RESEARCH CENTER FOR ENERGY AND SUSTAINABLE DEVELOPMENT, MACEDONIAN ACADEMY OF SCIENCES AND ARTS (RCESD - MASA)

Intended Nationally Determined Contributions

- Republic of Macedonia -

Background document

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The Republic of Macedonia is a non-Annex 1 country of the UN Convention on Climate Change and at the same time is a candidate country for EU membership.

The focus of the Macedonian INDC is placed on climate change mitigation

Introduction

International context

A new international after 2020 agreement is negotiated by the Parties to the UN Framework Convention on Climate Change (UNFCCC), and it will be adopted on the international conference in Paris, in December 2015. In order to prepare for the new global climate change agreement, all countries currently develop and determine their own national contributions, or in climate change terminology "Intended Nationally Determined Contribution (INDC)". The term "Intended" points to the fact that still there is no agreement on the legal status of the contributions and their final form, so they might be revised if, for example, the future agreement, changes the assumptions based on which a specific country has determined its contribution. Further on, the term "Nationally Determined" underlines the fact that the contributions shall not be determined collectively, and that countries will determine them independently, in line with their national circumstances. Finally, the term "Contribution" denotes the contribution that the country will have in achieving the global objective of stabilizing GHG concentrations in the atmosphere to a level that would prevent harmful anthropogenic impact on the climate system and limit global warming to less than 2°C. This contribution should be set on a fair and equal basis, in agreement with the possibilities and specific features of each and every country.

In order to ensure political will and commitment from all stakeholders, these contributions should be seen as a possibility for achieving numerous national objectives, above all sustainable development and transition to low-carbon economy.

The term "Intended Nationally Determined Contribution (INDC)" when directly translated into Macedonian does not clearly indicate the meaning of the English phrase, hence for the needs of this document and for the needs of the whole process in general in Macedonian language we will use the terms "национални придонеси кон климатските промени” or only "национални придонеси” and the acronym "INDC“, and this shall have the meaning as described above.

National context

The Macedonian INDC covers the CO_2 emissions from fossil fuel combustion and sectors as energy supply, buildings and transport

The Republic of Macedonia, is a non-Annex 1 country of the UN Convention on Climate Change (developing country) and until now it did not have quantified commitments for GHG emissions reduction. At the same time it has the status of an EU candidate country and it also has to follow the European Climate and Energy Policy.

At a strategic level, it is required to integrate climate change into energy planning, mainly through the key challenge of the National Sustainable Development Strategy, titled "Climate Change and Clean Energy". Further on, in the Energy Strategy of the Republic of Macedonia, in the chapter analyzing the energy sector in Macedonia with a focus on sustainable development, the strong link between energy production and climate change has been recognized. It is necessary further to coordinate with the Ministry of Environment and Physical planning is required, since it is the institution responsible for climate change, as well as appropriate harmonization of strategic and legislative energy related solutions with the strategic and legislative solutions for climate action.

Because of significant use of fossil fuels in the country, mainly due to the dominant use of domestic lignite for production of electricity, there is a significant potential for GHG emissions reduction. Having this in mind, but also taking into consideration the INDC of the European Union, **the focus of the Macedonian INDC is put on climate change mitigation** and on policies and measures leading to GHG emissions reduction. However this does not mean that climate change adaptation is less important. Vulnerable sectors and climate change adaptation shall be subject to a more detailed future analysis, from the point of view of INDC requirements.

Further on, according to the GHG Inventory, almost 80% of the CO_2 emissions are generated by fossil fuels combustion, with dominant participation of the sectors energy supply, buildings and transport. Due to these reasons, **the Macedonian INDC is focused on CO_2, and it covers sectors as energy supply, buildings and transport**.

In order to identify specific policies and measures for climate change mitigation, besides national strategic climate change documents (Third National Communication and the First Biennial Update Report on Climate Change), **the most recent strategic and planning documents relevant for these sectors**, were also considered. They are as follows:

- Energy Strategy
- Energy Efficiency Strategy
- Strategy on Renewable Energy Sources
- Program for Implementation of the Energy Strategy
- Energy Efficiency Action Plan
- Action Plan on Renewable Energy Sources
- Transport Sector Strategy
- Pre-Accession Economic Program
- Program of the Government of Republic of Macedonia
- Third National Communication on Climate Change
- First Biennial Update Report on Climate Change

The general process for establishing the Macedonian INDC was led by **the Ministry of Environment and Physical Planning (MOEPP)**, which is the institution responsible for climate change policies and national point of contact for UNFCCC. **The National Climate Change Committee (NCCC)** and the **Technical Group at the National Sustainable Development Council** were also part of this process as well as **other key stakeholders,** such as the Ministry of Economy and the Ministry of Transport and Communication as institutions responsible for policies in the target sectors, representatives of the business community, civil society organizations and the academic community. The participation of these stakeholders will assist the process of mainstreaming climate change into the existing planning processes, and it will also strengthen the institutional cooperation in the area of climate change. International institutions and donors in the country also have an important role in this process, primarily the United Nations Development Program and the Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ) which provided technical and financial support for this process.

Based on national strategic and planning documents relevant for the target sectors, as well as based on consultations with relevant policy makers and other actors, **specific policies and measures aimed at climate change mitigation** were identified (Table 1). Prioritization and decisions concerning the Macedonian INDC were made via intensive dialogue with relevant policy makers and other stakeholders and are based on environmental, economic and social performance of identified policies and measures.

Table 1. Identified climate change mitigation policies and measures

Sector	Policy / Measure
Energy supply	1. Reducing distribution loss 2. Large hydro power plants 3. Small hydro power plants 4. Solar power plants 5. Wind power plants 6. Biogas power plants 7. Biomass combined heat and power plants 8. Central heating of Bitola 9. Solar thermal collectors 10. 5% Biofuels 11. More natural gas power plants 12. Geothermal power plants 13. 10% Biofuels

Buildings	14.	Labeling of appliances
	15.	Public awareness campaigns and EE info centers
	16.	Retrofitting of buildings (as per the Rulebook on Energy Performance of Buildings and Directive 2010/31/EU)
	17.	Construction of new buildings (as per the Rulebook on Energy Performance of Buildings and Directive 2010/31/EU)
	18.	Phasing out incandescent light bulbs
	19.	Phasing out resistive heating devices
	20.	Construction of passive buildings
	21.	Gasification of households and of the commercial sector
Transport	22.	Increased use of the railway
	23.	Renewing the car fleet
	24.	Increased use of bicycles, walking and introduction of parking policy
	25.	Railway to Bulgaria
	26.	Electrification of transport

The process for determining the Macedonian INDCs

The Republic of Macedonia started its road to Paris 2015 several years ago, with the implementation of several relevant projects with components for climate change mitigation. These were projects for developing the Third National Communication to UNFCCC and the First Biennial Report on climate change and their implementation enabled creation of adequate knowledge base and strengthened analytical and institutional capacities (capacities of policy makers and of other stakeholders), in order to determine INDCs as part of the global efforts for climate change mitigation.

The Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ), on behalf of the Federal Ministry of Environment, Nature Protection, Construction and Nuclear Safety (BMUB), and the United Nations Development Program (UNDP) jointly helped the Ministry of Environment and Physical Planning during the preparation of the Macedonian INDCs. Both organizations provided assistance and support during the process of technical analysis and consultations with the policy makers and other stakeholders. The technical component of the process was carried out by the Research center for Energy and Sustainable Development at the Macedonian Academy for Sciences and Arts (RCESD- MASA), the national expert (NE) and the international expert (IE).

The process for determining the INDCs (Table 2) consists of two components - analytical component and consultations and dialogue with policy makers and other stakeholders. This was supported by a political process for adopting the determined INDCs and ensuring commitment for implementing relevant climate change mitigation policies and measures. Main products of this process are **the Background Document** and **the Submission Document.** The Background document (uploaded on the Macedonian web site for climate change[1]) contains detailed information and results of the analysis. The Submission Document is in a tabular format (following the example of the EU Submission Document) and contains a link to the Background Document which ensures transparency and better information of the international community concerning the Macedonian INDC.

Table 2. Macedonian INDC process in six steps

Steps	Responsibility (who : what)
Step 1: **Identification and validation of mitigation policies and measures** Bottom-up approach Implementation through technical workshops and/ or meetings with relevant stakeholders	NE, MASA: Presentations and discussion on technical workshops and/ or meetings IE: Quality control MOEPP: Leadership Ministry of Economy, Ministry of Transport and Communication and other stakeholders: Ensuring coherence with the sector policies, strategies and plans

[1] www.moepp.gov.mk; www.klimatskipromeni.mk

Steps	Responsibility (who : what)
Step 2: **Modeling identified mitigation measures and policies** With the MARKAL model Reviewing assumptions, entry data and key drivers during consultations with relevant stakeholders	MASA: Modeling IE: Advise and quality control NE: Coordination and support
Step 3: **Cost - benefit analysis and calculating additional benefits, assessment of mitigation policies and measures** By using the tool "Marginal Abatement Cost curve - MAC Curve" Additional benefits expressed through the potential for job creation; Developing a model for assessing jobs created	IE: Advice on methodologies, quality control, developing a model for assessing created jobs, evaluating mitigation policies and measures MASA: Analytical work - calculating costs and benefits NE: Coordination and support of the analytical work and of the evaluation of mitigation policies and measures
Step 4: **Developing scenarios and analysis of various types of contributions** Workshop with the stakeholders on prioritization of mitigation policies and measures	IE: Advice and quality control, presentation at the workshop MASA: Analytical work, presentation at the workshop NE: Coordination and support of the analytical work and moderation at the workshop MOEPP: Leadership Ministry of Economy, Ministry of Transport and Communication and other stakeholders: Prioritization

Step 5: **Writing draft-versions of the Background Document and of the Submission Document** Receiving comments from the stakeholders and the general public (uploading draft versions on the web site) Workshop with the stakeholders in order to discuss the draft versions and the decision on the type of the Macedonian INDC Finalizing the Background Document and the Submission Document	NE: Structure, content and writing, presentation and discussion on the workshop with the stakeholders, facilitating the decisions on the type of the Macedonian INDC IE: Advice, quality control, presentation and discussion on the workshop with the stakeholders, facilitating the decisions on the type of the Macedonian INDC MASA: Technical support (figures, tables, graphs) MOEPP: Advice and leadership Ministry of Economy, Ministry of Transport and Communication and other stakeholders: Discussion and comments on the draft-versions of the Background Document and of the Submission Document
Step 6: **The Government of Republic of Macedonia adopts the Background Document and the Submission Document** Presentations and discussions with high representatives of ministries and the donor community Public debate Uploading the final Background Document and the Submission Document on the climate change web site Submitting the Submission Document to the UNFCCC	MOEPP: Leadership NE: Presentations during workshops, meetings, public debate IE: Quality control, presentations during workshops, meetings, public debate

The following measures have the highest mitigation potential: Labelling appliances, More natural gas power plants and Phasing out electric resistive heaters and replacing them with heat pumps.

Assessment of mitigation policies and measures

Economic and environmental aspects

The first step in determining which policies and measures should be given priority is to plot the Marginal Abatement Cost Curve - MAC curve. MAC curve is a good way of presenting low-carbon options as an alternative to the business-as-usual. The MAC curve gives an overview of the costs and of the potential for reducing GHG emissions of low-carbon technologies in the general economy, or in specific sectors. It positions cheaper policies and measures to the left, and more expensive to the right. By crossing the MACC at the abscissa equal to the amount of necessary emissions reductions, it is possible to get simple estimate which policies and measures should be implemented for certain ambition level. It is recommended to review possibilities for implementing policies and measures with negative costs as soon as possible.

Before implementation of each measure cost and benefits, including co-benefits, should be established, and the best way of implementation should be enacted. Crucial criteria are continuity of newly created or enlarged sectors and maximisation of local added value and employment.

In order to plot the MAC curve two parameters are needed for every mitigation policy and measure - its mitigation potential and mitigation cost. One result from modelling policies and measures in Macedonian context is the mitigation potential, as presented on Figure 1. We can see that the three measures with highest mitigation potential are:

- Labeling of appliances
- More gas power plants
- Phasing out resistive heaters and replacing them with heat pumps.

Until 2030 by implementing measures with negative costs, CO_2 emissions can be reduced for more than 4 Mt compared to the business-as-usual scenario.

