct-europes-largest-solar-plant
[134] https://balkangreenenergynews.com/romania-to-subsidize-households-with-up-to-eur-610-million-for-photovoltaics/

(a) Social cost-benefit analysis in Scenario 1 for Romania

Table 103 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 1. The methodological approach is based on the European project PRODESA[135]. Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 4.35 billion) is divided by unitary investment cost (EUR 12,000) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 4.35 billion}}{\text{EUR 12,000}} = 362{,}500$ (4.9%).
- It is also assumed that the households do not need to install a new energy efficient boiler due to reduction of energy consumption for space heating. Therefore, the required investment costs are reduced for the households. Therefore, avoided costs from new fossil fuel boiler for the influenced households are deducted from the initial investment costs.
- The energy saving rates for space heating and cooling are assumed to be 50% due to improving the building envelops (Balaras, 2007).
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime of building envelope is on average 25 years. It is also considered that 10% of the value of the investment will be remained in the year 25.

Table 103 - the variables and their values for calculating SCBA in Scenario 1 for Romania

Variables	Values	Units
Available budget for fossil fuels	4,350,000,000	EUR
Unitary investment cost	12,000	EUR
Number of influenced households	362,500	number of households
Energy consumption for space cooling	40	kWh
Energy consumption for space heating	7,521	kWh
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	20	kWh
Energy savings in space heating	3,760	kWh
Electricity price	0.16	EUR/kWh
Existing fuel price for space heating	0.06	EUR/kWh
Remaining value	10%	% of capital cost
Discount rate	3%	%

The main difference of the SCBA compared to the typical cost benefit analyses is that it quantifies the external costs and benefits. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual

[135] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

household and not for the society and the national economy. More specifically, the electricity price is 0.16 $\frac{\text{EUR}}{kwh}$, while the price for space heating is equal to 0.06 $\frac{\text{EUR}}{kwh}$.

In particular, Table 104 presents external costs and benefit components which are considered to assess Scenario 1 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 104 - external costs and benefits and the descriptions in Scenario 1 for Romania

External costs and benefits	Description
Environmental costs from the implementations of the energy saving measure	The unit external-cost prices include both the effects on human health, agricultural production, and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit costs for the existing heating system (coal stove or boiler) were considered to be equal to 20.0 EUR/MWh, while unit cost for the existing cooling system (air conditioning unit) was estimated at 23.5 EUR/MWh.
Increasing the house value due to the improvement of the building envelope	The increase in the value of residential buildings is determined by calculating the cost savings due to improving the energy performance of the building envelope. A capital recovery coefficient is used, and the value is considered equal to 3%. The component needs to consider the year of implementation of the investment.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments

The results of the SCBA indicates the highly social effectiveness of Scenario 1 for the average-income group of households living in Romania. Therefore, the allocation of resources for improving the building envelope is highly recommended instead of investments on the development and expansion of the fossil gas network.

Table 105 - Results of social cost-benefit analysis in Scenario 1 for Romania

SCBA	NPV	IRR	B/C
Scenario 1	2,982,147,506	23%	1.85

Table 106 shows the main components including the fuel costs and benefits for Scenario 1 without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 106 - Cash flows for social cost-benefit analysis in Scenario 1 for Romania (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						2,734,367,820	3,655,462,185		-921,094,365
1	0	0	0	82,031,035	6,815,646	137,008,358			212,223,747
2	0	0	0	82,031,035	6,815,646	137,008,358			212,223,747
3	0	0	0	82,031,035	6,815,646	137,008,358			212,223,747
4	0	0	0	82,031,035	6,815,646	137,008,358			212,223,747

5	0	0	0	82,031,035	6,815,646	137,008,358			212,223,747
6	0	0	0	82,031,035	6,815,646	137,008,358			212,223,747
7	0	0	0	82,031,035	6,815,646	137,008,358			212,223,747
8	0	0	0	82,031,035	6,815,646	137,008,358			212,223,747
9	0	0	0	82,031,035	6,815,646	137,008,358			212,223,747
10	0	0	0	82,031,035	6,815,646	137,008,358			212,223,747
11	0	0	0	82,031,035	6,815,646	137,008,358			212,223,747
12	0	0	0	82,031,035	6,815,646	137,008,358			212,223,747
13	0	0	0	82,031,035	6,815,646	137,008,358			212,223,747
14	0	0	0	82,031,035	6,815,646	137,008,358			212,223,747
15	0	0	0	82,031,035	6,815,646	137,008,358			212,223,747
16	0	0	0	82,031,035	6,815,646	137,008,358			212,223,747
17	0	0	0	82,031,035	6,815,646	137,008,358			212,223,747
18	0	0	0	82,031,035	6,815,646	137,008,358			212,223,747
19	0	0	0	82,031,035	6,815,646	137,008,358			212,223,747
20	0	0	0	82,031,035	6,815,646	137,008,358			212,223,747
21	0	0	0	82,031,035	6,815,646	137,008,358			212,223,747
22	0	0	0	82,031,035	6,815,646	137,008,358			212,223,747
23	0	0	0	82,031,035	6,815,646	137,008,358			212,223,747
24	0	0	0	82,031,035	6,815,646	137,008,358			212,223,747
25	0	0	0	82,031,035	6,815,646	137,008,358		435,000,000	647,223,747
Total	**0**	**0**	**0**	**1,428,418,521**	**118,681,846**	**5,120,114,594**	**3,655,462,185**	**422,330,097**	**2,982,147,506**

Scenario 2 – Heat pump installations for Romania

Scenario 2 examines the allocation of the available budget for the development and expansion of the fossil gas network for the installation of heat pumps for the average-income group of households in the residential buildings. Households benefit from the investments due to reducing the energy demands and consequently energy costs for space heating. Similar to Scenario 1, the economic benefits of heat pump installations are calculated based on the collected Eurostat data on weighted average cost of purchasing energy products for space heating in the residential sector.

(a) Social cost-benefit analysis in Scenario 2 for Romania

Table 107 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 2. The methodological approach is based on the European project PRODESA[136]. Here are the other few assumptions which are mostly used for all Scenario:

[136] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

- The total budget (EUR 4.35 billion) is divided by unitary investment cost (EUR 6,500) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 4.35 billion}}{\text{EUR 6,500}} = 669{,}231$ (9.0%).
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households.
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime of heat pump is on average 12 years.

Table 107 - the variables and their values for calculating SCBA in Scenario 2 for Romania

Variables	Values	Units
Available budget for fossil fuels	4,350,000,000	EUR
Unitary investment cost	6,500	EUR
Avoided cost from new fossil fuel boiler	3,000	EUR
Number of influenced households	669,231	number of households
Energy consumption for space cooling	40	kWh
Energy consumption for space heating	7,521	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
Electricity price	0.16	EUR/kWh
Existing fuel price for space heating	0.06	EUR/kWh
Remaining value	0%	% of capital cost
Discount rate	3%	%

The SCBA considers all the expenditures and revenues from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is $0.16\,\frac{\text{EUR}}{kwh}$, while the price for space heating is equal to $0.06\,\frac{\text{EUR}}{kwh}$.

In particular, the following external costs and benefit components (Table 108) are considered to evaluate the Scenario 2 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 108 - external costs and benefits and the descriptions in Scenario 2 for Romania

External costs and benefits	Description

Environmental costs from the installation of heat pumps	The unit external-cost prices include both the effects on human health, agricultural production and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit costs for the existing heating system (coal stove or boiler) were considered to be equal to 27.2 EUR/MWh, while unit cost for the existing cooling system (air conditioning unit) was estimated at 23.5 EUR/MWh. Moreover, the unit cost for the installed heat pump was estimated at 14.2 EUR/MWh.
Multiple benefits from the installation of heat pumps	Multiple benefit means for example the improvement of comfort conditions in buildings and the fight against energy poverty, the reduction of morbidity and mortality cases, etc. The calculation was carried out considering that the multiple benefits are equal to 2% of the cost savings, which results from the installation of the heat pump. This component is obtained on an annual basis after the implementation of the investment under consideration.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The results of the SCBA indicates the highly social effectiveness of Scenario 2 for the average-income group of households living in Romania (Table 109). Therefore, the allocation of resources for installation of the heat pump is highly recommended instead of investments on the development and expansion of the fossil gas network.

Table 109 - Results of social cost-benefit analysis in Scenario 2 for Romania

SCBA	**NPV**	**IRR**	**B/C**
Scenario 2	2,062,703,100	18%	1.43

Table 110 shows the main components including the fuel costs and benefits for Scenario 2 without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 110 - Cash flows for social cost-benefit analysis in Scenario 2 for Romania (EUR)

Year	**O&M Cost**	**O&M Benefit**	**Fuel cost**	**Fuel benefit**	**External cost**	**External benefit**	**Investment cost**	**Remaining value**	**Net cash flow**
0						0	1,968,325,792		-1,968,325,792
1	0	0	228,981,731	298,630,141	60,749,424	396,066,583			404,965,569
2	0	0	228,981,731	298,630,141	60,749,424	396,066,583			404,965,569
3	0	0	228,981,731	298,630,141	60,749,424	396,066,583			404,965,569
4	0	0	228,981,731	298,630,141	60,749,424	396,066,583			404,965,569
5	0	0	228,981,731	298,630,141	60,749,424	396,066,583			404,965,569
6	0	0	228,981,731	298,630,141	60,749,424	396,066,583			404,965,569
7	0	0	228,981,731	298,630,141	60,749,424	396,066,583			404,965,569
8	0	0	228,981,731	298,630,141	60,749,424	396,066,583			404,965,569
9	0	0	228,981,731	298,630,141	60,749,424	396,066,583			404,965,569

10	0	0	228,981,731	298,630,141	60,749,424	396,066,583			404,965,569
11	0	0	228,981,731	298,630,141	60,749,424	396,066,583			404,965,569
12	0	0	228,981,731	298,630,141	60,749,424	396,066,583		0	404,965,569
Total	**0**	**0**	**2,279,285,064**	**2,972,565,616**	**604,700,005**	**3,942,448,345**	**1,968,325,792**	**0**	**2,062,703,100**

Scenario 3 – Integrated energy retrofitting of the energy upgrade of the building envelopes and installations of the heat pump

Scenario 3 indicates the integrated effects of the implementations of the improvement of the building envelopes together with installations of the heat pump (i.e., the combined effects of Scenarios 1 and 2).

(a) Social cost-benefit analysis in Scenario 3 for Romania

Table 111 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 3. The methodological approach is based on the European project PRODESA[137]. Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 4.35 billion) is divided by unitary investment cost with subsidy (EUR18,500) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 4.35 billion}}{\text{EUR 18,500}} = 235{,}135$ (3.2%).
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households (avoided fuel cost = EUR 3,000).
- The energy saving rates for space heating and cooling are assumed to be 50% due to improving the building envelops (Balaras, 2007).
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime is on average 25 years.

Table 111: The variables and their values for calculating SCBA in Scenario 3 for Romania

Variables	Values	Unit
Available budget for fossil fuels	4,350,000,000	EUR
Unitary investment cost-Building envelope	12,000	EUR
Unitary investment cost-Heat pump	6,500	EUR
Avoided cost from new fossil fuel boiler	3,000	EUR
Number of influenced households	235,135	number of households
Capacity factor PV	14%	%
Energy consumption for space cooling	40	kWh

[137] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

Energy consumption for space heating	7,521	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	20	kWh
Energy savings in space heating	3,760	kWh
Electricity consumption after interventions	3,016	kWh
Electricity price	0.16	EUR/kWh
Cost reduction due to net-metering	100%	
Electricity price-net metering	0.16	EUR/kWh
Existing fuel price for space heating	0.06	EUR/kWh
Remaining value	10%	% of capital cost
Discount rate	3%	%

The SCBA considers all the expenditures and benefits from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is $0.16\,\frac{\text{EUR}}{kwh}$, while the price for space heating and the electricity price-net metering are equal to $0.06\,\frac{\text{EUR}}{kwh}$ and $0.16\,\frac{\text{EUR}}{kwh}$.

In particular, presents external costs and benefit components are considered to assess the Scenario 3 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 112: the external costs and benefits and the descriptions for Scenario 3 for Romania

External costs and benefits	Description

Environmental costs from the implementations of the energy saving measure	The unit external-cost prices include both the effects on human health, agricultural production and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit costs for the existing heating system (coal stove or boiler) were considered to be equal to 27.2 EUR/MWh, while unit cost for the existing cooling system (air conditioning unit) was estimated at 23.5 EUR/MWh. Moreover, the unit cost for the installed heat pump was estimated at 14.2 EUR/MWh.
Increasing the house value due to the improvement of the building envelope	The increase in the value of residential buildings is determined by calculating the cost savings due to improving the energy performance of the building envelope. A capital recovery coefficient is used, and the value is considered equal to 3%. The component needs to consider the year of implementation of the investment.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The results of the SCBA indicate the social effectiveness of Scenario 3 for the average-income group of households living in Romania (Table 113). Therefore, the allocation of resources for ZEB is highly recommended instead of investments on the development and expansion of the fossil gas network. It should be noticed that social efficiency is significantly influenced by the double investment regarding the replacement of the heat pump (after the end of the 12-year life) with a new heat pump for the next 12 years, until the investment is repaid in the building envelope that has a lifespan of 25 years.

Table 113: Results of social cost-benefit analysis in Scenario 3 for Romania

SCBA	NPV	IRR	B/C
Scenario 3	3,018,132,783	24%	1.82

Table 114 shows the main components including the fuel costs and benefits for Scenario 3 without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 114: Cash flows for social cost-benefit analysis in Scenario 3 for Romania (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						2,181,495,041	3,062,684,533		-881,189,492
1	0	0	40,226,520	105,671,372	10,672,196	157,225,998			211,998,653
2	0	0	40,226,520	105,671,372	10,672,196	157,225,998			211,998,653
3	0	0	40,226,520	105,671,372	10,672,196	157,225,998			211,998,653
4	0	0	40,226,520	105,671,372	10,672,196	157,225,998			211,998,653
5	0	0	40,226,520	105,671,372	10,672,196	157,225,998			211,998,653
6	0	0	40,226,520	105,671,372	10,672,196	157,225,998			211,998,653
7	0	0	40,226,520	105,671,372	10,672,196	157,225,998			211,998,653
8	0	0	40,226,520	105,671,372	10,672,196	157,225,998			211,998,653
9	0	0	40,226,520	105,671,372	10,672,196	157,225,998			211,998,653
10	0	0	40,226,520	105,671,372	10,672,196	157,225,998			211,998,653

11	0	0	40,226,520	105,671,372	10,672,196	157,225,998			211,998,653
12	0	0	40,226,520	105,671,372	10,672,196	157,225,998			211,998,653
13	0	0	40,226,520	105,671,372	10,672,196	157,225,998			211,998,653
14	0	0	40,226,520	105,671,372	10,672,196	157,225,998			211,998,653
15	0	0	40,226,520	105,671,372	10,672,196	157,225,998			211,998,653
16	0	0	40,226,520	105,671,372	10,672,196	157,225,998			211,998,653
17	0	0	40,226,520	105,671,372	10,672,196	157,225,998			211,998,653
18	0	0	40,226,520	105,671,372	10,672,196	157,225,998			211,998,653
19	0	0	40,226,520	105,671,372	10,672,196	157,225,998			211,998,653
20	0	0	40,226,520	105,671,372	10,672,196	157,225,998			211,998,653
21	0	0	40,226,520	105,671,372	10,672,196	157,225,998			211,998,653
22	0	0	40,226,520	105,671,372	10,672,196	157,225,998			211,998,653
23	0	0	40,226,520	105,671,372	10,672,196	157,225,998			211,998,653
24	0	0	40,226,520	105,671,372	10,672,196	157,225,998			211,998,653
25	0	0	40,226,520	105,671,372	10,672,196	157,225,998		435,000,000	646,998,653
Total	**0**	**0**	**700,470,339**	**1,840,071,199**	**185,836,526**	**4,919,294,560**	**3,062,684,533**	**422,330,097**	**3,018,132,783**

Scenario 4 – Zero energy buildings by combining various investments for Romania

Scenario 4 examines the use of the available budget for the development and expansion of the gas network to promote zero-energy buildings. ZEB can be achieved through the combination of thermal insulation of external wall, the replacement of existing window frames with new energy efficient ones, and the installation of photovoltaic solar panel in residential buildings and the installation of a heat pump.

The benefits of households could be the reduction of energy costs due to both the reduced energy demand for space heating and cooling, as well as the operation of the heat pump. the economic benefits of heat pump installations are calculated based on the collected Eurostat data on weighted average cost of purchasing energy products for space heating in the residential sector.

(a) Social cost-benefit analysis in Scenario 4 for Romania

Table 115 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 4. The methodological approach is based on the European project PRODESA[138]. Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 4.35 billion) is divided by unitary investment cost with subsidy (EUR 22,368) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 4.35 billion}}{\text{EUR 22,368}} = 194{,}479$ (2.6%).

[138] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households (avoided fuel cost = EUR 3,000).
- The energy saving rates for space heating and cooling are assumed to be 50% due to improving the building envelops (Balaras, 2007).
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime is on average 25 years.

Table 115 - the variables and their values for calculating SCBA in Scenario 4 for Romania

Variables	Values	Units
Available budget for fossil fuels	4,350,000,000	EUR
Unitary investment cost-Building envelope	12,000	EUR
Unitary investment cost-Heat pump	6,500	EUR
Unitary investment cost-PV	3,868	EUR
Avoided cost from new fossil fuel boiler	3,000	EUR
Number of influenced households	194,479	number of households
Installed capacity PV	3	kW
Unitary investment cost PV	1,547	EUR/kW
Capacity factor PV	14%	%
Energy consumption for space cooling	40	kWh
Energy consumption for space heating	7,521	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	20	kWh
Energy savings in space heating	3,760	kWh
Electricity consumption after interventions	3,016	kWh
Electricity price	0.16	EUR/kWh
Cost reduction due to net-metering	50%	
Electricity price-net metering	0.08	EUR/kWh
Existing fuel price for space heating	0.06	EUR/kWh
Cost of operation and maintenance - Baseline Scenario	0	EUR
Cost of operation and maintenance - Alternative Scenario	100	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

The SCBA considers all the expenditures and benefits from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is $0.16\,\frac{\text{EUR}}{kwh}$, while the price for space heating and the electricity price-net metering are equal to $0.08\,\frac{\text{EUR}}{kwh}$ and $0.06\,\frac{\text{EUR}}{kwh}$, respectively.

In particular, Table 116 presents external costs and benefit components are assessed to assess the Scenario 4 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 116 - the external costs and benefits and the descriptions for Scenario 4 for Romania

External costs and benefits	Description
Environmental costs from the implementations of the energy saving measure	The unit external-cost prices include both the effects on human health, agricultural production and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit costs for the existing heating system (coal stove or boiler) were considered to be equal to 20.0 EUR/MWh, while unit cost for the existing cooling system (air conditioning unit) was estimated at 23.5 EUR/MWh. Moreover, the unit cost for the installed heat pump was estimated at 14.2 EUR/MWh. Finally, the unit cost for photovoltaic systems is considered equal to 14.1 EUR/MWh, while the corresponding price for the electricity used from the grid was taken equal to 48.5 EUR/MWh.
Increasing the house value due to the improvement of the building envelope	The increase in the value of residential buildings is determined by calculating the cost savings due to improving the energy performance of the building envelope. A capital recovery coefficient is used, and the value is considered equal to 3%. The component needs to consider the year of implementation of the investment.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The results of the SCBA also indicates the social effectiveness of Scenario 4 for the average-income group of households living in Romania (Table 117). Therefore, the allocation of resources for ZEB is highly recommended instead of investments on the development and expansion of the fossil gas network. It should be noticed that social efficiency is significantly influenced by the double investment regarding the replacement of the heat pump (after the end of the 12-year life) with a new heat pump for the next 12 years, until the investment is repaid in the building envelope that has a lifespan of 25 years.

Table 117 - Results of social cost-benefit analysis in Scenario 4 for Romania

SCBA	NPV	IRR	B/C
Scenario 4	3,863,476,625	73%	1.94

Table 118 shows the main components including the fuel costs and benefits for Scenario 4without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 118 - Cash flows for social cost-benefit analysis in Scenario 4 for Romania (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						2,851,175,047	3,165,180,010		-314,004,962
1	15,683,758	0	33,271,069	134,490,078	17,526,225	159,963,724			227,972,750
2	15,683,758	0	33,271,069	134,490,078	17,526,225	159,963,724			227,972,750
3	15,683,758	0	33,271,069	134,490,078	17,526,225	159,963,724			227,972,750
4	15,683,758	0	33,271,069	134,490,078	17,526,225	159,963,724			227,972,750
5	15,683,758	0	33,271,069	134,490,078	17,526,225	159,963,724			227,972,750
6	15,683,758	0	33,271,069	134,490,078	17,526,225	159,963,724			227,972,750
7	15,683,758	0	33,271,069	134,490,078	17,526,225	159,963,724			227,972,750
8	15,683,758	0	33,271,069	134,490,078	17,526,225	159,963,724			227,972,750
9	15,683,758	0	33,271,069	134,490,078	17,526,225	159,963,724			227,972,750
10	15,683,758	0	33,271,069	134,490,078	17,526,225	159,963,724			227,972,750
11	15,683,758	0	33,271,069	134,490,078	17,526,225	159,963,724			227,972,750
12	15,683,758	0	33,271,069	134,490,078	17,526,225	159,963,724			227,972,750
13	15,683,758	0	33,271,069	134,490,078	17,526,225	159,963,724			227,972,750
14	15,683,758	0	33,271,069	134,490,078	17,526,225	159,963,724			227,972,750
15	15,683,758	0	33,271,069	134,490,078	17,526,225	159,963,724			227,972,750
16	15,683,758	0	33,271,069	134,490,078	17,526,225	159,963,724			227,972,750
17	15,683,758	0	33,271,069	134,490,078	17,526,225	159,963,724			227,972,750
18	15,683,758	0	33,271,069	134,490,078	17,526,225	159,963,724			227,972,750
19	15,683,758	0	33,271,069	134,490,078	17,526,225	159,963,724			227,972,750
20	15,683,758	0	33,271,069	134,490,078	17,526,225	159,963,724			227,972,750
21	15,683,758	0	33,271,069	134,490,078	17,526,225	159,963,724			227,972,750
22	15,683,758	0	33,271,069	134,490,078	17,526,225	159,963,724			227,972,750
23	15,683,758	0	33,271,069	134,490,078	17,526,225	159,963,724			227,972,750
24	15,683,758	0	33,271,069	134,490,078	17,526,225	159,963,724			227,972,750
25	15,683,758	0	33,271,069	134,490,078	17,526,225	159,963,724		435,000,000	662,972,750
Total	**273,103,590**	**0**	**579,354,030**	**2,341,895,586**	**305,186,752**	**5,636,646,998**	**3,165,180,010**	**422,330,097**	**3,863,476,625**

Scenario 0 – The baseline Scenario for Romania

Romania focuses on fossil gas because a considerable amount of heating is still from the biomass. Scenario 0 examines the utilization of the available budget for the investment on the fossil gas expansion in order to install higher energy efficient boiler (EUR 4.35 billion). The CBA and SCBA are conducted to evaluate the costs and benefits of investments on the higher energy efficient boilers by average-income group of households. The average-income group usually cannot afford the initial investment cost for the energy efficiency investments.

(a) Social cost-benefit analysis in Scenario 0 for Romania

Table 119 presents the main variables and their values for calculation of social cost-benefit analysis. The methodological approach is based on the European project PRODESA[139]. Here are the other few assumptions which are similarly used for all Scenario:

- The total budget (EUR 4.35 billion) is divided by unitary investment cost (EUR 3,000) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to 1,450,000 (19.5%).
- It is assumed that the performance ratio of the energy efficient boilers is improved from 85% to 95% (assumption) efficiency.
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime of new gas boiler is equal to 15 years.

Table 119 - the variables and their values for calculating SCBA in Scenario 0 for Romania

Variables	Values	Units
Available budget for fossil fuels	4,350,000,000	EUR
Unitary investment cost	3,000	EUR
Number of affected households	1,450,000	Number of households
Unitary energy consumption for space cooling	40	kWh
Unitary energy consumption for space heating	7,521	kWh
Performance ratio of energy efficient boiler	95%	%
Performance ratio existing boiler	85%	%
Energy consumption after the interventions	6,729	kWh
Electricity price	0.16	EUR/kWh
Existing fuel price for space heating	0.06	EUR/kWh
Remaining value	30%	% of capital cost
Discount rate	3%	%

As mentioned in the methodology section, the SCBA considers all the expenditures and benefits from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition, the value added tax were deducted from the prices of energy products and the investment costs since these are costs for the individuals and not to the national economy and society. More specifically, while the NG price is equal to 0.06 $\frac{\text{EUR}}{kwh}$, the fuel price for space heating is considered to be equal to 0.058 $\frac{\text{EUR}}{kwh}$ $(NG_{Price} \times (1 - VAT))$.

In particular, the following external costs and benefit components (Table 120) are considered to evaluate the Scenario 0 in addition to the costs and benefits, which are quantified in the economic analysis:

[139] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

Table 120 – external costs and benefits and the descriptions in Scenario 0 for Romania

External costs and benefits	Description
Environmental costs from the implementations of the energy saving measure	The unit external-cost prices, which were used, concern both the effects on human health, agricultural production, and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit cost for the existing heating system (fossil gas boiler) was considered to be equal to 20.0 EUR/MWh, while the unit cost for the new fossil gas boiler amounted to 17.9 EUR/MWh.
Multiple benefits from the implementation of the energy saving measure	The multiple benefits are calculated to as a ratio of the cost saving due to the installation of the energy saving measure. The ratio is equal to 2% based on the type of multiple benefits which is considered for Romania. The multiple benefits are calculated annually, and the sum of these values are equal to the total multiple benefits of installations of energy saving measures.

The results of the social cost-benefit analysis do not indicate the social effectiveness of the Scenario 0. Therefore, implementing the Scenario 0 is not recommended as the CBA and SCBA do not support the Scenario 0 (Table 121).

Table 121 - Results of social cost-benefit analysis in Scenario 0 for Romania

SCBA	NPV	IRR	B/C
Scenario 0	-2,307,445,484	-8%	0.82

Table 122 shows the main components including the fuel costs and benefits without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 122 - Cash flows for social cost-benefit analysis in Scenario 0 for Romania (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						0	3,655,462,185		-3,655,462,185
1	0	0	578,923,343	647,031,972	174,652,717	219,462,837			112,918,749
2	0	0	578,923,343	647,031,972	174,652,717	219,462,837			112,918,749
3	0	0	578,923,343	647,031,972	174,652,717	219,462,837			112,918,749
4	0	0	578,923,343	647,031,972	174,652,717	219,462,837			112,918,749
5	0	0	578,923,343	647,031,972	174,652,717	219,462,837			112,918,749
6	0	0	578,923,343	647,031,972	174,652,717	219,462,837			112,918,749
7	0	0	578,923,343	647,031,972	174,652,717	219,462,837			112,918,749
8	0	0	578,923,343	647,031,972	174,652,717	219,462,837			112,918,749
9	0	0	578,923,343	647,031,972	174,652,717	219,462,837			112,918,749
10	0	0	578,923,343	647,031,972	174,652,717	219,462,837			112,918,749
11	0	0	578,923,343	647,031,972	174,652,717	219,462,837			112,918,749
12	0	0	578,923,343	647,031,972	174,652,717	219,462,837			112,918,749

13	0	0	578,923,343	647,031,972	174,652,717	219,462,837			112,918,749
14	0	0	578,923,343	647,031,972	174,652,717	219,462,837			112,918,749
15	0	0	578,923,343	647,031,972	174,652,717	219,462,837			112,918,749
Total	**0**	**0**	**6,911,149,295**	**7,724,225,683**	**2,084,992,793**	**2,619,933,106**	**3,655,462,185**	**0**	**-2,307,445,484**

Scenario PV – Photovoltaic solar panel installation for Romania

Scenario PV evaluates the utilisation of the available budget for the development and expansion of the fossil gas network for the installation of photovoltaic solar panel for the average-income group of households in the residential buildings. Households benefit from the investments due to generating the electricity and consequently reducing the energy costs for space heating. The economic benefits of photovoltaic solar panel are calculated based on the collected Eurostat data on weighted average cost of purchasing energy products for space heating in the residential sector.

(a) Social cost-benefit analysis in Scenario 3 for Romania

Table 123 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario PV. The methodological approach is based on the European project PRODESA[140]. Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 4.35 billion) is divided by unitary investment cost (EUR 2,321) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 4.35 billion}}{\text{EUR 2,321}} = 1{,}874{,}596\ (25.2\%)$.
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households.
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The lifetime of photovoltaic solar panel is on average 25 years.

Table 123 - the variables and their values for calculating SCBA in Scenario PV for Romania

Variables	Values	Units
Available budget for fossil fuels	4,350,000,000	EUR
Investment cost	2,321	EUR
Number of influenced households	1,874,596	number of households
Installed capacity PV	2	kW
Capacity factor PV	14%	%
Unitary investment cost	1,547	EUR/kW
Electricity consumption	1,743	kWh
Electricity price	0.16	EUR/kWh
Cost reduction due to net-metering	50%	
Electricity consumption-net metering	0.08	EUR/kWh
Cost of operation and maintenance - Baseline Scenario	0	EUR

[140] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

Cost of operation and maintenance - Alternative Scenario	100	EUR
Remaining value	0%	% of capital cost
Discount rate	3%	%

The SCBA considers all the expenditures and benefits from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is 0.16 $\frac{\text{EUR}}{kwh}$, while in the case of net metering equal to 0.08 $\frac{\text{EUR}}{kwh}$.
In particular, the following external costs and benefit components (Table 124) are considered to evaluate the Scenario 3 in addition to the costs and benefits:

Table 124 - the external costs and benefits and the descriptions in Scenario PV for Romania

External costs and benefits	Description
Environmental costs from the installation of the photovoltaic solar panel	The unit external-cost prices, which are used, concern both the impact on human health, agricultural production, and cultural heritage sites from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit cost for photovoltaic systems is considered equal to 14.1 EUR/MWh, while the corresponding price for the electricity used from the grid was taken equal to 48.5 EUR/MWh.

The results of the SCBA indicates the social effectiveness of Scenario PV for the average-income group of households living in Romania (Table 125). Therefore, the allocation of resources for installation of the photovoltaic solar panel is highly recommended instead of investments on the development and expansion of the fossil gas network.

