SEED MICAT

Support Energy Efficiency Deployment with the Multiple Impacts CAlculation Tool

Regional/Local Showcase

A SHOWCASE FOR THE ANALYSIS OF MULTIPLE IMPACTS OF ENERGY EFFICIENCY IN FRIULI VENEZIA GIULIA AND METROPOLITAN CITY OF MILAN

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LIST OF ABBREVIATIONS

AWU	Annual Work Unit
CBA	Cost Benefit Analysis
CMM	Metropolitan city of Milan
EE	Energy Efficiency
EP	Energy Poverty
EU	Europe Union
FTE	Full-Time Equivalent years
FVG	Friuli Venezia Giulia Region
GDC	Gross Domestic Consumption
GDP	Gross Domestic Product
MB	Multiple Benefits
MI	Multiple Impact
PER	Regional Energy Plan
RECs	Renewable Energy Communities RECs
RES	Renewable Energy Sources

EXECUTIVE SUMMARY

The analysis uses the MICATool application, powered by datasets from the Friuli-Venezia Giulia (FVG) Regional Energy Plan and evidence from the DeciWatt project for the Metropolitan City of Milan. For the latter, the database is supplemented by mandatory energy audits conducted on obsolete heating systems with a capacity exceeding 116 kW. The study examines two complementary decarbonisation strategies: the upgrading of generation and control systems for plant efficiency and the improvement of building envelope efficiency for the residential sector. The processing of these scenarios allows the tool to extract the socio-economic and environmental indicators necessary to assess the effectiveness of the interventions in the two territorial contexts.

The analysis was useful for testing the MICATool at regional and local level; for the FVG region, the number of inhabitants considered is 1,200,000, while the population analysed for the metropolitan city of Milan is just over 300,000 inhabitants. The input data are energy savings in MWh and investment in millions of euros for all the Energy Efficiency (EE) measures studied.
Observed Results for 2025–2030 are the following:

1. Economic Impact and Real Estate Value

Added Asset Value of Buildings (GDP): In the FVG region, the added asset value of buildings is projected to grow from €66,822,077 in 2025 to €184,546,366 by 2030. In Milan, this specific indicator contributes €2,689,317.81 to the GDP by 2030.
Investment Assumptions: These results are modelled based on an average technology lifetime of 25 years and an average subsidy rate of 30%.
Job Creation: The investments drive significant employment growth, estimated at 14 FTE-years in FVG and 7.49 FTE-years in Milan.

2. Social Impact and Energy Poverty

Energy Poverty Alleviation: The interventions show a strong social impact. Under the M/2 indicator, 423 people are lifted out of energy poverty in 2025, rising to 685 by 2030. Under the 2M indicator, the impact increases from 525 people (2025) to 987 people (2030).

3. Public Health and Productivity

Avoided Absenteeism: Improved living conditions lead to documented health gains, with 7 days of absence avoided in 2025, increasing to 13 days by 2030.
Mortality Reduction: The reduction in environmental and thermal risks results in 0.268 statistical lives saved in 2025, reaching 0.586 by 2030.

4. Environmental and Energy Metrics

Resource Efficiency: Significant savings in natural gas consumption (approx. 5 ktoe in FVG) allow the region to avoid the installation of 28 MW of new renewable capacity (only Solar technology). It is a positive thing because this energy measure reduces energy consumption without any needs of installation of energy production system. the renewable energy installations have an impact on the environments and CO2 emission while the saved energy hasn't got any impact.
The data confirms that EE provides a high return on investment beyond simple energy savings. By 2030, the synergy between building value appreciation (€184.5M), social welfare (987 people protected), and public health (13 days of productivity gained) establishes a clear pathway for sustainable urban and regional development.

1. INTRODUCTION

1.1 What are Multiple Impacts of Energy Efficiency and why are they important

Multiple Impacts (MIs) or Multiple Benefits (MBs) of Energy Efficiency (EE), indicate the full set of advantages deriving from EE policy measures. Also called non-energy, or co-benefits, these refer to, among others, increases in employment, GDP, productivity and energy security, positive impacts on health, ecosystems and crops[1]. The calculation of the MIs is performed via monetisation and aggregation of EE outcomes, as well as cost-benefit analyses.

Capturing MIs is deemed essential when assessing and comparing various investment options, pathways, or policies to achieve energy and climate policy objectives, and notably climate neutrality. The calculation of MIs is considered invaluable, as a too-narrow scope of analysis might lead to short-sighted decisions that may deliver higher benefits in the short term but fail to contribute to long-term goals, or that may seem profitable in one aspect, whereas being negative or less beneficial when considering other aspects, such as a societal viewpoint. Thus, in many cases, measures and policies' non-energy or non-climate benefits, can actually yield higher value than the mere energy-related benefits[2], and should, thus, be taken into consideration within planning processes.

1.2 The MICATool – how does it work and what should it be used for

The MICATool refers to the development of a comprehensive approach for estimating MIs of EE by providing a publicly available and easily usable online tool. The goal of the tool is to improve scientific knowledge and methods, enabling decision-makers to conduct simplified analyses for different data and policy scenarios, in order to compare and assess the relevance of the MIs and strengthen reporting and monitoring at three governance levels: EU, national and local.

The overarching methodology of the tool pertains to the quantification and monetisation concept of the MIs of EE improvements or renewable energy sources (RES), which is currently under development and will be integrated into the tool at a later stage. This concept defines the quantification chain from input data to outputs in the form of **quantified, monetised and aggregated** MIs. This approach allows for an **ex-ante** quantification of future impacts for various scenarios and policy measures at three governance levels (EU, national, and local), as well as an **ex-post** evaluation of already achieved impacts based on input data entered by tool users.

The following steps present in a nutshell the application of the methodology within the tool:

- First step: MIs are quantified based on impact factors or functions directly linked to specific input parameters (e.g. energy savings) à impacts = f (simple inputs).
- Second step: Monetised impacts are calculated from the quantified impacts, applying a monetisation factor (e.g. euros per tCO_2 avoided) à monetised impacts = (quantified impacts) x (monetisation factor)
- Third step: Monetised impacts are aggregated to provide an overall result.

For the performance of the calculations and results prompting, the tool deducts **information from various databases** (e.g. Eurostat, EU-SILCCEN, DEA Catalogues, ODYSSEE-MURE) **and models** (e.g. PRIMES, GAINS), based on the preferred assessment type (ex-post or ex-ante). More information regarding the execution and structure of the calculations can be found in this link: doc.micatool.eu.

The MICATool, providing results on impacts borne into not only the economy but also society and the environment, enables planners and actors engaged in planning, policymaking and investment processes to **easily select the types of impacts they want to factor in** the assessment.

The **flexible approach** of the MICATool indeed makes it possible to **include MIs in any assessment**, even when the users have limited data specific to their case. They can then get a first rough assessment and decide whether some of the impacts should be investigated further. When users have already more data at hand, they can enter them into the tool and get more accurate results. Moreover, users can also use the tool to explore how sensitive the results are to key parameters or input data.

Regardless of the situation, the MICATool can be used to **initiate the discussion** among stakeholders about what impacts can make a difference in the decision, and what options stand out as most beneficial, depending on considered impacts and the sensitivity to key parameters.

Supporting Policy Making

The MICATool assists decision-makers by:

- **Broadening the Scope of Analysis:** It enables planners to move beyond a narrow focus on energy or climate benefits, which can lead to short-sighted decisions. By capturing non-energy or non-climate benefits (MIs or MI), it reveals higher values that are essential for long-term planning and societal well-being.
- **Providing a Flexible Assessment Framework:** The tool allows users to conduct simplified analyses for different policy scenarios at three governance levels (EU, national, and local). Its flexible approach permits the inclusion of MIs even with limited case-specific data, providing a "rough assessment" that can guide further investigation.
- **Enhancing Stakeholder Engagement:** It serves as a platform to initiate discussions among stakeholders about which impacts are most significant for a decision and which policy options are most beneficial based on sensitivity to key parameters.

[1] Ürge-Vorsatz, D., Chatterjee, S., Thema, J., Suerkemper, F., Thomas, S., Teubler, J., Couder, J., Bouzarovski, S., Mzavanadze, N., & Below, D. von. (2017). *More than energy savings: Quantifying the MIs of EE in Europe*. CEU Research Pure Portal. https://research.ceu.edu/en/publications/more-than-energy-savings-quantifying-the-multiple-impacts-of-ener

[2] Chatterjee, S., & Ürge-Vorsatz, D. (2021). Measuring the productivity impacts of energy-efficiency: The case of high-efficiency buildings. *Journal of Cleaner Production*, *318*, 128535. https://doi.org/10.1016/j.jclepro.2021.128535

2. THE SHOWCASES FOR REGIONAL AND LOCAL LEVEL CASE STUDIES

The analysis of the current status quo highlights how integrating the MIs of EE is becoming a cornerstone of European and national policies. Within this framework, the implementation of the "Energy Efficiency First" (EE1st) principle in the Member States (specifically within the Italian local case studies analysed) is no longer viewed merely as a reduction in consumption, but as a holistic investment strategy.

