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Climate Change Mitigation in Buildings, Transport and Energy Supply Sectors

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LIST OF ABBREVIATIONS

CHP	Combined Heat and Power Plant
CO_2	Carbon Dioxide
EBRD	European Bank for Reconstruction and Development
EE	Energy Efficiency
EEAP	Energy Efficiency Action Plan
EU	European Union
GDP	Gross Domestic Product
HPP	Hydro Power Plants
INDCs	Intended Nationally Determined Contributions
LCP	Large Combustion Plants
LPG	Liquefied Petroleum Gas
MAC	Marginal Abatement Cost Curve
MARKAL	MARKet ALlocation
MOEPP	Ministry of Environment and Physical Planning
MRV	Monitoring, Reporting and Verification
QELRC	Quantified Emission Limitation and Reduction Commitment
RCESD-MASA	Research Center for Energy and Sustainable Development - Macedonian Academy of Sciences and Arts
RM	Republic of Macedonia
Sol.	Solar energy
TPP	Thermal Power Plant
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
WAM	With Additional Measures
WEM	With Existing Measures
WOM	Without Measures

UNITS

GW	Gigawatt
GWh	Gigawatt Hour
kt	Kiloton (thousand tons)
ktoe	Ton of oil equivalent
MEuro	Million Euros
MW	Megawatt
MWh	Megawatt Hour
PJ	Petajoule
km	Kilometer
pkm	Passenger kilometer
mpkm	Million passenger kilometers
t	Ton
tkm	Ton - kilometer
mtkm	Million ton - kilometers

1 INTRODUCTION

Just as the current international negotiations are coming to the decision making phase (the 21st COP on climate change, December 2015), it becomes more probable that for the first time all countries would commit to a universal climate agreement, containing commitments for all, developed and developing alike. Therefore, an adequate knowledge body generated through complex energy modeling and scenario analysis would be indispensable for developing countries as well, to set their mitigation contributions reflective of the national circumstances and, at the same time, being widely perceived as equitable and fair, and collectively sufficient to keep global temperature increase below 2°C.

Under the Third National Communication, the climate change mitigation analysis for the Republic of Macedonia, as a non-Annex I country under UNFCCC and a candidate for EU membership, was conducted by making use of MARKAL energy system model. The adopted approach implies an imposition of different GHG emissions reduction targets and analysis of the energy system behavior and its parameters as a result of the imposed target (**the so called top-down approach**). Thus, a baseline scenario and three groups of mitigation scenarios have been developed until 2050, reflecting different levels of ambition regarding CO_2 emissions reduction: (1) EU scenarios - end-year type mitigation targets imposing 20-40% reductions in 2030 and 40-80% reductions in 2050 compared to 1990 level as the base; (2) Quantified Emission Limitation of Reduction Commitment (QELRC) scenarios - a wide range of cumulative targets for 2021-28, ranging from -20% to +20% relative to 1990 level and, for each subsequent 8-year budget period, the targets are reduced for 10 percentage points; and (3) Baseline deviation scenarios - deviation compared to baseline emission level of -10% to -20% for 2020 , -15% to -30% for 2028 and -30% to -60% for 2050. In all mitigation scenarios, ever-increasing carbon price is introduced beyond 2020.

With this complex modeling, final energy consumption by different types of fuels, installed capacity of the power plants, production and import of electricity, primary energy supply, CO_2 emissions and total discounted costs (cumulative for the period 2011-2050), are all obtained for the baseline and for all mitigation scenarios. The comparative assessment of the mitigation scenarios based on cumulative emissions, the cumulative total costs of the system and the increment of the specific emission reduction costs, showed that the best scenario was the QELRC scenario with the medium level of ambition. This scenario was used as a basis for the development of the National Mitigation Action Plan.

The climate change mitigation analysis in this project (First Biennial Update Report on Climate Change - FBUR) is a continuation of the analysis carried out in the Third National Communication. Taking into consideration the developmental changes that happened in the interim period, first the baseline scenario was revised which reflects development without implementing mitigation measures, the so called **scenario without measures (WOM scenario).** This scenario shall be used as a reference scenario upon which the achieved emission reductions and the costs of mitigation will be determined.

Further on, with the application of an opposite approach, **the so called bottom-up approach**, starting from specific mitigation measures in different sectors[1], each measure has been modelled individually and its mitigation potential (achievable GHG reduction) and the specific reduction cost have been calculated. The measures are combined in the Marginal Abatement Cost curve, **MAC curve** from which the total mitigation potential is visible and information on economic aspects of mitigation can be obtained.

Next step is **prioritization** of mitigation measures, based on previously determined criteria[2] **with the participation of relevant stakeholders.** In this phase it will be determined (confirmed) which of the modelled measures have relatively high degree of certainty for implementation (those which have already been started/planned for near future, which are priority projects/polices in the sectoral strategic and planning documents or which are result of laws that have already been adopted or shall be adopted in future). Those are the so called existing measures which are an integral part of the first mitigation scenario - **WEM scenario –** with existing measures. The other measures are the so called additional measures and they are part of the second mitigation scenario – **scenario with additional measures - WAM scenario** which is created in order to gain insight to what limit you can go with the mitigation and at what cost. Indicative target for this scenario is the mitigation potential of the QELRC scenario from the Third National Communication with a medium level of ambition.

In summary, the analysis of climate change mitigation carried out within FBUR consists of the following:

- Revised baseline scenario in the key sectors (energy supply, buildings, transport) - **WOM scenario**
- Modelled **possible measures** in the energy supply, buildings and transport sectors as well as calculation of their mitigation potential (achievable GHG reduction) and the specific reduction cost **- Bottom-up modeling**
- **MAC curves** for 2020 and 2030, MAC curves based on cumulative reductions and costs for the period to 2020 and to 2030
- **Priority measures determined with the participation of stakeholders** in accordance with the previously **established criteria**
- **WEM** and **WAM** scenarios
- Conclusions on **the climate change mitigation potential, economical aspects of mitigation and level of ambition for national contributions** in the global efforts for GHG emissions reduction

[1] Duic N., Analyses and proposed actions for refining the mitigation scenarios developed within the Third National Communication Analysis and proposed activities for improving the climate change mitigation scenarios, developed for the Third national Communication on Climate Change, April 2014 (see Annex 2).

[2] Duic N., Criteria for prioritization of the proposed measures and actions from the climate change mitigation action plan, July 2014 (see Annex 3).

The WEM scenario measures shall be processed by the team for monitoring, reporting and verifying (MRV) of the mitigation policies and achievable emission reductions, which need to develop a conceptual framework and a roadmap for implementation of MRV.

The climate change mitigation analysis requires involvement of numerous associates/actors with specific responsibilities and tasks, cooperating among each other. The organization of the work of the main associates/ actors and the end results are schematically shown in Figure 1.