Table 125 - Results of social cost-benefit analysis in Scenario PV for Romania

SCBA	NPV	IRR	B/C
Scenario 3	416,564,089	4%	1.06

Table 126 shows the main components including the fuel costs and benefits for Scenario PV without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 126 - Cash flows for social cost-benefit analysis in Scenario PV for Romania (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0							3,655,462,185		-3,655,462,185
1	151,177,096	0	0	262,277,535	50,312,145	173,059,506			233,847,800
2	151,177,096	0	0	262,277,535	50,312,145	173,059,506			233,847,800
3	151,177,096	0	0	262,277,535	50,312,145	173,059,506			233,847,800

4	151,177,096	0	0	262,277,535	50,312,145	173,059,506			233,847,800
5	151,177,096	0	0	262,277,535	50,312,145	173,059,506			233,847,800
6	151,177,096	0	0	262,277,535	50,312,145	173,059,506			233,847,800
7	151,177,096	0	0	262,277,535	50,312,145	173,059,506			233,847,800
8	151,177,096	0	0	262,277,535	50,312,145	173,059,506			233,847,800
9	151,177,096	0	0	262,277,535	50,312,145	173,059,506			233,847,800
10	151,177,096	0	0	262,277,535	50,312,145	173,059,506			233,847,800
11	151,177,096	0	0	262,277,535	50,312,145	173,059,506			233,847,800
12	151,177,096	0	0	262,277,535	50,312,145	173,059,506			233,847,800
13	151,177,096	0	0	262,277,535	50,312,145	173,059,506			233,847,800
14	151,177,096	0	0	262,277,535	50,312,145	173,059,506			233,847,800
15	151,177,096	0	0	262,277,535	50,312,145	173,059,506			233,847,800
16	151,177,096	0	0	262,277,535	50,312,145	173,059,506			233,847,800
17	151,177,096	0	0	262,277,535	50,312,145	173,059,506			233,847,800
18	151,177,096	0	0	262,277,535	50,312,145	173,059,506			233,847,800
19	151,177,096	0	0	262,277,535	50,312,145	173,059,506			233,847,800
20	151,177,096	0	0	262,277,535	50,312,145	173,059,506			233,847,800
21	151,177,096	0	0	262,277,535	50,312,145	173,059,506			233,847,800
22	151,177,096	0	0	262,277,535	50,312,145	173,059,506			233,847,800
23	151,177,096	0	0	262,277,535	50,312,145	173,059,506			233,847,800
24	151,177,096	0	0	262,277,535	50,312,145	173,059,506			233,847,800
25	151,177,096	0	0	262,277,535	50,312,145	173,059,506		0	233,847,800
Total	**2,632,469,103**	**0**	**0**	**4,567,077,454**	**876,092,811**	**3,013,510,734**	**3,655,462,185**	**0**	**416,564,089**

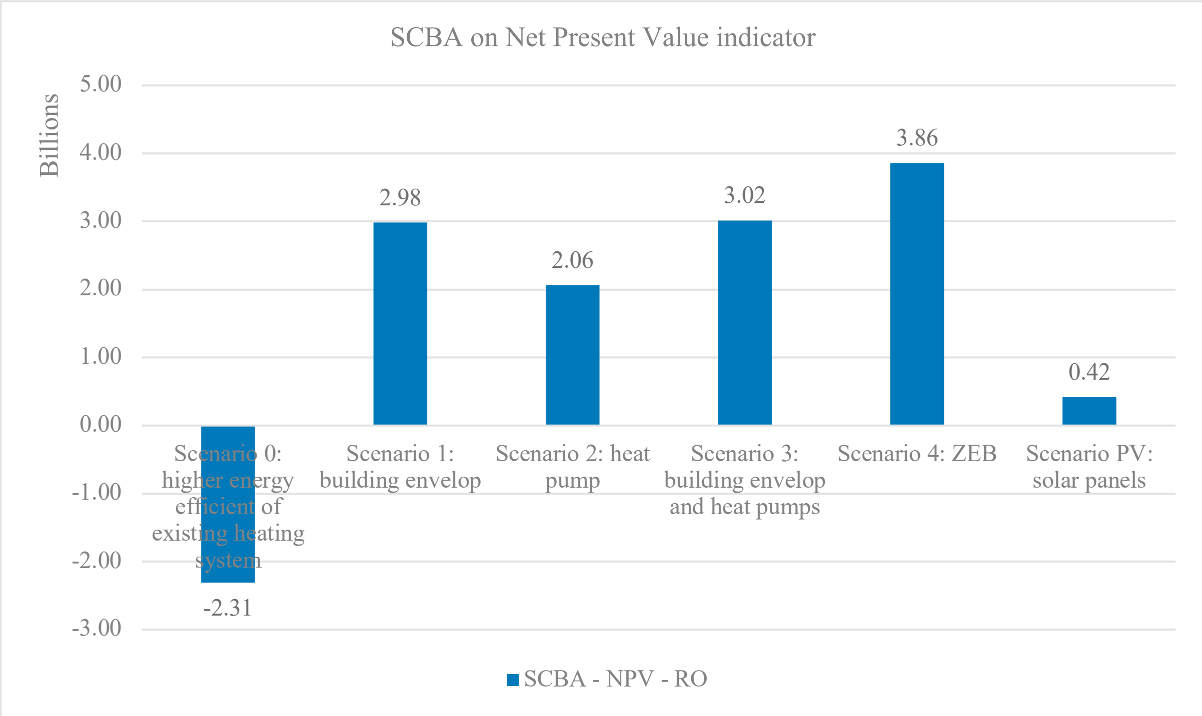
Conclusions for the case study of Romania

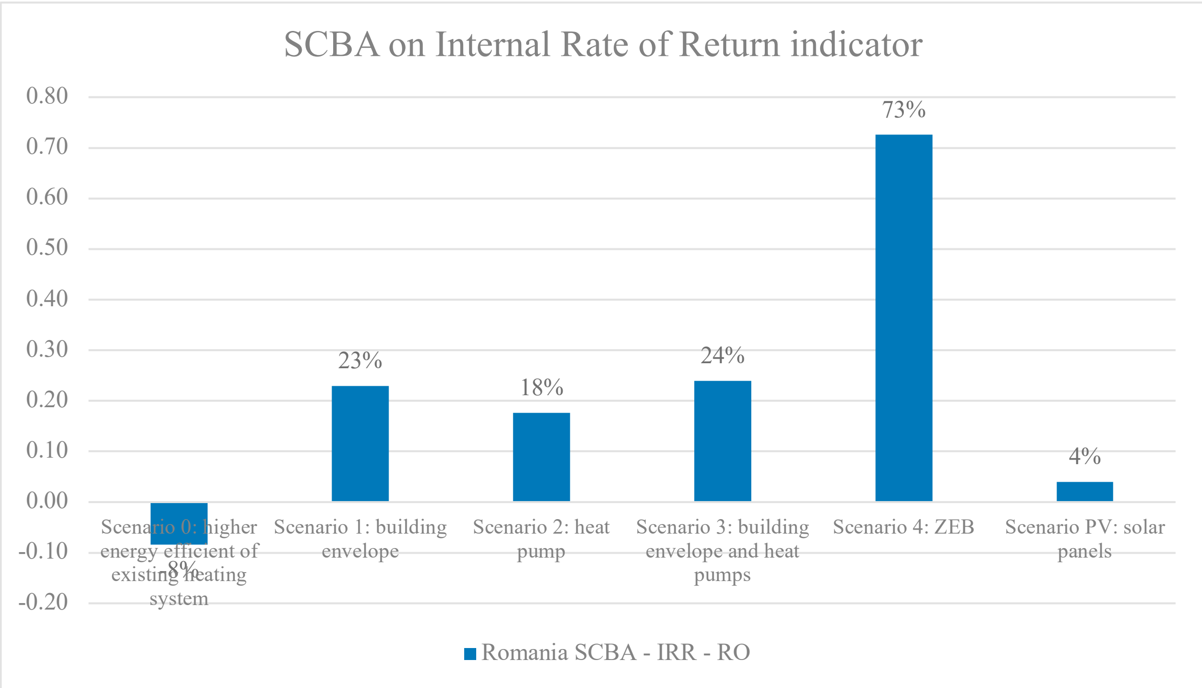
Romania highly depends on fossil fuels for its energy consumption. The national government plans to invest on the development and extension of the fossil gas by a substantial amount of capital amounting to 4.35 billion EUR, as to move its heating supply from biomass to gas. In the Scenario analyses, the allocation of the available budget, i.e., 4.35 billion EUR for demand side energy efficiency investments (in this study mainly energy retrofitting) were investigated. The energy saving technologies include: building envelope, i.e., insulation and window frames (Scenario 1); installation of heat pump (Scenario 2); integrated energy retrofitting of the energy upgrade of the building envelopes and installations of the heat pump (Scenario 3); zero energy building (Scenario 4); higher energy efficient gas boiler (Scenario 0); installation of photovoltaic solar panel (Scenario PV). The costs and benefits of these energy efficiency investments were calculated in monetary and non-monetary terms (external costs and benefits, e.g., environmental costs, multiple benefits, and increasing the value of the buildings).

Table 127 presents the summary of the financial and social benefits of all the Scenarios for Romania. Scenario 0 is the least beneficial investment, i.e., investments on a higher energy efficient boiler in terms of monetary indicators and mainly due to low fuel benefits of the investment in the long-term. When compared to the other Scenarios, Scenario 4, i.e., zero energy building, is highly recommended since the social benefits compared to other Scenarios are the highest.

Table 127 - Summarising Table – All Scenarios for Romania

Scenario	Indicators	SCBA
Scenario 1: building envelopes	NPV	2,982,147,506
	IRR	23%
	B/C	**1.85**
Scenario 2: Heat pumps	NPV	2,062,703,100
	IRR	18%
	B/C	**1.43**
Scenario 3: Building envelopes and heat pumps	NPV	3,018,132,783
	IRR	24%
	B/C	**1.82**
Scenario 4: ZEB	NPV	3,863,476,625
	IRR	73%
	B/C	**1.94**
Scenario 0	NPV	-2,307,445,484
	IRR	-8%
	B/C	**0.82**
Scenario PV: Solar panels	NPV	416,564,089
	IRR	4%
	B/C	**1.06**


SCBA on Net Present Value indicator
Billions
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
2.98
2.06
3.02
3.86
0.42
-2.31
Scenario 0: higher energy efficient of existing heating system
Scenario 1: building envelop
Scenario 2: heat pump
Scenario 3: building envelop and heat pumps
Scenario 4: ZEB
Scenario PV: solar panels
SCBA - NPV - RO


SCBA on Internal Rate of Return indicator
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-8%
23%
18%
24%
73%
4%
Scenario 0: higher energy efficient of existing heating system
Scenario 1: building envelope
Scenario 2: heat pump
Scenario 3: building envelope and heat pumps
Scenario 4: ZEB
Scenario PV: solar panels
Romania SCBA - IRR - RO

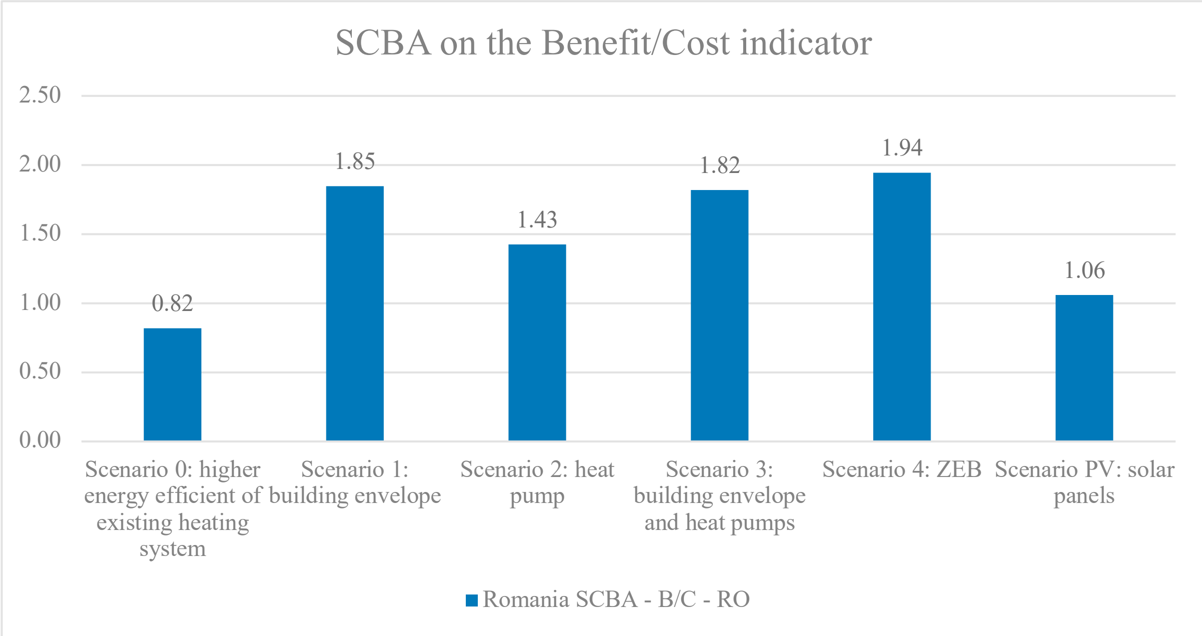


Figure 42 – summarizing figures – all the Scenarios – Romania

5.6 Scenario analyses for the case study of Slovakia

Scenario 1 – energy upgrade of the building envelopes for Slovakia

Scenario 1 evaluates the utilisation of the available budget to improve the insulation level of buildings in the residential sector and replace the windows with more energy efficient ones. Households' benefits will be energy saving for space heating and cooling and consequently reducing the energy costs. The economic benefits of improving the building envelopes are calculated using the Eurostat data of the average costs of energy for space heating. Table 128 presents the price of energy sources, the share of fuels used for space heating, and the amount devoted to space heating when considering the type of fuel individually. The sum of all the values in the second column will amount to 100, as it shows the share of each type of fuel in the total energy consumption for space heating. On the other hand, the third column will not as it illustrates the percentage devoted to space heating when considering the total consumption of the single type of fuel. This is useful to understand the role that space heating plays in the utilisation of one particular type of fuel. For example, in Slovakia, biomass is almost exclusively tied to space heating, however it is not the main fuel utilised for the latter end-use, but rather fossil gas.

Table 128: Overview of energy prices, share of fuels in space heating and shares devoted to space heating per type of fuel in Slovakia

Source of energy	Price (EUR/MWh)	Fuel share in space heating (%)	Share devoted to space heating (%)
Electricity	179.6	5.51	22.61
Heating oil	150	0	
LPG		0.23	58.57
Fossil gas	132	47.01	80.74
Solar thermal		0.017	4.89
Ambient heat		1.46	100
Biomass		27.56	91.43
District heating		17.35	82.65
Other		0.85	60.85

Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 1.122 billion) is divided by unitary investment cost (EUR 20,000) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 1.122 billion}}{\text{EUR 20,000}} = 56{,}100\ (3\%)$.
- It is also assumed that the households do not need to install a new energy efficient boiler due to reduction of energy consumption for space heating. Therefore, the required investment costs are reduced for the households. Since this Scenario considers the upgrade of the building envelope without changing the heating system, no avoided costs result since the households continue to operate the existing heating system.
- The energy saving rates for space heating and cooling are assumed to be 50% due to improving the building envelopes (Balaras, 2007).

- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime of building envelope is on average 25 years. It is also considered that 10% of the value of the investment will be remained in the year 25.
- The IRRs were approximated by assuming that the expected increase of the building value will occur in year 1 instead of year 0.

(a) Social cost-benefit analysis

Table 129 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 1. The methodological approach is based on the European project PRODESA[141].

Table 129: The variables and their values for calculating SCBA in Scenario 1 for Slovakia

Variable	Value	Unit
Available budget	1,122,000,000	EUR
Unitary investment cost	20,000	EUR
Avoided cost from new fossil fuel boiler	0	EUR
Number of influenced households	56,100	number of households
Energy consumption for space cooling	20	kWh
Energy consumption for space heating	12,083	kWh
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	10	kWh
Energy savings in space heating	6,041	kWh
Electricity price	0.15	EUR/kWh
Existing fuel price for space heating	0.11	EUR/kWh
Cost of operation and maintenance - Baseline scenario	0	EUR
Cost of operation and maintenance - Alternative scenario	0	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

The SCBA considers all the expenditures and revenues from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is $0.15\ \frac{\text{EUR}}{\text{kwh}}$, while the price for space heating is equal to $0.11\ \frac{\text{EUR}}{\text{kwh}}$. In particular, Table 146

[141] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

presents external costs and benefit components which are considered to assess Scenario 1 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 130 - external costs and benefit components for SCBA for Slovakia

External costs and benefits	Description
Environmental costs from the implementations of the energy saving measure	The unit external-cost prices include both the effects on human health, agricultural production, and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit cost for the existing heating system (coal stove or boiler) was considered to be equal to 27.2 EUR/MWh, while the unit cost for the existing cooling system (air conditioning unit) was estimated at 23.5 EUR/MWh.
Increasing the house value due to the improvement of the building envelope	The increase in the value of residential buildings is determined by calculating the cost savings due to improving the energy performance of the building envelope. A capital recovery coefficient is used, and the value is considered equal to 3%. The component needs to consider the year of implementation of the investment.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The SCBA also results in a positive NPV, with a B/C higher than 1. This indicates that a refurbishment of the building envelope by brings social benefits for Slovakian residents. Thus, Scenario 1 is recommended in terms of social benefits in Slovakia.

Table 131: Results of social cost-benefit analysis in Scenario 1 for Slovakia

SCBA	NPV	IRR	B/C
Scenario 1	1,576,242,630	54%	2.69

Table 132 shows the main components including the fuel costs and benefits for Scenario 1 without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 132: Cash flows for social cost-benefit analysis in Scenario 1 for Slovakia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						1,245,525,698	935,000,000		310,525,698
1	0	0	0	37,365,771	1,694,611	33,938,862			69,610,022
2	0	0	0	37,365,771	1,694,611	33,938,862			69,610,022
3	0	0	0	37,365,771	1,694,611	33,938,862			69,610,022
4	0	0	0	37,365,771	1,694,611	33,938,862			69,610,022
5	0	0	0	37,365,771	1,694,611	33,938,862			69,610,022
6	0	0	0	37,365,771	1,694,611	33,938,862			69,610,022
7	0	0	0	37,365,771	1,694,611	33,938,862			69,610,022
8	0	0	0	37,365,771	1,694,611	33,938,862			69,610,022
9	0	0	0	37,365,771	1,694,611	33,938,862			69,610,022

10	0	0	0	37,365,771	1,694,611	33,938,862			69,610,022
11	0	0	0	37,365,771	1,694,611	33,938,862			69,610,022
12	0	0	0	37,365,771	1,694,611	33,938,862			69,610,022
13	0	0	0	37,365,771	1,694,611	33,938,862			69,610,022
14	0	0	0	37,365,771	1,694,611	33,938,862			69,610,022
15	0	0	0	37,365,771	1,694,611	33,938,862			69,610,022
16	0	0	0	37,365,771	1,694,611	33,938,862			69,610,022
17	0	0	0	37,365,771	1,694,611	33,938,862			69,610,022
18	0	0	0	37,365,771	1,694,611	33,938,862			69,610,022
19	0	0	0	37,365,771	1,694,611	33,938,862			69,610,022
20	0	0	0	37,365,771	1,694,611	33,938,862			69,610,022
21	0	0	0	37,365,771	1,694,611	33,938,862			69,610,022
22	0	0	0	37,365,771	1,694,611	33,938,862			69,610,022
23	0	0	0	37,365,771	1,694,611	33,938,862			69,610,022
24	0	0	0	37,365,771	1,694,611	33,938,862			69,610,022
25	0	0	0	37,365,771	1,694,611	33,938,862		112,200,000	181,810,022
Total	0	0	0	650,655,688	29,508,518	1,836,508,115	935,000,000	108,932,039	1,576,242,630

Scenario 2 – Heat pump installations for Slovakia

Scenario 2 examines the allocation of the available budget for the installation of heat pumps for the average-income group of households in the residential buildings. Households benefit from the investments due to reducing the energy demands and consequently energy costs for space heating. Similarly to Scenario 1, the economic benefits of heat pump installations are calculated based on the collected Eurostat data on weighted average cost of purchasing energy products for space heating in the residential sector.

Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 1.122 billion) is divided by unitary investment cost (EUR 10,000) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 1.122 billion}}{\text{EUR 10,000}} = 112{,}200$ (6.1%).
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households.
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime of heat pump is on average 12 years.

(a) Social cost-benefit analysis for Scenario 2 for Slovakia

Table 133 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 2. The methodological approach is based on the European project PRODESA[142].

Table 133: The variables and their values for calculating SCBA in Scenario 2 for Slovakia

Variable	Value	Unit
Available budget for fossil fuels	1,122,000,000	EUR
Unitary investment cost	10,000	EUR
Avoided cost from new fossil fuel boiler	4,500	EUR
Number of influenced households	112,200	number of households
Energy consumption for space cooling	20	kWh
Energy consumption for space heating	12,083	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
Electricity price	0.15	EUR/kWh
Existing fuel price for space heating	0.11	EUR/kWh
Cost of operation and maintenance - Baseline scenario	0	EUR
Cost of operation and maintenance - Alternative scenario	0	EUR
Remaining value	0%	% of capital cost
Discount rate	3%	%

The main difference of the SCBA compared to CBA is that it quantifies the external costs and benefits. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is 0.15 $\frac{\text{EUR}}{\text{kwh}}$, while the price for space heating is equal to 0.11 $\frac{\text{EUR}}{\text{kwh}}$.

In particular, the following external costs and benefit components (Table 134) are considered to evaluate the Scenario 2 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 134: external costs and benefits and the descriptions in Scenario 2 for Slovakia

External costs and benefits	Description

[142] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

Environmental costs from the installation of heat pumps	The unit external-cost prices include both the effects on human health, agricultural production and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit costs for the existing heating system (coal stove or boiler) were considered to be equal to 27.2 EUR/MWh, while the unit cost for the installed heat pump was estimated at 14.2 EUR/MWh.
Multiple benefits from the installation of heat pumps	Multiple benefit means for example the improvement of comfort conditions in buildings and the fight against energy poverty, the reduction of morbidity and mortality cases, etc. The calculation was carried out considering that the multiple benefits are equal to 10% of the cost savings, which results from the installation of the heat pump. This component is obtained on an annual basis after the implementation of the investment under consideration.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The results of the SCBA indicates the highly social effectiveness of Scenario 2 for the average-income group of households living in Slovakia (Table 135). Therefore, the allocation of resources for installation of the heat pump is highly recommended.

Table 135: Results of social cost-benefit analysis in Scenario 2 for Slovakia

SCBA	NPV	IRR	B/C
Scenario 2	1,369,486,804	36%	2.10

Table 136 shows the main components including the fuel costs and benefits for Scenario 2 without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 136: Cash flows for social cost-benefit analysis in Scenario 2 for Slovakia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						0	514,250,000		-514,250,000
1	0	0	57,488,749	149,125,799	16,363,167	113,970,245			189,244,128
2	0	0	57,488,749	149,125,799	16,363,167	113,970,245			189,244,128
3	0	0	57,488,749	149,125,799	16,363,167	113,970,245			189,244,128
4	0	0	57,488,749	149,125,799	16,363,167	113,970,245			189,244,128
5	0	0	57,488,749	149,125,799	16,363,167	113,970,245			189,244,128
6	0	0	57,488,749	149,125,799	16,363,167	113,970,245			189,244,128
7	0	0	57,488,749	149,125,799	16,363,167	113,970,245			189,244,128
8	0	0	57,488,749	149,125,799	16,363,167	113,970,245			189,244,128
9	0	0	57,488,749	149,125,799	16,363,167	113,970,245			189,244,128
10	0	0	57,488,749	149,125,799	16,363,167	113,970,245			189,244,128
11	0	0	57,488,749	149,125,799	16,363,167	113,970,245			189,244,128
12	0	0	57,488,749	149,125,799	16,363,167	113,970,245		0	189,244,128

Total	0	0	572,243,235	1,484,398,801	162,879,032	1,134,460,270	514,250,000	0	1,369,486,804

Scenario 3 – Integrated energy retrofitting of the energy upgrade of the building envelopes and installations of the heat pump

Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 1.122 billion) is divided by unitary investment cost with subsidy (EUR 30,000) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 1.122 billion}}{\text{EUR 30,000}} = 37{,}400$ (2%).
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households (avoided fuel cost = EUR 4,500).
- The energy saving rates for space heating and cooling are assumed to be 50% due to improving the building envelops (Balaras, 2007).
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime is on average 25 years.

(a) Social cost-benefit analysis in Scenario 3 for Slovakia

Table 137 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 3. The methodological approach is based on the European project PRODESA[143].

Table 137: The variables and their values for calculating SCBA in Scenario 3 for Slovakia

Variable	Value	Unit
Available budget for fossil fuels	1,122,000,000	EUR
Unitary investment cost-Building envelope	20,000	EUR
Unitary investment cost-Heat pump	10,000	EUR
Unitary investment cost-PV	0	EUR
Avoided cost from new fossil fuel boiler	4,500	EUR
Number of influenced households	37,400	number of households
Installed capacity PV	0	kW
Unitary investment cost PV	1,560	EUR/kW
Capacity factor PV	12%	%
Energy consumption for space cooling	20	kWh
Energy consumption for space heating	12,083	kWh
Performance ratio existing boiler	85%	%

[143] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

COP heat pump	3.0	
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	10	kWh
Energy savings in space heating	6,041	kWh
Electricity consumption after interventions	4,968	kWh
Electricity price	0.15	EUR/kWh
Cost reduction due to net-metering	100%	
Electricity price-net metering	0.15	EUR/kWh
Existing fuel price for space heating	0.11	EUR/kWh
Cost of operation and maintenance - Baseline scenario	0	EUR
Cost of operation and maintenance - Alternative scenario	100	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

The SCBA considers all the expenditures and revenues from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is $0.15\ \frac{\mathrm{EUR}}{\mathrm{kwh}}$, while the price for space heating and the electricity price-net metering are equal to $0.11\ \frac{\mathrm{EUR}}{\mathrm{kwh}}$ and $0.15\ \frac{\mathrm{EUR}}{\mathrm{kwh}}$.

In particular, Table 158 presents external costs and benefit components are assessed to assess the Scenario 3 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 138: the external costs and benefits and the descriptions for Scenario 3 for Slovakia

External costs and benefits	Description

Environmental costs from the implementations of the energy saving measure	The unit external-cost prices include both the effects on human health, agricultural production and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit costs for the existing heating system (coal stove or boiler) were considered to be equal to 27.2 EUR/MWh, while unit cost for the existing cooling system (air conditioning unit) was estimated at 23.5 EUR/MWh. Moreover, the unit cost for the installed heat pump was estimated at 14.2 EUR/MWh. Finally, the unit cost for photovoltaic systems is considered equal to 14.1 EUR/MWh, while the corresponding price for the electricity used from the grid was taken equal to 48.5 EUR/MWh.
Increasing the house value due to the improvement of the building envelope	The increase in the value of residential buildings is determined by calculating the cost savings due to improving the energy performance of the building envelope. A capital recovery coefficient is used, and the value is considered equal to 3%. The component needs to consider the year of implementation of the investment.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The results of the SCBA indicate the social effectiveness of Scenario 3 for the average-income group of households living in Slovakia (Table 139). It should be noticed that social efficiency is significantly influenced by the double investment regarding the replacement of the heat pump (after the end of the 12-year life) with a new heat pump for the next 12 years, until the investment is repaid in the building envelope that has a lifespan of 25 years.

Table 139: Results of social cost-benefit analysis in Scenario 3 for Slovakia

SCBA	NPV	IRR	B/C
Scenario 3	1,795,611,170	77%	2.74

Table 160 shows the main components including the fuel costs and benefits for Scenario 3 without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 140: Cash flows for social cost-benefit analysis in Scenario 3 for Slovakia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						1,238,907,556	794,750,000		444,157,556
1	3,016,129	0	9,581,458	49,764,814	2,727,195	40,093,665			74,533,697
2	3,016,129	0	9,581,458	49,764,814	2,727,195	40,093,665			74,533,697
3	3,016,129	0	9,581,458	49,764,814	2,727,195	40,093,665			74,533,697
4	3,016,129	0	9,581,458	49,764,814	2,727,195	40,093,665			74,533,697
5	3,016,129	0	9,581,458	49,764,814	2,727,195	40,093,665			74,533,697
6	3,016,129	0	9,581,458	49,764,814	2,727,195	40,093,665			74,533,697
7	3,016,129	0	9,581,458	49,764,814	2,727,195	40,093,665			74,533,697
8	3,016,129	0	9,581,458	49,764,814	2,727,195	40,093,665			74,533,697
9	3,016,129	0	9,581,458	49,764,814	2,727,195	40,093,665			74,533,697

10	3,016,129	0	9,581,458	49,764,814	2,727,195	40,093,665			74,533,697
11	3,016,129	0	9,581,458	49,764,814	2,727,195	40,093,665			74,533,697
12	3,016,129	0	9,581,458	49,764,814	2,727,195	40,093,665			74,533,697
13	3,016,129	0	9,581,458	49,764,814	2,727,195	40,093,665			74,533,697
14	3,016,129	0	9,581,458	49,764,814	2,727,195	40,093,665			74,533,697
15	3,016,129	0	9,581,458	49,764,814	2,727,195	40,093,665			74,533,697
16	3,016,129	0	9,581,458	49,764,814	2,727,195	40,093,665			74,533,697
17	3,016,129	0	9,581,458	49,764,814	2,727,195	40,093,665			74,533,697
18	3,016,129	0	9,581,458	49,764,814	2,727,195	40,093,665			74,533,697
19	3,016,129	0	9,581,458	49,764,814	2,727,195	40,093,665			74,533,697
20	3,016,129	0	9,581,458	49,764,814	2,727,195	40,093,665			74,533,697
21	3,016,129	0	9,581,458	49,764,814	2,727,195	40,093,665			74,533,697
22	3,016,129	0	9,581,458	49,764,814	2,727,195	40,093,665			74,533,697
23	3,016,129	0	9,581,458	49,764,814	2,727,195	40,093,665			74,533,697
24	3,016,129	0	9,581,458	49,764,814	2,727,195	40,093,665			74,533,697
25	3,016,129	0	9,581,458	49,764,814	2,727,195	40,093,665		112,200,000	186,733,697
Total	52,520,300	0	166,843,345	866,562,053	47,489,041	1,937,064,459	794,750,000	108,932,039	1,795,611,170

Scenario 4 – zero energy buildings by combining various investments for Slovakia

Scenario 4 examines the use of the available budget to promote zero-energy buildings (ZEB) for households. ZEB can be achieved through the combination of thermal insulation of external wall, the replacement of existing window frames (not roofs and walls) with new energy efficient ones, and the installation of photovoltaic solar panel in residential buildings and the installation of a heat pump.

The benefits of households could be the reduction of energy costs due to both the reduced energy demand for space heating and cooling, as well as the operation of the heat pump. The economic benefits of heat pump installations are calculated based on the collected Eurostat data on weighted average cost of purchasing energy products for space heating in the residential sector.

Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 1.122 billion) is divided by unitary investment cost with subsidy (EUR 37,800) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 1.122 billion}}{\text{EUR 37,800}} = 29{,}683\ (1.6\%)$.
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households (avoided fuel cost = EUR 4,500).

- The energy saving rates for space heating and cooling are assumed to be 50% due to improving the building envelops (Balaras, 2007).
- The operation and maintenance costs are assumed higher for the alternative Scenario compared to the baseline one.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime is on average 25 years.