There has been a significant shift from a purely energy-centric approach to a multi-dimensional evaluation. Thanks to tools like the MICATool, it is now possible to quantify previously "invisible" benefits, such as the Added Asset Value of real estate, improvements in public health, and job creation. Implementing the EE1st principle requires that demand-side solutions (efficiency and conservation) take priority over the expansion of energy supply. Data shows that improving the building envelope not only reduces emissions but also directly addresses energy poverty, thereby stabilising the social fabric.

To test MICATool at the regional and local levels, the energy policies of two Italian public bodies with different territorial jurisdictions were examined: the regional energy plan of the Friuli Venezia Giulia region and the One Stop Shop of the Metropolitan City of Milan, DeciWatt.

While the regulatory framework is increasingly adopting these directives, the primary challenge remains with the standardisation of data collection at the local level. However, results from Friuli-Venezia Giulia and Milan confirm that EE is the main driver for an effective decoupling of economic growth from environmental impact. The impact of decarbonisation strategies was observed through a structured analytical process using the MICATool. The assessment begins with a detailed analysis of selected EE measures focusing on demand-side interventions such as building envelope insulation and heating system modernisation. This dual approach identifies the most effective synergies between energy savings and social benefits. Ultimately, the results serve as a basis for key learnings and policy recommendations aimed at simplifying the implementation of the “EE1st” principle in regional and local planning.

2.1 Discussion on the status quo of the analysis of MIs of EE and the implementation of the EE1st principle in FVG: Use of the MICATool at a regional level, in the Friuli Venezia Gulia Region

The energy context in Friuli Venezia Giulia is described in the regional plan (PER) [1]. The Regional Energy Plan (PER) [1] of Friuli-Venezia Giulia serves as the strategic cornerstone for the region's ecological transition, setting the ambitious goal of achieving **carbon neutrality by 2045**. This objective, known as the **'FVGreen' strategy**, positions the region at the forefront of the national landscape by anticipating European decarbonisation targets by five years. The Plan identifies theresidential **civil sector** as the primary field of action, recognising that deep building renovation is the key to drastically reducing greenhouse gas emissions.

Moving beyond purely technological approaches, the PER [1] promotes an integrated vision: on one hand, it emphasises the **component**, specifically improving the thermal insulation of the building envelope (essential for mitigating the severe climate of the Alpine and Pre-alpine zones); on the other, it focuses on the **active component**, encouraging the electrification of thermal consumption through the adoption of heat pumps and the widespread deployment of photovoltaics.

A central role is assigned to social and technological innovation, with strong support for the creation of **Renewable Energy Communities (RECs)** and the development of hydrogen-related supply chains. Within this framework, the Plan does not merely provide numerical targets but advocates for the use of advanced analytical tools to monitor the effectiveness of implemented policies. Integrating these regional guidelines into calculation models allows for the translation of strategic goals into concrete actions, ensuring that every investment results in measurable benefits - not only in terms of energy savings but also in economic sustainability and social well-being for the entire regional community.

2.2 MIs of EE measures Friuli Venezia Giulia

2.2.1 Selection of EE measures

The first scenario involves replacing obsolete gas boilers with heat pumps in public buildings, (including schools, town halls, and sports facilities).The analysis was conducted using data from the Friuli-Venezia Giulia PER and in line with the regional strategies and objectives set out in the Plan (action 07.2. Grant subsidies for the replacement of existing heat generators). The total number of buildings involved is 32,725.
The subsector taken into account is average tertiary. The time frame analysed is 2025–2030.

Table 1 Input data in terms of energy savings. Source: PER action 07.2. Grant subsidies for the replacement of existing heat generators.

Year	Energy saved [MWh]
2025	37,942
2030	75,885

The investment costs forecast for 2030 amount to €6 million, with an average subsidy rate of 40% (€2.4 million, non-repayable public funds). The average technological lifetime of a heat pump is considered to be 17 years. All input data is extracted by the PER FVG.

Table 2: Energy advanced input data. Source: PER FVG

Energy source	Energy consumption 2021 (ktep)	Energy consumption 2030 (ktep)	Energy Mix 2021	Energy Mix 2030
Renewable sources	340	347	26,2%	26,5%
Electricity	282	349	22%	27,22%
Natural gas	550	315	43%	24,6%
Oil products	104	48	8%	3,7%

2.2.2 Results of the measures' analysis. Measure 1, replacement of existing heat generators in the residential sector

This section describes the analysis of the benefits deriving from EE measures in public buildings, going beyond the logic of mere savings on energy bills. The aim is to quantify the multiple benefits that these measures generate for the community between now and 2025 and 2030.

Selection of indicators

It is important to note that the indicators presented were chosen based on their strategic relevance and the availability of robust data. Not all the indicators theoretically provided for in the models were used: only those considered relevant to the public building sector and capable of providing statistically significant results for the regional context were selected. This selection ensures an accurate analysis that can be directly traced back to the investments made.

Areas of impact analysed

Social impacts: Effects on public health, measured as a reduction in mortality, hospitalisations, and lost working days thanks to lower pollutant emissions.

Economic impacts: Stimulus to the local economy through increased regional GDP, job creation (FTE), improved energy intensity, and increased property asset value.

Environmental impacts: Primary energy savings (gas and oil) and avoid renewable capacity (MW of solar and wind power no longer needed).

These values form the basis for subsequent monetisation and cost-benefit analysis (CBA), which are essential tools for assessing the real return on investment for the regional system.

Quantification of physical values – Social impacts

Health effects linked to reduced air pollution

This indicator assesses the number of premature deaths and hospital admissions avoided following the implementation of EE measures and the resulting reduction in air pollution levels.

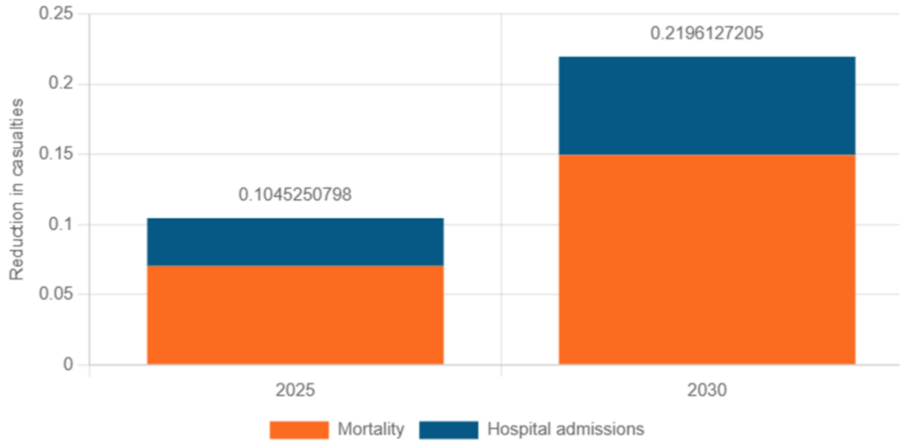

Figure 1: Health effects linked to reduced air pollution

Table 3: 2025 and 2030 Results

Year	Mortality avoided	**Hospital admissions avoided**	**Total cases**
2025	0.070	0.034	≈0.110
2030	0.150	0.070	≈0.220

By 2025, the health impacts are already significant:

Avoided lost working days due to air pollution

It shows the number of working days of absence avoided thanks to the reduction in air pollution. Specifically:

Table 4: 2025 and 2030 Results

Year	Absence avoided
2025	16
2030	32

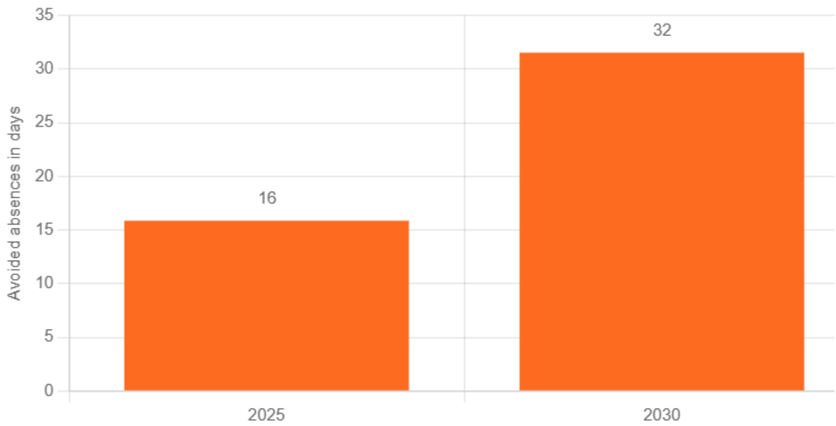

Figure 2: Avoided lost working days due to air pollution

In 2030, the benefit increases significantly (32 days): +100% compared to 2025.

