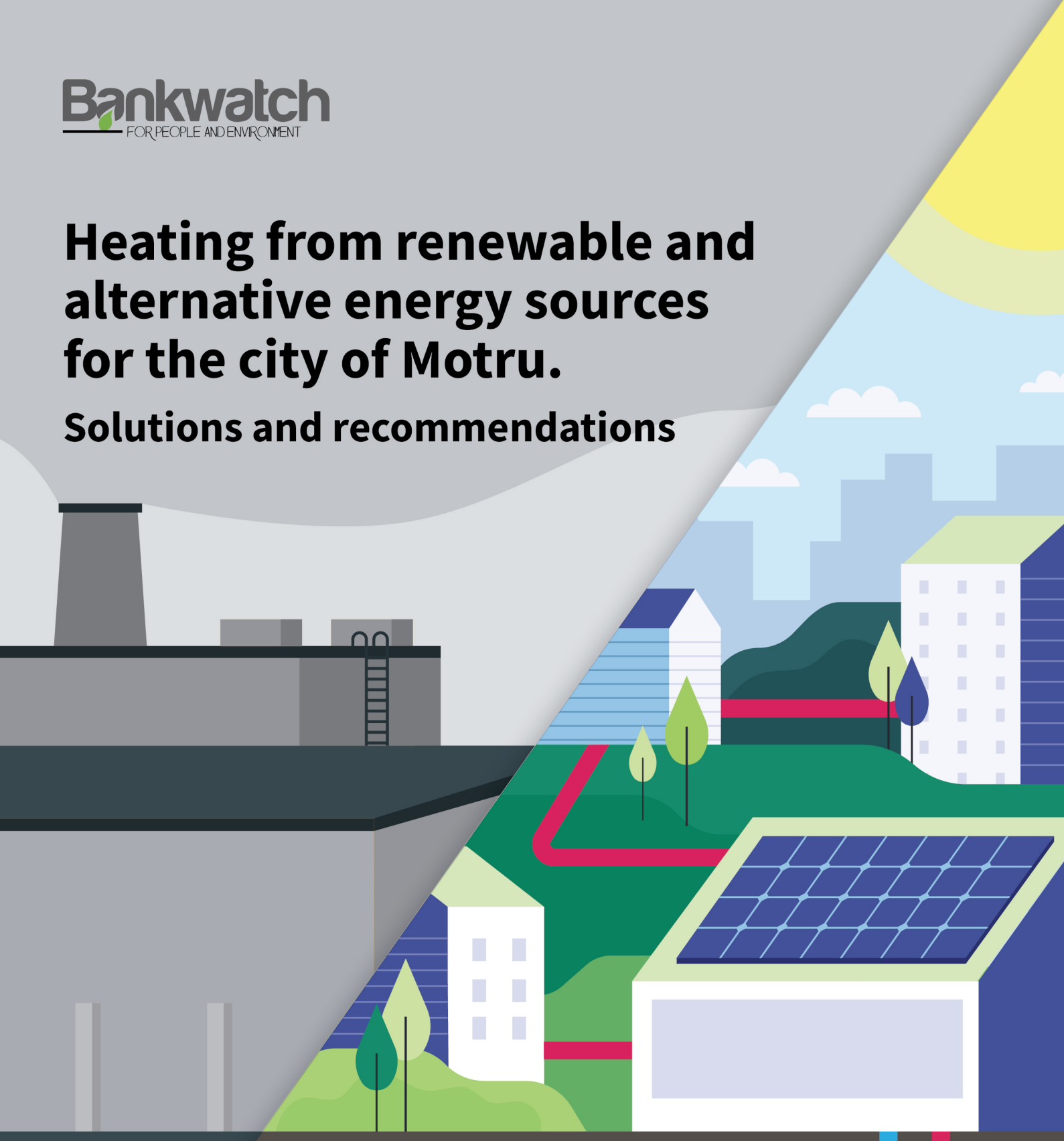
Bankwatch
FOR PEOPLE AND ENVIRONMENT

# Heating from renewable and alternative energy sources for the city of Motru.

## Solutions and recommendations



September 2022

ISPE

**Bankwatch Romania**
Mailing address:
Splaiul Independenței 1, bl. 16, sc. 1, ap. 6
Bucharest, 040125
+4031 438 2489
bucharest@bankwatch.org
www.bankwatch.ro


Association for the study: "Heating from renewable and alternative energy sources for the city of Motru. Solutions and recommendations"

September, 2022

ISPE DESIGN and CONSULTING
VAT number: RO40284726
Commerce Register no. J40/17658/11.12.2018
1-3 Lacul Tei blvd, PC. 30-33, Bucureşti 020371, Romania
Ph: +40 (0)37 282 1076, Fax: +40 (0)21 210 2334; office@ispe.ro

| | |
|---|---|
| Target: | **City of Motru** |
| Beneficiary/Client: | **Bankwatch Romania Association** |
| Reference/contract: | **27329 / 10/8916/2022** Position no: **1** |
| Consulting/Design: | **Study** |
| Contract name: | **Heating from renewable and alternative energy sources for the city of Motru. Solutions and recommendations.** |
| Deliverable name: | **Heating from renewable and alternative energy sources for the city of Motru. Solutions and recommendations.** |

AVIZAT C.T.E.
ISPE Proiectare şi Consultanţă S.A.
Nr. 210 din 28.09.2022
Orice observaţie cu privire la calitatea lucrării se va referi la acest număr

Date: **September 2022**

Director: **Dipl. Eng. Burnete Daniela Cristina**

Project Manager: **Ph.D. (Eng.) Dobrin Marian**

Technical Coordinator: **Ph.D. (Eng.) Dobrin Marian**

Deliverable name: **Heating from renewable and alternative energy sources for the city of Motru. Solutions and recommendations.**

Date of submission: **September 2022**

| Expertise (code - name) | Chapter | Responsibility - Name / Signature | | |
|---|---|---|---|---|
| | | Authors | Editors | Approved |
| Energetical analysis | ÷ | M.Sc.(Eng.) Moncea Dorina | M.Sc.(Eng.) Mitroi Lidia | Ph.D. (Eng.) Dobrin Marian |
| Public Relations and Communication | ÷ | M.Sc.(Eng.) Popescu Gloria | M.Sc.(Eng.) Vasile Camelia | Ph.D. (Eng.) Dobrin Marian |
| Financial analysis, funding sources | ÷ | M.Sc.(Ec.) Constantinescu Ileana | M.Sc.(Ec.) Lepadatu Bianca | Ph.D. (Eng.) Dobrin Marian |
| | | | | |
| | | | | |

Record of changes to the document:

| Rev. | No. | Change sheet code | Date | Rev. | No. | Change sheet code | Date |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

## SUMMARY

Page.

## Annexes



## Tables

## Figures

## Numerical data separators

| | |
|---|---|
| . | **Decimal separator** |
| , | **Thousand separator** |

## Acronyms and abbreviations

| | |
|---|---|
| **AFM** | Environmental Fund Administration |
| **ANPCI** | National Agency for Cadastral and Real Estate Publicity |
| **ANRE** | National Energy Regulatory Authority |
| **AP** | Priority axis |
| **ATR** | Technical permit for connection to the national power grid |
| **B/C** | Benefit/cost ratio |
| **CHPP** | Combined heat and power plant |
| **CNSP** | National Strategy and Forecasting Commission |
| **DHS** | District heating system / centralised thermal energy supply system |
| **d.h.w.** | Domestic hot water for domestic consumption |
| **DTP** | District thermal plant |
| **EBRD** | European Bank for Reconstruction and Development |
| **EC** | European Commission |
| **EE** | Energy Efficiency |
| **EIB** | European Investment Bank |
| **E-RES / SRE-E** | Electricity from renewable energy sources |
| **ETS** | Emissions Trading Scheme |
| **EU** | European Union |
| **GDP** | Gross domestic product |
| **HCL** | Local council decision |
| **HC-RES** | Renewable energy sources for heating and cooling |
| **HG** | Government decision |
| **HP** | Heat pumps |
| **HWB** | Hot water boiler |
| **INS** | National Institute of Statistics |

| | |
|---|---|
| **IPCC** | Intergovernmental Panel on Climate Change |
| **MDLPA** | Ministry of Development, Public Works and Administration |
| **ME** | Ministry of Energy |
| **MFP** | Ministry of Public Finance |
| **MIPE** | Ministry of Investment and European Projects |
| **MMAP** | Ministry of Environment, Water and Forests |
| **MT** | Cogeneration heat & power engines |
| **MU** | Measurement unit |
| **NPS** | National Power System |
| **OUG** | Government emergency ordinance |
| **PIF** | Commissioning |
| **PNIESC** | National Integrated Energy and Climate Change Plan |
| **PNRR** | National Recovery and Resilience Plan |
| **POIM** | Large Infrastructure Operational Programme |
| **POR** | Regional Operational Programme |
| **PV** | Photovoltaic solar panel (photovoltaic) |
| **PVPP** | Photovoltaic power plant |
| **DN** | Distribution network (secondary system) for thermal energy |
| **RED** | Electricity distribution network |
| **RES** | Renewable energy sources |
| **IRR** | Internal rate of financial return |
| **RPL** | Official Census of Population and Housing |
| **TN** | Transmission network (primary system) for thermal energy |
| **TP** | Thermal plant |
| **TS** | Thermal station |
| **UAT** | Territorial Administrative Unit |
| **UNEP** | United Nations Environment Programme |
| **NPV** | Net present value |
| **WtE** | Waste-to-energy plant |

## EXECUTIVE SUMMARY

The study “Heating from renewable and alternative energy sources for the city of Motru. Solutions and recommendations.” had as its main objective ‘to identify and analyse sustainable heating solutions for the city of Motru, located in Gorj County, Romania’.

The Motru locality was defined and took shape once the mining exploitation works started in the Oltenia coal basin, the city being declared a municipality under Law 180/2000. In this study, the analysed area is the city of Motru (approx. 1.32 $km^2$) – the perimeter served by the public service for thermal energy supply (heat and hot water for domestic consumption), which is operated by the company Uzina de Agent Termic și Alimentare cu Apă Motru (S.C. UATAA S.A.) subordinate to Motru Local Council.

In order to achieve the main objective of the study, several analyses have been carried out in the following chapters:

- diagnosis of the current state of UATAA centralised DHS, for both the cogeneration plant (CHPP) and the thermal energy (heat and domestic hot water) transmission-distribution infrastructure,
- assessment of heat demand and energy performance in buildings and industry,
- mapping and estimating theoretical local renewable energy potential.

The sources of data used in the analysis were varied, including: information provided by the mayoralty of the municipality of Motru, UATAA S.A., ApaRegio Gorj S.A. and Premier Energy S.A.; data collected from ANRE reports, the national electricity transmission operator Transelectrica, the National Institute of Statistics (INS), the National Commission for Strategy and Forecasting (CNSP); and data from scientific literature and European institutions.

Based on these analyses, technically and economically feasible heating solutions were identified and compared as alternatives to the current situation, which is based on the use of coal (lignite).

To this aim, five scenarios were identified and proposed for comparative analysis, with different technological solutions for electricity and/or heat generation. The main goal was to cover the heat energy demand (heating and domestic hot water) in a sustainable way, i.e. by phasing out fossil fuels and using renewable energy sources (RES), in a socially affordable and environmentally friendly manner.

The technical description of all five analysed scenarios is summarised in the table below by detailing the type of systems, technologies and equipment used.

| Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4a / 4b | Scenario 5 |
|---|---|---|---|---|
| Distributed heat supply<br>Motru CHPP closed<br>TS transformed into DTP<br>Rehabilitated-modernised distribution network<br>New equipment<br>19 x DTP (12 $MW_{th}$ on gas)<br>HPs (3.5 $MW_{th}$)<br>$_{roof}$PVs on DTP (83 $kW_p$) | Centralised heat supply<br>Motru CHPP modernised<br>Rehabilitated-modernised heating system (transmission-distribution networks, thermal stations)<br>New equipment<br>Motru CHPP [1 x WtE-CHP (0.63 $MW_e$, 2 $MW_{th}$) + 3 x CAF (3x3.5 $MW_{th}$) on gas]<br>PVPP (6.25 $MW_p$)<br>Existing equipment<br>HWB (4.6 $MW_{th}$) on gas | Centralised heat supply<br>Motru CHPP modernised<br>Rehabilitated-modernised heating system (transmission-distribution networks, thermal stations)<br>New equipment<br>Motru CHPP [1 x WtE-CHP (0.63 $MW_e$, 2 $MW_{th}$) + 3 x MT-CHP 3x3.3 $MW_e$, 3x3.2$MW_{th}$ on gas]<br>PVPP (6.25 $MW_p$)<br>$_{roof}$PV on TS (83 $kW_p$) | Centralised heat supply<br>Motru CHPP modernised<br>Rehabilitated-modernised heating system (transmission-distribution networks, thermal stations)<br>New equipment<br>Motru CHPP [1 x CHP (6.6 $MW_e$, 13.1 $MW_{th}$) on biomass]<br>PVPP (6.25 $MW_p$)<br>$_{roof}$PV on TS (83 $kW_p$) | Centralised heat supply<br>Motru CHPP modernised<br>Rehabilitated-modernised heating system (transmission-distribution networks, thermal stations)<br>New equipment<br>Motru TP [HPs 13.1 $MW_{th}$]<br>PVPP (6.25 $MW_p$)<br>$_{roof}$PV on TP (83 $kW_p$) |

The main techno-economic indicators for each scenario analysed are summarised in the following table:

| SCENARIOS / INDICATORS | | UM | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4a** | Scenario 4b** | Scenario 5 |
|---|---|---|---|---|---|---|---|---|
| Electricity | RES | % | 100 | 77 | 12 | 100 | 100 | 100 |
| | Fossil* | % | - | 23 | 88 | - | - | - |
| Thermal energy | RES | % | 25 | - | - | 100 | 100 | 100 |
| | Fossil* | % | 75 | 100 | 100 | - | - | - |
| $CO_2$ emissions reduction | | $t_{CO2}$ /year | 28,783 | 31,210 | 37,753 | 60,363 | 14,375 | 37,509 |
| Benefit/cost ratio | | - | 0.71 | 0.81 | 0.92 | 1.29 | 0.74 | 1.28 |

**) in scenario 1, the fossil fuel is methane gas and in scenarios 2 and 3 methane gas and municipal wastes (wet fraction);**) scenarios 4a and 4b differ only from the perspective of considering biomass as a certified renewable source, without or with $CO_2$ emissions.*

The five analysed scenarios were defined for the new source of thermal energy in the city of Motru, from the perspective of predominant RES use, in proportions ranging from 12 to 100 per cent, these being supplemented, in some cases, with methane gas as a transition fossil fuel and in others, with municipal waste.

Based on the results of the financial analysis developed for all five scenarios, the following can be mentioned:

- In **Scenarios 4a and 5**, the financial performance indicators are positive (positive NPVF/C, IRRF/C higher than the discount rate, B/C ratio > 1); the project is considered cost-effective for these two scenarios;
- For the other analysed scenarios, i.e. **Scenario 1, Scenario 2, Scenario 3 and Scenario 4b**, the financial performance indicators are negative.

In view of the above, in terms of financial indicators, the scenario with the best indicators is **Scenario 4a**, which presents the most favourable financial indicators.

However, given the dependence of the biomass-based CHPP operation on the provision of a constant and reliable flow of biomass that meets the requirements of 'sustainable biomass' in accordance with the provisions of MMAP Order 1534/2016, it was considered that **Scenario 5**, in which the use of ground-to-water heat pumps (HP) is proposed in combination with photovoltaic solar panels (PV), is more viable, easier to manage and more reliable in terms of continuity and safety of heat supply than **Scenario 4a**.

At the same time, taking into account the fact that biomass should only be recommended as a renewable energy source in **Scenario 4** (a and b) if it has no impacts on the ecological balance (forests/agriculture and biodiversity), **Scenario 5** demonstrates that 100 per cent heat supply from RES is possible, all year round.

# 1 INTRODUCTION

The city of Motru was declared a municipality according to Law no.180/23.10.2000, a community born as a result of the beginning of the coal mining industry and the establishment of miners' colonies. The administrative structure of Motru includes Dealu Pomilor, Horăști, Insurăței, Leurda and Ploștina localities, together with the subordinate villages of Lupoița, Roșiuța and Râpa. From an administrative-territorial point of view **(Figure 1-1),** the city of Motru (about 1.32 km$^2$) – the main perimeter analysed in this study – is subordinated to Motru UAT (Territorial Administrative Unit) (49.79 km$^2$), subordinated at the NUTS 3 level to Gorj County / RO412 (5,602 km$^2$), included in the South-West Oltenia Region (NUTS3/RO41).

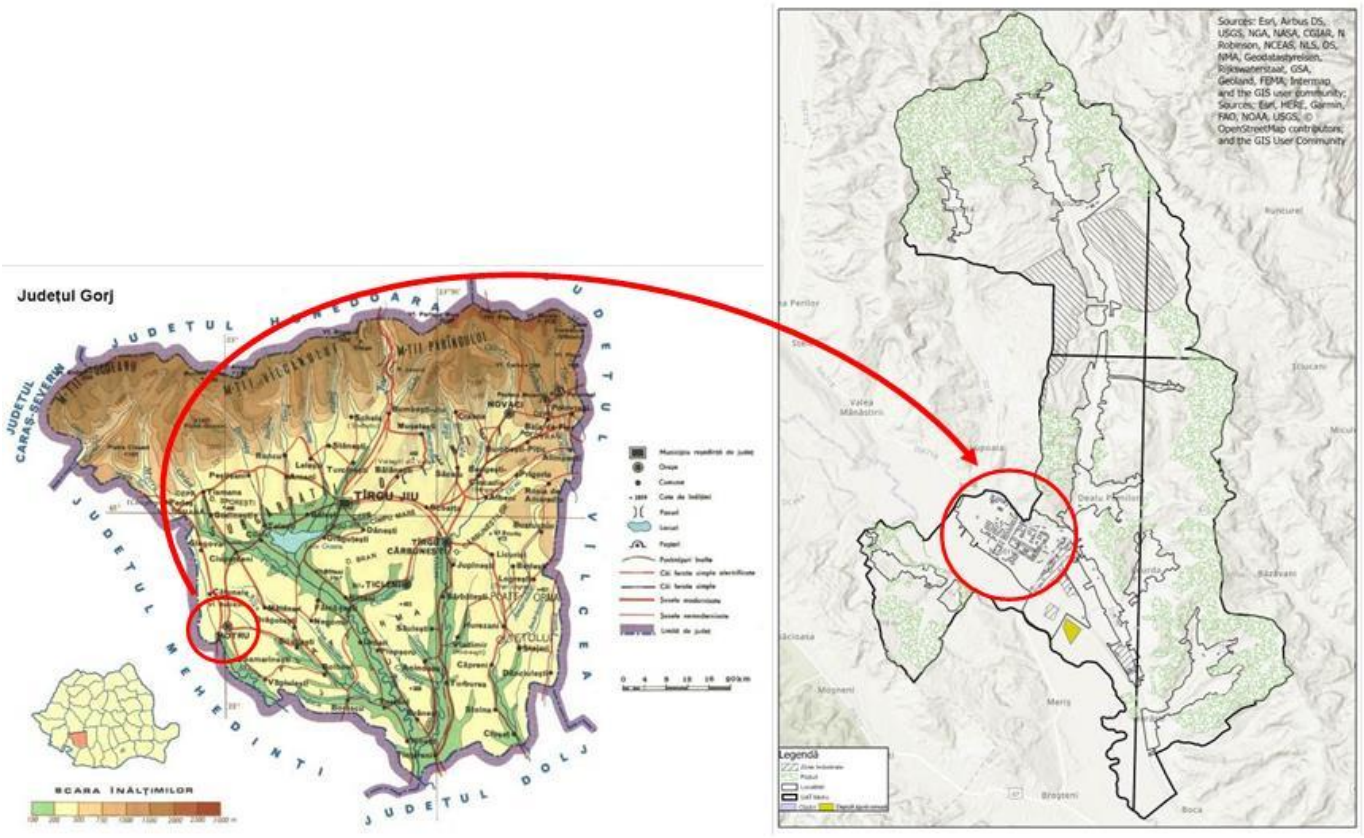



**Figure 1-1**: Location of Motru; map of the analysed territory
*Source: Gorj County Council; ANCPI; Esri*

The outlined area, analysed in this study, is the locality of Motru – the perimeter served by the public service for thermal energy supply (heat and hot water for domestic consumption), which is operated by the company Uzina de Agent Termic și Alimentare cu Apă Motru (S.C. UATAA S.A.) subordinated to Motru Local Council.

For the assessment of the RES theoretical potential, the analysis was extended to the footprint of Motru Territorial Administrative Unit in order to propose the repurposing, in terms of energy use,

of non-productive land, such as former mining perimeters / mine tailing dumps or ponds, or former industrial waste dumps (ash and slag).

The input data for the study was provided by the mayoralty of the municipality of Motru, UATAA S.A., ApaRegio Gorj S.A. - CED Motru and Premier Energy S.A., supplemented by information gathered from ANRE studies and reports, Transelectrica, INS statistics and CNSP forecasts. Useful information was also collected from scientific and European institutions' literature reviews (Chap. 7 Bibliography). The time period analysed is 2019 to 2021, with a view to 2030.

## 1.1 European, regional and local contexts for coal use

The 2030 Climate and Energy Framework, adopted by the European Council in October 2014 and revised in 2018 (for renewable energy and energy efficiency targets), includes the following EU key targets and policy objectives for the 2021 to 2030 period:

- Reducing greenhouse gas (GHG) emissions by at least 40 per cent compared to 1990 levels;
- A share of at least 32 per cent for renewable energy;
- Improve energy efficiency by at least 32.5 per cent.

As part of the European Green Deal, through the European Climate Act, the EU has set itself a binding target of achieving climate neutrality by 2050. As an intermediate step towards climate neutrality, the EU has increased its climate ambition for 2030, committing to reduce emissions by at least 55 per cent by 2030.

To bring current legislation in line with ambitions for 2030 and 2050, the EU is currently working on revising its climate, energy and transport legislation under the Fit for 55 package. The Fit for 55 package is made up of thirteen proposals; eight of them are revisions of existing laws and five are new proposals, of which the following are of interest:

- Amending the Renewable Energy Directive 2018/2001/EU, setting a new target of 40 per cent renewable energy use (up from 32 per cent) by 2030 and strengthening the sustainability criteria for bioenergy;
- Amendment of the Energy Efficiency Directive 2012/27/EU, which sets a more ambitious mandatory annual EU target, increased from 32.5 to 36 per cent.

Regarding the ban on using fossil fuels – in particular coal as a raw material in energy production – the European Commission, through DG Energy and the Coal Regions in Transition Initiative, notes that this is a long-term process, but is becoming a reality in Europe. At the same time, coal, still one of the main fuels in Europe's energy mix, provides about 230,000 jobs in the mining and energy production industry for 31 development regions (NUTS2) in 11 EU countries. The decline of the coal era has created a domino effect in the economies of European regions affected by

massive unemployment, energy poverty and economic regression as a result of the closure of mines and related power plants.

At the same time, in the context of Russia's invasion of Ukraine, which has massively disrupted the world's energy system, the EU has proposed additional investments through the REPowerEU Plan (EC, 2022) to provide the EU with energy independence from Russia even before 2030, and to further reduce the consumption of fossil fuels (coal, methane gas and oil).

The figure below shows the deadlines assumed by the MS (member states) to abandon the use of coal in energy production.


**Figure 1-2**: Deadlines for phasing out coal in power generation

*Source: EC-CRIT*[1]

In Romania there are two coal-intensive regions (NUTS 2), RO41 South-West Oltenia and RO42 West Region, which include the main areas of mining exploitation: the Oltenia basin (Rovinari, Motru, Jilț and Berbești-Alunu with lignite quarries), located mainly in RO412 Gorj county, and the Petroșani basin (underground hard coal mines) in the Valea Jiului micro-region (inside RO423 Hunedoara county).

[1] https://energy.ec.europa.eu/topics/oil-gas-and-coal/eu-coal-regions/coal-regions-transition_en

At the end of 2021, with the approval by the EC of the National Recovery and Resilience Plan,[2] Romania officially declared the year 2032 its coal phase-out deadline for the energy industry.

The sustainable transition to low-carbon power generation, compatible with our national energy security objectives, will be achieved by gradually phasing out reliance on coal. This complex process will be the subject of a regulatory act assuming a 2022 to 2032 timetable for the closure of the total installed coal and lignite-based capacity of 4,920 MW.

National policies on the gradual approach of the transition from coal are reflected in the following strategic documents, recommended to be considered by the Motru local public authority:

### National Integrated Energy and Climate Change Plan 2021-2030 – PNIESC,[3] January 2021

Through the effort undertaken to achieve the national targets below, Romania will contribute to reaching the EU's 2030 targets, as follows:

**Table 1-1**: National Targets 2030 - PNIESC

| Indicators | Targets |
|---|---|
| **Emissions from ETS sources (compared to 2005 level)** | **- 43.9 %** |
| **Emissions from non-ETS sources (compared to 2005 level)** | **- 2 %** |
| **Total share of renewable energy in gross final energy consumption** | 30.7 % |
| **Energy efficiency (compared to 2007 level)** | |
| **Primary energy consumption** | 32.3 Mtoe |
| **Final energy consumption** | 25.7 Mtoe |

*Source: PNIESC, 2020*

Based on the European Green Deal Investment Plan (EGDIP),[4] through this PNIESC, Romania also addresses the policies and interventions basis aimed at providing a socially just transition within it; Gorj County is in the foreground through the Decarbonisation Plan of Oltenia Energy Complex (CEO).

Among PNIESC's six main pillars, two are of interest to the current study, with its corresponding policies and measures:

- Pillar P1. Decarbonisation by cutting GHG emissions, with a focus on the energy sector, and by promoting RES use and increasing energy efficiency (EE);
- Pillar P2. Energy efficiency, by promoting investments in reducing final energy consumption, with a positive impact on both reducing GHG emissions and combatting energy poverty.

### National Recovery and Resilience Plan - PNRR [1]

[2] https://mfe.gov.ro/pnrr/

[3] http://www.mmediu.ro/app/webroot/uploads/files/PNIESC.pdf

[4] https://ec.europa.eu/commission/presscorner/detail/en/qanda_20_24

Within the six pillars of the PNRR, structured according to the European Recovery and Resilience Mechanism (Regulation (EU) 2021/241 establishing the Recovery and Resilience Facility), the following components under Pillar I - Green Transition, are of interest for supporting EE solutions and integration of RES, in the current Study:

- C5. Renovation wave;
- C6. Energy.

**National long-term renovation strategy** to support the renovation of the national stock of residential and non-residential buildings, both public and private, and its gradual transformation into a highly energy-efficient and decarbonised building stock by 2050 (**SNRTL),**[5] November 2020

This strategy, in order to achieve its impact indicators (e.g. final energy savings, increase in the number of nZEB buildings, reduce the number of people affected by energy poverty, etc.) proposes to renovate the existing building stock to increase energy performance through three renovation packages P1, P2 and P3:

- Minimum package - P1 package (to meet national technical regulations on the energy performance of buildings, i.e. close to class C of the Energy Performance Certificate according to the technical regulations in force);
- Medium package - P2 package (thorough refurbishment to avoid works that will have to be rebuilt later or replaced to meet future nZEB requirements, and with minimal RES use);
- Maximum renovation package - P3 package (deep renovation standard or nZEB, including all renewable energy options, such as photovoltaic panels on roofs, solar domestic hot water preparation or geothermal heat pumps).

These packages were defined for the reference buildings, selected for being representative of the existing building stock, respectively:

- Residential buildings with several apartments (multifamily / collective dwellings), connected or not connected to centralised DHS;
- Single-family (individual) buildings, with individual heating installations, operating on methane gas or solid biomass (firewood) stoves;
- Social, health and educational buildings connected or not connected to centralised DHS;
- Offices and other commercial buildings.

**Regional Operational Programme for the South-West Oltenia Region (POR SV) 2021-2027,**[6] version May 2022

Through the POR SV 21-27, a series of six Regional Specific Objectives (RSO) are assumed, out of which of interest for this study is:

[5] *https://legislatie.just.ro/Public/DetaliiDocument/236612*

[6] https://mfe.gov.ro/minister/perioade-de-programare/perioada-2021-2027/

- RSO.3 - Reducing carbon emissions by promoting energy efficiency, developing green infrastructure and improving urban public transport.

The main issue identified under this objective is the high energy consumption in both public buildings and the existing residential stock. The proposed measure to be addressed is the improvement of the energy efficiency of public and residential buildings, especially for vulnerable consumers.

At the level of the South-West Oltenia Region, some of the result indicators proposed by RDA SV Oltenia for 2029 are the following:

- Improved energy performance for 3,647 households, in multifamily residential buildings, and for 214,000 $m^2$ of public buildings in the region;
- Reduced annual primary energy consumption (from households, public buildings, business, etc.) by 37 per cent (from 155,000 MWh/year to 58,000 MWh/year);
- Reduced GHG emissions by 34 per cent (from 25,000 tonnes $CO_{2eq.}$/year to 8,000 tonnes $CO_{2eq.}$/year).

Eligible investments refers to measures to provide/increase energy efficiency and the use of RES, including consolidations in public buildings (deep renovation), with priority given to those with social functions, and multifamily residential buildings.

In addition, the POR SV Oltenia aims to provide support to public authorities and institutions for the preparation of project documentation and/or relevant strategic documents and to increase administrative capacity in the field of energy efficiency.

**Territorial Plan for Just Transition in Gorj County (PTTJ Gorj),**[7] version April 2022

PTTJ Gorj aims to mitigate the socio-economic impact of implementing PNRR reforms to replace coal in the energy mix by 2032, as well as to reduce the energy intensity of the economy by developing a sustainable mechanism to stimulate energy efficiency in industry and increase resilience.

Within PTTJ Gorj, according to OUG 75/2000 regarding the regime of disadvantaged areas, Motru UAT falls into this category.

On the background of the climate neutrality transition and avoiding double funding, in the South-West Oltenia region, Pillar I in PTTJ Gorj is of interest for this current study. Via Pillar I of PTTJ Gorj, investments to provide/increase energy efficiency and RES use are supported, in complementarity with POR SV 21-27 and PNRR by focusing on prosumers and public services' energy resilience:

- rehabilitating buildings serving children at risk of separation from their families; purchasing small-scale renewable energy production and storage capacities, including related

[7] https://mfe.gov.ro/minister/perioade-de-programare/perioada-2021-2027/

distribution networks, to supply renewable energy for essential public services in schools, hospitals, homes for the elderly, nurseries, social centres, vocational training centres, etc.

- creating prosumers by installing photovoltaic/solar-thermal panels at the household level.

In order to support the proposed investments, the Just Transition Mechanism (JTM) also adds Pillar II (which is supported by the InvestEU Programme) and Pillar III (EIB public sector lending facility) schemes to the PTTJ Gorj.

**Motru Local Development Strategy 2021-2027 (SDL 21-27),**[8] December 2020

The local development vision proposed by SDL 21-27 is as follows:

**Municipality of Motru 2027 – an attractive, safe, resilient and sustainable urban area!**

The fulfillment of this vision will be achieved through the attainment of the two major strategic objectives of Motru's socio-economic development: A) improving inhabitants' quality of life and B) increasing the attractiveness for economic activities. Among the result indicators to be monitored during the implementation of SDL 21-27, in relation to 2020 figures (reference year), the following are of interest for the current study, integrated in the sectoral objective A.III. Improving energy efficiency:

- 10 per cent reduction in annual final energy consumption (residential, public and commercial/industrial buildings);
- 20 per cent reduction in annual final energy consumption (public buildings under the administration of Motru UAT);
- 40 per cent reduction in annual final energy consumption in public lighting;
- 30 per cent reduction in $CO_2$ emissions from the centralised DHS operation (including the coal-based CHPP), by reducing specific fuel consumption from 180 gcc/kWh to 171 gcc/kWh.

SDL 21-27 also provides:

- granting tax incentives (tax reductions) for individuals and legal entities that carry out energy efficiency works in their homes/buildings with their own funds;
- repurposing of the post-mining heritage (especially those lands – former mining perimeters - that will be transferred back to the ownership of Motru UAT) through economic valorisation, within the framework of sectoral objective B.II Sustainable valorisation of the local specificity.

## 1.2 Reference legislative framework in the field of heat supply

This study is linked to the national, regional and local strategic documents mentioned in Chapter 1.1 and takes into account a number of national and European legal acts.

[8] https://primariamotru.ro/documente/strategia-de-dezvoltare-locala-a-municipiului-motru-pe-perioada-2021-2027/

**Primary national legislation**

- Law no. 196/2021 on the amendment and completion of Law no. 325/2006 on thermal energy supply public service, on the amendment of paragraph (5) of art. 10 of Law no. 121/2014 on energy efficiency and for the completion of para. (3) of art. 291 of Law no. 227/2015 on the Fiscal Code;
- Law no. 226/2021 on the establishment of social protection measures for vulnerable energy consumers;
- ANRE Order no. 13/2020 approving the Regulation for issuing technical approval on energy efficiency under the Centralised DHS Programme;
- GD no 1034/2020 for the approval of the National Strategy for Long-Term Renovation (SNRTL) to support the renovation of the national stock of residential and non-residential buildings, both public and private, and its gradual transformation into a highly energy-efficient and decarbonised building stock by 2050;
- GEO no. 53/2019 on the approval of the Multiannual Programme for the financing of investments for the upgrading, rehabilitation, retrofitting and extension or establishment of centralised DHSs in localities and for the amendment and completion of the Law no. 51/2006 on Community Public Utility Services;
- Order MLPDA-MMAP-MFP no. 3194/1.084/3.734/2019 approving the Regulation on the implementation of the Centralised DHS Programme;
- Law no. 207/2015 on the Tax Procedure Code, as amended and supplemented;
- Law no. 121/2014 on energy efficiency, as amended and supplemented;
- Law no. 325/2006 on thermal energy supply public service, as amended and supplemented;
- GD no. 246/2006 for the approval of the National Strategy regarding the acceleration of the development of public utilities community services;
- GD no. 882/2004 for the approval of the National Strategy regarding the supply of thermal energy to localities through centralised generation and distribution systems;

**European directives and regulations**

- Directive 2012/27/EU of the European Parliament and of the Council on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC;
- Directive 2018/2002/EU of the European Parliament and of the Council amending Directive 2012/27/EU on energy efficiency;
- Directive 2018/2001/EU of the European Parliament and of the Council on the promotion of the use of energy from renewable sources;

- Commission Delegated Regulation (EU) 2019/826 amending Annexes VIII and IX to Directive 2012/27/EU of the European Parliament and of the Council on the content of comprehensive assessments of the potential for efficient heating and cooling;

## 1.3 Current context of the heat market

According to studies by the United Nations Environment Programme (UNEP), heating, cooling and domestic hot water systems account for half of the overall energy consumption in buildings, and these are mainly concentrated in large urban areas.

