Support Energy Efficiency Deployment with the Multiple Impacts CAlculation Tool

National Showcase - ITALY

A SHOWCASE FOR THE ANALYSIS OF MULTIPLE IMPACTS OF ENERGY EFFICIENCY IN ITALY

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CONTENTS

List of Tables 3

List of Figures 3

List of Abbreviations 4

Executive Summary 0

1. Introduction 1

1.1 What are Multiple Impacts of Energy Efficiency and why are they important 1

1.2 The MICATool – how does it work and what should it be used for 1

2. The national showcase for Italy 3

2.1 Discussion on the status quo of the analysis of MIs of EE, and the implementation of the EE first principle in Italy 3

2.2 Multiple Impacts of EE measures 4

2.2.1 Selection of EE measures 4

EE Measure 1: promotion of sustainable mobility (modal shift) and development of transport infrastructures 4

EE Measure 2: support for the digital and energy transformation of Italian companies (Transition 5.0) 9

2.2.2 Results of the analysis of the EE measures 12

Quantification of physical values – Social impacts 13

Quantification of physical values – Economic impacts 14

Quantification of physical values – Environmental impacts 16

Monetisation 17

3. Conclusions 19

References 21

SEED MICAT PARTNERS 24

List of Tables

Table 1 - Summary of estimated energy savings related to the FS Group's 2025-2029 Strategic Plan (ex-ante assessment)

Table 2 - Hypotheses list for estimating energy savings for EE Measure 1

Table 3 - tax credits scheme established by the Transition 5.0 plan

Table 4 - Summary of estimated investments and energy savings in industry related to the Transition 5.0 plan (ex-ante assessment)

Table 5 – Final energy saving in ktoe activated by the Transition 5.0 plan (ex-ante assessment)

Table 6 - Estimated total investments related to the Transition 5.0 plan

Table 7 - Map of selected indicators for the analysis

Table 8 – Quantification of the social impacts of the two measures; Output from the MICATool

Table 9 - Quantification of the economic impacts of the two measures; Output from the MICATool.

Table 10 - Quantification of the environmental impacts of the two measures. Output from the MICATool.

Table 11 - Monetisation of the impacts for the two measures. Output from the MICATool.

List of Figures

FIGURE 1 – Specific avoided Health impacts per unit of primary energy saving for the two measures

FIGURE 2 - Specific avoided lost working days per unit of primary energy saving for the two measures

FIGURE 3 – Specific impact on GDP for every Euro invested for the two measures

FIGURE 4 - Specific impact on employment for every Billion Euro invested for the two measures

FIGURE 5 – Specific reduction in air pollution emissions per unit of primary energy saving for the two measures

FIGURE 6 – Comparison between CAPEX and total benefits (not discounted) for the FS Plan's measure (years 2025-2050)

FIGURE 7 – Comparison between CAPEX and total benefits (not discounted) for the Transition 5.0 measure for industry only (years 2024-2039)

List of Abbreviations

CAPEX	Capital Expenditure
CO_2	Carbon Dioxide
DNSH	Do No Significant Harm
EE	Energy efficiency
EE1st	Energy efficiency first
EEA	European Environmental Agency
ENEA	Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile
ESCo	Energy service company
ETS	Emission Trading System
FIRE	Federazione italiana per l'uso razionale dell'energia
FS	Ferrovie dello Stato
GDP	Gross domestic product
GHG	Greenhouse gases
GSE	Gestore dei Servizi Energetici
HDV	Heavy-Duty Vehicle
ISPRA	Istituto Superiore per la Protezione e la Ricerca Ambientale
KPI	Key Performance Indicator
MBs	Multiple Benefits
MIs	Multiple Impacts
NECP	National Energy and Climate Plan
NOx	Nitrogen oxides
O&M	Operations and Maintenance
PM2.5	Particulate matter (particles with a diameter of 2.5 microns or less)
RES	Renewable energy sources
RSE	Ricerca sul sistema energetico
SO_2	Sulfur dioxide
UM	Unit of measure
WHO	World Health Organization

EXECUTIVE SUMMARY

This report presents the national showcase of the MICATool applied at the Italian level.

Two Energy Efficiency measures with a national scope were analysed.
The first measure is the 2025-2029 Strategic Plan of the Italian Railways (*Ferrovie dello Stato Italiane)* Group to promote sustainable mobility in Italy.
The second measure is the "Transition 5.0 plan" set up by the Italian Government to support the transition of production processes to an efficient, sustainable and renewable energy model.

Final energy savings for both measures were estimated and used as input parameters for the MICATool. The MICATool enabled the quantification of social impacts (mortality and morbidity), economic impacts (GDP, employment, energy intensity, import dependence) and environmental impacts (primary energy, air pollutants and GHG emissions, RES target) associated with these two measures.

Results of the monetization section allow us to compare total cost of investments (distinguishing between private and public share) and total (undiscounted) benefits over the entire life of the two measures.

The analysis allowed us to draw positive conclusions regarding the usability of the MICATool (e.g. flexibility, clarity of the methodological factsheets), and the potential value added of its use during the policy planning process (e.g. policy intercomparison considering social impacts that are generally neglected).

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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 monetization 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, could 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, 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.

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 multiple impacts of energy efficiency 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

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) → 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) → 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.

2. THE NATIONAL SHOWCASE FOR ITALY

2.1 Discussion on the status quo of the analysis of MIs of EE, and the implementation of the EE first principle in Italy

The national transposition of the EE Directive 2023/1791 was expected by October 2025, but Italy is behind schedule and, as of March 2026, it has not been published yet. Once the national transposition will be released, it will establish how the EE1st principle will be fully implemented in Italy in all relevant sectors.

Meanwhile, in 2024, the Italian Ministry of Environment and Energy Security, submitted its updated National Energy and Climate Plan (NECP) to reflect the increased EU 2030 climate and energy ambitions, while also considering historical developments in recent years. The EE1st principle has been well considered in the NECP, even if it is explicitly mentioned only for infrastructure projects financed by cohesion policy funds (EC, 2023) (EC, 2025). Relevant policies in the NECP are, for example, measures for demand reduction in transport (modal shift and soft mobility), White Certificates, tax relief for residential and tertiary buildings, the National EE Fund, Transition plan 5.0, energy savings target for public administration, etc. (MASE, 2024).