Quantification of physical values – Economic impacts

Impact on energy intensity

The energy intensity is the quotient of primary energy consumption and GDP, thus describing the energy needed to generate a unit of GDP.
The use of energy intensity (the ratio between energy consumption and GDP) in a regional analysis is methodologically correct and necessary for three reasons:
Verification of Decoupling: It allows us to demonstrate that local economic growth is no longer linked to an increase in consumption but is driven by efficiency.
Alignment with Targets: It allows the region's contribution to national (NECP) and European decarbonisation targets to be measured.
System Efficiency: It monitors the capacity of the regional industry sector to generate added value by reducing structural energy waste.
The indicator is not used to compare absolute values with the national average, but to certify the trend of improvement in the economic efficiency of the territory following the investments made. Data comes from PER in particular from energy regional balance provided by Enea, within the contract signed by FVG Region to develop the regional plan.

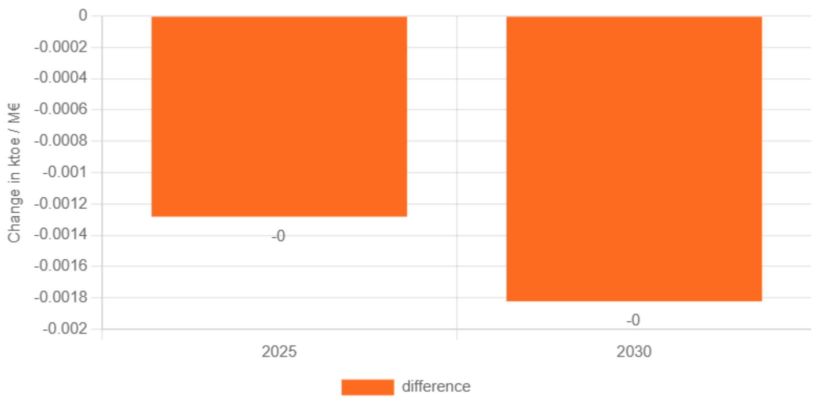

Figure 3: Impact on energy intensity

This trend reflects the evolution of energy intensity in the Friuli-Venezia Giulia region following the implementation of Measure 07.02.
Regional initiatives do not have a significant impact on national targets, and even the contribution of individual initiatives toward regional targets may seem modest. The importance of these initiatives lies in leveraging private investment. Although the improvement between 2025 and 2030 is minimal, I chose to include it because it is still considered significant and worth highlighting in this report.

This indicator shows the change in energy intensity in ktoe per million euros of GDP (ktoe/M€). As illustrated, both years there is a reduction in energy intensity.

- The efficiency of the economic system as a whole is increasing.
- There is a decoupling between economic growth and energy consumption.
- The region is in line with European sustainability and decarbonisation targets

Impact on gross domestic product

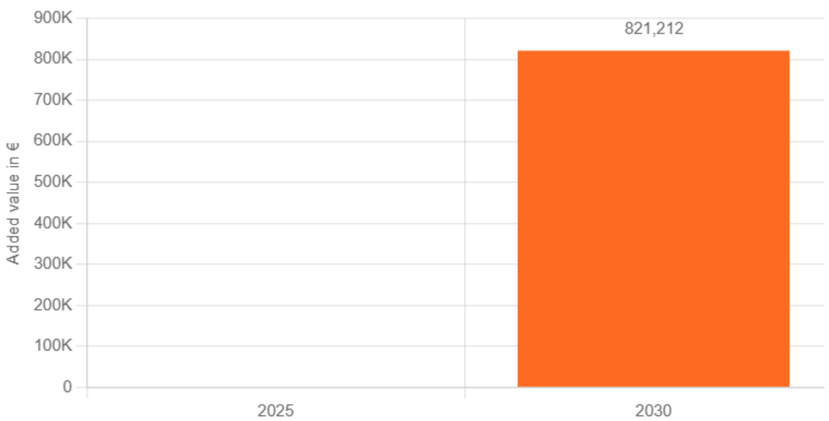

Figure 4: Impact on gross domestic product

Figure 4 shows the economic impact of EE measures on GDP, expressed in euros of added value generated. According to the MICATool simulation, the renovation of public buildings will produce an increase in regional GDP of €821,212 in 2030. This value reflects the relatively limited size of the planned investment (€6 million).

Additional employments

The indicator shows the number of full-time equivalent years (FTE-years) generated by the investment in improving the EE of heating systems in public buildings in the Friuli Venezia Giulia region. A value of 14 FTE-years in 2030 means that, in the year considered, the measure generates the equivalent of 14 full-time jobs for one year.

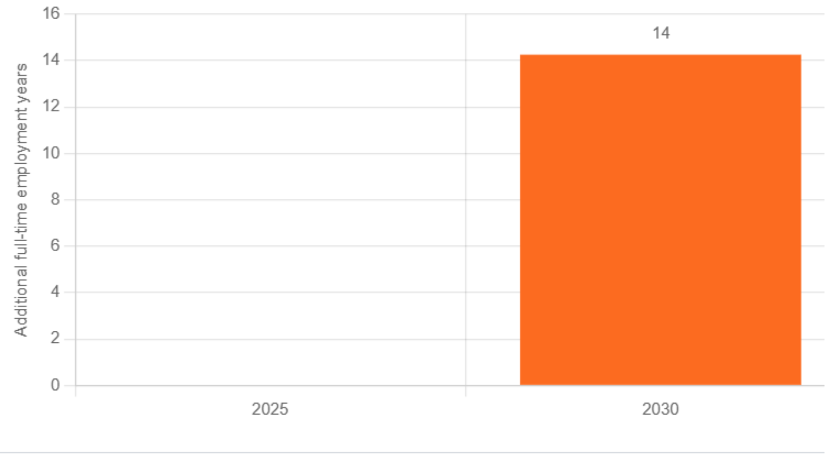

Figure 5: Additional employments

Added asset value of buildings

This indicator shows the increase in the asset value of real estate following the measures adopted, in millions of euros.

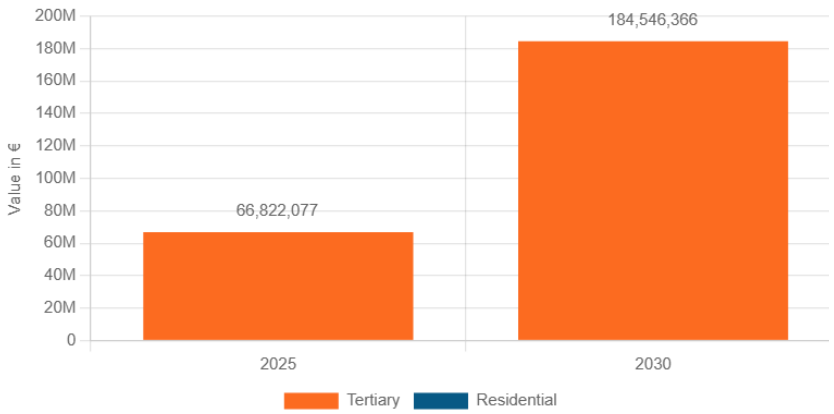

Figure 6: Added asset value of buildings

By 2030, the **added asset value of buildings** is expected to reach **€184,546,366**, representing a substantial increase from the 2025 valuation of **€66,822,077**.

Reduction of additionally needed generation capacity

This indicator highlights the amount of renewable electrical capacity that does not need to be installed thanks to the energy savings achieved by the intervention.

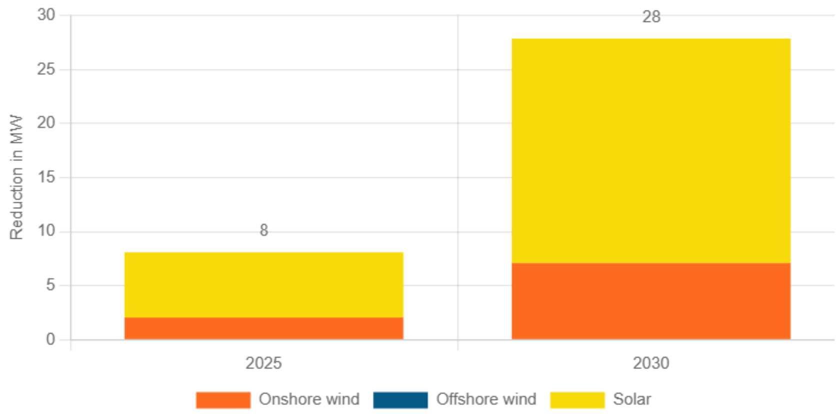

Figure 7: Reduction of additionally needed generation capacity

In 2030, avoided capacity is estimated at 21 MW for solar photovoltaics and 7 MW for wind power. This is a result from SEED MICAT, and the following issues have been identified:
1) There is no option to enter the energy mix in terms of RES at the local level. The Friuli Venezia Giulia region has no wind power plants and does not plan to install any new ones.
2) It is unclear whether the reduction in electricity generation from renewable sources is due to the phase-out of fossil fuels

Quantification of physical values – Environmental impacts

Primary savings by energy carrier

The energy saved in terms of primary energy carriers with the proposed measures is described. In 2025, we recorded savings of 0.424 ktoe in terms of oil and oil derivatives and approximately 2 ktoe in terms of natural gas. In 2030, we recorded savings of 1.8 ktoe in terms of oil and oil derivatives and approximately 5 ktoe in terms of natural gas. In both cases, the greatest savings were detected in natural gas consumption.