Internationally, centralised district heating systems (DHS) that produce energy in cogeneration, supplying heat to end-users and delivering electricity to the system, are now recognised as the most sustainable and cost-effective means of providing heat and domestic hot water in large urban areas. However, the potential of centralised systems remains largely untapped due to barriers created by energy policy at local, regional and national levels.

In the European Union (EU), district heating/cooling systems (DHCS) are a new direction in energy policy, as they are seen as the efficient, affordable and most environmentally friendly solution. Implementing these solutions can contribute at least 58 per cent to the EU's 2050 emissions reduction target. The most important district heating/cooling systems in Europe, which are based on advanced green energy generation, storage, waste heat recovery technologies, and have a modern infrastructure adapted to the new requirements, are the following:

- Paris - centralised heating/cooling system supplying more than 500,000 households, more than half of social and public housing; covering demand needs is based about 60 per cent on renewable energy;
- Copenhagen - centralised heating system covering more than 95 per cent of the city's heat demand, using new, efficient and environmentally friendly technologies (biomass, waste, geothermal, heat pumps, wind);
- Rotterdam, Helsinki, Oslo, Amsterdam, Frankfurt, London, Milan, Genoa and Warsaw.

According to the EU Heating and Cooling Strategy approved in 2016, ‘half of the energy produced in the EU is used for heating and cooling, but much of it is wasted’.

The development of centralised DHS must take into account the development perspective of cities and urban planning. At the same time, the use of alternative energy sources, thermal rehabilitation of buildings, final consumer metering, and creating the possibility to regulate indoor temperatures is a necessity for the centralised DHS in Romania.

According to ANRE's annual report for 2020 (ANRE, 2021), Romania today has centralised systems that are more than 50 years old. Out of more than 300 existing centralised DHSs at the end of the 1980s, only 47 operators remain active at the end of 2020, operating 50 centralised DHSs in 51 localities in 28 counties and Bucharest.

This drastic decline of the centralised heat supply systems in Romanian localities was due to: the collapse of the Romanian industry between 1992 and 2005, the poor quality of the public services offered to final consumers, the lack of investments in the upgrading and retrofitting of CHPPs and heat networks, the decision-makers' lack of interest in keeping centralised DHSs in operation.

All these barriers and issues have led to mass disconnection of consumers from the centralised DHS and a shift towards individual heating solutions.

According to the SNRTL, approved by HG no. 1034/2020, there are approximately 5.6 million buildings in Romania, of which 90 per cent are residential buildings, representing 582 million $m^2$ of heated floor space. Among residential buildings, single-family housing accounts for the largest share, with about 58 per cent of the total, followed by multifamily buildings with about 33 per cent.

The fuels used for heating the residential sector are (MDLPA, 2020): individual heating sources with firewood or biomass (49 per cent), individual systems running on methane gas (34 per cent), centralised DHS (13 per cent), fuel oil (3 per cent) and coal and geothermal energy (1 per cent).

The city of Motru experienced major development during the 1960s and 1990s, when the city's population doubled; districts including collective dwellings were planned, in parallel with the development of the coal-based centralised DHS.

Currently, thermal energy supply services (heat and domestic hot water) are provided by S.C. UATAA Motru S.A. The centralised DHS includes the generation, transmission, distribution and supply of thermal energy, covering 4,560 households, 15 public institutions and 114 businesses/enterprises. Residential consumers connected to the centralised DHS, in 2021, represent 68.05 per cent of the municipality's population.

The local authorities, together with the DHS operator, can cover the current demand, focusing on strengthening the position of SC UATAA Motru SA on the energy market, through a series of investments aiming at sustainable and responsible development, in order to guarantee safe, clean and efficient energy generation at European standards through strategic planning.

# 2 ANALYSIS OF THE EXISTING SITUATION REGARDING HEAT SUPPLY AND IDENTIFICATION OF DEFICIENCIES IN THE CITY OF MOTRU

## 2.1 General information on heat supply in Motru

In the city of Motru, the supply of thermal energy for heating and of domestic hot water preparation for consumption is carried out by:

- **Centralised DHS operated by SC UATAA SA Motru**

  The DHS includes a lignite and fuel oil-fired CHPP and a 24-km-long thermal energy transmission and distribution network.

  The main purchaser of thermal energy in Motru is the population (86 per cent of the total), which, as domestic consumers, receives thermal energy (heat and domestic hot water) for consumption throughout the year.

  Non-domestic consumers – public institutions have a share of approx. 8 per cent of the total generated thermal energy and economic enterprises / businesses a smaller share of about 6 per cent of the total.

- **Individual heating systems**

  This system is based on individual heating installations (thermal plants or stoves).

  Part of the population living in collective dwellings (blocks of flats) or individual households and part of the economic enterprises / businesses have chosen alternative heating sources (firewood or methane gas-based individual heating installations and stoves).

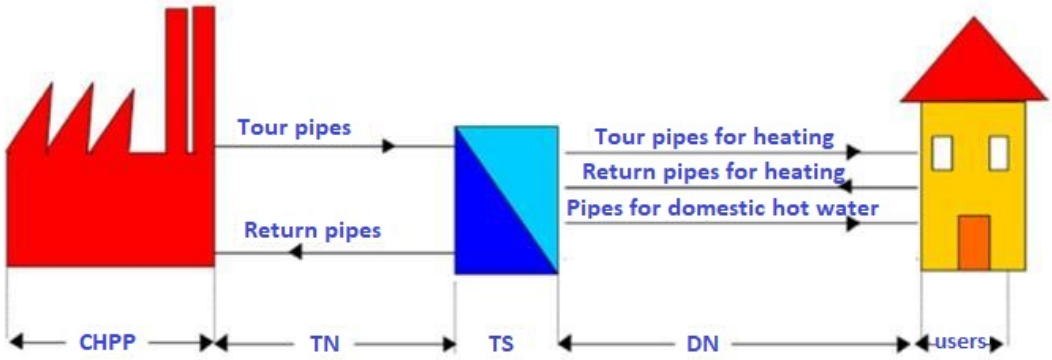
## 2.2 Description of Motru centralised DHS

The centralised DHS has the following main components:

- **the source of energy** – CHPP (cogeneration/combined heat and power plant);
- **primary heat networks** –piping system providing the transmission of thermal energy from the CHPP to the TS (thermal stations);
- **thermal stations (TS)** – provide the transfer of thermal energy between the primary and secondary thermal agents;
- **secondary heat networks** –piping system providing the distribution of the thermal energy from the TS to the final consumers;
- end users (domestic and non-domestic consumers).

Thermal energy in the form of hot water produced in the **source** (primary thermal agent) is transported through **the primary heat networks** to the **thermal stations**. At the TSs, heat is exchanged between the primary and secondary thermal agent and distributed via the **secondary heat networks** to the **final users/consumers**.

The simplified scheme of the centralised DHS in Motru is shown in the following figure:




**CHPP** = Gogeneration / Combined Heat and Power Plant
**TN** = Thermal Transmission Networks
**TS** = Thermal Stations
**DN** = Thermal Distribution Networks
**users** = Consumers

**Figure 2-1**: Motru centralised DHS structure

The operator of the centralised DHS is the company Uzina de Agent Termic și Alimentare cu Apă Motru (S.C. UATAA S.A.), subordinate to Motru Local Council.

Motru's centralised DHS operates according to the heat demand curve, which takes into account the outdoor temperature, so the shape of the curve is different from year to year. The following figure shows the shape of the thermal load curve.

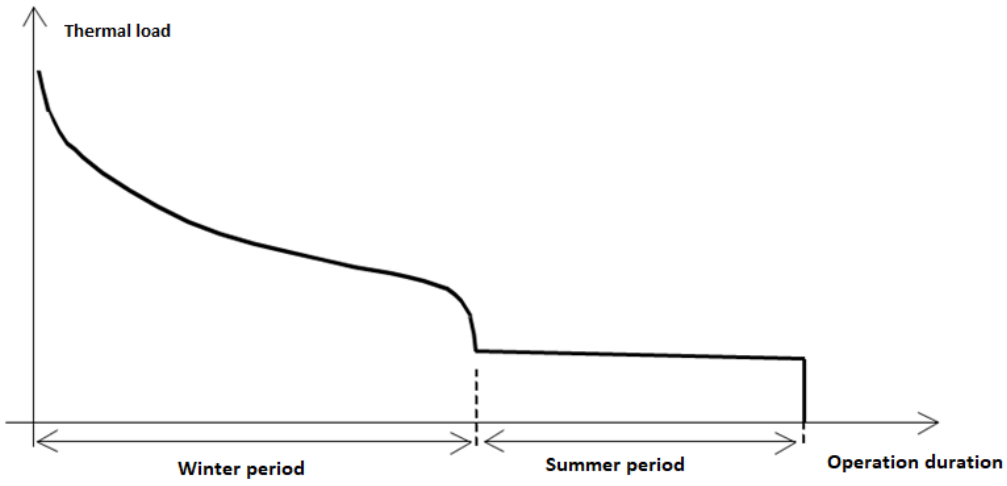



**Figure 2-2**: Heat demand curve

### 2.2.1 The Cogeneration Power Plant (CHPP)

**Figure 2-3**: SC UATAA SA Motru

The operator SC UATAA SA Motru, with its headquarters in Motru, 25 Calea Severinului, Gorj county, is active in the field of thermal energy cogeneration and distribution for heating and domestic hot water preparation supplying the Motru centralised DHS.

Motru CHPP includes the following **main equipment**:

- **2 steam boilers** 50 t/h each (40 bar; 450° C), CR0102 type, lignite/fuel-oil fired (commissioned/PIF in 1968-1969), one operational in winter and the second under conservation;
- **1** counter-pressure **steam turbine**, 5.5 MWe, (PIF 2008) operating in winter along with the abovementioned 50 t/h steam boiler;
- **2 hot water boilers**: 1 x 10 Gcal/h HWB, ASF type, running on lignite (PIF 1982) and 1 x 4 Gcal/h HWB, GIAC type, running on light-fuel-oil/fuel-oil or methane gas (PIF 2018), under conservation; the HWBs operate during the summer for the preparation of domestic hot water.

The total installed thermal capacity in Motru CHPP belonging to SC UATAA SA Motru is **46 $MW_{th}$**, of which:

- 29.70 $MW_{th}$ represents the cogeneration capacity (electrical and thermal energy);
- 16.28 $MW_{th}$ represents the separate thermal energy generation capacity.

The thermal energy required for the thermal and domestic hot water comfort of Motru consumers is produced in the CHPP of SC UATAA SA Motru, using mostly lignite as fuel.

In winter, the thermal energy is provided in cogeneration (electricity and heat) by operating a steam boiler together with the steam turbine. In summer, the thermal energy is only provided separately from the thermal energy capacities by operating one HWB.

The fuels used by Motru CHPP are the following:

- Coal - lignite

  Coal is the basic fuel (93 per cent) and is supplied by Complexul Energetic Oltenia on a contract basis and is transported in wagons, by rail. It is measured by weighing. The quantity available is approx. 70,000 tones/year, the lower calorific value is 1,870 kcal/kg.

- Fuel oil

The fuel oil is supplied by OILOPROD IMPEX on a contract basis and is transported via road vehicles. Measurement is by weighing. The lower calorific value is 9,670 kcal/kg.

- Methane gas is supplied by Premier Energy on a contract basis and is metered.

### 2.2.2 Thermal energy transmission and distribution networks

***Primary heat networks*** provide the transmission of the thermal energy (hot water via pipelines) from the CHPP to the TSs (Thermal Stations).

***Secondary heat networks*** provide the distribution of the thermal energy (medium and domestic hot water via pipelines) from TSs to end users (domestic and non-domestic consumers).

The transmission and distribution system is an arborescent type network, with a route length of 24 km, of which 22 km (92 per cent) is located underground and 2 km (8 per cent) above ground.

The total volume of the thermal networks is 1,297 $m^3$, of which transmission networks 1,127 $m^3$ and distribution networks 170 $m^3$.

Currently, heat losses in the transmission and distribution networks are about 46.8 per cent. These are caused by uninsulated pipe sections (approx. 40 per cent in transmission networks) and inadequate insulation (approx. 28 per cent in transmission and 25 per cent in distribution networks).

In Motru, there are 19 ***thermal stations*** connected to the thermal energy transmission system, operated by SC UATAA SA Motru. The TSs have a total installed capacity of 25.18 Gcal/h (29.28 $MW_{th}$).

### 2.2.3 Diagnosis of consumers

Out of the total number of 7,261 households in Motru municipality, 4,560 households are currently connected to the centralised DHS, which represents about 63 per cent.

Currently, the final consumers benefiting from the centralised heat supply service in Motru are:

- Individuals, i.e. 4,560 households (out of 7,261 total households built in the city) – termed residential or domestic consumers;
- Legal entities – termed non-domestic consumers, represented by:
  - 15 public institutions and other social-cultural entities;
  - 114 economic enterprises / businesses.

Metering was performed at consumers' connection by installing heat meters on the heating and hot water circuits as follows:

- for heating 12 per cent;
- for domestic hot water 100 per cent.

The housing stock connected to the centralised DHS is over 50 years old and the internal heating and hot water distribution installations are also obsolete.

### 2.2.4 Energy efficiency in buildings

The 118 collective dwellings / multifamily residential buildings (blocks of flats) are characterised by low energy efficiency, as no major works have been carried out to improve the energy performance of the buildings. In addition, there are approx. 706 individual housing / single-family residential buildings for which there is no data on energy performance improvement works.

Concerning public buildings, although there have been concerns, so far, out of the 12 public buildings belonging to Motru Local Council, only a few have been thermally rehabilitated (2 kindergartens, 1 high school, the House of Culture and one wing of Motru Municipal Hospital).

In order to reduce heat loss from residential and public buildings, it is imperative that the building envelope (facades, terraces/roofs, external joinery) is thermally renovated, with particular emphasis on multifamily/collective residential buildings (blocks of flats).

Choosing the solution for the thermal rehabilitation of multi-storey buildings at the envelope level (thermal, sound and waterproof insulation, condensate removal works, facades, terraces/roofs) should be made by mutual agreement and in collaboration with the building owners or owners' associations, considering the composition and the status of the existing building elements, determined during the technical expertise and energy audit phase, as well as the priority criteria specific to each situation.

The thermal renovation of the building envelope is carried out along with the thermal renovation of indoor installations.

According to Sectoral Objective A.III. Improve energy efficiency, of Motru Local Development Strategy 2021-2027 (Sigma Mobility Engineering, 2020), the local authorities have set a target of reducing the annual final energy consumption of residential, public and commercial/industrial buildings by 10 per cent.

The programme for the thermal rehabilitation of multifamily residential buildings aims to increase the energy performance of buildings, reduce heating bills and thus improve living conditions for the population, improve the aesthetic appearance of buildings, and relieve the local budget of large sums allocated to heat energy subsidies.

## 2.3 Heat demand for consumers connected to Motru centralised DHS

### 2.3.1 Consumer structure

The thermal energy consumers connected to the Motru centralised DHS are classified by type as follows:

- Household/residential or domestic consumers - apartments blocks / collective dwellings, houses, villas, etc.;

- Commercial/non-residential consumers (legal entities);
  - the public sector - administrative, education, health, social;
  - the private sector - banks, shops, enterpsises, etc.

The year 2021 is the last full year of centralised thermal energy supply (heat and domestic hot water). The consumers' structure connected to Motru centralised DHS is shown in the following table.

**Table 2-1**: Motru centralised DHS. Number and type of consumers

| Specification | MU | Consumers supplied from Motru centralised DHS |
|---|---|---|
| *Residential or domestic consumers* | | |
| Households (apartments + houses) | no. | 4,560 |
| *Commercial / non-residential consumers* | | |
| Public sector institutions | no. | 15 |
| Private sector enterprises / services | no. | 114 |
| *Connections* | | |
| Hot water connections (from TN) | no. | 76 |
| Heating connections (from DN) | no. | 201 |
| Hot water connections (from DN) | no. | 110 |
| Connection rate to Motru centralised DHS of residential consumers in Motru municipality | % | 68.05% |

*Source: UATAA field data*

The total number of thermal energy supply contracts in progress at the end of 2021 was 729, and the breakdown of these contracts by type of consumer is shown in the figure below:

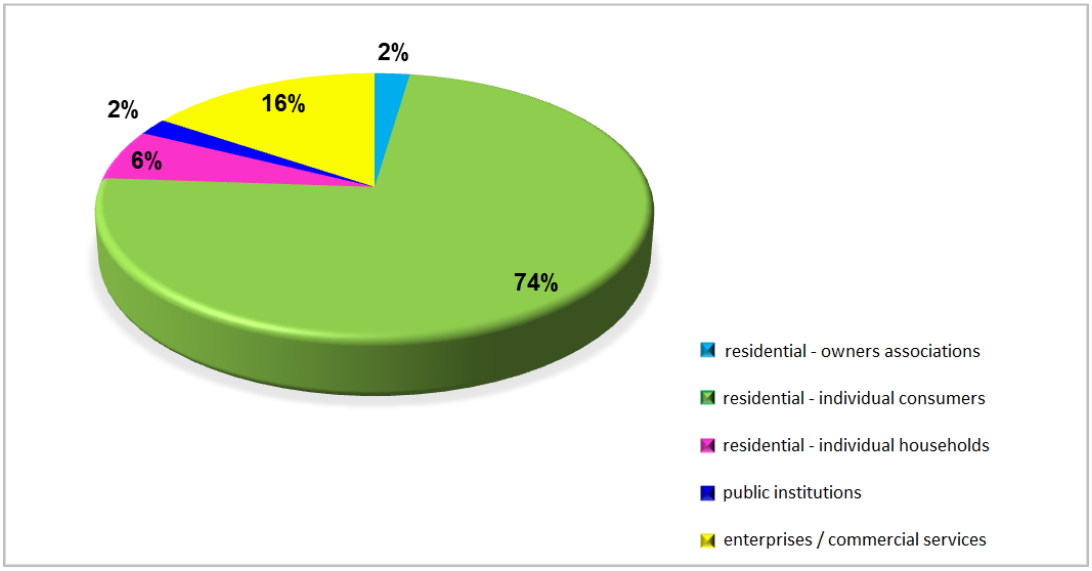



**Figure 2-4**: Number of heat supply contracts – 2021

*Source: UATAA field data*

The evolution of households connected to Motru centralised DHS during 2019-2021 is shown in the following graph, presenting a general downward trend. The rate of disconnections has remained approximately constant.

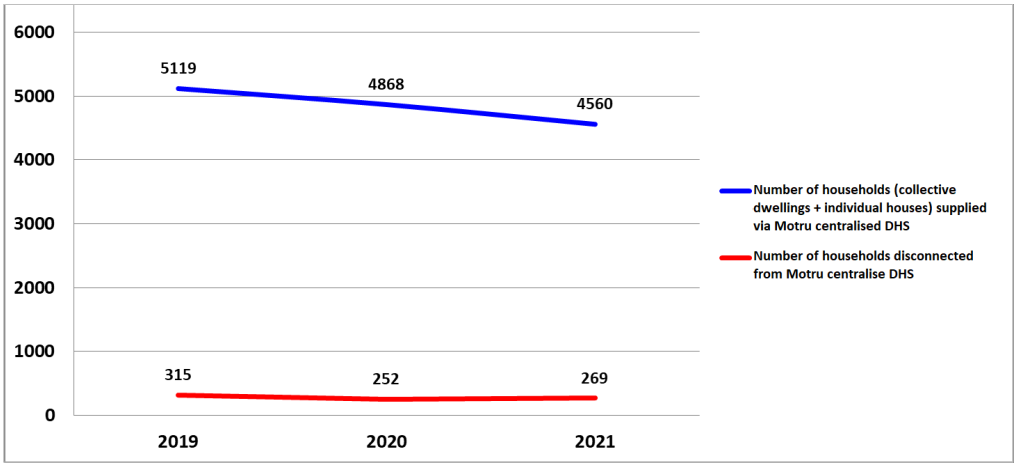



**Figure 2-5**: Evolution of the number of consumers supplied by Motru centralised DHS
*Source: UATAA and ANRE*

In 2021, the thermal energy consumption delivered from Motru centralised DHS, according to the type of consumers, was structured as shown in the following table.

**Table 2-2**: Annual thermal energy consumption delivered from Motru centralised DHS

| Specification | UM | 2021 | Medium 2019-2021 |
|---|---|---|---|
| Total amount of thermal energy sold by UATAA | % | 100 | 100 |
| Population (residential) | % | 85.6 | 86.2 |
| Public institutions | % | 8.3 | 8.0 |
| Enterprises / commercial services | % | 6.1 | 5.8 |

*Source: UATAA field data*

Statistics on the amount of thermal energy sold from Motru centralised DHS are shown in the following table.

**Table 2-3**: Quantity of thermal energy sold via Motru centralised DHS

| Specification | UM | 2019 | 2020 | 2021 | Medium 2019-2021 |
|---|---|---|---|---|---|
| Total centralised DHS | MWh/year | 53,827 | 53,566 | 50,618 | 52,670 |
| Households / residential | MWh/year | 46,480 | 46,420 | 43,318 | 45,406 |
| Public institutions | MWh/year | 4,239 | 4,097 | 4,225 | 4,187 |
| Enterprises | MWh/year | 3,109 | 3,049 | 3,075 | 3,078 |

*Source: UATAA and ANRE*

Compared to 2010, when the delivered thermal energy was about 76,674 MWh/year, in 2021 the thermal energy delivered to consumers has been reduced by 31 per cent, representing a significant reduction.

In Motru municipality, the downward trend of the thermal energy supplied in the centralised DHS is due to the following factors:

- Continuous degradation, in more than 50 years of operation, of the thermal energy transmission and distribution system, where intervention works (capital and periodic repairs), for maintenance, has been carried out only in the case of breakdowns, without major retrofitting and upgrading works; such issues leading to lack of continuity in the thermal energy supply and non-compliance with the thermal agent quality parameters;
- Substantial losses in the transmission and distribution networks, leading to higher fuel consumption and therefore higher $CO_2$ emissions;
- Climate change (reduction of periods of low temperatures);
- Reduction of the activity of some enterprises and institutions connected to Motru centralised DHS;
- Reduction of number of consumers due to DHS disconnection.

### 2.3.2 Hourly thermal energy demand in 2021

The hourly thermal energy demand for Motru centralised DHS for the year 2021 is shown in the following table.

**Table 2-4**: Hourly thermal energy demand in 2021

| Hourly thermal energy (heat and domestic hot water) demand by operating mode | | | | | |
|---|---|---|---|---|---|
| **Maximum winter** | | **Medium winter** | | **Medium summer** | |
| Gcal/h | $MW_{th}$ | Gcal/h | $MW_{th}$ | Gcal/h | $MW_{th}$ |
| 18 | 21 | 16 | 19 | 4 | 5 |

*Source: UATAA field data*

The data presented in the table also include the values of thermal energy losses in the transmission and distribution network.

The thermal energy supplied curve in 2021 covered by Motru centralised DHS is shown in the following figure.

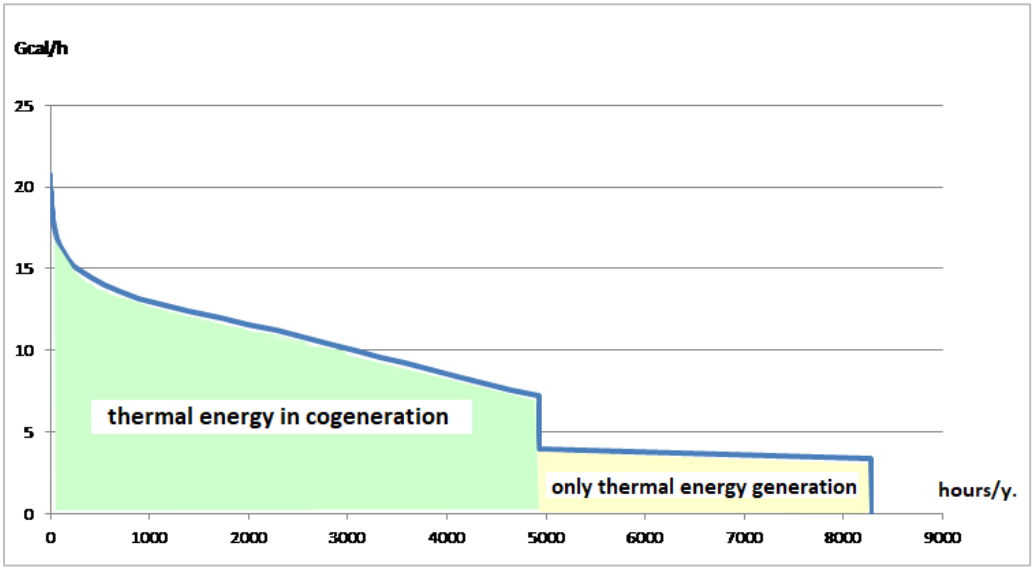



**Figure 2-6**: Annual curve of the thermal energy delivered in 2021 by Motru centralised DHS
*Source: ISPE data processing*

### 2.3.3 Annual thermal energy consumption in 2021

The total annual thermal energy (heat and domestic hot water) consumption at Motru centralised DHS level for 2021 is shown in the following table.

**Table 2-5**: Annual thermal energy demand in 2021

| **Motru Centralised DHS - Annual thermal energy consumption** | | | | | |
|---|---|---|---|---|---|
| **Annual thermal energy consumption at CHPP level** | | **Thermal energy losses via transmission and distribution networks** | | **Annual thermal energy consumption at consumers level** | |
| Gcal/year | MWh/year | Gcal/year | MWh/year | Gcal/year | MWh/year |
| 81,771 | 95,100 | 38,248 | 44,482 | 43,524 | 50,618 |

*Source: ISPE data processing*

The data presented in the above table show the thermal energy losses along the transmission and distribution networks, which are very high and represent about **46.8 per cent** of the annual thermal energy delivered by Motru CHPP.

The Sankey diagram for the energy flow balance of Motru centralised DHS for the year 2021 is shown in the following figure.

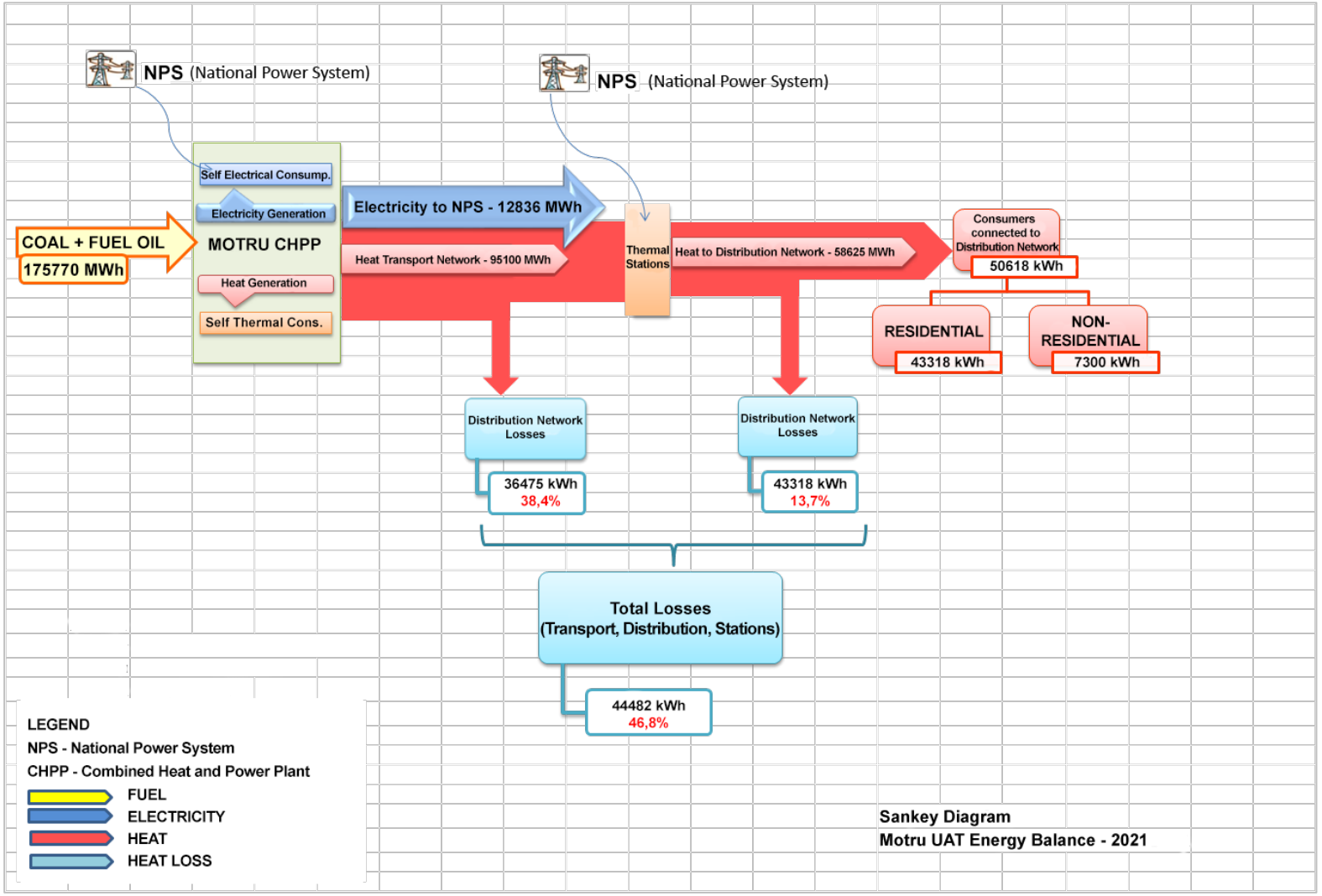



**Figure 2-7**: Sankey diagram for the thermal energy flow balance in Motru centralised DHS - 2021

### 2.3.4 Transmission and distribution system rehabilitation measures

In order to forecast the thermal energy demand, it was taken into consideration that the whole DHS will be retrofitted and upgraded, with heat losses reaching the values allowed by existing, efficient technologies. With this aim, the main measures considered to lead to an increase in DHS energy efficiency will mainly be the following:

- resizing and reconfiguration of pipeline routes (transmission and distribution) according to the existing consumption due to consummers' disconnection/reconnection;
- upgrading of thermal networks and implementation of modern technologies (e.g. pre-insulated pipes);
- replacement of damaged shut-off valves;
- use of plate heat exchangers;
- use of high-reliability, low-noise, variable speed pumps with frequency converters;
- use of modern expansion systems;
- implementation of a modern smart monitoring system and a dispatcher system for surveillance, remote monitoring and remote management of primary information.

### 2.3.5 Projection of thermal energy demand

The projection of thermal energy demand in a centralised DHS is influenced by several factors, the most important being:

- Implementation of thermal rehabilitation measures for existing buildings and promotion of better insulation standards for new buildings;
- Changes in the number of connected consumers, influenced in turn by demographic changes, including:
  - Number of permanent and temporary residents;
  - Number of inhabitants per household and number of active inhabitants relative to the number of inactive inhabitants.
- Disconnections, reconnections and connection of new consumers;
- Future development of the city's infrastructure;
- The standard of living, which is permanently in close correlation with the population's purchasing power;
- National and EU legislation and market requirements for energy efficiency improvements;
- Environmental legislation requirements and constraints;
- Municipal strategy for the development of the city and measures to encourage consumers to connect to the centralised DHS;
- Measures to improve the operational performance of the heat networks.

The analysis of the thermal energy demand takes into account the following assumptions:

**Table 2-6**: Assumptions regarding thermal energy demand

| **Hypothesis** | |
|---|---|
| **Thermal rehabilitation of buildings connected to the centralised DHS** | Annual rehabilitation rate **16 per cent**, representing a number of **approx. 700-800 apartments rehabilitated annually.**<br>The percentage was established considering the total number of households connected to Motru centralised DHS (4,560 apartments) and the implementation period of buildings' thermal rehabilitation projects in Motru municipality according to the *Local Development Strategy of Motru municipality for the period 2021-2027*. At the same time, EU Directive 2021/27 on energy efficiency with subsequent amendments specifies a rehabilitation percentage of at least 2 per cent of all public buildings. On the basis of these two elements, a 16 per cent per year rehabilitation rate has been taken as a calculation premise, i.e. over six years the period in which all buildings will be thermally rehabilitated. |
| | Improving the thermal insulation of apartments is expected to have a significant impact on the maximum hourly heat demand and consequently on the annual heat consumption, with a reduction of around **20 per cent** for each retrofitted apartment. |
| **Rehabilitation of the heat transmission and distribution system** | It is considered that the transmission and distribution networks' losses will be progressively reduced from the 2021 level to a maximum level of 15 per cent in the period 2021-2025, according to the *Local Development Strategy of Motru municipality for the period 2021-2027.* |
| **Disconnections vs. Reconnections and new consumers** | After the completion of the thermal network rehabilitation works, it is estimated that approximately 1,350 apartments (50 per cent of the households not connected to Motru centralised DHS) will be connected in the next five years, i.e. 270 apartments/year. |
| **Climate change impact** | Climate change impact leads to a 1.5 per cent per year decrease in consumer demand for thermal energy over the analysis period. |

The estimate of the evolution of thermal energy demand in the next 20 years is based on the existing situation (in the year 2021), correlated with the socio-economic evolution of the municipality, energy savings, change in the number of consumers and the impact of climate change.

These factors will cancel each other out and thus will not significantly affect the evolution of the hourly and annual thermal energy demand in Motru municipality.

Once the thermal energy demand forecasting is established at the consumer level, the evolution of the transmission and distribution networks' losses is then analysed, finally obtaining the projection of the thermal energy to be cogenerated at the CHPP level.

