

New Member States
Climate Protection and Economic Growth
Case Study Bulgaria and Romania

Synthesis Report

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1 Overview for decision-makers

Romania and Bulgaria are characterised by high energy and carbon intensities compared to the EU average. This is linked to the fact that they have low GDP per capita. To put it positively, these countries have great opportunities for catching up and need policies to realize them. Bulgaria, e.g., uses about four times as much energy per unit of GDP as the EU28 average, and has the lowest GDP per capita in the EU28. Before the financial crisis it experienced growth rates in the order of 6% without accumulating public debt and with decreasing unemployment.

The present study investigates options for these two countries to contribute to a EU-wide reduction of greenhouse gas emissions by 40% in 2030 (compared to 1990). The requirement was to combine computer simulations with individual assessments of specific policy measures.

In both countries, the period after the breakdown of the Soviet Union saw great economic losses and also reductions of greenhouse gas emissions due to the breakdown of the old industrial structure. Therefore we consider emissions reductions against a baseline of 2005 (the European numbers still refer to the baseline of 1990).

The computer simulations compare a 40% reduction scenario with a reference scenario (Business as Usual). The results suggest that if an EU 40% reduction target (compared to 1990) were to be split between member states based on cost-efficiency alone, this would imply reductions of around 40% compared to 2005 for both Bulgaria and Romania. The precise numbers in the simulation are 44.5% for Bulgaria (68% compared to 1990) and 38% for Romania (66% compared to 1990). In the reference scenario the reductions are about half that size (28% in Bulgaria and 24% in Romania, both compared to 2005). The bulk of the additional emissions reductions comes from the energy sector, followed by industry. It needs to be noted, that these calculations solely focus on a cost-efficient distribution and it is outside the scope of this study to analyse the impacts of other distribution options (such as the mechanism used for determining the 2020 non-ETS target, which is based on GDP per capita),

The key mechanism for emissions reduction is increasing energy efficiency. This mechanism works in the energy sector itself, in industry and in the economy as a whole due to structural changes towards an expansion of the services sector.

According to the model simulations, wind, biomass, nuclear and CCS all contribute to emissions reductions, while the contribution of photovoltaics and additional hydro capacities are negligible.

With regard to economic consequences, in the model simulations a 40% reduction implies a slight decrease in the annual rate of economic growth (by 0.09 and 0.05 percentage points over the period 2015-2030 for Bulgaria and Romania respectively). Given the great uncertainties of economic forecasts over such time horizons, this means that the effects of such an emissions reduction on economic growth are practically undetectable.

It is essential to notice that in these simulations unemployment stays at present levels, implying that Bulgaria and Romania use their productive resources less efficiently than before the financial crisis. These countries are too small to shift to a better growth path using only their own devices. The EU, however, is large enough for such a purpose. The

simulations assume that Europe as a whole suffers a permanent loss from the shock of the financial crisis, an effect known as hysteresis. This means that a short-term loss of efficiency in resource use becomes the new normal. It also means that presently there is an efficiency reserve that could be used to generate additional growth in low-carbon products and infrastructures. If the EU would realise this possibility, Bulgaria and Romania could achieve 40% reductions compared to 2005 with lower unemployment and higher GDP than in the reference scenario. Analysing such EU-wide developments, however, was not part of the present study.

In the study, the modelling results for Bulgaria and Romania were combined with an assessment of individual policy measures. With both methods, improving energy efficiency turns out to be a particularly promising approach for emissions reductions in these countries. Among the measures considered, the greatest economic advantage per emission reduction is to be expected from better use of excess heat in industry (including improvements of industrial buildings). Next come measures for retrofitting buildings: public ones, multi-family dwellings, and single-family dwellings. Another interesting measure to be implemented is the introduction of LED street lighting.

The assessments performed here also suggest that a more comprehensive analysis would require a larger study looking into the following issues:

First, the politically sensitive question of energy price subsidies would have to be tackled. One should not forget the toppling of the Bulgarian government by protests over increasing energy prices in 2013. However, subsidies and regulations enforce economically inefficient energy prices and can prevent cost-efficient investments. Energy subsidy reforms are politically challenging, but experiences from other countries and options including adequate social transfers to compensate low-income households could be investigated to tackle this question. An understanding of this situation by other member states and the Commission is a precondition for an economically efficient climate policy in Bulgaria and Romania.

Second, the role of education needs to be reconsidered. Our analysis suggests that there are no bottlenecks on the labour market that would make the climate policy measures considered unfeasible. But there is no doubt that the catch-up options available to Bulgaria and Romania would be greatly enhanced by improved opportunities for high-class education, especially in preparing skilled workers, technicians, engineers, etc. This would be beneficial to both countries particularly considering the brain drain they faced over the last two decades. Such an improvement cannot happen over night, but considering the time horizon up to 2030 it can make a decisive difference.

Third, two different ways of performing the investments required to achieve 40% emissions reduction need to be considered. Presently, there is a danger that such investments will crowd out the already reduced investments for other purposes, simply because the owners of financial capital prefer to keep it idle rather than running the risk of investments stranded due to lacking demand. On the other hand, there is an opportunity to use climate investments so as to mobilize some of that idle financial capital. This requires the design of incentives for financial investors, and such incentives would need to be implemented at a European scale.

In the course of this project, a new effort sharing decision (ESD Decision No. 406/2009/EC)¹ for the fair distribution of non-ETS emission reduction efforts was decided and implemented in October 2009. Therefore, the BMUB commissioned a supplementary study, investigating the changes in economic effects, taking into account the new effort sharing decision. The results can be found in the Report “New Member States Climate Protection and Economic Growth - Macroeconomic implications of a burden sharing non-ETS GHG target in Bulgaria and Romania” which can be downloaded on www.globalclimateforum.org.

2 Project design

2.1 Objective

The objective of the research project “New Member States: Climate Protection and Economic Growth” is to analyse economically feasible and implementable climate protection measures in Bulgaria and Romania. The question we attempt to answer is “How both countries can reduce emissions significantly and permanently while simultaneously achieve pre-2008/9 crisis sustainable growth?”

The project has been articulated around two main approaches. With a **Bottom-Up** approach we focus on single mitigation measures and their potential impacts, barriers and implementation. We use a **Top-Down** approach for a macroeconomic analysis of potential investments into renewable energies and energy efficiency activities.

2.2 Methodological remarks – Top-Down approach

We use the GEM-E3-NMS² model to quantify the economic and energy impacts in Romania and Bulgaria when EU28 adopts a 40% GHG emission reduction target in 2030. The emission reduction target is imposed at the EU28 emissions level and the model calculates the least cost allocation of the abatement effort among the member states. The focus of this study is on a cost-efficient approach and therefore it does not cover other effort sharing mechanisms (such as GDP per capita, which has been used for the 2020 agreement). Different abatement options including energy efficiency, renewables and fuel switching have been considered in the analysis.