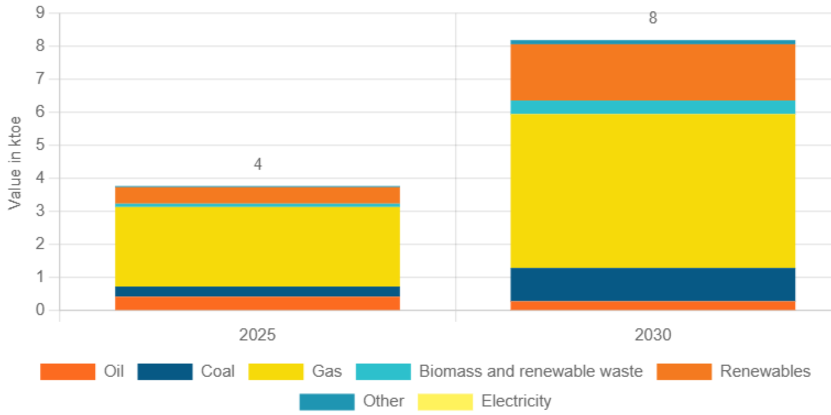

Figure 8: Primary savings by energy carrier

As expected, the action leads to a particularly marked contraction in consumption for natural gas, confirming it as the energy carrier most significantly impacted by the achieved savings.
Table 5 shows consumption data, divided by energy source, for the Friuli Venezia Giulia region up to 2021, where it is possible to see that the main energy source is natural gas. Through Action 7.2, the Region establishes funding lines for the replacement of heat generators, cooling units, and domestic hot water systems with high-efficiency appliances, prioritising those powered by renewable energy sources (RES) or hybrid systems. At present, the action does not include an assessment of energy savings in ktoe, as specific technical data regarding the pre-existing thermal plants and the exact specifications of the generators installed post-intervention are unavailable. For this reason, it is not possible to obtain a quantitative assessment using the MICATool, as the lack of detailed technical data—for both the pre- and post-intervention phases—prevents the tool from generating accurate estimates of the achieved savings.

Table 5: gross domestic consumption (ktoe) [pag. 32 FVG's PER]

Energy Sources	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Solid fuels	655	645	783	748	575	681	744	673	680	444	120	131
Oil	1052	1015	846	844	798	800	804	783	828	802	737	863
Gas	2209	2091	2045	1857	1556	1609	1933	2056	1920	1875	1747	1842
Renewable energy	526	449	527	598	662	610	631	724	794	783	806	842
Non-renewable waste	25	31	31	27	25	22	26	24	27	27	24	18
Electricity	-5	90	37	74	94	168	-10	28	50	121	194	260
GDC (TOTAL)	4462	4320	4270	4149	3710	3890	4128	4287	4299	4051	3629	3957

2.2.3 Summary for the measures' analysis: EE Measure 2: Evaluation of the MIs of improving the EE of residential building in Friuli-Venezia Giulia using MICATool

The Action 07.1 of the Friuli Venezia Giulia energy plan refers to a grant subsidy measure for improving the EE of building envelopes, with the aim of reducing the energy consumption of residential buildings through renovation work on the envelope (wall insulation, roofing, replacement of windows and doors, etc.). The plan sets out an annual reduction in energy consumption in the residential sector of 28 GWh by 2030, compared to a reference annual consumption of 14,979 GWh.

The estimated energy and economic contributions can be considered a good starting point, as the goal is to attract private investments. Its implementation will take place through annual calls for proposals in the period 2025–2030, with a total investment of approximately €86.2 million (€25.9 million in public funds and €60.4 million in private funds). The sub-sector studied was the average residential. The improvements concern the building envelope.

Table 6: input data for year used for Seed MICAT

Year	Energy saving [MWh]	Investment costs [Mio€]	Number of dwellings involved	Average number of households per building
2025	14979	0	4043.84	3.69
2030	28000	86.2	8824.20	3.69

The model utilizes an **average technology lifetime of 25 years** and an **average subsidy rate of 30%** as primary input data.

2.2.4 Results for the measures' analysis

Quantification of physical values – Social impacts

A) Social Indicators: health effects linked to reduced air pollution

It should be noted that avoided mortality accounts for most of the health impact, while hospital admissions represent a smaller but still significant proportion.

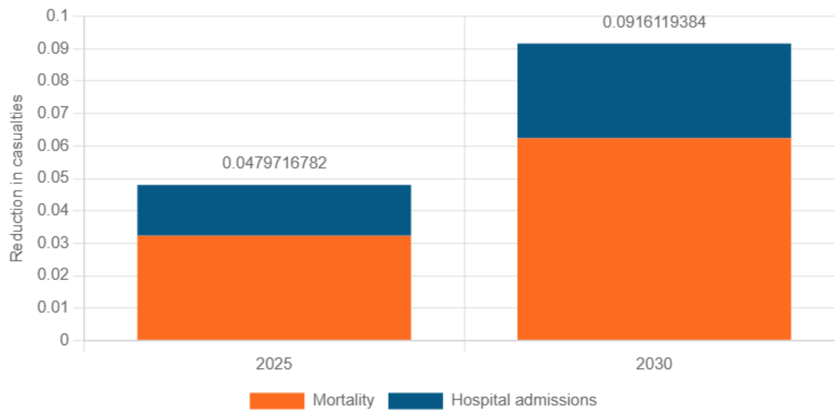

Figure 9: Health effects linked to reduced air pollution

Table 7: effects of air pollution

Year	Avoided deaths	**Avoided hospitalizations**	**Total cases**
2025	0.032	0.0157	≈0.0480
2030	0.061	0.029	≈0.090

In 2030, the effect is statistically significant.

Avoided lost working days due to air pollution

The indicator represents the effect of EE measures on the building envelope on the reduction of absenteeism from work.

The following values are observed:

The observed results demonstrate a reduction in absenteeism, with 7 days of absence avoided in 2025 and 13 days in 2030.

Alleviation of energy poverty (M/2)

In 2020, the percentage of households in energy poverty in the FVG regio was 5.7%, which translates into approximately 65,000 citizens in vulnerable conditions. Overall, the region has always been in a relatively advantageous position, with rates consistently below the national average, with a difference of around 2 percentage points. The national average stands at 9.1%.

This indicator defines the inability to spend more due to financial constraints. The data on EP are taken from the report Energy Poverty in Italy in 2024, compiled by the Energy Poverty Observatory (OIPE) [3].

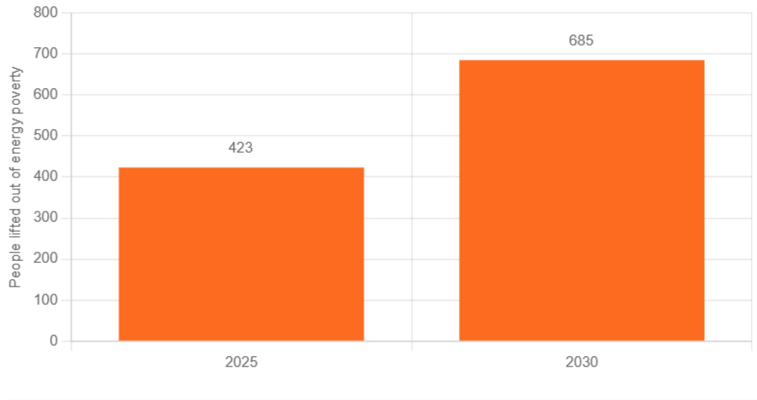

Figure 10: Alleviation of energy poverty (M/2)

The results show a significant social impact, with 423 people lifted out of energy poverty in 2025 and 685 people by 2030. Thanks to this action, by 2030, just over 1% of the population in energy poverty will be lifted out of EP.

Alleviation of energy poverty (2/M)

The 2/M metric (Two-times Median Expenditure Share Indicator) is one of the main indicators used at the European level to measure energy poverty due to overspending, that is, situations in which a household incurs excessively high energy expenditures.
This metric is very useful for identifying households that spend too much, for example, on heating or energy use in general.