**The options for thermal energy demand to be covered by the thermal energy sources in Motru city will be:**

**Option 1 - Distributed thermal energy (heat) supply system**

**Option 2 - Centralised thermal energy (heat) supply system**

The following options are defined for the thermal energy demand at the plant's boundary:

- **Option 1 -** in which consumer demand is according to 2021 level and losses in the distribution networks are gradually reduced from this level to a maximum of 8 per cent by 2025, and then remain constant. The hourly consumer demand decreases due to households' thermal rehabilitation and, at the same time, increases due to the connection of new consumers to the distributed thermal energy supply system;
- **Option 2 -** in which consumer demand is according to 2021 level and losses in the transmission and distribution networks are progressively reduced from this level to a maximum of 15 per cent by 2025, and then remain constant. The hourly consumer demand decreases due to households' thermal rehabilitation and, at the same time, increases due to the connection of new consumers to Motru centralised DHS.

Based on the above, the following tables show the evolution of hourly thermal energy demand at the multiple sources/single source (CHPP) level in the coming period:

**Table 2-7**: Evolution of hourly thermal energy demand - distributed thermal energy (heat) supply system

| Operating regime | Option 1 - Distributed system - hourly thermal energy (heat) demand | | | | | |
|---|---|---|---|---|---|---|
| | Heat demand at multiple sources level | | Heat losses on the transmission & distribution networks | | Heat demand at consumer level | |
| | Gcal/h | $MW_{th}$ | Gcal/h | $MW_{th}$ | Gcal/h | $MW_{th}$ |
| **Maximum winter** | 10.4 | 12.1 | 0.8 | 1.0 | 9.6 | 11.1 |
| **Medium winter** | 7.8 | 9.1 | 0.6 | 0.7 | 7.2 | 8.4 |
| **Medium summer** | 3.3 | 3.8 | 0.3 | 0.3 | 3.0 | 3.5 |

**Table 2-8**: Evolution of hourly thermal energy demand – centralised thermal energy (heat) supply system

| Operating regime | Option 2 - Centralised system - hourly heat demand | | |
|---|---|---|---|
| | Heat demand at the CHPP level | Heat losses on the transmission & distribution networks | Heat demand at consumer level |

| | Gcal/h | $MW_{th}$ | Gcal/h | $MW_{th}$ | Gcal/h | $MW_{th}$ |
|---|---|---|---|---|---|---|
| **Maximum winter** | 11.3 | 13.1 | 1.7 | 2.0 | 9.6 | 11.1 |
| **Medium winter** | 8.5 | 9.8 | 1.3 | 1.5 | 7.2 | 8.4 |
| **Medium summer** | 3.5 | 4.1 | 0.5 | 0.5 | 3.0 | 3.5 |

*Source: ISPE data processing*

The projections show that as the refurbishment/upgrading works are considered for increasing the energy efficiency at consumer and heat transmission and distribution system levels, the hourly thermal energy demand at sources' levels decreases.

Thermal energy will be delivered annually from Motru sources, based on the thermal energy load curve, depending on outdoor temperatures. For the two options, a distributed system versus a centralised system, the thermal energy annual curve is shown in the following figure.

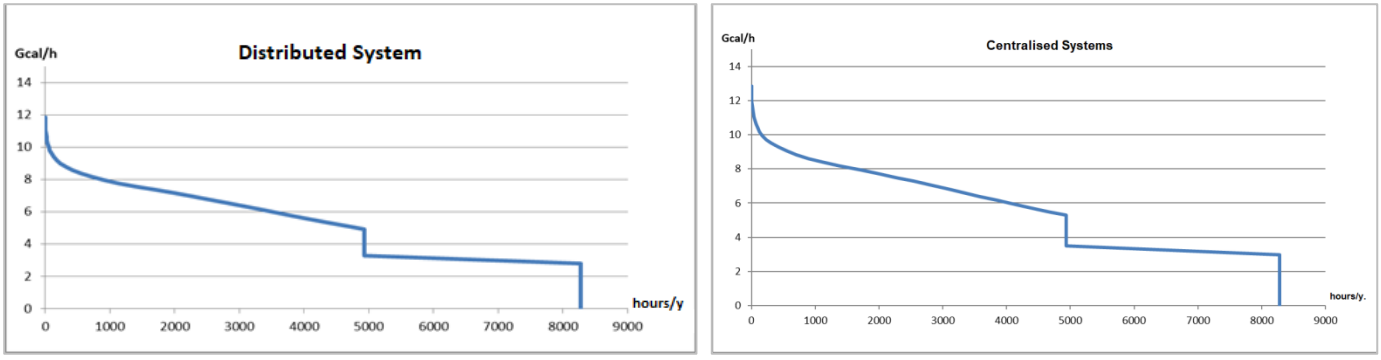



**Figure 2-8**: Annual curve of delivered thermal energy at sources level
*Source: ISPE data processing*

## 2.4 Relevant economic, social and environmental aspects

The majority of the population of Motru UAT is concentrated in the city of Motru, the area analysed in this study; in 2019, about 81.3 per cent of the total population lived there, with the highest density in urban areas (Sigma Mobility Engineering, 2020).

According to the study *Territorial disparities in Romania* (MDLPA, 2021), Gorj County's socio-economic specificities (Motru, Rovinari, Țicleni and Mătăsari) define it as an extractive area, where the lignite mining industry is the field of specialisation, with a higher share of turnover than other industries. The decline in the coal industry has had a domino effect in the county, from decreasing population income, decreasing local budget revenues and shrinking economy, to increasing unemployment, depopulation and an ageing population. The contrast between the low dynamic demographic situation and the standard of living in these areas (e.g. GDP per capita) may suggest that there is potential for recovery in the area.

Also, in the framework of the Territorial Plan for a Just Transition Gorj (CJG, 2022), according to GEO 75/2000 on disadvantaged areas regime, Motru UAT falls into this category. Within this

administrative structure there are 2 lignite quarries: Lupoaia and Roșiuța, with mining licenses valid until 2027 according to the National Agency for Mineral Resources (ANRM).

The characteristics stated above are reflected in the main socio-economic indicators presented in **Table 2-9 and Table 2-10,** by maintaining the decreasing trend of Motru's population (4 per cent decrease in 2021 compared to 2019) and its ageing, with the group ≥ 65 years old increasing by 8 per cent in 2021 and vitality decreasing by 10 per cent.

Regarding the number of registered unemployed, we believe that the slight decrease in local unemployment can be attributed to the increased migration from the region rather than to the economic recovery in Gorj County, which has probably also manifested itself locally, as the number of employees in Motru is not available for 2021.

**Table 2-9: Socio-demographic indicators at the level of Motru and Gorj County, 2019-2021**

| Indicators | MU | Gorj county | | | Motru UAT | | |
|---|---|---|---|---|---|---|---|
| | | 2019 | 2020 | 2021 | 2019 | 2020 | 2021 |
| **Total population by residence, of which** | no. | **358,836** | **355,528** | **352,084** | **21,975** | **21,572** | **21,049** |
| - population 0-14 years (demographic vitality) | no. | 47,455 | 46,250 | 45,343 | 2,744 | 2,615 | 2,464 |
| - population ≥ 65 years (demographic ageing) | no. | 55,895 | 57,024 | 57,904 | 2,450 | 2,543 | 2,658 |
| **Total registered unemployed, of which** | no. | **4,735** | **5,212** | **4,295** | **199** | **188** | **156** |
| - registered unemployed women | no. | 2,244 | 2,387 | 2,038 | 97 | 103 | 84 |
| **Unemployment rate** | % | **3.49** | **3.86** | **3.17** | : | : | : |
| **Female unemployment rate** | % | **3.64** | **3.81** | **3.26** | : | : | : |
| **Average number of employees** | no. | **75,145** | **73,411** | **74,300** | **5,353** | **5,083** | : |
| **Departures with / settlements of residence (migratory movement)** | no / no. | **4,885/2,095** | **7,083/5,418** | : | **551/123** | **942/143** | : |

*Source: National Institute of Statistics, National Employment Agency*

According to the Local Development Strategy of Motru 2021-2027 (SDL 21-27) (Sigma Mobility Engineering, 2020), the economic environment is dominated by the activity of the Motru-Jilț Mining Branch, belonging to Oltenia Energy Complex (Roșiuța and Lupoaia quarries). The Lupoaia quarry is scheduled for natural/accelerated closure by 2025.

**Table 2-10: Socio-economic indicators at the level of South-West Oltenia Region and Gorj County, 2019-2021**

| Indicators | MU | Gorj County | | | SV Oltenia Region | | |
|---|---|---|---|---|---|---|---|
| | | 2019 | 2020 | 2021 | 2019 | 2020 | 2021 |
| **GDP per capita** | euro/speaker | **12,200** | **10,987** | **12,379** | **9,000** | **8,900** | **9,882** |
| **Active enterprises** | no. | **7,224** | **7,663** | : | **42,475** | **45,029** | : |
| **Average net earnings** | euro/employee | **560** | **591** | **621** | **554** | **585** | **618** |

| Indicators | MU | Gorj County | | | SV Oltenia Region | | |
|---|---|---|---|---|---|---|---|
| | | 2019 | 2020 | 2021 | 2019 | 2020 | 2021 |
| **At-risk-of-poverty or social exclusion rate** | % | : | : | : | **42.8** | **42.9** | : |

*Source: EUROSTAT, National Institute of Statistics, National Commission for Strategy and Forecasting*

The impact of the Lupoaia quarry closure on the local economic environment will be strong, given that in 2018 the turnover of about RON 120 million for this mining branch represented 17 per cent of the total economic activities in Motru. Also, the trend of increasing poverty or social exclusion rate that is felt at regional level (NUTS 2) will certainly be influenced, in a negative sense, at both the county and local levels.

However, there is hope that the availability of funding sources for the period from 2021 to 2027 in the construction and renewable energy industries will boost economic recovery and retraining of the workforce.

Being integrated in a predominantly extractive area, the business environment in Motru UAT has not developed properly; it is dominated, according to turnover, by the retail sector, followed by wood exploitation and processing, construction, the food industry, public utilities and the textile industry (Sigma Mobility Engineering, 2020).

At the level of Motru UAT, environmental concerns are dominated by air quality issues. Thus, according to the pollutant emissions distribution maps ($SO_x$, $NO_x$, PM10, PM2.5, Ni, CO, Cd, C6H6, NMVOC) presented in the Air Quality Maintenance Plan in Gorj County 2017-2022 (CJ Gorj, 2016), Motru UAT must be concerned with:

- CO and C6H6 emissions from stationary sources;
- emissions of $NO_x$, CO, NMVOCs and heavy metals from transport (PM2.5 and PM10 less).

According to S.G.A. Gorj, the Motru river, which crosses Motru for 39 km (Motru - 18 km, Lupoaia - 8 km, Ploștina - 13 km), has some water quality problems due to wastewater discharges into natural receptors. Such an unfavourable situation has also been reported at SEAU ApaRegio Gorj (wastewater treatment plant), where the REZOPREST Motru enterprise sometimes discharges untreated or insufficiently treated wastewater (SGA Gorj, 2021).

Another important environmental issue is the negative impact of mine tailings and ash and slag dumps on soil quality and stability. These dumps, if not properly drained and stabilised, can cause landslides, bedrock failure, subsurface erosion and excessive subsidence. According to ApaRegio Gorj S.A. the localities affected by landslides were Motru, Lupoița, Ploștina and Dealul Pomilor.

Regarding the surface of degraded and unproductive land, in 2014 it was 3.96 $km^2$ (Sigma Mobility Engineering, 2020). To this surface will be added, after 2025, the land freed from the technological and legal burdens of the former Lupoaia quarry, in the perspective of ownership transfer from Complexul Energetic Oltenia to Motru Municipality. Once the former mining perimeter has been remediated, reclaimed and reinforced from a geo-mechanical and geo-

technical point of view, in order to provide mechanical stability and avoid landslides, several repurposing solutions will be available – either for agricultural or forestry, or for energy or tourism/recreational use.

## 2.5 Identified deficiencies

In the SV Oltenia region, energy efficiency is low, leading to unsustainable energy consumption. The residential building stock in the region represents 10.5 per cent of the total national stock (INS, 2020) and consists of 961,643 households of which 43.7 per cent (420,247) are located in urban areas. The majority of households are in multifamily buildings (collective dwellings), block of flats which have an average of 40 apartments.

In the region, 91.46 per cent of the total households were built before 1990, when there were no energy efficiency standards, and have low energy performance (150 to 400 kWh/sqm/year, according to ROENEF).

The building sector is one of the largest energy consumers, and this is due to the structure of average heat consumption, which accounts for about 70 per cent of total energy consumption.

The public centralised heat supply service is subject to the legal regime of 'economic services of general interest' and must meet the following basic requirements:

- continuity in terms of quality and quantity;
- adaptability to consumer requirements;
- non-discriminatory accessibility;
- transparency in decision-making and consumer protection

The centralised DHS in Motru municipality is facing the following difficulties/barriers:

- severe physical and moral wear and tear of installations and equipment;
- oversized capacities in relation to current consumer requirements;
- low energy efficiency when producing thermal energy;
- lack of financial resources for maintenance, retrofitting and upgrading works;
- high losses in the transmission and distribution networks, which also lead to additional fuel consumption and thus increased pollutant emissions;
- inadequate thermal insulation of the existing building stock (mainly residential).

These factors have led to increased thermal energy transmission & distribution costs and reduced quality of services.

A series of rehabilitation works are needed in all components of SACET Motru (sources, transmission and distribution networks) in order to increase the efficiency of heat supply to consumers. In view of the strategic programmes at European and national levels, it is necessary to make the heating system more efficient and to supply consumers in optimal conditions.

## 3 RENEWABLE POTENTIAL ASSESSMENT

The potential of renewable energy sources (RES) has never been properly determined at regional (NUTS 2 / RO41 or NUTS 3 / RO412) or local (Motru) levels.

In 2019, the EC through the JRC (Joint Research Centre), starting from an existing EURCO3232.5 scenario (EUCO scenarios, 2019), analysed the theoretical technical opportunities for renewable potential in coal-intensive regions for wind, solar PV, bioenergy and geothermal sources (Kapetaki, 2020). According to this report, the South-West Oltenia region (RO41) has an estimated technical potential as follows:

**Table 3-1**: Technical potential for wind, solar and bioenergy in the South-West Oltenia Region, 2019

| NUTS 2 region | **Wind** | | **Solar photovoltaic** | | | |
|---|---|---|---|---|---|---|
| | | | ground PV | | roof PV | |
| | Installed capacity (GW) | Estimated production (GWh/year) | Installed capacity (GW) | Estimated production (GWh/y) | Installed capacity (GW) | Estimated production (GWh/y) |
| RO41 | 11.21 | 22,104 | 30.48 | 3,852 | 3.40 | 4,302 |
| of which by repurposing former mining sites | 0.07 | 78.5 | 0.15 | 182.0 | - | - |
| **Bioenergy** | | | | | | |
| NUTS 2 region | Agricultural biomass | | Biogas from livestock | | Municipal solid waste | |
| | Thermal capacity (GWth) | Electrical capacity (GW)* | Thermal capacity (GWth) | Electrical capacity (GW)* | Thermal capacity (GWth) | Electrical capacity (GW)* |
| RO41 | 0.62 | 0.19 | 0.07 | 0.03 | 0.19 | 0.06 |
| **) Heat capacity is the heat input provided by the biomass fuel* | | | | | | |
| **Bioenergy - forest biomass** | | | | | | |
| NUTS 2 region | high potential scenario | | medium potential scenario | | low potential scenario | |
| | Thermal capacity (GWth) | Electrical capacity (GW)* | Thermal capacity (GWth) | Electrical capacity (GW)* | Thermal capacity (GWth) | Electrical capacity (GW)* |
| RO41 | 1.84 | 0.55 | 1.01 | 0.30 | 0.77 | 0.23 |
| **Geothermal** | | | | | | |
| NUTS 2 region | Technical maximum | | Technical realist | | Technically durable | |
| | Thermal capacity (GWth) | Electrical capacity (GW)** | Thermal capacity (GWth) | Electrical capacity (GW)** | Thermal capacity (GWth) | Electrical capacity (GW)** |
| RO41 | 651.88 | 78.23 | 39.1 | 4.69 | 1.2 | 0.14 |
| ***) Electrical capacity has been calculated under the assumption that all thermal capacity is converted to electrical* | | | | | | |

*Source: (Kapetaki, 2020).*

The JRC study also places RO41 in the top five regions with high solar PV potential alongside Spain and Poland: Castilla y León (ES41), Castilla-La Mancha (ES42) and Wielkopolskie (PL41).

At the level of Gorj County / NUTS 3 (RO421), the climate is temperate-continental with Mediterranean influences. The multiannual average temperature is +10.2 degrees Celsius, with increasing trends, so that the Motru area has frequently been affected by drought in the last decade. The prevailing wind direction is from the north in the mountainous area and from the south and south-east in the depressions.

The specific indicators of theoretical solar and wind technical potential at county level, presented in **Table 3-2, Figure 3-1** and **Figure 3-2 (a** and **b),** have been assessed as follows:

- for annual average values of specific PV power[9] (kWh/kWp) and direct normal solar irradiation intensity (kWh/m$^2$) according to the Global Solar Atlas 2.0 platform (Solargis, 2021), developed in recent years in partnership with the World Bank, with funding provided by the Energy Sector Management Assistance Programme (ESMAP); the atmospheric dataset was provided by the European Centre for Medium-Range Weather Forecasts (ECMWF) for the Global Solar Atlas 2.0 computer platform, with calculations and simulation performed by Solargis for the period from 1994 to 2018;
- for mean wind potential density (W/m$^2$) and mean wind speed (m/s) from the Global Wind Atlas 3.0 platform (DTU, 2022) owned and maintained by the Wind Energy Department of the Technical University of Denmark (DTU) and, in recent years, developed in partnership with the World Bank, with funding provided by the Energy Sector Management Assistance Programme (ESMAP); Atmospheric dataset for the Global Wind Atlas 3.0 computer platform was provided by the European Centre for Medium-Range Weather Forecasts (ECMWF), the simulation was carried out for the period from 2008 to 2017.

**Table 3-2**: Specific indicators on theoretical solar and wind technical potential, Gorj County

| **NUTS 3 region RO412** | **Solar** | | | | **Wind** | |
|---|---|---|---|---|---|---|
| | **Specific photovoltaic power output*** (annual average) | | **Direct normal irradiation intensity** (annual average) | | **Mean wind power density**** (at 100 m) | **Mean wind speed** (at 100 m) |
| MU | Min kWh/kWp | Max kWh/kWp | Min kWh/m$^2$ | Max kWh/m$^2$ | W/m$^2$ | m/s |
| Gorj County | 1,106 | 1,339 | 934 | 1,321 | 180.41 | 3.93 |

*Source: (Solargis, 2021), (DTU, 2022)*

*Note: *) Average annual values of photovoltaic electricity (AC) delivered by a PV system and normalised to 1 kWp of installed capacity in PV panels (© 2021 Solargis); **) Average wind potential density is a measure of wind resource. Higher average wind power densities indicate better wind resources (© 2022 DTU)*

[9] *average annual PV electricity produced by the total installed capacity of a PV system*

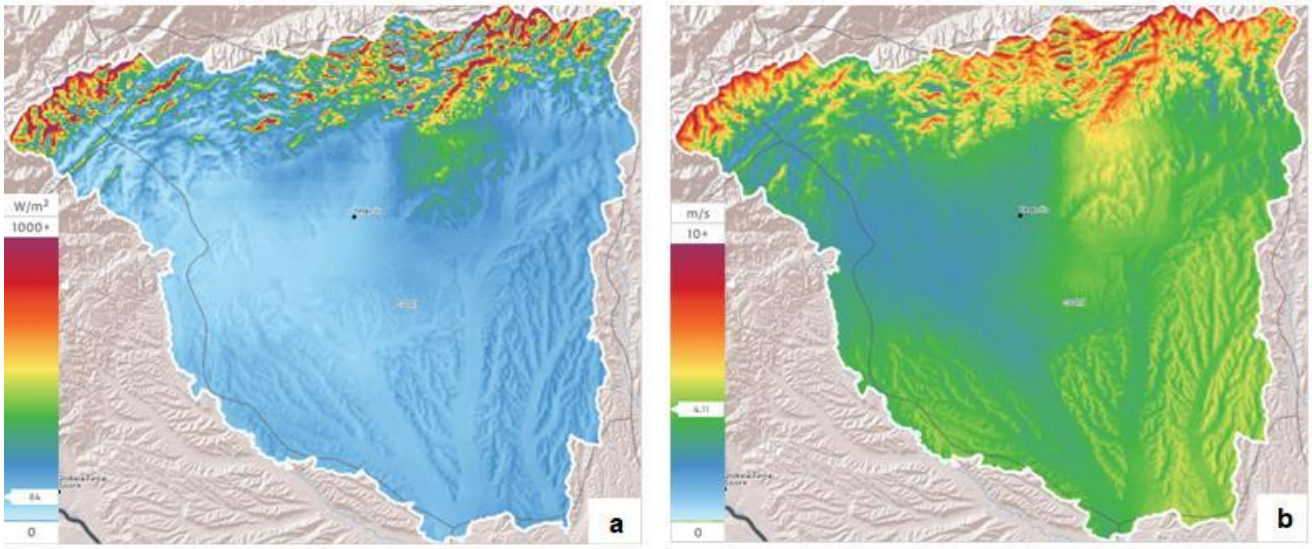



**Figure 3-1**: Map of mean wind power density at 100 m (W/m$^2$) (a) and mean wind speed (m/s) at 100 m (b) height, Gorj County

*Source: (DTU, 2022)*

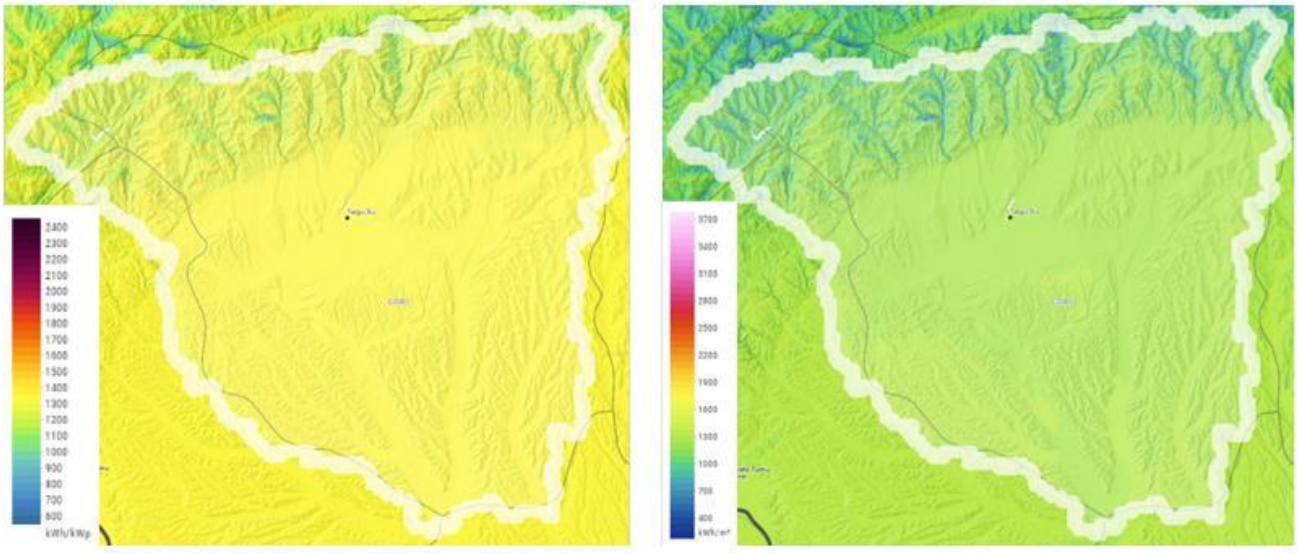


**Figure 3-2**: Map of specific PV power output (kWh/kWp) (a) and direct normal solar irradiation (kWh/m2) (b), Gorj County

*Source: (Solargis, 2021)*

As of April 2022 in Gorj County (NUTS 3 / RO412), Transelectrica had registered 216 contracts concluded with ATR (technical permit for connection to the national power grid) totalling: 51.2 MW installed in solar energy and 11.96 MW in hydro, micro and medium capacities. There is no installed capacity in wind energy.

In the Motru UAT area, there is an installed capacity of 533 kW in photovoltaic solar power, with installations commissioned in 2020 by eight individuals and one legal entity (DARCOM Group SRL) with a photovoltaic park of 480 kW commissioned in 2013.

In terms of geothermal potential, considering the national map drawn up by Dr Marcel G. Roșca, there is the prospect of geothermal resources in Gorj County, but they are unexplored and unexploited. No test boreholes have been drilled on Motru UAT territory either, and no mention of possible geothermal potential has been oulined in the scientific literature.

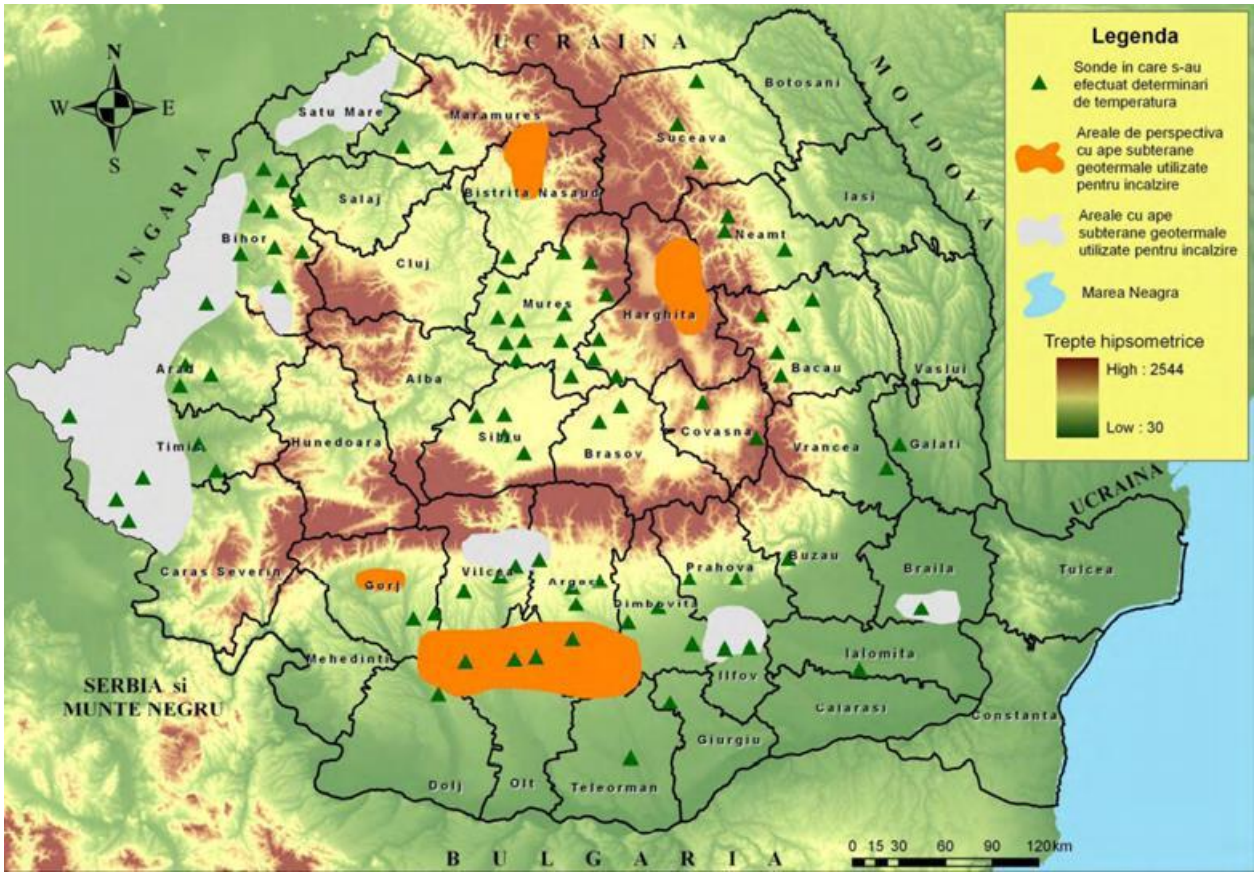



**Figure 3-3**: Map of used and prospective geothermal potential

*Source: (Rosca, 2011)*

Returning to the theoretical technical solar and wind renewable potential for Motru ATU's footprint, this is presented in **Figure 3-4 (a** and **b)** and in **Table 3-3**, by highlighting specific indicators at the level of the analysed outline (Motru urban area), UATAA ash and slag dumps' surface, and that of the former Lupoaia mining perimeter.

**Table 3-3**: Specific indicators on theoretical solar and wind technical potential, Motru UAT

| **Motru UAT** | **Solar** | | **Wind** | |
|---|---|---|---|---|
| | **Specific photovoltaic power output** (annual average) | **Direct normal irradiation intensity** (annual average) | **Mean wind power density** (at 100 m) | **Mean wind speed** (at 100 m) |
| M.U. | kWh/kWp | kWh/m$^2$ | W/m$^2$ | m/s |
| City of Motru (analysed outline) | 1,339 | 1,325 | 83.79 | 3.41 |
| UATAA ash & slag dump | 1,340 | 1,326 | 82.49 | 3.43 |
| Perimeter of the former Lupoaia mining quarry (lignite) | 1,339 | 1,316 | 87.32 | 3.70 |

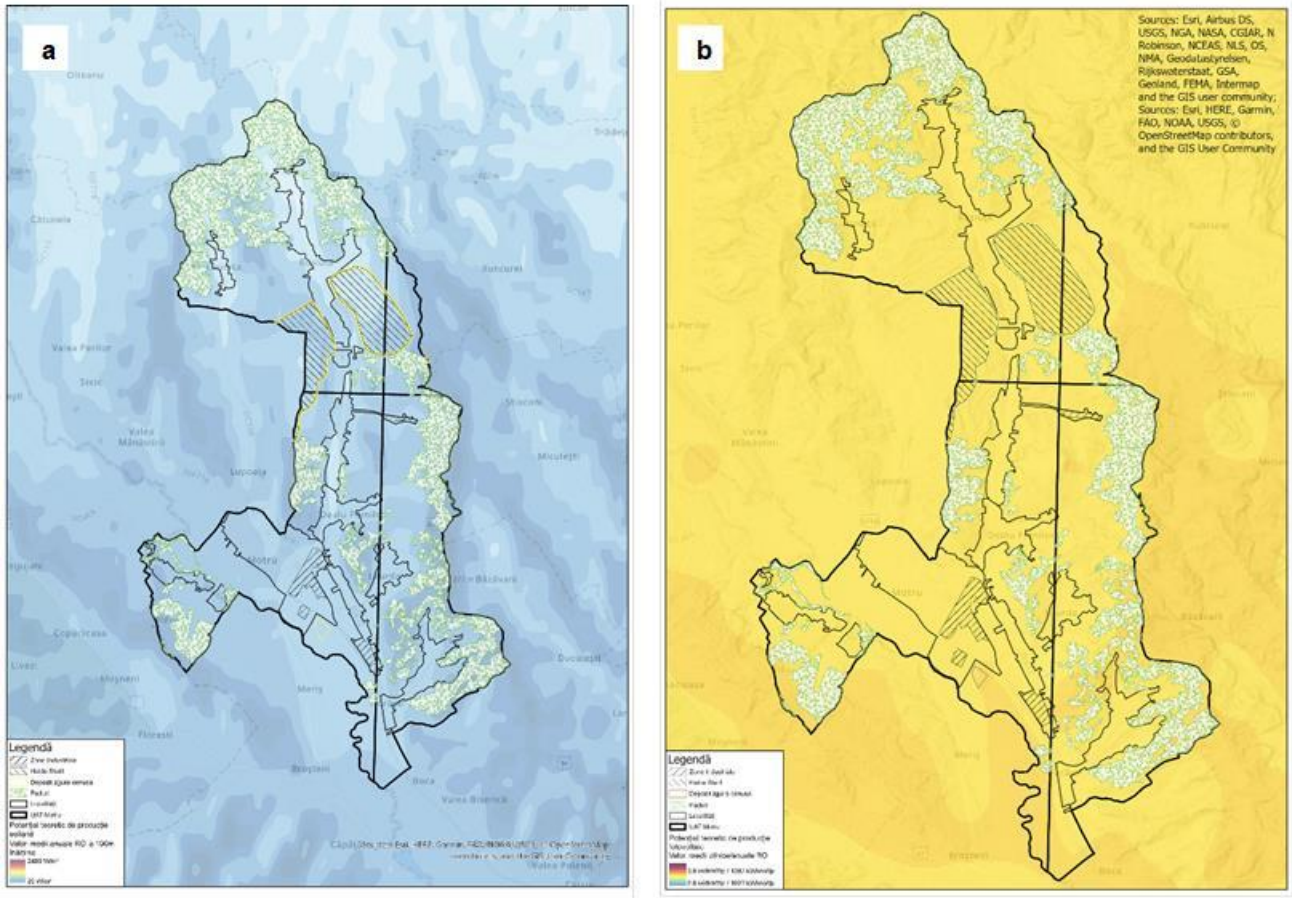



**Figure 3-4**: (a) Map of mean wind power density (W/m$^2$) at 100 m height; (b) Map of specific PV power output (kWh/kWp), Motru UAT

*Sources: ANCPI, Esri, (DTU, 2022) and (Solargis, 2021)*

Compared to the mountainous area of the county, where wind speed can exceed 9 m/s, the wind potential in the area of Motru UAT can be characterised as below medium to low, taking into account the range of variation of the indicators of the Wind Energy Department of the Technical University of Denmark (DTU, 2022).

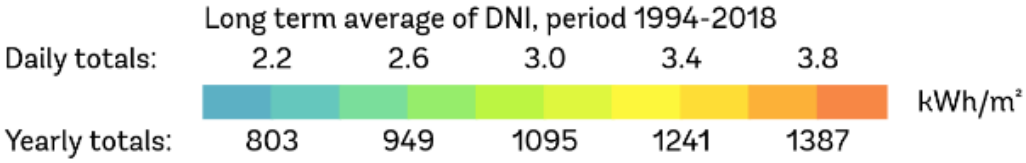



**Figure 3-5**: Normal irradiance intensity variation scale

On the other hand, if we analyse the range of Solargis solar indicators (**Figure 3-5**), i.e. the direct normal irradiation (daily and annual averages), we can say that Motru UAT benefits from a generous to high solar potential over a period of approx. 7 months (March-September) per year.