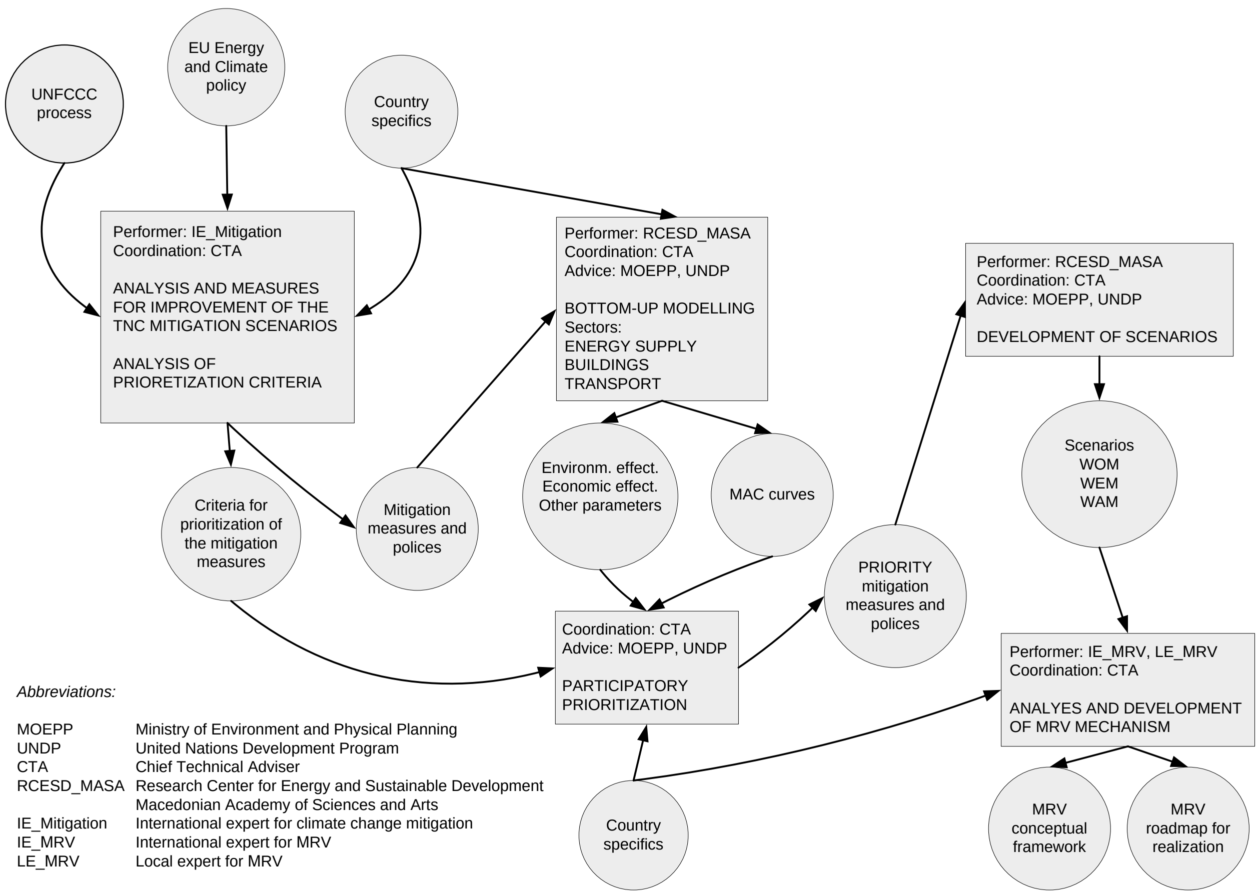

Figure 1. Workflow organization for the climate change mitigation

Besides the intensive analytical work, the mitigation analysis also includes an approach based on participation of several key stakeholders, especially for evaluation and prioritization of the measures given in the mitigation Action Plan, as well as for capacity building and knowledge transfer, implemented by a key technical advisor and international mitigation expert.

At the end it should be underlined that the results from this analysis are indicative and should be used in establishing/defining national contributions in the global GHG emission reductions (UNFCCC process). Besides this, having in mind that WOM, WEM and WAM scenarios are the main element of reporting for the national mitigation efforts of EU member countries, these activities also contribute to capacity building, both analytical capacities and the capacities of policy makers and all stakeholders to respond to the European requirements in this area.

2 SCENARIO WITHOUT MEASURES (WOM SCENARIO)

In order to assess the impact of different measures and policies, the first step is to develop a scenario without measures (WOM scenario) for the whole period of analysis, 2015-2035. In the scenario without measures the main features of the energy system in the Republic of Macedonia have been considered, such as the existing technologies, the available domestic resources and the possibilities for importing various fuels. Also, specific policies which are currently being implemented or have just been implemented were taken into consideration.

The scenario without measures was developed in line with the baseline scenario developed for the new Energy Development Strategy 2015-2035. Taking this into consideration, this scenario contains **specific assumptions on the energy supply side**:

- Use of domestic resources:
    - No new hydro power plants will be built because the investors are not interested and/or there is a resistance of the NGOs and the local population.
    - The capacity of the power plants with feed-in tariffs is limited to the capacity for which at least a decision for temporary preferential producer is issued by the Energy Regulatory Commission of the Republic of Macedonia. This capacity is 65.4 MW for small hydro power plants, 50 MW for wind power plants, 18 MW for solar power plants and 7 for biogas power plants.
- Supply technologies:
    - After revitalization, the TPP Oslomej is planned to work on imported high-quality coal.
    - A nuclear power plant shall not be built in the analyzed period.
- Energy imports:
    - An interconnection to a new gas pipe line is not considered (taking into account the current situation in the region), which means that there is only the capacity of the existing gas pipe line available.
    - The price of imported electricity is the price at the electricity market and in the following three years it is projected to be about 50 €/MWh[3], while in the period

[3] Taken from the Hungarian Power Exchange - HUPX (https://www.hupx.hu/en/Pages/hupx.aspx?remsession=1)

after it is projected to increase to 90 €/MWh[4], which gives this model a regional component.

On the demand side it is assumed that all the new technologies shall have the same efficiency as the existing ones, but there is a possibility for the model to switch from one technology, using one type of fuel to another with a different type of fuel.

Compared to the baseline scenario in the Energy Development Strategy, the only difference in the scenario without measures is the electricity part, because in this study specific measures which are already included in the scenarios in the Strategy are modeled, such as the measure for electricity import (market).

2.1 ENERGY DEMAND

In the MARKAL Model the energy demand was analyzed in five sectors: residential, industry, commercial and services sector, transport and agriculture. Each of these sectors is further divided into subsectors. Hence, the residential sector is divided into apartments, urban houses and rural houses; the industry sector is divided into iron and steel industry, non-ferrous metallurgy, chemical industry, ore exploitation industry, food industry, paper and printing industry and other industries. The commercial and services sector is divided to large and small facilities considering the floor area, while transport is divided into road transport (cars, buses, freight vehicles and motorcycles), rail transport and air transport. The only sector which is not divided into subsectors is agriculture, because it has a relatively low energy demand.

For each of the subsectors the final useful energy demand was defined, as for example for heating and hot water, cooling, cooking, lighting, energy for refrigerators and deep freezers and other energy needs in the residential and in the commercial and service sector. The energy demand for providing high temperature, low temperature and mechanical processes in the industry have also been taken into consideration, as well as road passenger (p) km and ton (t) km in transport.

Main drivers in projecting future energy demand in each of these sectors were GDP with an average annual rate of 4.9% (for the period 2012 -2035) (Figure 2) and population growth with an average annual rate of -0.09%[5].