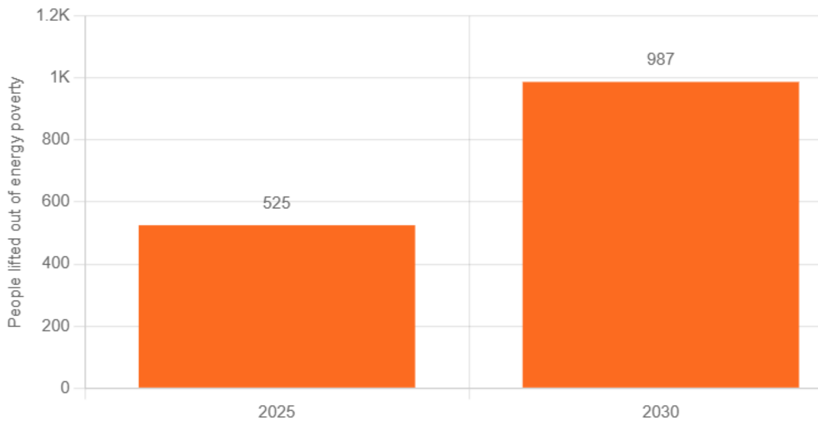

Figure 11: Alleviation of energy poverty (2/M)

Figure 11 shows how many people are lifted out of "energy overspending" thanks to measures to improve the EE of building envelopes.
Specifically: Regarding social impact, the 2M metric shows that 525 and 987 people are expected to be lifted out of energy poverty in 2025 and 2030, respectively 1.5% of the population is emerging

from EP. Improving the building envelope significantly reduces heating costs, thereby reducing the proportion of energy expenditure in relation to income.

Reduction in excess cold weather mortality

EE improvements in the residential sector can address the problem of mortality due to excessive cold, which occurs when indoor temperatures fall below adequate levels.

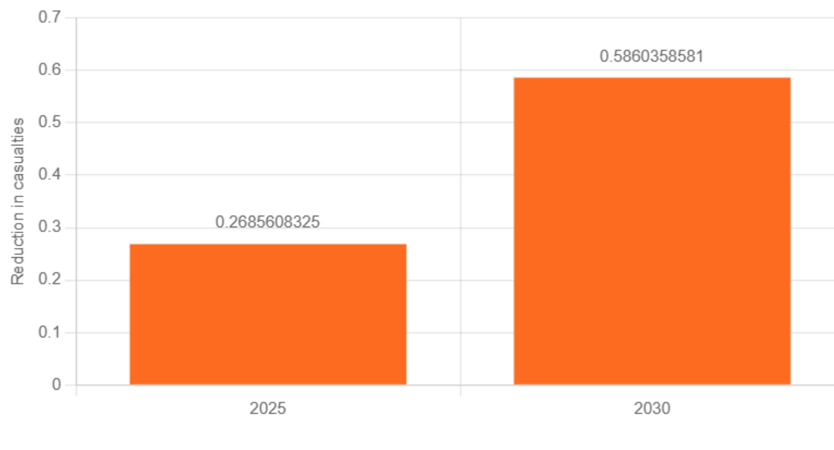

Figure 12: Reduction in excess cold weather mortality

The reduction in the number of deaths attributable to excessive cold is shown.
The observed impact on mortality shows a projected 0.268 lives saved in 2025, with a significant increase to 0.586 by 2030.

Quantification of physical values – Economic impacts

Impact on energy intensity

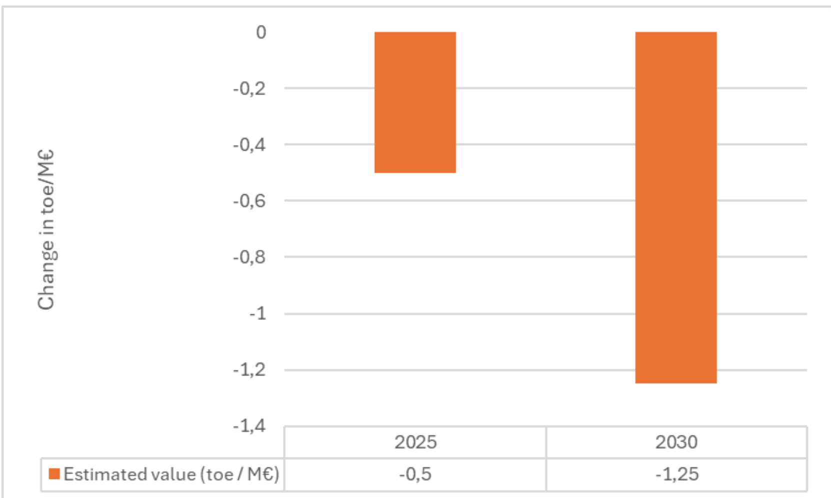

Figure 13: Impact on energy intensity

The value –1.25 toe/M€ indicates that, by 2030, regional energy intensity will decrease compared to 2025 (-0.5): for every million euros of GDP produced, less energy will be consumed than the baseline (reference consumption). The national improvement trend is consistent with the allocated resources, highlighting the increasing effectiveness of the measures over time.

Impact on gross domestic product

The GDP value is positive, with approximately €12.5 million in added value to regional GDP by 2030.

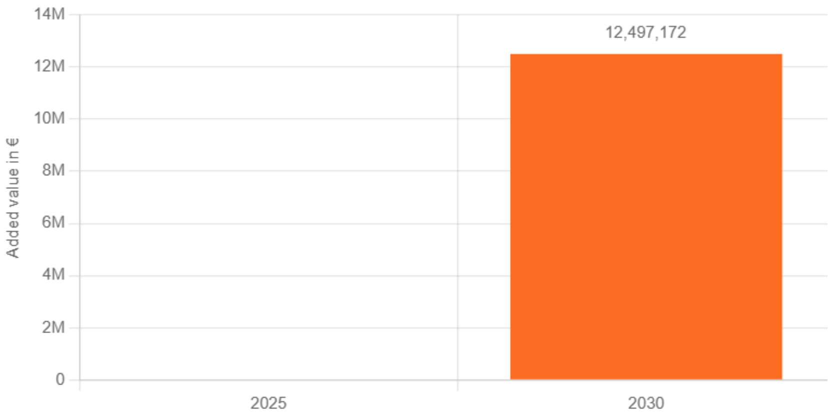

Figure 14: Impact on gross domestic product

Additional employments

An estimated 239 full-time equivalent years (FTE-years) of additional employment are expected by 2030.

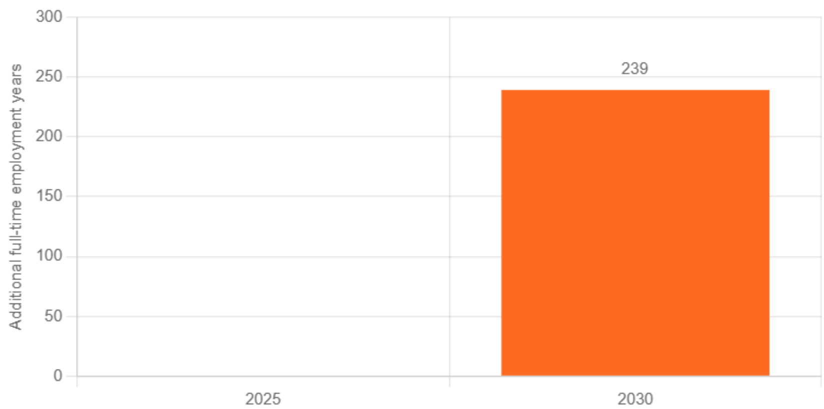

Figure 15: Additional employments

The FVG energy plan, on the other hand, provides an estimate of the employment generated equal to 1074.8 AWUs/year (Annual Work Units). For this case, MICATool provides a conservative estimate.

Added asset value buildings

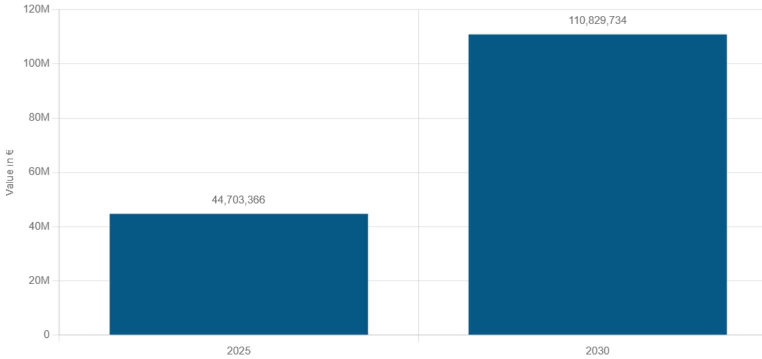

Figure 16: Added asset value buildings

The estimated asset value will increase from €44.7 million in 2025 to €110.8 million in 2030, representing growth of approximately 147%.

Quantification of physical values – Environmental impacts

Primary savings by energy carrier

The indicator measures the primary energy saved, broken down by energy carriers, thanks to the EE measures implemented in the building envelope.