With regard to the bioenergy potential of Motru UAT, the possibilities of energy use from the following renewable resources have been taken into account, considering the annual quantities recorded in **Table 3-4**:

- biogas from sludge from the wastewater treatment plant - SEAU Motru, belonging to CED Motru - ApaRegio Gorj;
- municipal solid waste, resulting from selective collection and extraction of the recyclable component, to which could be added biomass from the grooming of trees, parks and green spaces; the sanitation operator is Direcția Publică Motru S.A.

**Table 3-4**: Potential sources of bioenergy, Motru UAT

| Description | MU | 2019 | 2020 | 2021 |
|---|---|---|---|---|
| **Quantity of sludge extracted, SEAU Motru** | tone | **424** | **319** | **343** |
| **Total waste generated, of which** | tone | **3,119** | **3,197** | **3,371** |
| Waste disposed of after separate collection | tone | 2,974 | 3,066 | 3,271 |
| Recycled waste | tone | 145 | 131 | 100 |

*Source: DP Motru; CED Motru - ApaRegio Gorj*

Regarding the potential for heat recovery from existing industrial sources, both in the analysed outline and in Motru UAT, there are no opportunities for energy recovery from heat waste.

In the proposed scenarios and technical solutions analysed in the following chapters, the theoretical potential estimated above has been taken into account, with the actual technical possibilities of RES integration (solar, bioenergy, heat pumps) also being considered.

# 4 POSSIBLE SCENARIOS FOR COVERING THE LOCAL HEAT DEMAND - IDENTIFICATION AND DESCRIPTION

## 4.1 Targets and objectives

Based on the energy union strategy (COM/2015/080) and in view of protecting and preserving the environment, the EU energy policy aims in particular to:

- promote energy efficiency and energy savings;
- develop renewable energy sources;
- reduce greenhouse gas emissions.

In many Romanian localities, there are major sources of pollution – such as combustion plants producing electricity and/or heat, whether in a centralised or decentralised DHS for supplying thermal energy.

These DHSs face physical and moral wear of installations and equipment, and tear and high losses in the heat transport and distribution networks. These shortcomings result in increased environmental pollution.

Physical and moral wear and tear on equipment means its efficiency is reduced and therefore there is increased fuel consumption, higher operating costs and more pollution of emissions into the atmosphere.

Romania's Energy Strategy 2020-2030, with prospects for 2050, points out that making the fleet of power plants more efficient will lead to a decrease in the primary energy demand in order to meet final electricity consumption, and a significant reduction in greenhouse gas emissions. This conclusion is based on the fact that the thermal power plants in Romania, mostly built between 1960 and 1990, have a relatively low average efficiency of primary energy conversion into electricity and a high technological self-consumption compared to current requirements. Technological self-consumption will decrease by replacing old and inefficient plants when they reach the end of their technical or economic life-time. Following the implementation of such actions, it is estimated that the value of the technological self-consumption can decrease by approx. 11 per cent in 2030 compared to 2015 levels, leading to an increased energy efficiency and lower fuel consumption and reduced pollutant emissions into the atmosphere.

In accordance with the requirements of Article 14, in 2015 the Ministry of Regional Development and Public Administration and the Ministry of Energy submitted the *Report on the assessment of the national potential for the implementation of high-efficiency cogeneration and efficient district heating and cooling* to the European Commission. Thus, considering the current status of the entire heat supply system from source to consumer, it was estimated that it could have an improvement potential of at least 30 per cent. The potential for energy efficiency improvement includes, in addition to the upgrading of residential and non-residential buildings' energy performance, the upgrade/expansion of primary and secondary thermal networks, improved metering, and the promotion of efficient cogeneration. The potential for energy efficiency

measures in the thermal energy production sources is high and is mainly aimed at replacing sources using coal with new energy efficient installations (CHP/Trigeneration plants) using methane gas or renewable energy sources. The measures to be considered to stimulate reaching the targets inside this report, with time horizons of 2020 to 2030, are the following:

- Adapting the centralised DHSs to new heat demands, considering a highly efficient system operation in compliance with environmental protection standards;
- Increasing energy efficiency throughout the entire technological chain: resources, generation, transmission, distribution, consumption;
- Due to its technological advantages, maturity and a high degree of development, cogeneration is promoted as a fundamental vector for restructuring the thermal energy generation and distribution systems;
- Accelerating the upgrade of the local energy services infrastructure based on public and/or private financial support;
- Increasing the local public authority's involvement in compliance with the legislative framework in force;
- Promoting RES use to reduce heat prices and comply with environmental requirements.

At the national level, the policy related to thermal energy (heat) supply public services is an integral part of the national energy policy.

At governmental level, there are several authorities with responsibilities in the field of heat supply public services, namely:

- The Ministry of Development, Public Works and Administration - performing analysis, synthesis, decision-making, coordination, monitoring, planning and evaluation on implementation of standards and requirements for accelerating the development of public utilities, in line with similar norms at the European level;
- The Ministry of Energy, whose role is to stimulate business initiatives in the areas of industrial policies or sustainable development and to coordinate and manage national energy resources;
- The Ministry of the Environment, Waters and Forests for issues related to environmental conservation and protection;
- The Ministry of Labour and Social Protection for issues related to social protection policy in the field of heat supply;
- The National Energy Regulatory Authority for the activity of thermal energy cogeneration.

## 4.2 Technical analysis of scenarios

The five analysed scenarios are defined for the new thermal energy source in the city of Motru, in the perspective of RES predominant use with rates of 12 to 100 per cent, with the addition in some cases of a 'transition' fossil fuel – methane gas or municipal waste.

| Scenarios / Indicators | | UM | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4a | Scenario 4b | Scenario 5 |
|---|---|---|---|---|---|---|---|---|
| Electricity | RES | % | 100 | 77 | 12 | 100 | 100 | 100 |
| | Fossil* | % | - | 23 | 88 | - | - | - |
| Thermal energy | RES | % | 25 | - | - | 100 | 100 | 100 |
| | Fossil* | % | 75 | 100 | 100 | - | - | - |

**) Fossil fuel is represented by: methane gas (scenario 1); methane gas and municipal wastes (wet fraction) - in scenarios 2 and 3.*

The concept of these scenarios consists of the following approach:

- reducing environmental pollution through using RES and, in some scenarios, methane gas, in modern, highly efficient installations;
- optimising the thermal energy (heat) supply, from capacities with high efficiency, sized according to the thermal energy demand;
- using existing facilities and equipment as far as possible;
- maintaining operation of the heat transmission and distribution system.

In terms of the new source technological profile, the analysis will be developed for the following five 'technology mix' scenarios.

### Scenario 1

In this scenario, the thermal energy (heat) supply in Motru is the distributed system type, with several thermal energy sources (i.e. district, zonal).

It is considered that Motru CHPP is closing down and there are plans to build zonal/district thermal energy plants (DTPs) by transforming the existing thermal stations (TS).

In order to implement RES in Motru, the proposed scenario is based on the use of solar energy potential (roof PVs on TSs) in combination with heat pumps (HPs).

Equipment for new sources in this proposed scenario will include:

- 19 x DTP (zonal/district thermal energy plants), equipped with HWBs, totalling a heat load of 10.4 Gcal/h (12 $MW_{th}$), running on methane gas;
- air-to-water HPs providing 3 Gcal/h (3.5 $MW_{th}$), installed inside the TSs;
- roof PVs with an installed power of approx. 83 $kW_p$, located on TSs terraces.

### Scenario 2

In this scenario, the thermal energy (heat) supply in Motru is the centralised system type.

In order to implement RES in Motru, the proposed scenario is based on the use of solar energy potential (ground PVs on the ash and slag dump), in combination with a WtE plant based on sorted municipal waste.

Equipment for new sources in this proposed scenario will include:

- a CHP (cogeneration heat and power) plant for WtE based on sorted municipal waste (3,610 tones/year, 0.63 $MW_e$ and 2 $MW_{th}$);
- 3 HWBs x 3 Gcal/h (3.5 $MW_{th}$), running on methane gas;
- a PVP (ground PV plant) with an installed capacity of approx. 6.25 $MW_p$, located on the site of the former ash and slag dump.

From the existing source (Motru CHPP), the HWB (4 Gcal/h) running on methane gas is kept in operation to cover peak thermal energy loads.

### Scenario 3

In this scenario, the heat supply in Motru is the centralised system type.

In order to exploit the renewable potential in Motru, the proposed scenario is based on the use of solar energy potential (roof PVs on TSs and ground PVs on the former ash and slag dump) in combination with a WtE plant based on sorted municipal wastes.

Equipment for new sources in the proposed scenario will include:

- a CHP (cogeneration heat and power) plant for WtE based on sorted municipal wastes (3,610 tones/year, 0.63 $MW_e$ and 2 $MW_{th}$);
- 3 x (MT) cogeneration heat & power engines (3.3 $MW_e$ and 3.2 $MW_{th}$) running on methane gas;
- a PVP (ground PV plant) with an installed capacity of approx. 6.25 $MW_p$, located on the site of the former ash and slag dump;
- roof PVs with an installed power of approx. 83 $kW_p$, located on TSs terraces.

From the existing source (Motru CHPP), the HWB (4 Gcal/h) running on methane gas is kept in operation to cover peak thermal energy loads.

### Scenario 4

In this scenario, the heat supply in Motru is the centralised system type.

In order to exploit the renewable potential in Motru, the proposed scenario is based on the use of solar energy potential (roof PVs on TSs and ground PVs on the former ash and slag dump) in combination with a biomass-based cogeneration plant.

Equipment for new sources in the proposed scenario will include:

- a new CHPP running on certified biomass (23,710 tones/year) providing a maximum heat load of 11.3 Gcal/h (13.1 $MW_{th}$) and 6.6 $MW_e$;
- a PVP (ground PV plant) with an installed capacity of approx. 6.25 $MW_p$, located on the site of the former ash and slag dump;
- roof PVs with an installed power of approx. 83 $kW_p$, located on TSs terraces**.**

For Scenario 4, the analysis will be carried out considering two assumptions regarding the biomass used in the CHPP:

- **Scenario 4a** - biomass used with zero $CO_2$ emissions (as per Annex VI of Regulation (EU) no. 601/2012 on monitoring and reporting of GHG pursuant to Directive 2003/87/EC);
- **Scenario 4b** - biomass used with $CO_2$ emissions (according to 2006 IPCC Guidelines for National GHG Inventories).

**Scenario 5**

In this scenario, the heat supply in Motru is the centralised system type.

In order to exploit the renewable potential in Motru, the proposed scenario is based on the use of solar energy potential (roof PVs on TSs and ground PVs on the former ash and slag dump) in combination with ground-water heat pumps (HPs).

Equipment for new sources in the proposed scenario will include:

- 13 x ground-water HPs with a heat capacity of approx. 1 $MW_{th}$ each, installed in cascade, providing a maximum heat load of 11.3 Gcal/h (13.1 $MW_{th}$). The heat pumps will be connected in parallel/series groups to provide the required thermal energy;
- a PVP (ground PV plant) with an installed capacity of approx. 6.25 $MW_p$, located on the site of the former ash and slag dump**;**
- roof PVs with an installed power of approx. 83 $kW_p$, located on TSs terraces.

**Scenario 0**

The analysis also considered Scenario 0, in which the existing Motru CHPP will continue to operate with existing lignite-based equipment. The source equipment in this scenario is described in chap. 2.2.1.

The current status of Motru CHPP and the need to comply with environmental standards according to the legislation in force requires new investments, namely:

- upgrading of the 50 t/h steam boiler, including burners, grate;
- rehabilitation of the flue gas exhaust system, electrofilter;
- the construction of a flue gas desulphurisation plant;

- upgrading of the ash and slag evacuation system related to the operation of the 50 t/h steam boiler - CR 0102.

The total value of the investment covering the above upgrading works for lignite-based Motru CHPP is approx. **EUR 23,501,000.**

*

* *

For the analysed scenarios, the retrofitting and upgrading measures to be carried out within Motru centralised DHS, both at the level of final consumers (thermal rehabilitation of public and residential buildings) and at DHS level (transmission & distribution networks and TSs), are not included in the investment values. Only the positive effects of these retrofitting/upgrading works are considered in the analysis.

In order to increase the efficiency of Motru centralised DHS operation, these works were foreseen in ***Local Development Strategy of Motru municipality for the period 2021-2027*** (Sigma Mobility Engineering, 2020):

- Project on modernisation of the centralised heating system in Motru municipality - approx. EUR 37,600,000, with funding from the PODD/ESIF, local budget and other sources;
- Project on modernisation/rehabilitation of residential collective dwellings in Motru municipality - approx. EUR 11,000,000, with funding from POR SV/ESIF, local budget and other sources;
- Tax facilities for energy efficiency works in individual households - approx. EUR 70,000;
- Thermal rehabilitation and modernisation projects of public buildings belonging to Motru Local Council totalling approx. EUR 23,200,000.

## 4.3 Energy performance in the analysed scenarios

**Technical and economic premises**

The analysis is developed on the investment outline, considering the following:

- The equipment's operating regime for covering the thermal energy (heat) demand;
- The main equipment's technical and functional performances;
- Lifetime average annual performance: availability, heat and power generation, fuel consumption, overall efficiency, $CO_2$ emissions, etc.

For each scenario, the equipment has been selected and loaded in order to operate with maximum efficiency and be environmentally oriented, ensuring the continuity of supply to consumers.

The technical performance of the new equipment will be as follows:

**Table 4-1**: Technical performance for each technical scenario analysed

| | | |
|---|---|---|
| **Scenario 0** | | |
| **Source - Motru CHPP: 1 Steam Boiler (SB) + 1 Steam Turbine (ST)+ 2 HWB** | | |
| Thermal capacity in cogeneration | 29.70 | MWth |
| Separate thermal generation capacity | 16.28 | MWth |
| Electrical capacity ST | 5.5 | MWe |
| **Scenario 1** | | |
| **Roof PV on TS terraces** | | |
| Total PV installed capacity | 83 | kWp |
| Electricity from PV | 96 | MWh/year |
| **Sources - 19 DTP on methane gas (heating + domestic hot water: winter)** | | |
| Total thermal load - maximum | 12.1 | MWth |
| Fuel consumption (methane gas) | 13.5 | MWth |
| **Air-water HPs (domestic hot water: summer)** | | |
| Thermal energy at the level of HPs | 3.5 | MWth |
| | 11,671 | MWh/year |
| Electricity consumption HPs | 1.4 | MWe |
| | 4,668 | MWh/year |
| **Scenario 2** | | |
| **Ground PVP on the former ash and slag dump** | | |
| Total PV installed capacity | 6.25 | MWp |
| Electricity from PV | 7,187.5 | MWh/year |
| **Source - Motru CHPP: 3 new methane gas-fired HWB (heating + domestic hot water: winter)** | | |
| Unit capacities of new HWBs: | | |
| Thermal load | 3.5 | MWth |
| Hourly fuel consumption (methane gas) | 3.8 | MWth |
| **Source - Motru CHPP: 1 WtE plant (domestic hot water: summer)** | | |
| Municipal waste consumption | 3,613 | ton/year |
| Electricity generated | 0.63 | MW |
| Heat delivered | 1.8 | Gcal/h |
| **Scenario 3** | | |
| **Ground PVP on the former ash and slag dump** | | |
| Total PV installed capacity | 6.25 | MWp |
| Electricity from PV | 7,187.5 | MWh/year |
| **Roof PV on TS terraces** | | |

| | | |
|---|---|---|
| Total PV installed capacity | 83 | kWp |
| Electricity from PV | 96 | MWh/year |
| **Source - Motru CHPP: 3 MT (CHP engines) on methane gas (heating + domestic hot water: winter)** | | |
| Unit capacities of new MT: | | |
| Rated electrical power | 3.3 | MWe |
| Rated thermal input | 2.8 | Gcal/h |
| | 3.2 | MWth |
| Electrical efficiency | 43.5 | % |
| Cogeneration efficiency | 86.5 | % |
| Fuel consumption (methane gas) | 7.502 | MWth |
| **Source - Motru CHPP: 1 WtE plant (domestic hot water: summer)** | | |
| Municipal waste consumption | 3,613 | ton/year |
| Electrical power | 0.63 | MW |
| Heat delivered | 1.8 | Gcal/h |
| **Scenario 4** | | |
| **Ground PVP on the former ash and slag dump** | | |
| Total PV installed capacity | 6.25 | MWp |
| Electricity from PV | 7,187.5 | MWh/year |
| **Roof PV on TS terraces** | | |
| Total PV installed capacity | 83 | kWp |
| Electricity from PV | 96 | MWh/year |
| **Source – Motru CHPP: new biomass-based cogeneration plant (heat + domestic hot water: winter)** | | |
| Unit capacities of the new biomass-based cogeneration plant: | | |
| Rated electrical power | 6.6 | MWe |
| Rated thermal input | 11.3 | Gcal/h |
| | 13.1 | MWth |
| Electrical efficiency | 30 | % |
| Cogeneration efficiency | 90 | % |
| Biomass fuel consumption | 21.85 | MWth |
| **Scenario 5** | | |
| **Ground PVP on the former ash and slag dump** | | |
| Total PV installed capacity | 6.25 | MWp |
| Electricity from PV | 7,187.5 | MWh/year |
| **Roof PV on TS terraces** | | |
| Total PV installed capacity | 83 | kWp |

| | | |
|---|---|---|
| Electricity from PV | 96 | MWh/year |
| **Source – Motru CHPP: 13 ground-water HP (heat + domestic hot water: winter)** | | |
| Total heat capacity HP ground - water | 11.3 | Gcal/h |
| | 13.1 | MWth |
| Electricity consumption HP ground - water | 5.46 | MWe |

The quantities of electricity and heat produced and delivered annually, as well as fuel consumption, were determined on the basis of the equipment load and the assumptions described above.

In each of the analysed scenarios, the combustion of conventional fuels generates $CO_2$ emissions.

The $CO_2$ emissions calculation was carried out in accordance with the provisions of Annex II (Methodology for monitoring combustion emissions from activities included in Annex I to Directive 2003/87/EC) of Decision 589/2007/EC establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council of Europe. The $CO_2$ emission reductions resulting from the implementation of the investments were determined for each scenario as the difference between the $CO_2$ emissions of the existing lignite-fired Motru CHPP (**Scenario 0**) and the $CO_2$ emissions of each analysed scenario.

In addition, $CO_2$ emission reductions were determined for each scenario, considering that the new source will replace the equivalent electricity in the NPS (National Power System), currently produced in coal-fired power plants.

Starting from the specific $CO_2$ emissions, calculated at the national level for coal (853.76 $g_{CO2}$/kWh according to the ANRE 2020 Report), and considering that the lignite-fired CET Motru uses auxiliary fuel oil/methane gas, a weighted average specific emission on fossil fuels was determined of 615.14 $g_{CO2}$/kWh.

The avoided $CO_2$ emissions at the NPS level due to PV electricity generation, thermal engines, and biomass-based CHPP were determined based on the difference between the specific $CO_2$ emission on fossil fuels and the specific $CO_2$ emission calculated for the source and the amount of electricity produced by the analysed source.

$CO_2$ emissions for the amount of electricity purchased from the NPS were determined based on electricity consumed from the NPS and the specific $CO_2$ emissions on fossil fuels.

Thus, based on the elements presented above, the annual $CO_2$ emission reductions achieved as a result of the investments' implementation in all analysed scenarios were determined.

The specific $SO_2$ and PM (particulate matters) emissions from coal, based on which emission reductions have been calculated are the following:

- Specific emission for $SO_2$ 72.5 kg/TJ
- Specific emission for PM 10.9 kg/TJ

The emission factors used to determine the reductions in $SO_2$ and PM emissions are in accordance with the recorded operating data of coal-fired power plants in Romania.

The energy performances (electricity and heat generated/delivered; annual fuel consumption; $CO_2$ emissions and $CO_2$, $SO_2$ and PM emission reductions) in the analysed scenarios are shown in the following table.

**Table 4-2**: Energy performances in the analysed scenarios

| Specifications | MU | ANALYSED SCENARIOS | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Scenario 0 | | Scenario 1 | | Scenario 2 | | Scenario 3 | | Scenario 4a | | Scenario 4b | | Scenario 5 | |
| | | Year 3 | Last year | Year 3 | Last year | Year 3 | Last year | Year 3 | Last year | Year 3 | Last year | Year 3 | Last year | Year 3 | Last year |
| Electricity produced | MWh/y | 19,322 | 15,354 | 96 | 96 | 9,295 | 9,295 | 59,222 | 59,222 | 32,946 | 35,739 | 32,946 | 35,739 | 7,283 | 7,283 |
| Electricity produced by PV | MWh/y | | | 96 | 96 | 7,188 | 7,188 | 7,283 | 7,283 | 7,283 | 7,283 | 7,283 | 7,283 | 7,283 | 7,283 |
| Electricity produced by Motru CHPP | MWh/y | 19,322 | 15,354 | | | 2,108 | 2,108 | 51,939 | 51,939 | 25,663 | 28,456 | 25,663 | 28,456 | | |
| Electricity for self-technological consumption | MWh/y | 6,343 | 5,040 | 5,445 | 5,543 | 1,046 | 1,152 | 2,084 | 2,132 | 1,211 | 1,343 | 1,211 | 1,343 | 18,772 | 20,815 |
| Electricity delivered | MWh/y | 12,979 | 10,314 | 48 | 48 | 8,249 | 8,143 | 57,138 | 57,090 | 31,735 | 34,396 | 31,735 | 34,396 | | |
| Electricity purchased from the NPS | MWh/y | | | 5,397 | 5,495 | | | | | | | | | 11,489 | 13,532 |
| Thermal Energy (Heat) at sources limit | Gcal/h | 44,132 | 48,935 | 40,774 | 45,211 | 44,132 | 48,935 | 44,132 | 48,935 | 44,132 | 48,935 | 44,132 | 48,935 | 44,132 | 48,935 |
| Thermal Energy (Heat) at sources limit, of which: | MWh/y | 51,326 | 56,911 | 47,421 | 52,581 | 51,326 | 56,911 | 51,326 | 56,911 | 51,326 | 56,911 | 51,326 | 56,911 | 51,326 | 56,911 |
| Thermal Energy in Cogeneration | MWh/y | 41,187 | 45,669 | | | 7,003 | 7,003 | 49,000 | 54,585 | 51,326 | 56,911 | 51,326 | 56,911 | | |
| Thermal Energy generated in HWBs | MWh/y | 10,139 | 11,242 | 35,750 | 40,910 | 44,323 | 49,908 | 2,326 | 2,326 | | | | | | |
| Thermal Energy generated in HPs | MWh/y | | | 11,671 | 11,671 | | | | | | | | | 51,326 | 56,911 |
| Thermal Energy Loses in Heat Networks | MWh/y | 7,699 | 8,537 | 3,794 | 4,206 | 7,699 | 8,537 | 7,699 | 8,537 | 7,699 | 8,537 | 7,699 | 8,537 | 7,699 | 8,537 |
| | % | 15 | 15 | 8 | 8 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Thermal Energy sold, of which: | MWh/y | 43,627 | 48,374 | 43,627 | 48,374 | 43,627 | 48,374 | 43,627 | 48,374 | 43,627 | 48,374 | 43,627 | 48,374 | 43,627 | 48,374 |
| population (residential) | MWh/y | 37,335 | 41,398 | 37,335 | 41,398 | 37,335 | 41,398 | 37,335 | 41,398 | 37,335 | 41,398 | 37,335 | 41,398 | 37,335 | 41,398 |
| public institutions | MWh/y | 3,641 | 4,038 | 3,641 | 4,038 | 3,641 | 4,038 | 3,641 | 4,038 | 3,641 | 4,038 | 3,641 | 4,038 | 3,641 | 4,038 |
| enterprises and commercial services | MWh/y | 2,650 | 2,939 | 2,650 | 2,939 | 2,650 | 2939 | 2650 | 2939 | 2,650 | 2,939 | 2,650 | 2,939 | 2,650 | 2,939 |
| Annual Fuel Consumption | MWh/y | 112,009 | 132,571 | 39,722 | 45,456 | 59,016 | 65,087 | 119,642 | 126,099 | 85,543 | 94,852 | 85,543 | 94,852 | | |
| **Emissions Reduction** | | | | | | | | | | | | | | | |
| CO2 Emissions in Scenario 0 (Motru CHPP lignite-based) | tCO2/y | 40,096 | 47,457 | 40,096 | 47,457 | 40,096 | 47,457 | 40,096 | 47,457 | 40,096 | 47,457 | 40,096 | 47,457 | 40,096 | 47,457 |
| CO2 Emissions in analysed scenario | tCO2/y | | | 8,022 | 9,180 | 13,308 | 14,534 | 25,552 | 26,856 | 0 | 0 | 34,491 | 38,244 | 0 | 0 |
| CO2 Emissions due to the amount of electricity purchased from NPS | tCO2/y | | | 3,349 | 3,409 | | | | | | | | | 7,067 | 8,324 |
| CO2 Emissions avoided at NPS level due to electricity produced by PV | tCO2/y | | | 59 | 59 | 4,421 | 4,421 | 4,480 | 4,480 | 4,480 | 4,480 | 4,480 | 4,480 | 4,480 | 4,480 |
| CO2 Emissions avoided at NPS level due to electricity produced by MT | tCO2/y | | | | | | | 18,729 | 18,746 | | | | | | |
| CO2 Emissions avoided at NPS level due to electricity produced by biomass-based CHPP | tCO2/y | | | | | | | | | 15,786 | 17,504 | 4,289 | 4,756 | | |
| **CO2 Emissions Reduction** | **tCO2/y** | | | **28,783** | **34,926** | **31,210** | **37,344** | **37,753** | **43,826** | **60,363** | **69,441** | **14,375** | **18,449** | **37,509** | **43,613** |
| **SO2 Emission Reduction** | **tSO2/y** | | | **19.66** | **25.22** | **25.09** | **31.70** | **45.74** | **55.61** | **34.87** | **44.36** | **34.87** | **44.36** | **24.25** | **30.74** |
| **PM Emission Reduction** | **tPM/y** | | | **2.96** | **3.79** | **3.77** | **4.77** | **6.88** | **8.36** | **5.24** | **6.67** | **5.24** | **6.67** | **3.65** | **4.62** |

# 5 COMPARATIVE TECHNO-ECONOMIC ANALYSIS

## 5.1 Comparative techno-economic analysis of the identified scenarios

The comparative analysis will be carried out on the investment project outline, for each technologies mix considered, and will determine the financial and environmental performance of each analysed scenario.

### 5.1.1 Methodology

The comparative analysis will be carried out using the cost-benefit method, considering the discounting technique**.**

The main objective of the analysis is to determine the return on investment by calculating financial and environmental performance indicators. The financial indicators will be calculated for each analysed scenario, considering also the environmental impacts, i.e. the reduction of $CO_2$ emissions compared to the existing situation.

The comparative analysis comprises the following steps:

- Determine **the investment cash flow** over the analysis period and calculate the following financial performance indicators:
  - **Discounted net present financial value (NPV)** - which represents the cumulative discounted cash flow surplus over the analysis period, showing the ability of net revenues to support investment costs, regardless of how these costs are financed;
  - **Internal rate of return (IRR)** - which expresses that level of interest rate, for which discounted income equals discounted expenses, and which makes the value of net discounted income equal to zero;
  - **Benefit/cost ratio (B/C)** - expresses the extent to which total discounted costs can be covered from total discounted revenues.

**The cash flow** shows the soundness of the investment project, i.e. its ability to be self-sustaining from its generated sources, i.e. the net revenues must cover the investment costs, regardless of the way the investment objective is financed.

**The financial performance indicators** mentioned above are calculated on the assumption that the project will be financed from the beneficiary's own sources, without taking into account other attracted sources and related financial obligations.

***The project is considered cost-effective for positive NPV, IRR higher than the discount rate taken into account and B/C overunity.***

***The optimal scenario will be determined based on the maximum value of the performance indicators (maximum NPV, maximum IRR and maximum B/C).***

### 5.1.2 Investment costs

This sub-chapter presents the investment costs related to the analysed scenarios needed in order to cover the thermal energy (heat) demand in the city of Motru.

The total investment value, in prices valid on 31 May 2022 (EUR 1 = RON 4.943), for all five analysed scenarios, is shown in the table below:

**Table 5-1**: Total investment value for the analysed scenarios

| Specification | MU | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4a/4b | Scenario 5 |
|---|---|---|---|---|---|---|
| **Total investment (VAT excluded)** | thousand euros | 7,221.36 | 15,698.07 | 25,249.67 | 29,526.60 | 23,509.73 |

Total investment costs phasing is detailed in the table below:

**Table 5-2**: Staggered investment values (VAT excluded)

| Specification | MU | Year 1 | Year 2 | Total |
|---|---|---|---|---|
| **Scenario 1** | in EUR thousands | 2,888.54 | 4,332.82 | **7,221.36** |
| **Scenario 2** | in EUR thousands | 6,279.23 | 9,418.84 | **15,698.07** |
| **Scenario 3** | in EUR thousands | 10,099.87 | 15,149.80 | **25,249.67** |
| **Scenario 4** | in EUR thousands | 11,810.64 | 17,715.96 | **29,526.60** |
| **Scenario 5** | in EUR thousands | 9,403.89 | 14,105.84 | **23,509.73** |

### 5.1.3 Technical and economic premises

The analysis will be prepared on the investment outline of the recommended scenarios, taking into account the following technical and economic assumptions:

- **Technical premises**

The technical prerequisites for the implementation of heating solutions for the city of Motru are presented in chapter 4.3.

- **Economic premises**

The comparative techno-economic analysis is carried out on the project outline for each scenario based on the following economic assumptions.

- The comparative analysis will be developed on the investment targeted outline in thousands of euros;
- The reference period for the analysed scenarios is 22 years, which includes:
  - A 2-year investment period;

- A 20-year commercial operating period.

- The discount rate is 4 per cent, which is essentially a marginal efficiency rate or a recommended minimum efficiency limit for public investment;
- In the comparative analysis, it is assumed that the investment value financing is covered from the beneficiary's own sources;
- In the comparative analysis prices at book value (not including VAT or other taxes) are used;
- The exchange rate used in the analysis is RON 4.943 per euro, valid on 31 May 2022.

### 5.1.4 Evolution of prices

**Estimated evolution of the price of electricity delivered in the NPS**

The evolution of the price of electricity delivered on the DAM (day-ahead market) was stable according to the following elements:

- An initial price of EUR 175.04 / MWh was taken into account, representing the average trading price recorded on the DAM for the last 12 months (June 2021 - May 2022), determined according to information provided by OPCOM (Romanian gas and electricity market operator);
- The use of annual price change indices over the analysis period, in line with the methodology presented in the report *Energy Prices and Costs in Europe* (Oct 2020) and S&P Global Platts forecasts.

Considering the expected electricity price evolution trends at the European level, as well as the fact that the Romanian electricity market will be integrated with the European Union electricity market, this current study will consider the following evolution of the average electricity selling price on DAM over the whole analysis period:

Graphically, the evolution of the price of electricity sold in the NPS is shown in the following figure.

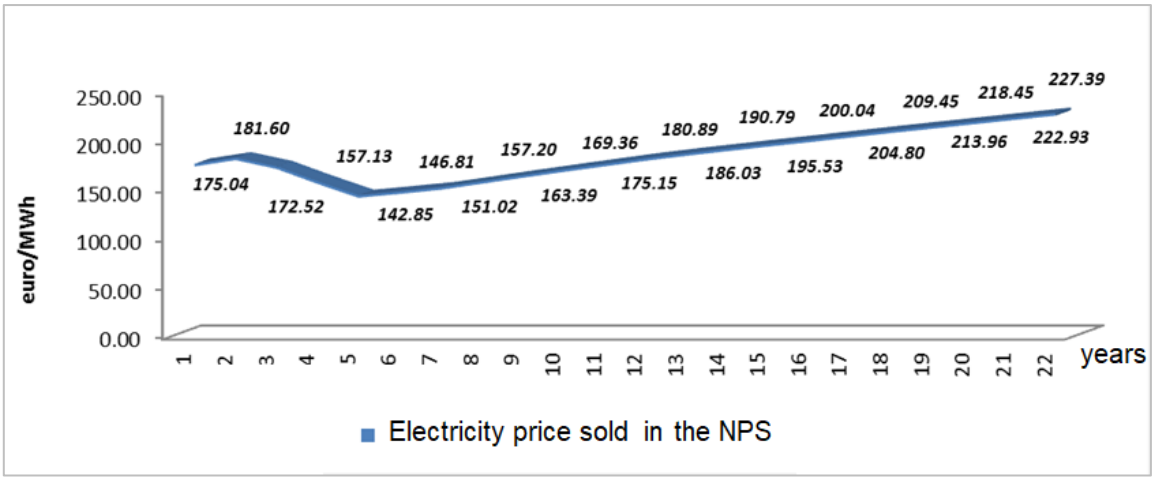



**Figure 5-1**: Evolution of the price of electricity sold in the NPS

- **Estimated evolution of the price of electricity purchased from the NPS**

The evolution of the price of electricity purchased from the NPS takes into account its evolution on the free market, and has been established according to the following elements:

- An initial price of EUR 263 / MWh was assumed, based on the market offers from electricity suppliers;
- The use of annual price change indices over the analysis period, in line with the methodology presented in the report *Energy Prices and Costs in Europe* (Oct 2020) and S&P Global Platts forecasts.
- The price of electricity purchased from the NPS is EUR 263 / MWh in the first year of the comparative analysis and EUR 341.65 / MWh in the last year of the reference period.

Graphically, the evolution of the price of electricity purchased from the NPS is shown in the following figure.