In addition, the multiple-impact approach is already used in Italy at company level and promoted by the Italian Federation for Energy Efficiency (FIRE) and the National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA, 2024). As part of the European *Multiple Benefits* project (2018-2021) (Fraunhofer ISI, 2025), FIRE supported the implementation of several pilot projects in which the multiple benefits assessment was applied to real cases in Italy. Two examples of multiple benefits quantified in the financial analysis of new investments in a manufacturing company and a wastewater treatment plant are summarised in (De Chicchis & Di Santo, 2023).
Moreover, an Italian engineering and consulting company (SOGESCA Srl) was a partner of the EU funded project KNOWnNEB (2022-2025) (e7 GmbH, 2025). During this LIFE project, a methodology for the inclusion of non-energy benefits in the energy auditing practise was developed.

From the perspective of an industrial company, important multiple benefits of EE are, for example, higher industrial productivity and competitiveness, less energy and environmental costs, less O&M costs, quality improvements of products/processes/services, enhancements in workplace safety and security, increased asset value, reduction of regulatory risks (legislative compliance), better corporate image, better access to credits, etc. (Tuzzolo, 2019). Evaluating these multiple benefits allows energy managers to improve the cash flow of a new investment projects (Net Present Value, Internal Rate of Return, Payback Time), and to propose new investments to business decision makers by leveraging other benefits to which they are sensitive (Tuzzolo, 2019). Therefore, the MIs approach can be useful for unlocking investment decisions in EE projects at company level.

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To our knowledge, based on online searches and consultations with national and regional public administrations, no public entities have applied the MIs approach in planning activities since the introduction of the EE1st principle under Directive (EU) 2023/1791. However, although the cost-benefit analysis of monetized MIs has not been explicitly applied, the EE1 principle has long been adopted by national and local public administrations. It is largely recognized, in fact, that energy efficiency and reduction of energy demand are crucial to reducing air pollution, GHG emissions and energy dependence on foreign sources. This is shown, for example, not only by the aforementioned NECP, but also at the regional level in the Regional Energy, Environment and Climate Program (PREAC), like that of the Lombardy Region, where energy planning (and, in particular, the reduction of energy consumption) is closely linked to regional and local plans to reduce air pollution.

2.2 Multiple Impacts of EE measures

2.2.1 Selection of EE measures

We selected two EE measures to apply the MICATool. The selection was based on the following criteria: relevance at a national geographical scale, alignment with the EE1st principle, prominence in the national context, possibility of estimating both investments and energy savings per commodity.

The first measure is an investment plan to promote sustainable mobility in Italy, in particular the modal shift from private to public transport. This plan was chosen because, following the EE1st principle, it is important to pursue demand reduction in the transport sector before the electrification of the car fleet.

The second measure is the “Transition 5.0 plan” set up by the Italian Government to support the transition of production processes to an efficient, sustainable and renewable energy model. It was selected because it consists of tax credits granted for clean energy investments; however, they are subject to the achievement of specific targets of energy consumption reduction. Therefore, even when supply side investments are incentivised, in its conception the measure is in line with the EE1st principle.

EE Measure 1: promotion of sustainable mobility (modal shift) and development of transport infrastructures

The measure is the 2025-2029 Strategic Plan of the Ferrovie dello Stato Italiane Group (FS group, 2024) (Gruppo FS Italiane, 2024). The FS Italiane Group is a company at the heart of the Italian mobility system with more than 96,000 employees and 17,600 km of railway line (Ferrovie dello Stato Italiane, 2025). By mobilising 100 billion euros of investment over five years, the FS Group aims to promote the modal shift of:

- passengers from private cars to rail (+100 million passengers per year by 2029),

- passengers from private cars to buses (+95 million passengers per year by 2029),
- freight from road to rail (+5% by 2029 in terms of millions of tons transported per year).

In addition, the company, which consumed approximately 6 TWh of electricity in 2023[3] (2% of total electricity consumption in Italy), has committed to installing more than 1 GW of photovoltaics by 2029 to reduce its indirect GHG emissions. This action implies savings of primary energy, not of final energy, therefore it is not considered in the MICATool and will not be discussed further below.

Table 1 summarises the estimated energy savings linked to these 3 considered targets. These energy savings are estimated to approximately 11 Mtoe of cumulative final energy savings from 2025 to 2050. To reach these goals, the main actions envisaged by the strategic plan refer to developing the railway infrastructure, new road works, purchase of new trains and low-carbon buses, actions to support multimodal freight transport, valorisation of real estate assets and creation of new urban parking lots.

Table 1 - Summary of estimated energy savings related to the FS Group's 2025-2029 Strategic Plan (ex-ante assessment)

Measure	UM	2025	2026	2027	2028	2029
M1.1 Passenger transport: from private cars to rail						
Final Energy savings (net total annual)	ktoe	79	158	238	317	396
Avoided diesel (cars)	ktoe	63	126	189	251	314
Avoided gasoline (cars)	ktoe	34	68	102	137	171
Increase in electricity (rail)	ktoe	18	36	53	71	89
M1.2 Passenger transport: from private cars to bus						
Final Energy savings (net total annual)	ktoe	5	11	16	21	27
Avoided diesel (cars)	ktoe	7	13	20	27	34
Avoided gasoline (cars)	ktoe	4	7	11	15	18
Increase in diesel (bus)	ktoe	5	10	15	20	26
M1.3 Freight transport: from HDVs to rail						
Final Energy savings (net total annual)	ktoe	8	16	24	32	41
Avoided diesel (HDVs)	ktoe	9	17	26	35	43
Increase in electricity (rail)	ktoe	1	1	2	2	3
Measure 1 - total						
Total Investments (*)	M€	20,000	20,000	20,000	20,000	20,000
Final energy savings (net total annual from M1.1, M1.2, M1.3)	ktoe	93	185	278	370	463

(*) The 100 billion euros of investment in five years has been arbitrarily distributed equally over the 5 years.

The methodology used to estimate energy savings reported in Table 1 for each sub-measure of the Plan is described below.

[3] of which 82% is electricity for railway traction (Ferrovie dello Stato Italiane, 2024)

M.1.1) Passenger transport: from private cars to rail

To estimate the impact of the modal shift from private cars to trains, the calculations were based solely on the demand for *additional* train-travel compared to the 2024 data. Then, a linear interpolation was applied for all data between 2024 and 2029, starting from the assumption that the 2024 data equals that of 2023.

The first step is to estimate the shifted transport demand in million passenger-km. In 2023, 648 million passengers made use of the FS group services, 74% of whom travelled on trains (Trenitalia) and the rest on buses (Busitalia) (Federturismo Confindustria, 2024). By 2029, the FS Group's plan aims to increase the number of passengers travelling by train by +100 million per year, i.e. +21% compared to 2023 (Gruppo FS Italiane, 2024). In 2023, the corresponding transport demand by train was 45,981 million passenger-km (Gruppo FS, 2025). Assuming that future new travellers have the same average distance covered as in 2023, we expect an *additional* transport demand by train of approximately 9,600 Mp*km by 2029, i.e. +21% compared to 2023.