A carbon tax has been used as a driver for the GHG emission reductions. The public revenues generated from this tax are recycled back into the economy (i.e. are not held by the government to reduce/increase its deficit/surplus) by reducing employers’ social security contributions. This recycling option has been found³ to be efficient both in terms of GDP and employment adjustment.

¹ <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32009D0406>

² GEM-E3-NMS is a recursive dynamic general equilibrium model that covers the whole world aggregated to 46 countries/regions (28 of which are the EU member states). All countries are linked through endogenous bilateral trade flows. The model represents a closed economic system (at the global level) in the sense that endowments/resources do not change. The model does not consider any transaction costs.

³ A detailed analysis on the impact on alternative recycling options has been performed within the MODELS EC funded project, http://www.ecmodels.eu/index_files/Page660.htm

In the GEM-E3-NMS model, the creation of un-sustained current account deficit is possible when no endogenous fiscal instrument is activated in order to prevent this imbalance. In the current simulations it has been assumed that the EU-wide interest rate would adjust so that EU current account would remain unchanged as % of GDP from the reference case⁴. This ensures that the GHG mitigation effort is financed by domestic resources without deteriorating the current account position of the country.

The GEM-E3-NMS model has been used to quantify the following scenarios:

- a reference scenario that already includes energy efficiency, renewable penetration and GHG mitigation policies (i.e. in 2030 EU reduces its GHG emissions by almost 30% compared to 1990).
- a GHG emission reduction scenario where EU reduces its emissions by 2030 by 40% as compared to 1990 levels.

Both scenarios have been quantified up to 2030 with a 5-year time step.

2.3 Methodological remarks – Bottom-Up approach

We use the **Bottom-Up approach** to analyse possible, plausible and feasible mitigation measures in Bulgaria and Romania, which could be implemented within the next few years so that considerable GHG-emission reductions by 2030 become feasible.

We focus on technology-related mitigation measures, however in our definition a technology can be seen as a technical instrument as well as one that changes behaviours of socio-economic agents and groups and therefore as a non-technical instrument. Main target of each of the measures is the reduction of GHG emissions.

After exhaustively screening possible mitigation measures, we selected, in cooperation with local experts, 7 and respectively 13 measures for Romania and Bulgaria to be evaluated in depth. Our selection criteria were: (a) expected implementability of the measure, (b) expected mitigation outcome and (c) availability of data for the in-depth evaluation process. Therefore all the evaluated measures are to be considered as examples only and at a certain extent all measures are transferable to the other country.

We assess the feasibility, plausibility and implementability of the measures in the two countries by the following indicators:

- Factor capacity (availability of appropriate labour force and capital),
- Competitiveness in international markets and
- Time constraints.

In section 4 we present the main findings of the GHG-emission reductions potential of the evaluated measures in both countries and provide an overview of their economic analysis.

For each measure, we provide the Net-Present-Value (NPV) and the abatement costs. The NPV reflects the individual economic efficiency of an investment as difference of the investment and discounted cash flows. If an investment is economically efficient, the NPV is positive.

⁴ The reference case describes the actual 20/20/20 EU climate package.

To ensure comparability of measures in their economic efficiency, abatement costs represent the costs per abated ton CO₂ for each measure. Negative abatement costs reflect a situation of monetary savings, mainly by fuel savings.

We assume an interest rate of 8% and all NPV and abatement cost calculations are based on the average life time of the different facilities.

We take a micro-economic perspective in our analysis. Therefore, fuel prices and interest rates are end-consumer prices. In the abatement costs' calculation, we neglect macroeconomic effects. All prices are kept constant over the period considered due to a lack of comprehensive price forecasts for Bulgaria and Romania. To overcome the resulting inaccuracy, we provide the sensitivity of the results. We take into account that the carbon intensity of power generation will change if the generation structure changes. The following table presents the fuel price parameters, interest rates and carbon intensities used for the calculations:

Table 1: Carbon intensity of fuels and electricity (tCO₂/GWh)

	2015	2030
Electricity Bulgaria (1)	563	378
Electricity Romania (1)	458	235
District Heating Bulgaria (2)	270	232
District Heating Romania (2)	249	253
Natural Gas	202	202
Coal	361	361

Source: (1) Authors assumptions based on IEA and GEM-E3-NMS, (2) Euroheat & Power

Table 2: Fuel prices used for the calculations (Euro/ MWh)

	Bulgaria	Romania
Electricity	100	120
District Heating	43	52
Natural Gas Households	60	30
Natural Gas Industry	35	30
Natural Gas power generation	-	20
Coal	30	-

Source: Authors assumptions based on Eurostat, European Commission and Euroheat & Power

3 Results - Top-Down approach

3.1 GHG emissions

Romania and Bulgaria are two countries characterised by high energy and carbon intensities compared to the EU average. Bulgaria, in 2010, had GDP energy intensity 4.2 times higher than the EU28 average, ranking first among all member states. It should also be noticed that both countries made significant progress in terms of energy efficiency over the last years. Bulgaria reduced the total primary energy supply (TPES) from 0.95

⁵ <http://www.euroheat.org/Romania-90.aspx> & <http://www.euroheat.org/Bulgaria-90.aspx>

⁶ [http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SWD:2014:0020\(52\):FIN:EN:PDF](http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SWD:2014:0020(52):FIN:EN:PDF)

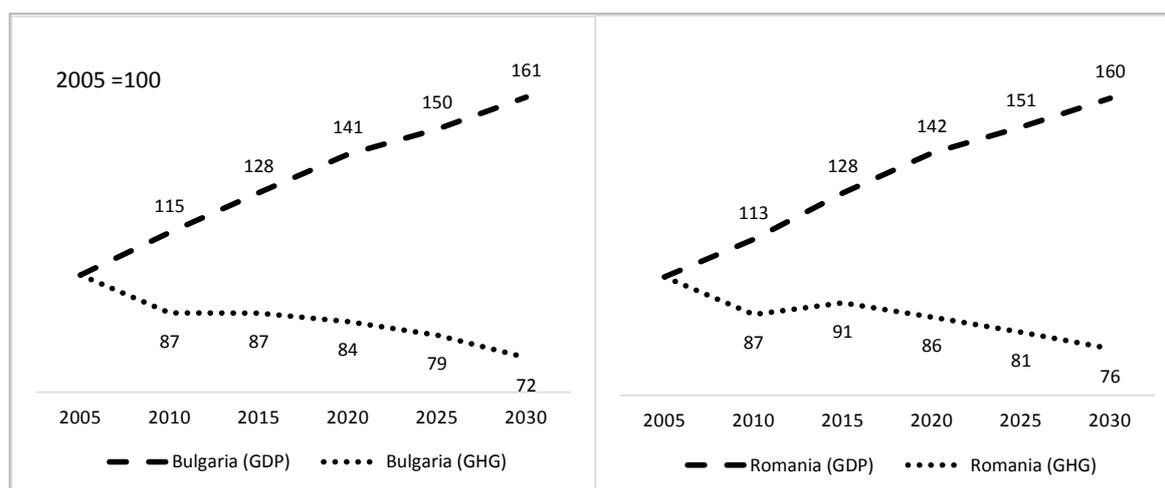
⁷ <http://www.euroheat.org/Romania-90.aspx>

toe/\$1,000 GDP to 0.57 between 2000 and 2011 and Romania from 0.48 to 0.31 toe/\$1,000 GDP.