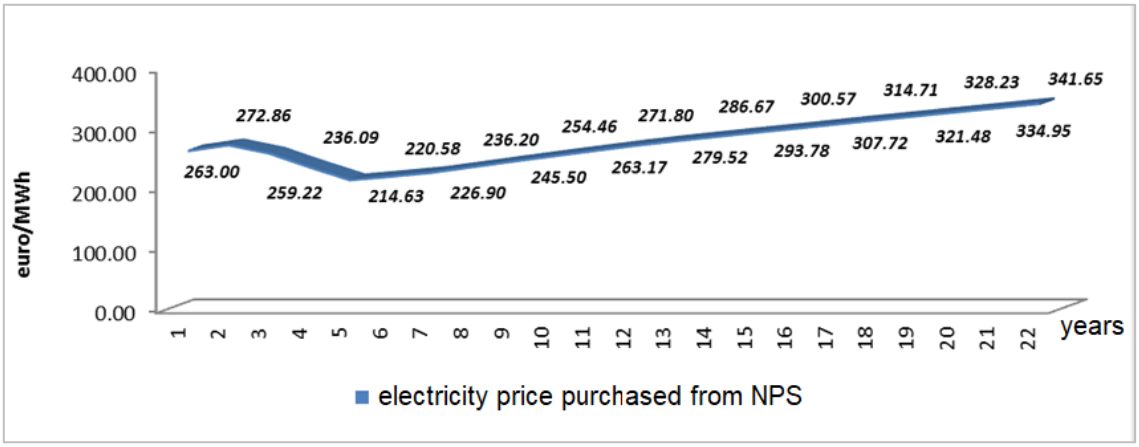



**Figure 5-2**: Evolution of the price of electricity purchased from the NPS

- **Estimated evolution of the average purchase price of $CO_2$**

In this current study, the average annual price of $CO_2$ emission allowances has an increasing trend, starting from the value of **RON 327.22 / $tCO_2$ (EUR 66.25 / $tCO_2$)**, calculated as the average of the closing prices (auction price) of all auction sessions held on the EEX common platform, during the period 1 May 2021 to 30 April 2022, according to the *Emission spot primary market auction report 2021* and *Emission spot primary market auction report 2022*.

Over the reference period, a linear annual price increase of RON 9.8932 / $tCO_2$ (EUR 2 / $tCO_2$) was assumed.

The evolution of the annual average price of $CO_2$ emission allowances was determined on the basis of the values estimated by the EC in Commission Staff Working Document - Impact Assessment Report (SWD(2021) 369 final), for the price of $CO_2$ emission allowances in 2030 in the scenario adapted for the new Fit for 55 climate policy package. This assumption is in line with the minimum evolution of the annual average price of $CO_2$ emission allowances as set out by the

EC in the *Guide to cost benefit analysis of investment project - economic appraisal for cohesion policy 2014 – 2020* and *Economic Appraisal Vademecum 2021-2027* and recommended for the justification of infrastructure investment projects. Graphically, the evolution of the purchase price of $CO_2$ emission allowances is shown in the following figure.

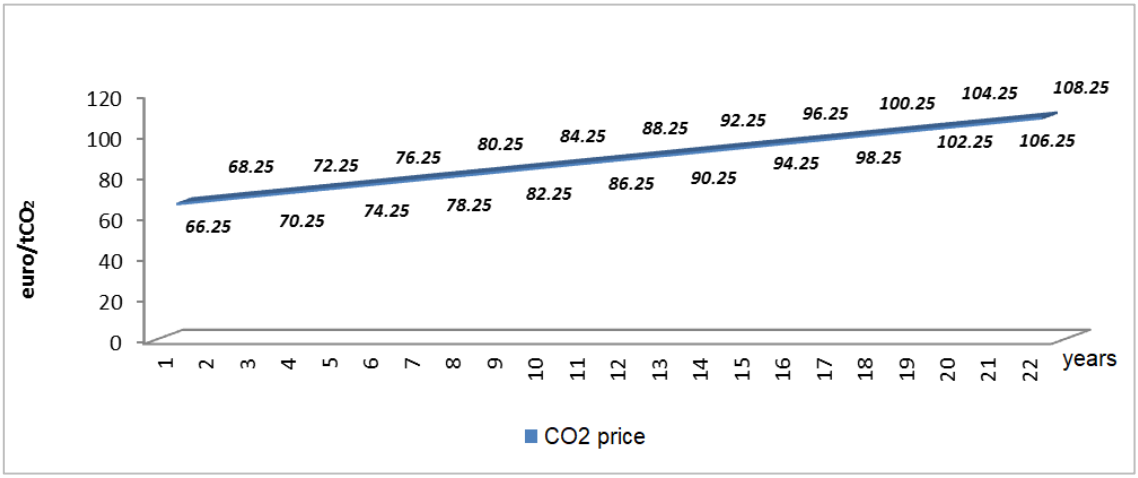



**Figure 5-3**: Evolution of $CO_2$ purchase price

- **Estimated evolution of thermal energy (heat) supply price**

The evolution of the heat price was stable according to the following elements:

- An initial price of EUR 38.16 / Gcal, excluding VAT (according to HCL Motru no. 216/2018), was considered for thermal energy (heat) delivered to domestic and non-domestic consumers;
- As the price does not cover the operating costs, an escalation rate of 3 per cent in year 2 of the reference period and 6 per cent by the end of the analysis period was considered.

Graphically, the evolution of thermal energy (heat) prices is shown in the following figure.

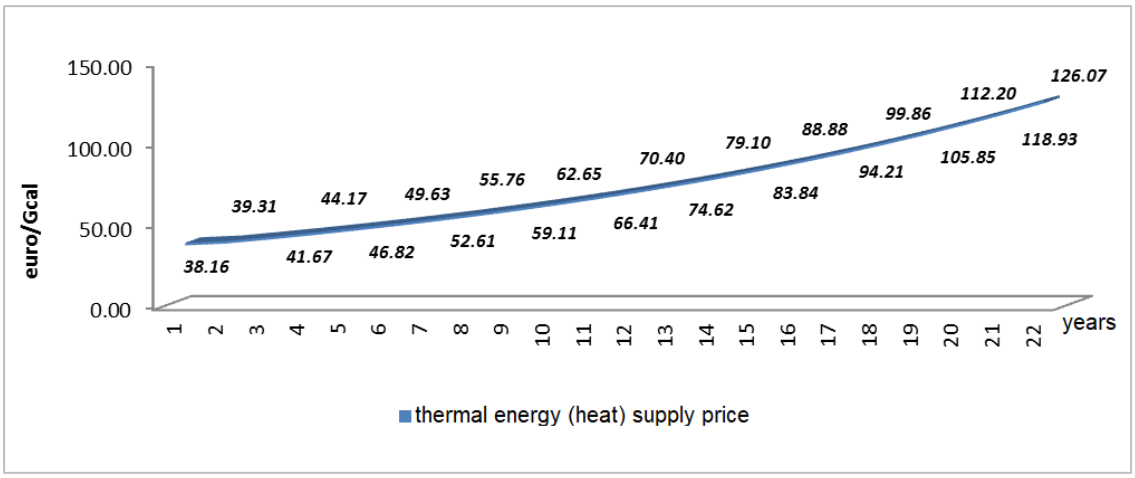



**Figure 5-4**: Evolution of the price of heat delivered to consumers

### 5.1.5 Annual operating costs

**The annual operating expenditure** for all five analysed scenarios was determined based on the following structure:

**Table 5-3**: Structure of the annual operating expenditure

| | |
|---|---|
| 1 | Material expenses |
| ***1.1*** | ***Variable material expenditures*** |
| 1.1.1 | Fuel expenditures |
| 1.1.2 | Expenditures on $CO_2$ emission allowances |
| 1.1.3 | Expenditures on technological water |
| 1.1.4 | Other variable expenditures |
| ***1.2*** | ***Fixed material expenditures related to implemented technologies specific to each analysed scenario*** |
| 1.2.1 | Repair and maintenance expenditures |
| 1.2.2 | Other fixed expenditures |
| ***2*** | ***Staff expenditure*** |

The annual operating costs are detailed for all five scenarios analysed in **Annexes A, B, C, D and E.**

### 5.1.6 Annual operating income

The annual operating revenues estimation takes into account the projection of electricity and thermal energy (heat) generation respectively, the quantities of electricity bought/sold and heat delivered, for each of the five analysed scenarios. Thus, the annual operating revenues are structured as follows:

- Revenues from the sale of generated electricity;
- Cost savings related to internal self-services' electricity, treated as revenues;
- Cost savings related to purchase of $CO_2$ certificates, treated as revenues;
- Revenues from the sale of thermal energy (heat) to final users/consumers.

**Revenues from the sale of electricity on the DAM** are determined on the basis of the annual quantities of electricity delivered on the DAM and the sales prices on this market, established and presented in Chapter 5.1.4 – Evolution of prices.

**Cost savings related to internal self-services' electricity**, assimilated as revenues, are determined on the basis of the annual quantity of electricity avoided to be purchased after the implementation of the project, for covering internal self-services, and the purchase prices, established and presented in Chapter 5.1.4 – Evolution of prices.

**Cost savings related to $CO_2$ certificates purchase**, assimilated as revenues, are determined on the basis of the amount of $CO_2$ avoided to be purchased after the implementation of the project and the price per $CO_2$ established and presented in Chapter 5.1.4 – Evolution of prices.

**Revenues from the sale of thermal energy (heat)** are determined on the basis of the annual quantities of heat delivered and the sales prices established and presented in Chapter 5.1.4 – Evolution of prices.

In comparison, the evolution of operating revenues for the five analysed scenarios is shown in the graph below.

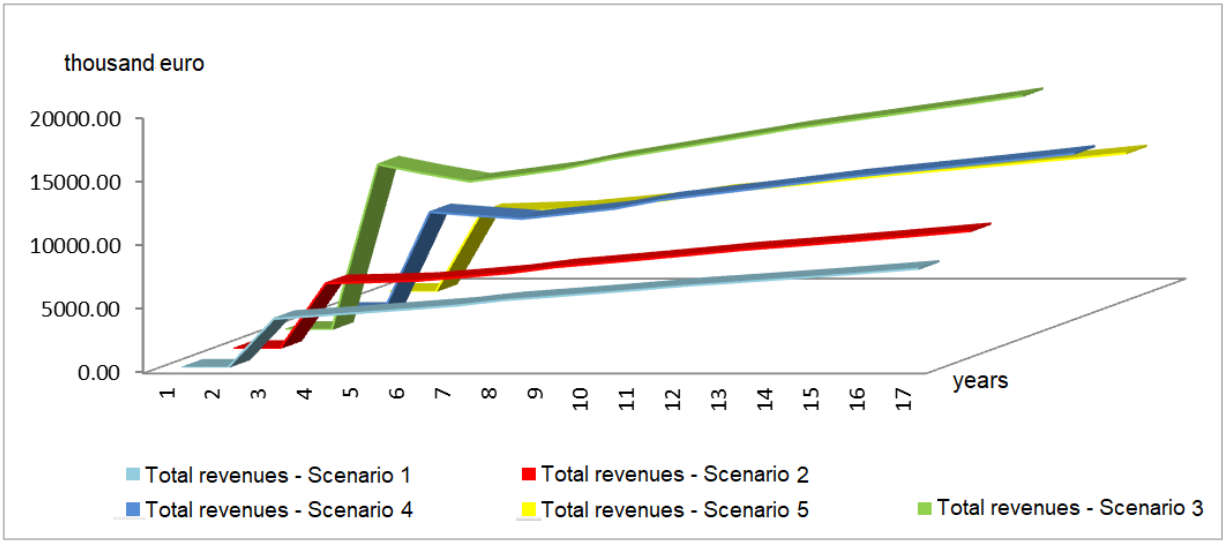



**Figure 5-5**: Evolution of total revenues for the analysed scenarios

The annual operating revenues for the five analysed scenarios are shown in **Annex A** for Scenario 1, **Annex B** for Scenario 2, **Annex C** for Scenario 3, **Annex D1** for Scenario 4a, **Annex D2** for Scenario 4b and **Annex E** for Scenario 5.

### 5.1.7 Comparative financial analysis of the analysed scenarios

The comparative financial analysis shows the ability of the revenues to cover the total costs of the analysed scenarios, regardless of how these scenarios are financed. Thus, in the cash flow calculation, the investment is considered to be 100 per cent from the beneficiary's **own sources.**

The financial flow was determined for each scenario on the basis of the following elements:

- operating income;
- operational expenditure;
- investment costs.

**Scenario 1**

The evolution of net cash flow and cumulative cash flow related to **Scenario 1** is shown graphically in the following figure.

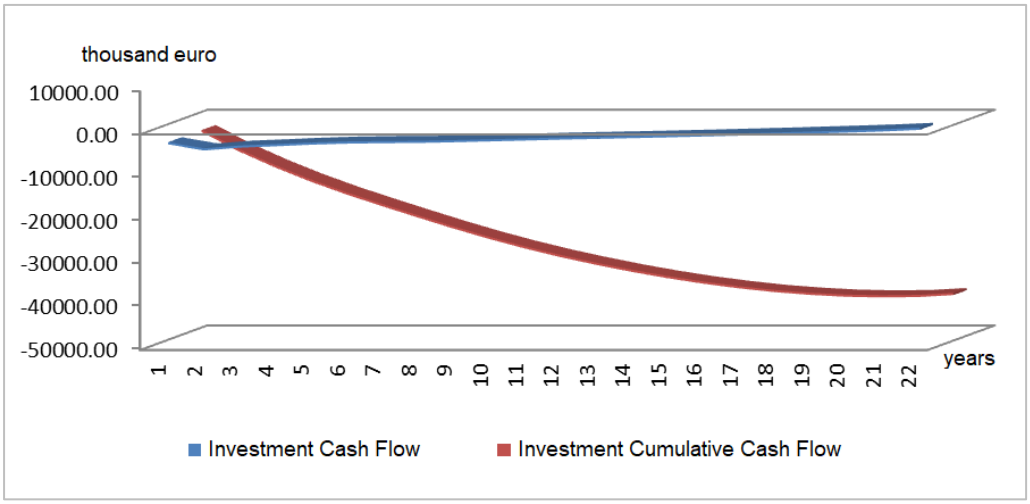



**Figure 5-6**: Evolution of investment cash flow in Scenario 1

In **Scenario 1**, the **investment cash flow** is negative until year 21 of the analysis period. In other words, the sources from operational activity do not cover the annual operating costs of the new investment.

**The investment cumulative cash flow** is negative over the entire analysis period, which means that the recovery of the investment value cannot be provided.

The investment cash flow for Scenario 1 is detailed in **Annex A.**

## Scenario 2

The evolution of the financial flow of the investment for **Scenario 2** is shown in the following graph.

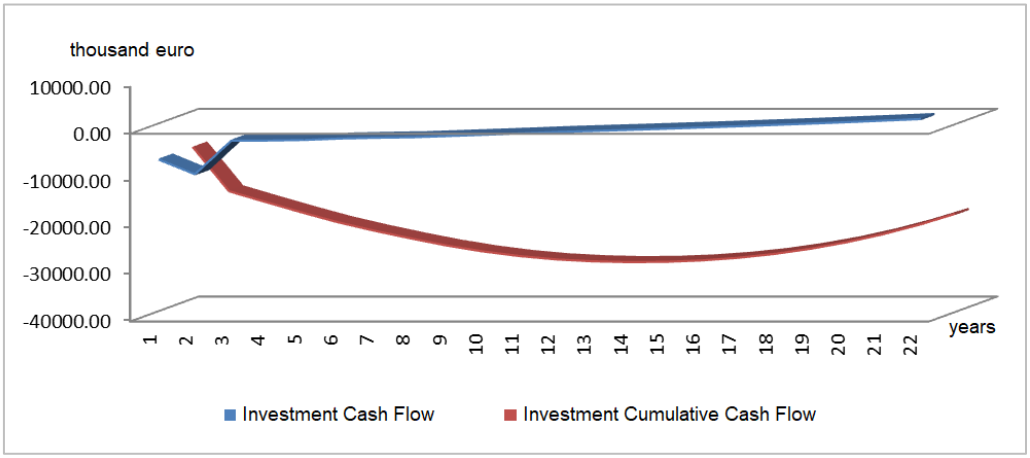



**Figure 5-7**: Evolution of investment cash flow - Scenario 2

In **Scenario 2**, the **investment cash flow** is positive from the 12$^{th}$ year of operation onwards, as the sources from operational activity cannot fully cover the annual operating costs of the new investment objective.

**The investment cumulative cash flow** is negative over the whole period of analysis, which means that the surplus resulting from the operational activity of the new investment cannot provide the recovery of the investment value in the first 20 years of commercial operation.

The investment cash flow for Scenario 2 is detailed in **Annex B.**

## Scenario 3

The evolution of the financial flow of the investment for **Scenario 3** is shown in the following graph:

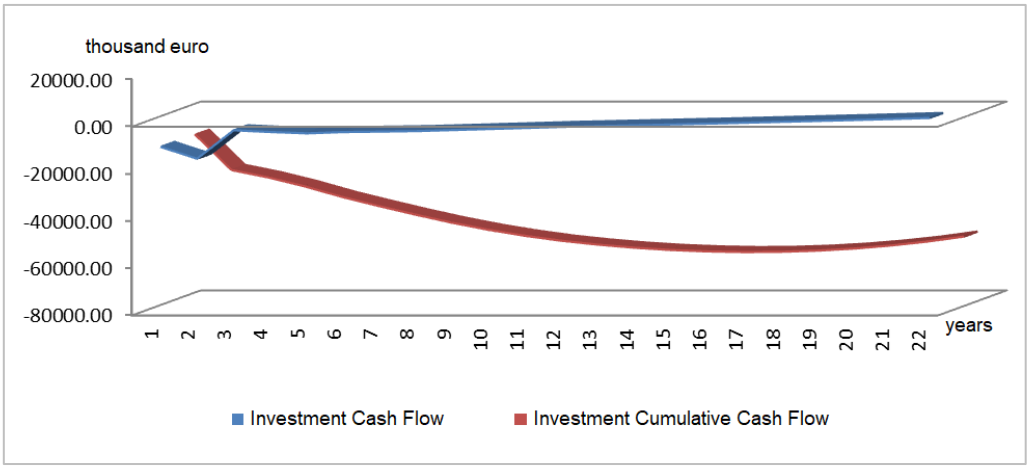



**Figure 5-8**: Evolution of financial flow - Scenario 3

In **Scenario 3**, the **investment cash flow** is positive from year 11 of the financial analysis. In other words, the sources from operational activity do not fully cover the annual operating expenses for the first eight years of operation of the new investment.

**The investment cumulative cash flow** is negative over the whole period of analysis, which means that the surplus resulting from the operational activity of the new investment cannot provide the recovery of the investment value in the first 20 years of commercial operation.

The investment cash flow for Scenario 3 is detailed in **Annex C.**

## Scenario 4

- **Scenario 4a - zero $CO_2$**

The evolution of the financial flow of the investment for **Scenario 4a** is shown in the following graph:

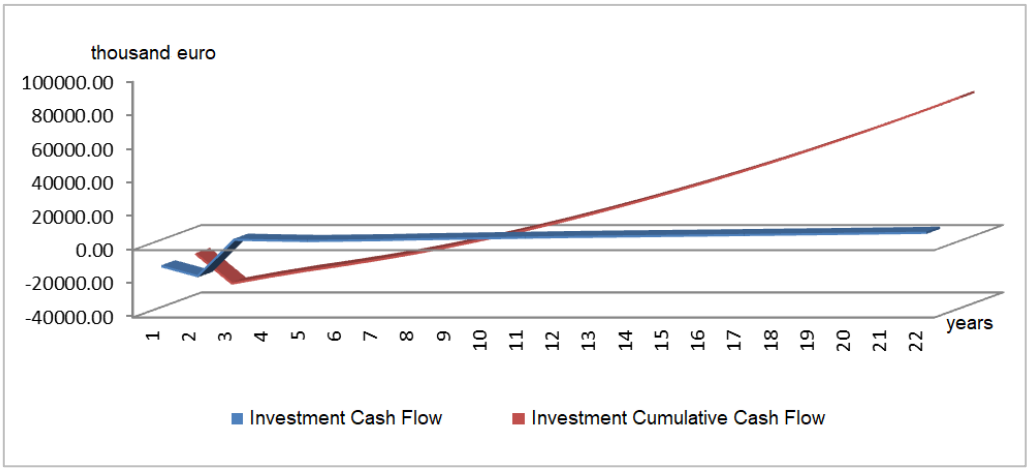



**Figure 5-9**: Evolution of financial flow - Scenario 4a

In **Scenario 4a**, the **investment cash flow** is positive over the entire period of operation of the new investment. In other words, the sources from operational activity fully cover the annual operating costs of the new investment.

**The investment cumulative cash flow** is positive from year 10 of the analysis (year eight of commercial operation), which means that the surplus resulting from the operational activity of the new investment objective can provide the recovery of the investment value in the first seven years of commercial operation.

The investment cash flow for Scenario 4a is detailed in **Annex D1.**

- **Scenario 4b - with $CO_2$**

The evolution of the financial flow of the investment for **Scenario 4b** is shown in the following graph:

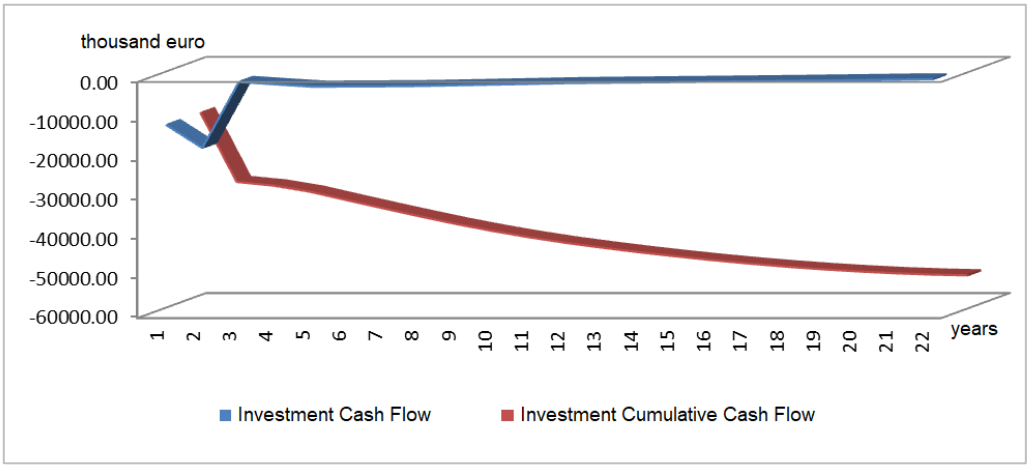



**Figure 5-10**: Evolution of financial flow - Scenario 4b

**In Scenario 4b, the investment cash flow** is negative over the entire operating period of the new investment. In other words, the sources from operating activity do not fully cover the annual operating expenses of the new investment.

**The investment cumulative cash flow** is also negative over the whole period of analysis, which means that the recovery of the investment value cannot be provided.

The investment cash flow for Scenario 4b is detailed in **Annex D2**.

**Scenario 5**

The evolution of the financial flow of the investment for **Scenario 5** is shown in the following graph:

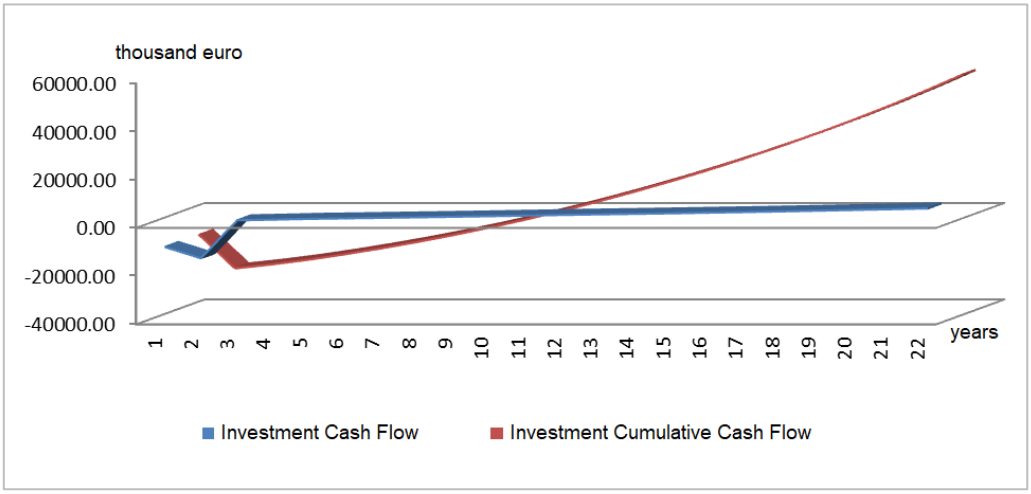



**Figure 5-11**: Evolution of financial flow - Scenario 5

In **Scenario 5**, the **investment cash flow** is positive over the entire period of operation of the new investment. In other words, the sources from operational activity fully cover the annual operating costs of the new investment.

**The investment cumulative cash flow** is positive from year 11 of the analysis (year nine of commercial operation), which means that the surplus resulting from the operational activity of the new investment objective can provide the recovery of the investment value in the first eight years of commercial operation.

The investment cash flow for Scenario 5 is detailed in **Annex E.**

### 5.1.8 Results of the financial comparative analysis

The financial performance indicators determined, based on the financial flow of investments for the five analysed scenarios, present the following values:

**Table 5-4**: Results of the financial comparative analysis

| Specification | MU | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 | | Scenario 5 |
|---|---|---|---|---|---|---|---|
| | | | | | Sc. 4a | Sc. 4b | |
| **Net present value (NPV)** | thousand euro | -31,016.11 | -21,783.27 | -17,876.93 | **37,692.17** | -44,010.81 | **24,347.36** |
| **Internal rate of return (IRR)** | % | N/A | -6,83 | -1.10 | **13.,50** | N/A | **11.47** |
| **Benefit/cost ratio** | - | 0.71 | 0.81 | 0.92 | **1.29** | 0.74 | **1.28** |

Based on the results of the financial analysis developed for the five analysed scenarios, the following can be highlighted:

- In Scenarios 4a and 5, the financial performance indicators are positive (positive NPVF/C, IRRF/C higher than the discount rate, B/C ratio > 1); the project is considered cost-effective for these two scenarios;
- For the other analysed scenarios, i.e. Scenario 1, Scenario 2, Scenario 3 and Scenario 4b, the financial performance indicators are negative.

Considering the above, in terms of financial indicators, the scenario with the best indicators is **Scenario 4a.**

It should be stressed that the biomass-based Motru CHPP will operate at design parameters only if a sustainable biomass supply chain is ensured, including a certificate of origin, with a continuous supply flow of biomass, required all year round. By imposing the use of certified biomass, the procedure for issuing certificates of origin for biomass originating from forestry and related industries, to be used for RES electricity generation, issued by MMAP Order no. 1534/2016, will be observed and the sustainability and traceability of the supply chain will be monitored and demonstrated. At the EC level a report is being developed on sustainability requirements for the use of solid and gaseous biomass sources for electricity generation, heating and cooling (COM(2010)11 final). In 2020, the ASRO (National Standardisation Organisation) standard SR CEN/TS 16214-2:2020 on Sustainability criteria for the production of biofuels and bioliquids for energy applications came into force in Romania.

Given the dependence of Motru CHPP's operation on the provision of a steady and reliable biomass flow, meeting the requirements of sustainable biomass in accordance with MMAP Order 1534/2016, **Scenario 5,** which proposes the use of ground-to-water HPs in combination with PVs, is considered to be more viable, easier to manage and more reliable in terms of continuity and safety of thermal energy (heat) supply than **Scenario 4a**.

According to the above, the proposed **optimal scenario is Scenario 5**:

***Motru centralised DHS supplying thermal energy (heat), by implementing the following investments in the source:***

- ***Motru CHPP equipped with 13 ground-water HPs (heating + domestic hot water);***
- ***Construction of a PVP with ground PVs with an installed power of approx. 6,25 MWp, located on the site of the former ash and slag dump;***
- ***Installation of roof PVs with an installed power of approx. 83 kWp, located on TSs terraces.***

In the proposed optimal scenario, **Scenario 5,** the source will have a technology mix with the following main equipment:

- PVP - photovoltaic park with ground solar panels with an installed capacity of approx. 6.25 MWp located on the site of the former ash and slag dump**;**
- Roof PVs - photovoltaic panels with an installed power of approx. 83 kWp, located on the terraces of the thermal stations (TS);
- Motru CHPP equipped with 13 ground-water HPs for supplying with thermal energy (heat and domestic hot water).

The technical performance of the new equipment in the recommended scenario, Scenario 5, will be as follows:

**Table 5-5**: Energy performance in the recommended Scenario 5

| **Scenario 5** | | |
|---|---|---|
| **Ground PVs on the former ash and slag dump** | | |
| Total PV installed capacity | 6.25 | MWp |
| Electricity generated by PVs | 7,187.5 | MWh/year |
| **Roof PVs on TSs terraces** | | |
| Total PV installed capacity | 83 | kWp |
| Electricity generated by PVs | 96 | MWh/year |
| **SOURCE - Motru CHPP with 13 ground-water HPs** | | |
| Total (ground-water) HPs thermal energy (heat + hot water) capacity | 11.3 | Gcal/h |
| | 13.1 | MWth |
| Electricity consumption (ground-water) HPs | 5.46 | MWe |

The annual quantities of electricity and heat generated and delivered were calculated based on the equipment loading under the operating assumptions described above.

The energy performance (electricity and heat generated/delivered, $CO_2$) in the recommended Scenario 5 is shown in the following table.

**Table 5-6**: Energy performance in the recommended Scenario 5

| **Specifications** | **MU** | **Recommended scenario** | |
|---|---|---|---|
| | | **Scenario 5** | |
| | | **Year 3** | **Last Year** |
| Electricity generated | MWh/year | 7,283 | 7,283 |
| Electricity for internal self-services | MWh/year | 18,772 | 20,815 |
| Electricity delivered | MWh/year | - | - |

| Specifications | MU | Recommended scenario | |
|---|---|---|---|
| | | Scenario 5 | |
| | | Year 3 | Last Year |
| Electricity purchased from the NPS | MWh/year | 11,489 | 13,532 |
| Thermal energy (heat) at the source limit | Gcal/h | 44,132 | 48,935 |
| Thermal energy (heat) at source limit, of which: | MWh/year | 51,326 | 56,911 |
| Heat energy from heat pumps | MWh/year | 51,326 | 56,911 |
| Heat losses from heat networks | MWh/year | 7,699 | 8,537 |
| | % | 15 | 15 |
| Thermal energy (heat) sold, of which: | MWh/year | 43,627 | 48,374 |
| - population / residential | MWh/year | 37,335 | 41,398 |
| - public institutions | MWh/year | 3,641 | 4,038 |
| - enterprises / commercial services | MWh/year | 2,650 | 2,939 |
| Annual fuel consumption | MWh/year | | |
| **Quantification of emission reductions** | | | |
| $CO_2$ emissions in Scenario 0 (Motru lignite-fired CHPP) | $tCO_2$/year | 40,096 | 47,457 |
| $CO_2$ emissions in the recommended scenario | $tCO_2$/year | 0 | 0 |
| $CO_2$ emissions due to electricity purchased from the NPS | $tCO_2$/year | 7,067 | 8,324 |
| $CO_2$ emissions avoided at NPS level due to PV electricity generation | $tCO_2$/year | 4,480 | 4,480 |
| **Reduction of $CO_2$** | **$tCO_2$/year** | **37,509** | **43,613** |
| **Reduction of $SO_2$** | **$tSO_2$/year** | **24.25** | **30.74** |
| **Reduction of PM** | **tPM/year** | **3.65** | **4.62** |

## 5.2 Funding sources available

This chapter will present the funding opportunities available to support the transition to a low-carbon economy, not strictly focused only on energy efficiency and RES integration for the community's thermal energy supply.

The first step for the Motru municipality to mobilise funding sources is to ensure that there is a sufficient number of quality projects prepared and prioritised.

Once the projects have been identified, the second step is the preparation of several **pre-investment studies**, such as:

- techno-economic feasibility studies;
- business plans;
- risk assessments;
- funding applications.

According to the Transition Financing Toolkit[10] within the EC - DG Energy platform and initiative called Coal Regions in Transition, there are a number of mechanisms to **assist in the preparation of projects and funding applications** such as:

- Joint Assistance to Support Projects in European Regions - JASPERS[11];
- European Local Energy Assistance - ELENA[12];
- Urban Investment Advisory Platform within the European Investment Advisory Centre (EIAH) - URBIS[13];
- Targeted Technical Support for Coal Regions TARGET[14] (Technical Assistance for Regions undergoing a Green Energy Transition);
- European Investment Advisory Hub (EIAH-European Investment Advisory Hub[15]);
- European Energy Efficiency Fund. [16]

**Targeted technical assistance for coal-intensive regions** - **TARGET** is a free assistance programme jointly developed by the EC and the EIB (European Investment Bank) to support coal, peat and oil shale regions in identifying and preparing green energy and energy efficiency projects, in particular clean/emission-free heating and energy-efficient building renovation. Motru municipality and project promoters (public or private entities) can apply for assistance.

**The European City Facility** (EUCF[17]) provides grants (non-reimbursable funds) to local authorities to develop investment concepts as well as technical assistance and institutional capacity building opportunities. Investment concepts translate a project idea into financial language to mobilise the necessary funding sources.

**Strengthening the administrative capacity** to mobilise funding sources among public authorities, SMEs and R&I entities can also be supported through the LIFE and Horizon Europe programmes. **The LIFE programme**[18] provides training for the creation of integrated programmes through its own dedicated calls for technical assistance (via the Funding and

[10] https://energy.ec.europa.eu/topics/oil-gas-and-coal/eu-coal-regions/resources/transition-financing-toolkit_ro

[11] https://jaspers.eib.org/

[12] https://www.eib.org/en/products/advising/elena/index.htm

[13] https://eiah.eib.org/about/initiative-urbis.htm

[14] https://energy.ec.europa.eu/topics/oil-gas-and-coal/eu-coal-regions/target-technical-assistance_en

[15] https://eiah.eib.org/

[16] https://www.eeef.lu/eeef-ta-facility.html

[17] https://www.eucityfacility.eu/apply-for-eucf-support/application-process.html

[18] https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/programmes/life2027

Tendering Platform). For the **Horizon Europe programme**, the network of National Contact Points[19] is the main structure providing guidance and training on all aspects of participating with project proposals from this source.

EU funding opportunities are diverse and can be of three types:

- grants (non-reimbursable funding);
- loans (on favourable terms);
- guarantees (whereby the financing partners take over part of the payment obligation if the debt cannot be repaid).