The second step is to estimate the transport demand in million vehicle-km avoided by all private cars removed from the road. Supposing an occupancy rate of passenger cars of 1.15 passengers/vehicle (commuting to/from work) (EEA, 2000)[4], the avoided transport demand by cars is 8,347 million vehicles-km (Mvkm) by 2029. Based on national car fleet data (ISPRA, 2025), we assumed that 66% are diesel-cars and 34% gasoline-cars.

The third step is to estimate the avoided fuel demand in ktoe/year. We assumed a specific consumption of 56.1 g fuel/km for diesel cars, and 57.7 g fuel/km for gasoline cars (INEMAR ARPA Lombardia, 2024). It follows that, by 2029, avoided fuel consumption is 314 ktoe of diesel and 171 ktoe of gasoline (see Table 1 for M1.1). A further hypothesis is that there is no rebound effect from increased train use (neither income-driven nor behaviourally driven).

Then, we estimated the extra-electricity consumption for train traction by the FS group. In its Corporate Sustainability Report, the FS group declares that energy consumption for railway traction in relation to passenger-km transported is 388.64 kJ/pkm (Ferrovie dello Stato Italiane, 2024). Multiplying the additional Mpkm by this specific consumption, we calculate an increase in electricity consumption equal to 89 ktoe by 2029 (see Table 1 for M1.1).

Finally, the net (final) energy saving for M1.1 is obtained by adding the diesel and petrol avoided by cars and subtracting the increase in electricity consumption by trains. The result is 396 ktoe avoided in 2029. This saving is extended until 2050 due to the long lifespan for the rail infrastructure.

[4] In Italy, the overall average occupancy rate of cars is 1.36 passengers/vehicle in 2023 (ISFORT (2024)). However, it is reasonable to assume that the new passengers transported by the FS group will mainly be users travelling for work (commuting and business trips). In this case, we believe that the average EU occupancy rate of 1.15 passengers/vehicle is still a valid assumption because in Italy the private car is still the primary means of transportation for commuting to/from work (company carpooling is not yet widespread) (Arval - Ipsos, 2024).

The table below describes the list of hypotheses utilised for assessing the expected energy savings of FS Group.

Table 2 - Hypotheses list for estimating energy savings for EE Measure 1

Hypotheses list:
1. **Passenger transport in 2029 is compared with 2024, considering only the additional demand**
2. **Transport statistics for 2024 = 2023 (at the time of writing, 2023 is the latest year available in the FS group's statistical data)**
3. **Linear interpolation between 2024 and 2029**
4. **Future new train travelers have the same annual distance covered as in 2023**
5. **Occupancy rate of passenger cars = 1.15 passengers/vehicle (source: EEA)** 6. **Specific consumption diesel cars = 56.1 g diesel/km (source: INEMAR ARPA Lombardia)**
7. **Specific consumption gasoline cars = 57.7 g gasoline/km (source: INEMAR ARPA Lombardia)**
8. **NCV diesel = 42.9 GJ/t (source: ISPRA)**
9. **NCV gasoline = 43.1 GJ/t (source: ISPRA)**
10. **Specific consumption for passenger train traction = 388.64 kJ/pkm (source: FS group)**

M.1.2) Passenger transport: from private cars to bus

As for M1.2, to estimate the impact of the modal shift from private cars to buses, we based our calculations solely on the demand for *additional* bus-travel compared to 2024, and we applied a linear interpolation of all data between 2024 and 2029, assuming 2024 equal the 2023 amounts.

The first step is to estimate the shifted transport demand in million passenger-km. In 2023, the FS group carried 648 million passengers, 26% of whom travelled on buses (Busitalia) (Federturismo Confindustria, 2024). By 2029, the FS Group's plan aims to increase the number of passengers travelling by bus by +95 million per year, i.e. +57% compared to 2023. In 2023, the corresponding transport demand by buses was 1.82 million passenger-km (Gruppo FS, 2025). Assuming that future new travellers have the same average distance covered as in 2023, we expect an *additional* transport demand by bus of 1,030 Mp*km by 2029, i.e. +57% compared to 2023.

The same assumptions for M1.2 were used regarding the occupancy rate of passenger cars, the share between diesel-cars and gasoline-cars, and specific consumptions for private cars. It follows that, by 2029, the total shifted transport demand from cars to buses is 896 Mvkm, and the avoided fuel consumption is 34 ktoe of diesel and 14 ktoe of gasoline (see Table 1 for M1.2).

Then, we estimated the additional diesel consumption for bus-traction by the FS group. In its Corporate Sustainability Report, the FS group declares that energy consumption for road traction in relation to passenger-km transported is 1,037.7 kJ/pkm (Ferrovie dello Stato Italiane, 2024). Multiplying the additional Mpkm by this specific consumption, we calculate an increase in diesel consumption equal to 26 ktoe by 2029 (see Table 1 for M1.2).

Finally, the net (final) energy saving for measure 1.2 is obtained by adding diesel and petrol avoided by cars and subtracting the extra diesel consumption of buses. The result is 27 ktoe avoided in 2029. These savings are extended until 2044, assuming a 15-year lifespan for buses (JRC, 2019).

M.1.3) Freight transport: from HDVs to rail

To estimate the impact of the modal shift from road to rail, we based our calculations solely on the demand for *additional* rail-travel compared to 2024, and we applied a linear interpolation of all data between 2024 and 2029, assuming 2024 = 2023.

The first step is to estimate the shifted freight transport demand in million tons-km. In 2023, the FS group carried about 37 million tons of freight (Mercitalia). By 2029, the FS Group's plan aims to increase this number by +5%. In 2023, the corresponding transport demand was 21,084 million tons-km (Gruppo FS, 2025). Assuming a constant average distance covered, we expect an *additional* freight transport demand of 1,054 Million tonnes per km (Mtkm) by 2029, i.e. +5% compared to 2023.

The second step is to estimate the transport demand in million vehicle-km avoided by all Heavy Duty Vehicles (HDVs) removed from the road. Supposing an occupancy rate of 4.6 tons/vehicle, the avoided road transport demand is 229 Mvkm by 2029.

To estimate the avoided fuel demand, we assumed a specific consumption of 184.3 g diesel/km for HDVs (INEMAR ARPA Lombardia, 2024). It follows that, by 2029, the avoided fuel consumption is expected to be 43 ktoe of diesel (see Table 1 for M1.3).