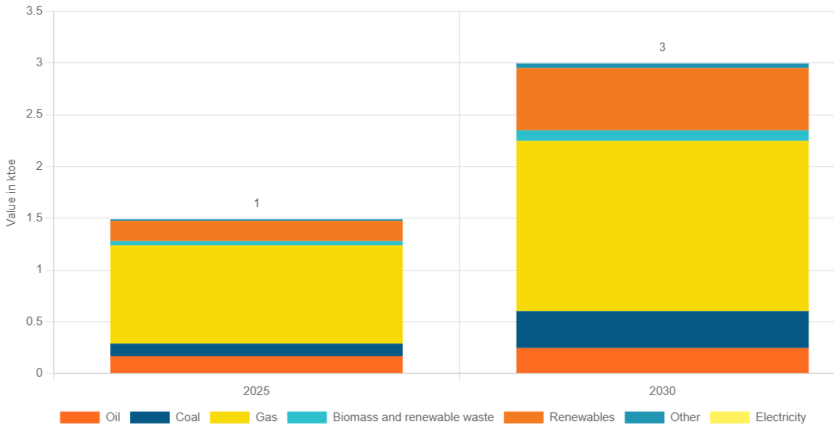

Figure 17: Primary savings by energy carrier

Table 8: Primary savings by energy carrier

Energy source	natural gas [ktoe]	renewable electricity sources [ktoe]	petroleum products[ktoe]	Coal[ktoe]	biomass and renewable waste [ktoe]
2025	0.957	0.197	0.167	0.121	0.040
2030	2.0	0.60	0.25	0.36	0.11

2.3 MIs of EE measures Metropolitan City of Milan

Regarding the **Metropolitan City of Milan (CMM)**, the current state of EE is characterised by urban density and plant complexity unique in Italy. Unlike the regional context of Friuli-Venezia Giulia, the challenge here is dominated by the management of large condominiums and massive public infrastructure.

The Energy Scenario for Milan

The Milanese context is distinguished by a strong dependence on natural gas, although the city boasts one of the most extensive district heating networks in Europe. However, the building stock is characterized by its age, with a vast portion of residential buildings constructed in the post-war period exhibiting extremely poor energy performance. In this scenario, EE is not only an environmental goal but a necessity to ensure the resilience of a metropolis subject to phenomena such as the urban heat island effect.

The DeciWatt Project and Plant Monitoring

A fundamental pillar of the current situation is the DeciWatt project, a system-wide initiative aimed at mapping and streamlining the city's thermal and electrical consumption. One of the most critical findings concerns obsolete thermal plants with high power output (exceeding 116 kW). These systems, often centralised in large residential complexes or public offices, represent energy consumption 'hotspots': their inefficiency not only inflates citizens' energy bills but also contributes significantly to CO2 emissions and particulate matter. The CMM OSS has been provided with a digital platform, "DeciWatt plarform", https://deciwatt.cittametropolitana.mi.it/, which integrates the following digital registers:

- the Lombardy Region EPC register (CENED), which is publicly available;
- the Lombardy Region Heating Systems Register (CURIT), containing information on TBSs (Technical Building System)s;
- the building register, made available by the municipalities where the trial is taking place. Just 24 municipalities have provided the CMM with the building register so far.

DeciWatt collects all the information to provide an energy characterisation of the buildings and to simulate energy renovation measures using the VENICE tool.

The VENICE tool (Energy and Economic Assessment of Energy Saving Measures on Building Categories) has been developed by ENEA and it aims to provide a broad assessment of the effects of measures to increase energy efficiency and/or production from renewable sources applied to residential and non-residential buildings, with and without the main incentives provided by current legislation. VENICE allows the aggregation of buildings depending on the type of owner (public/private) and the building category.

2.3.1 Selection of EE measures: Measure 1, local level Metropolitan City of Milan

The first case study for the metropolitan city of Milan concerns the replacement of standard boilers with hydronic heat pumps. The starting year for the analysis is 2025. The energy improvement scenarios, on the other hand, refer to 2030. The population under study is equal to 323,000 inhabitants. The number of dwellings analysed is 16,600. The energy mix under investigation, is taken from DATABASE of ISTAT family 2023 (database on household heating usage patterns in Italy) [2] and is summarized in the following table:

Table 9: Energy advanced input data (CMM)

Energy source	Energy Mix 2021	Energy Mix 2030
Biomass and waste	6%	7%
Electricity	5%	9%
Natural gas	84%	82%
oil products	3%	2%

This energy mix is also used for the case study on the energy upgrading of the building envelope. Energy savings for 2030 are estimated to 1,130 MWh. The energy saving data and those relating to the investment were calculated using the VENICE tool.
The investment costs forecast for 2030 amount to €1 million, with an average subsidy rate of 50%. The average technological lifetime of a heat pump is 17 years.

2.3.2 Results of the analysis of EE measures: Measure 1

Monetisation – Results of the monetisation of the physical values

For this Analysis related to a very local dimension, the relevant selected indicators are described below

Reduction of energy costs

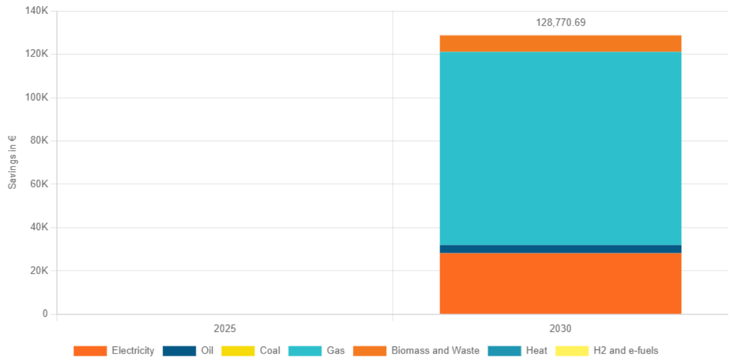

Figure 18: Reduction of energy costs

This indicator shows the monetisation of the decrease in energy costs. The largest share, as expected, is due to natural gas.

Reduction of greenhouse gas emissions

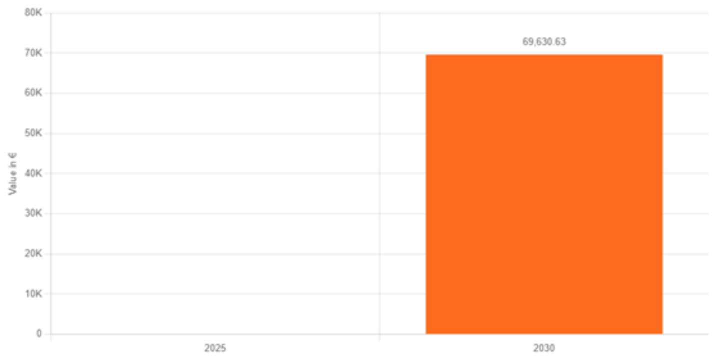

Figure 19: Primary savings by energy carrier

This Figure 19 shows the monetary benefits associated with reduced greenhouse gas emissions in euros. The value is 69630.63 €.

Health effects linked to reduced air pollution

Figure 20 shows the improvement in air quality from a monetary perspective.

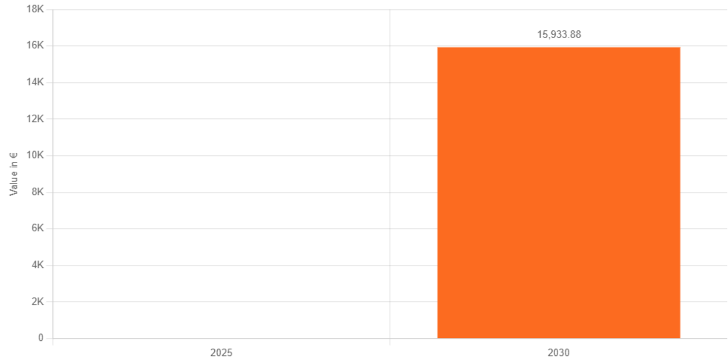

Figure 20: Health effects linked to reduced air pollution

Quantification of physical values – Economic impacts

Impact on gross domestic product

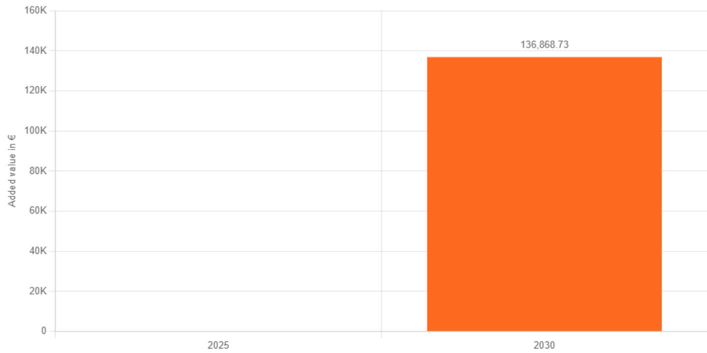

Figure 21: Impact on gross domestic product

Figure 21 shows the economic impact of EE measures on GDP, expressed in euros of added value generated. The renovation of residential private buildings will produce an increase in regional GDP of € 136,868 in 2030. This value reflects the relatively limited size of the planned investment (€1 million) and the limited sample of involved dwellings.