[4] Own assumption

[5] World Bank, Macedonia Green Growth Study, 2014

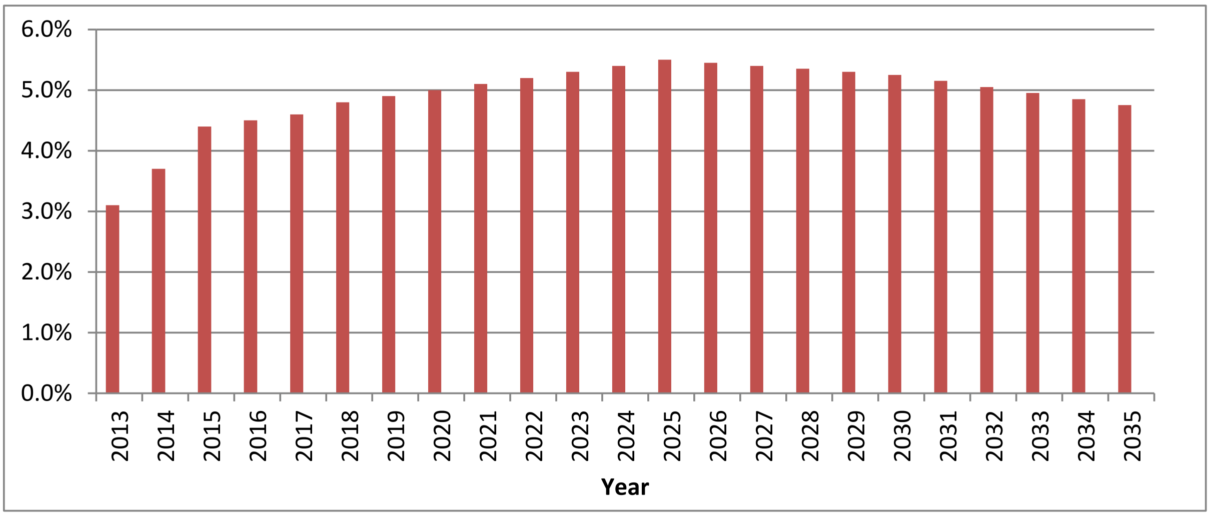

Figure 2. Annual GDP growth

Having in mind the GDP and population growth, it is evident that in the WOM scenario the energy demand in the residential sector shall grow with an average annual rate of 2.5%, in the commercial and service sector with 4.2%, in the industry with 2.7% and in agriculture with 2.8 % which in absolute numbers will be growth in the final energy demand from 46 PJ in 2013 to about 87 PJ in 2035 (Figure 3). In the transport sector there is an annual growth of the demand of 4.7% for road transport, or from 6,300 pkm in 2013 to about 17,800 pkm in 2035. In the freight transport the annual growth is 4.8%, that is from 6,500 tkm in 2013 to about 18,560 tkm in 2035 (Figure 4).

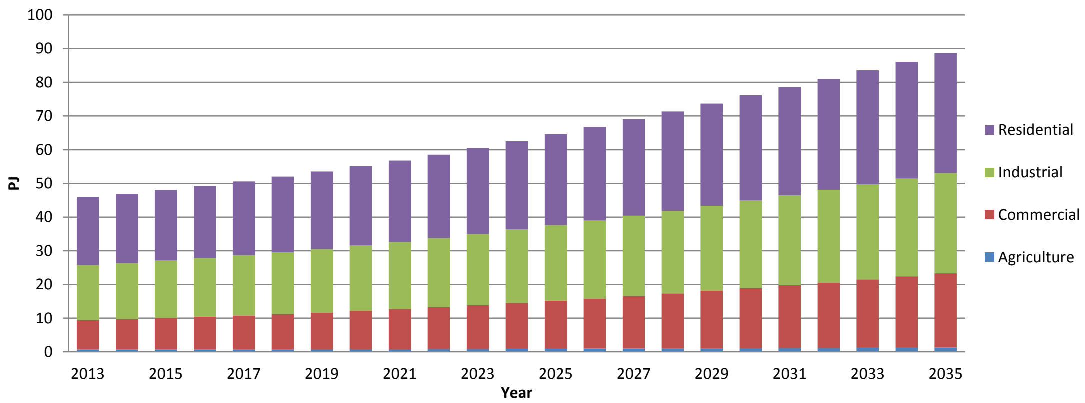

Figure 3. Energy demand growth in the residential, industry, commercial and service and agricultural sector in the WOM scenario

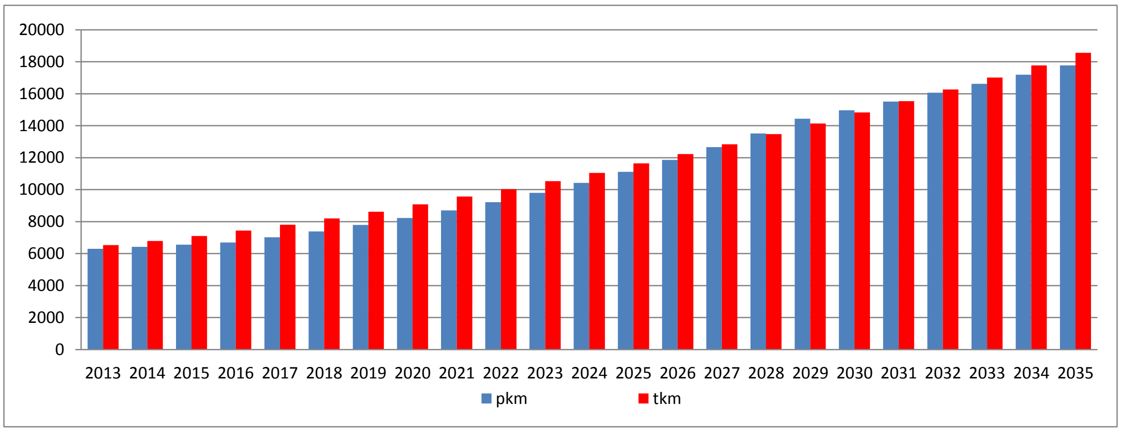

Figure 4. Growth of travel demand (in pkm) and freight transport (in tkm) in the WOM scenario

In order to cover the variations in the electricity demand in different seasons, in the MARKAL model nine specific periods which cover daily, night and peak consumption of electricity in the three periods of the year (winter, summer and spring-autumn) were analyzed. In order to distribute the electricity demand over the specific periods, one of the key issues is the load curve, which in the MARKAL model was entered for 2012, and it is shown on Figure 5.

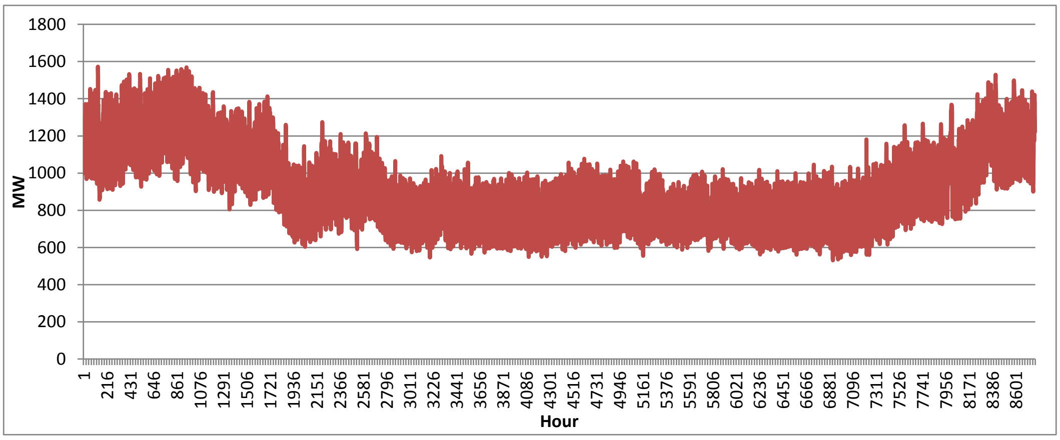

Figure 5. Electricity load profile[6]

2.1.1 Final energy consumption

By using the technologies available in the model on the demand side, the MARKAL model decides how to satisfy the end-use energy demand at lowest costs, thus presenting the final energy consumption.