Emissions are linked to the pace with which the economy grows, the rate of energy efficiency improvements and the structure of the energy system. Both countries significantly reduced their GHG emission over the last decade. The carbon intensity in Bulgaria decreased by ca. 50% between 1990 and 2011 and in Romania by ca. 62%. However, it has to be emphasized that the carbon intensity in Bulgaria is still twice higher than in Romania or e.g. in Poland. In recent years emission reductions are even higher in both countries as a result of the economic slowdown induced by the financial crisis.

In the reference scenario (Figure 1) both countries are assumed to accelerate growth while reducing CO₂ emissions. GDP increases by an average annual rate of 1.53% and 1.50 for Bulgaria and Romania respectively over the period 2015-2030. Emissions are projected to decline by 1.3% and 1.2% annually in Bulgaria and Romania respectively, over the same period. The annual energy efficiency improvement over 2005-2030 is 1.9% and 1.7% for Bulgaria and Romania respectively.

Figure 1: Reference growth for GDP and GHG emissions (2005 = 100)



Source: GEM-E3-NMS and authors calculations

In the model simulations, emission reductions are driven by a carbon tax that is presented in Table 3. In Bulgaria and Romania the revenues collected from this carbon tax amount to 0.2% and 0.3% of GDP respectively in 2030 and are used to reduce employers' social security contributions.

Table 3: Carbon tax in Euro 2005 per tn. of CO₂

	2015	2020	2025	2030
Carbon tax (Euro tn.CO₂)	12	21	33	58

Source: GEM-E3-NMS model output

If the EU were to a 40% target in 2030, we find that the optimal EU allocation of the abatement efforts to member states based on cost-efficiency would point to reductions of 44.5% and 38% in Bulgaria and Romania respectively (see Table 4). Even in this case both countries will still have high levels of energy and carbon intensities.

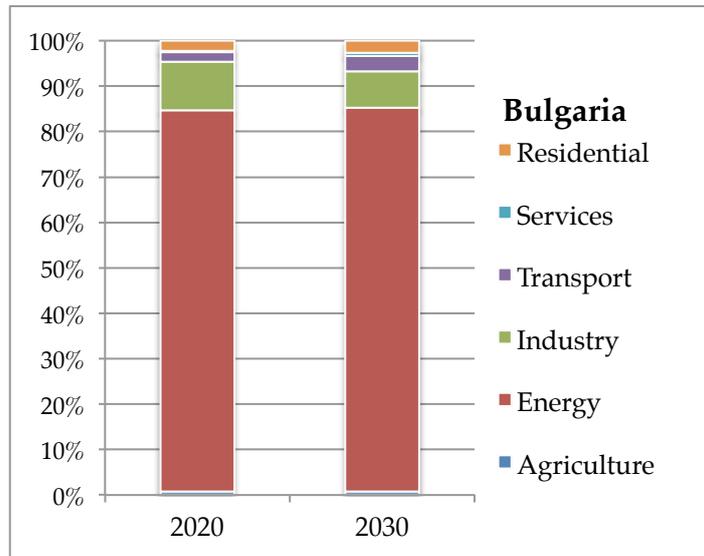
Table 4: Emission reduction in Bulgaria and Romania

	2015	2020	2025	2030	1990-2030	2005-2030
	% change from reference scenario					
Romania	-1.7%	-2.2%	-6.6%	-18.1%	-66%	-38.0%
Bulgaria	-1.8%	-2.8%	-11.3%	-22.7%	-68%	-44.5%

Source: Authors' estimations – GEM-E3-NMS model output

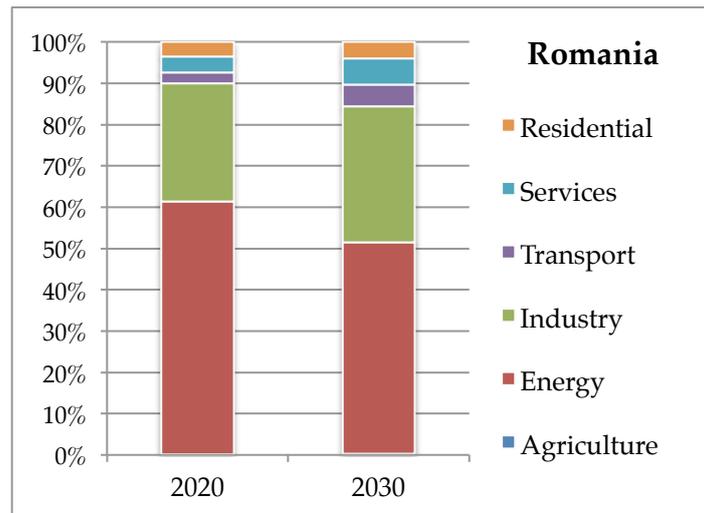
The main sectors contributing to the emission reduction are the energy sectors followed by the energy intensive industries. In particular, in Bulgaria 80% of the emission reductions are obtained in the energy sector.

Figure 2: Sectoral contribution to total emission reduction - Bulgaria



Source: Authors' estimations – GEM-E3-NMS model output

Figure 3: Sectoral contribution to total emission reduction - Romania



Source: Authors' estimations – GEM-E3-NMS model output

3.2 Economic impacts

Compared to the **reference case**, the net investments required to obtain the GHG emission reductions required by the approach analysed in the simulation are presented

in Table 5. These investments sum up in Bulgaria to ca. 2.4 bn Euro and in Romania to ca. 2.7 bn Euro. Annual investment requirements increase over the period of time considered following the increasing emission reductions.