Additional employments

The indicator shows the number of full-time equivalent years (FTE-years) generated by the investment in improving the EE of heating systems in private buildings.
The measure generates the equivalent of 7.49 full-time jobs for one year.

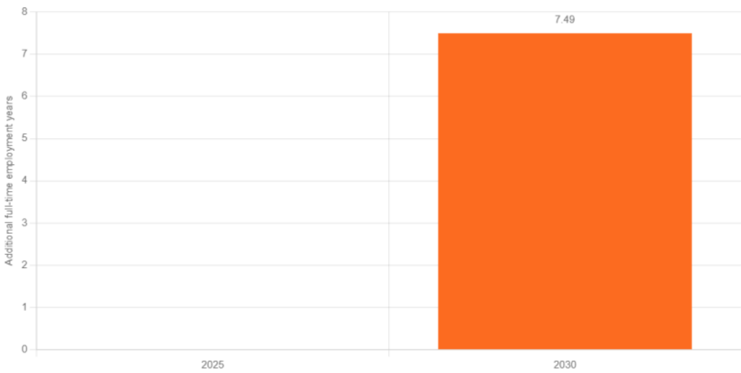

Figure 22: Additional employments

Added asset value of buildings

This indicator shows the increase in the asset value of real estate following the measures adopted, in millions of euros.

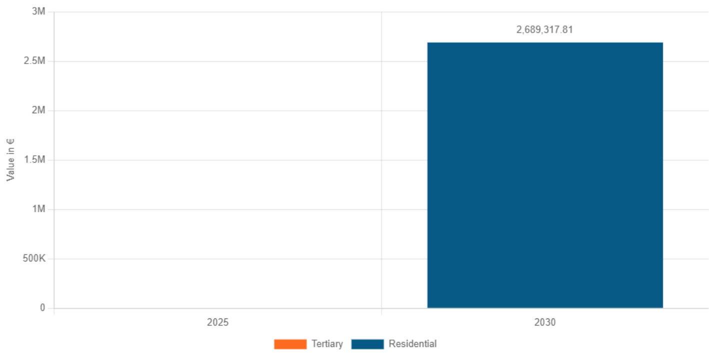

Figure 23: Added asset value of buildings

The results show that the added asset value of buildings is expected to reach 2,689,317,81 by 2030

Quantification of physical values – Environmental impacts

primary savings by energy carrier

The energy saved in terms of primary energy carriers with the proposed measures is described. In 2030 we recorded savings of 0.003 ktoe in terms of oil and oil derivatives and approximately 0.127 ktoe in terms of natural gas. the results are in line with the expected

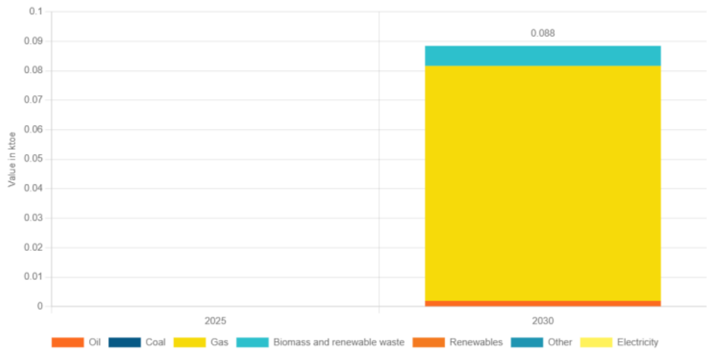

Figure 24: primary savings by energy carrier

2.3.3 Results of the analysis of EE measures: Measure 2

This case study for the metropolitan city of Milan studies the energy retrofitting of buildings. The started year for the analysis is 2025. The energy improvement scenarios, refer to 2030. The population under study is equal to 323,000 inhabitants. The number of dwellings analyzed is 16,600. Energy savings for 2030 are estimated to 18000 MWh. The investment costs forecast for 2030 amount to € 2.7 million, with an average subsidy rate of 50%. The average technological lifetime of is considered to be 25 years.

Monetisation – Results of the monetisation of the physical values

Reduction of energy costs

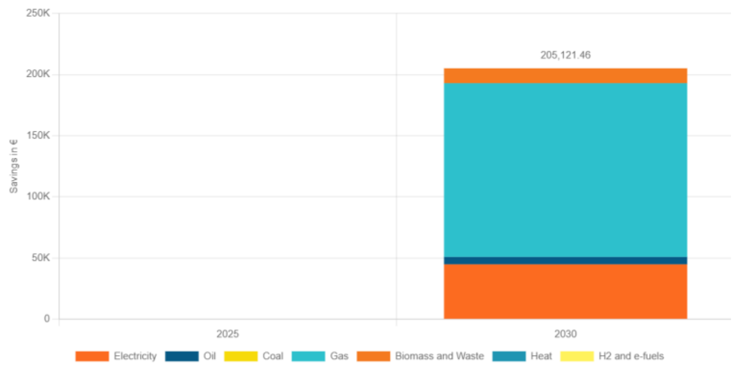

Figure 25: Reduction of energy costs

In this scenario too, the highest savings are due to natural gas, equal to €142,000.

Reduction of greenhouse gas emissions

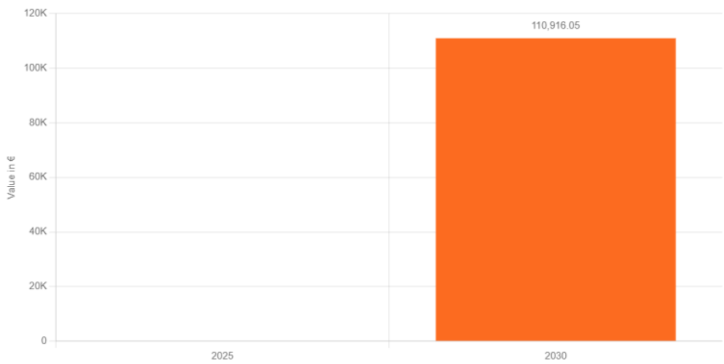

Figure 26: Primary savings by energy carrier

Insulating the building results in twice the monetary improvement compared to the case studied previously.

Health effects linked to reduced air pollution

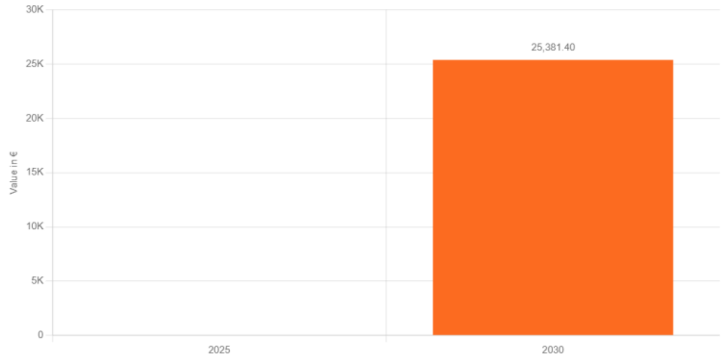

Figure 27: Health effects linked to reduced air pollution

The trend is the same as the indicator shown above, even for monetisation, which depends on improvements in air quality.

Quantification of physical values – Economic impacts

Impact on gross domestic product

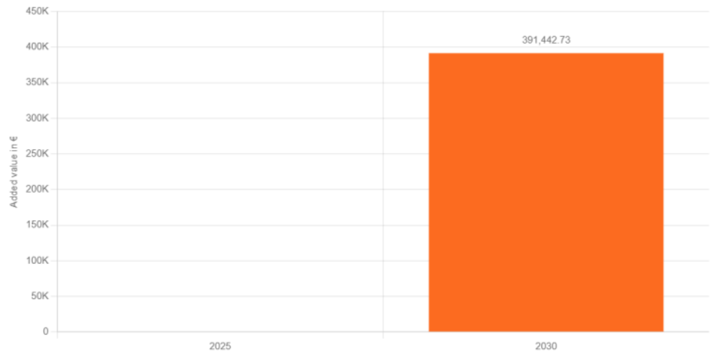

Figure 28: Impact on gross domestic product

The renovation of residential private buildings will produce an increase in regional GDP of nearly € 400,000 in 2030. This value reflects the relatively limited size of the planned investment (€2.7 million) and the limited sample of involved dwellings, as in the previous showcase.

Added asset value of buildings

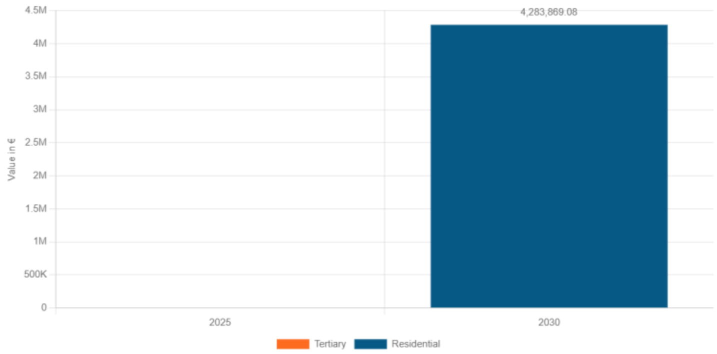

Figure 29: Added asset value of buildings

Energy retrofitting shows a significant increasing in the value of buildings, Measure 2, compared to efficiency measures that involve replacing the heating system, Measure 1. This comparison refers to Figure 23, which shows the same indicator but for the replacement of heating systems.