In the scenario without measures, the final energy grows for 97% or from 1,767 ktoe in 2012 it increases to 3,496 ktoe in 2035 (average annual growth of 3%), (Figure 6). As it can be seen, the most dominant fuels are electricity and diesel fuel which grow for 100% and 145% (average annual growth of 3%, 4%), respectively. The highest growth is evident in gas consumption from 22 ktoe in 2012 to 127 ktoe in 2035. Specific growth is also evident in the final consumption of other fuels, but at lower percentage.

[6] MEPSO hourly data - http://www.mepso.com.mk/ListanjeIzveshtai.aspx?categoryID=113

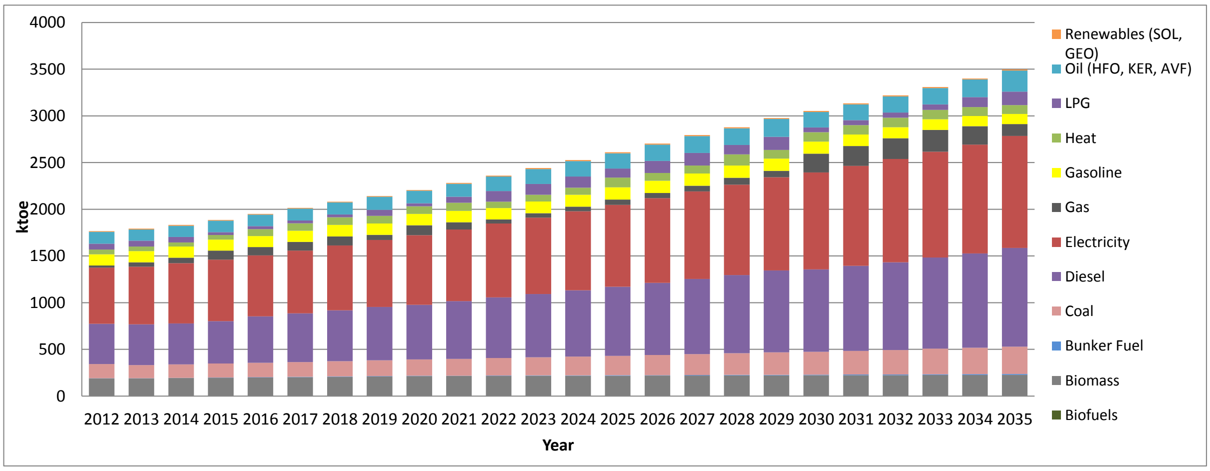

Figure 6. Final energy consumption by fuels by 2035 according to the WOM scenario

Regarding the final energy consumption in different sectors (Figure 7) the highest growth is evident in the transport sector, of 126% (annual growth of 3.6%), followed by commercial and services sector with overall growth of 115% (annual growth of 3.4%), industry sector with 84% (annual growth of 2.7%) and last is the residential sector with a growth of 82% (annual growth of 2.6%).

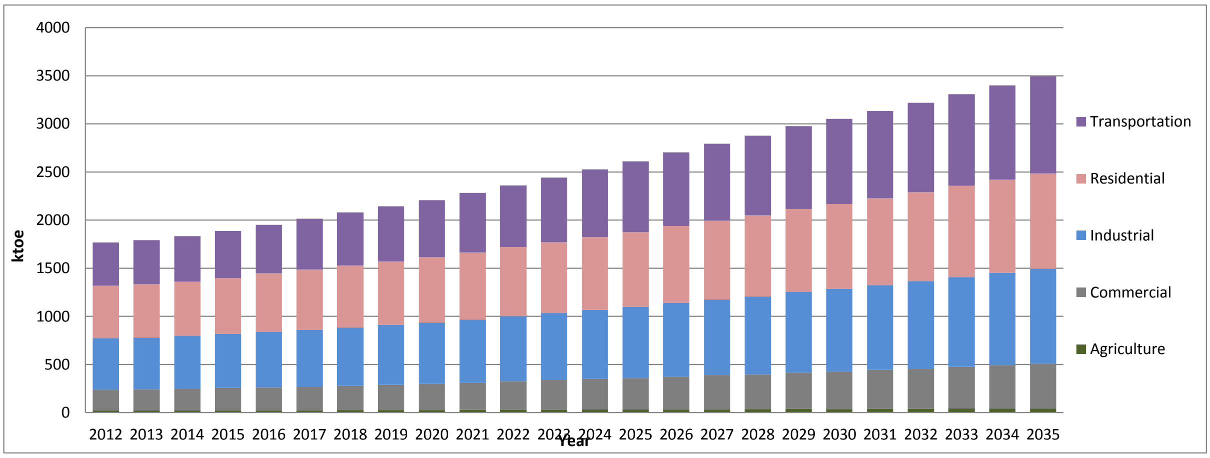

Figure 7. Final energy consumption by sectors according the WOM scenario

2.2 ENERGY SUPPLY

2.2.1 Electricity

In the scenario without measures the electricity demand will be satisfied mainly from domestic power plants, existing and new ones, and only small part will be imported. During this period, most of the electricity shall be generated by coal power plants (reaching 75% in 2035), than gas power plants (15%) and hydro power plants (10%), thus reducing the net imports to a minimum even in 2015 and completely avoiding it after 2030 (Figure 8). The electricity demand in this scenario will increase by 100%.

The electricity generation from coal, as the most cost-efficient option will increase from 4,325 GWh in 2012 to 11,977 GWh in 2035 (with an average annual growth of 4.5%). There will be high increase in the generation of gas power plants and gas combined heat and power (CHP) plants, which shall increase from 280 GWh in 2012 to 2,724 GWh in 2035, and the hydro power plants production shall increase from 1,041 GWh in 2012 (a year with relatively low hydrology) to 1,613 GWh in 2035 at average hydrology.

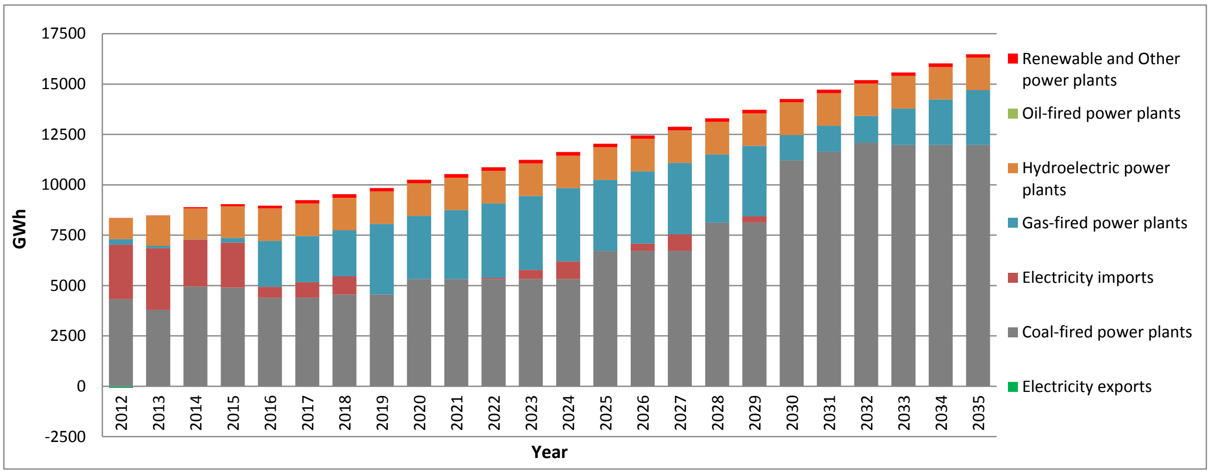

Figure 8. Production, import and export of electricity in the WOM scenario

In order to satisfy the growing electricity demand, besides the existing power plants, it is necessary to construct new power plants which should be as follows:

- Coal TPPs 2,359 MW (including the overhauled TPPs Bitola and Oslomej[7], two new TPPs of 600 MW each using imported coal, and two new TPPs of 200 MW each using domestic coal),
- Gas TPPs of 700 MW
- Hydro power plants of 92 MW (including HPP Sv. Petka which is already constructed and small hydro power plants with feed-in tariffs),
- Other renewable energy power plants of 71 MW (of which 50 MW are wind power plants, 14 MW are solar power plants and 7 MW are biogas plants).