Then, we estimated the additional electricity consumption for train traction by the FS group. In its Corporate Sustainability Report, the FS group declares that energy consumption for railway traction in relation to tons of freight-km transported is 107 kJ/tonnes per km (tkm) (Ferrovie dello Stato Italiane, 2024). Multiplying the additional Mtkm by this specific consumption, we calculate an increase in electricity consumption equal to 3 ktoe by 2029 (see Table 1 for M1.1).

Finally, the net (final) energy saving for measure 1.3 is obtained by adding the diesel avoided by HDVs and subtracting the increase in electricity consumption by trains. The result is 41 ktoe avoided in 2029. These savings are extended until 2050, assuming a long lifespan for the rail infrastructure.

For this case study, we chose to use future ETS2 values for the CO_2 prices, instead of the default social cost of carbon, to better represent the economic savings associated with avoided road journeys. The source of these values derives from the Italian NECP (MASE, 2024), based on EC projections.

EE Measure 2: support for the digital and energy transformation of Italian companies (Transition 5.0)

The second measure is the Transition 5.0 plan set up by the Italian Ministry of Enterprises and Made in Italy to support the digital and energy transformation of companies (Ministero delle Imprese e del Made in Italy, 2025).

The plan establishes a tax credits scheme on investments in:

- capital goods (material and immaterial goods functional to the technological and digital transformation of production processes),
- R&D activities,
- technological and digital training.

Tax credits are subject to specific EE targets. The measure is aimed at all companies residing in Italy and companies that have their headquarters abroad but operate permanently in Italy. Companies can belong to the industry, tertiary, agriculture or transport sectors[5]. As an alternative to companies, the tax credit can be recognized to certified energy service companies (ESCo) for innovation projects carried out at the client company.

The national authority in charge of the implementation and monitoring of the measure is the GSE (Gestore dei servizi energetici, 2025).

Eligible projects are innovation projects with investments made between 1 January 2024 and 31 December 2025 in one or more new tangible assets functional to the exercise of the business. Investments can be linked to material goods (e.g., production machines, motors) as well as immaterial goods (e.g., software, digital platforms, monitoring systems, IoT). Eligible innovation projects are also:

- investments in renewable energy plants for self-consumption (even at distance) except for biomass, but including energy storage systems and electrification of process heat through renewable electricity,
- expenses in training activities aimed at acquiring skills in technologies relevant to the digital and energy transition of production processes.

In compliance with the DNSH principle (Do No Significant Harm)[6], investments directly connected to the use of fossil fuels are not eligible. In addition, lighting systems, compressed air systems and general building systems are not eligible (as in the FAQs on the ministry website)[7].

Tax credits are granted with the clause of reaching a minimum percentage of primary energy saving[8] compared to the pre-intervention baseline: savings must be at least 3% on the entire production plant or, alternatively, minimum 5% on the specific production process affected by the investment.

[5] cfr. Table 44 of the NECP (English version) and FAQ on the ministry website
[6] This principle was introduced by Regulation (EU) 2020/852, also known as the EU Taxonomy Regulation, to promote sustainable investments consistent with climate and environmental goals.
[7] Further exclusions and conditions are specified in the Decreto interministeriale 24 luglio 2024 "Modalità attuative del Piano Transizione 5.0" (Articles 5-7)
[8] Primary energy as defined in the Decreto interministeriale 24 luglio 2024 "Modalità attuative del Piano Transizione 5.0" (Article 1)

The entity of tax credit depends on the size of the investment and the energy saving target, as described in Table 3.

Table 3 - Tax credits scheme established by the Transition 5.0 plan

	Primary energy saving		
Size of the investment	**3-6% on prod. plant, or 5-10% on prod. process**	**6-10% on prod. plant, or 10-15% on prod. process**	**> 10% on prod. plant, or > 15% on prod. process**
Up to 10 million €	35%	40%	45%
Over 10 million € (*)	5%	10%	15%

(*) *the maximum limit of eligible costs is 50 million € per beneficiary company.*

This tax credit can be combined with further incentives at national level (e.g., white certificates, other measures). It can be combined also with further incentives provided by the European Union programs, given that the support does not cover the same cost portions supported by Transition 5.0.

The allocated public budget is 6.3 billion € from 2024 to 2030 (mainly in 2024-2025) financed by the Next Generation EU-Italia (PNRR measure M7- Investment 15 "Transition 5.0").

To analyse the measure with the MICATool, we consider only investments made by industry. The reason is that the MICAT tool requires a breakdown of energy savings by commodity. Considering that the main policy measures for industry are Transition 5.0 and white certificates, and that these two measures are not mutually exclusive, it is reasonable to estimate this breakdown for industry alone based on the difference between the Reference and Policy scenarios of Italy's NECP. For the services and transport sectors, however, the Policy scenario differs from the Reference one due to the combination of many more sectoral measures and it would therefore not be possible to isolate the effect of Transition 5.0 alone. Since the measure has historically been dedicated to industry (the original measure was called *Industry 4.0*), we assume that 50% of expected savings and 50% of mobilised investments will be allocated to the industrial sector.

Table 4 summarises the estimated CAPEX and energy savings linked to this measure for the industrial sector only. The methodology used to estimate these savings in industry is described below.

Table 4 - Summary of estimated investments and energy savings in industry related to the Transition 5.0 plan (ex-ante assessment)

	UM	2024	2025	2026	2027	2028	2029	2030
Total investment (public + private)	M€	1,103	3,119	416	416	416	416	416
Final energy savings (*)	ktoe	35	115	115	115	115	115	115
of which electricity	ktoe	8%	8%	13%	15%	17%	16%	16%
of which natural gas	ktoe	92%	92%	87%	85%	83%	84%	84%

(*) Total annual saving considering only new investments made in years 2024 and 2025.

The impact of the Transition 5.0 plan was embedded in the updated NECP (MASE, 2024) for the purposes of Article 8 of the new EE Directive published in 2023. To this end, the Italian Ministry of Environment and Energy Security estimated that Transition 5.0 would generate 70 ktoe of new final energy saving in 2024 and 160 ktep of new final energy saving in 2025 (Table 5). These investments will continue to accrue energy savings in subsequent years, as long as the lifetime of the installed solution is not over. Therefore, the total annual saving is shown in Table 5 (230 ktoe per year from 2025 onwards). As explained above, we only consider the energy saving generated by the industrial sector, assuming that it represents 50% of the total. In Table 4, the distribution of savings between natural gas and electricity is estimated by comparing consumption by commodity in the Reference and Policy scenario underlying Italy's NECP. These savings are extended until 2039, assuming an average 15-year lifespan[9] for industrial technologies installed in 2024 and 2025 (approximately 1.7 Mtoe cumulative from 2024 to 2039).