Quantification of physical values – Environmental impacts

primary savings by energy carrier

As expected, the greatest improvement is achieved for natural gas, which is still Italy's main fossil fuel source.

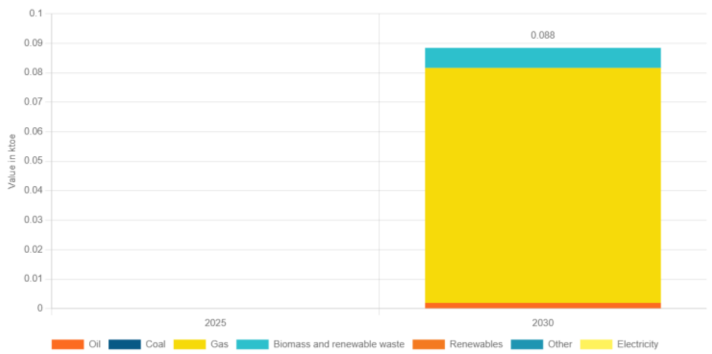

Figure 30:primary saving by carrier

2.3.4 Strategic Conclusion

The comparative analysis of the monetary benefits derived from greenhouse gas (GHG) emission reductions in the two Milanese scenarios reveals a clear hierarchy of effectiveness among the adopted energy efficiency measures:

- **Monetized Environmental Effectiveness**: Building envelope insulation (**Figure 26**) generates a significantly higher economic benefit from GHG reduction compared to the adoption of heat pumps alone (**Figure 19**). Specifically, the monetary improvement in the second case study is estimated to be approximately **twice** that of the first.
- **Key Data Points**: In Case Study 1, the monetary benefit associated with emission reduction is **€69,630.63**. In contrast, Case Study 2 reflects a reduction in energy demand at its source, leading to natural gas cost savings of **€142,000**.
- **Efficiency per Euro Invested**: Although the investment for building envelope retrofitting is higher (€2.7 million vs. €1 million), the technical return is drastically superior.

Table 10: Comparative Analysis: Environmental Impact and Performance

Performance Indicator	Case 1: Heat Pumps	Case 2: Building Envelope
Planned Investment	€ 1,000,000	€ 2,700,000
Energy Savings	1,130 MWh	18,000 MWh
Impact on Regional GDP	€136,87	~ € 400,000
Added Asset Value	€ 2,689,317	Significantly Higher
Efficiency Ratio	1,130 MWh/M€	6,666 MWh/M€

In summary, the analysis conducted using the **MICATool** demonstrates that the energy efficiency interventions planned for the Metropolitan City of Milan produce multidimensional benefits proportionate to the investments made. The national improvement trend is consistent with the projected investments, showing an efficiency for the building envelope scenario nearly **six times higher** than that of boiler replacement alone.

These findings validate the sustainability of current subsidy policies and suggest that prioritizing structural interventions on the building envelope is the most effective strategy to maximize energy savings, regional GDP growth (nearly **€400,000**), and real estate asset value by 2030. Furthermore, such measures act as a crucial tool for urban resilience, potentially mitigating risks like the **urban heat island effect** in Milan.

2.4 Learnings/policy recommendations

The **MICATool** supports policy making by providing a comprehensive, data-driven framework to evaluate the broader benefits of EE measures beyond simple energy savings.

Supporting Policy Making

The MICATool assists decision-makers by:

- **Broadening the Scope of Analysis:** It enables planners to move beyond a narrow focus on energy or climate benefits, which can lead to short-sighted decisions. By capturing non-energy or non-climate benefits (MIs or MI), it reveals higher values that are essential for long-term planning and societal well-being.
- **Providing a Flexible Assessment Framework:** The tool allows users to conduct simplified analyses for different policy scenarios at three governance levels (EU, national, and local). Its flexible approach permits the inclusion of MIs even with limited case-specific data, providing a "rough assessment" that can guide further investigation.
- **Enhancing Stakeholder Engagement:** It serves as a platform to initiate discussions among stakeholders about which impacts are most significant for a decision and which policy options are most beneficial based on sensitivity to key parameters.

Improving Policy Formulation and Instrument Refinement

The analysis of MIs (MIs) significantly improves policy formulation by:

- **Quantifying Socio-Economic and Environmental Benefits:** It extracts critical indicators—such as health effects from reduced pollution, job creation (FTE-years), and asset value increases—that help assess the true effectiveness of interventions.
- **Refining Implementation Instruments:** In the **Friuli-Venezia Giulia (FVG)** case, the analysis showed that improving the building envelope was statistically significant for alleviating energy poverty and reducing cold-weather mortality. Such findings allow policy makers to refine subsidies and grants—like action 07.1 of the FVG plan—to specifically target these high-impact social benefits.
- **Decoupling Growth from Consumption:** By demonstrating a reduction in **energy intensity**, the tool provides evidence that economic growth can be decoupled from energy consumption, aligning regional policies with European sustainability targets. The same trend is not evident at the local level

Comparing Pathways to Climate Neutrality (EE vs. Supply-Side)

The analysis of MIs allows for a robust comparison between energy demand (EE) and supply-side options:

Identifying "Hotspots": In the **Metropolitan City of Milan**, the tool highlighted that obsolete tbuildings whit old thermal plants) in F and G Energy classes. It is observed a positive impact on monetary benefits associated with reduced greenhouse gas emissions and on the energy costs, for both case studies take into account. However, it was difficult to analyze the social indicators, which can be considered insignificant for the analysis conducted. At the local level, this finding is likely due to the small sample size included in the analysis. It should be noted that only 24 out of 128 municipalities participate in the DeciWatt service, representing a total population of 320,000. We should find a way to represent the impacts at the local level, because some national indicators cannot be scaled down to the local level in any form. It is always necessary to contextualize the analysis and seek out new indicators.

The tool shows limitations when the sample studied is limited, and the reference territory scale is reduced, up to a group of small municipalities particularly for social indicators. However, there are no critical issues for economic indicators, which are in line with expectations.

CONCLUSIONS

The analysis conducted using the MICATool has provided an exceptionally clear and quantifiable overview of the benefits stemming from EE policies in the Friuli-Venezia Giulia and Metropolitan City of Milan case studies. The overall findings highlight that, by 2030, these interventions will far exceed simple fuel savings, evolving into a powerful driver of economic growth and social well-being. Notably, the impact on Gross Domestic Product is significant, fueled by an added asset value of buildings that reaches nearly €2.7 million in Milan and a substantial €184.5 million at the regional level in FVG. Alongside these economic figures, the research documented a profound impact on citizens' quality of life: lifting nearly one thousand people out of energy poverty and improving public health, which translates into 13 avoided days of work absence per year and the statistical saving of over half a human life by the end of the decade.

The experience of utilizing the MICATool has represented a fundamental added value for territorial planning processes, acting as a bridge between regulatory theory and operational practice. The tool’s primary value lies in its ability to reveal and monetize those "invisible" benefits—such as public health improvements or social equity—that often escape traditional analyses. Thanks to this methodology, policymakers now possess a scientific foundation to prioritize interventions, such as building envelope insulation, which guarantee the highest social and environmental return compared to investments focused solely on heating systems. Ultimately, the tool does more than just generate data; it provides a robust narrative to engage private investors and citizens, making the implementation of the "EE First" principle a concrete, transparent, and forward-looking strategy for the ecological transition of our cities.

Analysis of Critical Issues
Despite the positive outcomes, the application of the model highlighted several operational criticalities, particularly concerning the scalability of results from the local to the regional level. The primary challenge involved the difficulty in sourcing granular local and regional data essential for comparing and validating the simulation results generated by the MICATool. This lack of readily available data restricts the ability to perfectly calibrate simulation models to specific geographic contexts, occasionally complicating the direct alignment between theoretical estimates and actual territorial performance.

Summary of the "Data Gap" Impact:
Scalability: Difficulty in expanding local findings to a broader regional scope due to inconsistent data sets.
Validation: Challenges in benchmarking MICAtool. outputs against real-world regional statistics.

Policy Implications: The need for more integrated regional databases to support future energy efficiency planning.

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[2] Report completi ISTAT [2023-2024] https://www.istat.it/storage/ASI/2023/capitoli/C03.pdf

[3] La Povertà Energetica in Italia nel 2024, https://oipeosservatorio.it/wp-content/uploads/2025/12/2025_PE_ITA_2024.pdf [12/2025]

Annexes

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