That way, the total installed capacity shall increase for 73 %, that is from 1,836 MW in 2012 to 3,177 MW in 2035 (Figure 9). The highest increase is in the installed capacity of the thermal power plants and the gas CHP plants from 290 MW in 2012 to 700 MW in 2030 (or for 140%), then of coal TPPs from 743 MW in 2012 to 1,709 MW in 2035 (that is 130%), and of the hydro power plants from 601 MW in 2012 to 693 MW in 2035 (15%). Also, there is a significant increase in the nominal capacity of other renewable energy PP, which in 2035 shall provide for 75 MW compared to 4 MW in 2012.

[7] The shutdown of old TPPs has been modeled and the revitalized ones were introduced as new TPPs.

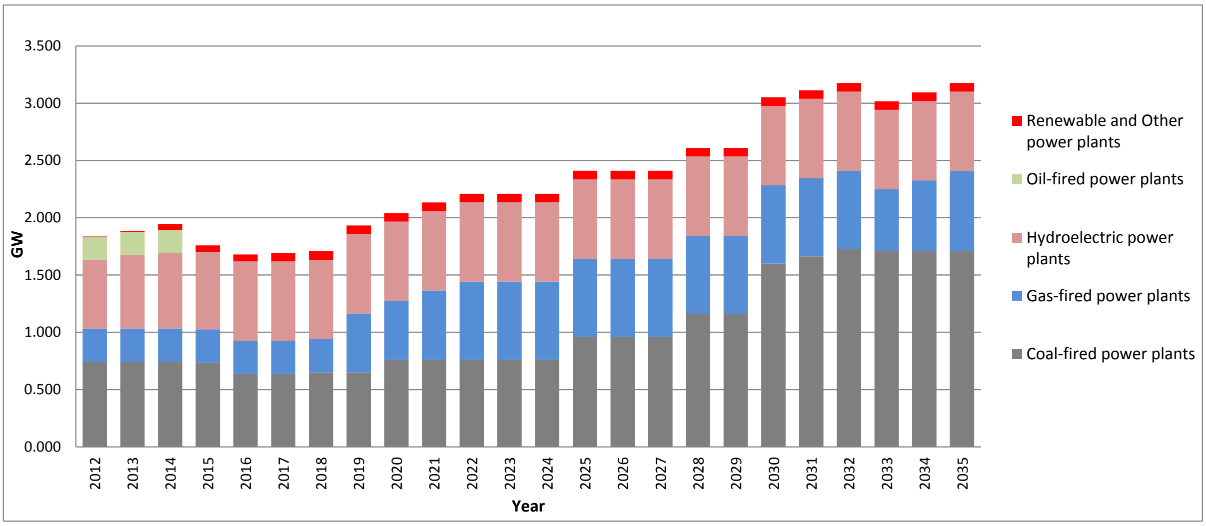

Figure 9. Total installed capacity of power plants in the WOM scenario

2.2.2 Primary energy

The primary energy demand, which consist of the energy demand for energy transformation and for the final energy consumption, will increase for 96% (annual growth of 3%) or in absolute numbers from 2,777 ktoe in 2012 to 5,430 ktoe in 2035 (Figure 10).

In order to satisfy primary energy demand, besides the domestic resources, a large part of the fuels will be imported. So, a growth in coal import is evident as a result of the fact that TPP Oslomej shall start using imported coal and new TPPs of 600 MW also using imported coal will be opened. The import of gas shall increase for 7 times, and the import of crude oil and oil derivatives shall increase for almost 50%. Concerning the domestic resources, a higher utilization of renewable energy sources can be noticed (for 67%), biomass (for 20%) and geothermal energy (for 15%).

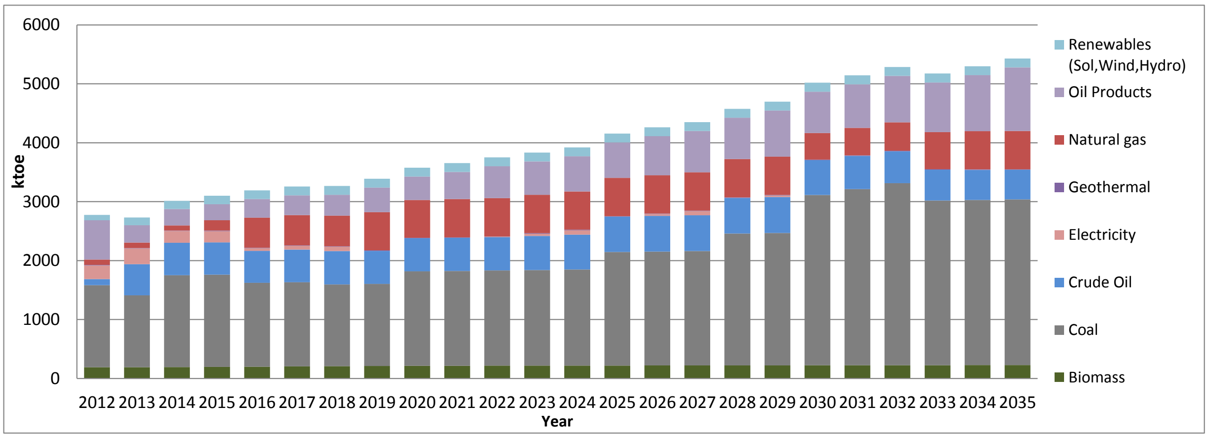

Figure 10. Primary energy needs according to the scenario without measures

2.3 GREENHOUSE GAS EMISSIONS

The total GHG emissions shall increase from 9,030 kt in 2012 to 18,340 kt in 2035, or by 100% (Figure 11). With the commissioning of the new coal TPPs in the period from 2028 to 2032 the highest growth of the emissions can be seen. During this period of time, the most dominant will be emissions from the power sector (60% to 70%), but the highest growth of GHG emissions shall be present in the commercial and sector with an average annual growth of 4.2%, followed by the transport sector with 3.7% and the residential sector with 3.2%