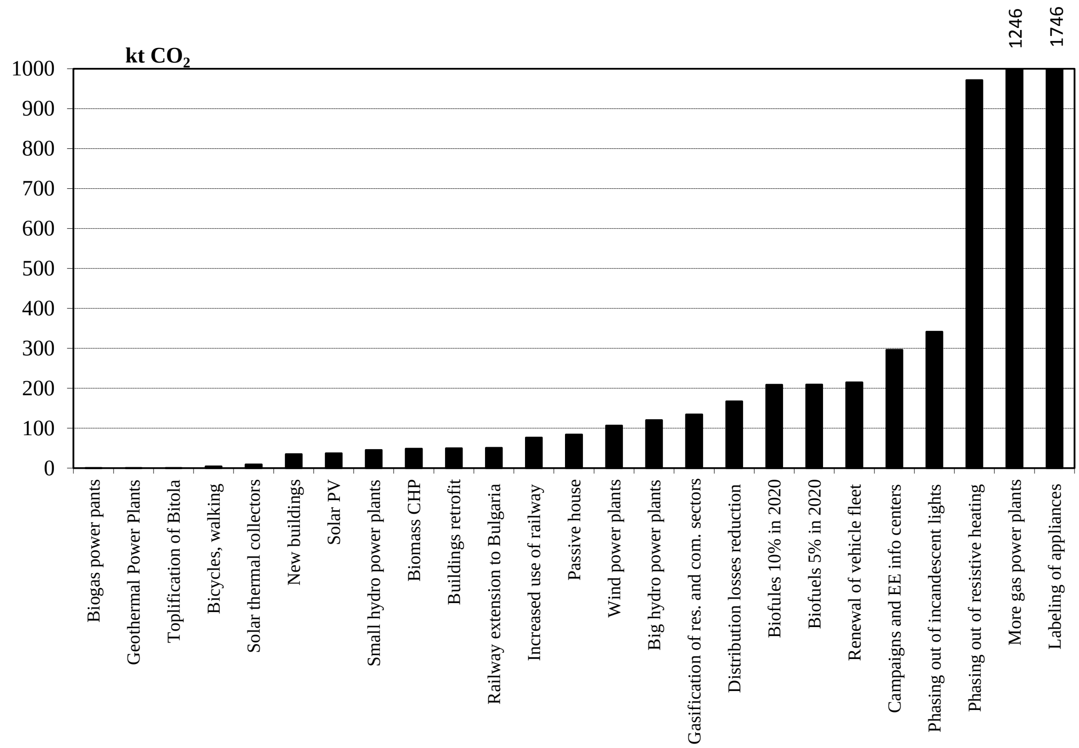

Figure 1. Reduction of CO_2 emissions in 2030

The costs for implementing mitigation policies and measures are presented in Figure 2. More than half of the measures have negative costs which means that they not only reduce emissions but they also save money. Also, some measures have positive mitigation costs which means that the GHG emissions reduction with these measures will be at the cost of the economy. It is generally accepted that we should analyze measures and policies which implementation costs are lower than 100 €/tCO_2. The policies and measures with negative costs (increased use of bicycles, walking and introducing a parking policy, solar thermal collectors, increased use of the railway and others) should be implemented in any case. Some of the policies and measures with reasonably low costs (for example wind power plants or retrofitting of buildings) should be also taken into consideration for possible implementation.

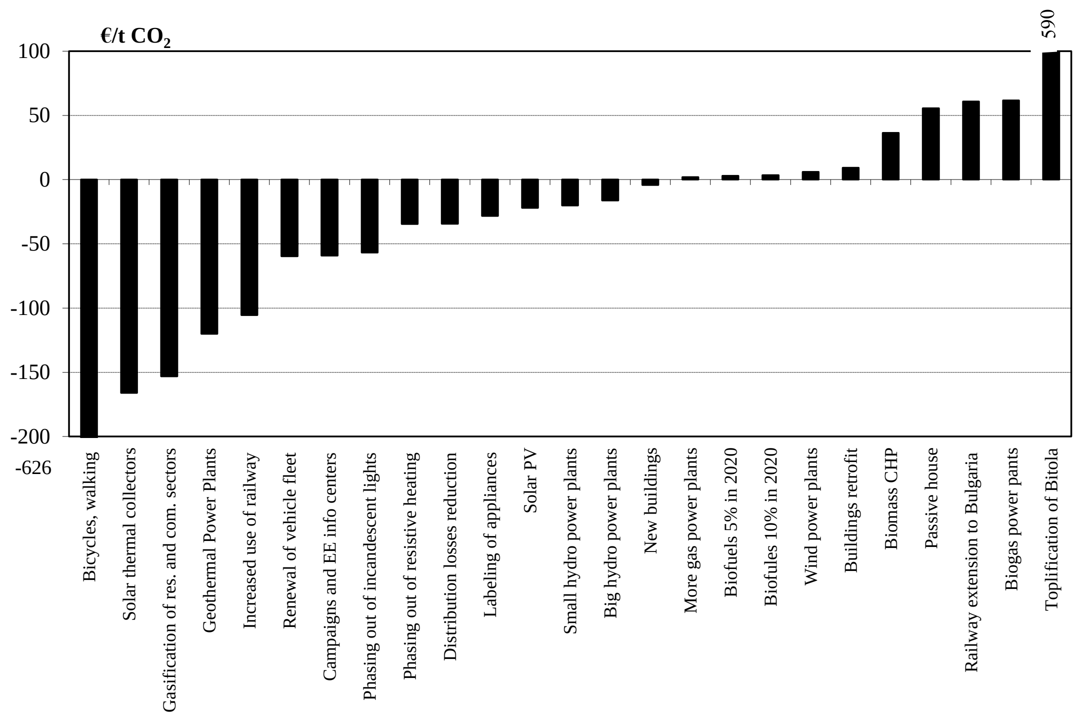

Figure 2. 2030 specific costs

Finally, by combining the two parameters (mitigation potential and cost) we obtain the MAC curve (Figure 3). By implementing policies and measures with negative cost by 2030, CO_2 emissions could be reduced for more than 4 Mt (22%) compared to the BAU scenario. Besides this, with relatively small investments, CO_2 emissions could be reduced for additional 2 Mt (additional 11%).

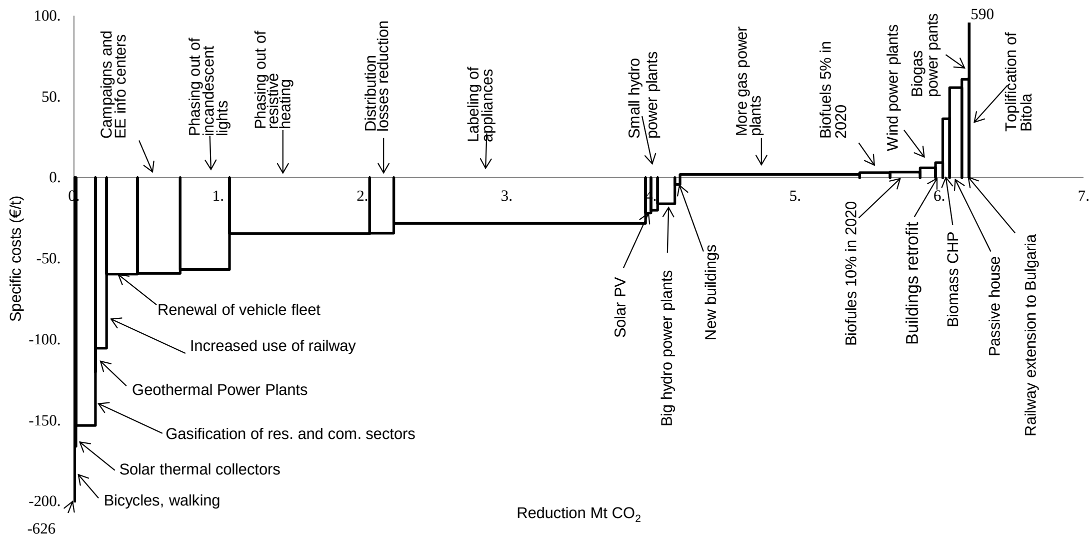

Figure 3. Marginal abatement cost curve for 2030

Social aspects

Policies and measures that mitigate the climate change often have positive co-benefits, one of them being increased employment. Since investment is needed to implement policies and measures, either in energy efficiency or in low carbon energy supply, the investment will have positive impact on gross domestic product and on jobs. Investment will mean project development, which will be good for engineering jobs, entrepreneurship, jobs in financial sector (thus mainly high quality white-collar jobs), and then once the investment is made, purchase and installation of equipment (which will be done by installers led by engineers, thus mixed white and blue-collar jobs). During lifetime, there are operation and maintenance jobs and for some technologies, there are fuel-handling jobs. There also might be billing jobs, etc.

Building new buildings to new efficiency standard and retrofitting old buildings could create 3500 jobs.

In order to estimate number of jobs created in energy efficiency policies and measures macroeconomic input-output method was used, based on investments, and factors from literature [2]. In case of energy supply technologies, newly installed power is used and factors from literature[3]. We have assessed the number of domestic jobs created as a result of the implementation of mitigation measures in the area of energy efficiency and energy supply in the Republic of Macedonia.

Energy efficiency measures can be divided as buildings related, transport related and industry related.

In this study we have assessed the number of jobs related to energy efficiency measures in the buildings sector, because of the highest potential for creation of new jobs, especially domestic ones. The most important measures are those related to retrofit of buildings (either bringing buildings to the existing standard, or to passive house standard that will come when recast of Buildings Directive is implemented), which will increase number of jobs in construction sector and construction materials industry (cement, brick and tile, insulation material industry, paints, scaffolding production, etc.). It is hugely important to keep the retrofit sector relatively constant, since retrofitting many buildings in one year and none in the next few would not benefit local economy. That is because sectors need time to grow, so big jump in one year would have to mean bringing non-local companies and workforce to satisfy the market. Besides this in the years with lower activity, this sector will have to disappear. Because of this, policies and measures need to be planned so that they will ensure constant and slowly growing investments. In total, building new buildings to new efficiency standard and retrofitting old could open 3500 jobs until 2030.

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[2] http://www.peri.umass.edu/fileadmin/pdf/research_brief/PERI_USGBC_Research_Brief.pdf

[3] Max Wei, Shana Patadia, Daniel M. Kammen, Putting renewables and energy efficiency to work:How many jobs can the clean energy industry generate in the US?, Energy Policy 38(2010); 919–931

Lightning improvement is related to buildings, but also to public lightning. Switch to LED lightning, which has much higher added value, will create employment since new channels for sales will be possible, and more innovative installation is possible. It may be estimated that $1 million investment will create 5.1 direct jobs, and 4.2 jobs are indirectly created. Jobs that are indirectly created are created throughout the economy in industries which supply goods and services to the industry in question. For example, if spending on the output of the construction industry increases by $1 million, we can estimate the number of direct jobs that are created in the construction industry in response to that increased spending, as well as the indirect jobs that are created in lumber, hardware, trucking, and other industries which supply the construction industry. These jobs will then induce additional 3.7 jobs in other sectors (induced employment results when workers in the direct and indirect industries spend their earnings, creating increased demand in industries such as retail, healthcare, and food services). With the application of this measure, in total 500 new jobs may be created by 2030.

The use of more renewable energy sources for production of electricity will open about 1300 jobs

It is difficult to estimate jobs related to more efficient **transport**. These jobs will most probably be on the vehicle production and supply chains, which will most probably not be in Macedonia. On the other hand, if electrification of personal vehicle is started, then there will be jobs related to chargers and smart chargers, which would be additional equipment installed in homes, businesses and on public parking places. Also, some jobs would be lost at petrol stations, petrol station servicing and fuel handling. Still, by 2030 big breakthrough of electrification is expected, so that is why these jobs are not assessed. It is also difficult to assess jobs related to modal shift towards the public transport, use of bikes, walking and railway. They should be related to new investments in alternative modes of transport, as well as maintenance of appropriate technologies.

Investments in **energy efficiency** in industries are also hard to assess because they are very specific and each industry and each process is not a subject of our analysis.

On the supply side**, policies and measures** include increase of efficiency of existing power plants, switch to lower carbon fossil fuels and switch to renewables in power, heat and transport application.

Increasing energy efficiency of current power plants will generate only a small number of jobs during retrofit phase, but in the long run retrofit will also bring automation, so no new jobs are expected. Switching part of power generation from coal to natural gas would increase number of jobs by 250 by 2030.

About 6000 green jobs may be expected by 2030 with the implementation of energy efficiency measures in buildings and low carbon energy supply

Using more renewables for power generation, in particular solar PV, wind, biomass, hydro, geothermal and landfill gas, would open some 1300 jobs by 2030, mainly in the sector of PV. PV is rather labor intensive, especially if small installations are placed on roofs. It might be best to go to small roof plants of 2 kW per home, since in that case this would also improve supply and distribution (mainly being consumed locally). Establishing such a sector has best employment perspective among supply technologies.