Table 5 – Final energy saving in ktoe activated by the Transition 5.0 plan (ex-ante assessment)

	2024	2025	2026	2027	2028	2029	2030
2024	70	70	70	70	70	70	70
2025		160	160	160	160	160	160
Total annual saving	70	230	230	230	230	230	230
of which in Industry (hp. 50%)	35	115	115	115	115	115	115

To estimate the total investment, an average tax rate of 25% is assumed (arithmetic mean of the tax rates shown in Table 3, ranging from 5% to 45%). The overall financial allocation is 6.3 billion € for the State, distributed over the years 2024-2030 as per Legislative Decree 2 March 2024, n. 19, paragraph 21. By dividing public spending by the average tax rate, the total investment (public + private) is estimated (Table 6). Since the measure is intended for private entities in all sectors, this value is divided by 2 to consider only investments made by industry. Furthermore, since the measure can incentivize both energy efficiency and renewable energy projects, the result is further divided by 2 to consider only investments made in energy efficiency.

Table 6 - Estimated total investments related to the Transition 5.0 plan

	UM	2024	2025	2026	2027	2028	2029	2030
Average share of investment supported by tax deductions (hp.)	%	25%	25%	25%	25%	25%	25%	25%
Investments paid by the State through tax deductions (*)	M€	1,103	3,119	416	416	416	416	416
Total investments (public + private)	M€	4,410	12,474	1,663	1,663	1,663	1,663	1,663
of which in Industry (hp. 50%) and for EE only (hp. 50%)	M€	1,103	3,119	416	416	416	416	416

(*) As in Legislative Decree 2 March 2024, n. 19, paragraph 21. The overall public financial allocation is 6.3 billion €.

[9] Industrial technologies have a wide lifespan, typically ranging from 15 to 50 years, largely dependent on machinery type, maintenance, and operating environment. Since it is not possible to know a priori which technologies will be selected by the industries, we have adopted a conservative value.

Regarding the global parameters, instead of the default social cost of carbon, for this case study we chose to use CO_2 prices that represent an average between future ETS1 and ETS2 values, to better represent the economic savings associated with avoided gas consumption. The source of these values derives from the Italian NECP (MASE, 2024), based on EC projections.

2.2.2 Results of the analysis of the EE measures

Table 7 maps all the indicators considered in the MICATool and highlights those that are relevant for these two EE measures. In total, there are 11 indicators of interest for this analysis: 2 social indicators related to air quality improvements, 5 economic indicators and 4 environmental indicators. In the MICATool there are additional indicators that have not been used for this analysis because they are relevant only for the building sector (e.g. energy poverty, asthma cases, asset value of buildings).

Table 7 - Map of selected indicators for the analysis

Category	Quantification	Monetisation	Selected for analysis
Social	Health effects linked to reduced air pollution	Health effects linked to reduced air pollution	**Yes**
	Avoided lost working days due to air pollution	Avoided lost working days due to air pollution	**Yes**
	Alleviation of energy poverty (M/2)	n.a. (it would overlap with "Reduction of energy costs")	No (relevant only for residential buildings)
	Alleviation of energy poverty (2M)	n.a. (it would overlap with "Reduction of energy costs")	No (relevant only for residential buildings)
	Avoided asthma cases	Avoided asthma cases	No (relevant only for residential buildings)
	Reduction in excess cold weather mortality	Avoided excess cold winter mortality	No (relevant only for residential buildings)
Economic	Impact on energy intensity	n.a. (no direct benefits)	**Yes**
	Impact on import dependence	n.a. (it would overlap with "Reduction of energy costs")	**Yes**
	Impact on gross domestic product	Impact on gross domestic product	**Yes**
	Additional employments	n.a. (not monetizable)	**Yes**
	Added asset value of buildings	Added asset value of buildings	No (relevant only for buildings)
	Reduction of additionally needed generation capacity	n.a. (it would overlap with "Reduction of energy costs")	**Yes**
Environ-mental	Primary savings by energy carrier	Reduction of energy costs	**Yes**

	Reduction in air pollution	n.a. (it would overlap with social indicators linked to air pollution)	**Yes**
	Reduction in greenhouse gas emissions	Reduction of greenhouse gas emissions	**Yes**
	Impact on RES targets	Impact on RES targets	**Yes**

Generally, in the MICATool, each quantified indicator has a corresponding monetised indicator. In some cases, monetisation is not done because some indicators are either just KPIs (with no direct benefit), or they are not monetisable (because a suitable monetisation approach was not found in the literature), or the monetisation is not done because it would constitute a double counting. For example, the environmental indicator "Reduction in air pollution" quantifies the avoided emissions of PM2.5, NOx and SO_2, and a monetisation would constitute a double counting with the two social indicators related to air quality.

Quantification of physical values – Social impacts

The social impacts linked to both measures are *Avoided Health effects* and *Avoided lost working days* due to reduced air pollution (Table 8). In the MICATool, these indicators measure the impact of EE solutions on mortality and morbidity thanks to the reduction of PM2.5 air pollution. In absolute values, the FS plan shows greater total benefits due to the higher final energy savings and the longer duration of the measure's effect. To put the mortality indicator into context, consider that in Italy, in 2022, 48,600 deaths were attributable to long-term exposure to PM2.5 concentrations above the WHO guideline level of 5 µg/m^3 (EEA, 2024).

Table 8 – Quantification of the social impacts of the two measures in the MICATool.

Social impact	UM	FS plan 2025-2050	Transition 5.0 (Ind) 2024-2039
Avoided health effects linked to reduced air pollution			
Mortality	Reduction in casualties (#)	520	18
Hospital admissions		231	8
Avoided lost working days due to air pollution			
Avoided absences	(days)	99,738	3,703

By exporting the results from the tool as an Excel file, it is possible to conduct further analysis to calculate the specific impacts per unit of energy saved so as to ensure comparability across different measures (that have different time spans) by placing results on a common scale. Figure 1 and Figure 2 show the specific impacts per unit of primary energy saving: the FS measure has higher specific benefits since avoided fuels (oil products) have higher emission factors for PM2.5 than those for the Transition 5.0 measure (gas and electricity).