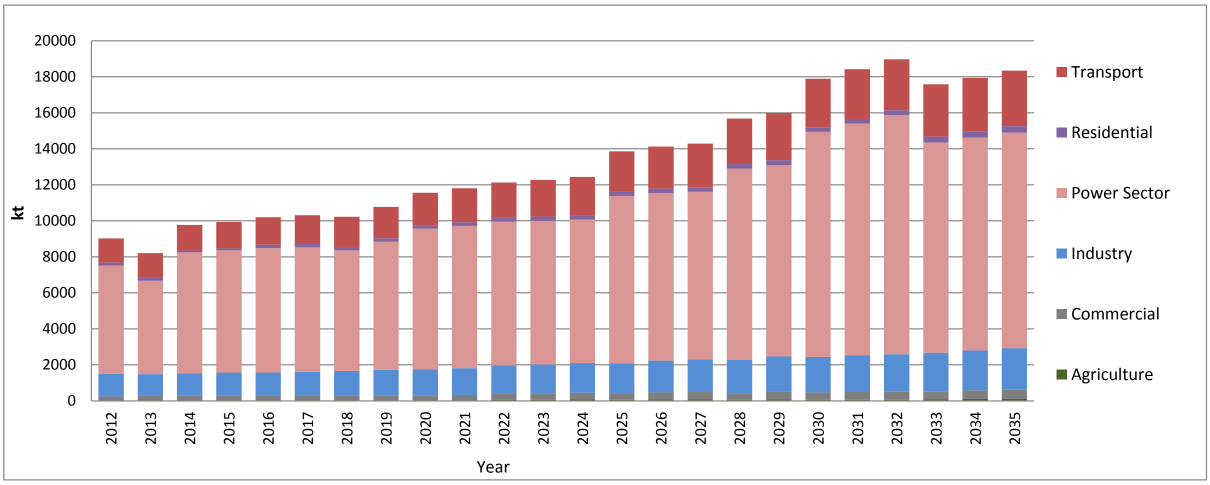

Figure 11. GHG emissions in the WOM scenario

2.4 ENERGY SYSTEM COSTS

The total energy system costs in the Republic of Macedonia are estimated to 43,729 M€ (discounted with a discount rate of 7.5% and expressed in 2012 €).

Compared to 2012 the energy system costs shall increase with an average annual rate of 6.2% (or in total for 279%). The highest growth is evident in the investments on the supply side (for electricity generation), from 11 M€ in 2013 to 521 M€ in 2035 (or an average annual increase of 19.5%). On the demand side there is also a significant increase in investments in new devices which in 2035 reach even 2,173 2012M€.

3 BOTTOM-UP MODELING OF POSSIBLE MITIGATION MEASURES

The identified portfolio of mitigation measures (Annex 2) was analyzed from the point of view of applicability in Macedonian conditions and only measures which, in Macedonian conditions, already have been initiated or assessed to be with relatively high potential for implementation have been selected for the bottom-up modeling exercise.

3.1 ENERGY DEMAND

3.1.1 Buildings

3.1.1.1 Labeling of appliances

The Rulebook on labelling and standard product information of the consumption of energy and other resources by energy-related products (Official Gazette of the Republic of Macedonia No. 154/2011 and 146/2012) was adopted in 2011, and it was amended in 2012. The implementation of this Rulebook gives an opportunity to the consumers to choose more energy efficient appliances.

By labeling appliances, the citizens shall be better informed about their performance and about their energy consumption. At the same time, in recent years, on the market higher energy class appliances (class A, B, C) are present, so it is expected lower class appliances which are still used in the residential and commercial sectors to be gradually replaced with new ones, which shall enable better energy use and reduction of energy demand.

In this analysis, mainly the residential, but also commercial and service sector have been covered.

Taking into consideration that higher class appliances are already available on the market, in the analysis it was assumed that by the end of the analyzed period the number of higher energy class appliances in households will be increased to 50%, and in the commercial sector the share of higher class hot water and lighting appliances would increase to 30%, and of heating and cooling appliances to 20%.

As a result of the increased use of more efficient devices, the yearly GHG emissions in 2020 shall decrease by 21 kt, and in 2030 by 142 kt. Cumulatively, the emissions shall decrease by 360 kt until 2020, or by 1,659 kt until 2030.

With the increased use of higher energy class devices, as a result of the reduced final energy consumption, the fuel costs shall decrease and at the same time due to lower consumption the investments in the energy sector shall also decrease. Compared to the WOM scenario, until 2020 the cumulative system costs shall decrease by 104 million Euros, and by 247 million Euros in 2030.

The specific reduction costs for 1 t CO_2 would be negative and would amount to 290 € in 2020 and 149 € in 2030 (Table 1).

Table 1. Economic and environmental assessment of the measure for labeling appliances

Labeling appliances	2020	2030	Cumulative 2020	Cumulative 2030
CO_2 (kt) reduction	21	142	360	1,659
Total cost difference (mil €)	-6	-12	-104	-247
Specific costs (€/t)	-268	-87	-290	-149

3.1.1.2 Public awareness campaigns, EE info centers

This measure (as one of the measures planned in the second EEAP) envisages introduction of awareness raising campaigns and opening of energy efficiency (EE) info centers, in order to increase the awareness and to inform the citizens of possibilities to improve EE and of related benefits. The awareness raising campaigns shall contain videos and printed materials which will make EE information more available to the citizens, and the info centers shall employ energy advisors who shall give free of charge advise to the citizens concerning possibilities of saving energy and related financial benefits.

The target group for this measure are the residential and the commercial sector, in which it is expected to have an increase in the use of more advanced appliances (for cooling, heating, sanitary hot water etc.), which would reduce energy consumption (in any form) in these sectors.

When modeling this measure it was assumed that it would be applied within a period of 5 years (2013-2017). This means that in this period of time investments shall be made in such awareness raising campaigns and in info centers, and it is assumed that about 400,000 Euros per year would be needed. Although this measure shall be applied in a period of five years, it is expected to have an extended effect, which means to have an increase in the use of more advanced and more efficient appliances even after 2017 as a result of the experience acquired and the good awareness of the citizens.

As a result of this measure the yearly CO_2 emissions would decrease by 1 kt in 2020 and by 32 kt in 2030, that is cumulatively by 300 kt until 2020 and by 967 kt until 2030.

Although specific investments are required for the implementation of this measure, as it can be seen in the table below (Table 2), the total costs shall be reduced as a result of the savings in the fuel costs, specifically for the fuel used by appliances in these sectors. The total savings by 2020 would be about 89 million Euros, and by 2030 they would reach 156 million Euros.

The specific reduction costs for 1 t CO_2 would be negative and would amount to 298 Euros until 2020, that is 161 Euros until 2030 (Table 2).

Table 2. Economic and environmental assessment for awareness campaigns and for the EE info centers

Awareness campaigns and EE info centers	2020	2030	Cumulative 2020	Cumulative 2030
CO_2 (kt) reduction	1	32	300	967
Total cost difference (mil €)	-2	-5	-89	-156
Specific costs (€/t)	-2,189	-164	-298	-161

3.1.1.3 Rulebook on energy performance of buildings

The Rulebook on energy performance of buildings, adopted in 2013 (Official Gazette of the Republic of Macedonia 94/2013), stipulates the minimum requirements for EE and the design and construction conditions for new buildings and retrofit building units. It also stipulates labeling new buildings and building units in accordance with their energy performance (energy certificates). Having in mind the provisions of this Rulebook, the following measures have been analyzed:

- Buildings retrofit in order to reduce heat loss,
- Energy performance certificates for buildings,

Target group are the residential buildings and buildings in the commercial and services sector. For the first measure an improvement of the building envelope is required, which covers improvement of outer walls insulation, roof and floors insulation as well as windows and doors. This will reduce heat loss in buildings. This measure, besides the existing buildings, shall be applied to the new buildings as well and it is assumed that they are being built in accordance with the newly stipulated regulations for improved insulation.