Using more renewables for heat supply is also a good option, like solar thermal, biomass, and heat pumps. Establishing solar thermal sector may open 600 jobs by 2030.

Using more biofuels for transport may also be good for employment in case that biofuels are locally produced. Meanwhile, local production of biofuels seems not to be economically viable option in Macedonian conditions.

In total, as shown on Figure 4, about 6000 green jobs may be expected by 2030, with the implementation of measures related to energy efficiency of buildings and low-carbon energy supply (renewables and gas).

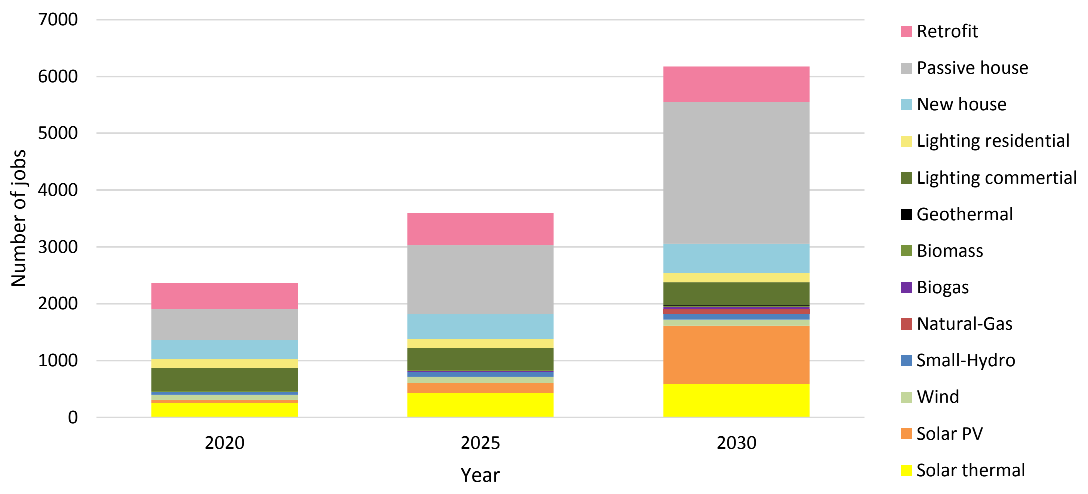


Figure 4. Number of domestic green jobs

Stakeholders participation

Integral component of the process implemented in order to determine INDC were consultations and dialogue with policy makers and other stakeholders in the target sectors **(MOEPP, Ministry of Economy, Ministry of Transport and Communications, the National Climate Change Committee, the Technical Group in the National Council on Sustainable Development as well as representatives from the civil and the academic sector)**. Consultations took place on technical meetings (with high representatives of line ministries and the appointed contact persons) and on topical workshops. Consultations were held in the following areas:

- Identification and validation of **possible mitigation policies and measures** in the target sectors in line with the sector policies and planning documents, as well as with the European Climate and Energy Policy
- Discussion and validation of **the modeling assumptions for the identified mitigation policies and measures** in line with the sector policies and planning documents, as well as with the European Climate and Energy Policy
- **Prioritization of the identified measures** and provision of guidelines for developing mitigation scenarios with the existing and with additional measures

Prioritization workshop was held on May 19th with the following agenda:

1) Presentation and discussion of the results from the background component: Modelled policies and measures were presented one by one, with a special focus on **environmental and economic effectiveness**
2) Setting up and determining the importance of criteria for evaluating mitigation policies and measures: although very important, still these two dimensions are not sufficient for a comprehensive assessment. In order to adopt a policy and to plan strategic measures based on better information, it is of highest importance to investigate and evaluate the **feasibility** of specific mitigation

policy/measure, taking into consideration that there might be cases when the policies/measures with high economic or environmental performance will not be implementable due to country specific obstacles. This may be a result of financial, legislative, administrative or technical obstacles (infrastructure and shortcomings in the supply chain, many stakeholders with different interests, lack of relevant data, studies and general knowledge). Further on, taking into consideration that measuring, reporting and verification are basic elements of the nationally appropriate mitigation actions, **the measurability of the emission reductions achieved** should be used in order to determine the priority policies/measures. Besides this, linking the methodologies for measuring the climate change mitigation activities shall open possibilities for connecting the national mitigation activities with international support (which is also one of the topics of the international negotiations concerning the future of the climate regime). Eventually, co-benefits (creation of jobs, health benefits, diversification of income, better life quality and others) could help to see the cost-effectiveness of the mitigation policies and measures. Appropriately, participants in the topical workshop gave their opinion about the importance of the following **criteria** which need to be applied in order to assess climate change mitigation policies and measures:

- Economic effectiveness (abatement cost)
- Environmental effectiveness (abatement scope)
- Feasibility (difficult/easy to implement)
- Measurability (possibility to measure and verify the reduction achieved)
- Co-benefits

It was concluded that all criteria should have equal importance when determining the priorities.

(3) Assessing climate change mitigation policies and measures: In a dialogue with the experts, the stakeholders expressed their views and opinions concerning the following selected mitigation policies and measures:

- Higher participation of renewable energy sources in production of electricity
- Introduction of a CO_2 tax
- 10% Biofuels
- Prohibiting the sale of incandescent light bulbs
- Prohibiting the sale of resistive heating devices
- Passive buildings

Stakeholders' opinion was taken into consideration during the development of climate change mitigation scenarios and in defining the boundaries of the Macedonian INDC.

On the **final workshop with the stakeholders** (June 26) the draft versions of the Background Document and the Submission Document were discussed and the recommendations for the Macedonian INDC were decided/verified. Before this workshop, the draft documents were uploaded on the climate change web site, where they were available for comments from the stakeholders and from the general public.

Developing mitigation scenarios

Business-as-usual (BAU) scenario

In order to assess the impact of specific measures and policies which have been or should be implemented, it is necessary to develop a business-as-usual scenario to which all the other scenarios will be compared. This is the so called scenario without measures (WOM). The business-as-usual scenario defines how the system will develop, taking into consideration the conditions of the base year and their application throughout the planning period. Besides this, in order to determine the energy needs it is necessary to use drivers that help projecting what the necessary quantities of energy will be for the planning period. The business-as-usual scenario for the development of the energy system of Macedonia until 2035 is based on the following assumptions and limitations:

Average annual growth of the GDP of 4.5%.

Reduction of the population with an average annual rate of 0.09%

Macroeconomic drivers:

- Gross Domestic Product projections (GDP): annual growth of 4.5% until 2035
- Population growth projections: -0.09% annually until 2035

Utilization of domestic resources:

- New big hydro power plants will not be built due to lack of interest among the investors and / or due to the resistance of the NGOs and the local communities.
- The capacity of power plants with feed-in tariffs is limited to the capacity for which the Energy Regulatory Commission has issued a decision for temporary preferential producer, which is 65.4 MW for small hydro power plants, 50 MW for wind power plants, 18 MW for solar power plants and 7 MW for biogas power plants.

Energy supply technologies:

Increase in the final energy consumption for 70%, from 1885 ktoe in 2012 to 3178 ktoe in 2030

- After its revitalization TPP Oslomej will work with imported high quality coal.
- No nuclear plant will be built in the analyzed period.
- No investments in reducing transmission and distribution loss

Energy import:

- No connections to a new gas pipeline are planned (taking into consideration the current condition in the region) which means that only the capacity of the existing gas pipeline is available.
- The price of the imported electricity is the price of electricity sold on the electricity market[4]. The predictions are that in the following 4-5 years it will maintain the level of 35-45 €/MWh depending on the season and the period, and until 2035 its price would increase to 70 €/MWh[5]
- The price of natural gas and oil derivate are defined per the prices presented in the World Energy Outlook 2014, New policy scenario

On the demand side:

There are no technologies with higher efficiency than those used in the base year. The only possibility on the demand side is the transfer from technology that uses one energy source to a technology that uses other energy source.

Final energy consumption

Taking into consideration the above mentioned limitations which were entered in the MARKAL model used to determine the development of the energy system in Macedonia, based on the lowest costs, it is predicted the final energy consumption to increase for 70% in 2030 compared to 2012, that is to raise from 1885 ktoe to 3178

[4] Hungarian Power Exchange – HUPX, https://www.hupx.hu/en/Pages/hupx.aspx?remsession=1
[5] IEA World Energy Investment Outlook , Special Report, 2014

Increase in the electricity production from 8294 GWh in 2012 to 14,487 GWh in 2030.

The total quantity shall be from domestic production

ktoe (Figure 5). The share of energy sources will stay almost the same. Still the most dominant energy source will be oil derivates with 38% and electricity with 33% (Figure 5). Natural gas has the highest share growth which from 1% in 2012 shall grow to 8% in 2030, and the biggest share reduction is evident for coal, which share will reduce from 11% to 8%.

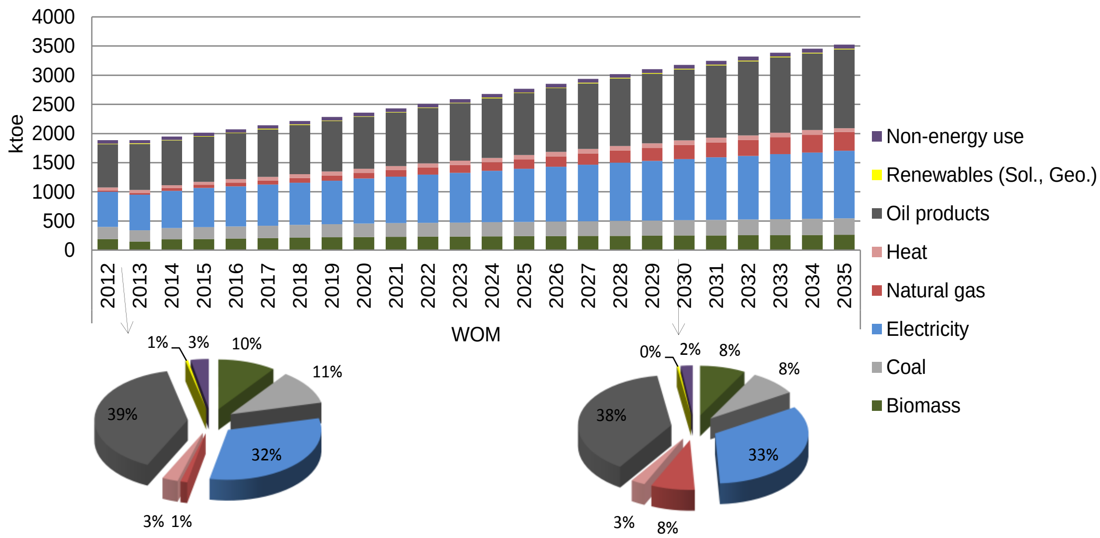


Figure 5. Final energy consumption in the BAU scenario

Special focus is put on electricity, because most of the GHG emissions are generated in the electricity production sector.

In order to satisfy final electricity consumption needs in 2012 (about 7000 GWh), it is necessary to provide about 8300 GWh from national production and from import, since the net import is about 33%. The domestic electricity is generated by coal power plants - 52%, hydropower plants - 12% and natural gas cogeneration heat and power - 4%. In 2030 it is predicted that the final consumption of electricity will be 12,196 GWh (74% more than in 2012) (Figure 6). In order to satisfy these quantities it will be necessary to generate 14,487 GWh (93% more than in 2012). It is foreseen that all electricity will be provided by domestic production in the following way: 72%

Increase of the nominal capacity for electricity production for 55%.

from the coal TPP, 14% from the natural gas combined heat and power PP, 12% from the Hydro PP and 1% from other renewable energy sources.