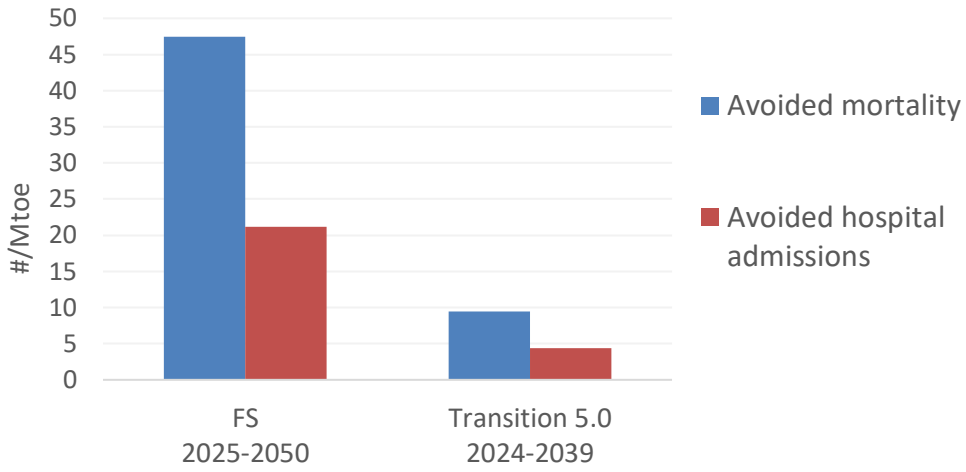

FIGURE 1 - SPECIFIC AVOIDED HEALTH IMPACTS PER UNIT OF PRIMARY ENERGY SAVING FOR THE TWO MEASURES

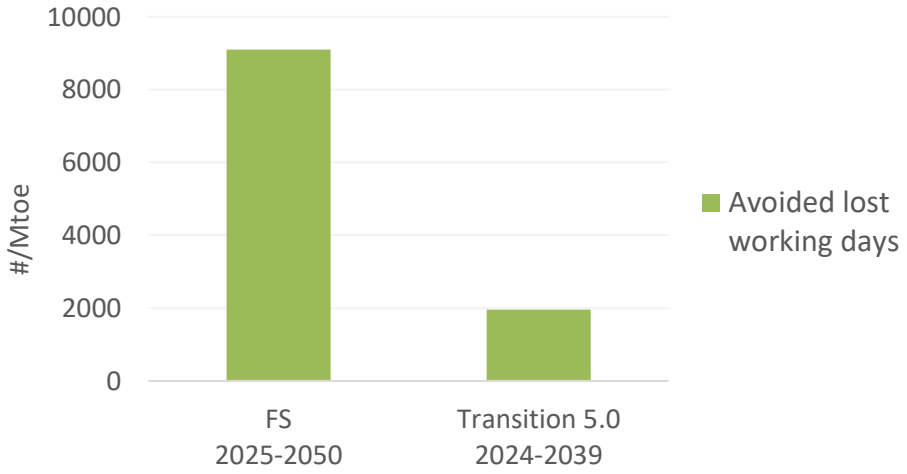

FIGURE 2 - SPECIFIC AVOIDED LOST WORKING DAYS PER UNIT OF PRIMARY ENERGY SAVING FOR THE TWO MEASURES

Quantification of physical values – Economic impacts

All the MICATool's economic indicators are relevant for these two measures, except for the indicator "Added asset value of buildings" (Table 7). The "Reduction of additionally needed generation capacity" indicator is calculated by the tool only for electricity savings (less electricity demand --> less additional RE capacity is needed). Therefore, it is relevant only for the Transition 5.0 measure (Table 7).

Figure 3 and Figure 4 show the specific impacts per unit of investment: the two measures are similar regarding the impact of GDP (0.62 – 0.67 euros of GDP per euro invested), as well as the impact on employment (about 11,000 additional full-time employment years per billion euro invested).

Table 9 - Quantification of the economic impacts of the two measures in the MICATool.

Economic impact	UM	FS plan 2025-2050	Transition 5.0 (Ind) 2024-2039
Impact on energy intensity	Change in ktoe/M€ (range min/max)	-0.20 / -0.79	-0.03 / -0.15
Impact on import dependence	Reduction in %-points (range min/max)	-0.02% / -2.29%	-0.01% / -0.02%
Impact on gross domestic product	Added value in Bill. €	61.8	4.2
Additional employments	Additional full-time employment years	1,089,813	73,988
Reduction of additionally needed generation capacity (wind + solar)	MW	0	166.6

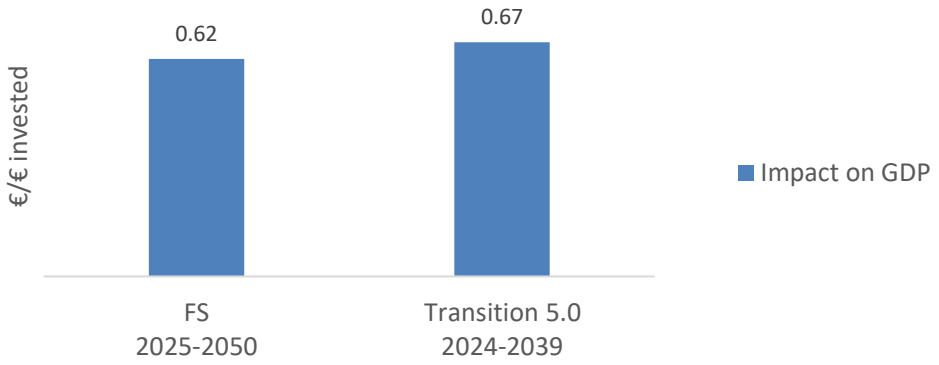

FIGURE 3 - SPECIFIC IMPACT ON GDP FOR EVERY EURO INVESTED FOR THE TWO MEASURES

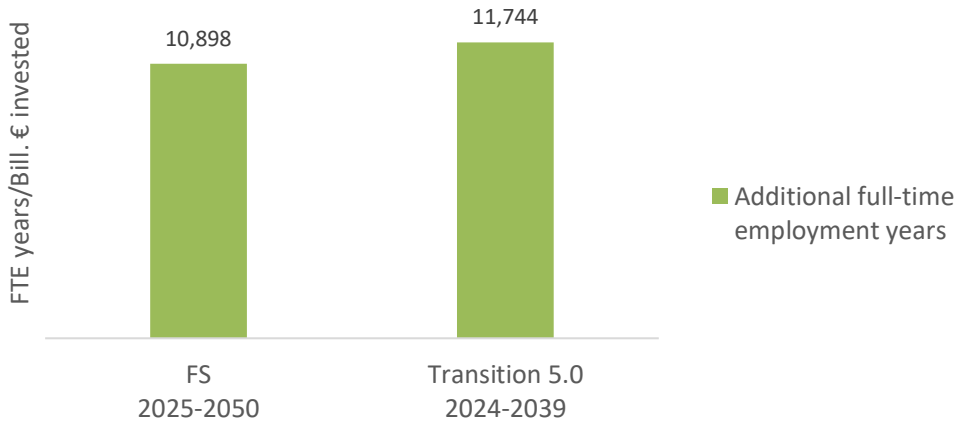

FIGURE 4 - SPECIFIC IMPACT ON EMPLOYMENT FOR EVERY BILLION EURO INVESTED FOR THE TWO MEASURES

Quantification of physical values – Environmental impacts

All the MICATool's environmental indicators are relevant for these two measures (Table 8). For the FS plan measure, final energy savings corresponds to primary energy savings (oil products). The Transition 5.0 measure shows electricity saving and the MICATool converts it into primary energy savings by fuels. Conversion factors derive from Eurostat energy balances (for past years) and from the PRIMES Reference Scenario 2020 (for future years).