(a) Social cost-benefit analysis in Scenario 4 for Slovakia

Table 141 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 4. The methodological approach is based on the European project PRODESA[144].

Table 141: The variables and their values for calculating SCBA in Scenario 4 for Slovakia

Variable	Value	Unit
Available budget	1,122,000,000	EUR
Unitary investment cost-Building envelope	20,000	EUR
Unitary investment cost-Heat pump	10,000	EUR
Unitary investment cost-PV	7,800	EUR
Avoided cost from new fossil fuel boiler	4,500	EUR
Number of influenced households	29,683	number of households
Installed capacity PV	5	kW
Unitary investment cost PV	1,560	EUR/kW
Capacity factor PV	12%	%
Energy consumption for space cooling	20	kWh
Energy consumption for space heating	12,083	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	10	kWh
Energy savings in space heating	6,041	kWh
Electricity consumption after interventions	4,968	kWh
Electricity price	0.15	EUR/kWh
Cost reduction due to net-metering	50%	
Electricity price-net metering	0.07	EUR/kWh
Existing fuel price for space heating	0.11	EUR/kWh
Cost of operation and maintenance - Baseline scenario	0	EUR
Cost of operation and maintenance - Alternative scenario	100	EUR
Remaining value	10%	% of capital cost

[144] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

Discount rate	3%	%

The SCBA considers all the expenditures and revenues from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is $0.15\,\frac{\text{EUR}}{\text{kwh}}$, while the price for space heating and the electricity price-net metering are both equal to $0.07\,\frac{\text{EUR}}{\text{kwh}}$.

In particular, Table 142 presents external costs and benefit components are assessed to assess the Scenario 4 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 142: the external costs and benefits and the descriptions for Scenario 4 for Slovakia

External costs and benefits	Description
Environmental costs from the implementations of the energy saving measure	The unit external-cost prices include both the effects on human health, agricultural production and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit costs for the existing heating system (coal stove or boiler) were considered to be equal to 27.2 EUR/MWh, while unit cost for the existing cooling system (air conditioning unit) was estimated at 23.5 EUR/MWh. Moreover, the unit cost for the installed heat pump was estimated at 14.2 EUR/MWh. Finally, the unit cost for photovoltaic systems is considered equal to 14.1 EUR/MWh, while the corresponding price for the electricity used from the grid was taken equal to 48.5 EUR/MWh.
Increasing the house value due to the improvement of the building envelope	The increase in the value of residential buildings is determined by calculating the cost savings due to improving the energy performance of the building envelope. A capital recovery coefficient is used, and the value is considered equal to 3%. The component needs to consider the year of implementation of the investment.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The results of the SCBA indicate the social effectiveness of Scenario 4 for the average-income group of households living in Slovakia (Table 143). Therefore, the allocation of resources for ZEB is highly recommended instead of investments on modernisation of biogas plants, district heating and cooling (DHC) and cogenerations. It should be noticed that social efficiency is significantly influenced by the double investment regarding the replacement of the heat pump (after the end of the 12-year life) with a new heat pump for the next 12 years, until the investment is repaid in the building envelope that has a lifespan of 25 years.

Table 143: Results of social cost-benefit analysis in Scenario 4 for Slovakia

SCBA	NPV	IRR	B/C
Scenario 4	1,899,757,822	84%	2.82

Table 144 shows the main components including the fuel costs and benefits for Scenario 4 without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 144: Cash flows for social cost-benefit analysis in Scenario 4 for Slovakia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						1,351,102,795	823,690,476		527,412,319
1	2,393,753	0	7,604,332	50,531,169	4,437,024	39,637,414			75,733,473
2	2,393,753	0	7,604,332	50,531,169	4,437,024	39,637,414			75,733,473
3	2,393,753	0	7,604,332	50,531,169	4,437,024	39,637,414			75,733,473
4	2,393,753	0	7,604,332	50,531,169	4,437,024	39,637,414			75,733,473
5	2,393,753	0	7,604,332	50,531,169	4,437,024	39,637,414			75,733,473
6	2,393,753	0	7,604,332	50,531,169	4,437,024	39,637,414			75,733,473
7	2,393,753	0	7,604,332	50,531,169	4,437,024	39,637,414			75,733,473
8	2,393,753	0	7,604,332	50,531,169	4,437,024	39,637,414			75,733,473
9	2,393,753	0	7,604,332	50,531,169	4,437,024	39,637,414			75,733,473
10	2,393,753	0	7,604,332	50,531,169	4,437,024	39,637,414			75,733,473
11	2,393,753	0	7,604,332	50,531,169	4,437,024	39,637,414			75,733,473
12	2,393,753	0	7,604,332	50,531,169	4,437,024	39,637,414			75,733,473
13	2,393,753	0	7,604,332	50,531,169	4,437,024	39,637,414			75,733,473
14	2,393,753	0	7,604,332	50,531,169	4,437,024	39,637,414			75,733,473
15	2,393,753	0	7,604,332	50,531,169	4,437,024	39,637,414			75,733,473
16	2,393,753	0	7,604,332	50,531,169	4,437,024	39,637,414			75,733,473
17	2,393,753	0	7,604,332	50,531,169	4,437,024	39,637,414			75,733,473
18	2,393,753	0	7,604,332	50,531,169	4,437,024	39,637,414			75,733,473
19	2,393,753	0	7,604,332	50,531,169	4,437,024	39,637,414			75,733,473
20	2,393,753	0	7,604,332	50,531,169	4,437,024	39,637,414			75,733,473
21	2,393,753	0	7,604,332	50,531,169	4,437,024	39,637,414			75,733,473
22	2,393,753	0	7,604,332	50,531,169	4,437,024	39,637,414			75,733,473
23	2,393,753	0	7,604,332	50,531,169	4,437,024	39,637,414			75,733,473
24	2,393,753	0	7,604,332	50,531,169	4,437,024	39,637,414			75,733,473
25	2,393,753	0	7,604,332	50,531,169	4,437,024	39,637,414		112,200,000	187,933,473
Total	41,682,778	0	132,415,354	879,906,707	77,262,561	2,041,314,939	823,690,476	108,932,039	1,899,757,822

Scenario 0 – The baseline Scenario for Slovakia

The share of fossil gas and biomass utilisation for space heating is almost 48% and 27% in Slovakia. This illustrates not only a high consumption but also dependence on this type of fuel in the country. For this reason, Scenario 0 examines the utilization of the available budget to install higher energy efficient boilers (EUR 321 million). However, this entails more energy efficient biomass boilers, as a considerable share of the population still utilises boilers running on coal. The CBA and SCBA are conducted to evaluate the costs and benefits of investment on the higher energy efficient boilers by average-income groups of households. The average-income groups usually cannot afford the initial investment cost for the energy efficiency investments.

Here are the other few assumptions which are similarly used for all Scenario:

- The total budget (EUR 1.122 billion) is divided by unitary investment cost (EUR 4,500) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to 249,333 (13.5%).
- It is assumed that the performance ratio of the energy efficient boilers is improved from 85% to 95% (assumption) efficiency.
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime of the new biomass boiler is equal to 15 years.

(a) Social cost-benefit analysis in Scenario 0 for Slovakia

Table 145 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 0. The methodological approach is based on the European project PRODESA[145].

Table 145: The variables and their values for calculating SCBA in Scenario 0 for Slovakia

Variable	Value	Unit
Available budget	1,122,000,000	EUR
Unitary investment cost	4,500	EUR
Avoided cost from natural gas boilers	0	EUR
Number of affected households	249,333	number of households
Unitary energy consumption for space cooling	20	kWh
Unitary energy consumption for space heating	12,083	kWh
Performance ratio of energy efficient boiler	95%	%
Performance ratio existing boiler	85%	%
Energy consumption after the interventions	10,811	kWh
Electricity price	0.15	EUR/kWh
Existing fuel price for space heating	0.11	EUR/kWh
Cost of operation and maintenance - Baseline scenario	0	EUR
Cost of operation and maintenance - Alternative scenario	0	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

[145] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

As mentioned in the methodology section, The SCBA considers all the expenditures and revenues from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition, the value added tax was deducted from the prices of energy products and the investment costs since these are costs for the individuals and not to the national economy and society. More specifically, while the NG price is equal to 0.079 $\frac{\mathrm{EUR}}{\mathrm{kwh}}$, the fuel price for space heating is considered to be equal to 0.0719 $\frac{\mathrm{EUR}}{\mathrm{kwh}}$ $(\mathrm{NG}_{\mathrm{Price}} \times\ (1 - \mathrm{VAT}))$.

In particular, the following external costs and benefit components (Table 146) are considered to evaluate the Scenario 0 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 146: external costs and benefits and the descriptions in Scenario 0 for Slovakia

External costs and benefits	Description
Environmental costs from the implementations of the energy saving measure	The unit external-cost prices, which were used, concern both the effects on human health, agricultural production, and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit costs for the existing heating system (coal stove or boiler) were considered to be equal to 27.2 EUR/MWh, while unit cost for the new biomass boiler was estimated at 11.2 EUR/MWh for Scenario 0 in Slovakia.
Multiple benefits from the implementation of the energy saving measure	The multiple benefits are calculated to as a ratio of the cost saving due to the installation of the energy saving measure. The ratio is equal to 2% based on the type of multiple benefits which is considered for Slovakia. The multiple benefits are calculated annually, and the sum of these values are equal to the total multiple benefits of installations of energy saving measures.

The results of the social cost-benefit analysis do not indicate a social effectiveness of the Scenario 0. Therefore, implementing the Scenario 0 is not recommended as the CBA and SCBA do not support it.

Table 147: Results of social cost-benefit analysis in Scenario 0 for Slovakia

SCBA	NPV	IRR	B/C
Scenario 0	-366,946,562	-3%	0.93

Table 148 shows the main components including the fuel costs and benefits without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 148: Cash flows for social cost-benefit analysis in Scenario 0 for Slovakia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						0	935,000,000		-935,000,000
1	0	0	296,507,437	331,390,665	48,249,847	60,950,513			47,583,894

2	0	0	296,507,437	331,390,665	48,249,847	60,950,513			47,583,894
3	0	0	296,507,437	331,390,665	48,249,847	60,950,513			47,583,894
4	0	0	296,507,437	331,390,665	48,249,847	60,950,513			47,583,894
5	0	0	296,507,437	331,390,665	48,249,847	60,950,513			47,583,894
6	0	0	296,507,437	331,390,665	48,249,847	60,950,513			47,583,894
7	0	0	296,507,437	331,390,665	48,249,847	60,950,513			47,583,894
8	0	0	296,507,437	331,390,665	48,249,847	60,950,513			47,583,894
9	0	0	296,507,437	331,390,665	48,249,847	60,950,513			47,583,894
10	0	0	296,507,437	331,390,665	48,249,847	60,950,513			47,583,894
11	0	0	296,507,437	331,390,665	48,249,847	60,950,513			47,583,894
12	0	0	296,507,437	331,390,665	48,249,847	60,950,513			47,583,894
13	0	0	296,507,437	331,390,665	48,249,847	60,950,513			47,583,894
14	0	0	296,507,437	331,390,665	48,249,847	60,950,513			47,583,894
15	0	0	296,507,437	331,390,665	48,249,847	60,950,513			47,583,894
Total	0	0	3,539,686,536	3,956,120,246	576,003,536	727,623,264	935,000,000	0	-366,946,562

Conclusions for the case study of Slovakia

The fossil gas (47%) and biomass (28%) are currently the main source of heating in Slovakia. It is expected that changing the heating system will enormously improve the energy performance of the Slovakian building sector. The results of the Scenario analyses indicate that Scenario 0 is the worst performing Scenario in terms of economic and social indicators compared to the others. NPV, IRR and B/C are the lowest for both economical and societal analyses in terms of costs and benefits for Scenario 0.

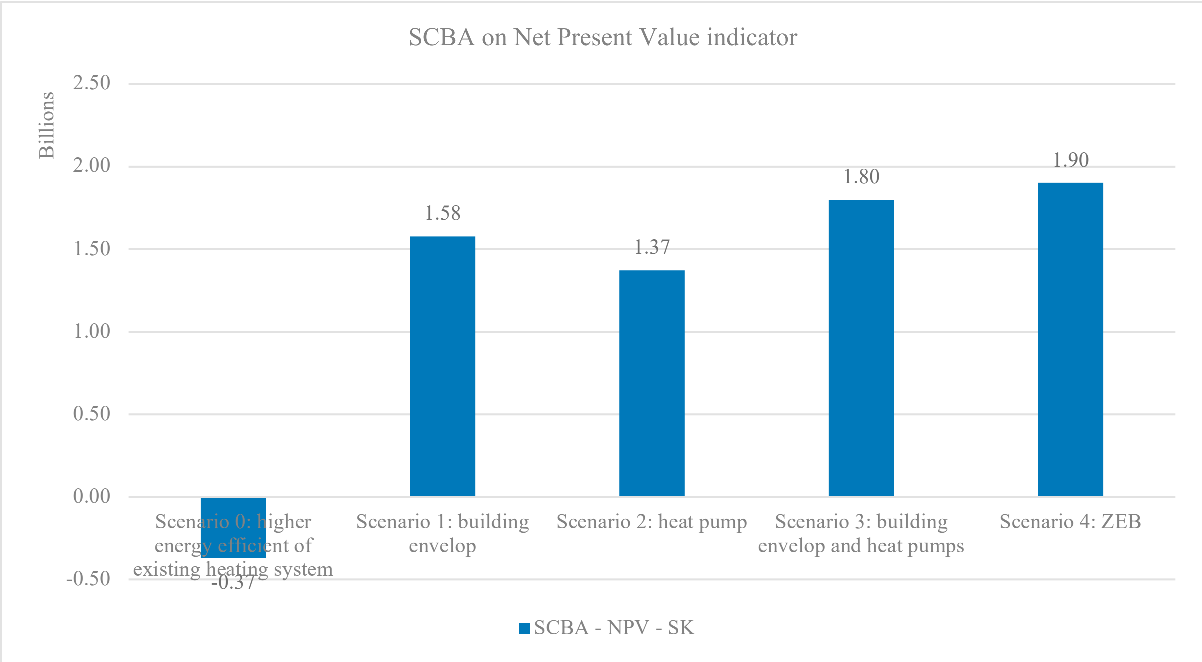
Scenario 2, i.e., installation of heat pump, is the best-performing Scenario in terms of pure economic analysis. The energy saving due to installation of heat pump compared to the gas boiler is considerably high and economically beneficial for the people living in Slovakia. According to a study from the UK[146], households can save up to 27% on their energy bills by installing a heat pump compared to a gas boiler. However, the prerequisite for installing the heat pump is a highly insulated building. Scenarios 4 and 3 are the first- and second-best performing Scenarios in terms of social costs and benefits. Both scenarios also present positive IRR when performing a CBA, indicating a potential positive economic outcome. To conclude, due to high economic social benefits, the implementation of Scenario 4 is highly recommended.

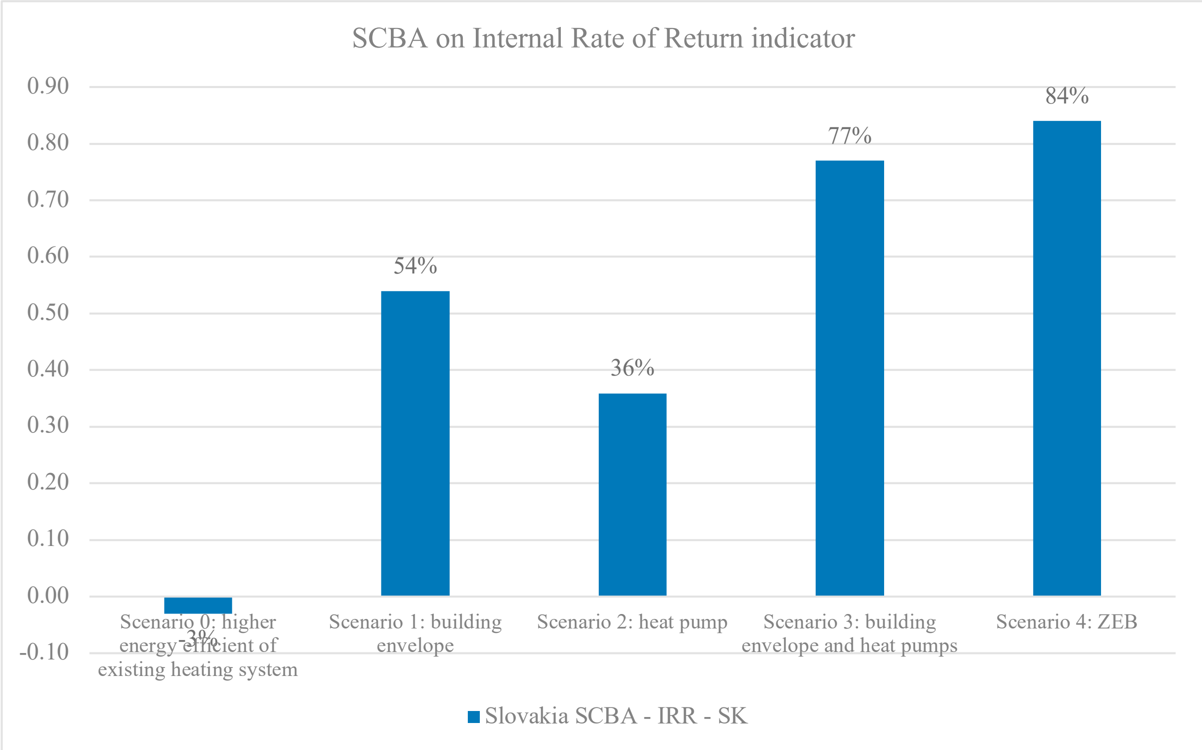
Table 149 - Summarizing Table – All Scenarios for Slovakia

Scenario Slovakia	Indicators	SCBA
Scenario 1: Building envelopes	NPV	1,576,242,630
	IRR	54%

[146] http://efaidnbmillionnnibpcajpcglclefindmkaj/https://www.raponline.org/wp-content/uploads/2022/02/Heat-pump-running-costs-v271.pdf

	B/C	2.69
Scenario 2: Heat pumps	NPV	1,369,486,804
	IRR	36%
	B/C	2.10
Scenario 3: Building envelopes and heat pumps	NPV	1,795,611,170
	IRR	77%
	B/C	2.74
Scenario 4: ZEB	NPV	1,899,757,822
	IRR	_84%
	B/C	2.82
Scenario 0: Higher energy efficiency heating systems	NPV	-366,946,562
	IRR	-3%
	B/C	0.93





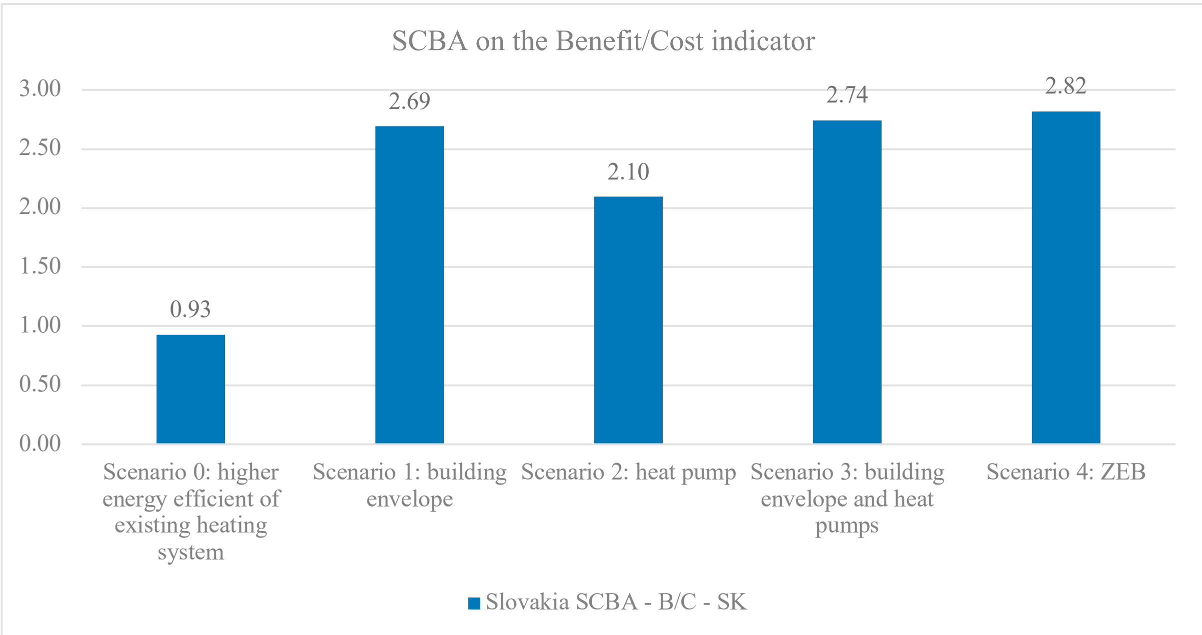


Figure 43 – summarizing figures – all Scenarios – Slovakia

5.7 Scenario analyses for the case study of Slovenia

Scenario 1 – energy upgrade of the building envelopes for Slovenia

Scenario 1 evaluates the utilisation of the available budget to improve the insulation level of the buildings and replace the windows with more energy efficient ones in the residential sector. Households' benefits will be energy saving for space heating and cooling and consequently reducing the energy costs. The economic benefits of improving the building envelopes are calculated using the Eurostat data of the average costs of energy for space heating. Table 150 presents the price of energy sources, the share of fuels used for space heating, and the amount devoted to space heating when considering the type of fuel individually. The sum of all the values in the second column will amount to 100, as it shows the share of each type of fuel in the total energy consumption for space heating. On the other hand, the third column will not as it illustrates the percentage devoted to space heating when considering the total consumption of the single type of fuel. This is useful to understand the role that space heating plays in the utilisation of one particular type of fuel. For example, in Slovenia, it can be seen that biomass and fossil gas are the most utilised type of fuel for space heating and that biomass is used prevalently for space heating.

Table 150 - Overview of energy prices, share of fuels in space heating and shares devoted to space heating per type of fuel in Slovenia

Source of energy	Price (EUR/MWh)	Fuel share in space heating (%)	Share devoted to space heating (%)
Electricity	102	0.203	0.86
Heating oil		0.001	0.14
LPG		0.008	0.14
Fossil gas	51	29.86	58.54
Solar thermal		0	-
Ambient heat		0	-
Biomass		54.59	85.64
District heating		14.75	100
Other		0.59	68.91

Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 103.4 million) is divided by unitary investment cost 16,000 to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 103.4 } milion}{\text{EUR 16,000}}$ = 6,463 (0.8%).
- It is also assumed that the households do not need to install a new energy efficient boiler due to reduction of energy consumption for space heating. Therefore, the required investment costs are reduced for the households. Since this Scenario considers the upgrade of the building envelope without changing the heating system, no avoided costs result since the households continue to operate the existing heating system.
- The energy saving rates for space heating and cooling are assumed to be 50% due to improving the building envelops (Balaras, 2007).

- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime of building envelope is on average 25 years. It is also considered that 10% of the value of the investment will be remained in the year 25.

(a) Social cost-benefit analysis in Scenario 1 for Slovenia

Table 151 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 1. The methodological approach is based on the European project PRODESA[147].

Table 151 - the variables and their values for calculating SCBA in Scenario 1 for Slovenia

Variable	Value	Unit
Available budget	103,400,000	€
Unitary investment cost	16,000	€
Number of influenced households	6,463	number of households
Energy consumption for space cooling	112	kWh
Energy consumption for space heating	9,206	kWh
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	56	kWh
Energy savings in space heating	4,603	kWh
Electricity price	0.09	€/kWh
Existing fuel price for space heating	0.05	€/kWh
Remaining value	10%	% of capital cost
Discount rate	3%	%

The SCBA considers all the expenditures and revenues from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is $0.09\,\frac{\mathrm{EUR}}{kwh}$, while the price for space heating is equal to $0.05\,\frac{\mathrm{EUR}}{kwh}$.

In particular, Table 152 presents external costs and benefit components which are considered to assess Scenario 1 in addition to the costs and benefits, which are quantified in the economic analysis:

[147] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

Table 152 - external costs and benefits and the descriptions in Scenario 1 for Slovenia

External costs and benefits	Description
Environmental costs from the implementations of the energy saving measure	The unit external-cost prices include both the effects on human health, agricultural production, and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit cost for the existing heating system (coal stove or boiler) was considered to be equal to 27.2 EUR/MWh, while the unit cost for the existing cooling system (air conditioning unit) was estimated at 23.5 EUR/MWh.
Increasing the house value due to the improvement of the building envelope	The increase in the value of residential buildings is determined by calculating the cost savings due to improving the energy performance of the building envelope. A capital recovery coefficient is used, and the value is considered equal to 3%. The component needs to consider the year of implementation of the investment.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The results of the SCBA indicates the highly social effectiveness of Scenario 1 for the average-income group of households living in Slovenia. Therefore, the allocation of resources for improving the building envelope is highly recommended instead of investments on the expansion of the gas network.

Table 153 - Results of social cost-benefit analysis in Scenario 1 for Slovenia

SCBA	NPV	IRR	B/C
Scenario 1	31,957,312	8%	1.38

Table 154 shows the main components including the fuel costs and benefits for Scenario 1 without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 154 - Cash flows for social cost-benefit analysis in Scenario 1 for Slovenia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						47,035,157	94,429,224		-47,394,066
1	0	0	0	1,411,055	148,738	3,011,060			4,273,377
2	0	0	0	1,411,055	148,738	3,011,060			4,273,377
3	0	0	0	1,411,055	148,738	3,011,060			4,273,377
4	0	0	0	1,411,055	148,738	3,011,060			4,273,377
5	0	0	0	1,411,055	148,738	3,011,060			4,273,377
6	0	0	0	1,411,055	148,738	3,011,060			4,273,377
7	0	0	0	1,411,055	148,738	3,011,060			4,273,377
8	0	0	0	1,411,055	148,738	3,011,060			4,273,377

9	0	0	0	1,411,055	148,738	3,011,060			4,273,377
10	0	0	0	1,411,055	148,738	3,011,060			4,273,377
11	0	0	0	1,411,055	148,738	3,011,060			4,273,377
12	0	0	0	1,411,055	148,738	3,011,060			4,273,377
13	0	0	0	1,411,055	148,738	3,011,060			4,273,377
14	0	0	0	1,411,055	148,738	3,011,060			4,273,377
15	0	0	0	1,411,055	148,738	3,011,060			4,273,377
16	0	0	0	1,411,055	148,738	3,011,060			4,273,377
17	0	0	0	1,411,055	148,738	3,011,060			4,273,377
18	0	0	0	1,411,055	148,738	3,011,060			4,273,377
19	0	0	0	1,411,055	148,738	3,011,060			4,273,377
20	0	0	0	1,411,055	148,738	3,011,060			4,273,377
21	0	0	0	1,411,055	148,738	3,011,060			4,273,377
22	0	0	0	1,411,055	148,738	3,011,060			4,273,377
23	0	0	0	1,411,055	148,738	3,011,060			4,273,377
24	0	0	0	1,411,055	148,738	3,011,060			4,273,377
25	0	0	0	1,411,055	148,738	3,011,060		10,340,000	14,613,377
Total	0	0	0	24,570,904	2,589,999	99,467,189	94,429,224	10,038,835	31,957,312

Scenario 2 – Heat pump installations for Slovenia

Scenario 2 examines the allocation of the available budget for the installation of heat pumps for the average-income group of households in the residential buildings. Households benefit from the investments due to reducing the energy demands and consequently energy costs for space heating. Similar to Scenario 1, the economic benefits of heat pump installations are calculated based on the collected Eurostat data on weighted average cost of purchasing energy products for space heating in the residential sector.

Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 103.4 million) is divided by unitary investment cost (EUR10,000) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 103.4 million}}{\text{EUR 10,000}} = 10{,}340$ (1.2%).
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households.
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.

- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime of heat pump is on average 12 years.

(a) Social cost-benefit analysis in Scenario 2 for Slovenia

Table 155 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 2. The methodological approach is based on the European project PRODESA[148].

Table 155 - the variables and their values for calculating SCBA in Scenario 2 for Slovenia

Variable	Value	Unit
Available budget	103,400,000	EUR
Unitary investment cost	10,000	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Number of influenced households	10,340	number of households
Energy consumption for space cooling	112	kWh
Energy consumption for space heating	9,206	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
Electricity price	0.09	EUR/kWh
Existing fuel price for space heating	0.05	EUR/kWh
Cost of operation and maintenance - Baseline scenario	0	EUR
Cost of operation and maintenance - Alternative scenario	0	EUR
Remaining value	0%	% of capital cost
Discount rate	3%	%

The SCBA considers all the expenditures and revenues from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is $0.09\ \frac{\text{EUR}}{kwh}$, while the price for space heating is equal to $0.05\ \frac{\text{EUR}}{kwh}$.

In particular, the following external costs and benefit components (Table 156) are considered to evaluate the Scenario 2 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 156 - external costs and benefits and the descriptions in Scenario 2 for Slovenia

External costs and benefits	Description

[148] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D26.

Environmental costs from the installation of heat pumps	The unit external-cost prices include both the effects on human health, agricultural production and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit costs for the existing heating system (coal stove or boiler) were considered to be equal to 27.2 EUR/MWh, while unit cost for the existing cooling system (air conditioning unit) was estimated at 23.5 EUR/MWh. Moreover, the unit cost for the installed heat pump was estimated at 14.2 EUR/MWh.
Multiple benefits from the installation of heat pumps	Multiple benefit means for example the improvement of comfort conditions in buildings and the fight against energy poverty, the reduction of morbidity and mortality cases, etc. The calculation was carried out considering that the multiple benefits are equal to 2% of the cost savings, which results from the installation of the heat pump. This component is obtained on an annual basis after the implementation of the investment under consideration.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The results of the SCBA indicates the highly social effectiveness of Scenario 2 for the average-income group of households living in Slovenia (Table 157). Therefore, the allocation of resources for installation of the heat pump is highly recommended instead of investments on the expansion of the gas network.

Table 157: Results of social cost-benefit analysis in Scenario 2 for Slovenia

SCBA	**NPV**	**IRR**	**B/C**
Scenario 2	25,828,983	10%	1.28

Table 158 shows the main components including the fuel costs and benefits for Scenario 2 without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 158: Cash flows for social cost-benefit analysis in Scenario 2 for Slovenia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						0	56,657,534		-56,657,534
1	0	0	2,519,773	4,407,538	1,148,972	7,547,975			8,286,768
2	0	0	2,519,773	4,407,538	1,148,972	7,547,975			8,286,768
3	0	0	2,519,773	4,407,538	1,148,972	7,547,975			8,286,768
4	0	0	2,519,773	4,407,538	1,148,972	7,547,975			8,286,768
5	0	0	2,519,773	4,407,538	1,148,972	7,547,975			8,286,768
6	0	0	2,519,773	4,407,538	1,148,972	7,547,975			8,286,768
7	0	0	2,519,773	4,407,538	1,148,972	7,547,975			8,286,768
8	0	0	2,519,773	4,407,538	1,148,972	7,547,975			8,286,768
9	0	0	2,519,773	4,407,538	1,148,972	7,547,975			8,286,768
10	0	0	2,519,773	4,407,538	1,148,972	7,547,975			8,286,768

11	0	0	2,519,773	4,407,538	1,148,972	7,547,975			8,286,768
12	0	0	2,519,773	4,407,538	1,148,972	7,547,975		0	8,286,768
Total	0	0	25,081,829	43,872,650	11,436,873	75,132,570	56,657,534	0	25,828,983

Scenario 3 – Integrated energy retrofitting of the energy upgrade of the building envelopes and installations of the heat pump

Scenario 3 indicates the integrated effects of the implementations of the improvement of the building envelopes together with installations of the heat pump (i.e., the combined effects of Scenarios 1 and 2).

Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 103.4 million) is divided by unitary investment cost with subsidy (EUR 26,000) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 103.4 } million}{\text{EUR 26,000}} = 3{,}977$ (0.5%).
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households (avoided fuel cost = EUR 4,000).
- The energy saving rates for space heating and cooling are assumed to be 50% due to improving the building envelops (Balaras, 2007).
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime is on average 25 years.

(a) Social cost-benefit analysis in Scenario 3 for Slovenia

Table 159 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 3. The methodological approach is based on the European project PRODESA[149].

Table 159: The variables and their values for calculating SCBA in Scenario 3 for Slovenia

Variable	Value	Unit
Available budget	103,400,000	EUR
Unitary investment cost-Building envelope	16,000	EUR
Unitary investment cost-Heat pump	10,000	EUR
Unitary investment cost-PV	0	€
Avoided cost from new fossil fuel boiler	4,000	€
Number of influenced households	3,977	number of households

[149] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

Capacity factor PV	12%	%
Energy consumption for space cooling	112	kWh
Energy consumption for space heating	9,206	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	56	kWh
Energy savings in space heating	4,603	kWh
Electricity consumption after interventions	5,683	kWh
Electricity price	0.09	€/kWh
Cost reduction due to net-metering	100%	
Electricity price-net metering	0.09	€/kWh
Existing fuel price for space heating	0.05	€/kWh
Remaining value	10%	% of capital cost
Discount rate	3%	%

The SCBA considers all the expenditures and revenues from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts, improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is 0.09 $\frac{\text{EUR}}{kwh}$, while the price for space heating is equal to 0.05 $\frac{\text{EUR}}{kwh}$.

In particular, Table 160 presents external costs and benefit components are considered to assess the Scenario 3 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 160: the external costs and benefits and the descriptions for Scenario 3 for Slovenia

External costs and benefits	Description

Environmental costs from the implementations of the energy saving measure	The unit external-cost prices include both the effects on human health, agricultural production and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit costs for the existing heating system (coal stove or boiler) were considered to be equal to 27.2 EUR/MWh, while unit cost for the existing cooling system (air conditioning unit) was estimated at 23.5 EUR/MWh. Moreover, the unit cost for the installed heat pump was estimated at 14.2 EUR/MWh.
Increasing the house value due to the improvement of the building envelope	The increase in the value of residential buildings is determined by calculating the cost savings due to improving the energy performance of the building envelope. A capital recovery coefficient is used, and the value is considered equal to 3%. The component needs to consider the year of implementation of the investment.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The results of the SCBA indicate the social effectiveness of Scenario 3 for the average-income group of households living in Slovenia (Table 161). Therefore, the allocation of resources for ZEB is highly recommended instead of investments in the gas grid. It should be noticed that social efficiency is significantly influenced by the double investment regarding the replacement of the heat pump (after the end of the 12-year life) with a new heat pump for the next 12 years, until the investment is repaid in the building envelope that has a lifespan of 25 years.

Table 161: Results of social cost-benefit analysis in Scenario 3 for Slovenia

CBA	NPV	IRR	B/C
Scenario 3	40,586,581	10%	1.50

Table 162 shows the main components including the fuel costs and benefits for Scenario 3 without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 162: Cash flows for social cost-benefit analysis in Scenario 3 for Slovenia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						41,045,770	79,901,651		-38,855,881
1	0	0	484,572	1,715,945	220,956	3,268,190			4,278,607
2	0	0	484,572	1,715,945	220,956	3,268,190			4,278,607
3	0	0	484,572	1,715,945	220,956	3,268,190			4,278,607
4	0	0	484,572	1,715,945	220,956	3,268,190			4,278,607
5	0	0	484,572	1,715,945	220,956	3,268,190			4,278,607
6	0	0	484,572	1,715,945	220,956	3,268,190			4,278,607
7	0	0	484,572	1,715,945	220,956	3,268,190			4,278,607
8	0	0	484,572	1,715,945	220,956	3,268,190			4,278,607
9	0	0	484,572	1,715,945	220,956	3,268,190			4,278,607
10	0	0	484,572	1,715,945	220,956	3,268,190			4,278,607

11	0	0	484,572	1,715,945	220,956	3,268,190			4,278,607
12	0	0	484,572	1,715,945	220,956	3,268,190			4,278,607
13	0	0	484,572	1,715,945	220,956	3,268,190			4,278,607
14	0	0	484,572	1,715,945	220,956	3,268,190			4,278,607
15	0	0	484,572	1,715,945	220,956	3,268,190			4,278,607
16	0	0	484,572	1,715,945	220,956	3,268,190			4,278,607
17	0	0	484,572	1,715,945	220,956	3,268,190			4,278,607
18	0	0	484,572	1,715,945	220,956	3,268,190			4,278,607
19	0	0	484,572	1,715,945	220,956	3,268,190			4,278,607
20	0	0	484,572	1,715,945	220,956	3,268,190			4,278,607
21	0	0	484,572	1,715,945	220,956	3,268,190			4,278,607
22	0	0	484,572	1,715,945	220,956	3,268,190			4,278,607
23	0	0	484,572	1,715,945	220,956	3,268,190			4,278,607
24	0	0	484,572	1,715,945	220,956	3,268,190			4,278,607
25	0	0	484,572	1,715,945	220,956	3,268,190		10,340,000	14,618,607
Total	0	0	8,437,919	29,880,000	3,847,542	97,955,251	79,901,651	10,038,835	40,586,581

Scenario 4 – Zero energy buildings by combining various investments for Slovenia

Scenario 4 examines the use of the available budget for the strengthening of the electricity distribution network to promote zero-energy buildings (ZEB). ZEB can be achieved through the combination of thermal insulation of external wall, the replacement of existing window frames with new energy efficient ones, and the installation of photovoltaic solar panel in residential buildings and the installation of a heat pump.

The benefits of households could be the reduction of energy costs due to both the reduced energy demand for space heating and cooling, as well as the operation of the heat pump. the economic benefits of heat pump installations are calculated based on the collected Eurostat data on weighted average cost of purchasing energy products for space heating in the residential sector.

Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 103.4 million) is divided by unitary investment cost with subsidy (EUR 34,541) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 103.4 million}}{\text{EUR 34,541}} = 2{,}994$ (0.4%).
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households (avoided fuel cost = EUR 4,000).
- The energy saving rates for space heating and cooling are assumed to be 50% due to improving the building envelops (Balaras, 2007).
- The operation and maintenance costs are assumed to be higher in the alternative Scenario compared to the baseline one.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.

- The lifetime is on average 25 years.

(a) Social cost-benefit analysis in Scenario 4 for Slovenia

Table 163 includes the main variables and their values for calculation of social cost-benefit analysis in case of Scenario 4. The methodological approach is based on the European project PRODESA[150].

Table 163 - the variables and their values for calculating SCBA in Scenario 4 for Slovenia

Variable	Value	Unit
Available budget	103,400,000	EUR
Unitary investment cost-Building envelope	16,000	EUR
Unitary investment cost-Heat pump	10,000	EUR
Unitary investment cost-PV	8,541	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Number of influenced households	2,994	number of households
Installed capacity PV	6.0	kW
Unitary investment cost PV	1,424	EUR/kW
Capacity factor PV	12%	%
Energy consumption for space cooling	112	kWh
Energy consumption for space heating	9,206	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	56	kWh
Energy savings in space heating	4,603	kWh
Electricity consumption after interventions	5,683	kWh
Electricity price	0.09	EUR/kWh
Cost reduction due to net-metering	50%	
Electricity price-net metering	0.05	EUR/kWh
Existing fuel price for space heating	0.05	EUR/kWh
Cost of operation and maintenance - Baseline scenario	0	EUR
Cost of operation and maintenance - Alternative scenario	100	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

The SCBA considers all the expenditures and revenues from energy efficiency investments. One of the distinct features of SCBA compared to other cost-benefit analyses is that it quantifies the external costs and benefits including the environmental and health impacts,

[150] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

improving the comfort levels. In addition to this difference, the taxes are deducted from the energy prices and investment costs since these taxes are the costs for the individual household and not for the society and the national economy. More specifically, the electricity price is $0.09\,\frac{\text{EUR}}{kwh}$, while the price for space heating and the electricity price-net metering are both equal to $0.05\,\frac{\text{EUR}}{kwh}$, respectively.

In particular, Table 164 presents external costs and benefits. These components are quantified in the economic analysis:

Table 164: the external costs and benefits and the descriptions for Scenario 4 for Slovenia

External costs and benefits	Description
Environmental costs from the implementations of the energy saving measure	The unit external-cost prices include both the effects on human health, agricultural production and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit costs for the existing heating system (coal stove or boiler) were considered to be equal to 27.2 EUR/MWh, while unit cost for the existing cooling system (air conditioning unit) was estimated at 23.5 EUR/MWh. Moreover, the unit cost for the installed heat pump was estimated at 14.2 EUR/MWh. Finally, the unit cost for photovoltaic systems is considered equal to 14.1 EUR/MWh, while the corresponding price for the electricity used from the grid was taken equal to 48.5 EUR/MWh.
Increasing the house value due to the improvement of the building envelope	The increase in the value of residential buildings is determined by calculating the cost savings due to improving the energy performance of the building envelope. A capital recovery coefficient is used, and the value is considered equal to 3%. The component needs to consider the year of implementation of the investment.
Macroeconomic impacts	The macroeconomic effects were assumed to be equal to 0.08 EUR/kWh due to the implemented energy efficiency investments.

The results of the SCBA indicate the social effectiveness of Scenario 4 for the average-income group of households living in Slovenia (Table 165). Therefore, the allocation of resources for ZEB is highly recommended instead of investments on the expansion of the electricity grid. It should be noticed that social efficiency is significantly influenced by the double investment regarding the replacement of the heat pump (after the end of the 12-year life) with a new heat pump for the next 12 years, until the investment is repaid in the building envelope that has a lifespan of 25 years.

Table 165: Results of social cost-benefit analysis in Scenario 4 for Slovenia

SCBA	NPV	IRR	B/C
Scenario 4	47,847,088	12%	1.52

Table 166 shows the main components including the fuel costs and benefits for Scenario 4 without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 166: Cash flows for social cost-benefit analysis in Scenario 4 for Slovenia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						49,337,112	83,493,904		-34,156,791
1	241,415	0	364,751	2,086,279	433,503	3,379,093			4,425,704
2	241,415	0	364,751	2,086,279	433,503	3,379,093			4,425,704
3	241,415	0	364,751	2,086,279	433,503	3,379,093			4,425,704
4	241,415	0	364,751	2,086,279	433,503	3,379,093			4,425,704
5	241,415	0	364,751	2,086,279	433,503	3,379,093			4,425,704
6	241,415	0	364,751	2,086,279	433,503	3,379,093			4,425,704
7	241,415	0	364,751	2,086,279	433,503	3,379,093			4,425,704
8	241,415	0	364,751	2,086,279	433,503	3,379,093			4,425,704
9	241,415	0	364,751	2,086,279	433,503	3,379,093			4,425,704
10	241,415	0	364,751	2,086,279	433,503	3,379,093			4,425,704
11	241,415	0	364,751	2,086,279	433,503	3,379,093			4,425,704
12	241,415	0	364,751	2,086,279	433,503	3,379,093			4,425,704
13	241,415	0	364,751	2,086,279	433,503	3,379,093			4,425,704
14	241,415	0	364,751	2,086,279	433,503	3,379,093			4,425,704
15	241,415	0	364,751	2,086,279	433,503	3,379,093			4,425,704
16	241,415	0	364,751	2,086,279	433,503	3,379,093			4,425,704
17	241,415	0	364,751	2,086,279	433,503	3,379,093			4,425,704
18	241,415	0	364,751	2,086,279	433,503	3,379,093			4,425,704
19	241,415	0	364,751	2,086,279	433,503	3,379,093			4,425,704
20	241,415	0	364,751	2,086,279	433,503	3,379,093			4,425,704
21	241,415	0	364,751	2,086,279	433,503	3,379,093			4,425,704
22	241,415	0	364,751	2,086,279	433,503	3,379,093			4,425,704
23	241,415	0	364,751	2,086,279	433,503	3,379,093			4,425,704
24	241,415	0	364,751	2,086,279	433,503	3,379,093			4,425,704
25	241,415	0	364,751	2,086,279	433,503	3,379,093		10,340,000	14,765,704
Total	4,203,792	0	6,351,463	36,328,688	7,548,649	108,177,766	83,493,904	10,038,835	47,847,088

Scenario 0 – The baseline Scenario for Slovenia

Slovenia's main source of fuel for space heating is biomass (54.59%) followed by fossil gas (29.86%). For this reason, Scenario 0 examines the utilization of the available budget for the improvement of fossil fuel boilers. The CBA and SCBA are conducted to evaluate the costs and benefits of investments on the higher energy efficient boilers for the whole population.

Here are the other few assumptions which are similarly used for all Scenario:

- The total budget (EUR 103.4 million) is divided by unitary investment cost (EUR 4,000) to calculate the number of households that can benefit from this investment. The number of influenced households is equal to 25,850 (3.1%).
- It is assumed that the performance ratio of the energy efficient boilers is improved from 85% to 95% (assumption) efficiency.

- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime of new gas boiler is equal to 15 years.

(a) Social cost-benefit analysis in Scenario 0 for Slovenia

Table 167 presents the main variables and their values for calculation of social cost-benefit analysis. The methodological approach is based on the open project PRODESA[151].

Table 167: the variables and their values for calculating SCBA in Scenario 0 for Slovenia

Variable	Value	Unit
Available budget	103,400,000	EUR
Unitary investment cost	4,000	EUR
Avoided cost from natural gas boilers	0	EUR
Number of affected households	25,850	number of households
Unitary energy consumption for space cooling	112	kWh
Unitary energy consumption for space heating	9,206	kWh
Performance ratio of energy efficient boiler	95%	%
Performance ratio existing boiler	85%	%
Energy consumption after the interventions	8,237	kWh
Electricity price	0.09	EUR/kWh
Existing fuel price for space heating	0.05	EUR/kWh
Remaining value	10%	% of capital cost
Discount rate	3%	%

As mentioned in the methodology section, the main difference of social cost-benefit analysis is that it quantifies the external costs and benefits and to evaluate the Scenarios more comprehensively. In addition, the value added tax were deducted from the prices of energy products and the investment costs since these are costs for the individuals and not to the national economy and society. More specifically, while the NG price is equal to 0.06 (EUR/kWh), the fuel price for space heating is considered to be equal to 0.058 (EUR/kWh) ($NG_{Price} \times (1 - VAT)$).

In particular, the following external costs and benefit components (Table 168) are considered to evaluate the Scenario 0 in addition to the costs and benefits, which are quantified in the economic analysis:

Table 168: the external costs and benefits and the descriptions in Scenario 0 for Slovenia

External costs and benefits	Description

[151] PRODESA, 2021. Economic evaluation of the energy efficiency projects, Deliverable D2.6.

Environmental costs from the implementations of the energy saving measure	The unit external-cost prices, which were used, concern both the effects on human health, agricultural production, and monuments from all primary and secondary pollutants, as well as the effects of climate change and the depletion of natural resources. More specifically, the unit cost for the existing heating system (fossil gas boiler) was considered to be equal to 20.0 /MWh, while the unit cost for the new fossil gas boiler amounted to 17.9 /MWh.
Multiple benefits from the implementation of the energy saving measure	The multiple benefits are calculated to as a ratio of the cost saving due to the installation of the energy saving measure. The ratio is equal to 2% based on the type of multiple benefits which is considered for Slovenia. The multiple benefits are calculated annually, and the sum of these values are equal to the total multiple benefits of installations of energy saving measures.

The results of the social cost-benefit analysis do not indicate the social effectiveness of the Scenario 0. Therefore, implementing the Scenario 0 is not recommended as the CBA and SCBA do not support the Scenario 0 (Table 169).

Table 169: Results of social cost-benefit analysis in Scenario 0 for Slovenia

SCBA	NPV	IRR	B/C
Scenario 0	-68,986,592	-11%	0.73

Table 170 shows the main components including the fuel costs and benefits without considering the discount rates for calculating SCBA and the economic indicators of NPV, IRR, and B/C.

Table 170: Cash flows for social cost-benefit analysis in Scenario 0 for Slovenia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						0	94,429,224		-94,429,224
1	0	0	9,858,966	11,018,845	3,811,453	4,782,817			2,131,242
2	0	0	9,858,966	11,018,845	3,811,453	4,782,817			2,131,242
3	0	0	9,858,966	11,018,845	3,811,453	4,782,817			2,131,242
4	0	0	9,858,966	11,018,845	3,811,453	4,782,817			2,131,242
5	0	0	9,858,966	11,018,845	3,811,453	4,782,817			2,131,242
6	0	0	9,858,966	11,018,845	3,811,453	4,782,817			2,131,242
7	0	0	9,858,966	11,018,845	3,811,453	4,782,817			2,131,242
8	0	0	9,858,966	11,018,845	3,811,453	4,782,817			2,131,242
9	0	0	9,858,966	11,018,845	3,811,453	4,782,817			2,131,242
10	0	0	9,858,966	11,018,845	3,811,453	4,782,817			2,131,242
11	0	0	9,858,966	11,018,845	3,811,453	4,782,817			2,131,242
12	0	0	9,858,966	11,018,845	3,811,453	4,782,817			2,131,242
13	0	0	9,858,966	11,018,845	3,811,453	4,782,817			2,131,242
14	0	0	9,858,966	11,018,845	3,811,453	4,782,817			2,131,242

15	0	0	9,858,966	11,018,845	3,811,453	4,782,817			2,131,242
Total	0	0	117,695,700	131,542,253	45,500,879	57,096,957	94,429,224	0	-68,986,592

Conclusions for the case study of Slovenia

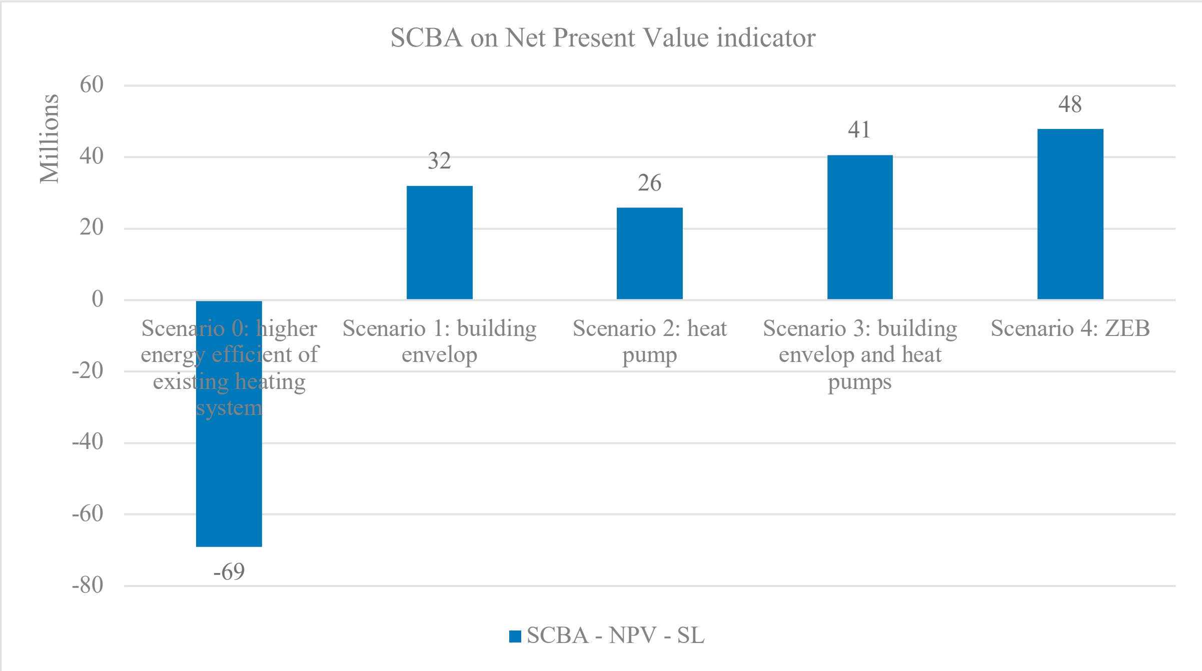
Slovenia relies heavily on biomass (~55%) and fossil gas (~30%) as a source of energy for space heating. The European Commission aims to reduce dependency on fossil fuel-based sources for heating systems. The results of the Scenario analyses are reported in the following subsection. It is interesting to see how none of the Scenarios performed positively from a purely economic perspective, presenting all negative NPVs, IRRs and B/C ratios lower than one. This is due to the rather low budget considered in this case. Nonetheless, it still illustrates how a higher rate of investments in structural energy efficiency in Slovenia is needed, to make it beneficial also from an economic perspective to the public authorities.

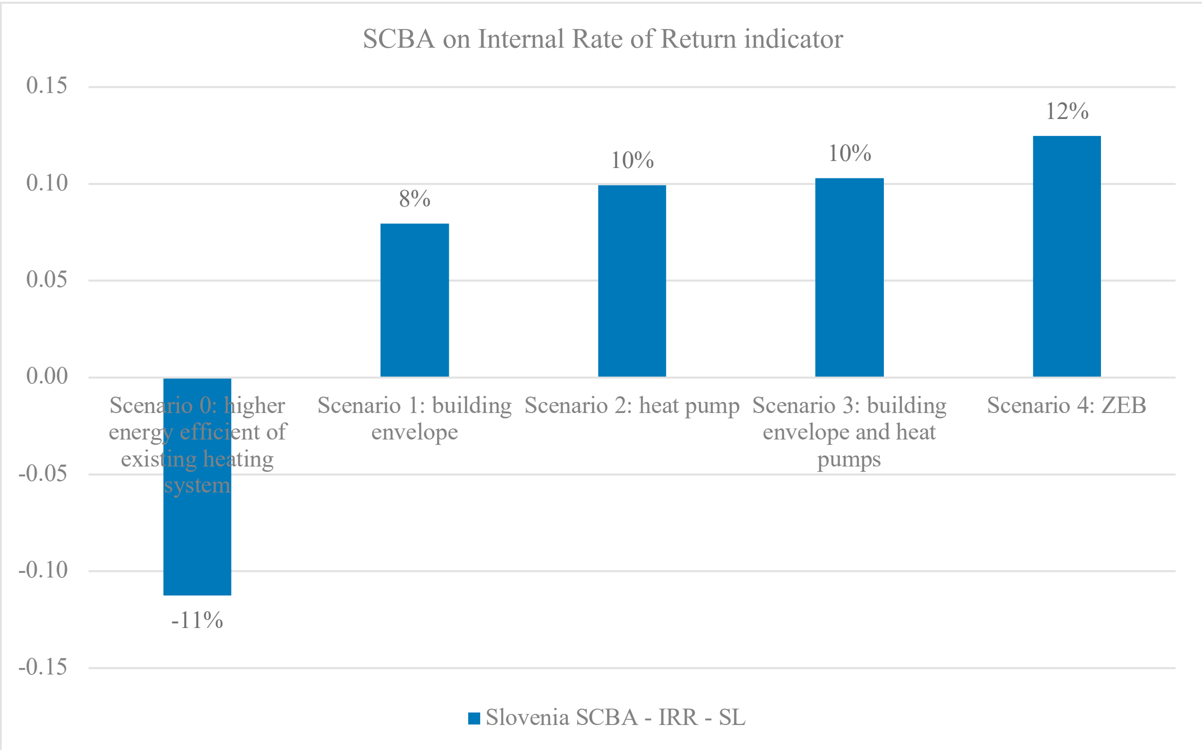
When performing a SCBA, Scenario 0 still presented a negative NPV. The comparison among the indicators for the economic and social analyses shows that the installation of heat pumps and building envelopes are highly beneficial for the society. Almost all the indicators reveal that Scenario 4 (investments on the zero energy buildings: heat pumps, building envelopes, and photovoltaic solar panels) and Scenario 3 (investments on heat pump and building envelope) are the first and the second-best Scenarios. However, the addition of PVs to Scenario 3 do indeed yield positive results, represented by the higher parameters of Scenario 4. Therefore, PVs should not be implemented as a stand-alone measure but rather be coupled together with other measures. To conclude, it is highly recommended to adopt a policy promoting zero energy buildings in Slovenia. Additionally, it was found that, to have an IRR of 3% in purely economic terms for Scenario 4, the government should apply a subsidy rate of 60%. In this way, the NPV would be positive also from a purely financial perspective.

Table 171 - Summarising Table – All Scenarios for Slovenia

Scenarios	Indicators	SCBA
Scenario 1: Building envelopes	NPV	31,957,312
	IRR	8%
	B/C	1.38
Scenario 2: Heat pumps	NPV	25,828,983
	IRR	10%
	B/C	1.28
Scenario 3: Building envelopes and heat pumps	NPV	40,586,581
	IRR	10%
	B/C	1.50
Scenario 4: ZEB	NPV	47,847,088
	IRR	12%
	B/C	1.52
Scenario 0:	NPV	-68,986,592

Higher energy Efficiency heating systems	IRR	-11%
	B/C	0.73





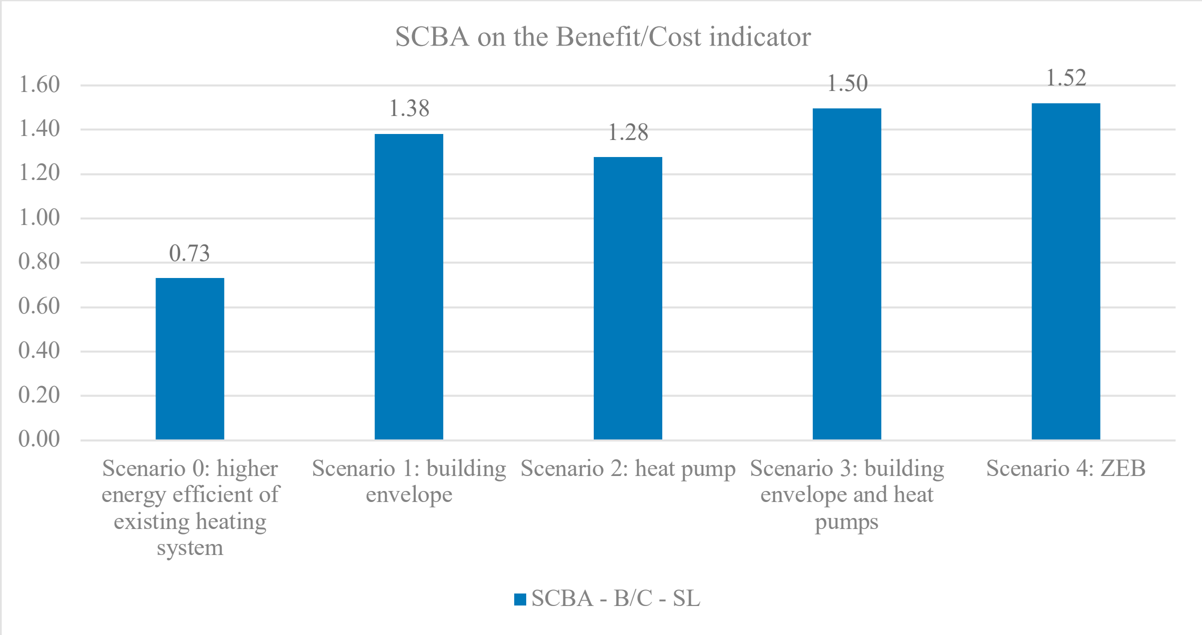


Figure 44 - summarizing figures – all Scenarios - Slovenia

6. DISCUSSION AND POLICY IMPLICATIONS

6.1 Comparison of the economic and social impacts of the different types of building energy retrofits

All countries under investigations need to invest with higher rates on the demand side energy efficiency investments compared to supply-side energy investments. In almost all countries, it has been identified that households can benefit considerably if their governments assign the investments on the supply-side energy investments for energy retrofitting of their buildings. Figure 45 shows the results of social cost benefit analyses for all countries. The supply side energy investments are mainly extracted from the available budget assigning to the development of the infrastructures related to the expansion or development of the fossil fuel related infrastructures. As shown in the figures and tables, Scenario 0 (improving only the energy efficiency level of the existing heating system) is the least economically beneficial investments for the households of the different target countries. Small discrepancies exist among the results of different countries. In addition, the results for social cost benefit analyses are consistent among all countries and Scenario 0 is the least socially beneficial Scenarios for all countries. For almost all countries, Scenario 2 (installation of heat pump) and 4 (zero-energy buildings by combining different investments) is the most economically beneficial for almost all countries.