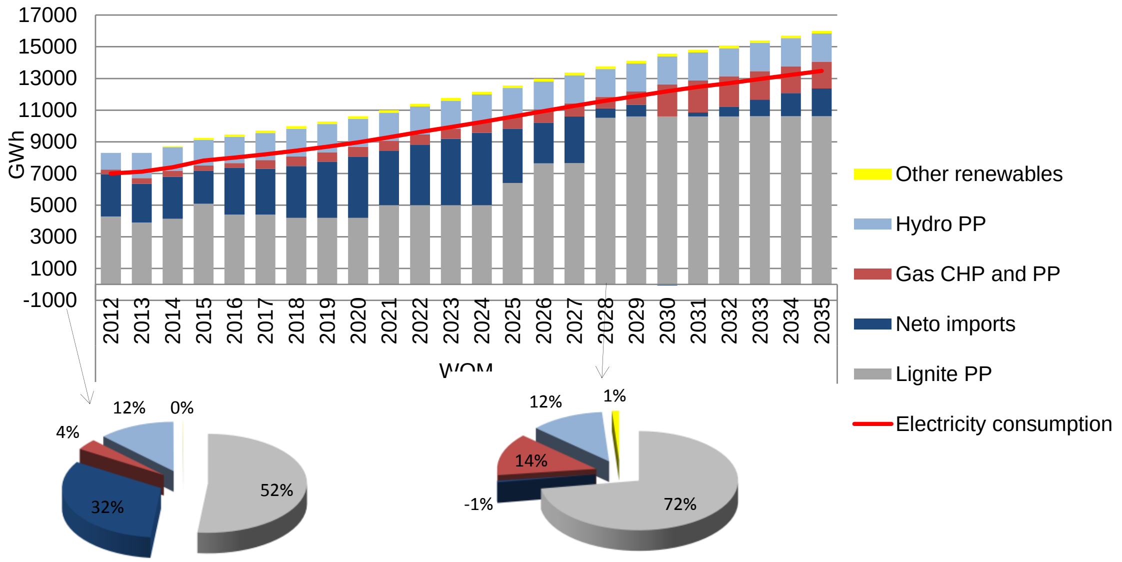


Figure 6. Electricity production in the BAU scenario

Installed capacity for electricity production

Increase of the total energy needs for 73% in 2030. Coal will have the highest share of 54%.

In order to satisfy the electricity needs from the domestic production it is necessary to increase the nominal capacity for 58% in 2030 compared to 2012, which means from 1836 MW to 2,893 MW (Figure 7). Coal TPP have the highest share of 55%, than hydro PP with 25%, cogeneration PP on gas with 18% and other renewable energy sources with 2%.

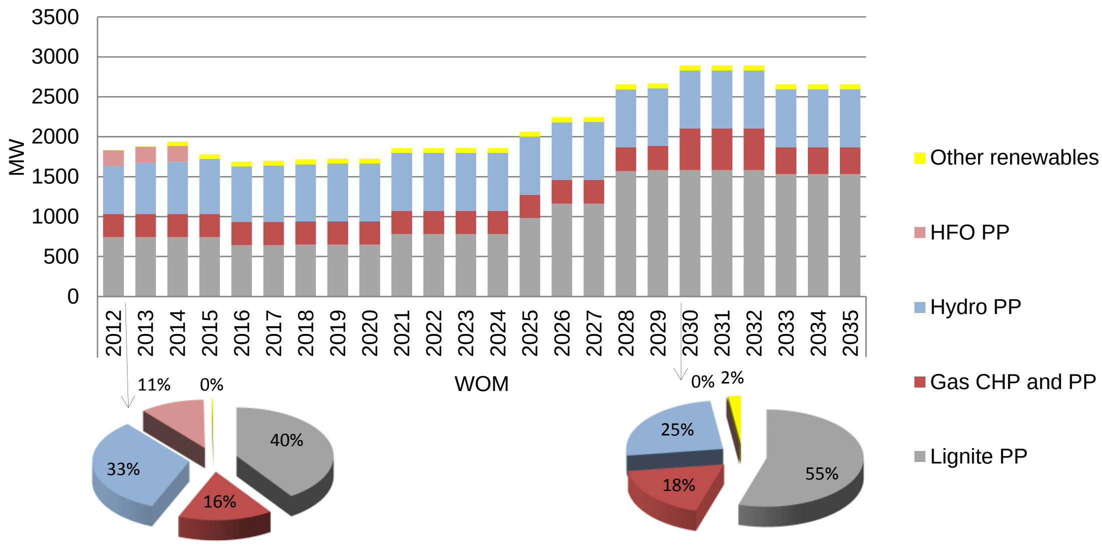


Figure 7. Total installed capacity for electricity production in the BAU scenario

Total energy needs

The total energy needs in 2030 are predicted to increase for 73%, which means that from about 2900 ktoe in 2012 they will increase to about 5100 ktoe in 2030 (Figure 8). The participation of coal, which in 2012 is about 50% will grow for additional 4%. On the second place, just as in 2012 it is predicted to have oil and oil derivates with share of 25%. It is predicted natural gas to have the highest growth, which shall increase its share for about 8.5% and in 2030 its share will be 12.3%. The participation of biomass shall be reduced for 1.5% and in 2030 its share will be 4.9%, and the share of other renewable energy sources (geothermal, solar energy) is predicted to be 3.5%, which is the same level as in 2012.

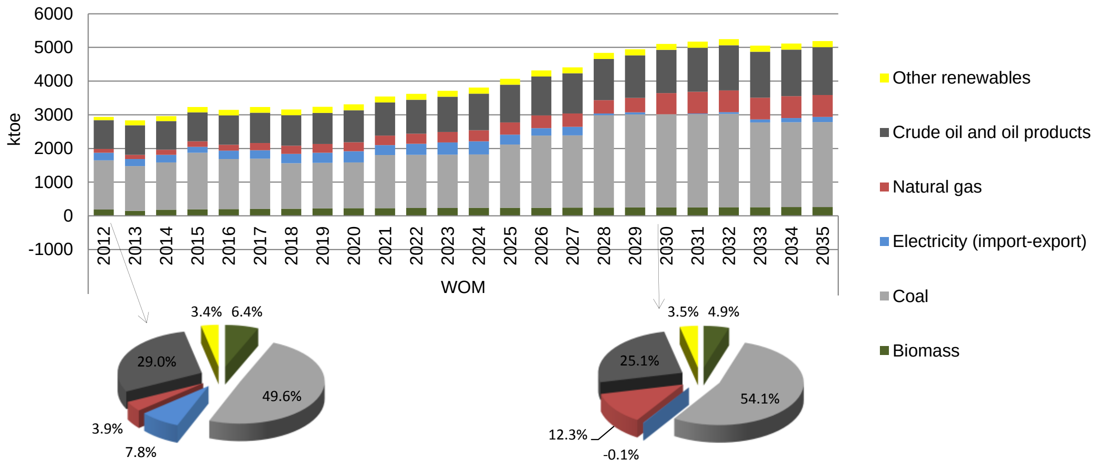


Figure 8. Total energy needs in the BAU scenario

CO_2 emissions

Increase of the CO_2 emissions for 87%, and in 2030 it is predicted that they will amount to 17,700 kt.

Taking into consideration the projected quantities of total energy needs it can be calculated that the CO_2 emissions will increase for 87%, and from 9500 kt in 2012, they will reach 17,700 kt (Figure 9). Highest level of CO_2 emissions will be reached in 2032 (17,900 kt), and after this it is expected emissions to decrease as a result of replacing TPP Bitola with new more efficient PP.

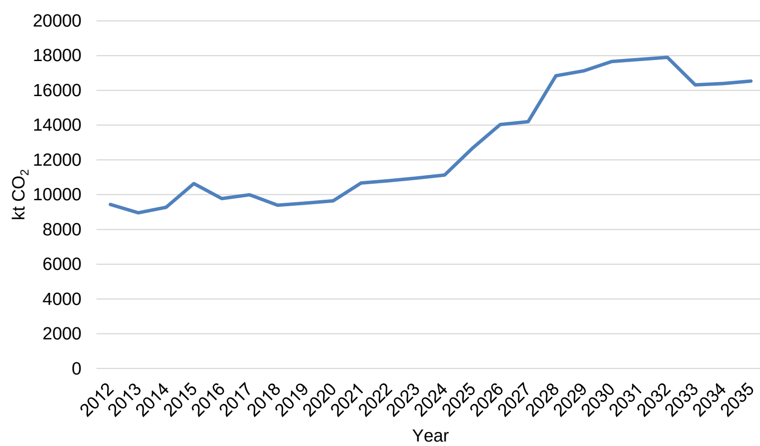


Figure 9. CO_2 emissions in the BAU scenario

The cost of the BAU scenario is estimated to be 40,427 M€.

The total cost of the energy system in the Republic of Macedonia discounted with the discount rate of 7.5% and expressed in 2012 € in the BAU scenario is estimated to be 40,427 M€. This cost includes investments on the supply and on the demand side, maintenance cost, fuel costs and delivery costs for the whole period from 2012 to 2035.

System costs

Compared to 2012, the system costs in 2030 shall increase for more than three times (Figure 10). The highest growth is predicted in investments on the supply side which shall be increased in average for 17.8% and from 7 M€ in 2013 they will increase to 260 M€ in 2030. On the demand side, there will be also investments in new appliances and these investments reach up to 1833 M€ in 2030.

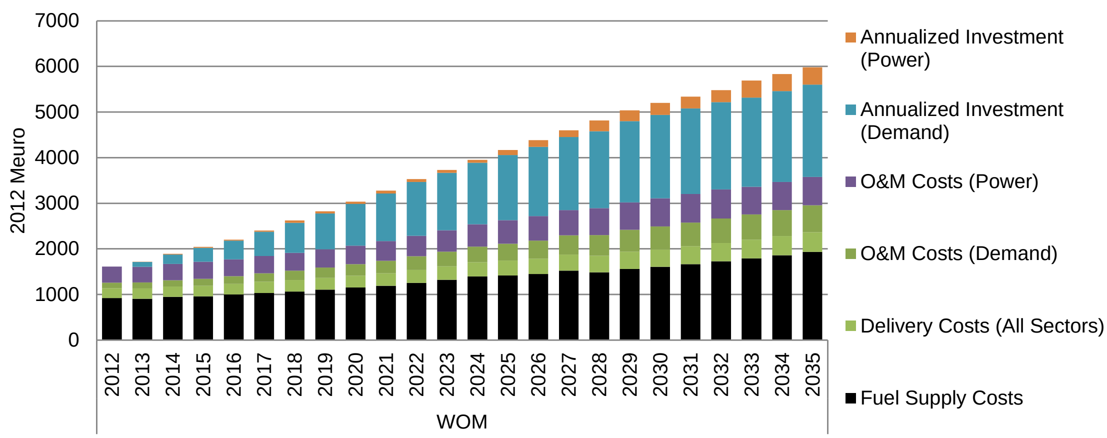


Figure 10. Annual costs of the energy system in the baseline scenario

Total undiscounted investments in the BAU scenario in the period between 2015 and 2030 which contain investments both on the supply and on the demand side amount to 21 billion Euros. In relation to the GDP predicted for the whole period, the investments in the energy sector would present about 11%.

Table 3 contains the summarized results for the BAU scenario. In order to achieve predicted quantities of final energy consumption, it is necessary for it to grow with an average growth rate of 2.9% in the period between 2012 and 2030, while electricity consumption should grow for 3.1%, the installed capacity for 2.6%, and the total energy needs should grow for 3.1%.

Table 3. BAU scenario indicators

	2012	2020	2030	Annual growth rate 2012/2020 (%)	Annual growth rate 2012/2030 (%)	Total growth 2012/2020 (%)	Total growth 2012/2020 (%)
Final energy (ktoe)	1885	2357	3178	2.8%	2.9%	25.0%	68.6%
Electricity consumption (GWh)	6998	8973	12196	3.2%	3.1%	28.2%	74.3%
Electricity production (GWh)	8294	10618	14487	3.1%	3.1%	28.0%	74.7%
Nominal capacity (GW)	1836	1727	2893	-0.8%	2.6%	-5.9%	57.6%
Total energy needs (ktoe)	2939	3313	5097	1.5%	3.1%	12.7%	73.4%
CO_2 emissions (kt)	9438	9640	17663	0.3%	3.5%	2.1%	87.1%

Mitigation scenario

The mitigation scenario contains 17 mitigation policies and measures

The mitigation scenario contains 17 measures/policies which contribute to reducing GHG emissions. These are measures that have relatively high probability for implementation – they have already been started/are planned for the near future, present priority projects/policies in the sector strategic and planning documents or are foreseen in already adopted laws or are planned in the laws which are to be adopted in future. These are the so called existing measures. That is why the mitigation scenario is also called scenario with existing measures (WEM scenario). Table 4 contains the stakeholders responsible for implementation of each measure/policy. It also contains indicative reductions of CO_2 emissions. These reductions are indicative because they show how much each measure/policy independently will contribute to reducing GHG emissions, but this does not mean that if all measures are implemented the reduction will be a simple sum of the reductions achieved by the measures/policies individually. This is a result of the interdependency between specific measures.

The measure which independently most contributes to GHG emissions reduction is the measure Labelling of appliances, with 1,746 kt.

