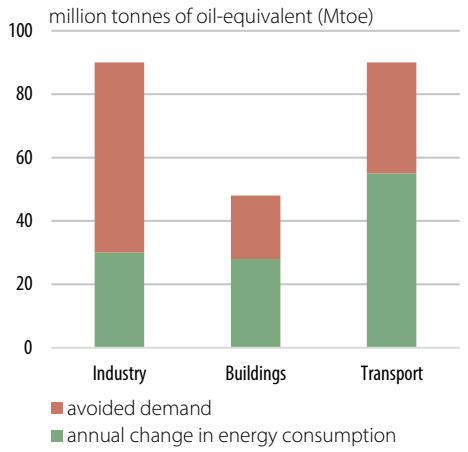
Box 2. Assessments of the macroeconomic impact of energy efficiency measures

Energy efficiency or the first fuel

Energy efficiency measures are often considered the most valuable "form" of energy or "the first fuel", according to the International Energy Agency (IEA). The estimates made by this institution show that, in the absence of energy efficiency measures, in 2010-2019 the cumulative increase in global energy consumption would have been approximately two times higher than that actually recorded (Chart A). At the same time, efforts to improve energy efficiency are expected to make the largest contribution (40 percent), over the following two decades, to the policy mix aimed at greenhouse gas emissions abatement.



Source: *World Energy Outlook*, 2020

Chart A
Estimated impact of energy efficiency measures, 2010-2019

At the EU level, improved energy efficiency is one of the five dimensions of the energy union strategy[1], part of the process for counteracting climate change and transitioning to a modern, competitive and efficient economy from the point of view of resource use. In addition, the sizeable, broad-based increases in energy prices over the past two years have highlighted the significant challenges the EU further faces in the field of energy (limited diversification of energy sources and, implicitly, high import dependence, security risks that affect energy producing and transit countries, etc.), emphasising the need to rapidly implement energy efficiency programmes.

Some of the benefits of energy efficiency investments may be quantified (for instance, effects on economic growth, on employment, etc.), while others, such as improved health and well-being impacts, are harder to assess[2]. The box further presents the main macro-level impacts of energy efficiency measures, reviewing a number of quantitative results in the literature.

Benefits conditional on potential availability constraints on the supply side

Energy efficiency improvements exert two types of favourable macroeconomic impacts: investment impacts and energy cost reduction impacts. Investment impacts are associated with investments in new and more energy efficient technologies, whereas energy cost reduction impacts are related to a reduction in energy expenditure. A schematic representation of the aforementioned impacts is given in Chart B. Positive effects are expected also on the fiscal front (public budget). However, some negative, crowding-out effects cannot be ruled out (i.e. the resources employed to implement investments in energy efficiency improvements, particularly those referring to capital and labour force, reduce those used in other business

1 Together with improved energy efficiency, the EU's energy policy also refers to diversifying Europe's sources of energy, enabling a fully integrated internal energy market, decarbonising the economy and supporting breakthroughs in low-carbon and clean energy technologies (https://energy.ec.europa.eu/topics/energy-strategy/energy-union_en).

2 The IEA (2014) produced a comprehensive analysis of the multiple benefits of energy efficiency improvements.

sectors). Reducing consumption of fossil fuels, and implicitly their imports, would lead to an improved trade balance too. As far as Romania is concerned, the effects associated with the volume component are assessed to be relatively limited (our country is among the EU Member States the least dependent on energy imports – 31.6 percent of the energy needs in 2021 versus a 55.5 percent average need at the EU level), a potentially larger impact being however linked to price effects.