Table 172 - The least beneficial Scenarios per country

Indicators		NPV	IRR	B/C
Bulgaria	CBA	Scenario 1: building envelopes	Scenario 2: heat pumps	Scenario 1: building envelopes
	SCBA	Scenario 1: building envelopes	Scenario 1: building envelopes	Scenario 1: building envelopes
Croatia	CBA	Scenario 0: higher energy efficiency heating system	Scenario 0: higher energy efficiency heating system	Scenario 1: building envelopes
	SCBA	Scenario 0: higher energy efficiency heating system	Scenario 0: higher energy efficiency heating system	Scenario 0: higher energy efficiency heating system
Hungary	CBA	Scenario 0: higher energy efficiency heating system	Scenario 2: heat pumps	Scenario 1: building envelopes
	SCBA	Scenario 0: higher energy efficiency heating system	Scenario 0: higher energy efficiency heating system	Scenario 0: higher energy efficiency heating system
Poland	CBA	Scenario 0: higher energy efficiency heating system	Scenario 0: higher energy efficiency heating system	Scenario 1: building envelopes
	SCBA	Scenario 0: higher energy efficiency heating system	Scenario 0: higher energy efficiency heating system	Scenario 0: higher energy efficiency heating system
Romania	CBA	Scenario 0: higher energy efficiency heating system	Scenario 0: higher energy efficiency heating system	Scenario 1: building envelopes
	SCBA	Scenario 0: higher energy efficiency heating system	Scenario 0: higher energy efficiency heating system	Scenario 0: higher energy efficiency heating system

Slovakia	CBA	Scenario 0: higher energy efficiency heating system	Scenario 0: higher energy efficiency heating system	Scenario 1: building envelopes
	SCBA	Scenario 0: higher energy efficiency heating system	Scenario 0: higher energy efficiency heating system	Scenario 0: higher energy efficiency heating system
Slovenia	CBA	Scenario 0: higher energy efficiency heating system	Scenario 0: higher energy efficiency heating system	Scenario 1: building envelopes
	SCBA	Scenario 0: higher energy efficiency heating system	Scenario 0: higher energy efficiency heating system	Scenario 0: higher energy efficiency heating system

Table 173 - The best performing Scenarios per country

Indicators		NPV	IRR	B/C
Bulgaria	CBA	Scenario 2: heat pumps	Scenario 4: ZEB	Scenario 0: higher energy efficiency heating system
	SCBA	Scenario 4: ZEB	Scenario 4: ZEB	Scenario 4: ZEB
Croatia	CBA	Scenario 4: ZEB	Scenario 4: ZEB	Scenario 2: heat pumps
	SCBA	Scenario 4: ZEB	Scenario 1: building envelopes	Scenario 4: ZEB
Hungary	CBA	Scenario 2: heat pumps	Scenario 4: ZEB	Scenario 0: higher energy efficiency heating system
	SCBA	Scenario 4: ZEB	Scenario 4: ZEB	Scenario 4: ZEB
Poland	CBA	Scenario 2: heat pumps	Scenario 4: ZEB	Scenario 0: higher energy efficiency heating system
	SCBA	Scenario 4: ZEB	Scenario 4: ZEB	Scenario 4: ZEB
Romania	CBA	Scenario 2: heat pumps	Scenario 4: ZEB	Scenario 0: higher energy efficiency heating system
	SCBA	Scenario 4: ZEB	Scenario 4: ZEB	Scenario 4: ZEB
Slovakia	CBA	Scenario 2: heat pumps	Scenario 2: heat pumps	Scenario 2: heat pumps
	SCBA	Scenario 4: ZEB	Scenario 4: ZEB	Scenario 4: ZEB
Slovenia	CBA	Scenario 2: heat pumps	Scenario 4: ZEB	Scenario 2: heat pumps
	SCBA	Scenario 4: ZEB	Scenario 4: ZEB	Scenario 4: ZEB

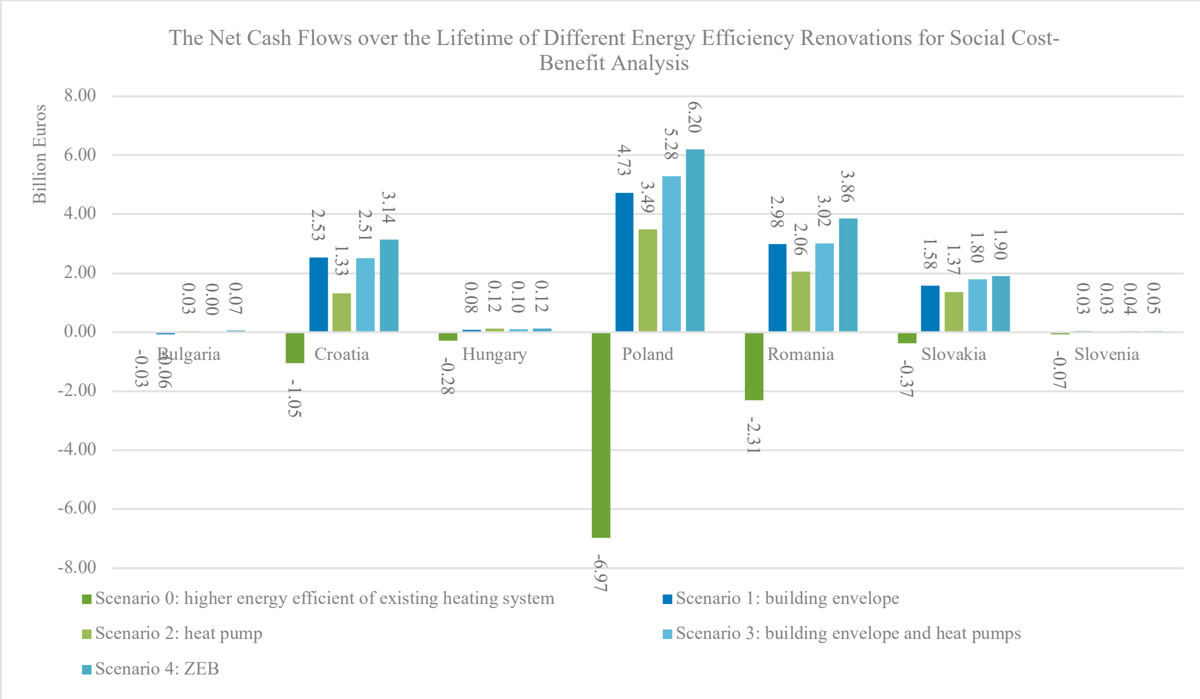


Figure 45 - The Net Cash Flows over the Lifetime of Different Energy Efficiency Renovations for Social Cost-Benefit Analysis

6.2 The impacts of the policy measures for the households

The previous research indicates low motivations of households towards energy retrofits due to the huge initial investment costs, lack of subsidies and grant on energy retrofits. The energy crisis imposes higher pressure for finding innovative solutions for reducing the energy consumption in the building sector. However, the allocation of the public resources on the demand side energy efficiency investments still are not sufficient. As shown, the residential sectors of the target countries can benefit from the more efficient houses with higher quality of life, if the available budgets on the supply side energy investments (Table 174) allocated for the energy retrofitting of the buildings.

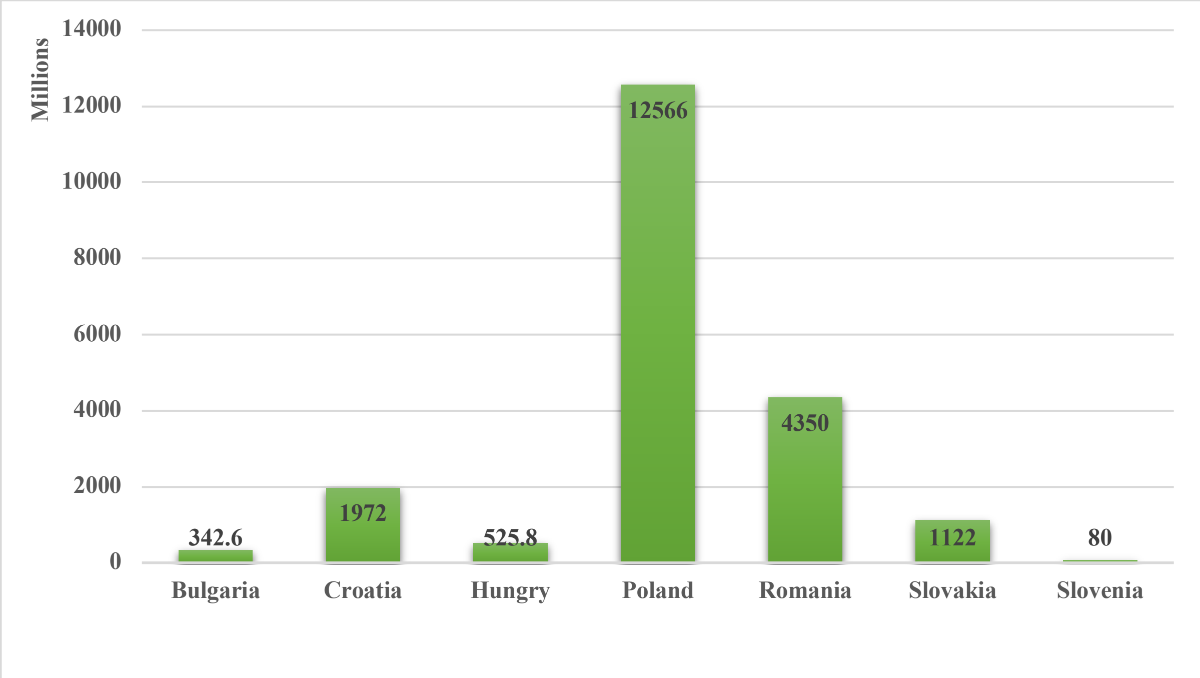


Figure 46 – Total available budgets from the supply-side energy investments

Table 174: the types of supply-side energy investments and the amounts per country

Countries	Bulgaria	Croatia	Hungary	Poland	Romania	Slovakia	Slovenia
Allocated supply side energy investments	Project related to the production of green hydrogen and biogas; gas interconnector between countries	LNG terminal, gas transmission pipeline, NECP: fossil gas transportation and distribution	500 MW gas turbine power plant	Gas power plants, upgrade of the LNG terminal and Gas pipelines and other gas infrastructure elements	Gas grid and gas projects	biogas plants, LNG terminal plans, biomass, gas related projects	Gas interconnectors
Amount	342.6 million	1.972 billion	500 million	12.566 billion	4.35 billion	321 million	103.4 million

The installations of higher energy efficient heating systems and photovoltaic solar panels need lower investment costs compared to other energy retrofitting, therefore the number of households benefitting from these investments are higher compared to other energy efficiency measures investments. In Poland, almost 3 million and 4 million buildings benefit from the allocation of available budget on supply side energy investments for installations of the higher energy efficient heating systems and photovoltaic solar panels. In addition, with the same amount of investments, more than 385 thousands of buildings can be transformed to zero energy buildings with the highest possibility for energy savings and improving the comfort levels. As mentioned, the Scenario 4 (zero-energy buildings by combining different investments) leads to the highest social benefits for the people living in Poland.

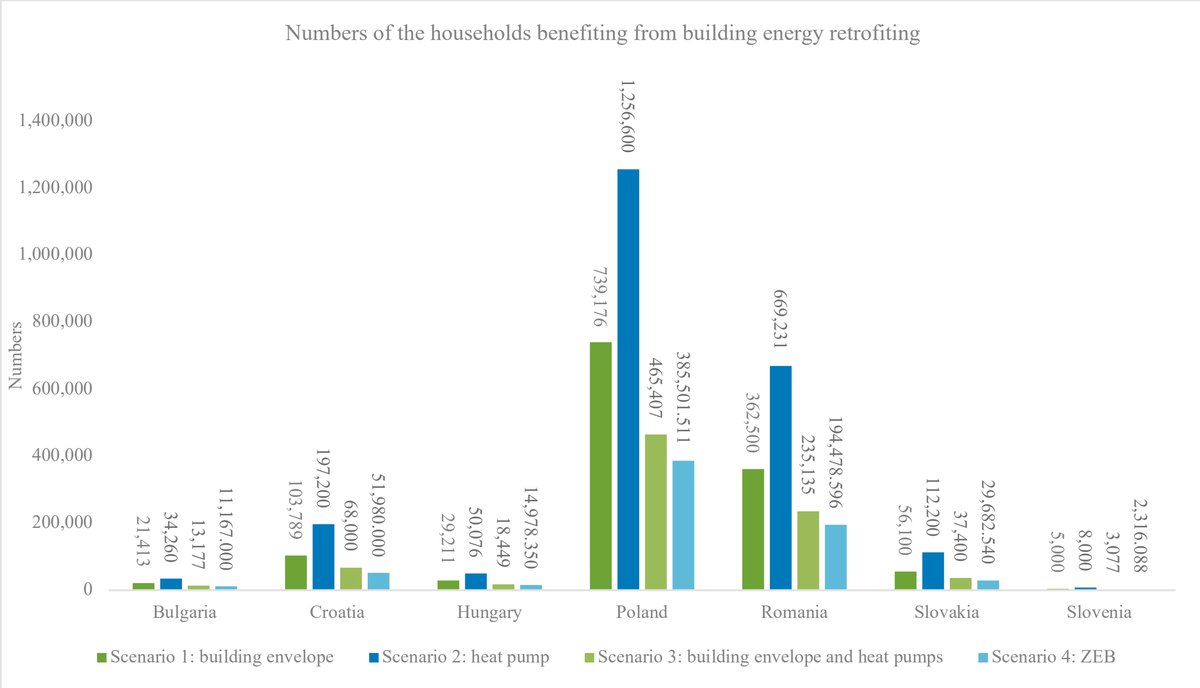


Figure 47 - Numbers of the households benefiting from building energy retrofitting

6.3 Proposed designs of the policy interventions in the long term

EU commission defines strategies for accelerating the energy transition in the building sectors including the Fit for 55, renovation wave strategy, and REPowerEU. The prioritization of investments in energy upgrades is fully in line with the European Energy Efficiency First Principle (as defined in the European Governance Regulation and the Revised Energy Efficiency Directive - Article 3 - in the Fit-for-55 package presented by The European Commission). In REPowerEU, the European Commission encourages their member states to find the quickest and cheapest ways to address the current energy crisis and reducing the bills for their citizens, *doubling solar photovoltaic capacity and the rate of deployment of heat pumps* (Table 175). Table 175 summarises the energy efficiency targets by the EU commission.

Table 175: energy efficiency targets related to the current research

EU proposal	Targets related to the energy efficiency measures in the building sector
Fit for 55	• renewable energy share in buildings: at least a 49% in 2030 • renewable targets for heating and cooling: 0.8% increase per year until 2026 and 1.1% from 2026-2030
Renovation wave strategy	• residential and non-residential buildings: at least double the annual energy renovation rate of by 2030 and to foster deep energy renovations • 35 million buildings renovated by 2030
REPowerEU	• energy Efficiency Target (2030): from 9% to 13% • renewable: doubling solar photovoltaic capacity and the rate of deployment of heat pumps • reduce demand during peak price hours by at least 5% and electricity demand by at least 10%

The current study addresses one of the main challenges of the European countries in achieving the energy efficiency renovation targets. Based on the findings of the current research, it is recommended that policy interventions in the target countries need to be shifted towards prioritizing demand-side energy efficiency investments, such as providing subsidies for energy efficiency renovations. This approach is suggested as a preferable alternative to focusing on supply-side energy investments, such as the expansion of the natural gas infrastructure. Scenario 0 (installations of the higher energy efficiency heating system) does not provide benefits in terms of social cost benefit analyses for all the countries. Therefore, Scenario 0 is not considered in the proposed policy during the long-term. The results of all the social-cost benefit analyses indicate that Scenarios 1 to 4 contribute considerably for the residents if the external costs and benefits of these Scenarios are considered when evaluating these Scenarios. The indicators of SCBA are all positive for these Scenarios and in comparison, with the supply side energy investment are highly beneficial for these countries.

In any case, it is recommended to evaluate alternative means of financing the required investments in accordance with the provisions of the NECP, such as, indicatively, the introduction of tax incentives and the provision of low-interest loans to supplement the foreseen resources for the provision of direct subsidies. For the financial convenience of consumers, it would also be important to establish a legislative framework to provide for programmes to save and reduce energy consumption among household consumers by energy providers or other market players (through various forms of Energy Performance Contracting (EPC)). The investment in energy saving can thus be paid for by energy providers and the amount saved is received back by the provider from the next bill to repay his investment.

6.4 Limitation of the current study and future research

Different data sources for calculating different indicators are used. In this research, the input data is the average value for each parameter. These values were validated by the experts of different countries. However, a sensitivity analysis is deemed necessary to assess the impact on results associated to changes in relevant parameters taking into consideration that the degree of uncertainty of a Cost-Benefit Analysis is usually very high. The most uncertain parameters must be identified to ensure through the sensitivity analysis that their potential fluctuation cannot alter significantly the derived outcomes of the CBA and SCBA. In addition, due to the limitation of accessing data, not all variables are included in the research for example the expenditures on the installations of different energy saving measures.

ANNNEXES

Appendix I

Figure 48 presents a list of the possible impacts of energy efficiency projects.

#	Impact (pre-aggr.)	Unit (physical)	No. of sub-impacts
1	human health	DALY	3-4
2	eco-systems: acidification, eutrophication, ozone exposure	% change in area affected	3
3	eco-systems: crop loss	% change in area affected, t of crop loss	1
4	air pollution emissions (mid-points)	t	nr. of pollutants
5	avoided GHG emissions	t CO2eq	2
6	material footprint/resource impacts	t	4
7	energy cost savings/available income effect	€	1
8	productivity	work days lost	3
9	gross employment/GDP (temporary)	job years	1
10	public budget (temporary)	% of budget or GDP	1
11	energy security	import expenses as share of GDP	1
12	energy system: Value of lost load	% €	1

Figure 48: Categorization of Impacts of energy efficiency measures (COMBI project, HORIZON 2020)

Appendix II - Cost-benefit analysis for all different Scenarios

Scenario analyses for the case study of Bulgaria

Cost-benefit analysis for Scenario 1 for Bulgaria

Table 180 indicates the actual and assumed values for calculating CBA. Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 342.6 million) is divided by unitary investment cost (EUR 16,000) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 342.6 million}}{\text{EUR 16,000}} = 21{,}413$ (0.7%).
- It is also assumed that the households do not need to install a new energy efficient boiler due to reduction of energy consumption for space heating. Therefore, the required investment costs are reduced for the households. Since this Scenario considers the upgrade of the building envelope without changing the heating system, no avoided costs result since the households continue to operate the existing heating system.
- The energy saving rates for space heating and cooling are assumed to be 50% due to improving the building envelopes (Balaras, 2007).
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime of building envelope is on average 25 years. It is also considered that 10% of the value of the investment will be remained in the year 25.

Table 180: The variables and their values for calculating CBA in Scenario 1 for Bulgaria

Variables	Values	Units
Available budget for hydrogen and biogas to be spent for households	342,600,000	EUR
Unitary investment cost	16,000	EUR
Unitary investment cost with subsidy	16,000	EUR
Avoided cost from new fossil fuel boiler	0	EUR
Number of influenced households	21,413	Number of households
Energy consumption for space cooling	41	kWh
Energy consumption for space heating	4,466	kWh
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	22	kWh
Energy savings in space heating	2,233	kWh
Electricity price	0.11	EUR/kWh
Existing fuel price for space heating	0.05	EUR/kWh
Cost of operation and maintenance - baseline Scenario	0	EUR
Cost of operation and maintenance - alternative Scenario	0	EUR
Remaining value	10%	% of capital cost

Discount rate	3%	%

Table 181 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments. The discount rate is not considered in the table.

Table 181: Cash flows for cost-benefit analysis in Scenario 1 for Bulgaria (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					342,600,000		-342,600,000
1	0	0	0	2,457,481			2,457,481
2	0	0	0	2,457,481			2,457,481
3	0	0	0	2,457,481			2,457,481
4	0	0	0	2,457,481			2,457,481
5	0	0	0	2,457,481			2,457,481
6	0	0	0	2,457,481			2,457,481
7	0	0	0	2,457,481			2,457,481
8	0	0	0	2,457,481			2,457,481
9	0	0	0	2,457,481			2,457,481
10	0	0	0	2,457,481			2,457,481
11	0	0	0	2,457,481			2,457,481
12	0	0	0	2,457,481			2,457,481
13	0	0	0	2,457,481			2,457,481
14	0	0	0	2,457,481			2,457,481
15	0	0	0	2,457,481			2,457,481
16	0	0	0	2,457,481			2,457,481
17	0	0	0	2,457,481			2,457,481
18	0	0	0	2,457,481			2,457,481
19	0	0	0	2,457,481			2,457,481
20	0	0	0	2,457,481			2,457,481
21	0	0	0	2,457,481			2,457,481
22	0	0	0	2,457,481			2,457,481
23	0	0	0	2,457,481			2,457,481
24	0	0	0	2,457,481			2,457,481
25	0	0	0	2,457,481		34,260,000	36,717,481
Total	0	0	0	42,792,476	342,600,000	33,262,136	-283,444,757

Table 182 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 1 in monetary terms using the data provided in Table 10. Based on the calculated values, the investment is not beneficial in monetary terms and the cost-effectiveness is low ($NPV < 0, IRR < 3\%, and\ B/C < 1$).

Table 182: Results of cost-benefit analysis in Scenario 1 for Bulgaria

CBA	NPV	IRR	B/C
Scenario 1	-283,444,757	-6%	0.22

Cost-benefit analysis for Scenario 2 for Bulgaria

Table 183 indicates the actual and assumed values for calculating CBA. Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 342.6 million) is divided by unitary investment cost (EUR 10,000) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 342.6 million}}{\text{EUR 10,000}} = 34{,}260$ (1.2%).
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households.
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime of heat pump is on average 12 years.

Table 183: The variables and their values for calculating CBA in Scenario 2 for Bulgaria

Variables	Values	Units
Available budget for the production of hydrogen and biogas	342,600,000	EUR
Unitary investment cost	10,000	EUR
Unitary investment cost with subsidy	10,000	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Number of influenced households	34,260	number of households
Energy consumption for space cooling	41	kWh
Energy consumption for space heating	4,466	kWh
Performance ratio existing boiler	30%	%
COP heat pump	3	
Electricity price	0.11	EUR/kWh
Existing fuel price for space heating	0.05	EUR/kWh
Remaining value	0%	% of capital cost
Discount rate	3%	%

Table 184 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments. The discount rate is not included in the table, and it is used for calculation of NPV.

Table 184: Cash flows for cost-benefit analysis in Scenario 2 for Bulgaria (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					205,560,000		- 205,560,000
1	0	0	1,672,473	7,711,427			6,038,954
2	0	0	1,672,473	7,711,427			6,038,954
3	0	0	1,672,473	7,711,427			6,038,954
4	0	0	1,672,473	7,711,427			6,038,954
5	0	0	1,672,473	7,711,427			6,038,954
6	0	0	1,672,473	7,711,427			6,038,954
7	0	0	1,672,473	7,711,427			6,038,954
8	0	0	1,672,473	7,711,427			6,038,954
9	0	0	1,672,473	7,711,427			6,038,954
10	0	0	1,672,473	7,711,427			6,038,954
11	0	0	1,672,473	7,711,427			6,038,954
12	0	0	1,672,473	7,711,427		0	6,038,954
Total	0	0	16,647,803	76,759,573	205,560,000	0	- 145,448,229

Table 185 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 3 in monetary terms using the data provided in Table 204. Based on the calculated values, the investment is not beneficial in monetary terms and the cost-effectiveness is low ($NPV < 0, IRR < 3\%, and\ B/C < 1$).

Table 185: Results of cost-benefit analysis in Scenario 2 for Bulgaria

CBA	NPV	IRR	B/C
Scenario 2	-145,448,229	-13%	0.35

Cost-benefit analysis for Scenario 3 for Bulgaria

Table 186 indicates the actual and assumed values for calculating CBA. Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 342.6 million) is divided by unitary investment cost with subsidy (EUR 26,000) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 342.6 million}}{\text{EUR 26,000}} = 13{,}177\ (0.4\%)$.
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households (avoided fuel cost = EUR 4,000).
- The energy saving rates for space heating and cooling are assumed to be 50% due to improving the building envelops (Balaras, 2007).
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime is on average 25 years.

Table 186: the variables and their values for calculating CBA in Scenario 3 for Bulgaria

Variable	Value	Unit
Available budget for the production of hydrogen and biogas	342,600,000	EUR
Unitary investment cost-Building envelope	16,000	EUR
Unitary investment cost-Heat pump	10,000	EUR
Unitary investment cost-PV	0	EUR
Unitary investment cost with subsidy	26,000	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Installed capacity PV	0	kW
Unitary investment cost PV	0	EUR/kW
Number of influenced households	13,177	number of households
Energy consumption for space cooling	41	kWh
Energy consumption for space heating	4,466	kWh
Performance ratio existing boiler	30%	%
COP heat pump	3.0	
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	20	kWh
Energy savings in space heating	2,233	kWh
Electricity consumption after interventions	4,460	kWh
Electricity price	0.11	EUR/kWh
Cost reduction due to net-metering	100%	
Electricity price-net metering	0.11	EUR/kWh
Existing fuel price for space heating	0.05	EUR/kWh
Remaining value	10%	% of capital cost
Discount rate	3%	%

Table 187 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments. The discount rate is not included in the table, and it is used for calculation of NPV.

Table 187: Cash flows for cost-benefit analysis in Scenario 3 for Bulgaria (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					289,892,308		-289,892,308
1	0	0	321,629	2,995,263			2,673,633
2	0	0	321,629	2,995,263			2,673,633
3	0	0	321,629	2,995,263			2,673,633
4	0	0	321,629	2,995,263			2,673,633

5	0	0	321,629	2,995,263			2,673,633
6	0	0	321,629	2,995,263			2,673,633
7	0	0	321,629	2,995,263			2,673,633
8	0	0	321,629	2,995,263			2,673,633
9	0	0	321,629	2,995,263			2,673,633
10	0	0	321,629	2,995,263			2,673,633
11	0	0	321,629	2,995,263			2,673,633
12	0	0	321,629	2,995,263			2,673,633
13	0	0	321,629	2,995,263			2,673,633
14	0	0	321,629	2,995,263			2,673,633
15	0	0	321,629	2,995,263			2,673,633
16	0	0	321,629	2,995,263			2,673,633
17	0	0	321,629	2,995,263			2,673,633
18	0	0	321,629	2,995,263			2,673,633
19	0	0	321,629	2,995,263			2,673,633
20	0	0	321,629	2,995,263			2,673,633
21	0	0	321,629	2,995,263			2,673,633
22	0	0	321,629	2,995,263			2,673,633
23	0	0	321,629	2,995,263			2,673,633
24	0	0	321,629	2,995,263			2,673,633
25	0	0	321,629	2,995,263		34,260,000	36,933,633
Total	**0**	**0**	**5,600,581**	**52,156,949**	**289,892,308**	**33,262,136**	**-226,973,172**

Table 188 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 3 in monetary terms using the data provided in Table 187. Based on the calculated values, the investment is not beneficial in monetary terms and the cost-effectiveness is low ($NPV < 0, IRR < 3\%, and\ B/C < 1$).

Table 188: Results of cost-benefit analysis in Scenario 3 for Bulgaria

CBA	**NPV**	**IRR**	**B/C**
Scenario 3	-226,973,172 EUR	-5%	0.29

Cost-benefit analysis for Scenario 4 for Bulgaria

Table 189 indicates the actual and assumed values for calculating CBA. Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 342.6 million) is divided by unitary investment cost with subsidy (EUR 30,680) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 342.6 million}}{\text{EUR 30,680}} = 11{,}167$ (0.4%).

- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households (avoided fuel cost = EUR 4,000).
- The energy saving rates for space heating and cooling are assumed to be 50% due to improving the building envelops (Balaras, 2007).
- The operation and maintenance costs are assumed higher for the alternative Scenario compared to the baseline one.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime is on average 25 years.

Table 189: The variables and their values for calculating CBA in Scenario 4 for Bulgaria

Variables	Values	Units
Available budget for the production of hydrogen and biogas	342,600,000	EUR
Unitary investment cost-Building envelope	16,000	EUR
Unitary investment cost-Heat pump	10,000	EUR
Unitary investment cost-PV	4,680	EUR
Unitary investment cost with subsidy	30,680	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Installed capacity PV	3.0	kW
Unitary investment cost PV	1,560	EUR/kW
Number of influenced households	11,167	number of households
Energy consumption for space cooling	41	kWh
Energy consumption for space heating	4,466	kWh
Performance ratio existing boiler	30%	%
COP heat pump	3.0	
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	20	kWh
Energy savings in space heating	2,233	kWh
Electricity consumption after interventions	4,460	kWh
Electricity price	0.11	EUR/kWh
Cost reduction due to net-metering	50%	
Electricity price-net metering	0.05	EUR/kWh
Existing fuel price for space heating	0.05	EUR/kWh
Cost of operation and maintenance - Baseline Scenario	0	EUR
Cost of operation and maintenance - Alternative Scenario	100	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

Table 190 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments. The discount rate is not included in the table, and it is used for calculation of NPV.

Table 190: Cash flows for cost-benefit analysis in Scenario 4 for Bulgaria (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					297,932,464		-297,932,464
1	1,116,688	0	272,567	5,260,126			3,870,871
2	1,116,688	0	272,567	5,260,126			3,870,871
3	1,116,688	0	272,567	5,260,126			3,870,871
4	1,116,688	0	272,567	5,260,126			3,870,871
5	1,116,688	0	272,567	5,260,126			3,870,871
6	1,116,688	0	272,567	5,260,126			3,870,871
7	1,116,688	0	272,567	5,260,126			3,870,871
8	1,116,688	0	272,567	5,260,126			3,870,871
9	1,116,688	0	272,567	5,260,126			3,870,871
10	1,116,688	0	272,567	5,260,126			3,870,871
11	1,116,688	0	272,567	5,260,126			3,870,871
12	1,116,688	0	272,567	5,260,126			3,870,871
13	1,116,688	0	272,567	5,260,126			3,870,871
14	1,116,688	0	272,567	5,260,126			3,870,871
15	1,116,688	0	272,567	5,260,126			3,870,871
16	1,116,688	0	272,567	5,260,126			3,870,871
17	1,116,688	0	272,567	5,260,126			3,870,871
18	1,116,688	0	272,567	5,260,126			3,870,871
19	1,116,688	0	272,567	5,260,126			3,870,871
20	1,116,688	0	272,567	5,260,126			3,870,871
21	1,116,688	0	272,567	5,260,126			3,870,871
22	1,116,688	0	272,567	5,260,126			3,870,871
23	1,116,688	0	272,567	5,260,126			3,870,871
24	1,116,688	0	272,567	5,260,126			3,870,871
25	1,116,688	0	272,567	5,260,126		34,260,000	38,130,871
Total	19,445,060	0	4,746,255	91,595,356	297,932,464	34,260,000	-214,165,656

Table 191 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 4 in monetary terms using the data provided in Table 30. Based on the calculated values, the investment is not beneficial in monetary terms and the cost-effectiveness is low ($NPV < 0, IRR < 3\%, and\ B/C < 1$).

Table 191: Results of cost-benefit analysis in Scenario 4 for Bulgaria

CBA	NPV	IRR	B/C
Scenario 4	-214,165,656	-5%	0.39

Cost-benefit analysis in Scenario 0 for Bulgaria

Table 192 shows the actual and few assumed values (e.g., the performance ratio of the EE boiler) for calculating the CBA. Here are the other few assumptions which are similarly used for all Scenario:

- The total budget (EUR 342.6 million) is divided by unitary investment cost (EUR 4,000) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to 85,560 (2.9%).
- It is assumed that the performance ratio of the energy efficient boilers is improved from 30% to 95% (assumption) efficiency.
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime of the new biomass boiler is equal to 15 years.

Table 192: The variables and their values for calculating CBA in Scenario 0 for Bulgaria

Variable	Value	Unit
Available budget for the production of hydrogen and biogas	342,600,000	EUR
Unitary investment cost	4,000	EUR
Unitary investment cost with subsidy	4,000	EUR
Avoided cost from new fossil fuel boiler	0	EUR
Number of influenced households	85,650	number of households
Unitary energy consumption for space cooling	41	kWh
Unitary energy consumption for space heating	4,466	kWh
Performance ratio of energy efficient boiler	95%	%
Performance ratio existing boiler	30%	%
Energy consumption after the interventions	1,410	kWh
Electricity price	0.11	EUR/kWh
Existing fuel price for space heating	0.05	EUR/kWh
Cost of operation and maintenance - Baseline Scenario	0	EUR
Cost of operation and maintenance - Alternative Scenario	0	EUR
Remaining value	10%	% of capital cost
Discount rate	1%	%

Table 193 shows the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments without considering the discount rates.