Table 4. Tabular overview of policies and measures contained in the mitigation scenario:

Policy /measure	Relevant stakeholders for implementation	Sources of funding	Indicative CO_2 emissions reduction
Labeling of appliances	Ministry of Economy Energy Agency, manufacturers and vendors of household appliances	Private sector	1746
Public awareness campaigns and EE info centers	Ministry of Economy Energy Agency,	Budget of the Republic of Macedonia	296
Retrofitting buildings	Ministry of Economy Energy Agency, Construction companies	Private sector	50
Construction of new buildings	Ministry of Economy	Private sector	35

	Energy Agency, Construction companies		
Increased use of the railway	Ministry of Transport and Communication	Budget of the Republic of Macedonia	77
Renewing the car fleet	Ministry of transport and Communication, Ministry of Interior Ministry of Economy	Private sector	214
Increased use of bicycles, walking and introduction of parking policy	Ministry of Environment and Physical Planning local self-government	Private sector	4
Reducing distribution loss	Electricity distribution companies	Distribution companies	167
Large hydro power plants	Ministry of Environment and Physical Planning Ministry of Economy Energy Agency, AD ELEM	AD ELEM, Public private partnership	121
Small hydro power plants	Ministry of Environment and Physical Planning Ministry of Economy Energy Agency, private investors	Private sector	46
Solar power plants	Ministry of Environment and Physical Planning Ministry of Economy Energy Agency, private investors	Private sector	37
Wind power plants	Ministry of Environment and Physical Planning Ministry of Economy Energy Agency, AD ELEM private investors	AD ELEM, Private sector	106
Biogas power plants	Ministry of Environment and Physical Planning Ministry of Economy Energy Agency,	Private sector	0.5

	private investors		
Biomass combined heat and power plants	Ministry of Environment and Physical Planning Ministry of Economy Energy Agency, private investors	Private sector	48
Central heating of Bitola	AD ELEM	AD ELEM	0.8
Solar thermal collectors	Ministry of Economy	Private sector	9.4
5% Biofuels	Ministry of Economy	Private sector	209
			Total: 3166

CO_2 emissions are projected to be 12,435 kt in 2030

The key indicators of the mitigation scenario, in which all measures/policies listed in Table 4 are implemented, are presented in Table 5 and they point to the following:

Average annual growth of the final energy of 2,2%, of electricity of 1,7%, total energy needs of 1,8%, CO_2 emissions of 1,5%

- Average annual growth of the final energy of 2.2%, or total growth of 48% in 2030, compared to 2012. The absolute amount in 2030 is predicted to be 2,979 ktoe. Compared to the BAU scenario there is a reduction compared to the annual average growth of 0.7% (Figure 11).
- The electricity consumption in 2030 is projected to 9,188 GWh which compared to 2012 is an increase of 31% and the average annual growth is 1.5%. Compared to the BAU scenario, there is a reduction in the average annual growth of 1.6% (Figure 11).
- Electricity production follows the consumption and compared to 2012 it is increased for 30%, while the average annual growth is 1.4%
- As a result to the measures/policies the total nominal capacity will increase for 50%
- The total energy needs in 2030 are predicted to be about 4,000 ktoe, which in comparison to 2012 is an increase of 37% or an average annual growth rate of 1.8%.
- CO_2 emissions shall increase for 32% and in 2030 they will amount to 12,435kt. The emissions trend is presented in Figure 12.

The cost of the mitigation scenario is reduced in comparison to the BAU scenario for 2555 M€.

Additional annual investments needed for implementation of this scenario are assessed to be 2.2% of GDP.

Table 5. Indicators for the Mitigation scenario

	2012	2020	2030	Annual growth rate 2012/2020 (%)	Annual growth rate 2012/2030 (%)	Total growth 2012/2020 (%)	Total growth 2012/2020 (%)
Final energy (ktoe)	1885	2496	2797	3.6%	2.2%	32.4%	48.4%
Electricity consumption (GWh)	6998	8501	9188	2.5%	1.5%	21.5%	31.3%
Electricity production (GWh)	8294	9964	10734	2.3%	1.4%	20.1%	29.4%
Nominal capacity (GW)	1836	2248	2753	2.6%	2.3%	22.4%	49.9%
Total energy needs (ktoe)	2939	3572	4035	2.5%	1.8%	21.5%	37.3%
CO_2 emissions (kt)	9438	10753	12435	1.6%	1.5%	13.9%	31.8%

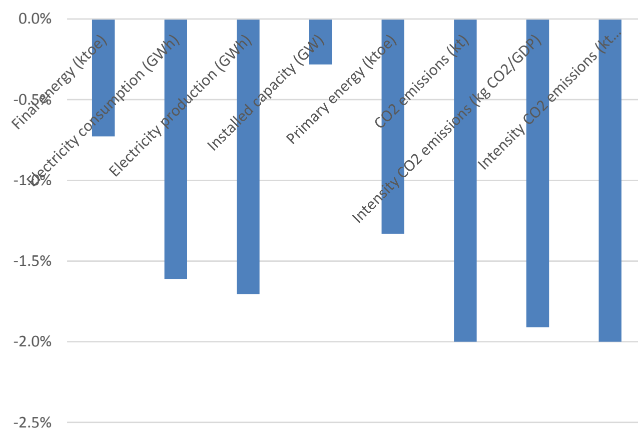


Figure 11. Difference in the annual growth between the mitigation scenario and the BAU scenario

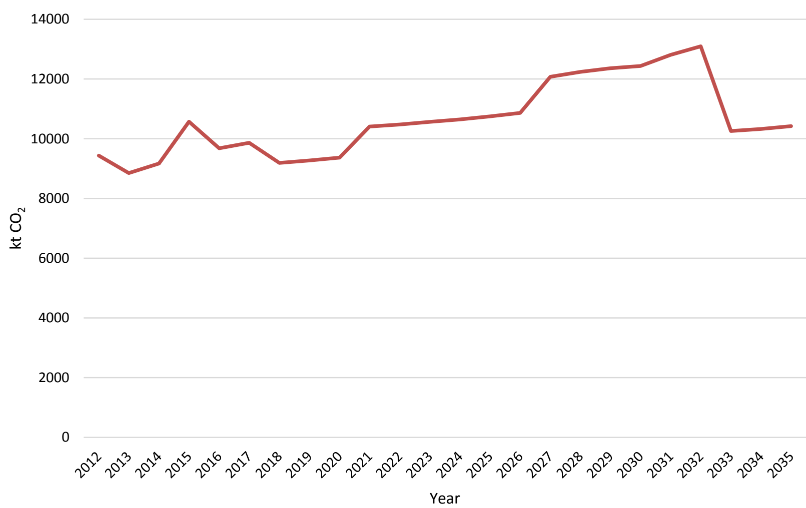


Figure 12. CO_2 emissions in the mitigation scenario

The total cost of the energy system in the Republic of Macedonia discounted with the discount rate of 7.5% and expressed in 2012 € in the mitigation scenario is assessed at 37,871 M€ for the whole period 2012-20135, which is a reduction compared to the BAU scenario for 2,555 M€.

Concerning investments on the supply and the demand side, the implementation of this scenario, compared to the BAU scenario requires additional investments of 4,268 M€ or additional annual investments of 267 M€. These annual investments require 2.2% of GDP.

Higher ambition mitigation scenario

The higher ambition mitigation scenario contains 24 mitigation policies and measures

The higher ambition mitigation scenario includes all measures implemented in the mitigations scenario (Table 4) and nine additional measures (Table 6). This is the so called scenario with additional measures (WAM scenario). Retrofitting of buildings and construction of new buildings are replaced with the measure for construction of passive buildings. Concerning indicative emission reduction in the higher ambition mitigation scenario besides the measure for labelling of appliances (implemented in the mitigation scenario) most contributing measure is the measure for having more gas power plants. Reductions achieved with this measure are 1,247 kt.

Table 6. Tabular overview of policies and measures contained in the higher ambition mitigation scenario

Policy /measure	Relevant implementation actors	Sources of funding	Indicative CO_2 emissions reduction
All measures contained in the mitigation scenario, without retrofitting of old buildings and construction of new buildings			Total: 3,082
Phasing out incandescent light bulbs	Ministry of Economy Energy Agency, Manufacturers and vendors of household appliances	Private sector, budget of the Republic of Macedonia, budgets of the local self-governments.	342
Phasing out resistive heating devices	Ministry of Economy Energy Agency,	Private sector	972
Construction of passive buildings	Ministry of Economy Energy Agency, Construction companies	Private sector	84
Gasification of households and of the commercial sector	Ministry of Economy Households, commercial and service sector	Private sector	135
Railway to Bulgaria	Ministry of Transport and Communication	Budget of the Republic of Macedonia	51
Electrification of transport		Private sector	

Average annual growth of total energy needs of 1.4%, and of CO_2 emissions of 1%

More natural gas power plants	Ministry of Environment and Physical Planning Ministry of Economy Energy Agency, private investors	AD ELEM, PPP	1247
Geothermal power plants	Ministry of Environment and Physical Planning Ministry of Economy Energy Agency, private investors		0.6
10% Biofuels	Ministry of Economy		209
			Total: 6,122

Indicators describing this scenario are given in Table 7 and they show the following:

Average annual growth of the final energy of 2,1%, and of electricity of 1%.

- Average annual growth of the final energy of 2.1%, or total growth of 44% in 2030, compared to 2012. The absolute amount in 2030 is predicted to be 2,717 ktoe. Compared to the BAU scenario there is a reduction in the annual average growth of 0.9% (Figure 13).
- The electricity consumption in 2030 is projected to be 8.371 GWh which compared to 2012 is an increase for 20% and the average annual growth is 1%. Compared to the BAU scenario, there is a reduction in the average annual growth of 2.1% (Figure 11)
- Electricity production follows the consumption and compared to 2012 it is increased for 30%, while the average annual growth is 1.4%
- As a result to the measures/policies the total nominal capacity will increase for 45%
- The total energy needs in 2030 are predicted to be about 3,800 ktoe, which in comparison to 2012 is an increase for 30% or an average annual growth rate of 1.4%.
- CO_2 emissions shall increase for 20% and in 2030 it is predicted that they will amount to 11,359 kt (Figure 14).

Table 7. Indicators for the higher ambition mitigation scenario

	2012	2020	2030	Annual growth rate 2012/2020 (%)	Annual growth rate 2012/2030 (%)	Total growth 2012/2020 (%)	Total growth 2012/2020 (%)
Final energy (ktoe)	1885	2415	2717	3.1%	2.1%	28.1%	44.2%
Electricity consumption (GWh)	6998	7483	8371	0.8%	1.0%	6.9%	19.6%
Electricity production (GWh)	8294	8708	9724	0.6%	0.9%	5.0%	17.2%
Nominal capacity (GW)	1836	2248	2665	2.6%	2.1%	22.4%	45.2%
Total energy needs (ktoe)	2939	3467	3790	2.1%	1.4%	18.0%	28.9%
CO_2 emissions (kt)	9438	10741	11359	1.6%	1.0%	13.8%	20.4%

CO_2 emissions are projected to 11.359 kt in 2030

The cost of the mitigation scenario is reduced in comparison to the BAU scenario for 3250 M€.

Additional annual investments needed for implementation of this scenario are assessed to be 2.3% of the GDP.

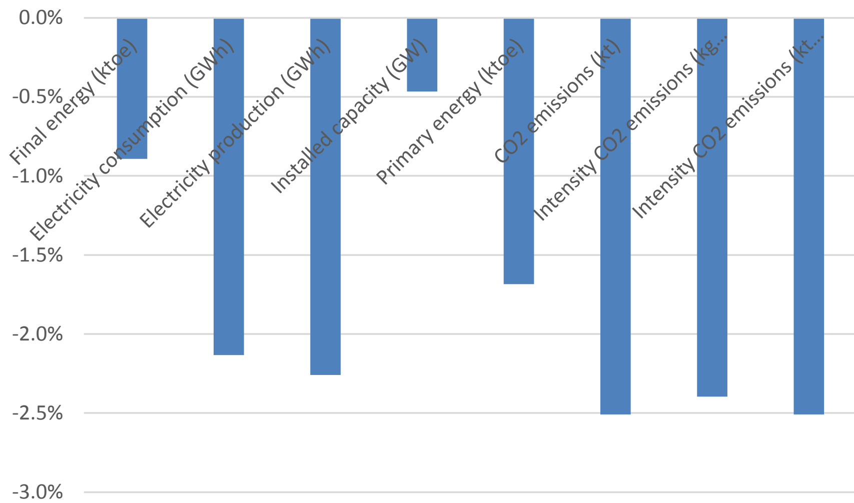


Figure 13. Difference in the annual growth between the higher ambition mitigation scenario and the BAU scenario

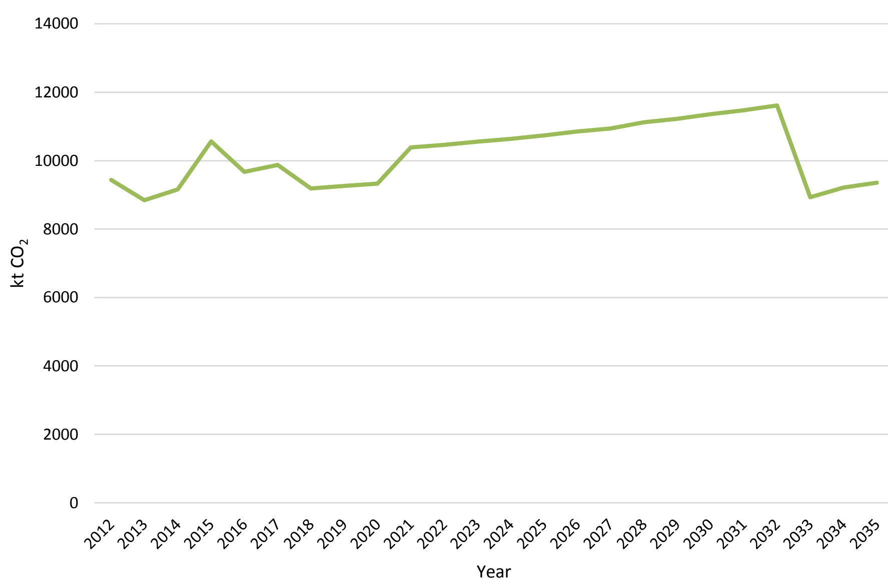


Figure 14. CO_2 emissions in the higher ambition mitigation scenario

The total cost of the energy system in the Republic of Macedonia discounted with the discount rate of 7.5% and expressed in 2012 € in the higher ambition mitigation scenario is assessed to 37,176 M€ for the whole period 2012-20135, which is a reduction of 3,250 M€ compared to the BAU scenario.