Table 5: Additional than the reference expenditures in a 40% EU-scenario

	Investment expenditure (% of GDP)			Annual investment expenditure (in m Euro)		
	2020	2025	2030	2020	2025	2030
Bulgaria	0.11	0.37	1.13	43	153	501
Romania	0.06	0.09	0.33	85	136	532

Source: Authors' estimations & GEM-E3-NMS model output

The decarbonisation of the Romanian and Bulgarian energy system includes the substitution of imported energy fuels with equipment and services part of which is domestically produced. The GEM-E3-NMS simulations imply that in the 40% scenario the annual GDP growth rate of Bulgaria and Romania over the period 2015-2030 will be 1.44% and 1.45% respectively. It should be noted that in the reference scenario the respective growth rates were 1.53% and 1.50%.

Table 6: GDP impact in Romania and Bulgaria

	2015	2020	2030	2005-2030	2005-2030
				40% scenario	Reference
% change from reference scenario				average annual growth rate	
Romania	-0.04%	-0.13%	-0.70%	1.45%	1.50%
Bulgaria	-0.11%	-0.28%	-1.33%	1.44%	1.53%

Source: Authors' estimations – GEM-E3-NMS model output

Unemployment rate in both countries remains virtually unchanged compared to the reference scenario, in 2030 the rate for Bulgaria is 11.9%, and in Romania 7.8%.

At sectoral level, it is the energy and energy intensive industries that present the highest production reductions as compared to the reference scenario. Sectors contributing to the decarbonisation process such as equipment goods, electrical goods, construction and a small part of agriculture (biofuels) are marginally affected or even increase their production compared to the reference scenario (Table 7).

Table 7: Sectoral production

% change from reference	2015-2030	
	Bulgaria	Romania
Agriculture	-0.90%	0.22%
Energy	-2.44%	-1.97%
Ferrous metals	-4.27%	-6.04%
Non-ferrous metals	-4.48%	-0.83%
Chemical Products	-6.87%	-2.23%
Paper Products	-2.66%	0.40%
Non-metallic minerals	-5.59%	-2.21%
Electric Goods	-0.76%	3.02%
Transport equipment	-1.62%	-0.02%

Other Equipment Goods	-1.07%	0.28%
Consumer Goods Industries	-0.59%	1.04%
Construction	0.61%	-0.37%
Services	-0.34%	-0.38%

Source: Authors' estimations – GEM-E3-NMS model output

However, our analysis did not take into account potential financial inflows related to EU climate and energy policy. Such flows would have the potential to significantly alter the outcome of the analysis but are outside the scope of this analysis.

3.3 Abatement options and power generation

Reducing GHG emissions requires the adoption of different abatement options at different scales. The abatement options considered are: i) Fuel substitution, ii) Deployment of low-carbon energy sources such as RES and nuclear and iii) Energy efficiency. In the short term, where the power generation sector and the potential for structural changes in the transport fleet are limited, the majority of the emission reductions are achieved through the implementation of energy efficiency measures. This is particularly the case in Romania where energy efficiency measures are considered the most cost efficient option and deliver almost 70% of the emission reductions in 2020.

Emission reductions in the power sector are driven by a reduction of electricity production and a change in the power mix. Power generation in Bulgaria and Romania is reduced as compared to the reference scenario by 2% and 0.4% respectively. This is the net effect on power generation of the increased energy efficiency and the increase of generation costs induced by the penetration of Renewables in the system. The **share of renewable** electricity increases in both countries (by 6% in Bulgaria and 3% in Romania – excluding hydro energy).

Table 8: Power generation mix changes

	Bulgaria			Romania		
	Reference		40% scenario	Reference		40% scenario
Power mix	2010	2030	2030	2010	2030	2030
Fossil based	52%	55%	48%	45%	34%	22%
% of which CCS	0%	0%	10%	0%	0%	1%
Nuclear	34%	27%	28%	19%	19%	27%
RES (excl. Hydro)	2%	10%	16%	1%	18%	21%
Hydro	12%	8%	9%	35%	29%	29%

Source: Authors' estimations – GEM-E3-NMS model output

3.3.1 Key findings of the top-down approach

The GEM-E3-NMS model has been used to calculate the economically optimal contribution of Bulgaria and Romania to a EU 40% GHG emission reduction target based on a EU-wide cost-efficient approach. Several emission reduction options available to Bulgaria and Romania have been evaluated including energy efficiency, RES deployment and fuel switching. The model results show that:

- If allocation of the abatement effort across member states were to be based only on macro-economic cost criteria the optimal contribution of Bulgaria and Romania would be a reduction of their emissions by 44.5% and 38% respectively as compared to 2005 levels (68% and 66% compared to 1990).
- The adjustment to the new low carbon economy requires 1.3% and 0.7% of GDP in 2030 for Bulgaria and Romania respectively by 2030.
- In the short-term, energy efficiency is considered to be the most cost efficient abatement option for both countries whereas significant fuel switching is required by 2030.
- Improving energy efficiency requires goods and services that are mainly domestically produced (e.g. construction sector). This supports domestic activity in the sectors providing the energy efficiency services and the equipment.
- Bulgaria and Romania are importers of equipment for renewables. Therefore, a significant increase (mainly in the short term where costs of certain RES technologies are high) would deteriorate their current account.

4 Results - Bottom-Up approach

4.1 Overview

The **20 measures** evaluated in this project are **examples** of technically feasible implementation of emission reduction technologies in Bulgaria and Romania. They do not represent the complete set of potential solutions but they show the heterogeneity of mitigation measures in respect of emission reduction potentials, economic efficiency and abatement costs.

The results show that with the implementation of a few measures, significant reductions compared to the current GHG-emissions, are feasible. However, not all the measures considered are economically efficient when compared to actual appliances and competitive technologies available **at a microeconomic level**. Nevertheless a significant number of measures have abatement costs below 30 Euro/tCO₂ or negative on a micro economic level. If we take the actual structure of regulated fuel prices into account and accept increasing fuel prices over the next years, these measures show, even at a macroeconomic level, feasible solutions for a GHG emissions reduction.

We relate the evaluated measures **to the results of the Top-Down approach**. In our understanding, they are a potential subset of the reference scenario and the 40% EU-emissions reduction scenario described in section 3. We emphasize that all the measures evaluated can be **implemented in both countries**.

In our analysis the two main sectors showing high emission reduction potential are the energy sector and the building sector. Both need a significant modernisation over the next years. Hence, a replacement of out-dated electricity production facilities can be used to implement less carbon intensive generation. The modernisation needs of building infrastructure can be combined with energy retrofitting. Such combinations reduce relative investment needs so that the measures become economically more efficient.

A third important sector is the **industry sector**. In our estimations, this sector is underrepresented. The main reason is the complexity of the industrial energy consumption and the related complexity of the data needed for computations. Due to weak data availability for the industry sector, an up- and down-scaling of facility-based calculations is critical.