Table 193: Cash flows for cost-benefit analysis in Scenario 0 for Bulgaria (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					342,600,000		- 342,600,000
1	0	0	6,087,969	19,278,567			13,190,598
2	0	0	6,087,969	19,278,567			13,190,598
3	0	0	6,087,969	19,278,567			13,190,598
4	0	0	6,087,969	19,278,567			13,190,598
5	0	0	6,087,969	19,278,567			13,190,598
6	0	0	6,087,969	19,278,567			13,190,598
7	0	0	6,087,969	19,278,567			13,190,598
8	0	0	6,087,969	19,278,567			13,190,598
9	0	0	6,087,969	19,278,567			13,190,598
10	0	0	6,087,969	19,278,567			13,190,598
11	0	0	6,087,969	19,278,567			13,190,598
12	0	0	6,087,969	19,278,567			13,190,598
13	0	0	6,087,969	19,278,567			13,190,598
14	0	0	6,087,969	19,278,567			13,190,598
15	0	0	6,087,969	19,278,567			13,190,598
Total	0	0	72,677,773	230,146,282	342,600,000	0	- 185,131,491

Table 194 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 0 in monetary terms using the data provided in Table 29. Based on the calculated values, the investment is not beneficial in monetary terms and the cost-effectiveness is low ($NPV < 0, IRR < 3\%, and\ B/C < 1$).

Table 194: Results of cost-benefit analysis in Scenario 0 for Bulgaria

CBA	NPV	IRR	B/C
Scenario 1	-185,131,491	-6%	0.55

Scenario analyses for the case study of Croatia

Cost-benefit analysis for Scenario 1 for Croatia

Table 195: the variables and their values for calculating CBA in Scenario 1 for Croatia

Variable	Value	Unit
Available budget for the creation of an LNG terminal and fossil gas transportation and distribution	1,972,000,000	EUR
Unitary investment cost	6,000	EUR
Unitary investment cost with subsidy	6,000	EUR
Number of influenced households	328,667	number of households
Energy consumption for space cooling	354	kWh
Energy consumption for space heating	11,951	kWh
% of energy savings in space cooling	30%	%
% of energy savings in space heating	30%	%
Energy savings in space cooling	106	kWh
Energy savings in space heating	3,585	kWh
Electricity price	0.11	EUR/kWh
Existing fuel price for space heating	0.03	EUR/kWh
Remaining value	10%	% of capital cost
Discount rate	3%	%

Table 196 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments. The discount rate is not considered in the table.

Table 196: Cash flows for cost-benefit analysis in Scenario 1 for Croatia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					1,972,000,000		-1,972,000,000
1	0	0	0	44,467,908			44,467,908
2	0	0	0	44,467,908			44,467,908
3	0	0	0	44,467,908			44,467,908
4	0	0	0	44,467,908			44,467,908
5	0	0	0	44,467,908			44,467,908
6	0	0	0	44,467,908			44,467,908
7	0	0	0	44,467,908			44,467,908
8	0	0	0	44,467,908			44,467,908
9	0	0	0	44,467,908			44,467,908
10	0	0	1,212	44,467,908			44,466,696
11	0	0	0	44,467,908			44,467,908
12	0	0	0	44,467,908			44,467,908
13	0	0	2,912	44,467,908			44,464,996
14	0	0	0	44,467,908			44,467,908

15	0	0	0	44,467,908			44,467,908
16	0	0	0	44,467,908			44,467,908
17	0	0	0	44,467,908			44,467,908
18	0	0	0	44,467,908			44,467,908
19	0	0	0	44,467,908			44,467,908
20	0	0	0	44,467,908			44,467,908
21	0	0	0	44,467,908			44,467,908
22	0	0	0	44,467,908			44,467,908
23	0	0	0	44,467,908			44,467,908
24	0	0	0	44,467,908			44,467,908
25	0	0	0	44,467,908		197,200,000	241,667,908
Total	0	0	2,885	774,326,250	1,972,000,000	191,456,311	-1,103,492,817

Table 197 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 1 in monetary terms using the data provided in Table 196. Based on the calculated values, the parameters obtained are not economically beneficial ($\mathrm{NPV} < 0, \mathrm{IRR} < 3\%$, and $\mathrm{B/C} < 1$). What this means is that, without any subsidies, such a scenario would be detrimental to the macroeconomy of the country, as it performs badly when considering purely economic benefits. Of course, in a real-life situation, other social factors would also be included in the multiple benefits analysis, which is what will be done in the next subsection with the SCBA.

Table 197: Results of cost-benefit analysis in Scenario 1 for Croatia

CBA	NPV	IRR	B/C
Scenario 1	-1,103,492,817	-3%	0.49

Cost-benefit analysis for Scenario 2 for Croatia

Table 198: The variables and their values for calculating CBA in Scenario 2 for Croatia

Variable	Value	Unit
Available budget for the creation of an LNG terminal and fossil gas transportation and distribution	1,972,000,000	EUR
Unitary investment cost	8,000	EUR
Unitary investment cost with subsidy	8,000	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Number of influenced households	246,500	number of households
Energy consumption for space cooling	354	kWh
Energy consumption for space heating	11,951	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
Electricity price	0.11	EUR/kWh
Existing fuel price for space heating	0.03	EUR/kWh
Remaining value	0%	% of capital cost
Discount rate	3%	%

Table 199 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments. The discount rate is not included in the table, and it is used for calculation of NPV.

Table 199: Cash flows for cost-benefit analysis in Scenario 2 for Croatia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					986,000,000		-986,000,000
1	0	0	88,473,030	101,925,643			13,452,614
2	0	0	88,473,030	101,925,643			13,452,614
3	0	0	88,473,030	101,925,643			13,452,614
4	0	0	88,473,030	101,925,643			13,452,614
5	0	0	88,473,030	101,925,643			13,452,614
6	0	0	88,473,030	101,925,643			13,452,614
7	0	0	88,473,030	101,925,643			13,452,614
8	0	0	88,473,030	101,925,643			13,452,614
9	0	0	88,473,030	101,925,643			13,452,614
10	0	0	1,212	101,925,643			101,924,431
11	0	0	88,473,030	101,925,643			13,452,614
12	0	0	0	101,925,643		0	101,925,643
Total	0	0	3,125	1,014,568,261	986,000,000	0	-724,208,085

Table 200 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 2 in monetary terms using the data provided in Table 199. Based on the calculated values, the parameters obtained are not economically beneficial ($\mathrm{NPV} < 0, \mathrm{IRR} < 3\%,$ and $\mathrm{B/C} < 1$). What this means is that, without any subsidies, such a scenario would be detrimental to the macroeconomy of the country, as it performs badly when considering purely economic benefits. Of course, in a real-life situation, other social factors would also be included in the multiple benefits analysis, which is what will be done in the next subsection with the SCBA.

Table 200: Results of cost-benefit analysis in Scenario 2 for Croatia

CBA	NPV	IRR	B/C
Scenario 1	-724,208,085	-11%	1.03

Cost-benefit analysis for Scenario 3 for Croatia

Table 201: the variables and their values for calculating CBA in Scenario 3 for Croatia

Variable	**Value**	**Unit**
Available budget for the creation of an LNG terminal and fossil gas transportation and distribution	1,972,000,000	EUR
Unitary investment cost-Building envelope	6,000	EUR
Unitary investment cost-Heat pump	8,000	EUR

Unitary investment cost with subsidy	14,000	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Number of influenced households	140,857	number of households
Energy consumption for space cooling	354	kWh
Energy consumption for space heating	11,951	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
% of energy savings in space cooling	30%	%
% of energy savings in space heating	30%	%
Energy savings in space cooling	106	kWh
Energy savings in space heating	3,585	kWh
Electricity consumption after interventions	7,284	kWh
Electricity price	0.11	EUR/kWh
Cost reduction due to net-metering	100%	
Electricity price-net metering	0.11	EUR/kWh
Existing fuel price for space heating	0.03	EUR/kWh
Remaining value	10%	% of capital cost
Discount rate	3%	%

Table 202 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments. The discount rate is not included in the table, and it is used for calculation of NPV.

Table 202: Cash flows for cost-benefit analysis in Scenario 3 for Croatia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					1,408,571,429		-1,408,571,429
1	0	0	35,389,212	59,827,932			24,438,720
2	0	0	35,389,212	59,827,932			24,438,720
3	0	0	35,389,212	59,827,932			24,438,720
4	0	0	35,389,212	59,827,932			24,438,720
5	0	0	35,389,212	59,827,932			24,438,720
6	0	0	35,389,212	59,827,932			24,438,720
7	0	0	35,389,212	59,827,932			24,438,720
8	0	0	35,389,212	59,827,932			24,438,720
9	0	0	35,389,212	59,827,932			24,438,720
10	0	0	35,389,212	59,827,932			24,438,720
11	0	0	35,389,212	59,827,932			24,438,720
12	0	0	35,389,212	59,827,932			24,438,720
13	0	0	35,389,212	59,827,932			24,438,720
14	0	0	35,389,212	59,827,932			24,438,720

15	0	0	35,389,212	59,827,932			24,438,720
16	0	0	35,389,212	59,827,932			24,438,720
17	0	0	35,389,212	59,827,932			24,438,720
18	0	0	35,389,212	59,827,932			24,438,720
19	0	0	35,389,212	59,827,932			24,438,720
20	0	0	35,389,212	59,827,932			24,438,720
21	0	0	35,389,212	59,827,932			24,438,720
22	0	0	35,389,212	59,827,932			24,438,720
23	0	0	35,389,212	59,827,932			24,438,720
24	0	0	35,389,212	59,827,932			24,438,720
25	0	0	35,389,212	59,827,932		197,200,000	221,638,720
Total	0	0	616,237,572	1,041,792,619	1,408,571,429	191,456,311	-888,832,563

Table 203 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 3 in monetary terms using the data provided in Table 86. Based on the calculated values, the parameters obtained are not economically beneficial ($\mathrm{NPV} < 0, \mathrm{IRR} < 3\%,$ and $\mathrm{B/C} < 1$). What this means is that, without any subsidies, such a scenario would be detrimental to the macroeconomy of the country, as it performs badly when considering purely economic benefits. Of course, in a real-life situation, other social factors would also be included in the multiple benefits analysis, which is what will be done in the next subsection with the SCBA.

Table 203: Results of cost-benefit analysis in Scenario 3 for Croatia

CBA	NPV	IRR	B/C
Scenario 3	-888,832,563	-3%	0.61

Cost-benefit analysis for Scenario 4 for Croatia

Table 204: The variables and their values for calculating CBA in Scenario 4 for Croatia

Variable	Value	Unit
Available budget for the creation of an LNG terminal and fossil gas transportation and distribution	1,972,000,000	EUR
Unitary investment cost-Building envelope	6,000	EUR
Unitary investment cost-Heat pump	8,000	EUR
Unitary investment cost-PV	8,546	EUR
Unitary investment cost with subsidy	22,546	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Installed capacity PV	6	kW
Unitary investment cost PV	1,526	EUR/kW
Number of influenced households	87,467	number of households
Energy consumption for space cooling	354	kWh
Energy consumption for space heating	11,951	kWh

Performance ratio existing boiler	85%	%
COP heat pump	3.0	
% of energy savings in space cooling	30%	%
% of energy savings in space heating	30%	%
Energy savings in space cooling	106	kWh
Energy savings in space heating	3,585	kWh
Electricity consumption after interventions	7,284	kWh
Electricity price	0.11	EUR/kWh
Cost reduction due to net-metering	30%	
Electricity price-net metering	0.03	EUR/kWh
Existing fuel price for space heating	0.03	EUR/kWh
Cost of operation and maintenance - Baseline scenario	0	EUR
Cost of operation and maintenance - Alternative scenario	100	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

Table 205 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments. The discount rate is not included in the table, and it is used for calculation of NPV.

Table 205: Cash flows for cost-benefit analysis in Scenario 4 for Croatia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					1,622,131,289		-1,622,131,289
1	8,746,718	0	21,975,417	84,425,434			53,703,299
2	8,746,718	0	21,975,417	84,425,434			53,703,299
3	8,746,718	0	21,975,417	84,425,434			53,703,299
4	8,746,718	0	21,975,417	84,425,434			53,703,299
5	8,746,718	0	21,975,417	84,425,434			53,703,299
6	8,746,718	0	21,975,417	84,425,434			53,703,299
7	8,746,718	0	21,975,417	84,425,434			53,703,299
8	8,746,718	0	21,975,417	84,425,434			53,703,299
9	8,746,718	0	21,975,417	84,425,434			53,703,299
10	8,746,718	0	21,975,417	84,425,434			53,703,299
11	8,746,718	0	21,975,417	84,425,434			53,703,299
12	8,746,718	0	21,975,417	84,425,434			53,703,299
13	8,746,718	0	21,975,417	84,425,434			53,703,299
14	8,746,718	0	21,975,417	84,425,434			53,703,299
15	8,746,718	0	21,975,417	84,425,434			53,703,299
16	8,746,718	0	21,975,417	84,425,434			53,703,299
17	8,746,718	0	21,975,417	84,425,434			53,703,299
18	8,746,718	0	21,975,417	84,425,434			53,703,299

19	8,746,718	0	21,975,417	84,425,434			53,703,299
20	8,746,718	0	21,975,417	84,425,434			53,703,299
21	8,746,718	0	21,975,417	84,425,434			53,703,299
22	8,746,718	0	21,975,417	84,425,434			53,703,299
23	8,746,718	0	21,975,417	84,425,434			53,703,299
24	8,746,718	0	21,975,417	84,425,434			53,703,299
25	8,746,718	0	21,975,417	84,425,434		197,200,000	250,903,299
Total	152,307,888	0	382,661,185	1,470,112,545	1,622,131,289	191,456,311	-592,803,999

Table 206 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 4 in monetary terms using the data provided in Table 205. Based on the calculated values, the parameters obtained are not economically beneficial ($\text{NPV} < 0, \text{IRR} < 3\%,$ and $\text{B}/\text{C} < 1$). What this means is that, without any subsidies, such a scenario would be detrimental to the macroeconomy of the country, as it performs badly when considering purely economic benefits. Of course, in a real-life situation, other social factors would also be included in the multiple benefits analysis, which is what will be done in the next subsection with the SCBA.

Table 206: Results of cost-benefit analysis in Scenario 4 for Croatia

CBA	NPV	IRR	B/C
Scenario 4	-592,803,999	0%	0.77

Cost-benefit analysis in Scenario 0 for Croatia

Table 207: The variables and their values for calculating CBA in Scenario 0 for Croatia

Variable	**Value**	**Unit**
Available budget for the creation of an LNG terminal and fossil gas transportation and distribution	1,972,000,000	EUR
Unitary investment cost	4,000	EUR
Unitary investment cost with subsidy	4,000	EUR
Number of influenced households	493,000	number of households
Unitary energy consumption for space cooling	354	kWh
Unitary energy consumption for space heating	11,951	kWh
Performance ratio of energy efficient boiler	95%	%
Performance ratio existing boiler	85%	%
Energy consumption after the interventions	10,693	kWh
Electricity price	0.11	EUR/kWh
Existing fuel price for space heating	0.03	EUR/kWh
Remaining value	10%	% of capital cost
Discount rate	3%	%

Table 208 shows the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments without considering the discount rates.

Table 208: Cash flows for cost-benefit analysis in Scenario 0 for Croatia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					1,972,000,000		-1,972,000,000
1	0	0	182,393,257	203,851,287			21,458,030
2	0	0	182,393,257	203,851,287			21,458,030
3	0	0	182,393,257	203,851,287			21,458,030
4	0	0	182,393,257	203,851,287			21,458,030
5	0	0	182,393,257	203,851,287			21,458,030
6	0	0	182,393,257	203,851,287			21,458,030
7	0	0	182,393,257	203,851,287			21,458,030
8	0	0	182,393,257	203,851,287			21,458,030
9	0	0	182,393,257	203,851,287			21,458,030
10	0	0	182,393,257	203,851,287			21,458,030
11	0	0	182,393,257	203,851,287			21,458,030
12	0	0	182,393,257	203,851,287			21,458,030
13	0	0	182,393,257	203,851,287			21,458,030
14	0	0	182,393,257	203,851,287			21,458,030
15	0	0	182,393,257	203,851,287			21,458,030
Total	0	0	2,177,398,857	2,433,563,428	1,972,000,000	0	-1,715,835,429

Table 209 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 0 in monetary terms using the data provided in Table 100. Based on the calculated values, the investment is not beneficial in monetary terms and the cost-effectiveness is low ($\mathrm{NPV} < 0, \mathrm{IRR} < 3\%,$ and $\mathrm{B/C} < 1$).

Table 209: Results of cost-benefit analysis in Scenario 0 for Croatia

CBA	NPV	IRR	B/C
Scenario 1	-1,715,835,429	-17%	0.59

Scenario analyses for the case study of Hungary

Cost-benefit analysis for Scenario 1 for Hungary

Table 210 - The variables and their values for calculating CBA in Scenario 1 for Hungary

Variable	Values	Unit
Available budget for the expansion of the electricity grid and the development of gas turbine power plant	500,000,000	EUR
Unitary investment cost	18,000	EUR
Unitary investment cost with subsidy	18,000	EUR
Avoided cost from new fossil fuel boiler	0	EUR
Number of influenced households	27,778	number of households
Energy consumption for space cooling	39	kWh
Energy consumption for space heating	11,388	kWh
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	19	kWh
Energy savings in space heating	5,694	kWh
Electricity price	0.09	EUR/kWh
Existing fuel price for space heating	0.03	EUR/kWh
Cost of operation and maintenance - Baseline Scenario	0	EUR
Cost of operation and maintenance - Alternative Scenario	0	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

Table 211 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments.

Table 211 - Cash flows for cost-benefit analysis in Scenario 1 for Hungary (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					500,000,000		-525,800,000
1	0	0	0	4,653,531			4,653,531
2	0	0	0	4,653,531			4,653,531
3	0	0	0	4,653,531			4,653,531
4	0	0	0	4,653,531			4,653,531
5	0	0	0	4,653,531			4,653,531
6	0	0	0	4,653,531			4,653,531
7	0	0	0	4,653,531			4,653,531
8	0	0	0	4,653,531			4,653,531

9	0	0	0	4,653,531			4,653,531
10	0	0	0	4,653,531			4,653,531
11	0	0	0	4,653,531			4,653,531
12	0	0	0	4,653,531			4,653,531
13	0	0	0	4,653,531			4,653,531
14	0	0	0	4,653,531			4,653,531
15	0	0	0	4,653,531			4,653,531
16	0	0	0	4,653,531			4,653,531
17	0	0	0	4,653,531			4,653,531
18	0	0	0	4,653,531			4,653,531
19	0	0	0	4,653,531			4,653,531
20	0	0	0	4,653,531			4,653,531
21	0	0	0	4,653,531			4,653,531
22	0	0	0	4,653,531			4,653,531
23	0	0	0	4,653,531			4,653,531
24	0	0	0	4,653,531			4,653,531
25	0	0	0	4,653,531		50,000,000	54,653,531
Total	**0**	**0**	**0**	**81,032,622**	**500,000,000**	**48,543,689**	**-395,087,100**

Table 212 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 1 in monetary terms using the data provided in table 211. Based on the calculated values, the investment is not beneficial in monetary terms and the cost-effectiveness is low ($NPV < 0, IRR < 3\%, and\ B/C < 1$).

Table 212 - Results of cost-benefit analysis in Scenario 1 for Hungary

CBA	**NPV**	**IRR**	**B/C**
Scenario 1	-395,087,100	-6%	0.26

Cost-benefit analysis in Scenario 2 for Hungary

Table 213 - The variables and their values for calculating CBA in Scenario 2 for Hungary

Variable	**Value**	**Unit**
Available budget for the expansion of the electricity grid and the development of gas turbine power plant	500,000,000	EUR
Unitary investment cost	10,500	EUR
Unitary investment cost with subsidy	10,500	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Number of influenced households	47,619	number of households
Energy consumption for space cooling	39	kWh
Energy consumption for space heating	11,388	kWh
Performance ratio existing boiler	85%	%

COP heat pump	3.0	
Electricity price	0.09	EUR/kWh
Existing fuel price for space heating	0.03	EUR/kWh
Cost of operation and maintenance - Baseline Scenario	0	EUR
Cost of operation and maintenance - Alternative Scenario	0	EUR
Remaining value	0%	% of capital cost
Discount rate	3%	%

Table 214 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments. The discount rate is not included in the table, and it is used for calculation of NPV.

Table 214 - Cash flows for cost-benefit analysis in Scenario 2 for Hungary (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					309,523,810		-309,523,810
1	0	0	14,566,001	15,780,738			1,214,737
2	0	0	14,566,001	15,780,738			1,214,737
3	0	0	14,566,001	15,780,738			1,214,737
4	0	0	14,566,001	15,780,738			1,214,737
5	0	0	14,566,001	15,780,738			1,214,737
6	0	0	14,566,001	15,780,738			1,214,737
7	0	0	14,566,001	15,780,738			1,214,737
8	0	0	14,566,001	15,780,738			1,214,737
9	0	0	14,566,001	15,780,738			1,214,737
10	0	0	14,566,001	15,780,738			1,214,737
11	0	0	14,566,001	15,780,738			1,214,737
12	0	0	14,566,001	15,780,738		0	1,214,737
Total	**0**	**0**	**144,990,029**	**157,081,528**	**309,523,810**	**0**	**-297,432,310**

Table 215 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 2 in monetary terms using the data provided in table 116. Based on the calculated values, the investment is not beneficial in monetary terms and the cost-effectiveness is low ($NPV < 0, IRR < 3\%, and\ B/C < 1$).

Table 215 - Results of cost-benefit analysis in Scenario 2

CBA	NPV	IRR	B/C
Scenario 2	-297,432,310	-30%	0.35

Cost-benefit analysis for Scenario 3 for Hungary

Table 216: the variables and their values for calculating CBA in Scenario 3 for Hungary

Variable	Value	Unit
Available budget for the expansion of the electricity grid and the development of gas turbine power plant	500,000,000	EUR
Unitary investment cost-Building envelope	18,000	EUR
Unitary investment cost-Heat pump	10,500	EUR
Unitary investment cost with subsidy	28,500	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Number of influenced households	17,544	number of households
Energy consumption for space cooling	39	kWh
Energy consumption for space heating	11,388	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	19	kWh
Energy savings in space heating	5,694	kWh
Electricity consumption after interventions	4,752	kWh
Electricity price	0.09	EUR/kWh
Cost reduction due to net-metering	100%	
Electricity price-net metering	0.09	EUR/kWh
Existing fuel price for space heating	0.03	EUR/kWh
Cost of operation and maintenance - Baseline Scenario	0	EUR
Cost of operation and maintenance - Alternative Scenario	0	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

Table 217 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments. The discount rate is not included in the table, and it is used for calculation of NPV.

Table 217: Cash flows for the cost-benefit analysis in Scenario 3 for Hungary (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					429,824,561		-429,824,561
1	0	0	2,683,211	5,846,050			3,162,840
2	0	0	2,683,211	5,846,050			3,162,840
3	0	0	2,683,211	5,846,050			3,162,840
4	0	0	2,683,211	5,846,050			3,162,840
5	0	0	2,683,211	5,846,050			3,162,840
6	0	0	2,683,211	5,846,050			3,162,840

7	0	0	2,683,211	5,846,050			3,162,840
8	0	0	2,683,211	5,846,050			3,162,840
9	0	0	2,683,211	5,846,050			3,162,840
10	0	0	2,683,211	5,846,050			3,162,840
11	0	0	2,683,211	5,846,050			3,162,840
12	0	0	2,683,211	5,846,050			3,162,840
13	0	0	2,683,211	5,846,050			3,162,840
14	0	0	2,683,211	5,846,050			3,162,840
15	0	0	2,683,211	5,846,050			3,162,840
16	0	0	2,683,211	5,846,050			3,162,840
17	0	0	2,683,211	5,846,050			3,162,840
18	0	0	2,683,211	5,846,050			3,162,840
19	0	0	2,683,211	5,846,050			3,162,840
20	0	0	2,683,211	5,846,050			3,162,840
21	0	0	2,683,211	5,846,050			3,162,840
22	0	0	2,683,211	5,846,050			3,162,840
23	0	0	2,683,211	5,846,050			3,162,840
24	0	0	2,683,211	5,846,050			3,162,840
25	0	0	2,683,211	5,846,050		50,000,000	53,162,840
Total	**0**	**0**	**46,723,143**	**101,798,136**	**429,824,561**	**48,543,689**	**-350,869,290**

Table 218 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 3 in monetary terms using the data provided in table 130. Based on the calculated values, the investment is not beneficial in monetary terms and the cost-effectiveness is low ($NPV < 0, IRR < 3\%, and\ B/C < 1$).

Table 218: Results of cost-benefit analysis in Scenario 3 for Hungary

CBA	NPV	IRR	B/C
Scenario 3	-350,869,290	-6%	0.32

Cost-benefit analysis in Scenario 4 for Hungary

Table 219 - The variables and their values for calculating CBA in Scenario 4 for Hungary

Variable	Value	Unit
Available budget for the expansion of the electricity grid and the development of gas turbine power plant	500,000,000	EUR
Unitary investment cost-Building envelope	18,000	EUR
Unitary investment cost-Heat pump	10,500	EUR
Unitary investment cost-PV	6,604	EUR

Unitary investment cost with subsidy	35,104	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Installed capacity PV	4	kW
Unitary investment cost PV	1,651	EUR/kW
Number of influenced households	14,243	number of households
Energy consumption for space cooling	39	kWh
Energy consumption for space heating	11,388	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	19	kWh
Energy savings in space heating	5,694	kWh
Electricity consumption after interventions	4,752	kWh
Electricity price	0.09	EUR/kWh
Cost reduction due to net-metering	50%	
Electricity price-net metering	0.05	EUR/kWh
Existing fuel price for space heating	0.03	EUR/kWh
Cost of operation and maintenance - Baseline Scenario	0	EUR
Cost of operation and maintenance - Alternative Scenario	100	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

Table 220 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments. The discount rate is not included in the table, and it is used for calculation of NPV.

Table 220 - Cash flows for cost-benefit analysis in Scenario 4 for Hungary (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					443,026,436		-443,026,436
1	1,424,339	0	2,178,427	7,954,664			4,351,898
2	1,424,339	0	2,178,427	7,954,664			4,351,898
3	1,424,339	0	2,178,427	7,954,664			4,351,898
4	1,424,339	0	2,178,427	7,954,664			4,351,898
5	1,424,339	0	2,178,427	7,954,664			4,351,898
6	1,424,339	0	2,178,427	7,954,664			4,351,898
7	1,424,339	0	2,178,427	7,954,664			4,351,898
8	1,424,339	0	2,178,427	7,954,664			4,351,898
9	1,424,339	0	2,178,427	7,954,664			4,351,898
10	1,424,339	0	2,178,427	7,954,664			4,351,898

11	1,424,339	0	2,178,427	7,954,664			4,351,898
12	1,424,339	0	2,178,427	7,954,664			4,351,898
13	1,424,339	0	2,178,427	7,954,664			4,351,898
14	1,424,339	0	2,178,427	7,954,664			4,351,898
15	1,424,339	0	2,178,427	7,954,664			4,351,898
16	1,424,339	0	2,178,427	7,954,664			4,351,898
17	1,424,339	0	2,178,427	7,954,664			4,351,898
18	1,424,339	0	2,178,427	7,954,664			4,351,898
19	1,424,339	0	2,178,427	7,954,664			4,351,898
20	1,424,339	0	2,178,427	7,954,664			4,351,898
21	1,424,339	0	2,178,427	7,954,664			4,351,898
22	1,424,339	0	2,178,427	7,954,664			4,351,898
23	1,424,339	0	2,178,427	7,954,664			4,351,898
24	1,424,339	0	2,178,427	7,954,664			4,351,898
25	1,424,339	0	2,178,427	7,954,664		50,000,000	54,351,898
Total	**24,802,227**	**0**	**37,933,272**	**138,515,746**	**443,026,436**	**48,543,689**	**-343,365,911**

Table 221 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 4 in monetary terms using the data provided in Table 220. Based on the calculated values, the investment is not beneficial in monetary terms and the cost-effectiveness is low ($NPV < 0, IRR < 3\%, and\ B/C < 1$).

Table 221 - Results of cost-benefit analysis in Scenario 4 for Hungary

CBA	**NPV**	**IRR**	**B/C**
Scenario 4	-343,365,911	-5%	0.37

Cost-benefit analysis in Scenario 0 for Hungary

Table 222 – The variables and their values for calculating CBA in Scenario 0 for Hungary

Variable	**Value**	**Unit**
Available budget for the investment on the expansion of the electricity grid and the development of gas turbine power plant	500,000,000	EUR
Unitary investment cost	4,000	EUR
Unitary investment cost with subsidy	4,000	EUR
Avoided cost from new fossil fuel boiler	0	EUR
Number of influenced households	125,000	number of households
Unitary energy consumption for space cooling	39	kWh
Unitary energy consumption for space heating	11,388	kWh
Performance ratio of energy efficient boiler	95%	%
Performance ratio existing boiler	85%	%

Energy consumption after the interventions	10,189	kWh
Electricity price	0.09	EUR/kWh
Existing fuel price for space heating	0.03	EUR/kWh
Cost of operation and maintenance - Baseline Scenario	0	EUR
Cost of operation and maintenance - Alternative Scenario	0	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

Table 223 shows the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments without considering the discount rates.

Table 223 – Cash flows for cost-benefit analysis in Scenario 0 for Hungary (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					500,000,000		-500,000,000
1	0	0	37,063,970	41,424,437			4,360,467
2	0	0	37,063,970	41,424,437			4,360,467
3	0	0	37,063,970	41,424,437			4,360,467
4	0	0	37,063,970	41,424,437			4,360,467
5	0	0	37,063,970	41,424,437			4,360,467
6	0	0	37,063,970	41,424,437			4,360,467
7	0	0	37,063,970	41,424,437			4,360,467
8	0	0	37,063,970	41,424,437			4,360,467
9	0	0	37,063,970	41,424,437			4,360,467
10	0	0	37,063,970	41,424,437			4,360,467
11	0	0	37,063,970	41,424,437			4,360,467
12	0	0	37,063,970	41,424,437			4,360,467
13	0	0	37,063,970	41,424,437			4,360,467
14	0	0	37,063,970	41,424,437			4,360,467
15	0	0	37,063,970	41,424,437			4,360,467
Total	**0**	**0**	**442,467,266**	**494,522,238**	**500,000,000**	**0**	**-447,945,028**

Table 224 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 0 in monetary terms based on these values. According to the results, the investment is not beneficial in monetary terms and the cost-effectiveness is low ($NPV < 0, IRR < 3\%, and\ B/C < 1$).