Concerning investments on the supply and on the demand side, the implementation of this scenario, compared to the BAU scenario requires additional investments of 4504 M€ or average annual additional investments of 281 M€. These annual investments require 2.3% of the GDP.

Comparative analysis of the mitigation potential

In the BAU scenario (WOM), CO_2 emissions by 2030 shall increase almost twofold (from about 9000 kt they will grow to almost 18,000 kt). With the 17 measures included in the mitigation scenario (WEM), in 2030 a reduction of 30% may be achieved compared to the BAU scenario. With the higher ambition scenario (WAM scenario), which includes additional and improved measures, in 2030 a reduction of 36% may be achieved in comparison to the BAU scenario. In all scenarios it is predicted that emissions will have a гроњинг trend, reaching its maximum in the period between 2030 and 2032, and after that they will start to decrease.

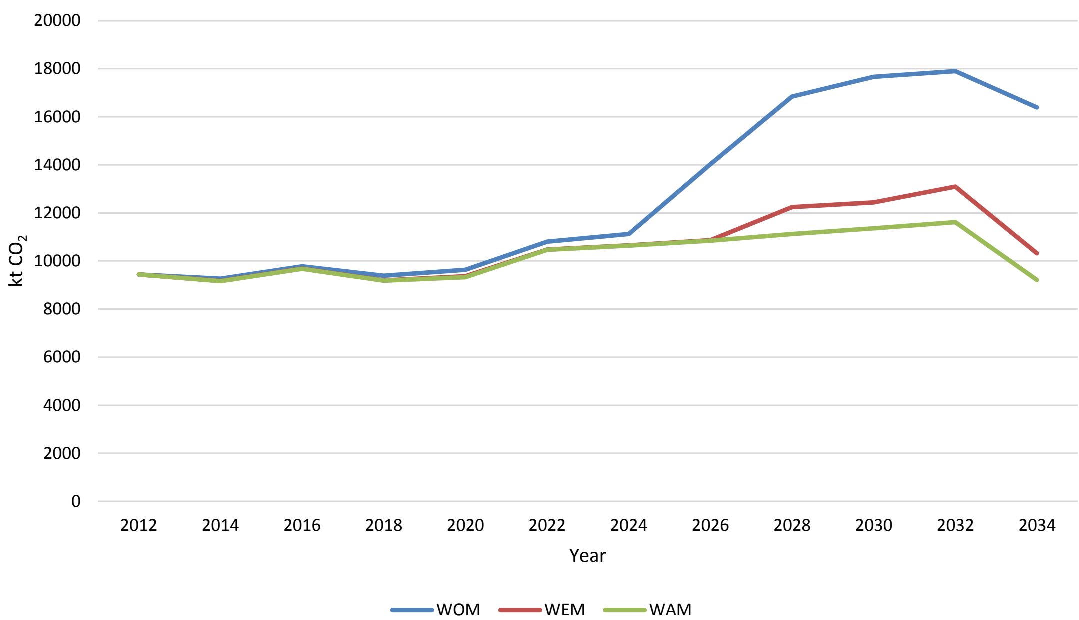


Figure 15. Comparison of CO_2 emissions

CO_2 emissions per GDP in the BAU scenario will decrease with an annual rate of 1.1%, however on the other hand CO_2 emissions per capita will increase with a rate of 3.6%, so in in 2030 CO_2/GDP shall be 1.08 kg (Figure 16), and CO_2/capita will be 8.63t (Figure 17) .

In the mitigation scenario, CO_2/GDP shall be reduced with an annual rate of 3%, while CO_2/capita will be increased with a rate of 1.6%, which means that CO_2 per GDP is reduced for 43%, while CO_2 per capita is increased for 33% compared to 2012. In absolute values CO_2/GDP is predicted to be 0.76 kg (Figure 16), and CO_2/capita 6.07 kt (Figure 17).

In the higher ambition mitigation scenario, CO_2/GDP shall be reduced with an annual rate of 3.5%, while CO_2/capita will be increased with a rate of 1.1%, that is, CO_2 per GDP is reduced for 47%, while CO_2 per capita is increased for 21% compared to 2012. In absolute values CO_2/GDP is predicted to be 0.7 kg (Figure 16), and CO_2/capita 5.55 t (Figure 17).

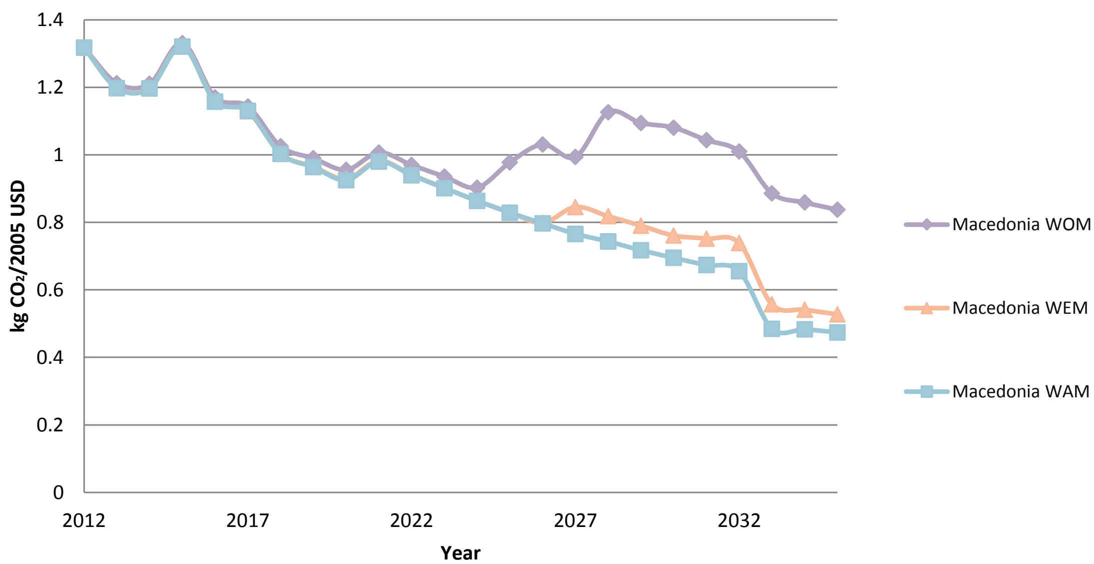


Figure 16. Comparing emissions in kg CO_2/2005 USD

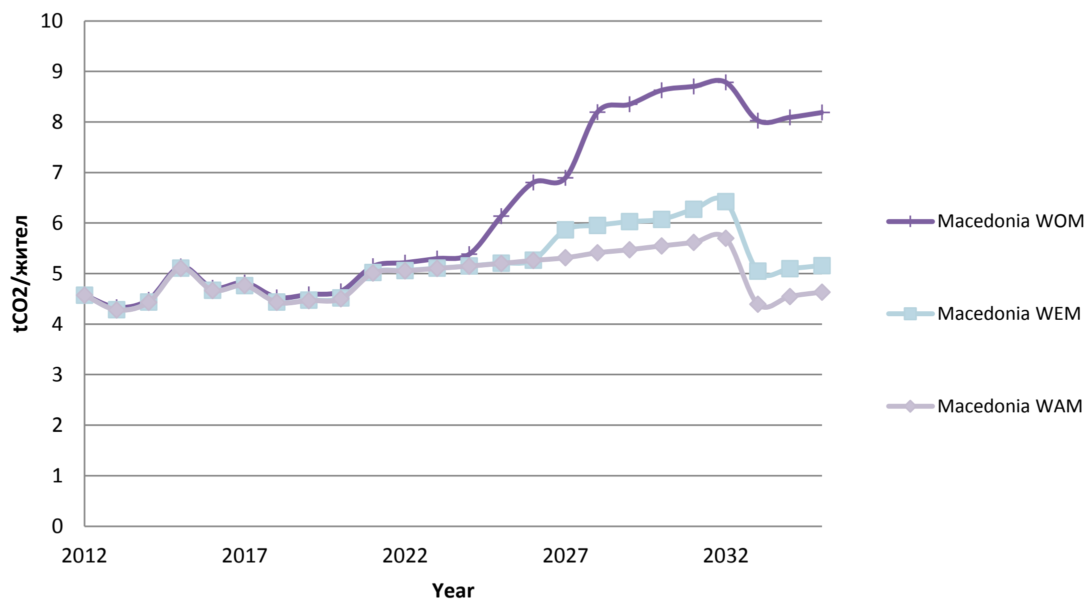


Figure 17. Comparing emissions in tCO_2/capita

The Republic of Macedonia has similar CO_2 emissions per GDP with Bulgaria and Estonia (). The reduction trend is similar with the one of Poland and Romania. According to this indicator, in 2030, the Republic of Macedonia shall reach the level of 2012 of countries as Lithuania, Hungary, Slovenia and other countries in this group with about 0.4 kg CO_2/2005 USD. (Figure 18).

The Republic of Macedonia is in the same group of European countries with lower CO_2 emissions per capita, such as Lithuania, Portugal, Sweden and Hungary. In the BAU scenario there is an upward trend, while in the mitigation scenarios this indicator in 2035 would reach the level of 2012 (Figure 19).