Nevertheless, we assume that the efficient use of excess heat – as described for some appliances in Bulgaria – can be implemented in a broader range of industrial sub-sectors. A replacement and optimisation of motor systems – that account for e.g. for up to 65% of electricity consumption in the EU27 industry* – account for further significant and widely economical efficient emission reduction potential. The implementation of obligatory energy audits can help to discover energy saving potentials in industrial companies.

We don't expect **any significant barrier** in respect to the availability of skilled and unskilled work force for the implementation, maintenance and operation of technical facilities of the measures. Direct employment effects will not account for more than a few thousand new jobs in both countries till 2030. However, an efficient implementation of the measures – e.g. the energy retrofitting of buildings or energy efficiency measures in the industry – can support the creation of highly specialised jobs in these fields (e.g. energy auditors) and can help to reduce the alarming brain-drain in both countries.

We consider that the **main barrier** for the implementation of the measures is the actual availability of financial capital, even if a measure is economically efficient for the user. The potential **timeline** of implementation will therefore mainly depend on the development of the macro as well micro economic conditions in both countries. As long as economic prospects are not optimistic, high interests and risk-aversion (of banks and lenders) reduce the amount of credits and as a result, of investments.

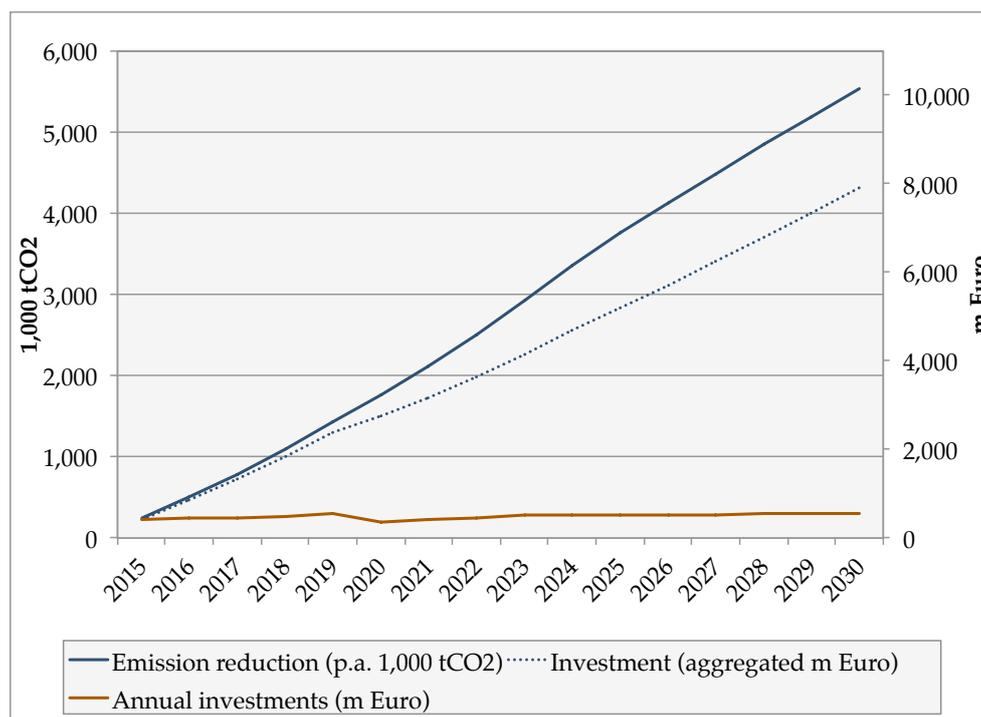
In both countries the **government** can **support** the implementation of such measures by the definition of high threshold levels (e.g. energy consumption of buildings), capacity building activities, financial and/or interest rate supports and – even if this is a complex topic – adjustments of end-user energy prices.

4.2 Focus on Bulgaria

The overall emission reduction potential of the evaluated measures in Bulgaria is ca. 5.5 Mt CO₂ in 2030. The necessary investment to reach this result is ca. 7.9 bn Euro till 2030 while the annual investments are between 350 and 550 m Euro till 2030 (see Figure 4).

Table 9 summarizes the aggregated results for the 13 measures we considered. It includes the aggregated investments till 2030, the emissions reduction potential in 2030 as well as the needed investment and the NPV per facility and the abatement costs for those measures where these figures can be estimated.

* ABB (without year) „Energy efficiency makes a difference“
[http://www05.abb.com/global/scot/scot201.nsf/veritydisplay/cd6d14453239c791c125750800332bd2/\\$file/energy_efficiency_makes_difference_191108.pdf](http://www05.abb.com/global/scot/scot201.nsf/veritydisplay/cd6d14453239c791c125750800332bd2/$file/energy_efficiency_makes_difference_191108.pdf)

Figure 4: Emission reduction and investment trajectories Bulgaria 2015 - 2030


Source: Authors' computations

Table 9: Results of the evaluation of mitigation measures in Bulgaria

Expected investment needs 2015 - 2030	Expected emission reduction in 2030	Average investment per facility	Net-Present-Value of one installation	Abatement costs
<i>mill Euro</i>	<i>1,000 t CO₂</i>	<i>Euro</i>	<i>Euro</i>	<i>Euro</i>
Energy retrofit of family buildings to A and B class standard				
1,100	1,348	4,500	2,400	-15
Energy retrofit of multi-family buildings to A and B class standard				
2,183	1,829	55,000	57,000	-37
Energy retrofit of public buildings to A and B class standard				
2,554	1,547	135,000	93,000	-35
Early introduction of an ambitious nZEB standard for all new buildings [building part]				
890	227	40,000	-20,000	48
Implementation of RES on household level - Solar water heating				
<i>Solar PV for installation in all nZEB buildings</i>				
254	54	10,200	-3,600	53
<i>Solar water heating</i>				
500	166	1,500	-240	20.0
<i>Wooden briquettes</i>				
0	152	0.0	n.a.	+/- 0
Utilisation of excess heat in industries				
10	28	50,000.0	155,000	-70.0

Implementation of LED lighting				
<i>Administrative buildings</i>				
229	74	34.0	2	17.0
<i>Street Light</i>				
154	98	113.0	50.0	-20.0
Development of Intermodal freight transport				
66	11	n.a.	n.a.	15.8
Sum I				
7,901	5,534			
Grid upgrade to fit the renewable potential				
638	n.a.	n.a.	n.a.	n.a.
Introduction of 80% smart meters with load control functions				
852	n.a.	n.a.	n.a.	n.a.
Sum II				
9,380	5,534			

Source: Authors' computations

Building Sector

A significant emission reduction potential results from the **retrofitting of existing family and multi-family buildings as well as public and commercial buildings.**

We assume a trajectory of a modernisation that starts with 4,000 family buildings and 800 multi-family buildings in 2015, increases up to 14,000 resp. 2,500 in 2023 and stays at that level till 2030. Over the period 2015-2030 ca. 176,000 family buildings and 31,000 multi-family buildings will be retrofitted. Therefore, we consider mainly such buildings that are heated by fossil fuels and district heating and buildings constructed before 2000. The Net-Present-Value (NPV) is mainly determined by the type of energy source used for heating and the energy standard of the modernisation Class (Class A or B). In family houses, the average NPV (weighted average of all used energy sources) is ca. 2,400 Euro, with a value range between 34 Euro for a Class B retrofitting (lower standard) and using coal and 17,000 Euro for Class A and using electricity. The investment for one house is ca. 4,000 Euro (Class B) and ca. 4,800 Euro (Class A). The average abatement costs are -15 Euro/tCO₂.