The energy performance certificates of buildings provide information on energy consumption, mainly for cooling and heating purposes. As a result of this, the second measure assumes that citizens, knowing the energy performance of buildings, will commit to improving the energy class of the building by using more advanced technologies/appliances (more efficient ones) and will improve the insulation of buildings. Since these two measures are in some way complementary, in this analysis the impact of the two measures is shown together.

As a result of these measures, the yearly CO_2 emissions in 2020 shall decrease by 833 kt, and in 2030 by 2,343 kt. Cumulatively, the emissions shall decrease by 3,622 kt until 2020, and by 16,578 kt until 2030.

The reduction in the final energy demand, primarily for cooling and heating, shall reduce the fuel costs, as well as investments in the energy sector. Hence, compared to the WOM scenario, until 2020, the cumulative costs shall decrease by 394 million Euros, or by 1,223 million Euros until 2030.

The specific reduction costs for 1 t CO_2 would be negative and would amount to 109 Euros by 2020 and 74 Euros by 2030 (Table 3).

Table 3. Economic and environmental analysis of the measures contained in the Rulebook on energy performance of buildings

Rulebook on energy performance of buildings	2020	2030	Cumulative 2020	Cumulative 2030
CO_2 (kt) reduction	833	2,343	3,622	16,578
Total cost difference (mil €)	-68	-70	-394	-1,223
Specific costs (€/t)	-81	-30	-109	-74

3.1.1.4 Phasing out of incandescent light bulbs

A lot of countries around the world, including EU member countries[8], have adopted decisions to phase out the incandescent light bulbs from general use and to replace them with energy efficient lights. The rules that have been adopted forbid production, import and sales of this type of lights bulbs.

Following the example of these countries, with this measure it is assumed that as of 2016 the Republic of Macedonia would also introduce a ban on sales of incandescent lights, considering them to be inefficient. Also, it is assumed that the phasing out period will be 1 to 2 years, and after this period of time only efficient lights will be used (CFL, LED).

By applying this measure, compared to the WOM scenario, the consumption of electricity for lighting would be reduced, and as a result yearly CO_2 emissions would decrease by 66 kt in 2020 and by 153 kt in 2030, and cumulatively by 361 kt until 2020 and by 1,864 kt in 2030.

At the same time, the introduction of this measure shall reduce the total system costs cumulatively by 98 million Euros until 2020 and by 277 million Euros until 2030.

The specific reduction costs for 1 t CO_2 would also be negative and would amount to 273 Euros until 2020 and 149 Euros by 2030 (Table 4).

Table 4. Economic and environmental analysis of the measure for phasing out incandescent lights

Phasing out incandescent lights	2020	2030	Cumulative 2020	Cumulative 2030
CO_2 (kt) reduction	66	153	361	1,864
Total cost difference (mil €)	-13	-12	-98	-277
Specific costs (€/t)	-193	-78	-273	-149

[8] REGULATION (EU) C(2012)4641/F1 of 12.7.2012 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of electrical lamps and luminaires (http://ec.europa.eu/transparency/regdoc/rep/3/2012/EN/3-2012-4641-EN-F1-1.Pdf)

3.1.1.5 Phasing out of resistive heating devices

This measure assumes that as of 2017 the Republic of Macedonia shall introduce a ban on selling heating devices with resistive heaters, such as electric heat stove, electric heaters etc. which are used in the households. It is assumed that the phasing out period for these technologies shall be 10 years, taking into consideration the fact that a large number of households still use these type of devices and their life expectancy is longer compared to the incandescent lights.

As a result, the consumption of electricity used for heating shall be reduced and compared with the WOM scenario, the yearly CO_2 emissions would be reduced by 55 kt in 2020 and by 401 kt in 2030, which means that cumulatively they will be reduced by 154 kt until 2020 and by 2,594 kt until 2030.

With this the total system costs cumulatively shall be reduced by 50 million Euros until 2020, that is by 270 million Euros until 2030.

The specific reduction costs for 1 t CO_2 once again would be negative and would amount to 322 Euros by 2020, that is 104 Euros by 2030 (Table 5).

Table 5. Economic and environmental assessment of phasing out of resistive heating devices

Phasing out of resistive heating devices	2020	2030	Cumulatively 2020	Cumulatively 2030
CO_2 (kt) reduction	55	401	154	2,594
Total cost difference (mil €)	-8	-17	-50	-270
Specific costs (€/t)	-152	-43	-322	-104

3.1.2 Transport

The transport sector, as the fastest growing sector and one of the sectors that most contribute to the increase of GHG emissions, is also subject to many CO_2 reduction measures. In order to reduce the GHG emissions, in this study numerous measures have been reviewed and they are explained below.

3.1.2.1 Increased use of railway

In order to improve the use of the railway, the Government of the Republic of Macedonia with the assistance of the European Bank for Reconstruction and Development ordered 150 freight cars. The investment costs is estimated to about 13 M€, and this would significantly improve the freight transport. On the other hand, the Government also ordered six compositions consisting of a locomotive and passenger wagons, each of them providing transport for 1200 passengers and this investment is assessed to be in the range of 24 M€. These investments should contribute to increased use of the railway which would ultimately lead to higher number of passengers and transport of goods. This measure was analyzed in order to see the effect of these investments on CO_2 emissions reductions.

It was assumed that part of the people that currently use individual cars for travel would use the railway in the future. If in 2012 the number of mpkm (million passenger km) was 99, and in 2011 145 mpkm, first it was assumed that the railway will meet the level of 2011, and that it would increase until it reaches 270 mpkm at the end of the analyzed period. This increase above all is a result of attracting people that use individual cars for longer distances travel to use the railway, or in average it would be 0.1% per year. Also, there will be people who would decide to use trains instead of buses, so until the end of the period it is assumed that 11 mpkm would change their travel habits and would decide to use a train instead of bus.

Concerning transport of goods, there is also a significant decrease, having in mind that in 2007 there were 778 mtkm (million ton km), while in 2012 this number is almost reduced by half and amounts to 423 mtkm. It is assumed that by the end of the analyzed period, tkms in the railway transport would increase to about 1000 mtkm, and the tkm in the freight transport with trucks would be reduced for the same amount.

According to these data, it can be seen that the cumulative reduction of CO_2 emissions by 2030 are 525 kt, while the costs compared to the reference scenario are reduced for 113 M€ (Table 6). This measure has a negative specific cost of 214 €/t.

Table 6. Economic and environmental assessment of increased use of railway

Increased use of railway	2020	2030	Cumulative 2020	Cumulative 2030
CO_2 (kt) reduction	26	56	96	525
Total cost difference (mil €)	-7	-9	-30	-113
Specific costs (€/t)	-275	-162	-310	-214

3.1.2.2 Extension of railway to Bulgaria

The increase in the number of trains only, is not sufficient for increased use of the railway, so it is necessary to have connections with the neighboring countries. Therefore, the possibility for extending the railway to Bulgaria was analyzed, which traditionally is one of the biggest trading partners of the Republic of Macedonia. According to the data from the State Statistical Office in 2005 about 875 kt of goods were transported of which 190 kt were exported and 675 kt were imported. If it is assumed that half of these goods were transported with Macedonian trucks, and that each truck travelled 400 km in average, it means that they all have travelled 175 mtkm in total. By the extension of the railway it is assumed that half of this trading exchange would be carried out by rail and that would increase over time. The extension of the railway to Bulgaria according to the projections of the Government would require an investment of 600 M€ and should be finished by 2022.