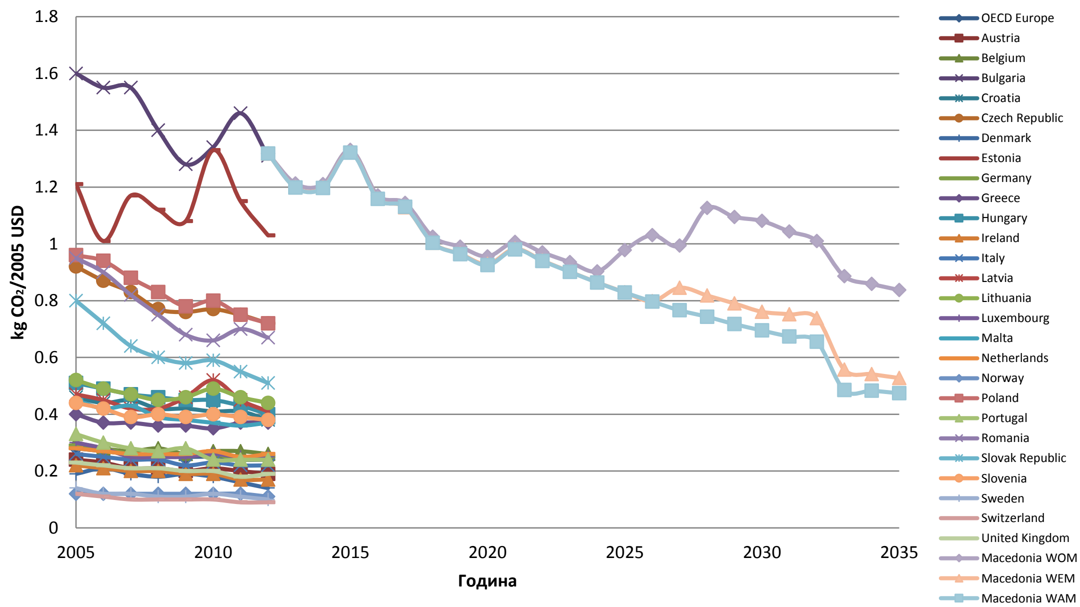


Figure 18. Comparison of emissions of EU member countries in kg CO_2/2005 USD

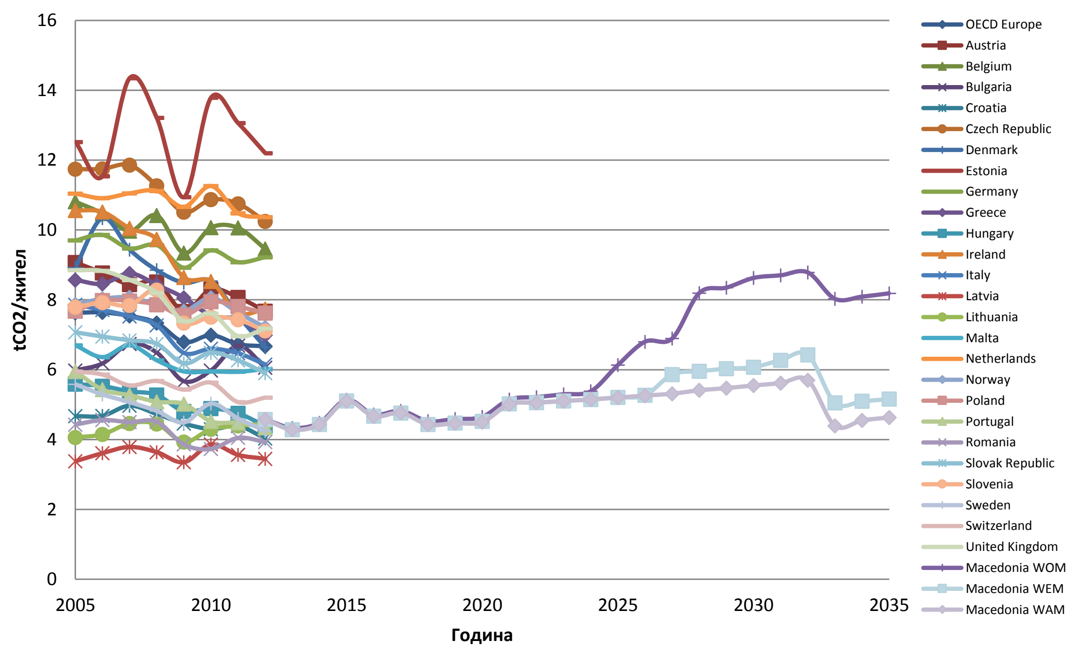


Figure 19. Comparison of EU member countries in t CO_2/capita

Intended Nationally Determined Contributions

30% reduction of CO_2 emissions in 2030 in the mitigation scenario and 36% in the higher ambition mitigation scenario in comparison to the BAU scenario

Baseline scenario target

For this type of target a comparison is made of the emissions in the mitigation scenarios with the BAU scenario in a specific year. In our case this is 2030 (this is the target year of almost all countries) and relevant deviations are presented in Table 8.

Table 8. Comparison of CO_2 emissions with the BAU scenario emissions

	CO_2 emissions in 2030 (kt)	Deviation from the baseline scenario
BAU scenario	17,663	
Mitigation scenario	12,435	-30%
Higher ambition mitigation scenario	11,359	-36%

Base year target

87% higher emissions in 2030 in the BAU scenario, 31% in the mitigation scenario and 20% higher ambition mitigation scenario in comparison to the 1990 emission levels

In this type of target the emissions in a specific year (end year) are compared to the emissions in the base year. In our case, the end year is 2030, while the base year is 1990 (same as in the EU target). Energy sector emissions (which corresponds to the emissions covered by the Macedonian INDC) in 1990, according to the First Biennial Update Report on Climate change were 9445 kt . In relation to this amount, in the mitigation scenario there is an increase of 31% while in the higher ambition mitigation scenario the increase is 20% (Table 9).

Table 9. Comparison of CO_2 emissions in 2030 with emissions in 1990 (base year 1990)

CO_2 emissions in 1990 (kt)	9,445	
	CO_2 emissions in 2030 (kt)	**Deviation from the base year**
BAU scenario	17,663	**+87%**
Mitigation scenario	12,435	**+31%**
Higher ambition mitigation scenario	11,359	**+20%**

2005 is also the year which very often is used for comparison of CO_2 emissions. According to the First Biennial Update Report on Climate Change, CO_2 emissions in 2005 amount to 9,278 kt. If we compare emissions from the mitigation scenario, an increase of 34% is visible, while in the higher ambition mitigation scenario there is an increase of 22% compared to 2005 emissions (Table 10).

90% higher emissions in 2030 in the baseline scenario, 34% in the mitigation scenario and 22% in the higher ambition scenario compared to emissions in 2005

Table 10. Comparison of CO_2 emissions in 2030 with other base years (2005 and 2012)

CO_2 emissions in 2005 (kt)	9,278		
CO_2 emissions in 2012 (kt)	9,438		
	CO_2 emissions in 2030 (kt)	**Compared to 2005 level**	**Compared to 2012 level**
BAU scenario	17,663	**+90%**	**+87%**
Mitigation scenario	12,435	**+34%**	**+32%**
Higher ambition mitigation scenario	11,359	**+22%**	**+20%**

From these comparisons we can conclude that the most favorable way for expressing the Macedonian mitigation targets is with an end year reduction, when the base year is 1990. This corresponds to the EU type of objective.

Recommendation

Based on the complex modeling and detailed analysis implemented, the following INDC may be recommended for the Republic of Macedonia:

To reduce the CO_2 emissions from fossil fuels combustion for 30%, that is, for 36% at a higher level of ambition, by 2030 compared to the business as usual (BAU) scenario. The CO_2 emissions from fossil fuels combustion cover almost 80% of the total GHG emissions in the country with a dominant share of the following sectors: energy supply, buildings and transport.

Expressed as a base year target (which is the type of EU INDC), the CO_2 emissions in 2030 shall increase for 31%, that is, for 20% at a higher level of ambition, compared to the CO_2 emissions in 1990.The CO_2 emissions shall have a growing trend, peaking between 2030 and 2032.

Appendix: Modeling of identified mitigation policies and measures

Approach and methodology

The programming package MARKAL (MARKet ALlocation) has been used for projecting energy needed until 2035. MARKAL is a complex model for planning the development of the energy sector on local, national and / or regional level. Different parameters, such as energy prices, prices and features of power plants, performance of buildings and others are used as entry data based on which the program selects the optimal technolgical mix for satisfying the energy demand at a minimum price.

In order to satisfy the energy needs the MARKAL model selects those technolgies which have the lowest cost for production of electricity, which includes the investment cost for a specific energy plant, fixed and variable maintenance cost as well as costs for the fuel used by the specific power plant or if the imported electricity is cheaper, than the model uses imported electricity. MARKAL during the optimization process balances the power of electricity produced.

The model is divided into two parts, energy supply and energy demand. On the supply side and on the demand side there are two typs of technologies: existing and new ones. Existing tehcnologies are those which are used in the base year, which in this case is 2012. These technologies have specific life cycle and once it is finished they will be replaced with new ones.

Results

All measures/policies used in the mitigation scenario and in the higher ambition mitigation scenario are presented in a tabular view.

Energy supply

Table 11. Detailed overview of the measure Reducing distribution loss

Mitigation policy/measure	Reducing distribution loss
Type	Technical
Description	Investments in reducing distribution loss
Sector	Energy supply
Relevant planning documents, legal and regulatory acts	MK: Energy Development Strategy of the Republic of Macedonia; Development Plan for AD EVN Macedonia
Modeling assumptions	Investments in reducing distribution loss from 17% to 11%
Implementation timeframe	2015-2035
CO_2 reductions (kt) in 2030	167
2030 specific costs (€/t)	-34.3

Table 12. Detailed overview of the measure Large hydro power plants

Mitigation policy/measure	Large hydro power plants
Type	Technical
Description	Construction of large hydro power plants
Sector	Energy supply
Relevant planning documents, legal and regulatory acts	MK: Energy Development Strategy of the Republic of Macedonia; Strategy on Renewable Energy Sources Development Plan for AD ELEM

Modeling assumptions	It is assumed that the following large hydro power plants will be constructed: • Boshkov Most • Lukovo Pole • Gradec • Shplilje upgrade and revitalization • Veles • Globochica II • Channel Vardar - Kozjak • Chebren
Implementation timeframe	2016-2035
CO_2 reductions (kt) in 2030	120
2030 specific costs (€/t)	-16.2

Table 13. Detailed overview of the measure Small hydro power plants

Mitigation policy/measure	Small hydro power plants
Type	Technical
Description	Construction of small hydro power plants
Sector	Energy supply
Relevant planning documents, legal and regulatory acts	MK: Decree on feed-in tariffs for electricity, 17.04.2013; Energy Development Strategy of the Republic of Macedonia; Strategy on Renewable Energy Sources
Modeling assumptions	It is assumed that small hydro power plants of 180 MW will be built by 2035

Implementation timeframe	2015-2035
CO_2 reductions (kt) in 2030	45.6
2030 specific costs (€/t)	-20.1

Table 14. Detailed overview of the measure Wind power plants

Mitigation policy/measure	Wind power plants
Type	Technical
Description	Construction of wind power plants
Sector	Energy supply
Relevant planning documents, legal and regulatory acts	MK: Decree on feed-in tariffs for electricity, 17.04.2013; Energy Development Strategy of the Republic of Macedonia; Strategy on Renewable Energy Sources
Modeling assumptions	It is assumed that additional 263 MW wind power plants to be constructed by 2035
Implementation timeframe	2016-2035
CO_2 reductions (kt) in 2030	106.5
2030 specific costs (€/t)	6

Table 15. Detailed overview of the measure Solar power plants

Mitigation policy/measure	Solar Power plants
Type	Technical
Description	Construction of solar power plants
Sector	Energy supply
Relevant planning documents, legal and regulatory acts	MK: Decree on feed-in tariffs for electricity, 17.04.2013; Energy Development Strategy of the Republic of Macedonia; Strategy on Renewable Energy Sources
Modeling assumptions	It is assumed that additional 180 MW solar power plants will be constructed by 2035
Implementation timeframe	2016-2035
CO_2 reductions (kt) in 2030	37.2
2030 specific costs (€/t)	-21.9

Table 16. Detailed overview of the measure Biogas power plants

Mitigation policy/measure	Biogas power plants
Type	Technical
Description	Construction of biogas power plants
Sector	Energy supply
Relevant planning documents, legal and regulatory acts	MK: Decree on feed-in tariffs for electricity, 17.04.2013; Energy Development Strategy of the Republic of Macedonia; Strategy on Renewable Energy Sources

Modeling assumptions	It is assumed that additional 15 MW biogas power plants will be constructed by 2035
Implementation timeframe	2015-2035
CO_2 reductions (kt) in 2030	0.46
2030 specific costs (€/t)	61.5

Table 17. Detailed overview of the measure Biomass combined heat and power plants

Mitigation policy/measure	Biomass combined heat and power plants
Type	Technical
Description	Construction of biomass combined heat and power plants
Sector	Energy supply
Relevant planning documents, legal and regulatory acts	MK: Decree on feed-in tariffs for electricity, 17.04.2013; Energy Development Strategy of the Republic of Macedonia; Strategy on Renewable Energy Sources
Modeling assumptions	It is assumed that additional 15 MW biomass combined heat and power plants will be constructed by 2035
Implementation timeframe	2020-2035
CO_2 reductions (kt) in 2030	48.4
2030 specific costs (€/t)	36.4

Table 18. Detailed overview of the measure Central heating of Bitola

Mitigation policy/measure	Central heating of Bitola
Type	Technical
Description	Utilization of the waste heat from the TPP Bitola
Sector	Energy supply
Relevant planning documents, legal and regulatory acts	MK: Energy Development Strategy of the Republic of Macedonia; Development Plan for AD ELEM
Modeling assumptions	It is assumed that a heat distributions system will be constructed which will utilize the waste heat of the operation of TPP Bitola.
Implementation timeframe	2015-2019
CO_2 reductions (kt) in 2030	0.76
2030 specific costs (€/t)	590.6

Table 19. Detailed overview of the measure Solar thermal collectors

Mitigation policy/measure	Solar thermal collectors
Type	Technical
Description	Installing hot water solar thermal collectors
Sector	Energy supply
Relevant planning documents, legal and regulatory acts	MK: Energy Development Strategy of the Republic of Macedonia; Strategy on Renewable Energy Sources
Modeling assumptions	60% of hot water needs in urban areas and 50% of those in rural areas by 2035 will be covered by solar collectors