Table 224 - Results of cost-benefit analysis in Scenario 0 for Hungary

CBA	NPV	IRR	B/C

Scenario 0	-447,945,028	-19%	0.52

Scenario analyses for the case study of Poland

Cost-benefit analysis for Scenario 1 for Poland

Table 225- The variables and their values for calculating CBA in Scenario 1 for Poland

Variable	Values	Unit
Available budget for the expansion of the gas infrastructure and gas power plants	12,566,000,000	EUR
Unitary investment cost	17,000	EUR
Unitary investment cost with subsidy	17,000	EUR
Avoided cost from new fossil fuel boiler	0	EUR
Number of influenced households	739,176	number of households
Energy consumption for space cooling	0	kWh
Energy consumption for space heating	9,379	kWh
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	0	kWh
Energy savings in space heating	4,690	kWh
Electricity price	0.15	EUR/kWh
Existing fuel price for space heating	0.06	EUR/kWh
Cost of operation and maintenance - Baseline Scenario	0	EUR
Cost of operation and maintenance - Alternative Scenario	0	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

Table 226 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments.

Table 226 - Cash flows for cost-benefit analysis in Scenario 1 for Poland (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					12,566,000,000		-12,566,000,000
1	0	0	0	208,679,937			208,679,937
2	0	0	0	208,679,937			208,679,937
3	0	0	0	208,679,937			208,679,937

4	0	0	0	208,679,937			208,679,937
5	0	0	0	208,679,937			208,679,937
6	0	0	0	208,679,937			208,679,937
7	0	0	0	208,679,937			208,679,937
8	0	0	0	208,679,937			208,679,937
9	0	0	0	208,679,937			208,679,937
10	0	0	0	208,679,937			208,679,937
11	0	0	0	208,679,937			208,679,937
12	0	0	0	208,679,937			208,679,937
13	0	0	0	208,679,937			208,679,937
14	0	0	0	208,679,937			208,679,937
15	0	0	0	208,679,937			208,679,937
16	0	0	0	208,679,937			208,679,937
17	0	0	0	208,679,937			208,679,937
18	0	0	0	208,679,937			208,679,937
19	0	0	0	208,679,937			208,679,937
20	0	0	0	208,679,937			208,679,937
21	0	0	0	208,679,937			208,679,937
22	0	0	0	208,679,937			208,679,937
23	0	0	0	208,679,937			208,679,937
24	0	0	0	208,679,937			208,679,937
25	0	0	0	208,679,937		1,256,600,000	1,465,279,937
Total	**0**	**0**	**0**	**3,633,774,556**	**12,566,000,000**	**1,220,000,000**	**-8,332,066,285**

Table 227 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 1 in monetary terms using the data provided in Table 226. Based on the calculated values, the investment is not beneficial in monetary terms and the cost-effectiveness is low ($NPV < 0, IRR < 3\%, and\ B/C < 1$).

Table 227 - Results of cost-benefit analysis in Scenario 1 for Poland

CBA	**NPV**	**IRR**	**B/C**
Scenario 1	-8,332,066,285	-4%	0.39

Cost-benefit analysis in Scenario 2 for Poland

Table 228 - The variables and their values for calculating CBA in Scenario 2 for Poland

Variable	Value	Unit
Available budget for the expansion of the gas infrastructure and gas power plants	12,566,000,000	EUR
Unitary investment cost	10,000	EUR
Unitary investment cost with subsidy	10,000	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Number of influenced households	1,256,600	number of households
Energy consumption for space cooling	0	kWh
Energy consumption for space heating	9,379	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
Electricity price	0.15	EUR/kWh
Existing fuel price for space heating	0.06	EUR/kWh
Cost of operation and maintenance - Baseline Scenario	0	EUR
Cost of operation and maintenance - Alternative Scenario	0	EUR
Remaining value	0%	% of capital cost
Discount rate	3%	%

Table 229 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments. The discount rate is not included in the table, and it is used for calculation of NPV.

Table 229 - Cash flows for cost-benefit analysis in Scenario 2 for Poland (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					7,539,600,000		-7,539,600,000
1	0	0	488,879,548	709,511,784			220,632,236
2	0	0	488,879,548	709,511,784			220,632,236
3	0	0	488,879,548	709,511,784			220,632,236
4	0	0	488,879,548	709,511,784			220,632,236
5	0	0	488,879,548	709,511,784			220,632,236
6	0	0	488,879,548	709,511,784			220,632,236
7	0	0	488,879,548	709,511,784			220,632,236
8	0	0	488,879,548	709,511,784			220,632,236
9	0	0	488,879,548	709,511,784			220,632,236
10	0	0	488,879,548	709,511,784			220,632,236
11	0	0	488,879,548	709,511,784			220,632,236

12	0	0	488,879,548	709,511,784		0	220,632,236
Total	**0**	**0**	**4,866,308,978**	**7,062,483,136**	**7,539,600,000**	**0**	**-5,343,425,842**

Table 230 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 2 in monetary terms using the data provided in table 229. Based on the calculated values, the investment is not beneficial in monetary terms and the cost-effectiveness is low ($NPV < 0, IRR < 3\%, and\ B/C < 1$).

Table 230 - Results of cost-benefit analysis in Scenario 2

CBA	NPV	IRR	B/C
Scenario 2	-5,343,425,842	-13%	0.57

Cost-benefit analysis for Scenario 3 for Poland

Table 231: the variables and their values for calculating CBA in Scenario 3 for Poland

Variable	Value	Unit
Available budget for the expansion of the gas infrastructure and gas power plants	12,566,000,000	EUR
Unitary investment cost-Building envelope	17,000	EUR
Unitary investment cost-Heat pump	10,000	EUR
Unitary investment cost with subsidy	0	EUR
Avoided cost from new fossil fuel boiler	27,000	EUR
Number of influenced households	4,000	number of households
Energy consumption for space cooling	0	kWh
Energy consumption for space heating	0	kWh
Performance ratio existing boiler	465,407	%
COP heat pump	0	
% of energy savings in space cooling	9,379	%
% of energy savings in space heating	85%	%
Energy savings in space cooling	3.0	kWh
Energy savings in space heating	50%	kWh
Electricity consumption after interventions	50%	kWh
Electricity price	0	EUR/kWh
Cost reduction due to net-metering	4,690	
Electricity price-net metering	3,599	EUR/kWh
Existing fuel price for space heating	0.15	EUR/kWh
Cost of operation and maintenance - Baseline Scenario	100%	EUR
Cost of operation and maintenance - Alternative Scenario	0.15	EUR
Remaining value	0.06	% of capital cost
Discount rate	0	%

Table 232 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments. The discount rate is not included in the table, and it is used for calculation of NPV.

Table 232: Cash flows for the cost-benefit analysis in Scenario 3 for Poland (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					10,704,370,370		-10,704,370,370
1	0	0	90,533,250	262,782,142			172,248,893
2	0	0	90,533,250	262,782,142			172,248,893
3	0	0	90,533,250	262,782,142			172,248,893
4	0	0	90,533,250	262,782,142			172,248,893
5	0	0	90,533,250	262,782,142			172,248,893
6	0	0	90,533,250	262,782,142			172,248,893
7	0	0	90,533,250	262,782,142			172,248,893
8	0	0	90,533,250	262,782,142			172,248,893
9	0	0	90,533,250	262,782,142			172,248,893
10	0	0	90,533,250	262,782,142			172,248,893
11	0	0	90,533,250	262,782,142			172,248,893
12	0	0	90,533,250	262,782,142			172,248,893
13	0	0	90,533,250	262,782,142			172,248,893
14	0	0	90,533,250	262,782,142			172,248,893
15	0	0	90,533,250	262,782,142			172,248,893
16	0	0	90,533,250	262,782,142			172,248,893
17	0	0	90,533,250	262,782,142			172,248,893
18	0	0	90,533,250	262,782,142			172,248,893
19	0	0	90,533,250	262,782,142			172,248,893
20	0	0	90,533,250	262,782,142			172,248,893
21	0	0	90,533,250	262,782,142			172,248,893
22	0	0	90,533,250	262,782,142			172,248,893
23	0	0	90,533,250	262,782,142			172,248,893
24	0	0	90,533,250	262,782,142			172,248,893
25	0	0	90,533,250	262,782,142		1,256,600,000	1,428,848,893
Total	**0**	**0**	1,576,468,848	4,575,864,256	10,704,370,370	1,220,000,000	-7,104,815,804

Table 233 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 3 in monetary terms using the data provided in Table 232. Based on the calculated values, the investment is not beneficial in monetary terms and the cost-effectiveness is low ($NPV < 0, IRR < 3\%, and\ B/C < 1$).

Table 233: Results of cost-benefit analysis in Scenario 3 for Poland

CBA	NPV	IRR	B/C
Scenario 3	-7,104,815,804	-4%	0.47

Cost-benefit analysis in Scenario 4 for Poland

Table 234 - The variables and their values for calculating CBA in Scenario 4 for Poland

Variable	Value	Unit
Available budget for the expansion of the gas infrastructure and gas power plants	12,566,000,000	EUR
Unitary investment cost-Building envelope	17,000	EUR
Unitary investment cost-Heat pump	10,000	EUR
Unitary investment cost-PV	5,597	EUR
Unitary investment cost with subsidy	13,983	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Installed capacity PV	4	kW
Unitary investment cost PV	1,599	EUR/kW
Number of influenced households	898,660	number of households
Energy consumption for space cooling	0	kWh
Energy consumption for space heating	9,379	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	0	kWh
Energy savings in space heating	4,690	kWh
Electricity consumption after interventions	3,599	kWh
Electricity price	0.15	EUR/kWh
Cost reduction due to net-metering	50%	
Electricity price-net metering	0.07	EUR/kWh
Existing fuel price for space heating	0.06	EUR/kWh
Cost of operation and maintenance - Baseline Scenario	0	EUR
Cost of operation and maintenance - Alternative Scenario	100	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

Table 235 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments. The discount rate is not included in the table, and it is used for calculation of NPV.

Table 235 - Cash flows for cost-benefit analysis in Scenario 4 for Poland (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					11,023,993,956		-11,023,993,956
1	38,550,151	0	74,989,577	319,234,768			205,695,040
2	38,550,151	0	74,989,577	319,234,768			205,695,040
3	38,550,151	0	74,989,577	319,234,768			205,695,040
4	38,550,151	0	74,989,577	319,234,768			205,695,040
5	38,550,151	0	74,989,577	319,234,768			205,695,040
6	38,550,151	0	74,989,577	319,234,768			205,695,040
7	38,550,151	0	74,989,577	319,234,768			205,695,040
8	38,550,151	0	74,989,577	319,234,768			205,695,040
9	38,550,151	0	74,989,577	319,234,768			205,695,040
10	38,550,151	0	74,989,577	319,234,768			205,695,040
11	38,550,151	0	74,989,577	319,234,768			205,695,040
12	38,550,151	0	74,989,577	319,234,768			205,695,040
13	38,550,151	0	74,989,577	319,234,768			205,695,040
14	38,550,151	0	74,989,577	319,234,768			205,695,040
15	38,550,151	0	74,989,577	319,234,768			205,695,040
16	38,550,151	0	74,989,577	319,234,768			205,695,040
17	38,550,151	0	74,989,577	319,234,768			205,695,040
18	38,550,151	0	74,989,577	319,234,768			205,695,040
19	38,550,151	0	74,989,577	319,234,768			205,695,040
20	38,550,151	0	74,989,577	319,234,768			205,695,040
21	38,550,151	0	74,989,577	319,234,768			205,695,040
22	38,550,151	0	74,989,577	319,234,768			205,695,040
23	38,550,151	0	74,989,577	319,234,768			205,695,040
24	38,550,151	0	74,989,577	319,234,768			205,695,040
25	38,550,151	0	74,989,577	319,234,768		1,256,600,000	1,462,295,040
Total	671,279,474	0	1,305,804,577	5,558,882,169	11,023,993,956	1,220,000,000	-6,842,036,681

Table 236 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 4 in monetary terms using the data provided in Table 235. Based on the calculated values, the investment is not beneficial in monetary terms ($NPV < 0, IRR < 3\%, B/C < 1$).

Table 236 - Results of cost-benefit analysis in Scenario 4 for Poland

CBA	**NPV**	**IRR**	**B/C**
Scenario 4	-6,842,036,681	-3%	0.52

Cost-benefit analysis in Scenario 0 for Poland

Table 237 – The variables and their values for calculating CBA in Scenario 0 for Poland

Variable	Value	Unit
Available budget for the expansion of the gas infrastructure and gas power plants	12,566,000,000	EUR
Unitary investment cost	4,000	EUR
Unitary investment cost with subsidy	4,000	EUR
Avoided cost from new fossil fuel boiler	0	EUR
Number of influenced households	3,141,500	number of households
Unitary energy consumption for space cooling	0	kWh
Unitary energy consumption for space heating	9,379	kWh
Performance ratio of energy efficient boiler	95%	%
Performance ratio existing boiler	85%	%
Energy consumption after the interventions	8,392	kWh
Electricity price	0.15	EUR/kWh
Existing fuel price for space heating	0.06	EUR/kWh
Cost of operation and maintenance - Baseline Scenario	0	EUR
Cost of operation and maintenance - Alternative Scenario	0	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

Table 238 shows the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments without considering the discount rates.

Table 238 – Cash flows for cost-benefit analysis in Scenario 0 for Poland (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					12,566,000,000		-12,566,000,000
1	0	0	1,587,065,834	1,773,779,461			186,713,627
2	0	0	1,587,065,834	1,773,779,461			186,713,627
3	0	0	1,587,065,834	1,773,779,461			186,713,627
4	0	0	1,587,065,834	1,773,779,461			186,713,627
5	0	0	1,587,065,834	1,773,779,461			186,713,627
6	0	0	1,587,065,834	1,773,779,461			186,713,627
7	0	0	1,587,065,834	1,773,779,461			186,713,627
8	0	0	1,587,065,834	1,773,779,461			186,713,627
9	0	0	1,587,065,834	1,773,779,461			186,713,627
10	0	0	1,587,065,834	1,773,779,461			186,713,627
11	0	0	1,587,065,834	1,773,779,461			186,713,627
12	0	0	1,587,065,834	1,773,779,461			186,713,627

13	0	0	1,587,065,834	1,773,779,461			186,713,627
14	0	0	1,587,065,834	1,773,779,461			186,713,627
15	0	0	1,587,065,834	1,773,779,461			186,713,627
Total	**0**	**0**	**18,946,288,900**	**21,175,264,065**	**12,566,000,000**	**0**	**-10,337,024,835**

Table 239 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 0 in monetary terms based on these values. According to the results, the investment is not beneficial in monetary terms and the cost-effectiveness is low ($NPV < 0, IRR < 3\%, and\ B/C < 1$).

Table 239 - Results of cost-benefit analysis in Scenario 0 for Poland

CBA	NPV	IRR	B/C
Scenario 0	-10,337,024,835	-15%	0.67

Scenario analyses for the case study of Romania

Cost-benefit analysis for Scenario 1 for Romania

Table 240 indicates the actual and assumed values for calculating CBA. Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 4.35 billion) is divided by unitary investment cost (EUR 12,000) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 4.35 billion}}{\text{EUR 12,000}} = 362{,}500$ (4.9%).
- It is also assumed that the households do not need to install a new energy efficient boiler due to reduction of energy consumption for space heating. Therefore, the required investment costs are reduced for the households. Therefore, avoided costs from new fossil fuel boiler for the influenced households are deducted from the initial investment costs.
- The energy saving rates for space heating and cooling are assumed to be 50% due to improving the building envelops (Balaras, 2007).
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime of building envelope is on average 25 years. It is also considered that 10% of the value of the investment will be remained in the year 25.

Table 240 - The variables and their values for calculating CBA in Scenario 1 for Romania

Variables	Values	Units
Available budget for fossil fuels	4,350,000,000	EUR
Unitary investment cost	12,000	EUR
Unitary investment cost with subsidy	12,000	EUR
Number of influenced households	362,500	Number of households
Energy consumption for space cooling	40	kWh
Energy consumption for space heating	7,521	kWh
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	20	kWh
Energy savings in space heating	3,760	kWh
Electricity price	0.17	EUR/kWh
Existing fuel price for space heating	0.06	EUR/kWh
Cost of operation and maintenance - baseline Scenario	0	EUR
Cost of operation and maintenance - alternative Scenario	0	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

Table 241 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments. The discount rate is not considered.

Table 241 - Cash flows for cost-benefit analysis in Scenario 1 for Romania (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					4,350,000,000		-4,350,000,000
1	0	0	0	86,132,586			86,132,586
2	0	0	0	86,132,586			86,132,586
3	0	0	0	86,132,586			86,132,586
4	0	0	0	86,132,586			86,132,586
5	0	0	0	86,132,586			86,132,586
6	0	0	0	86,132,586			86,132,586
7	0	0	0	86,132,586			86,132,586
8	0	0	0	86,132,586			86,132,586
9	0	0	0	86,132,586			86,132,586
10	0	0	0	86,132,586			86,132,586
11	0	0	0	86,132,586			86,132,586
12	0	0	0	86,132,586			86,132,586
13	0	0	0	86,132,586			86,132,586
14	0	0	0	86,132,586			86,132,586
15	0	0	0	86,132,586			86,132,586
16	0	0	0	86,132,586			86,132,586
17	0	0	0	86,132,586			86,132,586
18	0	0	0	86,132,586			86,132,586
19	0	0	0	86,132,586			86,132,586
20	0	0	0	86,132,586			86,132,586
21	0	0	0	86,132,586			86,132,586
22	0	0	0	86,132,586			86,132,586
23	0	0	0	86,132,586			86,132,586
24	0	0	0	86,132,586			86,132,586
25	0	0	0	86,132,586		435,000,000	521,132,586
Total	**0**	**0**	**0**	**1,499,839,447**	**4,350,000,000**	**422,330,097**	**-2,642,402,131**

Table 242 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 1 in monetary terms using the data provided in Table 241. Based on the calculated values, the investment is not beneficial in monetary terms and the cost-effectiveness is low ($NPV < 0, IRR < 3\%, and\ B/C < 1$).

Table 242 - Results of cost-benefit analysis in Scenario 1 for Romania

CBA	NPV	IRR	B/C
Scenario 1	-2,642,402,131	-3%	0.44

Cost-benefit analysis in Scenario 2 for Romania

Table 243 indicates the actual and assumed values for calculating CBA. Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 4.35 billion) is divided by unitary investment cost (EUR 6,500) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 4.35 billion}}{\text{EUR 6,500}}$ = 669,231 (9.0%).
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households.
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime of heat pump is on average 12 years.

Table 243 - The variables and their values for calculating CBA in Scenario 2 for Romania

Variables	Values	Units
Available budget for fossil fuels	4,350,000,000	EUR
Unitary investment cost	6,500	EUR
Unitary investment cost with subsidy	6,500	EUR
Avoided cost from new fossil fuel boiler	3,000	EUR
Number of influenced households	669,231	number of households
Energy consumption for space cooling	40	kWh
Energy consumption for space heating	7,521	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
Electricity price	0.17	EUR/kWh
Existing fuel price for space heating	0.06	EUR/kWh
Remaining value	0%	% of capital cost
Discount rate	3%	%

Table 244 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments. The discount rate is not included in the table, and it is used for calculation of NPV.

Table 244 - Cash flows for cost-benefit analysis in Scenario 2 for Romania (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					2,342,307,692		-2,342,307,692
1	0	0	240,430,817	313,561,648			73,130,831
2	0	0	240,430,817	313,561,648			73,130,831
3	0	0	240,430,817	313,561,648			73,130,831
4	0	0	240,430,817	313,561,648			73,130,831

5	0	0	240,430,817	313,561,648				73,130,831
6	0	0	240,430,817	313,561,648				73,130,831
7	0	0	240,430,817	313,561,648				73,130,831
8	0	0	240,430,817	313,561,648				73,130,831
9	0	0	240,430,817	313,561,648				73,130,831
10	0	0	240,430,817	313,561,648				73,130,831
11	0	0	240,430,817	313,561,648				73,130,831
12	0	0	240,430,817	313,561,648			0	73,130,831
Total	**0**	**0**	**2,393,249,317**	**3,121,193,897**	**2,342,307,692**		**0**	**-1,614,363,113**

Table 245 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 2 in monetary terms using the data provided in Table 273. Based on the calculated values, the investment is not beneficial in monetary terms and the cost-effectiveness is low ($NPV < 0, IRR < 3\%, and\ B/C < 1$).

Table 245 - Results of cost-benefit analysis in Scenario 2

CBA	**NPV**	**IRR**	**B/C**
Scenario 2	-1,614,363,113	-13%	0.66

Cost-benefit analysis for Scenario 3 for Romania

Table 246 indicates the actual and assumed values for calculating CBA. Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 4.35 billion) is divided by unitary investment cost with subsidy (EUR18,500) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 4.35 billion}}{\text{EUR 18,500}} = 235{,}135\ (3.2\%)$.
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households (avoided fuel cost = EUR 3,000).
- The energy saving rates for space heating and cooling are assumed to be 50% due to improving the building envelops (Balaras, 2007).
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime is on average 25 years.

Table 246: the variables and their values for calculating CBA in Scenario 3 for Romania

Variable	**Value**	**Unit**
Available budget for fossil fuels	4,350,000,000	EUR
Unitary investment cost-Building envelope	12,000	EUR
Unitary investment cost-Heat pump	6,500	EUR

Unitary investment cost-PV	0	EUR
Unitary investment cost with subsidy	18,500	EUR
Avoided cost from new fossil fuel boiler	3,000	EUR
Installed capacity PV	0	kW
Unitary investment cost PV	0	EUR/kW
Number of influenced households	235,135	number of households
Energy consumption for space cooling	40	kWh
Energy consumption for space heating	7,521	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	20	kWh
Energy savings in space heating	3,760	kWh
Electricity consumption after interventions	3,016	kWh
Electricity price	0.17	EUR/kWh
Cost reduction due to net-metering	100%	
Electricity price-net metering	0.17	EUR/kWh
Existing fuel price for space heating	0.06	EUR/kWh
Remaining value	10%	% of capital cost
Discount rate	3%	%

Table 247 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments. The discount rate is not included in the table, and it is used for calculation of NPV.

Table 247: Cash flows for the cost-benefit analysis in Scenario 3 for Romania (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					3,644,594,595		-3,644,594,595
1	0	0	42,237,846	110,954,940			68,717,094
2	0	0	42,237,846	110,954,940			68,717,094
3	0	0	42,237,846	110,954,940			68,717,094
4	0	0	42,237,846	110,954,940			68,717,094
5	0	0	42,237,846	110,954,940			68,717,094
6	0	0	42,237,846	110,954,940			68,717,094
7	0	0	42,237,846	110,954,940			68,717,094
8	0	0	42,237,846	110,954,940			68,717,094
9	0	0	42,237,846	110,954,940			68,717,094
10	0	0	42,237,846	110,954,940			68,717,094
11	0	0	42,237,846	110,954,940			68,717,094

12	0	0	42,237,846	110,954,940			68,717,094
13	0	0	42,237,846	110,954,940			68,717,094
14	0	0	42,237,846	110,954,940			68,717,094
15	0	0	42,237,846	110,954,940			68,717,094
16	0	0	42,237,846	110,954,940			68,717,094
17	0	0	42,237,846	110,954,940			68,717,094
18	0	0	42,237,846	110,954,940			68,717,094
19	0	0	42,237,846	110,954,940			68,717,094
20	0	0	42,237,846	110,954,940			68,717,094
21	0	0	42,237,846	110,954,940			68,717,094
22	0	0	42,237,846	110,954,940			68,717,094
23	0	0	42,237,846	110,954,940			68,717,094
24	0	0	42,237,846	110,954,940			68,717,094
25	0	0	42,237,846	110,954,940		435,000,000	503,717,094
Total	**0**	**0**	**735,493,856**	**1,932,074,759**	**3,644,594,595**	**422,330,097**	**-2,240,255,269**

Table 248 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 3 in monetary terms using the data provided in Table 247. Based on the calculated values, the investment is not beneficial in monetary terms and the cost-effectiveness is low ($NPV < 0, IRR < 3\%, and\ B/C < 1$).

Table 248: Results of cost-benefit analysis in Scenario 3 for Romania

CBA	NPV	IRR	B/C
Scenario 3	-2,240,255,269	-3%	0.54

Cost-benefit analysis in Scenario 4 for Romania

Table 249 indicates the actual and assumed values for calculating CBA. Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 4.35 billion) is divided by unitary investment cost with subsidy (EUR 22,368) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 4.35 billion}}{\text{EUR 22,368}} = 194{,}479$ (2.6%).
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households (avoided fuel cost = EUR 3,000).
- The energy saving rates for space heating and cooling are assumed to be 50% due to improving the building envelops (Balaras, 2007).
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime is on average 25 years.

Table 249 - The variables and their values for calculating CBA in Scenario 4 for Romania

Variable	Value	Unit
Available budget for fossil fuels	4,350,000,000	EUR
Unitary investment cost-Building envelope	12,000	EUR
Unitary investment cost-Heat pump	6,500	EUR
Unitary investment cost-PV	3,868	EUR
Unitary investment cost with subsidy	22,368	EUR
Avoided cost from new fossil fuel boiler	3,000	EUR
Installed capacity PV	3	kW
Unitary investment cost PV	1,547	EUR/kW
Number of influenced households	194,479	number of households
Energy consumption for space cooling	40	kWh
Energy consumption for space heating	7,521	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	20	kWh
Energy savings in space heating	3,760	kWh
Electricity consumption after interventions	3,016	kWh
Electricity price	0.17	EUR/kWh
Cost reduction due to net-metering	50%	
Electricity price-net metering	0.08	EUR/kWh
Existing fuel price for space heating	0.06	EUR/kWh
Cost of operation and maintenance - Baseline Scenario	0	EUR
Cost of operation and maintenance - Alternative Scenario	100	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

Table 250 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments. The discount rate is not included in the table, and it is used for calculation of NPV.

Table 250 - Cash flows for cost-benefit analysis in Scenario 4 for Romania (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					3,766,564,211		-3,766,564,211
1	19,447,860	0	34,934,622	141,214,582			86,832,100
2	19,447,860	0	34,934,622	141,214,582			86,832,100

3	19,447,860	0	34,934,622	141,214,582			86,832,100
4	19,447,860	0	34,934,622	141,214,582			86,832,100
5	19,447,860	0	34,934,622	141,214,582			86,832,100
6	19,447,860	0	34,934,622	141,214,582			86,832,100
7	19,447,860	0	34,934,622	141,214,582			86,832,100
8	19,447,860	0	34,934,622	141,214,582			86,832,100
9	19,447,860	0	34,934,622	141,214,582			86,832,100
10	19,447,860	0	34,934,622	141,214,582			86,832,100
11	19,447,860	0	34,934,622	141,214,582			86,832,100
12	19,447,860	0	34,934,622	141,214,582			86,832,100
13	19,447,860	0	34,934,622	141,214,582			86,832,100
14	19,447,860	0	34,934,622	141,214,582			86,832,100
15	19,447,860	0	34,934,622	141,214,582			86,832,100
16	19,447,860	0	34,934,622	141,214,582			86,832,100
17	19,447,860	0	34,934,622	141,214,582			86,832,100
18	19,447,860	0	34,934,622	141,214,582			86,832,100
19	19,447,860	0	34,934,622	141,214,582			86,832,100
20	19,447,860	0	34,934,622	141,214,582			86,832,100
21	19,447,860	0	34,934,622	141,214,582			86,832,100
22	19,447,860	0	34,934,622	141,214,582			86,832,100
23	19,447,860	0	34,934,622	141,214,582			86,832,100
24	19,447,860	0	34,934,622	141,214,582			86,832,100
25	19,447,860	0	34,934,622	141,214,582		435,000,000	521,832,100
Total	**338,648,452**	**0**	**608,321,732**	**2,458,990,365**	**3,766,564,211**	**422,330,097**	**-2,046,785,607**

Table 251 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 4 in monetary terms using the data provided in Table 250 Based on the calculated values, the investment is beneficial in monetary terms.

Table 251 - Results of cost-benefit analysis in Scenario 4 for Romania

CBA	**NPV**	**IRR**	**B/C**
Scenario 4	-2,046,785,607	-2%	0.61

Cost-benefit analysis in Scenario 0 for Romania

Table 252 shows the actual and few assumed values (e.g., the performance ratio of the EE boiler) for calculating the CBA. Here are the other few assumptions which are similarly used for all Scenario:

- The total budget (EUR 4.35 billion) is divided by unitary investment cost (EUR 3,000) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to 1,450,000 (19.5%).

- It is assumed that the performance ratio of the energy efficient boilers is improved from 85% to 95% (assumption) efficiency.
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The installation costs are also not considered since it is assumed that the installers pay these costs. Therefore, these values are assumed to be zero.
- The lifetime of new gas boiler is equal to 15 years.

Table 252 – The variables and their values for calculating CBA in Scenario 0 for Romania

Variable	Value	Unit
Available budget for fossil fuels	4,350,000,000	EUR
Unitary investment cost	3,000	EUR
Unitary investment cost with subsidy	3,000	EUR
Avoided cost from new fossil fuel boiler	0	EUR
Number of influenced households	1,450,000	number of households
Unitary energy consumption for space cooling	40	kWh
Unitary energy consumption for space heating	7,521	kWh
Performance ratio of energy efficient boiler	95%	%
Performance ratio existing boiler	85%	%
Energy consumption after the interventions	6,729	kWh
Electricity price	0.17	EUR/kWh
Existing fuel price for space heating	0.06	EUR/kWh
Cost of operation and maintenance - Baseline Scenario	0	EUR
Cost of operation and maintenance - Alternative Scenario	0	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

Table 253 shows the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments without considering the discount rates.

Table 253 – Cash flows for cost-benefit analysis in Scenario 0 for Romania (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					4,350,000,000		-4,350,000,000
1	0	0	607,869,511	679,383,571			71,514,060
2	0	0	607,869,511	679,383,571			71,514,060
3	0	0	607,869,511	679,383,571			71,514,060
4	0	0	607,869,511	679,383,571			71,514,060
5	0	0	607,869,511	679,383,571			71,514,060
6	0	0	607,869,511	679,383,571			71,514,060
7	0	0	607,869,511	679,383,571			71,514,060
8	0	0	607,869,511	679,383,571			71,514,060

9	0	0	607,869,511	679,383,571			71,514,060
10	0	0	607,869,511	679,383,571			71,514,060
11	0	0	607,869,511	679,383,571			71,514,060
12	0	0	607,869,511	679,383,571			71,514,060
13	0	0	607,869,511	679,383,571			71,514,060
14	0	0	607,869,511	679,383,571			71,514,060
15	0	0	607,869,511	679,383,571			71,514,060
Total	**0**	**0**	**7,256,706,760**	**8,110,436,967**	**4,350,000,000**	**0**	**-3,496,269,793**

Table 254 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 0 in monetary terms based on these values. According to the results, the investment is not beneficial in monetary terms and the cost-effectiveness is low ($NPV < 0, IRR < 3\%, and\ B/C < 1$).