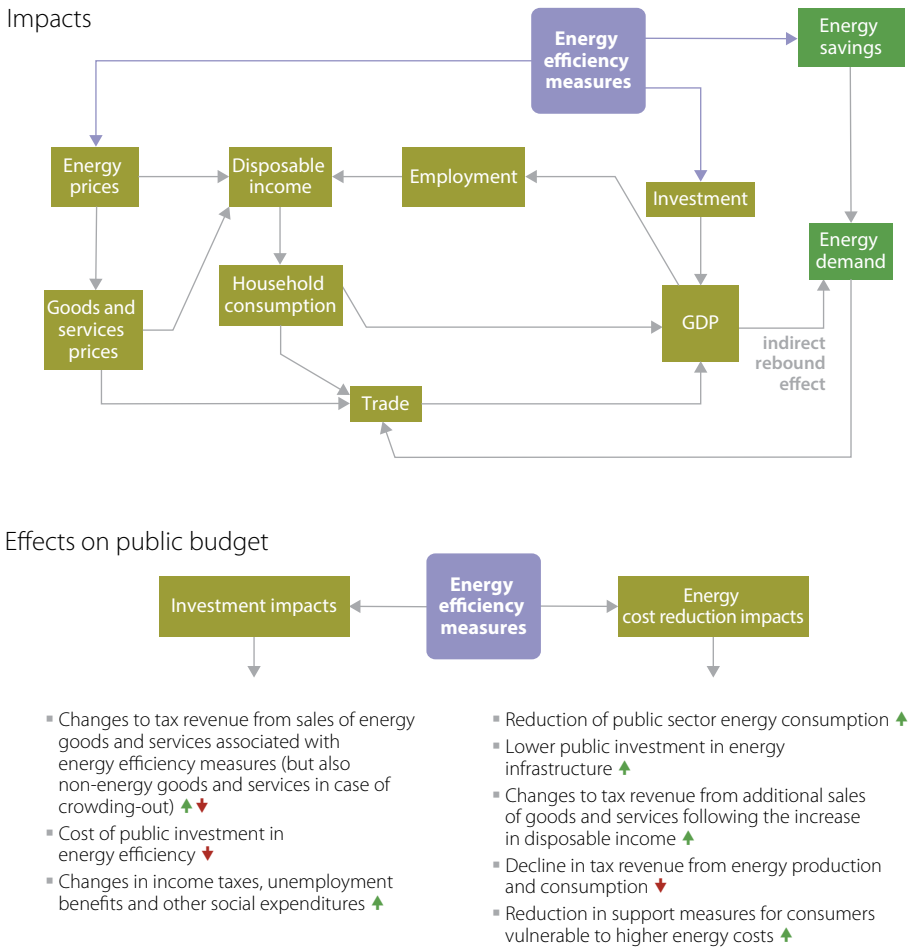


Chart B
Impacts of energy efficiency measures

Source: NBR elaboration based on *Cambridge Econometrics* (2012) and EC (2017)

It is difficult to compare the findings in the literature on the impact of energy efficiency measures not just because of the variety of the metrics used, but also because of the economic structure specific to each country. In fact, the estimated impact on economic activity may vary even for the same country, depending on the time period under analysis and implicitly the level of economic development (Fouquet, 2014). An analysis of the IEA (2014) of several studies carried out during 2008-2013 focusing on the economies of the United Kingdom, Germany, the EU, as well as on the global level, found a 1.3 mean for change in GDP per unit on investment (EUR/EUR) and a 9.95 mean for jobs created per year per unit of investment (jobs/EUR million). The large distribution of estimates is nevertheless relevant to the elevated uncertainty associated with these assessments (Table A).

In a more recent study, the EC (2017) assesses the economic, social and environmental impacts of an increase in the EU's energy efficiency target over the next 15 years[3]. The results at the EU level indicate an up to 4.1 percentage point GDP impact and an up to 2.1 percentage point employment impact by 2030 for the most ambitious improvement taken into account (i.e. a 13 percentage point increase in the energy efficiency target beyond the reference level) yet in a favourable scenario in which there is no crowding out[4]. The estimated results for Romania were much smaller (+0.6 percentage point increase in GDP and +0.8 percentage point increase in employment), as the economic impact of energy efficiency improvements is transmitted mostly via the trade channel, namely a decline in energy imports, and trade effects are relatively limited in Romania's case, as already mentioned.

Table A
Estimates of the macroeconomic impact of energy efficiency measures

	Range	Mean	Median
Amount invested per PED savings (EUR billion/Mtoe)	0.09-0.63	0.51	0.45
GDP per unit of investment (EUR/EUR)	0.91-3.73	1.31	1.81
Jobs created per year per unit of investment (jobs/EUR million)	9.2-17.07	9.95	11.64
Jobs created per year per PED savings (jobs per ktoe)	0.76-19.61	0.92	7.06

Note: PED = primary energy demand; EUR/Mtoe = euros per million tonnes of oil-equivalent; ktoe = thousand tonnes of oil-equivalent.

Source: IEA (2014)

The estimated impact depends on the current capacity utilisation rate in the economy. The potential availability constraints on the supply side (particularly with respect to capital and labour resources) could require a relocation of the resources of other business sectors with a view to implementing energy efficiency measures, leading to possible imbalances in the sectors adversely affected. As far as the EU is concerned, this risk is assessed to be relatively high in a scenario involving the transition to more ambitious targets[5], given that manufacturing operates at approximately 81 percent of available capacity[6].

Another factor with a potential to mitigate the favourable estimated impact of energy efficiency measures refers to rebound effects.

Rebound effects

Energy efficiency programmes aim to reduce energy consumption; yet, in an apparently counterintuitive way, energy efficiency gains may encourage a behavioural change of economic agents precisely in the sense of a higher use of energy resources. Thus, at least part of the expected energy savings driven by improved energy efficiency could be cancelled. Rebound effects are computed by

3 The energy efficiency target currently aims to save 32.5 percent of the expected energy use by 2030 in case no energy efficiency measures are taken.

4 In comparison with the release date of the said study, the European Commission has recently allocated extremely large investment funds to tackle climate change. For instance, over EUR 15 billion have been made available to Romania by 2030 for energy projects under the Recovery and Resilience Facility and the Modernisation Fund.