Implementation timeframe	2015-2035
CO_2 reductions (kt) in 2030	9.4
2030 specific costs (€/t)	-166

Table 20. Detailed overview of the measure 5% Biofuels

Mitigation policy/measure	5% Biofuels
Type	Regulations
Description	5% participation of biofuels by 2020
Sector	Energy supply
Relevant planning documents, legal and regulatory acts	MK: *The Law and Action Plan on Biofuels are under preparation;* EU: *DIRECTIVE 2003/30/EC on the promotion of the use of biofuels or other renewable fuels for transport*
Modeling assumptions	It is assumed that the implementation of the Directive will be postponed until 2025, that is 5% participation of biofuels by 2020 and 10% by 2025, and this percentage will be maintained until 2035
Implementation timeframe	2015-2035
CO_2 reductions (kt) in 2030	210
2030 specific costs (€/t)	3

Table 21. Detailed overview of the measure Construction of natural gas power plants

Mitigation policy/measure	More natural gas power plants
Type	Technical
Description	Construction of natural gas power plants
Sector	Energy supply
Relevant planning documents, legal and regulatory acts	MK:
Modeling assumptions	It is assumed that 1.090 MW natural gas power plants will be constructed until 2035, which is 750 MW more than in the WOM scenario.
Implementation timeframe	2025-2035
CO_2 reductions (kt) in 2030	1,248
2030 specific costs (€/t)	1.89

Table 22. Detailed overview of the measure Geothermal power plants

Mitigation policy/measure	Geothermal power plants
Type	Technical
Description	Construction of geothermal power plants
Sector	Energy supply
Relevant planning documents, legal and regulatory acts	MK: Energy Development Strategy of the Republic of Macedonia; Strategy on Renewable Energy Sources
Modeling assumptions	It is assumed that additional 15 MW geothermal power plants to be constructed by 2035
Implementation timeframe	2015-2035
CO_2 reductions (kt) in 2030	0.6
2030 specific costs (€/t)	-120

Table 23. Detailed overview of the measure 10% Biofuels

Mitigation policy/measure	10% Biofuels
Type	Regulations
Description	10% participation of biofuels by 2020
Sector	Energy supply
Relevant planning documents, legal and regulatory acts	MK: *The Law and Action Plan on Biofuels are under preparation;* EU: *DIRECTIVE 2003/30/EC on the promotion of the use of biofuels or other renewable fuels for transport*
Modeling assumptions	The Directive 2003/30/EC will be implemented, and 10% participation of biofuels is assumed by 2025, and this percentage will be maintained until 2035
Implementation timeframe	2015-2035
CO_2 reductions (kt) in 2030	210
2030 specific costs (€/t)	3.4

Buildings

Table 24. Detailed overview of the measure Labeling of appliances

Mitigation policy/measure	Labeling of appliances
Type	Regulations
Description	Penetration of appliances with higher efficiency (class A++,A+,A, Б)
Sector	Buildings (households, commercial and service sector)
Relevant planning documents, legal and regulatory acts	MK: *Rulebook on labelling consumption of energy and other resources on devices using energy*. EU: *DIRECTIVE 2010/30/EU* *on the indication by labelling and standard product information of the consumption of energy and* *other resources by energy-related products;* *New EU Energy Labels for Domestic Ovens and Range Hoods:* *Commission Delegated Regulation (EU) No 65/2014*
Modeling assumptions	Households: participation of more efficient technologies, 40% by 2035; Commercial sector: participation of more efficient technologies, 30% by 2035;
Implementation timeframe	2015-2035
CO_2 reductions (kt) in 2030	1,746
2030 specific costs (€/t)	-28

Table 25. Detailed overview of the measure Phasing out incandescent light bulbs

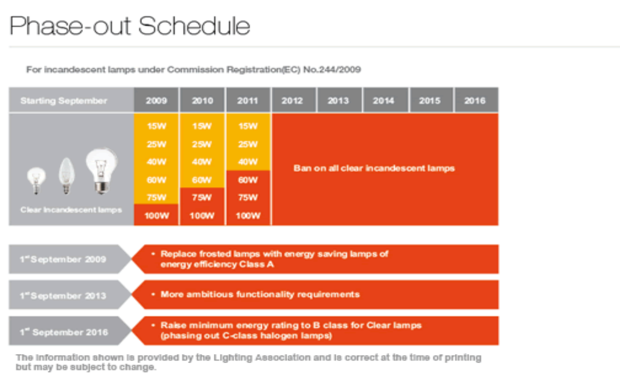
Mitigation policy/measure	Phasing out incandescent light bulbs
Type	Policy, regulation
Description	Replacing incandescent light bulbs with halogen ones (at the beginning) and later with compact fluorescent (CFL) and LED
Sector	Buildings (households, commercial and service sector)
Relevant planning documents, legal and regulatory acts	EU: COMMISSION REGULATION (EC) No 244/2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for non-directional household lamps 
Modeling assumptions	It is assumed that a Regulation will be adopted on prohibiting sales of incandescent light bulbs, its implementation will start in 2016, and it is assumed that there will be 2-3 years of transition period
Implementation timeframe	2016-2035
CO_2 reductions (kt) in 2030	342
2030 specific costs (€/t)	-57

Table 26. Detailed overview of the measure Phasing out resistive heating devices

Mitigation policy/measure	Phasing out heating devices with resistive heaters
Type	Policy, regulation
Description	Phasing out heating devices with resistive heaters and their replacement with heat pumps.
Sector	Buildings (households, commercial and service sector)
Relevant planning documents, legal and regulatory acts	EU Climate and Energy Policy
Modeling assumptions	A Decision should be adopted in 2017, prohibiting the sale of resistive heating devices. It is assumed that heating devices with resistive heaters will be gradually replaced with heat pumps. The transition period would be about 15.
Implementation timeframe	2017-2035
CO_2 reductions (kt) in 2030	972
2030 specific costs (€/t)	-35

Table 27. Detailed overview of the measure Public awareness campaigns and EE info centers

Mitigation policy/measure	Public awareness campaigns and EE info centers
Type	Capacity building, public awareness raising
Description	Raising public awareness about the importance and benefits from buying and using appliances with higher efficiency class.
Sector	Buildings (households, commercial and service sector)

Relevant planning documents, legal and regulatory acts	MK: Second Energy Efficiency Action Plan of the Republic of Macedonia
Modeling assumptions	Annual investment of 400,000 Euros in public awareness campaigns in the period 2015-2020, which will increase the participation of higher efficiency class devices to up to 10% in 2035
Implementation timeframe	2015-2020
CO_2 reductions (kt) in 2030	296
2030 specific costs (€/t)	-59

Table 28. Detailed overview of the measure Retrofitting buildings

Mitigation policy/measure	Retrofitting buildings
Type	Regulation, technical
Description	Retrofitting existing buildings
Sector	Buildings (households)
Relevant planning documents, legal and regulatory acts	MK: *Rulebook on energy performance of buildings* EU*: DIRECTIVE 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL* *on the energy performance of buildings*
Modeling assumptions	1% annual rate of refurbishing of the existing buildings, in order to meet the standard of C class or higher (90 kWh/m^2)
Implementation timeframe	2015-2035
CO_2 reductions (kt) in 2030	50
2030 specific costs (€/t)	9.3

Table 29. Detailed overview of the measure Construction of new buildings

Mitigation policy/measure	Construction of new buildings
Type	Regulation, technical
Description	Construction of new buildings
Sector	Buildings (households)
Relevant planning documents, legal and regulatory acts	MK: *Rulebook on energy performance of buildings* EU: *DIRECTIVE 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL* *on the energy performance of buildings*
Modeling assumptions	Construction of new buildings, which will meet the standard of C class or higher (90 kWh/m^2)
Implementation timeframe	2015-2035
CO_2 reductions (kt) in 2030	35
2030 specific costs (€/t)	-4

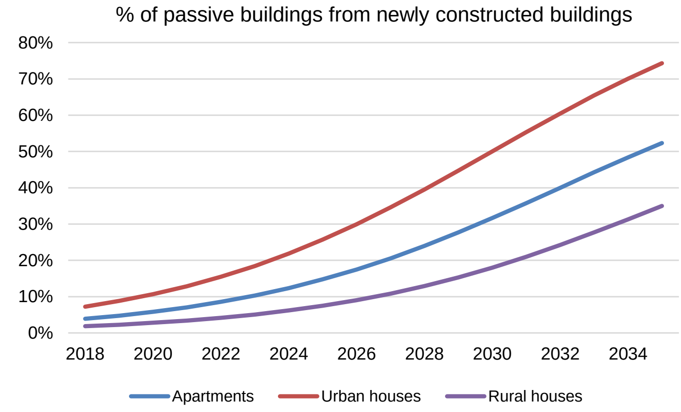
Table 30. Detailed overview of the measure Gasification of households and of the commercial sector

Mitigation policy/measure	Gasification of households and of the commercial sector
Type	Technical
Description	Gasification of households, of the commercial and of the service sector
Sector	Households, commercial and service sector
Relevant planning documents, legal and regulatory acts	MK: *Energy Development Strategy of the Republic of Macedonia;* *Program of the Government of Republic of Macedonia*

Modeling assumptions	Gradual gasification of households and of the commercial and the service sector in the first 4 to 5 years, and this process will intensify after 2020.
Implementation timeframe	2015-2035
CO_2 reductions (kt) in 2030	134.7
2030 specific costs (€/t)	-153

Table 31. Detailed overview of the measure Construction of passive buildings

Mitigation policy/measure	Construction of passive buildings
Type	Regulation, technical
Description	Construction of new buildings
Sector	Buildings (households)
Relevant planning documents, legal and regulatory acts	EU: *DIRECTIVE 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL* *on the energy performance of buildings,* *“member States shall ensure that by 31 December 2020 all new buildings are nearly zero-energy buildings”*
Modeling assumptions	Construction of new buildings, which meet the standard of at least A+ class (15 kWh/m^2) The penetration of passive buildings is planned as in the graph

	
Implementation timeframe	2018-2035
CO_2 reductions (kt) in 2030	84
2030 specific costs (€/t)	55.5

Transport

Table 32. Detailed overview of the measure Increased use of the railway

Mitigation policy/measure	Increased use of the railway
Type	Technical
Description	Increased use of the railway
Sector	Transport
Relevant planning documents, legal and regulatory acts	MK: *Program of the Government of Republic of Macedonia*
Modeling assumptions	Increased use of the railway is assumed due to the commitment of the Government. The Government has used a project with the EBRD and ordered 150 cargo cars and six compositions consisting of a locomotive and passenger cars.
Implementation timeframe	2015-2022
CO_2 reductions (kt) in 2030	76.8
2030 specific costs (€/t)	-105.5

Table 33. Detailed overview of the measure Renewing the car fleet

Mitigation policy/measure	Renewing the car fleet
Type	Regulation, technical
Description	Buying new cars with lower consumption
Sector	Transport
Relevant planning documents, legal and regulatory acts	MK:

Modeling assumptions	It is assumed that only new vehicles will be bought, that is vehicles which meet EU emission standards: CO2 emissions in 2020 of 95 g/km 2020, 70 gCO2/km by 2025
Implementation timeframe	2015-2035
CO_2 reductions (kt) in 2030	214.8
2030 specific costs (€/t)	-59.7

Table 34. Detailed overview of the measure Increased use of bicycles, walking and introduction of parking policy

Mitigation policy/measure	Increased use of bicycles, walking and introduction of parking policy
Type	Regulation, technical
Description	Increased use of bicycles, walking and introduction of parking policy
Sector	Transport
Relevant planning documents, legal and regulatory acts	MK: Second Energy Efficiency Action Plan of the Republic of Macedonia
Modeling assumptions	It is assumed that appropriate parking policy will be introduced which would reduce the use of cars in the city area, and would contribute to increased use of bicycles. It is also assumed that people, especially in smaller towns where a lot of them use cars for short distances, would increase their use of bicycles or walking.
Implementation timeframe	2015-2022
CO_2 reductions (kt) in 2030	4.4
2030 specific costs (€/t)	-626

Table 35. Detailed overview of the measure Railway to Bulgaria

Mitigation policy/measure	Railway to Bulgaria
Type	Technical
Description	Construction of a railway to Bulgaria
Sector	Transport
Relevant planning documents, legal and regulatory acts	MK: *Program of the Government of Republic of Macedonia*
Modeling assumptions	It is assumed that a railway to Bulgaria would be built, which according to the prognosis of the Government of the Republic of Macedonia would cost 600 million Euros.
Implementation timeframe	2015-2022
CO_2 reductions (kt) in 2030	50.9
2030 specific costs (€/t)	60.8