The share of district heating and electricity as energy sources for multi-family buildings is much higher than those of single-family houses. The average NPV for blocks of ca. 1,300 m² is 57,000 Euro per block with the highest NPV results in a retrofit of blocks that use electricity (153,000 Euro). The investment needs are 53,000 Euro (Class B) and 63,000 Euro (Class A). The average abatement costs are ca. -35 Euro/t CO₂ and range between 3 Euro and -67 Euro depending on the fuel source.

Public buildings use district heating, gasoil and natural gas for heating. We assume that till 2030 20% of the public buildings will be retrofitted. For the calculation of the NPV we assume lower energy prices (50% compared to private households) and a lower interest rate (6%). The abatement costs are around -35 Euro/t CO₂ and the NPV is ca. 93,000 Euro for a building of 3,200 m².

The currently highest energy standard of buildings is the near-zero (nZEB) standard. Compared to Class B standard, the (average) energy consumption per m² is reduced by 30%. We assume an early introduction of the nZEB standard so that all new buildings (21.000 by 2020 in our calculations) have to fulfil this standard. An early introduction of an nZEB standard is not efficient from an economic point of view. In our analysis, we focus only on the building-related part of the measure and do not consider the use of RES (see the RES at household level measures). The abatement costs at micro level for the building part is 48 Euro/tCO₂ and the NPV for one building with ca. 330m² floor area is ca. -20.000 Euro. The additional investment compared to energy Class B building is ca. 40.000 Euro.

Households

In this sector we focus on the implementation of renewable energy sources at household level. The **implementation of renewable energy sources at household level** covers a wide range of potential technical solutions. In this evaluation we highlight three of them: solar water heating, PV solar and the use of wooden briquettes.

We evaluate the installation of **solar PV** equipment in all new nZEB buildings – 21.000 buildings by 2019. We assume further a penetration of up to 40.000 dwellings by 2030 for installation of **solar heating** equipment. As a third measure we evaluate the replacement of coal by **wooden briquettes**. Therefore we assume that till 2030 ca. 26,000 households (6% of households that use coal for heating) substitute coal.

Under given fuel prices and interest rates, solar PV installation is not efficient for households that consume the produced electricity from an economic point of view. The abatement costs are ca. 53 Euro/tCO₂.

Comparatively, the abatement costs for solar water heating (20 Euro) is lower but still positive. An increase of electricity prices by 1% p.a. and a lower interest of 6% (instead of 8%) would lead to a situation where the measures become economically efficient.

The economically efficiency of a substitution of coal by wooden briquettes depends only on the price development of coal and wooden briquettes. Wooden briquette prices differ between EU countries and they are highly volatile. Our calculations are based on a price of wooden briquettes of 170 Euro/ton for Bulgaria⁹. Under this assumption, prices of coal and wooden briquettes are equivalent so that the abatement costs are around zero.

Industry Sector

The **utilisation of excess heat** in the Bulgarian light industry is one potential measure in the industry sector but which accounts for only minor emissions reduction potential in our analysis (28.000 t CO₂ in 2030). We assume only 200 utilities by 2030 in our computations. However, this measure is highly economically efficient for companies. The average investment for one economizer is ca. 50.000 Euro and the NPV is 155.000 Euro. The annual savings of fuel costs (mainly natural gas) are ca. 24.000 Euro if we assume constant gas prices. We consider that this kind of technology can account for more than 100.000 t CO₂ reduction by 2030 if a higher penetration can be established. For a more in depth assessment, additional research is needed.

⁹ <http://energiment.wordpress.com/2013/08/30/comparing-wood-fuels-prices-in-2013-across-eu/>

This measure is an example of a wide range of economically efficient mitigation options in industrial production. Further examples for efficient modernisation options are motor systems and industrial heat production. We expect that in the Bulgarian economy at least 2-3 Mt CO₂ can be abated by 2030 by implementing these measures. For an analysis of this potential and an identification of supporting policy measures, a better data availability is essential.

Transport sector

The transport sector contributes a significant part of the GHG emissions in Bulgaria, as it is the case in other EU countries. With the **Development of Intermodal freight transport**, we evaluated one possible measure for this sector but with only minor emissions reductions.

We expect that the electrification of the road transport will not play an important role in Bulgaria over the next two decades and therefore will not lead to significant emissions reductions, at least due to an increase of the individual transport demand related to an expected increase in wealth.

Electricity consumption

With the measure **Implementation of LED lighting** we give one example for electricity savings in public and commercial buildings and in street lighting.

The two lamp types that can be replaced in public buildings are luminescent lamps (ca. 22% share) and CFL lamps (ca. 78% share). We assume that over the next 10 years, all lamps of the two types will be replaced by LED lamps. The average NPV is 2.0 Euro per replacement with an investment need of 34 Euro. Therefore a replacement of luminescent lamps is more economically efficient (NPV ca. 37 Euro) due to higher costs of this lamps and resulting lower difference investments. The average abatement costs are 17 Euro.

We assume that by 2030 LED lamps can replace 1.3 million street lamps. Such a replacement is economically feasible. The NPV is 50 Euro if we assume a 10-year lifetime of the lamps and it is still positive if we assume only a 7-year lifetime. The investment need for one lamp is 113 Euro. The abatement costs are around -20 Euro/t CO₂.