**Table 5-7**: European funding sources

| Type of funding | Areas of interest | Beneficiaries | Implementation via |
|---|---|---|---|
| **European Regional Development Fund - ERDF[20]** | | | |
| **Grants, loans and guarantees** | - Innovation and research<br>- Digital transition<br>- Support for SMEs<br>- **Low carbon economy** | Regional public and private entities, with a special focus on disadvantaged regions and areas, notably rural areas and outermost regions | Operational programmes<br>URBACT[21]<br>Innovative Urban Actions[22]<br>INTERREG[23] |
| **European Social Fund+ - ESF+[24]** | | | |
| **Grants** | - **Investing in youth, in particular to help them find a qualification and a job**<br>- Support for the most vulnerable suffering from job and income losses<br>- Promoting social innovation, social entrepreneurship and cross-border labour mobility under the new Employment and Social Innovation (EaSI) strand | Public administrations, workers' and employers' organisations (trade unions, federations, professional associations), NGOs, charities and companies | Operational programmes<br>Funding and bidding platform[25] for EaSI<br>ESF+ technical assistance |
| **Cohesion Fund (CF)[26]** | | | |
| **Grants** (the level of funding from the Cohesion Fund for a programme can be up to 85%) | - Trans-European transport networks, in particular priority projects of European interest identified by the EU.<br>- Infrastructure projects under the Connecting Europe Facility (CEF)<br>- **Environmental projects related to energy** or transport (e.g. improving energy efficiency, use of RES, developing rail transport, supporting intermodality and | Public and regional authorities in Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Greece, Hungary, Latvia, Lithuania, Malta, Poland, Portugal, **Romania**, Slovakia and Slovenia | Operational programmes |

19 https://www.horizoneuropencpportal.eu/

20 https://ec.europa.eu/regional_policy/en/funding/erdf/

21 https://urbact.eu/

22 https://uia-initiative.eu/en

23 https://www.interregeurope.eu/

24 https://ec.europa.eu/esf/main.jsp?catId=62&langId=en

25 https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/programmes/esf

26 https://ec.europa.eu/regional_policy/en/2021_2027/

| Type of funding | Areas of interest | Beneficiaries | Implementation via |
|---|---|---|---|
| | strengthening public transport, etc.). | | |
| **HORIZON Europe[27]** | | | |
| **Grants and awards** | - **Pillar II / Cluster V and VI focus: climate, energy and mobility; food, bioeconomy, natural resources, agriculture and environment**<br>- Focus on 'mission areas': **climate change adaptation**, including societal transformation; **climate neutral and smart cities**; healthy oceans, seas, coastal and inland waters; soil health and food. | Scientists and academics, research organisations, universities, industry, SMEs, students, etc. | Funding & Tender platform [28] |
| **Just Transition Fund - FTJ[29]** | | | |
| **Fair Transition Fund / Grant**<br>**Invest EU Programme**<br>**EIB loans for the public sector** | Supporting investments in SMEs aimed at diversification; creation of new firms; research and innovation; environmental rehabilitation; **clean energy, energy efficiency and heating projects; upskilling and re-skilling of workers**; job-search assistance and active inclusion of job-seeker programmes; conversion of existing carbon-intensive facilities. | National and local authorities, busiSEN ses and startups in the territories most negatively affected by the transition process (as identified in the Territorial Just Transition Plans) | EU Member States / NUTS 3 level (county) for Romania |
| **FTJ - Public Sector Loan Facility** | | | |
| **Grants and loans** | Energy and transport infrastructure; heating networks; public transport; **energy efficiency measures**; social infrastructure. | Exclusively for public authorities | EU Member States / NUTS 3 level (county) for Romania<br>EC published first calls for proposals<br>JTM-2022-2025-PSLF-STANDALONE-PROJECTS<br>JTM-2022-2025-PSLF-LOAN-SCHEMES |
| **LIFE Programme[30]** | | | |
| **Grants** | - Focus on Environment' and 'Climate Action under four sub-programmes: nature and biodiversity, circular economy and quality of life, climate change mitigation and adaptation and – most importantly for coal regions – the transition to clean energy;<br>- Contribute to the transition to a **clean**, circular, **energy-efficient**, low-carbon and climate-resilient **economy**, including through the transition to clean energy; protect and improve the quality of the environment; halt and reverse biodiversity | EU national or local authorities, private commercial organisations and private non-commercial organisations (e.g. NGOs) | LIFE website [30] |

27 https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en

28 https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/programmes/horizon

29 https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/finance-and-green-deal/just-transition-mechanism_en#financing

30 https://cinea.ec.europa.eu/life_en

| Type of funding | Areas of interest | Beneficiaries | Implementation via |
|---|---|---|---|
| | loss, thus contributing to sustainable development. | | |
| **Connecting European Facility - CEF[31]** | | | |
| **Grants**, with different co-financing rates depending on the type of project; mixed calls | **Energy**; transport; digitisation.<br>The new CEF (2021-2027) will focus more on climate change, digital connectivity and renewable electricity. | Industry, SMEs, research organisations, other public and private entities established in a Member State or in a third country associated to the programme or created under EU law and international organisations | CEF website [31] |
| **Research Fund for Coal and Steel - RFCS[32]** | | | |
| **Grants** | - For steel: clean production processes; optimised use and conservation of resources, **energy savings and improvements in industrial efficiency**; reduced emissions from steel production.<br>- For coal: health and safety at work; environmental protection; technologies supporting the transition from coal in coal regions. | Universities, research centres and companies | RFCS website [32] |
| **Modernisation Fund[33]** | | | |
| **Grants**, guarantees, loans, capital injections (decision at Member State level) | **Renewable energy production and use; energy efficiency**; energy storage; modernisation of energy networks, including district heating, pipelines and grids; just transition in carbon-dependent regions: redeployment, retraining and upskilling of workers, education, job search initiatives and start-ups. | Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, **Romania** and Slovakia | Member States select the investments they wish to make |
| **Innovation Fund[34]** | | | |
| **Grant** (maximum 60 per cent of new investment and operating costs) | Innovative low-carbon technologies and processes in energy-intensive industries, including carbon-intensive substitutes; **innovative renewable energy; energy storage**; carbon capture and storage (CCS); carbon capture and use (CCS). | EU Member States | Funding platform and auctions[35] |
| **Recovery and Resilience Facility - RRF[36]** | | | |
| **Grants and loans** | **Clean technologies and renewables**; **energy efficient buildings**; sustainable transport and charging stations; fast broadband rollout; digitisation of public administration and services; cloud data capabilities and sustainable processors; | EU Member States; indirectly, EU citizens, public or private organisations and businesses | Member States (based on the PNRR) |

31 https://cinea.ec.europa.eu/connecting-europe-facility/energy-infrastructure-connecting-europe-facility_en

32 https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/research-fund-coal-and-steel-rfcs_en

33 https://ec.europa.eu/clima/eu-action/funding-climate-action/modernisation-fund_en

34 https://cinea.ec.europa.eu/innovation-fund_en

35 https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/programmes/horizon

36 https://mfe.gov.ro/pnrr/

| Type of funding | Areas of interest | Beneficiaries | Implementation via |
|---|---|---|---|
| | education and training to support digital skills. | | |
| **REPowerEU[37]** | | | |
| **Grants and loans** | Residential building sector: energy efficiency and heat pumps<br>Solar and wind energy | EU Member States by updating/amending the Regulation establishing the Recovery and Resilience Mechanism | Member States (based on updated PNRR) |
| **Invest EU[38]** | | | |
| **Grants, loans and guarantees** | - **Sustainable infrastructure**; research, innovation and digitisation; SMEs; social investment and skills.<br>- Coal regions in particular can use this mechanism for strategic investments that focus on building stronger value chains as well as supporting activities in critical infrastructure and technologies | Public and private investors, project promoters and SMEs | Financial partners for implementation (e.g. EIB) |
| **INTERREG[39]** | | | |
| **Grants** | - P1 - Smarter Europe<br>(i) development and strengthening of research and innovation capacities and adoption of advanced technologies<br>(iv) skills development for smart specialisation, industrial transition and modern entrepreneurs<br>- **P2 - A greener, low-carbon Europe**<br>(ii) promotion of renewable energy<br>(iv) promoting climate change adaptation and disaster risk prevention, resilience, taking into account ecosystem-based approaches<br>(v) promoting access to water and sustainable water management<br>(vii) Improving the protection and conservation of nature, biodiversity and green infrastructure, including in urban areas, and reducing all forms of pollution<br>- P3 - A more social Europe<br>- P4 - Better governance cooperation | Local, regional and national public authorities and organisations set up and run by public authorities responsible for research, innovation, technology transfer institutions, sectoral agencies and regional development agencies, networks, clusters and associations, research and development institutions, universities with research facilities, business support organisations (e.g. chamber of commerce, business innovation centres, technology information centres), higher education, education/training centres and schools, NGOs, private enterprises, including SMEs, or industrial and technology centres and parks | Transnational Danube Programme[40] |
| **Interregional Innovation Investments (I3)[41] Instrument** | | | |
| **Financial support and consultancy in the form of a grant** | - interregional innovation investment projects under the common smart specialisation priorities (S3), targeting mature partnerships to help them accelerate market uptake and expansion<br>- increasing the capacity of regional innovation ecosystems in less developed | Legal entities (public or private bodies) established in one of the eligible countries | EIASME Platform (European Innovation Council and SME Executive Agency) |

37 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52022DC0230&from=EN

38 https://europa.eu/investeu/home_en

39 https://www.interregeurope.eu/

40 https://www.interreg-danube.eu/about-dtp/priorities-objectives-2021-2027

41 https://eismea.ec.europa.eu/programmes/interregional-innovation-investments-i3-instrument_en

| Type of funding | Areas of interest | Beneficiaries | Implementation via |
|---|---|---|---|
| | regions to participate in global value chains, as well as the capacity to participate in partnerships with other regions | | |
| **New European Bauhaus[42]** | | | |
| **Awards**<br>**Stars in the making** | - Reconnecting with nature<br>- Regaining a sense of belonging<br>- Prioritising places and people who need it most<br>- **Modelling a circular industrial ecosystem and supporting life cycle thinking** | EU and non-EU citizens ≤ and ≥ 30 years old | Bauhaus Platform |

*Source: Transition Financing Toolkit, EC - Initiative for Coal Regions in Transition, 2021 Brussels*

**The operational programmes**[43] (OPs), prepared by MIPE under the Partnership Agreement 2021-2027 with the European Commission, to support the implementation of future projects based on the timetable for calls for proposals and guidelines for applicants are the following:

1. Smart Growth, Digitisation and Financial Instruments Operational Programme (POCIDIF)
2. **Sustainable Development Operational Programme** (PODD)
3. **The Just Transition Operational Programme** (POTJ)
4. Technical Assistance Operational Programme (POAT)
5. Health Operational Programme (POS)
6. Education and Employment Operational Programme (POEO)
7. Inclusion and Social Dignity Operational Programme (POIDS)
8. Aquaculture and Fisheries Operational Programme (POAP)
9. Transport Operational Programme (POT)
10. **Regional Operational Programmes** (POR)

The operational programmes 2021-2027 with focus on the energy sector, energy efficiency and RES integration are: the POTJ (which will be implemented in only six counties in Romania, including Gorj/RO412) and the PODD, and related POEO managed at the national level and **POR Sud-Vest Oltenia** managed at regional level – NUTS 2 / RO41 by RDA Sud-Vest Oltenia[44] as the managing authority.

Of great importance is facilitating access to private finance for local SMEs – an element of many urban transition/development strategies. Local financial institutions in EU countries can access

[42] https://prizes.new-european-bauhaus.eu/

[43] https://mfe.gov.ro/minister/perioade-de-programare/perioada-2021-2027/

[44] https://por2021-2027.adroltenia.ro/

EU funds to provide loans, micro-finance or equity finance through venture capital funds or social investors. For more information, visit the **European Investment Fund (EIF)** website.[45]

Other programmes and non-reimbursable sources are available through: **EEA and Norway** grants,[46] **EBRD Green Cities**,[47] and national programmes supported from the state and/or local budget such as:

- Environmental Fund Administration Programmes;[48]
- **the Swiss-Romanian Cooperation Programme**[49] - Sustainable Energy Management Action Fund[50] according to GD 158/2020;
- **ElectricUp**,[51] managed by the Ministry of Energy;
- **Programme on increasing the energy performance of collective dwellings**[52] managed by the Ministry of Development, Public Works and Administration (MDLPA).

Regarding well-structured IT platforms with sufficient information on funding sources, we recommend:

- **The Covenant of Mayors** has an interactive funding guide[53] which covers all EU funding sources as well as information on support services and innovative funding schemes;
- At the national level, **the new information platform of the Ministry of European Investment and Projects (MIPE)**[54] provides information support on the sources of funding available at the European, EEA and national levels, necessary for all categories of public stakeholders in the development of a project (legal entities, public entities, SMEs, large enterprises, NGOs and individuals).

The calls for proposals calendar still available for the 2014-2020 programming period can be consulted at the link in the footnote[55] and on the website of the Rural Investment Funding Agency[56] and the calls opened by the European Commission are available at the link in the footnote.[57]

[45] *https://www.eif.org/index.htm*
[46] https://www.eeagrants.ro/stiri/sumar-apeluri
[47] https://www.ebrdgreencities.com/
[48] https://www.afm.ro/programe_finantate.php
[49] https://www.eda.admin.ch/countries/romania/en/home/enlargement-contribution/contribution.html
[50] https://www.mdlpa.ro/pages/fondulactiunedomeniulmanagementenergiedurabila
[51] http://energie.gov.ro/electricup/
[52] https://www.mdlpa.ro/pages/proiectdeogpentrumodificareasicompletareaoug18crestereaperformanteienergetice07012022
[53] https://www.eumayors.eu/support/funding.html
[54] https://oportunitati-ue.gov.ro/
[55] https://mfe.gov.ro/calendar/
[56] https://afir.info/
[57] https://oportunitati-ue.gov.ro/apeluri-deschise-de-comisia-europeana/

## 6 CONCLUSIONS AND RECOMMENDATIONS

Diversification of electricity and heat generation sources in Motru municipality and the use of the local potential related to RES and alternative energy sources, can lead to positive results and benefits:

- for human health and the environment;
- for local socio-economic development:
  - attracting investors interested in developing RES projects;
  - obtaining high scores in funding application evaluations under the 2021-2027 operational programmes;
  - the possibility of achieving energy independence;
  - strengthening the market position of the UATAA operator of the centralised DHS.

Based on the techno-economic analysis carried out, the following can be highlighted:

- The comparative financial analysis of the five analysed scenarios aiming to supply Motru city with thermal energy (heat) using RES and, in some cases, methane gas as transition fuel, led to the following results:

**Table 6-1**: Results of the comparative financial analysis

| Specification | MU | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 | | Scenario 5 |
|---|---|---|---|---|---|---|---|
| | | | | | Sc. 4a | Sc. 4b | |
| **Net present value (NPV)** | thousand euro | -31,016.11 | -21,783.27 | -17,876.93 | **37,692.17** | -44,010.81 | **24,347.36** |
| **Internal rate of return (IRR)** | % | N/A | -6.83 | -1.10 | **13.50** | N/A | **11.47** |
| **Benefit/cost ratio** | - | 0.71 | 0.81 | 0.92 | **1.29** | 0.74 | **1.28** |

- The results of the comparative financial analysis, presented in **Table 6-1**, highlight the following:
  - **In Scenarios 4a and 5, the financial performance indicators are positive (positive NPVF/C, IRRF/C higher than the discount rate, B/C ratio > 1); the project is considered cost-effective for these two scenarios;**
  - **For the other scenarios analysed, i.e. Scenario 1, Scenario 2, Scenario 3 and Scenario 4b, the financial performance indicators are negative.**

Considering the above, in terms of financial indicators, the scenario with the best indicators is Scenario 4a, which shows the most favourable financial indicators.

Given the dependence of the biomass-based CHPP operation on the provision of a constant and reliable flow of biomass that meets the requirements of 'sustainable biomass' in accordance with the provisions of MMAP Order 1534/2016, it was considered that **Scenario 5**, in which the use of ground-to-water heat pumps (HP) in combination with photovoltaic solar panels (PV) is proposed, is more viable, easier to manage and more reliable in terms of continuity and safety of heat supply than **Scenario 4a**.

At the same time, taking into account the caution in recommending the use of biomass as a renewable energy source in Scenario 4 (a and b), without any impacts on the ecological balance (forests/agriculture and biodiversity), Scenario 5 demonstrates, without restraints, that 100 per cent heat supply from RES is possible, all year round.

For Scenario 5, the comparative financial analysis also shows that the reduction of electricity costs could be achieved by not buying electricity from the NPS and instead using the electricity generated locally by the PVP (ground PVs on the former ash and slag dump).

Additionally, due to the retrofitting and upgrading of the heat transmission and distribution networks, with losses falling within the accepted technical limits, i.e. 15 per cent, the operating cost reduction in Motru's centralised DHS may have favourable impacts by reducing the price of the thermal energy (heat) supplied to the population.

Non-reimbursable funding is available for the implementation of investment projects in the field of RES integration. Obtaining such funding eases the financial burden on electricity and heat producers, such as UATAA.

Currently, European funding opportunities are available via the National Recovery and Resilience Plan (PNRR) - Pillar I. Green Transition - Component C6. Energy, for: investments in new RES-based electricity generation capacities and the development of flexible, high-efficient gas-fired generation capacities for CHP (combined heat and power) in district heating.

In order to reduce the amount of electricity purchased from the NPS to operate Motru's centralised DHS, local generation of green electricity and its use can contribute to a large extent to the financial balancing of UATAA – the centralised DHS operator – and to reducing the pressure on local budgets.

The diversification of resources and RES integration in the thermal energy supply services can contribute to increasing the performance of Motru's centralised DHS, with direct positive impact on the satisfaction and comfort levels of end-users/consumers.

For the successful implementation of such an RES integration project, the main recommendation is a step-by-step approach to the transition from coal, so that all stakeholders are transparently, fairly and promptly informed and engaged. To this aim, the human resource effort and skills required have to be synchronised and prepared in advance for the planning, implementation and development of all future investment projects.

This step-by-step approach will provide the time needed both to re- and up-skill UATAA employees for the operation and maintenance of new electricity and/or heat generation technologies, and to build capacity and skills at the local institutional level to prepare the project applications to access all available funding sources.

It is also advisable that, in parallel with the process of changing the local energy mix, energy efficiency be increased by starting the renovation wave of residential and public buildings, preceded by the retrofitting and ugrading of existing heat networks.

The regional and local financial mechanisms through which the local authority can attract investors, to develop the local economy, create jobs and support the local budget, should not be neglected as the coal mining and energy industry shrinks completely.

The European Commission, through DG-Energy and the Coal Regions in Transition Initiative, draws attention to the fact that transition from coal is a long process, but with proper planning and good management, it leads to socio-economic transformation beneficial to all the stakeholders involved.

## 7 BIBLIOGRAPHY

ANRE (2021) *Report on the state of the public centralised heat supply services for 2020*

EC (2010) *Report from the Commission to the Council and the European Parliament on sustainability requirements for the use of solid and gaseous biomass sources for electricity, heating and cooling COM(2010)11 final*. Brussels: European Commission.

EC (2022) *REPowerEU Plan - COM(2022) 230 final.* Brussels: European Commission.

CJGorj. (2016). *County plan for maintaining air quality 2017-2022.* Targul Jiu: Gorj County Council.

CJGorj. (2022). *Territorial Plan for Just Transition in Gorj County - PTTJ Gorj.* Târgu Jiu.

CRIT (2021). *Transition Financing Toolkit.* Brussels: EC - Initiative for Coal Regions in Transition.

DTU. (2022). *Romania / Gorj*. Retrieved from Global Wind Atlas 3.0: https://globalwindatlas.info/area/Romania/Gorj

EUCO scenarios. (2019). *Modelling scenarios.* Brussels: EUCO.

Kapetaki, Z. (2020). *Clean energy technologies in coal regions: Opportunities for jobs and growth: Deployment potential and impacts.* Luxemburg: Publications Office of the European Union.

MDLPA (2021). *Background study "Territorial disparities in Romania".* Bucharest: Ministry of Development, Public Works and Administration.

Ministry of Energy (2019). Romania's Energy Strategy 2020-2030, with a view to 2050

Ministry of Development, Public Works and Administration (2020). National Long-Term Renovation Strategy to support the renovation of the national stock of residential and non-residential buildings, both public and private, into a highly energy-efficient and decarbonised building stock by 2050.

Roșca, M. (2011) Geothermal Resources of Romania. *Geoelec Workshop.* Athens.

SGA Gorj. (2021). *Presentation of SGA Gorj.* Târgu Jiu: National Administration of Romanian Waters - Jiu Basin Administration.

Sigma Mobility Engineering (2020). *Local Development Strategy of Motru 2021-2027 - SDL Motru.* Motru: Municipality of Motru.

Solargis. (2021). *Romania / Gorj*. Retrieved from Global Solar Atlas 2.0: https://globalsolaratlas.info/map?c=44.959454,23.208618,10&r=ROU:ROU.21_1

***Premises***

| | | |
|---|---|---|
| Total Investment (VAT excluded) | 7221.36 | thousand euro |
| Discount Rate | 4% | |

***Financial Analysis - Scenario 1***

***Distributed Heat Supply System (CTZ + roof PV + HPs)***

| Specification | M.U. | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 | Year 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Electricity purchased from the NPS for 19 x CTZ and HPs*** | MWh | 0.00 | 0.00 | 5444.90 | 5461.67 | 5476.53 | 5489.56 | 5502.22 | 5542.51 | 5542.51 | 5542.51 | 5542.51 |
| ***Electricity generated by roof PVs, of which:*** | MWh | 0.00 | 0.00 | 95.62 | 95.62 | 95.62 | 95.62 | 95.62 | 95.62 | 95.62 | 95.62 | 95.62 |
| - for internal self-services of 19 x CTZ | MWh | 0.00 | 0.00 | 47.81 | 47.81 | 47.81 | 47.81 | 47.81 | 47.81 | 47.81 | 47.81 | 47.81 |
| - delivered in NPS | MWh | 0.00 | 0.00 | 47.81 | 47.81 | 47.81 | 47.81 | 47.81 | 47.81 | 47.81 | 47.81 | 47.81 |
| | | | | | | | | | | | | |
| ***Thermal Energy (Heat) generated, of which:*** | ***Gcal*** | ***0.00*** | ***0.00*** | ***40774.36*** | ***41536.61*** | ***42212.36*** | ***42804.64*** | ***43379.80*** | ***45211.38*** | ***45211.38*** | ***45211.38*** | ***45211.38*** |
| - by 19 x CTZ | Gcal | 0.00 | 0.00 | 30739.36 | 31501.61 | 32177.36 | 32769.64 | 33344.80 | 35176.38 | 35176.38 | 35176.38 | 35176.38 |
| - by HPs | Gcal | 0.00 | 0.00 | 10035.00 | 10035.00 | 10035.00 | 10035.00 | 10035.00 | 10035.00 | 10035.00 | 10035.00 | 10035.00 |
| ***Thermal Energy (Heat) sold, of which:*** | ***Gcal*** | ***0.00*** | ***0.00*** | ***37512.41*** | ***38213.68*** | ***38835.37*** | ***39380.27*** | ***39909.42*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** |
| - to non-domestic consumers | Gcal | 0.00 | 0.00 | 5409.95 | 5511.08 | 5600.74 | 5679.32 | 5755.64 | 5998.65 | 5998.65 | 5998.65 | 5998.65 |
| - to domestic consumers | Gcal | 0.00 | 0.00 | 32102.47 | 32702.60 | 33234.63 | 33700.95 | 34153.78 | 35595.82 | 35595.82 | 35595.82 | 35595.82 |
| | | | | | | | | | | | | |
| **Prices** | | | | | | | | | | | | |
| - electricity purchased from the NPS | euro/MWh | 263.00 | 272.86 | 259.22 | 236.09 | 214.63 | 220.58 | 226.90 | 236.20 | 245.50 | 254.46 | 263.17 |
| - electricity sold to the NPS | euro/MWh | 175.04 | 181.60 | 172.52 | 157.13 | 142.85 | 146.81 | 151.02 | 157.20 | 163.39 | 169.36 | 175.15 |
| - thermal energy (heat) sold to non-domestic consumers | euro/Gcal | 38.16 | 39.31 | 41.67 | 44.17 | 46.82 | 49.63 | 52.61 | 55.76 | 59.11 | 62.65 | 66.41 |
| - thermal energy (heat) sold to domestic consumers | euro/Gcal | 38.16 | 39.31 | 41.67 | 44.17 | 46.82 | 49.63 | 52.61 | 55.76 | 59.11 | 62.65 | 66.41 |

| Specification | M.U. | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 | Year 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **TOTAL REVENUES, of which:** | **thousand euro** | **0.00** | **0.00** | **3836.91** | **4085.22** | **4342.04** | **4609.50** | **4891.08** | **5305.37** | **5571.46** | **5850.22** | **6142.38** |
| Revenues from sold electricity, generated by roof PVs and sold to the NPS | thousand euro | 0.00 | 0.00 | 8.25 | 7.51 | 6.83 | 7.02 | 7.22 | 7.52 | 7.81 | 8.10 | 8.37 |
| Costs savings related to the 19 x CTZ internal self-services' electricity, treated as revenues | thousand euro | 0.00 | 0.00 | 12.39 | 11.29 | 10.26 | 10.55 | 10.85 | 11.29 | 11.74 | 12.17 | 12.58 |
| Costs savings related to CO2 certificates purchase, treated as revenues | thousand euro | 0.00 | 0.00 | 2253.20 | 2378.60 | 2506.74 | 2637.60 | 2773.58 | 2967.19 | 3093.38 | 3223.92 | 3359.03 |
| Revenues from the sale of thermal energy (heat) to final users/consumers, of which: | thousand euro | 0.00 | 0.00 | 1563.07 | 1687.83 | 1818.21 | 1954.34 | 2099.44 | 2319.36 | 2458.53 | 2606.04 | 2762.40 |
| - to non-domestic consumers | thousand euro | 0.00 | 0.00 | 225.42 | 243.41 | 262.22 | 281.85 | 302.78 | 334.49 | 354.56 | 375.84 | 398.39 |
| - to domestic consumers | thousand euro | 0.00 | 0.00 | 1337.65 | 1444.41 | 1555.99 | 1672.49 | 1796.66 | 1984.87 | 2103.96 | 2230.20 | 2364.01 |
| | | | | | | | | | | | | |
| **TOTAL COSTS, of which:** | **thousand euro** | **2888.54** | **4332.82** | **7520.61** | **7436.04** | **7325.49** | **7349.16** | **7521.56** | **7895.26** | **7986.07** | **8075.11** | **8162.83** |
| **TOTAL OPERATING COSTS, of which:** | thousand euro | **0.00** | **0.00** | **7520.61** | **7436.04** | **7325.49** | **7349.16** | **7521.56** | **7895.26** | **7986.07** | **8075.11** | **8162.83** |
| - PVs operating costs | thousand euro | 0.00 | 0.00 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 |
| - 19 x CTZ operating costs | thousand euro | 0.00 | 0.00 | 5309.63 | 5194.64 | 5054.56 | 5049.64 | 5193.20 | 5511.13 | 5583.58 | 5654.26 | 5723.61 |
| - HPs operating costs | thousand euro | 0.00 | 0.00 | 102.83 | 102.83 | 102.83 | 102.83 | 102.83 | 102.83 | 102.83 | 102.83 | 102.83 |
| - Costs for CO2 certificates | thousand euro | 0.00 | 0.00 | 563.56 | 593.98 | 623.52 | 652.10 | 680.95 | 736.71 | 755.07 | 773.43 | 791.80 |
| - Staff / personnel costs | thousand euro | 0.00 | 0.00 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 |
| | | | | | | | | | | | | |
| **TOTAL INVESTMENT, of which:** | **thousand euro** | **2888.54** | **4332.82** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| - roof PVs | thousand euro | 34.5904 | 51.8856 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| - 19 x CTZ | thousand euro | 1017.34 | 1526.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| - HPs | thousand euro | 1836.6096 | 2754.9144 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | | | | | | | | | | | |
| ***Investment Cash Flow*** | ***thousand euro*** | ***-2888.54*** | ***-4332.82*** | ***-3683.70*** | ***-3350.81*** | ***-2983.45*** | ***-2739.66*** | ***-2630.48*** | ***-2589.89*** | ***-2414.61*** | ***-2224.89*** | ***-2020.44*** |
| ***Investment Cumulative Cash Flow*** | ***thousand euro*** | ***-2888.54*** | ***-7221.36*** | ***-10905.06*** | ***-14255.87*** | ***-17239.33*** | ***-19978.99*** | ***-22609.47*** | ***-25199.36*** | ***-27613.97*** | ***-29838.86*** | ***-31859.30*** |

**Results**

| | | |
|---|---|---|
| NPV | -31016.11 | thousand euro |
| IRR | #NUM! | |
| B/C | 0.71 | |

| Year 12 | Year 13 | Year 14 | Year 15 | Year 16 | Year 17 | Year 18 | Year 19 | Year 20 | Year 21 | Year 22 |
|---|---|---|---|---|---|---|---|---|---|---|
| 5542.51 | 5542.51 | 5542.51 | 5542.51 | 5542.51 | 5542.51 | 5542.51 | 5542.51 | 5542.51 | 5542.51 | 5542.51 |
| 95.62 | 95.62 | 95.62 | 95.62 | 95.62 | 95.62 | 95.62 | 95.62 | 95.62 | 95.62 | 95.62 |
| 47.81 | 47.81 | 47.81 | 47.81 | 47.81 | 47.81 | 47.81 | 47.81 | 47.81 | 47.81 | 47.81 |
| 47.81 | 47.81 | 47.81 | 47.81 | 47.81 | 47.81 | 47.81 | 47.81 | 47.81 | 47.81 | 47.81 |
| ***45211.38*** | ***45211.38*** | ***45211.38*** | ***45211.38*** | ***45211.38*** | ***45211.38*** | ***45211.38*** | ***45211.38*** | ***45211.38*** | ***45211.38*** | ***45211.38*** |
| 35176.38 | 35176.38 | 35176.38 | 35176.38 | 35176.38 | 35176.38 | 35176.38 | 35176.38 | 35176.38 | 35176.38 | 35176.38 |
| 10035.00 | 10035.00 | 10035.00 | 10035.00 | 10035.00 | 10035.00 | 10035.00 | 10035.00 | 10035.00 | 10035.00 | 10035.00 |
| ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***42160.38*** |
| 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 6564.56 |
| 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 |
| 271.80 | 279.52 | 286.67 | 293.78 | 300.57 | 307.72 | 314.71 | 321.48 | 328.23 | 334.95 | 341.65 |
| 180.89 | 186.03 | 190.79 | 195.53 | 200.04 | 204.80 | 209.45 | 213.96 | 218.45 | 222.93 | 227.39 |
| 70.40 | 74.62 | 79.10 | 83.84 | 88.88 | 94.21 | 99.86 | 105.85 | 112.20 | 118.93 | 126.07 |
| 70.40 | 74.62 | 79.10 | 83.84 | 88.88 | 94.21 | 99.86 | 105.85 | 112.20 | 118.93 | 126.07 |

| Year 12 | Year 13 | Year 14 | Year 15 | Year 16 | Year 17 | Year 18 | Year 19 | Year 20 | Year 21 | Year 22 | TOTAL | TOTAL DISCOUNTED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **6448.73** | **6691.95** | **6945.12** | **7208.91** | **7483.97** | **7771.07** | **8070.91** | **8384.30** | **8712.08** | **9055.17** | **9485.85** | **130892.27** | **77526.42** |
| 8.65 | 8.89 | 9.12 | 9.35 | 9.56 | 9.79 | 10.01 | 10.23 | 10.44 | 10.66 | 10.87 | **176.22** | **107.46** |
| 13.00 | 13.36 | 13.71 | 14.05 | 14.37 | 14.71 | 15.05 | 15.37 | 15.69 | 16.01 | 16.33 | **264.77** | **161.46** |
| 3498.94 | 3565.86 | 3632.23 | 3698.05 | 3763.33 | 3828.05 | 3892.23 | 3955.85 | 4018.93 | 4081.46 | 4143.44 | **67271.62** | **40.615.25** |
| 2928.14 | 3103.83 | 3290.06 | 3487.46 | 3696.71 | 3918.52 | 4153.63 | 4402.84 | 4667.01 | 4947.04 | 5315.20 | **63179.66** | **36.642.25** |
| 422.29 | 447.63 | 474.48 | 502.95 | 533.13 | 565.12 | 599.03 | 634.97 | 673.07 | 713.45 | 827.60 | **9172.67** | **5.310.22** |
| 2505.85 | 2656.20 | 2815.58 | 2984.51 | 3163.58 | 3353.40 | 3554.60 | 3767.88 | 3993.95 | 4233.59 | 4487.60 | **54006.99** | **31,332.04** |
| **8250.25** | **8332.73** | **8412.19** | **8491.50** | **8569.12** | **8648.89** | **8727.84** | **8805.68** | **8883.55** | **8961.40** | **9039.20** | **171615.85** | **108542.53** |
| **8250.25** | **8332.73** | **8412.19** | **8491.50** | **8569.12** | **8648.89** | **8727.84** | **8805.68** | **8883.55** | **8961.40** | **9039.20** | **164394.49** | **101759.15** |
| 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 | **8.65** | **5.43** |
| 5792.68 | 5856.79 | 5917.89 | 5978.84 | 6038.11 | 6099.52 | 6160.10 | 6219.58 | 6279.09 | 6338.58 | 6398.02 | **115353.44** | **71.307.72** |
| 102.83 | 102.83 | 102.83 | 102.83 | 102.83 | 102.83 | 102.83 | 102.83 | 102.83 | 102.83 | 102.83 | **2056.59** | **1.292.06** |
| 810.16 | 828.52 | 846.88 | 865.24 | 883.60 | 901.96 | 920.32 | 938.68 | 957.04 | 975.40 | 993.76 | **16092.67** | **9.751.58** |
| 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | **30883.14** | **19,402.36** |
| **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **7221.36** | **6783.38** |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **86.48** | **81.23** |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **2543.36** | **2.389.10** |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **4591.52** | **4,313.04** |
| ***-1801.52*** | ***-1640.78*** | ***-1467.06*** | ***-1282.58*** | ***-1085.15*** | ***-877.82*** | ***-656.93*** | ***-421.38*** | ***-171.47*** | ***93.77*** | ***446.65*** | ***-40723.59*** | ***-31016.11*** |
| ***-33660.83*** | ***-35301.60*** | ***-36768.67*** | ***-38051.25*** | ***-39136.40*** | ***-40014.22*** | ***-40671.15*** | ***-41092.54*** | ***-41264.00*** | ***-41170.23*** | ***-40723.59*** | ***-637464.62*** | |

***Premises***

| | | |
|---|---|---|
| Total Investment (VAT excluded) | 15698.07 | thousand euro |
| Discount Rate | 4% | |