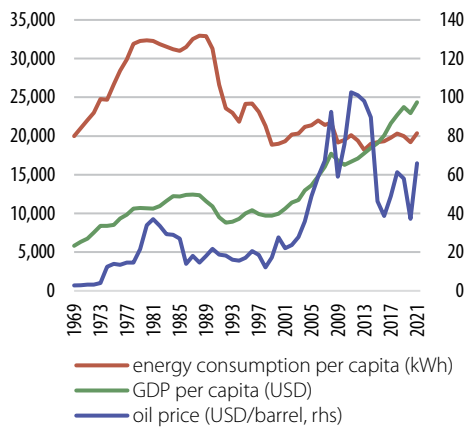
5 For example, it is estimated that, in the EC's scenario envisaging a 13 percentage point increase in the energy efficiency target beyond the reference level, the degree of investment that is crowded out at the EU level is 19 percent.

6 The capacity utilisation rate is lower in Romania, i.e. approximately 73 percent (Eurostat data, average for 2021 and 2022).

reference to the energy envisaged to be saved via energy efficiency measures (the latter being calculated as the estimated energy gains multiplied by the energy consumed prior to the implementation of these measures).

At the microeconomic level, rebound effects are split into direct rebound effects (refer to the direct consumption of energy goods and services) and indirect rebound effects (refer to the consumption of non-energy goods and services) that touch both households and businesses. These effects stem from changes in the disposable income of households/firms (the wealth effect) and from changes in the relative price of energy as compared with that of other goods/services/production factors (substitution effect) respectively. At the macroeconomic level, energy consumption may change following the implementation of energy efficiency measures as a result of several factors, such as the boost to economic activity amid the new investments in the energy sector (growth effect), the change in the structure of the economy towards a higher share of energy-intensive sectors (composition effect), etc.

Although the papers in the literature that analyse rebound effects are extremely diverse in terms of the assumptions and methodologies employed, they broadly converge with respect to results[7]. Thus, estimates of direct rebound effects tend to converge between 10 percent and 30 percent, whereas economy-wide rebound effects may erode more than half of the expected energy savings from improved energy efficiency (on average, 60 percent), as suggested by the results.



Source: Our World in Data, NIS, Voinea *et al.* (2018), U.S. Energy Information Administration

Chart C
Variables employed in the estimation

As far as Romania is concerned, an estimate of the size of economy-wide rebound effects was made based on the methodology presented by Bruns *et al.* (2019), namely a vector autoregressive (VAR) model applied to annual data (Chart C). The structural relations were identified using the independent component analysis, the innovation associated with energy consumption being interpreted as an energy technology shock, where innovation, according to the definition of structural shocks, is independent from economic activity (GDP), and hence from energy demand, and from the energy price (proxied by the oil price). Estimates of rebound effects stood around 30 percent after four years (i.e. 30 percent of the potential energy savings amid energy efficiency measures would be lost following an increase in energy consumption after the implementation of these measures). The results should be interpreted with caution, given the issues related to statistical data collection over such a long period of time. In addition, starting in the 1990s, Romania underwent wide-ranging economic restructuring, which led to a substantial reduction in energy consumption, regardless of the implementation of energy efficiency programmes. At the same time, the estimated impact does not capture the potential divergences across economic sectors. For instance, in a recent study, Baležentis *et al.* (2021) estimated rebound effects in the residential sector in

[7] Brockway *et al.* (2021) reviewed the 33 most important studies that examine the impact of rebound effects.

EU Member States over the period from 2000 to 2015. Romania ranks among the countries with the highest estimates (approximately 90 percent), together with states such as Bulgaria, Czechia, Hungary, Slovenia, but also Italy and Spain. In fact, van Benthem (2015) argued that the step-up in economic activity in developing countries is as energy-intensive as the similar process recorded in the past in industrialised countries, despite the major improvements in the energy efficiency of various technologies. Thus, energy savings linked to the latter technologies seem to have been (partially) offset by a shift towards more energy-intensive consumer habits. Nonetheless, at the EU level, Baležentis *et al.* (2021) identified a decline in rebound effects in time.

Conclusions

As of 2021, the EU enshrined into law the climate neutrality objective, i.e. achieving net zero greenhouse gas emissions by 2050. At the same time, the European Green Deal set the intermediate target of reducing net greenhouse gas emissions by at least 55 percent by 2030. Energy efficiency measures play a central role in the proposed energy strategy and shall make the largest contribution to the policy mix addressing the need for reducing greenhouse gas emissions.

Most models that assess energy efficiency programmes (such as the integrated assessment models used by the IPCC or the global energy models implemented by the IEA) anticipate a decoupling of energy consumption from gross domestic product of unprecedented magnitude. Although this matter does not invalidate them, there are however question marks over both the transmission mechanisms included in the models (for instance, a potential lack of or incomplete incorporation of rebound mechanisms in these models) and the policy mix needed to meet the target of reducing greenhouse gas emissions. A failure to achieve the expected decoupling of energy consumption from GDP would have significant consequences, as it could require the implementation of additional measures (a higher share allocated to alternative energy sources, such as wind and solar power, more efficient fossil fuel combustion, etc.) in order to reach the targets.

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