Figure 5 shows the specific impacts per unit of primary energy saving: the FS measure has higher specific benefits since avoided fuels (oil products) have higher emission factors than those for the Transition 5.0 measure (gas and electricity).

Table 10 - Quantification of the environmental impacts of the two measures in the MICATool.

Environmental impact	UM	FS plan 2025-2050	Transition 5.0 (Ind) 2024-2039
Primary savings	ktoe	10,956	1,887
Reduction in air pollution			
SO_2	kt	2.2	0.1
NOx		34.7	1.7
PM2.5		1.1	0.01
Reduction in GHG emissions	$ktCO_2$	32,933	3,821
Impact on RES targets	Change in %-points (range min/max)	0.01% - 0.13%	0.00% - 0.03%

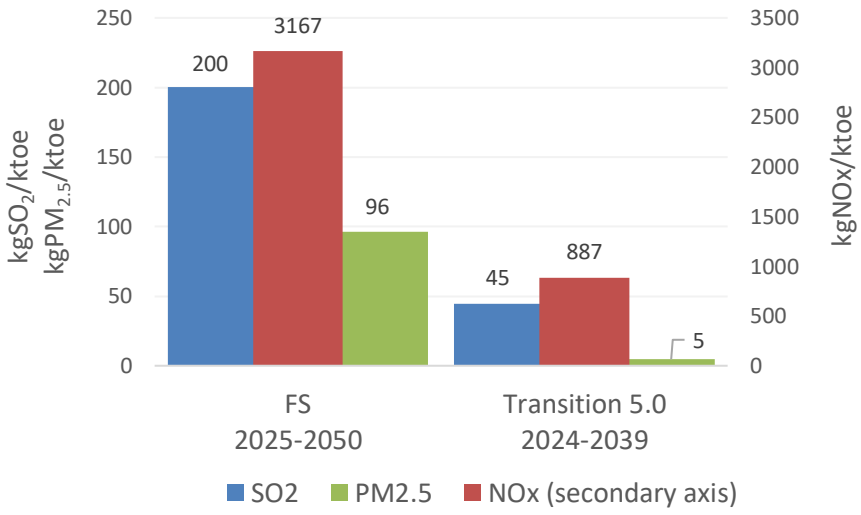

FIGURE 5 – SPECIFIC REDUCTION IN AIR POLLUTANT EMISSIONS PER UNIT OF PRIMARY ENERGY SAVING FOR THE TWO MEASURES

Monetisation

Results of the monetisation of the physical values are shown in Table 11. Figure 6 and Figure 7 compare total investments and total benefits over the entire life of the two measures (not discounted values).

For the FS plan, as a result of 100 billion € of investment, 89 billion € in multiple social benefits can be achieved. For the Transition 5.0 measure, 5.9 billion € of social benefits can be generated with 6.3 billion € of investment (public + private). In both cases, impact on GDP is by far the largest monetised benefit: it represents 69% of total benefits in the FS plan's measure and 71% in the Transition 5.0 measure.

Table 11 - Monetisation of the impacts for the two measures in the MICATool.

Monetisation	UM	FS plan 2025-2050	Transition 5.0 (Ind) 2024-2039
Avoided health effects due to reduced air pollution			
Mortality	M€	1,929.9	59.6
Hospital admissions		1.2	0.04
Total		1,931.1	59.7
Avoided lost working days due to air pollution	M€	21.2	0.7
Impact on GDP	M€	61,804.7	4,202.0
Reduction of energy costs			
Oil	M€	23,106.8	-
Electricity		0	412.8
Gas		0	748.7
Total		23,106.8	1,161.5
Reduction in GHG emissions	M€	1,722.0	377.5
Impact on RES targets	M€	555.3	76.1
TOTAL	M€	**89,141.0**	**5,877.4**

When looking at Figure 6 and Figure 7, it should be noted that the MICATool adopts a societal perspective. Therefore, for example, in the FS plan, avoided energy costs shown by the tool are those linked to avoided fuel consumption by private cars (net of the increase in FS consumption). These are counted as a benefit to society because they represent a net reduction in public energy expenditure. However, from the passengers' point of view, these benefits should be offset by the costs of travelling by train (i.e. train tickets). Vice versa, from the FS point of view, the increasing number of passengers translates into more sales, generating an additional positive cash flow. However, from the community's point of view, this is just a financial transfer from a private actor to the other and it is correct the MICATool does not highlight it.