***Financial Analysis - Scenario 2***

***Centralised Heat Supply System (HWB + WtE-CHP + ground PVs)***

| Specification | M.U. | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 | Year 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Generated Electricity, of which:*** | ***MWh*** | ***0.00*** | ***0.00*** | ***9295.08*** | ***9295.08*** | ***9295.08*** | ***9295.08*** | ***9295.08*** | ***9295.08*** | ***9295.08*** | ***9295.08*** | ***9295.08*** |
| - by ground PVs | MWh | 0.00 | 0.00 | 7187.50 | 7187.50 | 7187.50 | 7187.50 | 7187.50 | 7187.50 | 7187.50 | 7187.50 | 7187.50 |
| - by WtE-CHP | MWh | 0.00 | 0.00 | 2107.58 | 2107.58 | 2107.58 | 2107.58 | 2107.58 | 2107.58 | 2107.58 | 2107.58 | 2107.58 |
| ***Internal electrical self-services*** | ***MWh*** | ***0.00*** | ***0.00*** | ***1046.18*** | ***1064.33*** | ***1080.42*** | ***1094.52*** | ***1108.22*** | ***1151.83*** | ***1151.83*** | ***1151.83*** | ***1151.83*** |
| ***Electricity delivered in NPS*** | ***MWh*** | ***0.00*** | ***0.00*** | ***8248.90*** | ***8230.75*** | ***8214.66*** | ***8200.56*** | ***8186.86*** | ***8143.25*** | ***8143.25*** | ***8143.25*** | ***8143.25*** |
| | | | | | | | | | | | | |
| ***Thermal Energy (Heat) generated, of which:*** | ***Gcal*** | ***0.00*** | ***0.00*** | ***44132.25*** | ***44957.27*** | ***45688.68*** | ***46329.73*** | ***46952.26*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** |
| - by HWBs | Gcal | 0.00 | 0.00 | 38110.58 | 38935.60 | 39667.01 | 40308.07 | 40930.59 | 42913.01 | 42913.01 | 42913.01 | 42913.01 |
| - by WtE-CHP | Gcal | 0.00 | 0.00 | 6021.67 | 6021.67 | 6021.67 | 6021.67 | 6021.67 | 6021.67 | 6021.67 | 6021.67 | 6021.67 |
| ***Thermal Energy (Heat) sold, of which:*** | ***Gcal*** | ***0.00*** | ***0.00*** | ***37512.41*** | ***38213.68*** | ***38835.37*** | ***39380.27*** | ***39909.42*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** |
| - to non-domestic consumers | Gcal | 0.00 | 0.00 | 5409.95 | 5511.08 | 5600.74 | 5679.32 | 5755.64 | 5998.65 | 5998.65 | 5998.65 | 5998.65 |
| - to domestic consumers | Gcal | 0.00 | 0.00 | 32102.47 | 32702.60 | 33234.63 | 33700.95 | 34153.78 | 35595.82 | 35595.82 | 35595.82 | 35595.82 |
| | | | | | | | | | | | | |
| **Prices** | | | | | | | | | | | | |
| - electricity purchased from the NPS | euro/MWh | 263.00 | 272.86 | 259.22 | 236.09 | 214.63 | 220.58 | 226.90 | 236.20 | 245.50 | 254.46 | 263.17 |
| - electricity sold to the NPS | euro/MWh | 175.04 | 181.60 | 172.52 | 157.13 | 142.85 | 146.81 | 151.02 | 157.20 | 163.39 | 169.36 | 175.15 |
| - thermal energy (heat) sold to non-domestic consumers | euro/Gcal | 38.16 | 39.31 | 41.67 | 44.17 | 46.82 | 49.63 | 52.61 | 55.76 | 59.11 | 62.65 | 66.41 |
| - thermal energy (heat) sold to domestic consumers | euro/Gcal | 38.16 | 39.31 | 41.67 | 44.17 | 46.82 | 49.63 | 52.61 | 55.76 | 59.11 | 62.65 | 66.41 |

| Specification | M.U. | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 | Year 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **TOTAL REVENUES, of which:** | **thousand euro** | **0.00** | **0.00** | **5139.25** | **5228.27** | **5336.17** | **5631.86** | **5944.08** | **6409.14** | **6724.90** | **7051.13** | **7389.08** |
| Revenues from sold electricity, generated by ground PVs and WtE-CHP | thousand euro | 0.00 | 0.00 | 1423.11 | 1293.30 | 1173.43 | 1203.90 | 1236.34 | 1280.16 | 1330.56 | 1379.12 | 1426.29 |
| Costs savings related to the internal self-services' electricity, treated as revenues | thousand euro | 0.00 | 0.00 | 271.19 | 251.28 | 231.89 | 241.43 | 251.46 | 272.07 | 282.78 | 293.10 | 303.12 |
| Costs savings related to CO2 certificates purchase, treated as revenues | thousand euro | 0.00 | 0.00 | 1881.88 | 1995.86 | 2112.64 | 2232.19 | 2356.84 | 2537.55 | 2653.04 | 2772.86 | 2897.26 |
| Revenues from the sale of thermal energy (heat) to final users/consumers, of which: | thousand euro | 0.00 | 0.00 | 1563.07 | 1687.83 | 1818.21 | 1954.34 | 2099.44 | 2319.36 | 2458.53 | 2606.04 | 2762.40 |
| - to non-domestic consumers | thousand euro | 0.00 | 0.00 | 225.42 | 243.41 | 262.22 | 281.85 | 302.78 | 334.49 | 354.56 | 375.84 | 398.39 |
| - to domestic consumers | thousand euro | 0.00 | 0.00 | 1337.65 | 1444.41 | 1555.99 | 1672.49 | 1796.66 | 1984.87 | 2103.96 | 2230.20 | 2364.01 |
| | | | | | | | | | | | | |
| **TOTAL COSTS, of which:** | **thousand euro** | **6279.23** | **9418.84** | **7413.12** | **7448.90** | **7446.12** | **7427.14** | **7585.04** | **7931.66** | **7985.69** | **8039.83** | **8094.11** |
| **TOTAL OPERATING COSTS, of which:** | thousand euro | **0.00** | **0.00** | **7413.12** | **7448.90** | **7446.12** | **7427.14** | **7585.04** | **7931.66** | **7985.69** | **8039.83** | **8094.11** |
| HWBs operating costs | thousand euro | 0.00 | 0.00 | 4722.72 | 4716.67 | 4672.99 | 4614.12 | 4731.84 | 5009.79 | 5034.75 | 5059.83 | 5085.03 |
| WtE operating costs | thousand euro | 0.00 | 0.00 | 178.86 | 178.86 | 178.86 | 178.86 | 178.86 | 178.86 | 178.86 | 178.86 | 178.86 |
| ground PVs operating costs | thousand euro | 0.00 | 0.00 | 32.50 | 32.50 | 32.50 | 32.50 | 32.50 | 32.50 | 32.50 | 32.50 | 32.50 |
| Costs for CO2 certificates | thousand euro | 0.00 | 0.00 | 934.88 | 976.72 | 1017.62 | 1057.51 | 1097.68 | 1166.36 | 1195.42 | 1224.49 | 1253.56 |
| Staff / personnel costs | thousand euro | 0.00 | 0.00 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 |
| | | | | | | | | | | | | |
| **TOTAL INVESTMENT, of which:** | thousand euro | **6279.23** | **9418.84** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| - HWBs | thousand euro | 879.228 | 1318.842 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| - WtE | thousand euro | 2800 | 4200 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| - ground PVs | thousand euro | 2600.00 | 3900.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | | | | | | | | | | | |
| ***Investment Cash Flow*** | **thousand euro** | ***-6279.23*** | ***-9418.84*** | ***-2273.87*** | ***-2220.63*** | ***-2109.95*** | ***-1795.28*** | ***-1640.95*** | ***-1522.52*** | ***-1260.79*** | ***-988.71*** | ***-705.03*** |
| ***Investment Cumulative Cash Flow*** | **thousand euro** | ***-6279.23*** | ***-15698.07*** | ***-17971.94*** | ***-20192.57*** | ***-22302.52*** | ***-24097.80*** | ***-25738.75*** | ***-27261.28*** | ***-28522.07*** | ***-29510.78*** | ***-30215.80*** |

**Results**

| | | |
|---|---|---|
| NPV | -21783.27 | thousand euro |
| IRR | -6.83% | |
| B/C | 0.81 | |

| Year 12 | Year 13 | Year 14 | Year 15 | Year 16 | Year 17 | Year 18 | Year 19 | Year 20 | Year 21 | Year 22 |
|---|---|---|---|---|---|---|---|---|---|---|
| ***9295.08*** | ***9295.08*** | ***9295.08*** | ***9295.08*** | ***9295.08*** | ***9295.08*** | ***9295.08*** | ***9295.08*** | ***9295.08*** | ***9295.08*** | ***9295.08*** |
| 7187.50 | 7187.50 | 7187.50 | 7187.50 | 7187.50 | 7187.50 | 7187.50 | 7187.50 | 7187.50 | 7187.50 | 7187.50 |
| 2107.58 | 2107.58 | 2107.58 | 2107.58 | 2107.58 | 2107.58 | 2107.58 | 2107.58 | 2107.58 | 2107.58 | 2107.58 |
| ***1151.83*** | ***1151.83*** | ***1151.83*** | ***1151.83*** | ***1151.83*** | ***1151.83*** | ***1151.83*** | ***1151.83*** | ***1151.83*** | ***1151.83*** | ***1151.83*** |
| ***8143.25*** | ***8143.25*** | ***8143.25*** | ***8143.25*** | ***8143.25*** | ***8143.25*** | ***8143.25*** | ***8143.25*** | ***8143.25*** | ***8143.25*** | ***8143.25*** |
| | | | | | | | | | | |
| ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** |
| 42913.01 | 42913.01 | 42913.01 | 42913.01 | 42913.01 | 42913.01 | 42913.01 | 42913.01 | 42913.01 | 42913.01 | 42913.01 |
| 6021.67 | 6021.67 | 6021.67 | 6021.67 | 6021.67 | 6021.67 | 6021.67 | 6021.67 | 6021.67 | 6021.67 | 6021.67 |
| ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** |
| 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 |
| 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 |
| | | | | | | | | | | |
| 271.80 | 279.52 | 286.67 | 293.78 | 300.57 | 307.72 | 314.71 | 321.48 | 328.23 | 334.95 | 341.65 |
| 180.89 | 186.03 | 190.79 | 195.53 | 200.04 | 204.80 | 209.45 | 213.96 | 218.45 | 222.93 | 227.39 |
| 70.40 | 74.62 | 79.10 | 83.84 | 88.88 | 94.21 | 99.86 | 105.85 | 112.20 | 118.93 | 126.07 |
| 70.40 | 74.62 | 79.10 | 83.84 | 88.88 | 94.21 | 99.86 | 105.85 | 112.20 | 118.93 | 126.07 |

| Year 12 | Year 13 | Year 14 | Year 15 | Year 16 | Year 17 | Year 18 | Year 19 | Year 20 | Year 21 | Year 22 | TOTAL | TOTAL DISCOUNTE D |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **7740.75** | **8023.38** | **8312.29** | **8611.53** | **8919.94** | **9242.77** | **9577.26** | **9923.86** | **10284.76** | **10660.82** | **11052.94** | **157204.19** | **93579.65** |
| 1473.07 | 1514.91 | 1553.69 | 1592.22 | 1629.00 | 1667.77 | 1705.63 | 1742.30 | 1778.89 | 1815.35 | 1851.66 | **30070.70** | **18,350.39** |
| 313.07 | 321.96 | 330.20 | 338.39 | 346.21 | 354.45 | 362.49 | 370.29 | 378.06 | 385.81 | 393.53 | **6292.78** | **3,817.64** |
| 3026.47 | 3082.68 | 3138.35 | 3193.46 | 3248.02 | 3302.04 | 3355.51 | 3408.43 | 3460.80 | 3512.62 | 3563.89 | **57732.40** | **34,799.48** |
| 2928.14 | 3103.83 | 3290.06 | 3487.46 | 3696.71 | 3918.52 | 4153.63 | 4402.84 | 4667.01 | 4947.04 | 5243.86 | **63108.31** | **36,612.15** |
| 422.29 | 447.63 | 474.48 | 502.95 | 533.13 | 565.12 | 599.03 | 634.97 | 673.07 | 713.45 | 756.26 | **9101.32** | **5,280.11** |
| 2505.85 | 2656.20 | 2815.58 | 2984.51 | 3163.58 | 3353.40 | 3554.60 | 3767.88 | 3993.95 | 4233.59 | 4487.60 | **54006.99** | **31,332.04** |
| | | | | | | | | | | | | |
| **8148.50** | **8203.03** | **8257.68** | **8312.46** | **8367.37** | **8422.41** | **8477.58** | **8532.87** | **8588.30** | **8643.86** | **8699.56** | **177723.30** | **115362.92** |
| **8148.50** | **8203.03** | **8257.68** | **8312.46** | **8367.37** | **8422.41** | **8477.58** | **8532.87** | **8588.30** | **8643.86** | **8699.56** | **162025.23** | **100616.95** |
| 5110.36 | 5135.82 | 5161.40 | 5187.12 | 5212.96 | 5238.93 | 5265.03 | 5291.26 | 5317.62 | 5344.11 | 5370.74 | **101283.07** | **62,991.54** |
| 178.86 | 178.86 | 178.86 | 178.86 | 178.86 | 178.86 | 178.86 | 178.86 | 178.86 | 178.86 | 178.86 | **3577.13** | **2,247.34** |
| 32.50 | 32.50 | 32.50 | 32.50 | 32.50 | 32.50 | 32.50 | 32.50 | 32.50 | 32.50 | 32.50 | **650.00** | **408.36** |
| 1282.63 | 1311.70 | 1340.76 | 1369.83 | 1398.90 | 1427.97 | 1457.04 | 1486.10 | 1515.17 | 1544.24 | 1573.31 | **25631.89** | **15,567.35** |
| 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | **30883.14** | **19,402.36** |
| | | | | | | | | | | | | |
| **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **15698.07** | **14745.97** |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **2198.07** | **2,064.76** |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **7000.00** | **6,575.44** |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **6500.00** | **6,105.77** |
| | | | | | | | | | | | | |
| ***-407.75*** | ***-179.65*** | ***54.61*** | ***299.07*** | ***552.57*** | ***820.36*** | ***1099.68*** | ***1390.98*** | ***1696.46*** | ***2016.96*** | ***2353.38*** | ***-20519.11*** | ***-21783.27*** |
| ***-30623.55*** | ***-30803.20*** | ***-30748.59*** | ***-30449.52*** | ***-29896.95*** | ***-29076.58*** | ***-27976.90*** | ***-26585.92*** | ***-24889.46*** | ***-22872.50*** | ***-20519.11*** | ***-552233.09*** | |

***Premises***

| | | |
|---|---|---|
| Total Investment (VAT excluded) | 25249.67 | thousand euro |
| Discount Rate | 4% | |

***Financial Analysis - Scenario 3***

*Centralised Heat Supply System (WtE-CHP + 3 MT-CHP + ground PVs + roof PVs)*

| Specification | M.U. | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 | Year 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Generated electricity, of which:*** | ***MWh*** | ***0.00*** | ***0.00*** | ***59222.17*** | ***59222.17*** | ***59222.17*** | ***59222.17*** | ***59222.17*** | ***59222.17*** | ***59222.17*** | ***59222.17*** | ***59222.17*** |
| - by ground and roof PVs | MWh | 0.00 | 0.00 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 |
| - by MT-CHP | MWh | 0.00 | 0.00 | 49831.46 | 49831.46 | 49831.46 | 49831.46 | 49831.46 | 49831.46 | 49831.46 | 49831.46 | 49831.46 |
| - by WtE-CHP | MWh | 0.00 | 0.00 | 2107.58 | 2107.58 | 2107.58 | 2107.58 | 2107.58 | 2107.58 | 2107.58 | 2107.58 | 2107.58 |
| ***Internal electrical self-services*** | ***MWh*** | ***0.00*** | ***0.00*** | ***2083.80*** | ***2092.05*** | ***2099.36*** | ***2105.77*** | ***2112.00*** | ***2131.82*** | ***2131.82*** | ***2131.82*** | ***2131.82*** |
| ***Electricity delivered in NPS*** | ***MWh*** | ***0.00*** | ***0.00*** | ***57138.37*** | ***57130.12*** | ***57122.81*** | ***57116.39*** | ***57110.17*** | ***57090.35*** | ***57090.35*** | ***57090.35*** | ***57090.35*** |
| ***Thermal Energy (Heat) generated, of which:*** | ***Gcal*** | ***0.00*** | ***0.00*** | ***44132.25*** | ***44957.27*** | ***45688.68*** | ***46329.73*** | ***46952.26*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** |
| - by MT-CHP | Gcal | 0.00 | 0.00 | 38110.58 | 38935.60 | 39667.01 | 40308.07 | 40930.59 | 42913.01 | 42913.01 | 42913.01 | 42913.01 |
| - by WtE-CHP | Gcal | 0.00 | 0.00 | 6021.67 | 6021.67 | 6021.67 | 6021.67 | 6021.67 | 6021.67 | 6021.67 | 6021.67 | 6021.67 |
| ***Thermal Energy (Heat) sold, of which:*** | ***Gcal*** | ***0.00*** | ***0.00*** | ***37512.41*** | ***38213.68*** | ***38835.37*** | ***39380.27*** | ***39909.42*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** |
| - to non-domestic consumers | Gcal | 0.00 | 0.00 | 5409.95 | 5511.08 | 5600.74 | 5679.32 | 5755.64 | 5998.65 | 5998.65 | 5998.65 | 5998.65 |
| - to domestic consumers | Gcal | 0.00 | 0.00 | 32102.47 | 32702.60 | 33234.63 | 33700.95 | 34153.78 | 35595.82 | 35595.82 | 35595.82 | 35595.82 |
| **Prices** | | | | | | | | | | | | |
| - electricity purchased from the NPS | euro/MWh | 263.00 | 272.86 | 259.22 | 236.09 | 214.63 | 220.58 | 226.90 | 236.20 | 245.50 | 254.46 | 263.17 |
| - electricity sold to the NPS | euro/MWh | 175.04 | 181.60 | 172.52 | 157.13 | 142.85 | 146.81 | 151.02 | 157.20 | 163.39 | 169.36 | 175.15 |
| - thermal energy (heat) sold to non-domestic consumers | euro/Gcal | 38.16 | 39.31 | 41.67 | 44.17 | 46.82 | 49.63 | 52.61 | 55.76 | 59.11 | 62.65 | 66.41 |
| - thermal energy (heat) sold to domestic consumers | euro/Gcal | 38.16 | 39.31 | 41.67 | 44.17 | 46.82 | 49.63 | 52.61 | 55.76 | 59.11 | 62.65 | 66.41 |

| Specification | M.U. | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 | Year 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **TOTAL REVENUES, of which:** | **thousand euro** | **0.00** | **0.00** | **12982.54** | **12268.89** | **11630.20** | **12099.78** | **12598.35** | **13346.49** | **13949.66** | **14551.94** | **15157.28** |
| Revenues from sold electricity, generated by ground & roof PVs,MT-CHP and WtE-CHP | thousand euro | 0.00 | 0.00 | 9857.57 | 8976.88 | 8159.76 | 8385.08 | 8624.53 | 8974.87 | 9328.22 | 9668.70 | 9999.36 |
| Costs savings related to the internal self-services' electricity, treated as revenues | thousand euro | 0.00 | 0.00 | 540.16 | 493.92 | 450.59 | 464.49 | 479.22 | 503.55 | 523.37 | 542.47 | 561.03 |
| Costs savings related to CO2 certificates purchase, treated as revenues | thousand euro | 0.00 | 0.00 | 1021.74 | 1110.26 | 1201.65 | 1295.86 | 1395.16 | 1548.71 | 1639.55 | 1734.74 | 1834.49 |
| Revenues from the sale of thermal energy (heat) to final users/consumers, of which: | thousand euro | 0.00 | 0.00 | 1563.07 | 1687.83 | 1818.21 | 1954.34 | 2099.44 | 2319.36 | 2458.53 | 2606.04 | 2762.40 |
| - to non-domestic consumers | thousand euro | 0.00 | 0.00 | 225.42 | 243.41 | 262.22 | 281.85 | 302.78 | 334.49 | 354.56 | 375.84 | 398.39 |
| - to domestic consumers | thousand euro | 0.00 | 0.00 | 1337.65 | 1444.41 | 1555.99 | 1672.49 | 1796.66 | 1984.87 | 2103.96 | 2230.20 | 2364.01 |
| **TOTAL COSTS, of which:** | **thousand euro** | **10099.87** | **15149.80** | **14297.67** | **14232.20** | **14100.45** | **13951.48** | **14194.12** | **14638.00** | **14744.74** | **14851.73** | **14959.00** |
| **TOTAL OPERATING COSTS, of which:** | thousand euro | **0.00** | **0.00** | **14297.67** | **14232.20** | **14100.45** | **13951.48** | **14194.12** | **14638.00** | **14744.74** | **14851.73** | **14959.00** |
| 3 x MT-CHP operating costs | thousand euro | 0.00 | 0.00 | 10746.70 | 10613.94 | 10415.89 | 10201.70 | 10378.82 | 10726.86 | 10779.88 | 10833.17 | 10886.72 |
| Costs for CO2 certificates | thousand euro | 0.00 | 0.00 | 1795.03 | 1862.32 | 1928.61 | 1993.84 | 2059.36 | 2155.20 | 2208.91 | 2262.62 | 2316.33 |
| WtE-CHP operating costs | thousand euro | 0.00 | 0.00 | 178.86 | 178.86 | 178.86 | 178.86 | 178.86 | 178.86 | 178.86 | 178.86 | 178.86 |
| ground & roof PVs operating costs | thousand euro | 0.00 | 0.00 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 |
| Staff / personnel costs | thousand euro | 0.00 | 0.00 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 |
| **TOTAL INVESTMENT, of which:** | thousand euro | **10099.87** | **15149.80** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| - 3 x MT-CHP | thousand euro | 4665.276 | 6997.914 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| - WtE-CHP | thousand euro | 2800.00 | 4200.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| - ground & roof PVs | thousand euro | 2634.5904 | 3951.8856 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ***Investment Cash Flow*** | **thousand euro** | ***-10099.87*** | ***-15149.80*** | ***-1315.13*** | ***-1963.31*** | ***-2470.25*** | ***-1851.70*** | ***-1595.78*** | ***-1291.51*** | ***-795.07*** | ***-299.79*** | ***198.29*** |
| ***Investment Cumulative Cash Flow*** | **thousand euro** | ***-10099.87*** | ***-25249.67*** | ***-26564.79*** | ***-28528.10*** | ***-30998.36*** | ***-32850.06*** | ***-34445.84*** | ***-35737.35*** | ***-36532.42*** | ***-36832.21*** | ***-36633.93*** |

**Results**

| | | |
|---|---|---|
| NPV | -17876.93 | thousand euro |
| IRR | -1.10% | |
| B/C | 0.92 | |

| Year 12 | Year 13 | Year 14 | Year 15 | Year 16 | Year 17 | Year 18 | Year 19 | Year 20 | Year 21 | Year 22 | TOTAL | TOTAL DISCOUNTED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***59222.17*** | ***59222.17*** | ***59222.17*** | ***59222.17*** | ***59222.17*** | ***59222.17*** | ***59222.17*** | ***59222.17*** | ***59222.17*** | ***59222.17*** | ***59222.17*** | ***1184443.33*** | ***744.127.75*** |
| 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 145662.45 | 91.512.58 |
| 49831.46 | 49831.46 | 49831.46 | 49831.46 | 49831.46 | 49831.46 | 49831.46 | 49831.46 | 49831.46 | 49831.46 | 49831.46 | 996629.22 | 626.133.34 |
| 2107.58 | 2107.58 | 2107.58 | 2107.58 | 2107.58 | 2107.58 | 2107.58 | 2107.58 | 2107.58 | 2107.58 | 2107.58 | 42151.67 | 26.481.83 |
| ***2131.82*** | ***2131.82*** | ***2131.82*** | ***2131.82*** | ***2131.82*** | ***2131.82*** | ***2131.82*** | ***2131.82*** | ***2131.82*** | ***2131.82*** | ***2131.82*** | ***42470.30*** | ***26.647.36*** |
| ***57090.35*** | ***57090.35*** | ***57090.35*** | ***57090.35*** | ***57090.35*** | ***57090.35*** | ***57090.35*** | ***57090.35*** | ***57090.35*** | ***57090.35*** | ***57090.35*** | ***1141973.04*** | ***717,480.39*** |
| | | | | | | | | | | | | |
| ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | **962080.31** | **600.962.79** |
| 42913.01 | 42913.01 | 42913.01 | 42913.01 | 42913.01 | 42913.01 | 42913.01 | 42913.01 | 42913.01 | 42913.01 | 42913.01 | 841646.98 | 525.300.42 |
| 6021.67 | 6021.67 | 6021.67 | 6021.67 | 6021.67 | 6021.67 | 6021.67 | 6021.67 | 6021.67 | 6021.67 | 6021.67 | 120433.33 | 75.662.37 |
| ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | **817768.26** | **510.818.37** |
| 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 117936.47 | 73.668.93 |
| 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 699831.79 | 437,149.44 |
| | | | | | | | | | | | | |
| 271.80 | 279.52 | 286.67 | 293.78 | 300.57 | 307.72 | 314.71 | 321.48 | 328.23 | 334.95 | 341.65 | 6073.71 | 3.882.17 |
| 180.89 | 186.03 | 190.79 | 195.53 | 200.04 | 204.80 | 209.45 | 213.96 | 218.45 | 222.93 | 227.39 | 4042.33 | 2.583.76 |
| 70.40 | 74.62 | 79.10 | 83.84 | 88.88 | 94.21 | 99.86 | 105.85 | 112.20 | 118.93 | 126.07 | 1610.26 | 966.22 |
| 70.40 | 74.62 | 79.10 | 83.84 | 88.88 | 94.21 | 99.86 | 105.85 | 112.20 | 118.93 | 126.07 | 1610.26 | 966.22 |

| Year 12 | Year 13 | Year 14 | Year 15 | Year 16 | Year 17 | Year 18 | Year 19 | Year 20 | Year 21 | Year 22 | TOTAL | TOTAL DISCOUNTED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **15773.97** | **16290.98** | **16795.37** | **17308.53** | **17820.03** | **18358.26** | **18902.50** | **19451.51** | **20014.31** | **20591.52** | **21183.79** | **321075.91** | **193511.48** |
| 10327.34 | 10620.64 | 10892.53 | 11162.66 | 11420.52 | 11692.33 | 11957.75 | 12214.84 | 12471.35 | 12727.01 | 12981.55 | **210443.50** | **128.335.43** |
| 579.43 | 595.88 | 611.14 | 626.29 | 640.76 | 656.01 | 670.90 | 685.33 | 699.72 | 714.06 | 728.34 | **11766.66** | **7.166.40** |
| 1939.06 | 1970.62 | 2001.64 | 2032.11 | 2062.03 | 2091.40 | 2120.23 | 2148.50 | 2176.23 | 2203.41 | 2230.04 | **35757.44** | **21.397.50** |
| 2928.14 | 3103.83 | 3290.06 | 3487.46 | 3696.71 | 3918.52 | 4153.63 | 4402.84 | 4667.01 | 4947.04 | 5243.86 | **63108.31** | **36.612.15** |
| 422.29 | 447.63 | 474.48 | 502.95 | 533.13 | 565.12 | 599.03 | 634.97 | 673.07 | 713.45 | 756.26 | **9101.32** | **5.280.11** |
| 2505.85 | 2656.20 | 2815.58 | 2984.51 | 3163.58 | 3353.40 | 3554.60 | 3767.88 | 3993.95 | 4233.59 | 4487.60 | **54006.99** | **31,332.04** |
| | | | | | | | | | | | | |
| **15066.53** | **15174.33** | **15282.40** | **15390.74** | **15499.36** | **15608.25** | **15717.41** | **15826.86** | **15936.58** | **16046.58** | **16156.86** | **326924.94** | **211388.41** |
| **15066.53** | **15174.33** | **15282.40** | **15390.74** | **15499.36** | **15608.25** | **15717.41** | **15826.86** | **15936.58** | **16046.58** | **16156.86** | **301675.27** | **187670.16** |
| 10940.54 | 10994.63 | 11048.98 | 11103.61 | 11158.52 | 11213.70 | 11269.15 | 11324.88 | 11380.89 | 11437.18 | 11493.75 | **218949.50** | **136.637.34** |
| 2370.04 | 2423.76 | 2477.47 | 2531.18 | 2584.89 | 2638.60 | 2692.32 | 2746.03 | 2799.74 | 2853.45 | 2907.16 | **47606.86** | **28.969.33** |
| 178.86 | 178.86 | 178.86 | 178.86 | 178.86 | 178.86 | 178.86 | 178.86 | 178.86 | 178.86 | 178.86 | **3577.13** | **2.247.34** |
| 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | **658.65** | **413.80** |
| 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | **30883.14** | **19,402.36** |
| | | | | | | | | | | | | |
| **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **25249.67** | **23718.25** |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **11663.19** | **10.955.81** |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.00** | **6.575.44** |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6586.48 | **6,187.00** |
| | | | | | | | | | | | | |
| ***707.44*** | ***1116.65*** | ***1512.97*** | ***1917.79*** | ***2320.67*** | ***2750.01*** | ***3185.09*** | ***3624.66*** | ***4077.74*** | ***4544.94*** | ***5026.93*** | ***-5849.03*** | ***-17876.93*** |
| ***-35926.48*** | ***-34809.83*** | ***-33296.86*** | ***-31379.07*** | ***-29058.40*** | ***-26308.38*** | ***-23123.29*** | ***-19498.63*** | ***-15420.90*** | ***-10875.96*** | ***-5849.03*** | ***-600019.43*** | |

***Premises***

| | | |
|---|---|---|
| Total Investment (VAT excluded) | 29526.60 | thousand euro |
| Discount Rate | 4% | |

***Financial Analysis - Scenario 4a***

***Centralised Heat Supply System (biomass-based CHP + ground & roof PVs)***

| Specification | M.U. | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 | Year 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Generated electricity, of which:*** | ***MWh*** | ***0.00*** | ***0.00*** | ***32946.03*** | ***33425.77*** | ***33851.09*** | ***34223.86*** | ***34585.86*** | ***35738.64*** | ***35738.64*** | ***35738.64*** | ***35738.64*** |
| - by ground and roof PVs | MWh | 0.00 | 0.00 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 |
| - by biomass-based CHP plant | MWh | 0.00 | 0.00 | 25662.90 | 26142.65 | 26567.96 | 26940.74 | 27302.74 | 28455.51 | 28455.51 | 28455.51 | 28455.51 |
| ***Internal electrical self-services*** | ***MWh*** | ***0.00*** | ***0.00*** | ***1211.21*** | ***1233.85*** | ***1253.93*** | ***1271.52*** | ***1288.60*** | ***1343.01*** | ***1343.01*** | ***1343.01*** | ***1343.01*** |
| ***Electricity delivered in NPS*** | ***MWh*** | ***0.00*** | ***0.00*** | ***31734.82*** | ***32191.92*** | ***32597.16*** | ***32952.34*** | ***33297.26*** | ***34395.62*** | ***34395.62*** | ***34395.62*** | ***34395.62*** |
| | | | | | | | | | | | | |
| ***Thermal Energy (Heat) generated, of which:*** | ***Gcal*** | ***0.00*** | ***0.00*** | ***44132.25*** | ***44957.27*** | ***45688.68*** | ***46329.73*** | ***46952.26*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** |
| - by biomass-based CHP plant | Gcal | 0.00 | 0.00 | 44132.25 | 44957.27 | 45688.68 | 46329.73 | 46952.26 | 48934.67 | 48934.67 | 48934.67 | 48934.67 |
| ***Thermal Energy (Heat) sold, of which:*** | ***Gcal*** | ***0.00*** | ***0.00*** | ***37512.41*** | ***38213.68*** | ***38835.37*** | ***39380.27*** | ***39909.42*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** |
| - to non-domestic consumers | Gcal | 0.00 | 0.00 | 5409.95 | 5511.08 | 5600.74 | 5679.32 | 5755.64 | 5998.65 | 5998.65 | 5998.65 | 5998.65 |
| - to domestic consumers | Gcal | 0.00 | 0.00 | 32102.47 | 32702.60 | 33234.63 | 33700.95 | 34153.78 | 35595.82 | 35595.82 | 35595.82 | 35595.82 |
| | | | | | | | | | | | | |
| **Prices** | | | | | | | | | | | | |
| - electricity purchased from the NPS | euro/MWh | 263.00 | 272.86 | 259.22 | 236.09 | 214.63 | 220.58 | 226.90 | 236.20 | 245.50 | 254.46 | 263.17 |
| - electricity sold to the NPS | euro/MWh | 175.04 | 181.60 | 172.52 | 157.13 | 142.85 | 146.81 | 151.02 | 157.20 | 163.39 | 169.36 | 175.15 |
| - thermal energy (heat) sold to non-domestic consumers | euro/Gcal | 38.16 | 39.31 | 41.67 | 44.17 | 46.82 | 49.63 | 52.61 | 55.76 | 59.11 | 62.65 | 66.41 |
| - thermal energy (heat) sold to domestic consumers | euro/Gcal | 38.16 | 39.31 | 41.67 | 44.17 | 46.82 | 49.63 | 52.61 | 55.76 | 59.11 | 62.65 | 66.41 |

| Specification | M.U. | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 | Year 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **TOTAL REVENUES, of which:** | **thousand euro** | **0.00** | **0.00** | **10168.73** | **10010.04** | **9873.97** | **10362.14** | **10874.76** | **11747.65** | **12256.73** | **12770.31** | **13291.05** |
| Revenues from sold electricity, generated by ground & roof PVs and biomass-based CHP | thousand euro | 0.00 | 0.00 | 5474.93 | 5058.33 | 4656.37 | 4837.63 | 5028.41 | 5407.16 | 5620.04 | 5825.17 | 6024.39 |
| Costs savings related to the internal self-services' electricity, treated as revenues | thousand euro | 0.00 | 0.00 | 313.97 | 291.30 | 269.13 | 280.47 | 292.39 | 317.23 | 329.71 | 341.75 | 353.44 |
| Costs savings related to CO2 certificates purchase, treated as revenues | thousand euro | 0.00 | 0.00 | 2816.76 | 2972.58 | 3130.26 | 3289.70 | 3454.52 | 3703.91 | 3848.46 | 3997.36 | 4150.82 |
| Revenues from the sale of thermal energy (heat) to final users/consumers, of which: | thousand euro | 0.00 | 0.00 | 1563.07 | 1687.83 | 1818.21 | 1954.34 | 2099.44 | 2319.36 | 2458.53 | 2606.04 | 2762.40 |
| - to non-domestic consumers | thousand euro | 0.00 | 0.00 | 225.42 | 243.41 | 262.22 | 281.85 | 302.78 | 334.49 | 354.56 | 375.84 | 398.39 |
| - to domestic consumers | thousand euro | 0.00 | 0.00 | 1337.65 | 1444.41 | 1555.99 | 1672.49 | 1796.66 | 1984.87 | 2103.96 | 2230.20 | 2364.01 |
| | | | | | | | | | | | | |
| **TOTAL COSTS, of which:** | **thousand euro** | **11810.64** | **17715.96** | **6250.24** | **6477.44** | **6703.62** | **6928.59** | **7160.27** | **7566.88** | **7743.88** | **7926.19** | **8113.97** |
| **TOTAL CHELTUIELI DE OPERARE, din care:** | **thousand euro** | **0.00** | **0.00** | **6250.24** | **6477.44** | **6703.62** | **6928.59** | **7160.27** | **7566.88** | **7743.88** | **7926.19** | **8113.97** |
| biomass-based CHP operating costs | thousand euro | 0.00 | 0.00 | 4673.15 | 4900.35 | 5126.53 | 5351.50 | 5583.18 | 5989.79 | 6166.79 | 6349.10 | 6536.88 |
| Costs for CO2 certificates | thousand euro | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ground & roof PVs operating costs | thousand euro | 0.00 | 0.00 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 |
| Staff / personnel costs | thousand euro | 0.00 | 0.00 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 |
| | | 0% | | | | | | | | | | |
| **TOTAL INVESTMENT, of which:** | **thousand euro** | **11810.64** | **17715.96** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| - biomass-based CHP | thousand euro | 9176.050577 | 13764.07587 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| - ground & roof PVs operating costs | thousand euro | 2634.59 | 3951.89 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | | | | | | | | | | | |
| ***Investment Cash Flow*** | ***thousand euro*** | ***-11810.64*** | ***-17715.96*** | ***3918.49*** | ***3532.60*** | ***3170.35*** | ***3433.55*** | ***3714.49*** | ***4180.77*** | ***4512.85*** | ***4844.12*** | ***5177.07*** |
| ***Investment Cumulative Cash Flow*** | ***thousand euro*** | ***-11810.64*** | ***-29526.60*** | ***-25608.11*** | ***-22075.51*** | ***-18905.16*** | ***-15471.61*** | ***-11757.12*** | ***-7576.35*** | ***-3063.50*** | ***1780.62*** | ***6957.69*** |