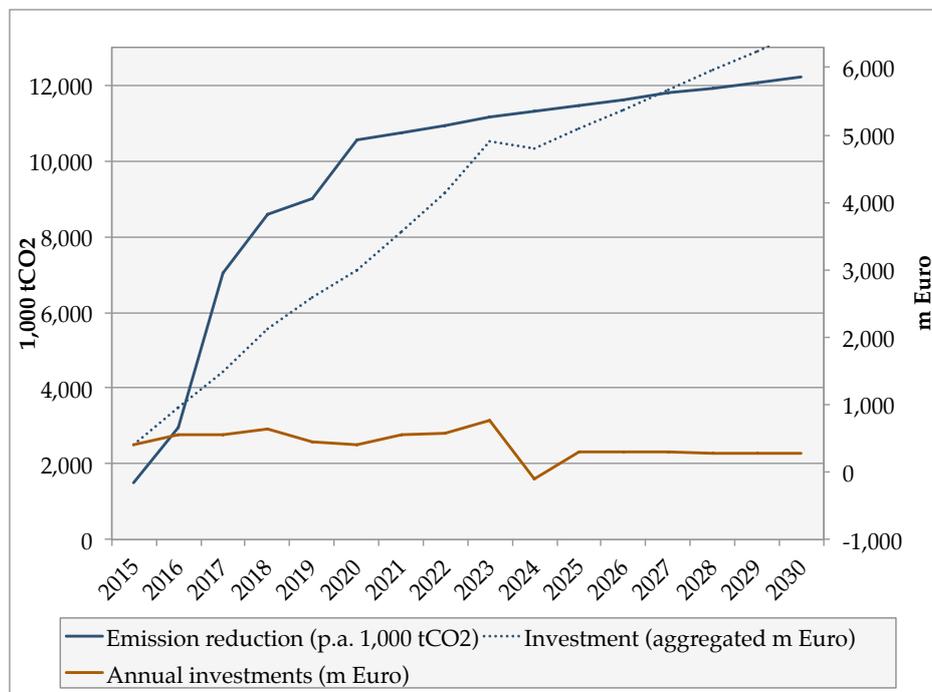
Energy Sector

The two measures **Grid upgrade to fit the renewable potential** and **Introduction of 80% smart meters with load control functions** are necessary for an efficient implementation of further renewable energy capacities to the Bulgarian grid. The actual grid is widely out-dated and mainly structured for a central generation of electricity in coal, nuclear and large hydro power plants. For an implementation of renewable power plants with relatively low capacities, the grid needs to be expanded on different voltage levels. Without such expansion, new renewable capacities cannot run efficiently. On the demand side, a more efficient electricity use will support an efficient load management in the national electricity grids. A stepwise introduction of smart meters can support such efficient load management so that the overall generation capacities can be lower. Both measures can help to reduce emission by 2.8 Mt CO₂ in 2030. As this measure doesn't produce any emissions mitigation in itself, we estimate only the investment need.

4.3 Focus on Romania

The overall emissions reduction potential of the evaluated potential mitigation measures is ca. 12 Mt CO₂ and the investment needs are ca. 6 bn Euro till 2030 (see Figure 5). In Table 10 we summarise the investments and emission reductions per measure as well as the NPV and abatement costs.

Figure 5: Emission reduction and investment trajectories Romania 2015 – 2030



Source: Authors' computations

Table 10: Results of the evaluation of mitigation measures in Romania

Expected investment needs 2015 - 2030	Expected emission reduction in 2030	Average investment per facility	Net-Present-Value of one installation	Abatement costs
<i>mill Euro</i>	<i>1,000 t CO₂</i>	<i>Euro</i>	<i>Euro</i>	<i>Euro</i>
Energy retrofit of residential blocks				
2,244	816	103,000	-32,000	36
Energy retrofit of public buildings				
1,201	369	300,000	-146,000	75
Early replacement of old white ware with A+++, A++, A+ standard				
644	64	180*	140*	780*/350'
Natural gas Combined-Cycle Power plants - (2.450 MW)				
1,065	9,229	600 Euro/kW	n.a.	20"
Standalone Biomass (solid, gas or municipal waste) CHP				
325	509	2,500 (Euro/kW)	n.a.	40"
Transport sector: Modernisation and new intermodal freight terminals				

182	n.a.	n.a.	n.a.	n.a.
Transport sector: Modernisation trains				
78	65	1,000,000	110,000	-5
Transport sector: Structural changes freight transport				
n.a.	1,048	n.a.	n.a.	-5
Trans-sectoral: Modernisation of pumps				
800	122	n.a.	n.a.	n.a.
Sum I				
6,539	12,222			

Source: Authors' computations - * average appliances; ´ whole measure, “compared to coal

Building sector

For the calculation of the aggregated effect of the measure we assumed that ca. 20.000 multi-family buildings would be retrofitted by 2030. Under given prices for natural gas and district heating and high interest rates, a retrofitting of existing multi-family blocks in Romania is not efficient from an economic point of view for the owners of dwellings if we assume costs of ca. 55 Euro per m² for retrofitting.

The investment needs for one average dwelling in such blocks is ca. 2.200 Euro and ca. 103.000 for the whole block. Under the assumption of a 25 years use of the dwelling, the NPV is in average -700 Euro (-32.000 per block), whereby the NPV for such dwellings that use district heating is only -300 and that of natural gas -1.000 Euro. The same difference is reflected in the abatement costs. While the average abatement cost is 36 Euro/tCO₂ the costs for both types of heating vary between 12 Euro and 60 Euro.

The retrofitting of blocks that use district heating can become economical efficient if either prices for district heating increase 1% p.a. plus the interest rate is 7% instead of 8% or an interest rate decreased to 6% due to government support.

A retrofit of blocks that use natural gas might become efficient if the retrofitting runs in parallel to usual modernisation and if government supports the investment.

We face a similar situation in the retrofitting of public buildings. If we assume renovation costs of 60 Euro/m² the NPV is -146.000 with an average investment need of 300.000 Euro for such a building. The abatement costs are 75 Euro.

While the abatement cost of building retrofitting is high, the emissions reduction potential in the building stock of Romania cannot be neglected. Beside multi-family buildings and public buildings, commercial buildings would also need retrofitting. Most of the building stock has to be modernised within the next decade so that the costs for an energetic retrofitting can be reduced.

Household sector

With this measure we give an example for potential electricity savings in households. Therefore we assume that refrigerators, washing machines, electric ovens and dry tumblers will be replaced ca. 1-2 years before the end of their lifetime and that more efficient appliances will be used (5% more A+++, A++, A+ and 15% less A). Under these assumptions, a moderate emissions reduction of 65,000 CO₂ in 2030 will become possible. However an earlier and/or a purchase of more energy efficient appliances is not efficient from an economic point of view for a household. The (not weighted) average NPV for all

appliances is 140 Euro (190 Euro investment) if we compare each appliance with the next lower efficiency class. The abatement costs per single average white ware is 780 Euro/t CO₂ (up to 1.400 Euro for some of the appliances) respectively 350 Euro/t CO₂ if we consider the whole measure till 2030. Due to insufficient data availability, the estimation of the results of this measure is not fully accurate. The wide supply of different appliances and their energy consumption cannot be taken into account. However it becomes clear that a speedup of the replacement of existing white ware is not meaningful from an economic point of view. Comparatively, a regulatory measure of maximum energy consumption for white ware appliances could lead to a significant decline of electricity consumption in households.