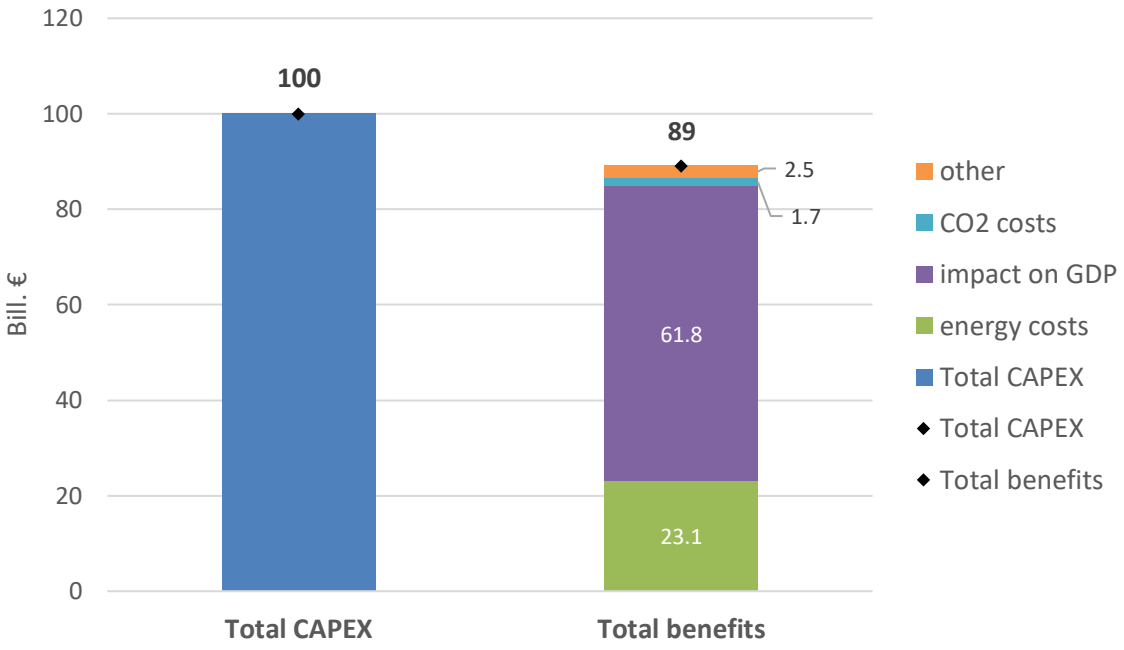

FIGURE 6 – COMPARISON BETWEEN CAPEX AND TOTAL BENEFITS (NOT DISCOUNTED) FOR THE FS PLAN'S MEASURE (YEARS 2025-2050). OTHER: HEALTH EFFECTS LINKED TO REDUCED AIR POLLUTION, AVOIDED LOST WORKING DAYS DUE TO AIR POLLUTION, IMPACT ON RES TARGETS.

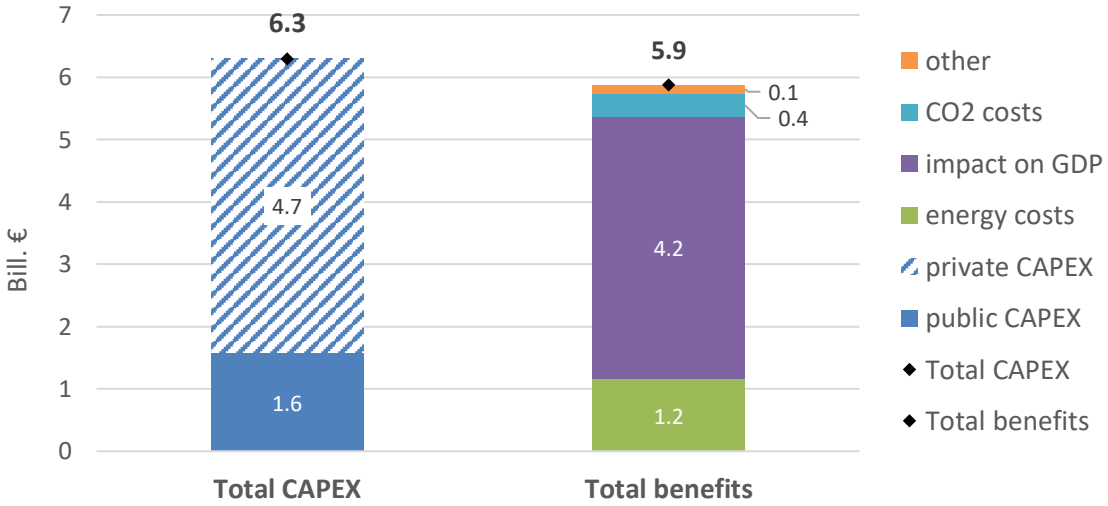

FIGURE 7 - COMPARISON BETWEEN CAPEX AND TOTAL BENEFITS (NOT DISCOUNTED) FOR THE TRANSITION 5.0 MEASURE FOR INDUSTRY ONLY (YEARS 2024-2039). OTHER: HEALTH EFFECTS LINKED TO REDUCED AIR POLLUTION, AVOIDED LOST WORKING DAYS DUE TO AIR POLLUTION, IMPACT ON RES TARGETS.

3. CONCLUSIONS

The showcase for Italy focuses on two energy efficiency measures which were selected based on their national scope, their alignment with the EE 1st principle and because they target different sectors (transport, industry).

The first measure is the 2025-2029 Strategic Plan of the Italian Railways Group (*Ferrovie dello Stato Italiane)* to promote the modal shift of passengers from private cars to rail and buses, and the modal shift of freight from road to rail. The second measure is the "Transition 5.0 plan" set up by the Italian Government which consists in a tax credits scheme for clean energy investments made by private companies.

Before using the tool, the final energy savings corresponding to these two measures were estimated. In both cases, we performed an ex-ante evaluation. The analysis led to an estimate of approximately 11 Mtoe of cumulative savings from 2025 to 2050 for the FS plan, and approximately 1.7 Mtoe of cumulative savings from 2024 to 2039 for the Transition 5.0 plan, considering only investments made in the industrial sector.

By applying the MICATool, the quantification of social impacts (mortality and morbidity), economic impacts (GDP, employment, energy intensity, import dependence) and environmental impacts (primary energy, air pollutants, GHG emissions, RES target) was performed.

Results show that the FS measure has higher social benefits per unit of energy saving since avoided fuels (oil products) have higher PM2.5 emission factors than avoided fuels related to the Transition 5.0 measure (gas and electricity).
Quantification of economic impact shows that the two measures are similar regarding the economic return for each Euro of total investment (0.62 – 0.67 € of additional GDP generated per euro invested), as well as the impact on employment (about 11,000 additional full-time employment years per billion euro invested).
Results of the monetisation section allow us to compare total cost of investments (distinguishing between private and public share) and total (undiscounted) social benefits over the entire life of the two measures. For the FS plan, as a result of 100 billion € of investment, 89 billion € in multiple social benefits can be achieved. For the Transition 5.0 measure, 10 billion € of social benefits can be generated with 12.6 billion € of investment (public + private). In both cases, impact on GDP is by far the largest monetised benefit: it represents 69% of total benefits in the FS plan's measure and 83% in the Transition 5.0 measure.

Regarding the experience of using the MICATool, a general conclusion is that the tool is flexible and allows the user to adjust various calculation parameters. A preliminary step that can take some time is figuring out in what format to prepare the inputs. However, the documentation on how to enter energy savings is well described in the online MICAT's documentation. In addition, the documentation clearly explains assumptions and methodologies of the implemented indicators, and it is important to study the factsheets to understand how to interpret the results.

Then, once the inputs have been estimated, results can be obtained in just a few seconds. This is an important characteristic of the MICATool. Several organizations in Italy have extensive professional expertise in one or more indicators, but it is difficult to be specialized in all of them, or it can take weeks or months to perform comprehensive assessments with more advanced modelling tools.

The MICATool can be an added value for the planning processes because it is useful for comparing the effects of different policy measures, also taking into account social impacts that are generally neglected. For example, in case of a limited budget, it would be possible to design or choose the policy measure that brings the greatest benefits to society. As these factors are made finally visible, the tool enables policy makers to make trade-offs between economic efficiency, environmental benefits, and public vs. private costs.

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