Table 254 - Results of cost-benefit analysis in Scenario 0 for Romania

CBA	**NPV**	**IRR**	**B/C**
Scenario 0	-3,496,269,793	-14%	0.70

Cost-benefit analysis in Scenario PV for Romania

Table 255 indicates the actual and assumed values for calculating CBA. Here are the other few assumptions which are mostly used for all Scenario:

- The total budget (EUR 4.35 billion) is divided by unitary investment cost (EUR 2,321) to calculate the number of households that can benefit from this investment.
- The number of influenced households is equal to $\frac{\text{EUR 4.35 billion}}{\text{EUR 2,321}} = 1{,}874{,}596\ (25.2\%)$.
- It is assumed that the households do not need to install new gas boilers and therefore, the investment costs are reduced for the influenced households.
- The operation and maintenance costs are assumed the same for baseline and alternative Scenarios.
- The lifetime of photovoltaic solar panel is on average 25 years.

Table 255 - The variables and their values for calculating CBA in Scenario PV for Romania

Variable	**Value**	**Unit**
Available budget for fossil fuels	4,350,000,000	EUR
Investment cost	2,321	EUR
Unitary investment cost with subsidy	2,321	EUR
Installed capacity PV	2	kW
Unitary investment cost without VAT	1,300	EUR/kW
Unitary investment cost	1,547	EUR/kW
Number of influenced households	1,874,596	number of households
Electricity consumption	1,743	kWh

Electricity price	0.17	EUR/kWh
Cost reduction due to net-metering	50%	
Electricity price-net metering	0.08	EUR/kWh
Cost of operation and maintenance - Baseline Scenario	0	EUR
Cost of operation and maintenance - Alternative Scenario	100	EUR
Remaining value	0%	% of capital cost
Discount rate	3%	%

Table 256 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments. The discount rate is not included in the table, and it is used for calculation of NPV.

Table 256 - Cash flows for cost-benefit analysis in Scenario PV for Romania (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	External cost	External benefit	Investment cost	Remaining value	Net cash flow
0						0	1,968,325,792		-1,968,325,792
1	0	0	228,981,731	298,630,141	60,749,424	396,066,583			404,965,569
2	0	0	228,981,731	298,630,141	60,749,424	396,066,583			404,965,569
3	0	0	228,981,731	298,630,141	60,749,424	396,066,583			404,965,569
4	0	0	228,981,731	298,630,141	60,749,424	396,066,583			404,965,569
5	0	0	228,981,731	298,630,141	60,749,424	396,066,583			404,965,569
6	0	0	228,981,731	298,630,141	60,749,424	396,066,583			404,965,569
7	0	0	228,981,731	298,630,141	60,749,424	396,066,583			404,965,569
8	0	0	228,981,731	298,630,141	60,749,424	396,066,583			404,965,569
9	0	0	228,981,731	298,630,141	60,749,424	396,066,583			404,965,569
10	0	0	228,981,731	298,630,141	60,749,424	396,066,583			404,965,569
11	0	0	228,981,731	298,630,141	60,749,424	396,066,583			404,965,569
12	0	0	228,981,731	298,630,141	60,749,424	396,066,583		0	404,965,569
Total	**0**	**0**	**2,279,285,064**	**2,972,565,616**	**604,700,005**	**3,942,448,345**	**1,968,325,792**	**0**	**2,062,703,100**

Table 257 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario PV in monetary terms using the data provided in Table 256. Based on the calculated values, the investment is not beneficial in monetary terms and the cost-effectiveness is low ($NPV < 0, IRR < 3\%, and\ B/C < 1$).

Table 257 - Results of cost-benefit analysis in Scenario PV for Romania

CBA	**NPV**	**IRR**	**B/C**
Scenario 3	-2,818,830,361	-5%	0.63

Scenario analyses for the case study of Slovakia

Cost-benefit analysis for Scenario 1 for Slovakia

Table 258: The variables and their values for calculating CBA in Scenario 1 for Slovakia

Variable	Value	Unit
Available budget	1,122,000,000	EUR
Unitary investment cost	20,000	EUR
Unitary investment cost with subsidy	20,000	EUR
Avoided cost from new fossil fuel boiler	0	EUR
Number of influenced households	56,100	number of households
Energy consumption for space cooling	20	kWh
Energy consumption for space heating	12,083	kWh
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	10	kWh
Energy savings in space heating	6,041	kWh
Electricity price	0.18	EUR/kWh
Existing fuel price for space heating	0.13	EUR/kWh
Cost of operation and maintenance - Baseline scenario	0	EUR
Cost of operation and maintenance - Alternative scenario	0	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

Table 259 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments. The discount rate is not considered in the table.

Table 259: Cash flows for cost-benefit analysis in Scenario 1 for Slovakia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					1,122,000,000		-1,122,000,000
1	0	0	0	44,838,925			44,838,925
2	0	0	0	44,838,925			44,838,925
3	0	0	0	44,838,925			44,838,925
4	0	0	0	44,838,925			44,838,925
5	0	0	0	44,838,925			44,838,925

6	0	0	0	44,838,925			44,838,925
7	0	0	0	44,838,925			44,838,925
8	0	0	0	44,838,925			44,838,925
9	0	0	0	44,838,925			44,838,925
10	0	0	0	44,838,925			44,838,925
11	0	0	0	44,838,925			44,838,925
12	0	0	0	44,838,925			44,838,925
13	0	0	0	44,838,925			44,838,925
14	0	0	0	44,838,925			44,838,925
15	0	0	0	44,838,925			44,838,925
16	0	0	0	44,838,925			44,838,925
17	0	0	0	44,838,925			44,838,925
18	0	0	0	44,838,925			44,838,925
19	0	0	0	44,838,925			44,838,925
20	0	0	0	44,838,925			44,838,925
21	0	0	0	44,838,925			44,838,925
22	0	0	0	44,838,925			44,838,925
23	0	0	0	44,838,925			44,838,925
24	0	0	0	44,838,925			44,838,925
25	0	0	0	44,838,925		112,200,000	157,038,925
Total	0	0	0	780,786,825	1,122,000,000	108,932,039	-287,625,830

Table 260 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 1 in monetary terms using the data provided in Table 259. Based on the calculated values, the investment is not beneficial in monetary terms and the cost-effectiveness is low ($\mathrm{NPV} < 0, \mathrm{IRR} < 3\%,$ and $\mathrm{B/C} < 1$).

Table 260: Results of cost-benefit analysis in Scenario 1 for Slovakia

CBA	NPV	IRR	B/C
Scenario 1	-287,625,830	1%	0.79

Cost-benefit analysis for Scenario 2 for Slovakia

Table 261: The variables and their values for calculating CBA in Scenario 2 for Slovakia

Variable	**Value**	**Unit**
Available budget	1,122,000,000	EUR
Unitary investment cost	10,000	EUR
Unitary investment cost with subsidy	10,000	EUR
Avoided cost from new fossil fuel boiler	4,500	EUR
Number of influenced households	112,200	number of households
Energy consumption for space cooling	20	kWh
Energy consumption for space heating	12,083	kWh
Performance ratio existing boiler	85%	%

COP heat pump	3.0	
Electricity price	0.18	EUR/kWh
Existing fuel price for space heating	0.13	EUR/kWh
Cost of operation and maintenance - Baseline scenario	0	EUR
Cost of operation and maintenance - Alternative scenario	0	EUR
Remaining value	0%	% of capital cost
Discount rate	3%	%

Table 262 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments. The discount rate is not included in the table, and it is used for calculation of NPV.

Table 262: Cash flows for cost-benefit analysis in Scenario 2 for Slovakia

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					617,100,000		-617,100,000
1	0	0	68,986,498	178,950,959			109,964,461
2	0	0	68,986,498	178,950,959			109,964,461
3	0	0	68,986,498	178,950,959			109,964,461
4	0	0	68,986,498	178,950,959			109,964,461
5	0	0	68,986,498	178,950,959			109,964,461
6	0	0	68,986,498	178,950,959			109,964,461
7	0	0	68,986,498	178,950,959			109,964,461
8	0	0	68,986,498	178,950,959			109,964,461
9	0	0	68,986,498	178,950,959			109,964,461
10	0	0	68,986,498	178,950,959			109,964,461
11	0	0	68,986,498	178,950,959			109,964,461
12	0	0	68,986,498	178,950,959		0	109,964,461
Total	0	0	686,691,882	1,781,278,561	617,100,000	0	477,486,679

Table 263 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 2 in monetary terms using the data provided in Table 262. Based on the calculated values, the investment is beneficial in monetary terms.

Table 263: Results of cost-benefit analysis in Scenario 2 for Slovakia

CBA	NPV	IRR	B/C
Scenario 1	477,486,679	14%	1.37

Cost-benefit analysis for Scenario 3 for Slovakia

Table 264: the variables and their values for calculating CBA in Scenario 3 for Slovakia

Variable	Value	Unit
Available budget	1,122,000,000	EUR
Investment cost	4,680	EUR
Number of influenced households	239,744	number of households
Installed capacity PV	3	kW
Capacity factor PV	12%	%
Unitary investment cost	1,560	EUR/kW
Electricity consumption	2,944	kWh
Electricity price	0.15	EUR/kWh
Cost reduction due to net-metering	50%	
Electricity consumption-net metering	0.07	EUR/kWh
Cost of operation and maintenance - Baseline scenario	0	EUR
Cost of operation and maintenance - Alternative scenario	100	EUR
Remaining value	0%	% of capital cost
Discount rate	3%	%

Table 265 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments. The discount rate is not included in the table, and it is used for calculation of NPV.

Table 265: Cash flows for cost-benefit analysis in Scenario 3 for Slovakia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					953,700,000		-953,700,000
1	3,740,000	0	11,497,750	59,717,777			44,480,027
2	3,740,000	0	11,497,750	59,717,777			44,480,027
3	3,740,000	0	11,497,750	59,717,777			44,480,027
4	3,740,000	0	11,497,750	59,717,777			44,480,027
5	3,740,000	0	11,497,750	59,717,777			44,480,027
6	3,740,000	0	11,497,750	59,717,777			44,480,027
7	3,740,000	0	11,497,750	59,717,777			44,480,027
8	3,740,000	0	11,497,750	59,717,777			44,480,027
9	3,740,000	0	11,497,750	59,717,777			44,480,027
10	3,740,000	0	11,497,750	59,717,777			44,480,027
11	3,740,000	0	11,497,750	59,717,777			44,480,027
12	3,740,000	0	11,497,750	59,717,777			44,480,027
13	3,740,000	0	11,497,750	59,717,777			44,480,027
14	3,740,000	0	11,497,750	59,717,777			44,480,027
15	3,740,000	0	11,497,750	59,717,777			44,480,027
16	3,740,000	0	11,497,750	59,717,777			44,480,027

17	3,740,000	0	11,497,750	59,717,777			44,480,027
18	3,740,000	0	11,497,750	59,717,777			44,480,027
19	3,740,000	0	11,497,750	59,717,777			44,480,027
20	3,740,000	0	11,497,750	59,717,777			44,480,027
21	3,740,000	0	11,497,750	59,717,777			44,480,027
22	3,740,000	0	11,497,750	59,717,777			44,480,027
23	3,740,000	0	11,497,750	59,717,777			44,480,027
24	3,740,000	0	11,497,750	59,717,777			44,480,027
25	3,740,000	0	11,497,750	59,717,777		112,200,000	156,680,027
Total	65,125,172	0	200,212,015	1,039,874,464	953,700,000	108,932,039	-125,575,378

Table 266 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 3 in monetary terms using the data provided in Table 265. Based on the calculated values, the investment is not beneficial in monetary terms ($\text{NPV} < 0, \text{IRR} < 3\%, \text{and B/C} < 1$).

Table 266: Results of cost-benefit analysis in Scenario 3 for Slovakia

CBA	NPV	IRR	B/C
Scenario 3	-125,575,378	2%	0.94

Cost-benefit analysis for Scenario 4 for Slovakia

Table 267: The variables and their values for calculating CBA in Scenario 4 for Slovakia

Variable	**Value**	**Unit**
Available budget	1,122,000,000	EUR
Unitary investment cost-Building envelope	20,000	EUR
Unitary investment cost-Heat pump	10,000	EUR
Unitary investment cost-PV	7,800	EUR
Unitary investment cost with subsidy	37,800	EUR
Avoided cost from new fossil fuel boiler	4,500	EUR
Installed capacity PV	5	kW
Unitary investment cost PV	1,560	EUR /kW
Number of influenced households	29,683	number of households
Energy consumption for space cooling	20	kWh
Energy consumption for space heating	12,083	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	10	kWh
Energy savings in space heating	6,041	kWh
Electricity consumption after interventions	4,968	kWh

Electricity price	0.18	EUR/kWh
Cost reduction due to net-metering	50%	
Electricity price-net metering	0.09	EUR/kWh
Existing fuel price for space heating	0.13	EUR/kWh
Cost of operation and maintenance - Baseline scenario	0	EUR
Cost of operation and maintenance - Alternative scenario	100	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

Table 268 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments. The discount rate is not included in the table, and it is used for calculation of NPV.

Table 268: Cash flows for cost-benefit analysis in Scenario 4 for Slovakia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					988,428,571		-988,428,571
1	2,968,254	0	9,125,198	60,637,403			48,543,951
2	2,968,254	0	9,125,198	60,637,403			48,543,951
3	2,968,254	0	9,125,198	60,637,403			48,543,951
4	2,968,254	0	9,125,198	60,637,403			48,543,951
5	2,968,254	0	9,125,198	60,637,403			48,543,951
6	2,968,254	0	9,125,198	60,637,403			48,543,951
7	2,968,254	0	9,125,198	60,637,403			48,543,951
8	2,968,254	0	9,125,198	60,637,403			48,543,951
9	2,968,254	0	9,125,198	60,637,403			48,543,951
10	2,968,254	0	9,125,198	60,637,403			48,543,951
11	2,968,254	0	9,125,198	60,637,403			48,543,951
12	2,968,254	0	9,125,198	60,637,403			48,543,951
13	2,968,254	0	9,125,198	60,637,403			48,543,951
14	2,968,254	0	9,125,198	60,637,403			48,543,951
15	2,968,254	0	9,125,198	60,637,403			48,543,951
16	2,968,254	0	9,125,198	60,637,403			48,543,951
17	2,968,254	0	9,125,198	60,637,403			48,543,951
18	2,968,254	0	9,125,198	60,637,403			48,543,951
19	2,968,254	0	9,125,198	60,637,403			48,543,951
20	2,968,254	0	9,125,198	60,637,403			48,543,951
21	2,968,254	0	9,125,198	60,637,403			48,543,951
22	2,968,254	0	9,125,198	60,637,403			48,543,951
23	2,968,254	0	9,125,198	60,637,403			48,543,951
24	2,968,254	0	9,125,198	60,637,403			48,543,951

25	2,968,254	0	9,125,198	60,637,403		112,200,000	160,743,951
Total	51,686,645	0	158,898,424	1,055,888,049	988,428,571	108,932,039	-89,538,247

Table 269 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 4 in monetary terms using the data provided in Table 268. Based on the calculated values, the investment is not beneficial in monetary terms and the cost-effectiveness is low.

Table 269: Results of cost-benefit analysis in Scenario 4 for Slovakia

CBA	NPV	IRR	B/C
Scenario 4	-89,538,247	2%	0.97

Cost-benefit analysis in Scenario 0 for Slovakia

Table 270: The variables and their values for calculating CBA in Scenario 0 for Slovakia

Variable	Value	Unit
Available budget	1,122,000,000	EUR
Unitary investment cost	4,500	EUR
Unitary investment cost with subsidy	4,500	EUR
Avoided cost from new fossil fuel boiler	0	EUR
Number of influenced households	249,333	number of households
Unitary energy consumption for space cooling	20	kWh
Unitary energy consumption for space heating	12,083	kWh
Performance ratio of energy efficient boiler	95%	%
Performance ratio existing boiler	85%	%
Energy consumption after the interventions	10,811	kWh
Electricity price	0.18	EUR/kWh
Existing fuel price for space heating	0.13	EUR/kWh
Cost of operation and maintenance - Baseline scenario	0	EUR
Cost of operation and maintenance - Alternative scenario	0	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

Table 271 shows the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments without considering the discount rates.

Table 271: Cash flows for cost-benefit analysis in Scenario 0 for Slovakia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					1,122,000,000		-1,122,000,000
1	0	0	355,808,924	397,668,798			41,859,873

2	0	0	355,808,924	397,668,798			41,859,873
3	0	0	355,808,924	397,668,798			41,859,873
4	0	0	355,808,924	397,668,798			41,859,873
5	0	0	355,808,924	397,668,798			41,859,873
6	0	0	355,808,924	397,668,798			41,859,873
7	0	0	355,808,924	397,668,798			41,859,873
8	0	0	355,808,924	397,668,798			41,859,873
9	0	0	355,808,924	397,668,798			41,859,873
10	0	0	355,808,924	397,668,798			41,859,873
11	0	0	355,808,924	397,668,798			41,859,873
12	0	0	355,808,924	397,668,798			41,859,873
13	0	0	355,808,924	397,668,798			41,859,873
14	0	0	355,808,924	397,668,798			41,859,873
15	0	0	355,808,924	397,668,798			41,859,873
Total	0	0	4,247,623,843	4,747,344,295	1,122,000,000	0	-622,279,548

Table 272 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 0 in monetary terms using the data provided in Table 271. Based on the calculated values, the investment is not beneficial in monetary terms and the cost-effectiveness is low ($\mathrm{NPV} < 0, \mathrm{IRR} < 3\%,$ and $\mathrm{B/C} < 1$).

Table 272: Results of cost-benefit analysis in Scenario 0 for Slovakia

CBA	NPV	IRR	B/C
Scenario 0	-622,279,548	-7%	0.88

Scenario analyses for the case study of Slovenia

Cost-benefit analysis for Scenario 1 for Slovenia

Table 273: The variables and their values for calculating CBA in Scenario 1 for Slovenia

Variable	**Value**	**Unit**
Available budget	103,400,000	EUR
Unitary investment cost	16,000	EUR
Unitary investment cost with subsidy	16,000	EUR
Avoided cost from new fossil fuel boiler	0	EUR
Number of influenced households	6,463	number of households
Energy consumption for space cooling	112	kWh
Energy consumption for space heating	9,206	kWh
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	56	kWh

Energy savings in space heating	4,603	kWh
Electricity price	0.10	EUR/kWh
Existing fuel price for space heating	0.05	EUR/kWh
Cost of operation and maintenance - Baseline scenario	0	EUR
Cost of operation and maintenance - Alternative scenario	0	EUR
Remaining value	10%	% of capital cost
Discount rate	3%	%

Table 274 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments.

Table 274 - Cash flows for cost-benefit analysis in Scenario 1 for Slovenia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					103,400,000		-103,400,000
1	0	0	0	1,545,105			1,545,105
2	0	0	0	1,545,105			1,545,105
3	0	0	0	1,545,105			1,545,105
4	0	0	0	1,545,105			1,545,105
5	0	0	0	1,545,105			1,545,105
6	0	0	0	1,545,105			1,545,105
7	0	0	0	1,545,105			1,545,105
8	0	0	0	1,545,105			1,545,105
9	0	0	0	1,545,105			1,545,105
10	0	0	1,212	1,545,105			1,543,893
11	0	0	0	1,545,105			1,545,105
12	0	0	0	1,545,105			1,545,105
13	0	0	2,912	1,545,105			1,542,193
14	0	0	0	1,545,105			1,545,105
15	0	0	0	1,545,105			1,545,105
16	0	0	0	1,545,105			1,545,105
17	0	0	0	1,545,105			1,545,105
18	0	0	0	1,545,105			1,545,105
19	0	0	0	1,545,105			1,545,105
20	0	0	0	1,545,105			1,545,105
21	0	0	0	1,545,105			1,545,105
22	0	0	0	1,545,105			1,545,105
23	0	0	0	1,545,105			1,545,105
24	0	0	0	1,545,105			1,545,105
25	0	0	0	1,545,105		10,340,000	11,885,105
Total	0	0	2,885	26,905,140	103,400,000	10,038,835	-71,559,303

Table 275 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 1 in monetary terms using the data provided in Table 274. Based on the calculated values, the investment is not beneficial in monetary terms and the cost-effectiveness is low ($NPV < 0, IRR < 3\%, and\ B/C < 1$).

Table 275- Results of cost-benefit analysis in Scenario 1 for Slovenia

CBA	NPV	IRR	B/C
Scenario 1	-71,559,303	-4%	0.36

Cost-benefit analysis in Scenario 2 for Slovenia

Table 276 - The variables and their values for calculating CBA in Scenario 2 for Slovenia

Variable	Value	Unit
Available budget	103,400,000	EUR
Unitary investment cost	10,000	EUR
Unitary investment cost with subsidy	10,000	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Number of influenced households	10,340	number of households
Energy consumption for space cooling	112	kWh
Energy consumption for space heating	9,206	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
Electricity price	0.10	EUR/kWh
Existing fuel price for space heating	0.05	EUR/kWh
Remaining value	0%	% of capital cost
Discount rate	3%	%

Table 277 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments. The discount rate is not included in the table, and it is used for calculation of NPV.

Table 277 - Cash flows for cost-benefit analysis in Scenario 2 for Slovenia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					62,040,000		-62,040,000
1	0	0	2,759,151	4,826,254			2,067,103
2	0	0	2,759,151	4,826,254			2,067,103
3	0	0	2,759,151	4,826,254			2,067,103
4	0	0	2,759,151	4,826,254			2,067,103

5	0	0	2,759,151	4,826,254			2,067,103
6	0	0	2,759,151	4,826,254			2,067,103
7	0	0	2,759,151	4,826,254			2,067,103
8	0	0	2,759,151	4,826,254			2,067,103
9	0	0	2,759,151	4,826,254			2,067,103
10	0	0	1,212	4,826,254			4,825,042
11	0	0	2,759,151	4,826,254			2,067,103
12	0	0	0	4,826,254		0	4,826,254
Total	0	0	3,125	48,040,551	62,040,000	0	-37,476,673

Table 278 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 2 in monetary terms using the data provided in table 277. Based on the calculated values, the investment is not beneficial in monetary terms and the cost-effectiveness is low ($NPV < 0, IRR < 3\%, and\ B/C < 1$).

Table 278 - Results of cost-benefit analysis in Scenario 2

CBA	NPV	IRR	B/C
Scenario 2	-37,476,673	-9%	0.77

Cost-benefit analysis for Scenario 3 for Slovenia

Table 279: the variables and their values for calculating CBA in Scenario 3 for Slovenia

Variable	Value	Unit
Available budget	103,400,000	€
Unitary investment cost-Building envelope	16,000	€
Unitary investment cost-Heat pump	10,000	€
Unitary investment cost with subsidy	26,000	€
Avoided cost from new fossil fuel boiler	4,000	€
Number of influenced households	3,977	number of households
Energy consumption for space cooling	112	kWh
Energy consumption for space heating	9,206	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	56	kWh
Energy savings in space heating	4,603	kWh
Electricity consumption after interventions	5,683	kWh
Electricity price	0.10	€/kWh
Cost reduction due to net-metering	100%	
Electricity price-net metering	0.10	€/kWh
Existing fuel price for space heating	0.05	€/kWh

Remaining value	10%	% of capital cost
Discount rate	3%	%

Table 280 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments. The discount rate is not included in the table, and it is used for calculation of NPV.

Table 280: Cash flows for the cost-benefit analysis in Scenario 3 for Slovenia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					87,492,308		-87,492,308
1	0	0	530,606	1,878,960			1,348,354
2	0	0	530,606	1,878,960			1,348,354
3	0	0	530,606	1,878,960			1,348,354
4	0	0	530,606	1,878,960			1,348,354
5	0	0	530,606	1,878,960			1,348,354
6	0	0	530,606	1,878,960			1,348,354
7	0	0	530,606	1,878,960			1,348,354
8	0	0	530,606	1,878,960			1,348,354
9	0	0	530,606	1,878,960			1,348,354
10	0	0	530,606	1,878,960			1,348,354
11	0	0	530,606	1,878,960			1,348,354
12	0	0	530,606	1,878,960			1,348,354
13	0	0	530,606	1,878,960			1,348,354
14	0	0	530,606	1,878,960			1,348,354
15	0	0	530,606	1,878,960			1,348,354
16	0	0	530,606	1,878,960			1,348,354
17	0	0	530,606	1,878,960			1,348,354
18	0	0	530,606	1,878,960			1,348,354
19	0	0	530,606	1,878,960			1,348,354
20	0	0	530,606	1,878,960			1,348,354
21	0	0	530,606	1,878,960			1,348,354
22	0	0	530,606	1,878,960			1,348,354
23	0	0	530,606	1,878,960			1,348,354
24	0	0	530,606	1,878,960			1,348,354
25	0	0	530,606	1,878,960		10,340,000	11,688,354
Total	0	0	9,239,521	32,718,600	87,492,308	10,038,835	-59,074,787

Table 281 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 3 in monetary terms using the data provided in Table 280. Based on the calculated values, the investment is not beneficial in monetary terms and the cost-effectiveness is low ($NPV < 0, IRR < 3\%, and\ B/C < 1$).

Table 281: Results of cost-benefit analysis in Scenario 3 for Slovenia

CBA	NPV	IRR	B/C
Scenario 3	-59,074,787	-4%	0.44

Cost-benefit analysis in Scenario 4 for Slovenia

Table 282 - The variables and their values for calculating CBA in Scenario 4 for Slovenia

Variable	Value	Unit
Available budget	103,400,000	EUR
Unitary investment cost-Building envelope	16,000	EUR
Unitary investment cost-Heat pump	10,000	EUR
Unitary investment cost-PV	0	EUR
Avoided cost from new fossil fuel boiler	4,000	EUR
Number of influenced households	3,977	number of households
Installed capacity PV	0.0	kW
Unitary investment cost PV	0	EUR/kW
Capacity factor PV	12%	%
Energy consumption for space cooling	112	kWh
Energy consumption for space heating	9,206	kWh
Performance ratio existing boiler	85%	%
COP heat pump	3.0	
% of energy savings in space cooling	50%	%
% of energy savings in space heating	50%	%
Energy savings in space cooling	56	kWh
Energy savings in space heating	4,603	kWh
Electricity consumption after interventions	5,683	kWh
Electricity price	0.09	EUR/kWh
Cost reduction due to net-metering	100%	
Electricity price-net metering	0.09	EUR/kWh
Existing fuel price for space heating	0.05	EUR/kWh
Remaining value	10%	% of capital cost
Discount rate	3%	%

Table 283 presents the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments. The discount rate is not included in the table, and it is used for calculation of NPV.

Table 283 - Cash flows for cost-benefit analysis in Scenario 4 for Slovenia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					91,425,824		-91,425,824
1	299,354	0	399,402	2,284,476			1,585,719
2	299,354	0	399,402	2,284,476			1,585,719
3	299,354	0	399,402	2,284,476			1,585,719
4	299,354	0	399,402	2,284,476			1,585,719
5	299,354	0	399,402	2,284,476			1,585,719
6	299,354	0	399,402	2,284,476			1,585,719
7	299,354	0	399,402	2,284,476			1,585,719
8	299,354	0	399,402	2,284,476			1,585,719
9	299,354	0	399,402	2,284,476			1,585,719
10	299,354	0	399,402	2,284,476			1,585,719
11	299,354	0	399,402	2,284,476			1,585,719
12	299,354	0	399,402	2,284,476			1,585,719
13	299,354	0	399,402	2,284,476			1,585,719
14	299,354	0	399,402	2,284,476			1,585,719
15	299,354	0	399,402	2,284,476			1,585,719
16	299,354	0	399,402	2,284,476			1,585,719
17	299,354	0	399,402	2,284,476			1,585,719
18	299,354	0	399,402	2,284,476			1,585,719
19	299,354	0	399,402	2,284,476			1,585,719
20	299,354	0	399,402	2,284,476			1,585,719
21	299,354	0	399,402	2,284,476			1,585,719
22	299,354	0	399,402	2,284,476			1,585,719
23	299,354	0	399,402	2,284,476			1,585,719
24	299,354	0	399,402	2,284,476			1,585,719
25	299,354	0	399,402	2,284,476		10,340,000	11,925,719
Total	5,212,702	0	6,954,852	39,779,913	91,425,824	10,038,835	-58,875,024

Table 284 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 4 in monetary terms using the data provided in Table 283. Based on the calculated values, the investment is not beneficial in monetary terms and the cost-effectiveness is low.

Table 284- Results of cost-benefit analysis in Scenario 4 for Slovenia

CBA	NPV	IRR	B/C
Scenario 4	-58,875,024	-4%	0.48

Cost-benefit analysis in Scenario 0 for Slovenia

Table 285: The variables and their values for calculating CBA in Scenario 0 for Slovenia

Variable	Value	Unit
Available budget	103,400,000	EUR
Unitary investment cost	4,000	EUR
Unitary investment cost with subsidy	4,000	EUR
Number of influenced households	25,850	number of households
Unitary energy consumption for space cooling	112	kWh
Unitary energy consumption for space heating	9,206	kWh
Performance ratio of energy efficient boiler	95%	%
Performance ratio existing boiler	85%	%
Energy consumption after the interventions	8,237	kWh
Electricity price	0.10	EUR/kWh
Existing fuel price for space heating	0.05	EUR/kWh
Remaining value	10%	% of capital cost
Discount rate	3%	%

Table 286 shows the main components for calculating the economic indicators of NPV, IRR, and B/C including the fuel costs and benefits for the demand side energy efficiency investments without considering the discount rates.

Table 286: Cash flows for cost-benefit analysis in Scenario 0 for Slovenia (EUR)

Year	O&M Cost	O&M Benefit	Fuel cost	Fuel benefit	Investment cost	Remaining value	Net cash flow
0					103,400,000		-103,400,000
1	0	0	10,795,568	12,065,635			1,270,067
2	0	0	10,795,568	12,065,635			1,270,067
3	0	0	10,795,568	12,065,635			1,270,067
4	0	0	10,795,568	12,065,635			1,270,067
5	0	0	10,795,568	12,065,635			1,270,067
6	0	0	10,795,568	12,065,635			1,270,067
7	0	0	10,795,568	12,065,635			1,270,067
8	0	0	10,795,568	12,065,635			1,270,067
9	0	0	10,795,568	12,065,635			1,270,067
10	0	0	10,795,568	12,065,635			1,270,067
11	0	0	10,795,568	12,065,635			1,270,067
12	0	0	10,795,568	12,065,635			1,270,067
13	0	0	10,795,568	12,065,635			1,270,067
14	0	0	10,795,568	12,065,635			1,270,067
15	0	0	10,795,568	12,065,635			1,270,067
Total	0	0	128,876,791	144,038,767	103,400,000	0	-88,238,025

Table 287 shows the results of the calculations for the NPV, IRR, and B/C. The NPV, IRR, and B/C are calculated to evaluate the impact of Scenario 0 in monetary terms based on these values. According to the results, the investment is not beneficial in monetary terms and the cost-effectiveness is low ($NPV < 0, IRR < 3\%, and\ B/C < 1$).

Table 287: Results of cost-benefit analysis in Scenario 0 for Slovenia

CBA	NPV	IRR	B/C
Scenario 0	-88,238,025	-16%	0.62