Energy sector

We focus on two potential mitigation measures in the Romanian energy sector. The first is the installation of 7 natural gas combined-cycle power plants (CCPP) with an aggregated installed capacity of 2,450 MW by 2019. The second measure evaluates the effects of 12 stand-alone biomass CHPs.

The estimation of these measures can only give a hint on the range of potential results. The main reasons are the wide range of potential equipment costs (investments in Euro/kW) and the development of fuel prices. Nevertheless, both measures show a important emissions reduction potential compared to the use of coal power plants.

For the estimation of the abatement cost we compare the generation of electricity and heat of both types of fuel with the generation from a coal (lignite) power plant. The abatement costs of a modern natural gas CCPP is ca. 20 Euro/tCO₂ and that of a biomass CHP ca. 40 Euro.

Transport sector

While within the transport sector significant emissions reductions are possible, user behaviour plays a major role to enable them. In this evaluation, we focus on three aspects in the freight sector: “Modernizing intermodal terminals and building new intermodal terminals (Timisoara, Suceava and Brasov)”, “Modernising diesel trains (replacing engines)” and “Structural change in mode of freight transport”.

Modernisation and building of new intermodal terminals have no direct effect on emissions reduction.

We estimate that the emission reduction potential of a modernisation of 78 diesel trains sum up to ca. 64,000 tCO₂ till 2030. The measure is economically efficient under the assumption of a diesel price for rail companies of at least 40 Euro/MWh¹⁰ (ca. 0.40 Euro/litre) and investments of 1 m Euro per train. The abatement costs in such a case are ca. -5 Euro/t CO₂.

A shift from road to rail transport can lead to an emission reduction of ca. 1 Mt CO₂. We assume a moderate increase of inland freight transport of 3% p.a. till 2030. We further assume that the relative share of inland road transport decreases from 48% today (52% rail) to 36% in 2030. We focus only on heavy trucks. An accurate assessment of the abatement costs is impossible due to inadequate data availability. Based on cost

¹⁰ The current end consumer price including VAT is ca. 1.3 Euro/litre.

differences of freight transport per tonne-kilometre, we estimate that the abatement costs are ca. -5 Euro/tCO₂, but further investigations are needed.

Industrial use of pumps

In the Romanian industry (and with lower intensity in other sectors) ca. 3.4 TWh electricity is used for pumps. We estimate that at least ca. 18% of this consumption can be saved through the optimisation of existing pumps and replacement of inefficient appliances. The annual saving potential of ca. 0.63 TWh correspond to 1.4% of the Romania electricity consumption in 2011.

Due to the wide range of potential appliances and related costs of modernisation and new pumps, we are not able to specify NPV and abatement costs. Further research is needed to analyse the overall emission reduction potential of pumps and further technical applications in the industry sector and the related costs of the implementation.

5 Concluding remarks

The objective of this study was the evaluation of the socio-economic consequences of various emission reduction targets – if set at country level – in Bulgaria and Romania. Due to the current political debate about a EU-wide 40% emissions reduction target for 2030, our analysis focused on this 40% goal. At the macro level, we analysed how an allocation of member states targets based solely on EU-wide cost efficiency would impact Bulgaria and Romania.

Our results show that a contribution of Bulgaria and Romania to an economically optimal emission reduction of 40% in the EU28 till 2030 would require a 66% (Romania) and 68% (Bulgaria) emissions reduction compared to 1990 (or 23% and 18% reductions from the reference scenario). It is outside the scope of this study to analyse the impacts of other distribution options (such as the mechanism used for determining the 2020 non-ETS target, which is based on GDP per capita),

In order for both countries to reduce their GHG emissions, important structural changes in the energy sector as well as in the industry sector are required. The Bulgarian energy sector has to contribute to more than 80% to the national emissions reduction target and the Romanian one to more than 50% in 2030. This is mainly driven by an increase of the use of renewable energy sources and an increase of the use of nuclear compared to the reference scenario. It should be emphasized that, due to the need of modernization of the existing power generation and the grids in both countries, retrofitting of the energy sector by 2030 will be unavoidable even in the reference scenario. Social, economic as well as cultural challenges are to be expected from a decrease of the production and use of domestic fossil fuels. Resulting structural changes in the mining sector have to be anticipated early and have to be supported by educational and training programs.

There are three main processes that drive emission reduction in the industry and households: (1) structural change of the economy to less energy intensive supplies and/or demands, (2) energy efficiency increase by replacement of out-dated equipment and (3) replacement of equipment before its end of life time. The replacement of machinery and durable goods as well as the energy retrofitting of existing facilities (e.g. buildings) can led to economic benefits resulting from fuel sale savings. It will be a challenge to assure that companies and consumers in both countries will use such win-win options.

Therefore energy price policy has to be adapted, financing frameworks and schemes have to be improved and adequate regulatory schemes and support have to be established.

Romania and Bulgaria are two EU member states that face significant challenges in respect of economic restructuring and development. Therefore it is particularly important to evaluate the impact on GDP growth in both countries of such emissions reduction. The GDP changes in 2030 in Bulgaria and Romania (compared to the reference scenario) will be low (-0.7% in Romania and -1.3% in Bulgaria) and implies a slight decrease in the annual rate of economic growth by 0.09 and 0.05 percentage points over the period 2015-2030 for Bulgaria and Romania respectively. Considering that economic forecasts over such time horizons are highly uncertain, this means that the effects of such emissions reduction trajectories on economic growth are practically undetectable.

The results of the macroeconomic evaluation give an overview of the expected economic impact in both countries when they perform the described emissions reduction trajectories. The results show in which sectors the most efficient (economically optimal) reductions are possible but they do not define discrete measures at a micro level.

Therefore a second objective of the study was to describe and evaluate potential discrete emission reduction measures in both countries. We analyse, as illustrative examples, 13 measures in Bulgaria and 7 in Romania that lead to emission reductions of 5.5 Mt CO₂ and respectively 12 Mt CO₂ by 2030. Not all of the measures are economically feasible from a microeconomic point of view. Abatement costs range from -35 Euro up to 1.200 Euro/t CO₂. The feasibility and economical efficiency of the measures depend on several conditions: e.g. the development of fuel prices and their subsidies, the development of technology costs and the development of capital markets. Furthermore, the framework of policy instruments and measures will have a significant influence on the implementability of these single measures.

An important outcome of this study is that for a macro and micro economic efficient implementation of emissions reduction targets in the relevant socio-economic sectors of Bulgaria and Romania and their efficient political support, further information and better data are desirable. More comprehensive analysis that focus on single economic players and technologies can help to increase the economic efficiency of the implementation and avoid windfall gains.