**Results**

| | | |
|---|---|---|
| NPV | 37692.17 | thousand euro |
| IRR | 13.50% | |
| B/C | 1.29 | |

| Year 12 | Year 13 | Year 14 | Year 15 | Year 16 | Year 17 | Year 18 | Year 19 | Year 20 | Year 21 | Year 22 | TOTAL | TOTAL DISCOUNTED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***35738.64*** | ***35738.64*** | ***35738.64*** | ***35738.64*** | ***35738.64*** | ***35738.64*** | ***35738.64*** | ***35738.64*** | ***35738.64*** | ***35738.64*** | ***35738.64*** | **705112.15** | **440972.45** |
| 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 145662.45 | 91512.58 |
| 28455.51 | 28455.51 | 28455.51 | 28455.51 | 28455.51 | 28455.51 | 28455.51 | 28455.51 | 28455.51 | 28455.51 | 28455.51 | 559449.70 | 349459.86 |
| ***1343.01*** | ***1343.01*** | ***1343.01*** | ***1343.01*** | ***1343.01*** | ***1343.01*** | ***1343.01*** | ***1343.01*** | ***1343.01*** | ***1343.01*** | ***1343.01*** | **26404.29** | **16493.42** |
| ***34395.62*** | ***34395.62*** | ***34395.62*** | ***34395.62*** | ***34395.62*** | ***34395.62*** | ***34395.62*** | ***34395.62*** | ***34395.62*** | ***34395.62*** | ***34395.62*** | **678707.86** | **424479.02** |
| | | | | | | | | | | | | |
| ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | **962080.31** | **600962.79** |
| 48934.67 | 48934.67 | 48934.67 | 48934.67 | 48934.67 | 48934.67 | 48934.67 | 48934.67 | 48934.67 | 48934.67 | 48934.67 | 962080.31 | 600962.79 |
| ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | **817768.26** | **510818.37** |
| 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 117936.47 | 73668.93 |
| 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 699831.79 | 437149.44 |
| | | | | | | | | | | | | |
| 271.80 | 279.52 | 286.67 | 293.78 | 300.57 | 307.72 | 314.71 | 321.48 | 328.23 | 334.95 | 341.65 | 6073.71 | 3882.17 |
| 180.89 | 186.03 | 190.79 | 195.53 | 200.04 | 204.80 | 209.45 | 213.96 | 218.45 | 222.93 | 227.39 | 4042.33 | 2583.76 |
| 70.40 | 74.62 | 79.10 | 83.84 | 88.88 | 94.21 | 99.86 | 105.85 | 112.20 | 118.93 | 126.07 | 1610.26 | 966.22 |
| 70.40 | 74.62 | 79.10 | 83.84 | 88.88 | 94.21 | 99.86 | 105.85 | 112.20 | 118.93 | 126.07 | 1610.26 | 966.22 |

| Year 12 | Year 13 | Year 14 | Year 15 | Year 16 | Year 17 | Year 18 | Year 19 | Year 20 | Year 21 | Year 22 | TOTAL | TOTAL DISCOUNTED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **13824.26** | **14272.30** | **14716.68** | **15170.56** | **15627.91** | **16106.16** | **16593.10** | **17088.28** | **17597.50** | **18121.48** | **18660.99** | **279134.59** | **167521.65** |
| 6221.99 | 6398.69 | 6562.50 | 6725.25 | 6880.60 | 7044.36 | 7204.27 | 7359.16 | 7513.70 | 7667.73 | 7821.09 | **125331.75** | **76,097.27** |
| 365.03 | 375.40 | 385.01 | 394.55 | 403.67 | 413.28 | 422.66 | 431.74 | 440.81 | 449.85 | 458.85 | **7330.23** | **4,445.40** |
| 4309.10 | 4394.38 | 4479.11 | 4563.29 | 4646.92 | 4730.01 | 4812.54 | 4894.53 | 4975.97 | 5056.86 | 5137.20 | **83364.29** | **50,366.83** |
| 2928.14 | 3103.83 | 3290.06 | 3487.46 | 3696.71 | 3918.52 | 4153.63 | 4402.84 | 4667.01 | 4947.04 | 5243.86 | **63108.31** | **36,612.15** |
| 422.29 | 447.63 | 474.48 | 502.95 | 533.13 | 565.12 | 599.03 | 634.97 | 673.07 | 713.45 | 756.26 | **9101.32** | **5,280.11** |
| 2505.85 | 2656.20 | 2815.58 | 2984.51 | 3163.58 | 3353.40 | 3554.60 | 3767.88 | 3993.95 | 4233.59 | 4487.60 | **54006.99** | **31,332.04** |
| | | | | | | | | | | | | |
| **8307.39** | **8506.60** | **8711.80** | **8923.15** | **9140.84** | **9365.06** | **9596.00** | **9833.88** | **10078.89** | **10331.25** | **10591.18** | **197783.72** | **129829.48** |
| **8307.39** | **8506.60** | **8711.80** | **8923.15** | **9140.84** | **9365.06** | **9596.00** | **9833.88** | **10078.89** | **10331.25** | **10591.18** | **168257.11** | **102093.70** |
| 6730.30 | 6929.52 | 7134.71 | 7346.06 | 7563.75 | 7787.97 | 8018.91 | 8256.79 | 8501.80 | 8754.16 | 9014.09 | **136715.33** | **82,277.54** |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.00** | **0.00** |
| 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | **658.65** | **413.80** |
| 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | **30883.14** | **19,402.36** |
| | | | | | | | | | | | | |
| **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **29526.60** | **27735.79** |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **22940.13** | **21,548.79** |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **6586.48** | **6,187.00** |
| | | | | | | | | | | | | |
| ***5516.87*** | ***5765.69*** | ***6004.88*** | ***6247.41*** | ***6487.07*** | ***6741.11*** | ***6997.09*** | ***7254.40*** | ***7518.61*** | ***7790.23*** | ***8069.81*** | ***81350.87*** | ***37692.17*** |
| ***12474.56*** | ***18240.25*** | ***24245.13*** | ***30492.54*** | ***36979.62*** | ***43720.72*** | ***50717.82*** | ***57972.22*** | ***65490.83*** | ***73281.06*** | ***81350.87*** | ***357909.31*** | |

***Premises***

| | | |
|---|---|---|
| Total Investment (VAT excluded) | 29526.60 | thousand euro |
| Discount Rate | 4% | |

***Financial Analysis - Scenario 4b***

***Centralised Heat Supply System (biomass-based CHP + ground & roof PVs)***

| Specification | M.U. | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 | Year 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Generated electricity, of which:*** | ***MWh*** | ***0.00*** | ***0.00*** | ***32946.03*** | ***33425.77*** | ***33851.09*** | ***34223.86*** | ***34585.86*** | ***35738.64*** | ***35738.64*** | ***35738.64*** | ***35738.64*** |
| - by ground and roof PVs | MWh | 0.00 | 0.00 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 |
| - by biomass-based CHP plant | MWh | 0.00 | 0.00 | 25662.90 | 26142.65 | 26567.96 | 26940.74 | 27302.74 | 28455.51 | 28455.51 | 28455.51 | 28455.51 |
| ***Internal electrical self-services*** | ***MWh*** | ***0.00*** | ***0.00*** | ***1211.21*** | ***1233.85*** | ***1253.93*** | ***1271.52*** | ***1288.60*** | ***1343.01*** | ***1343.01*** | ***1343.01*** | ***1343.01*** |
| ***Electricity delivered in NPS*** | ***MWh*** | ***0.00*** | ***0.00*** | ***31734.82*** | ***32191.92*** | ***32597.16*** | ***32952.34*** | ***33297.26*** | ***34395.62*** | ***34395.62*** | ***34395.62*** | ***34395.62*** |
| ***Thermal Energy (Heat) generated, of which:*** | ***Gcal*** | ***0.00*** | ***0.00*** | ***44132.25*** | ***44957.27*** | ***45688.68*** | ***46329.73*** | ***46952.26*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** |
| - by biomass-based CHP plant | Gcal | 0.00 | 0.00 | 44132.25 | 44957.27 | 45688.68 | 46329.73 | 46952.26 | 48934.67 | 48934.67 | 48934.67 | 48934.67 |
| ***Thermal Energy (Heat) sold, of which:*** | ***Gcal*** | ***0.00*** | ***0.00*** | ***37512.41*** | ***38213.68*** | ***38835.37*** | ***39380.27*** | ***39909.42*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** |
| - to non-domestic consumers | Gcal | 0.00 | 0.00 | 5409.95 | 5511.08 | 5600.74 | 5679.32 | 5755.64 | 5998.65 | 5998.65 | 5998.65 | 5998.65 |
| - to domestic consumers | Gcal | 0.00 | 0.00 | 32102.47 | 32702.60 | 33234.63 | 33700.95 | 34153.78 | 35595.82 | 35595.82 | 35595.82 | 35595.82 |
| **Prices** | | | | | | | | | | | | |
| - electricity purchased from the NPS | euro/MWh | 263.00 | 272.86 | 259.22 | 236.09 | 214.63 | 220.58 | 226.90 | 236.20 | 245.50 | 254.46 | 263.17 |
| - electricity sold to the NPS | euro/MWh | 175.04 | 181.60 | 172.52 | 157.13 | 142.85 | 146.81 | 151.02 | 157.20 | 163.39 | 169.36 | 175.15 |
| - thermal energy (heat) sold to non-domestic consumers | euro/Gcal | 38.16 | 39.31 | 41.67 | 44.17 | 46.82 | 49.63 | 52.61 | 55.76 | 59.11 | 62.65 | 66.41 |
| - thermal energy (heat) sold to domestic consumers | euro/Gcal | 38.16 | 39.31 | 41.67 | 44.17 | 46.82 | 49.63 | 52.61 | 55.76 | 59.11 | 62.65 | 66.41 |

| Specification | M.U. | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 | Year 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **TOTAL REVENUES, of which:** | **thousand euro** | **0.00** | **0.00** | **7745.74** | **7471.49** | **7222.70** | **7601.26** | **8003.38** | **8678.55** | **9111.15** | **9548.23** | **9992.48** |
| Revenues from sold electricity, generated by ground & roof PVs and biomass-based CHP | thousand euro | 0.00 | 0.00 | 5474.93 | 5058.33 | 4656.37 | 4837.63 | 5028.41 | 5407.16 | 5620.04 | 5825.17 | 6024.39 |
| Costs savings related to the internal self-services' electricity, treated as revenues | thousand euro | 0.00 | 0.00 | 313.97 | 291.30 | 269.13 | 280.47 | 292.39 | 317.23 | 329.71 | 341.75 | 353.44 |
| Costs savings related to CO2 certificates purchase, treated as revenues | thousand euro | 0.00 | 0.00 | 393.78 | 434.02 | 478.99 | 528.81 | 583.15 | 634.81 | 702.87 | 775.28 | 852.26 |
| Revenues from the sale of thermal energy (heat) to final users/consumers, of which: | thousand euro | 0.00 | 0.00 | 1563.07 | 1687.83 | 1818.21 | 1954.34 | 2099.44 | 2319.36 | 2458.53 | 2606.04 | 2762.40 |
| - to non-domestic consumers | thousand euro | 0.00 | 0.00 | 225.42 | 243.41 | 262.22 | 281.85 | 302.78 | 334.49 | 354.56 | 375.84 | 398.39 |
| - to domestic consumers | thousand euro | 0.00 | 0.00 | 1337.65 | 1444.41 | 1555.99 | 1672.49 | 1796.66 | 1984.87 | 2103.96 | 2230.20 | 2364.01 |
| **TOTAL COSTS, of which:** | **thousand euro** | **11810.64** | **17715.96** | **8673.22** | **9016.00** | **9354.89** | **9689.48** | **10031.65** | **10635.98** | **10889.47** | **11148.27** | **11412.54** |
| **TOTAL CHELTUIELI DE OPERARE, din care:** | **thousand euro** | **0.00** | **0.00** | **8673.22** | **9016.00** | **9354.89** | **9689.48** | **10031.65** | **10635.98** | **10889.47** | **11148.27** | **11412.54** |
| biomass-based CHP operating costs | thousand euro | 0.00 | 0.00 | 4673.15 | 4900.35 | 5126.53 | 5351.50 | 5583.18 | 5989.79 | 6166.79 | 6349.10 | 6536.88 |
| Costs for CO2 certificates | thousand euro | 0.00 | 0.00 | 2422.99 | 2538.56 | 2651.27 | 2760.89 | 2871.37 | 3069.10 | 3145.59 | 3222.07 | 3298.56 |
| ground & roof PVs operating costs | thousand euro | 0.00 | 0.00 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 |
| Staff / personnel costs | thousand euro | 0.00 | 0.00 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 |
| | | 0% | | | | | | | | | | |
| **TOTAL INVESTMENT, of which:** | **thousand euro** | **11810.64** | **17715.96** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| - biomass-based CHP | thousand euro | 9176.05058 | 13764.07587 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| - ground & roof PVs | thousand euro | 2634.59 | 3951.89 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ***Investment Cash Flow*** | ***thousand euro*** | ***-11810.64*** | ***-17715.96*** | ***-927.49*** | ***-1544.51*** | ***-2132.19*** | ***-2088.22*** | ***-2028.26*** | ***-1957.43*** | ***-1778.32*** | ***-1600.03*** | ***-1420.05*** |
| ***Investment Cumulative Cash Flow*** | ***thousand euro*** | ***-11810.64*** | ***-29526.60*** | ***-30454.09*** | ***-31998.60*** | ***-34130.79*** | ***-36219.01*** | ***-38247.28*** | ***-40204.70*** | ***-41983.02*** | ***-43583.06*** | ***-45003.11*** |

**Results**

| | | |
|---|---|---|
| NPV | -44010.81 | thousand euro |
| IRR | #NUM! | |
| B/C | 0.74 | |

| Year 12 | Year 13 | Year 14 | Year 15 | Year 16 | Year 17 | Year 18 | Year 19 | Year 20 | Year 21 | Year 22 | TOTAL | TOTAL DISCOUNTED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *35738.64* | *35738.64* | *35738.64* | *35738.64* | *35738.64* | *35738.64* | *35738.64* | *35738.64* | *35738.64* | *35738.64* | *35738.64* | 705112.15 | 440.972.45 |
| 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 145662.45 | 91.512.58 |
| 28455.51 | 28455.51 | 28455.51 | 28455.51 | 28455.51 | 28455.51 | 28455.51 | 28455.51 | 28455.51 | 28455.51 | 28455.51 | 559449.70 | 349.459.86 |
| *1343.01* | *1343.01* | *1343.01* | *1343.01* | *1343.01* | *1343.01* | *1343.01* | *1343.01* | *1343.01* | *1343.01* | *1343.01* | 26404.29 | 16,493.42 |
| *34395.62* | *34395.62* | *34395.62* | *34395.62* | *34395.62* | *34395.62* | *34395.62* | *34395.62* | *34395.62* | *34395.62* | *34395.62* | 678707.86 | 424,479.02 |
| | | | | | | | | | | | | |
| *48934.67* | *48934.67* | *48934.67* | *48934.67* | *48934.67* | *48934.67* | *48934.67* | *48934.67* | *48934.67* | *48934.67* | *48934.67* | 962080.31 | 600.962.79 |
| 48934.67 | 48934.67 | 48934.67 | 48934.67 | 48934.67 | 48934.67 | 48934.67 | 48934.67 | 48934.67 | 48934.67 | 48934.67 | 962080.31 | 600.962.79 |
| *41594.47* | *41594.47* | *41594.47* | *41594.47* | *41594.47* | *41594.47* | *41594.47* | *41594.47* | *41594.47* | *41594.47* | *41594.47* | 817768.26 | 510.818.37 |
| 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 117936.47 | 73.668.93 |
| 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 699831.79 | 437,149.44 |
| | | | | | | | | | | | | |
| 271.80 | 279.52 | 286.67 | 293.78 | 300.57 | 307.72 | 314.71 | 321.48 | 328.23 | 334.95 | 341.65 | 6073.71 | 3,882.17 |
| 180.89 | 186.03 | 190.79 | 195.53 | 200.04 | 204.80 | 209.45 | 213.96 | 218.45 | 222.93 | 227.39 | 4042.33 | 2.583.76 |
| 70.40 | 74.62 | 79.10 | 83.84 | 88.88 | 94.21 | 99.86 | 105.85 | 112.20 | 118.93 | 126.07 | 1610.26 | 966.22 |
| 70.40 | 74.62 | 79.10 | 83.84 | 88.88 | 94.21 | 99.86 | 105.85 | 112.20 | 118.93 | 126.07 | 1610.26 | 966.22 |

| Year 12 | Year 13 | Year 14 | Year 15 | Year 16 | Year 17 | Year 18 | Year 19 | Year 20 | Year 21 | Year 22 | TOTAL | TOTAL DISCOUNTED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **10449.21** | **10820.76** | **11188.65** | **11566.04** | **11946.90** | **12348.67** | **12759.11** | **13177.81** | **13610.54** | **14058.03** | **14521.06** | **211821.76** | **126670.16** |
| 6221.99 | 6398.69 | 6562.50 | 6725.25 | 6880.60 | 7044.36 | 7204.27 | 7359.16 | 7513.70 | 7667.73 | 7821.09 | **125331.75** | **76,097.27** |
| 365.03 | 375.40 | 385.01 | 394.55 | 403.67 | 413.28 | 422.66 | 431.74 | 440.81 | 449.85 | 458.85 | **7330.23** | **4,445.40** |
| 934.05 | 942.84 | 951.08 | 958.77 | 965.92 | 972.51 | 978.56 | 984.06 | 989.01 | 993.41 | 997.27 | **16051.46** | **9.515.34** |
| 2928.14 | 3103.83 | 3290.06 | 3487.46 | 3696.71 | 3918.52 | 4153.63 | 4402.84 | 4667.01 | 4947.04 | 5243.86 | **63108.31** | **36,612.15** |
| 422.29 | 447.63 | 474.48 | 502.95 | 533.13 | 565.12 | 599.03 | 634.97 | 673.07 | 713.45 | 756.26 | **9101.32** | **5,280.11** |
| 2505.85 | 2656.20 | 2815.58 | 2984.51 | 3163.58 | 3353.40 | 3554.60 | 3767.88 | 3993.95 | 4233.59 | 4487.60 | **54006.99** | **31,332.04** |
| | | | | | | | | | | | | |
| **11682.44** | **11958.14** | **12239.83** | **12527.66** | **12821.84** | **13122.55** | **13429.98** | **13744.35** | **14065.85** | **14394.70** | **14731.12** | **265096.55** | **170680.97** |
| **11682.44** | **11958.14** | **12239.83** | **12527.66** | **12821.84** | **13122.55** | **13429.98** | **13744.35** | **14065.85** | **14394.70** | **14731.12** | **235569.94** | **142945.18** |
| 6730.30 | 6929.52 | 7134.71 | 7346.06 | 7563.75 | 7787.97 | 8018.91 | 8256.79 | 8501.80 | 8754.16 | 9014.09 | **136715.33** | **82,277.54** |
| 3375.05 | 3451.54 | 3528.03 | 3604.52 | 3681.01 | 3757.49 | 3833.98 | 3910.47 | 3986.96 | 4063.45 | 4139.94 | **67312.83** | **40,851.49** |
| 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | **658.65** | **413.80** |
| 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | **30883.14** | **19,402.36** |
| | | | | | | | | | | | | |
| **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **29526.60** | **27735.79** |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **22940.13** | **21,548.79** |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **6586.48** | **6,187.00** |
| | | | | | | | | | | | | |
| *-1233.23* | *-1137.39* | *-1051.18* | *-961.62* | *-874.94* | *-773.88* | *-670.87* | *-566.54* | *-455.31* | *-336.67* | *-210.06* | *-53274.79* | *-44010.81* |
| *-46236.34* | *-47373.73* | *-48424.90* | *-49386.53* | *-50261.46* | *-51035.35* | *-51706.22* | *-52272.75* | *-52728.06* | *-53064.73* | *-53274.79* | *-938925.76* | |

***Premises***

| | | |
|---|---|---|
| Total Investment (VAT excluded) | 23509.73 | thousand euro |
| Discount Rate | 4% | |

***Financial Analysis - Scenario 5***

***Centralised Heat Supply System (ground-water HPs + ground & roof PVs)***

| Specification | M.U. | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 | Year 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***Electricity purchased from the NPS for ground-water HPs*** | MWh | 0.00 | 0.00 | 11488.85 | 11839.77 | 12150.88 | 12423.56 | 12688.36 | 13531.59 | 13531.59 | 13531.59 | 13531.59 |
| ***Generated electricity from ground & roof PVs, of which:*** | MWh | 0.00 | 0.00 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 |
| - for internal self-services of the ground-water HPs | MWh | 0.00 | 0.00 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 |
| - delivered in NPS | MWh | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | | | | | | | | | | | |
| ***Thermal Energy (Heat) generated, of which:*** | ***Gcal*** | ***0.00*** | ***0.00*** | ***44132.25*** | ***44957.27*** | ***45688.68*** | ***46329.73*** | ***46952.26*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** |
| - by ground-water HPs | Gcal | 0.00 | 0.00 | 44132.25 | 44957.27 | 45688.68 | 46329.73 | 46952.26 | 48934.67 | 48934.67 | 48934.67 | 48934.67 |
| ***Thermal Energy (Heat) sold, of which:*** | ***Gcal*** | ***0.00*** | ***0.00*** | ***37512.41*** | ***38213.68*** | ***38835.37*** | ***39380.27*** | ***39909.42*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** |
| - to non-domestic consumers | Gcal | 0.00 | 0.00 | 5409.95 | 5511.08 | 5600.74 | 5679.32 | 5755.64 | 5998.65 | 5998.65 | 5998.65 | 5998.65 |
| - to domestic consumers | Gcal | 0.00 | 0.00 | 32102.47 | 32702.60 | 33234.63 | 33700.95 | 34153.78 | 35595.82 | 35595.82 | 35595.82 | 35595.82 |
| | | | | | | | | | | | | |
| **Prices** | | | | | | | | | | | | |
| - electricity purchased from the NPS | euro/MWh | 263.00 | 272.86 | 259.22 | 236.09 | 214.63 | 220.58 | 226.90 | 236.20 | 245.50 | 254.46 | 263.17 |
| - electricity sold to the NPS | euro/MWh | 175.04 | 181.60 | 172.52 | 157.13 | 142.85 | 146.81 | 151.02 | 157.20 | 163.39 | 169.36 | 175.15 |
| - thermal energy (heat) sold to non-domestic consumers | euro/Gcal | 38.16 | 39.31 | 41.67 | 44.17 | 46.82 | 49.63 | 52.61 | 55.76 | 59.11 | 62.65 | 66.41 |
| - thermal energy (heat) sold to domestic consumers | euro/Gcal | 38.16 | 39.31 | 41.67 | 44.17 | 46.82 | 49.63 | 52.61 | 55.76 | 59.11 | 62.65 | 66.41 |

| Specification | M.U. | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 | Year 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **TOTALREVENUES, of which:** | **thousand euro** | **0.00** | **0.00** | **6267.75** | **6379.90** | **6511.64** | **6850.56** | **7206.54** | **7743.58** | **8095.02** | **8456.69** | **8829.90** |
| | | | | | | | | | | | | |
| Costs savings related to the internal self-services' of ground-water HPs, treated as revenues | thousand euro | 0.00 | 0.00 | 1887.91 | 1719.49 | 1563.18 | 1606.52 | 1652.58 | 1720.31 | 1788.03 | 1853.30 | 1916.68 |
| Costs savings related to CO2 certificates purchase, treated as revenues | thousand euro | 0.00 | 0.00 | 2816.76 | 2972.58 | 3130.26 | 3289.70 | 3454.52 | 3703.91 | 3848.46 | 3997.36 | 4150.82 |
| Revenues from the sale of thermal energy (heat) to final users/consumers, of which: | thousand euro | 0.00 | 0.00 | 1563.07 | 1687.83 | 1818.21 | 1954.34 | 2099.44 | 2319.36 | 2458.53 | 2606.04 | 2762.40 |
| - to non-domestic consumers | thousand euro | 0.00 | 0.00 | 225.42 | 243.41 | 262.22 | 281.85 | 302.78 | 334.49 | 354.56 | 375.84 | 398.39 |
| - to domestic consumers | thousand euro | 0.00 | 0.00 | 1337.65 | 1444.41 | 1555.99 | 1672.49 | 1796.66 | 1984.87 | 2103.96 | 2230.20 | 2364.01 |
| | | | | | | | | | | | | |
| **TOTAL COSTS, of which:** | **thousand euro** | **9403.89** | **14105.84** | **4634.61** | **4452.26** | **4265.34** | **4398.18** | **4537.19** | **4855.51** | **4981.35** | **5102.60** | **5220.36** |
| **TOTAL OPERATING COSTS, of which:** | thousand euro | **0.00** | **0.00** | **4634.61** | **4452.26** | **4265.34** | **4398.18** | **4537.19** | **4855.51** | **4981.35** | **5102.60** | **5220.36** |
| Ground & roof PVs operating costs | thousand euro | 0.00 | 0.00 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 |
| Ground-water HPs operating costs | thousand euro | 0.00 | 0.00 | 3057.52 | 2875.17 | 2688.25 | 2821.09 | 2960.10 | 3278.42 | 3404.26 | 3525.51 | 3643.27 |
| Costs for CO2 certificates | thousand euro | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ground & roof PVs operating costs | thousand euro | 0.00 | 0.00 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 |
| | | | | | | | | | | | | |
| **TOTAL INVESTMENT, of which:** | **mii euro** | **9403.89** | **14105.84** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** |
| - ground & roof PVs | mii euro | 2634.59 | 3951.89 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| - ground-water HPs | mii euro | 6769.30 | 10153.96 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | | | | | | | | | | | |
| ***Investment Cash Flow*** | **thousand euro** | ***-9403.89*** | ***-14105.84*** | ***1633.14*** | ***1927.64*** | ***2246.30*** | ***2452.38*** | ***2669.35*** | ***2888.06*** | ***3113.67*** | ***3354.09*** | ***3609.54*** |
| ***Investment Cumulative Cash Flow*** | **thousand euro** | ***-9403.89*** | ***-23509.73*** | ***-21876.59*** | ***-19948.96*** | ***-17702.66*** | ***-15250.28*** | ***-12580.93*** | ***-9692.87*** | ***-6579.20*** | ***-3225.11*** | ***384.43*** |

**Reults**

| | | |
|---|---|---|
| NPV | 24347.36 | thousand euro |
| IRR | 11.47% | |
| B/C | 1.28 | |

| Year 12 | Year 13 | Year 14 | Year 15 | Year 16 | Year 17 | Year 18 | Year 19 | Year 20 | Year 21 | Year 22 | TOTAL | TOTAL DISCOUNTED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13531.59 | 13531.59 | 13531.59 | 13531.59 | 13531.59 | 13531.59 | 13531.59 | 13531.59 | 13531.59 | 13531.59 | 13531.59 | 263565.28 | 164,111.23 |
| 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 145662.45 | 91,512.58 |
| 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 7283.12 | 145662.45 | 91,512.58 |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | | | | | | | | | | | |
| ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | ***48934.67*** | 962080.31 | 600,962.79 |
| 48934.67 | 48934.67 | 48934.67 | 48934.67 | 48934.67 | 48934.67 | 48934.67 | 48934.67 | 48934.67 | 48934.67 | 48934.67 | 962080.31 | 600,962.79 |
| ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | ***41594.47*** | 817768.26 | 510,818.37 |
| 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 5998.65 | 117936.47 | 73,668.93 |
| 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 35595.82 | 699831.79 | 437,149.44 |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| 271.80 | 279.52 | 286.67 | 293.78 | 300.57 | 307.72 | 314.71 | 321.48 | 328.23 | 334.95 | 341.65 | 6073.71 | 3,882.17 |
| 180.89 | 186.03 | 190.79 | 195.53 | 200.04 | 204.80 | 209.45 | 213.96 | 218.45 | 222.93 | 227.39 | 4042.33 | 2,583.76 |
| 70.40 | 74.62 | 79.10 | 83.84 | 88.88 | 94.21 | 99.86 | 105.85 | 112.20 | 118.93 | 126.07 | 1610.26 | 966.22 |
| 70.40 | 74.62 | 79.10 | 83.84 | 88.88 | 94.21 | 99.86 | 105.85 | 112.20 | 118.93 | 126.07 | 1610.26 | 966.22 |

| Year 12 | Year 13 | Year 14 | Year 15 | Year 16 | Year 17 | Year 18 | Year 19 | Year 20 | Year 21 | Year 22 | TOTAL | TOTAL DISCOUNTED |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **9216.79** | **9533.98** | **9857.05** | **10190.42** | **10532.72** | **10889.71** | **11258.23** | **11638.72** | **12033.50** | **12443.41** | **12869.37** | **186805.47** | **111574.15** |
| | | | | | | | | | | | | |
| 1979.55 | 2035.77 | 2087.88 | 2139.66 | 2189.09 | 2241.19 | 2292.06 | 2341.34 | 2390.51 | 2439.52 | 2488.31 | **40332.86** | **24,595.18** |
| 4309.10 | 4394.38 | 4479.11 | 4563.29 | 4646.92 | 4730.01 | 4812.54 | 4894.53 | 4975.97 | 5056.86 | 5137.20 | **83364.29** | **50,366.83** |
| 2928.14 | 3103.83 | 3290.06 | 3487.46 | 3696.71 | 3918.52 | 4153.63 | 4402.84 | 4667.01 | 4947.04 | 5243.86 | **63108.31** | **36,612.15** |
| 422.29 | 447.63 | 474.48 | 502.95 | 533.13 | 565.12 | 599.03 | 634.97 | 673.07 | 713.45 | 756.26 | **9101.32** | **5,280.11** |
| 2505.85 | 2656.20 | 2815.58 | 2984.51 | 3163.58 | 3353.40 | 3554.60 | 3767.88 | 3993.95 | 4233.59 | 4487.60 | **54006.99** | **31,332.04** |
| | | | | | | | | | | | | |
| **5337.17** | **5441.62** | **5538.45** | **5634.65** | **5726.48** | **5823.28** | **5917.80** | **6009.36** | **6100.71** | **6191.76** | **6282.41** | **129960.82** | **87226.80** |
| **5337.17** | **5441.62** | **5538.45** | **5634.65** | **5726.48** | **5823.28** | **5917.80** | **6009.36** | **6100.71** | **6191.76** | **6282.41** | **106451.08** | **65142.95** |
| 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | 32.93 | **658.65** | **413.80** |
| 3760.08 | 3864.53 | 3961.36 | 4057.56 | 4149.39 | 4246.19 | 4340.71 | 4432.27 | 4523.62 | 4614.67 | 4705.32 | **74909.30** | **45,326.79** |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **0.00** | **0.00** |
| 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | 1544.16 | **30883.14** | **19,402.36** |
| | | | | | | | | | | | | |
| **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **0.00** | **23509.73** | **22083.85** |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **6586.48** | **6,187.00** |
| 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | **16923.26** | **15,896.85** |
| | | | | | | | | | | | | |
| ***3879.62*** | ***4092.36*** | ***4318.61*** | ***4555.77*** | ***4806.24*** | ***5066.43*** | ***5340.43*** | ***5629.36*** | ***5932.79*** | ***6251.65*** | ***6586.96*** | ***56844.65*** | ***24347.36*** |
| ***4264.05*** | ***8356.41*** | ***12675.01*** | ***17230.78*** | ***22037.03*** | ***27103.46*** | ***32443.89*** | ***38073.25*** | ***44006.04*** | ***50257.69*** | ***56844.65*** | ***173906.46*** | ***33383.66*** |

Bankwatch
FOR PEOPLE AND ENVIRONMENT

ISPE®