Taking into consideration that the implementation of this measure will start after 2020, the comparisons with the WOM scenario were made only for 2030 and cumulatively until 2030. The cumulative savings of CO_2 emissions in 2030 would be 229 kt, and the total costs are 56 M€ higher than those in the WOM scenario (Table 7). Consequently, the specific costs are 246 €/t, which makes this measure one of the costlier ones. However, it is important to underline that this measure would also generate many other benefits.

Table 7. Economic and environmental assessment of the extension of the railway to Bulgaria

Railway to Bulgaria	2030	Cumulative 2030
CO_2 (kt) reduction	27	229
Total costs difference (mil €)	4	56
Specific costs (€/t)	168	246

3.1.2.3 Increased use of bicycles, walking and introduction of parking policy

The introduction of appropriate parking policy would reduce the use of cars in the urban areas, and would increase the use of bicycles. Also, in this part it is assumed that people, especially in smaller towns where very often they use individual cars for shorter distances, they would start use bicycles more often or they would walk. Part of the population, which in the WOM scenario use cars for short distances (about 2 km) would use a bicycle or would walk. It is very difficult to generalize the investment in new bicycle trails or walking trails because it depends on the terrain on which it is being built. Also it is very complicated to determine how many people would use them. According to the data of the City of Skopje, for the construction of the trail of 7.5 km on the left side of the river Vardar, they spent about 22 million denars or 45,000 €/km. On the other hand in Dojran, for the construction of a trail of 2.6 km, 53 million Euros or 330,000 €/km have been spent. Because of this the construction of new trails was not analyzed but it was assumed that people would use the existing trails. This measure is mostly aimed at smaller towns where there is not much traffic, and where there is room for walking or cycling. So, only the investment in new bicycles was taken into consideration. From the pkms that use individual cars for short distances, it is assumed that 0.1% annually would start using a bicycle and 0.01% would start walking. According to this, it can be assessed that cumulative savings until 2030 will be 38 kt, and the marginal costs will be -647 €/t (Table 8). The high negative specific costs are a result of the small investment (bicycle) or no investment (walking), and with this measure people replace individual cars which require an investment and have maintenance and fuel costs.

Table 8. Economic and environmental analysis of the measure for Increased use of bicycles and walking

Cycling, walking	2020	2030	Cumulative 2020	Cumulative 2030
CO_2 (kt) reduction	2	5	6	38
Total cost difference (mil €)	-1	-2	-6	-24
Specific costs (€/t)	-702	-494	-910	-647

3.1.2.4 Renewal of the vehicle fleet

One of the EE measures in the transport sector is to replace the old vehicle fleet. In order to see the benefits of this measure, in the WOM scenario only the use of old vehicles (but not older than 8 years) was modelled. The introduction of this measure shall reduce the total discounted costs for the whole period by 217 M€. Analyzed by years, in 2020 the introduction of this measure also reduces the CO_2 emissions by 20 kt, while in 2030 by 140 kt (Table 9). The total costs in 2020 will be reduced by 2 M€, and in 2030 by 13 M€. The cumulative emissions will be reduced until 2020 by 240 kt, and in 2030 they are 1,345 kt, and the total discounted costs are reduced by 49 M€ until 2020 and by 217 M€ until 2030. According to this, the replacement of the old vehicle fleet during the whole period will have negative specific costs and until 2030 the costs shall amount to 161 €/t. This means that this measure is a "win-win" measure, because the emissions are reduced at negative costs, compared to the WOM scenario.

We should underline that the old vehicle fleet is renewed based on the lowest price, so the old vehicles are replaced with vehicles having internal combustion engines. These vehicles are cheaper compared to the others, such as hybrid vehicles, PHEV 10, PHEV 40, electrical vehicles etc.

Table 9. Economic and environmental assessment of the measure for renewing the vehicle fleet

Renewal of the vehicle fleet	2020	2030	Cumulative 2020	Cumulative 2030
CO_2 (kt) reduction	20	140	240	1,345
Total cost difference (mil €)	-2	-13	-49	-217
Specific costs (€/t)	-93	-93	-203	-161

3.1.2.5 Improving vehicle efficiency, tax exemption for hybrid and electric vehicles

For the previous measure (renewal of the vehicle fleet) the model selected vehicles with internal combustion engines. The other technologies available to the model have not been selected because the total costs are higher than those for internal combustion vehicles. The price of vehicles in this type of analysis depends on the realistic price on the market, but also on the discount rate. The discount rate can vary and it depends on whether people believe more in one or another technology. Although the total cost for maintenance and use of hybrid vehicles is slightly higher compared to the internal combustion vehicles, they are cheaper for persons who travel more than 20,000 km per year. However certain surveys show that people still do not trust these types of vehicles. As a result of this, these vehicles in the model have a higher discount rate (8%) compared to the internal combustion vehicles (6%), while electrical vehicles, PHEV 10 and PHEV 40 vehicles have 10% discount rate. Some of these vehicles have three times higher efficiency, however high investments costs are the ones which prevent their selection by the model. In this regard, an analysis was conducted concerning how the model selects a specific technology. By equalizing the discount rates (6%), that is by increasing the trust in this type of vehicles, the hybrid vehicles in the beginning of the analyzed period become more cost-effective compared to internal combustion vehicles. The future increase in efficiency of the internal combustion vehicles once again represses hybrid vehicles and makes them inefficient. In order to increase the attractiveness of these vehicles it is planned to exempt their owners from paying annual registration tax to an amount which is not higher than 100€ and at the same time it is assumed that the penetration of these vehicles may reach maximum 10% until 2035. This measure shall enable the penetration of HEV vehicles which together with the internal combustion vehicles contribute for the renewal of the car fleet.

The introduction of HEV vehicles causes additional reductions in the CO_2 emissions by 130 kt until 2030 in the measure for renewing the car fleet, or the total reduction is 1,476 kt (Table 10). The costs for introducing hybrid vehicles shall increase by 6 M€, and the marginal costs are 44 €/t, but seen in total, this measure still has negative costs of 145 €/t.

Table 10. Economic and environmental assessment of the measure for improving of vehicle efficiency and tax exemption

Improving vehicle efficiency, tax exemption	2020	2030	Cumulative 2020	Cumulative 2030
CO_2 (kt) reduction	24	158	257	1,476
Total cost difference (mil €)	-1	-13	-47	-213
Specific costs (€/t)	-56	-83	-184	-145

The introduction of subsidies for buying electrical vehicles was also analyzed. In some European states the Government subsidizes electrical vehicles and the subsidies amount to 5,000 € in Romania, Portugal and Iceland, 15,000 € in Amsterdam and 29,300 € in Denmark. In this case subsidies of 5,000€ were used but this intervention still did not make electrical vehicles efficient, so they were not taken into consideration.

Concerning PHEV 10 vehicles, it is necessary the Government to introduce annual subsidies in the amount of 450 Euros and this would make them investment worthy but only after 2030. According to this, these vehicles would still remain a luxury and would not penetrate much on the market, at least not in the Republic of Macedonia. From the above stated it can be concluded that the only technology which can realistically be subsidized in Macedonia in order to contribute to emission reduction, and which would not overburden the budget are the hybrid vehicles.

3.2 ENERGY SUPPLY

This part of the document, presents a detailed explanation of the GHG emissions reduction measures implemented in the energy sector, which generates the biggest share of GHG emissions in Macedonia. According to the Third National Communication on Climate Change, this sector contributes with 73% or in absolute numbers the emissions from this sector range from 8,500 to 9,000 kt CO_2-eq.

3.2.1 Electricity

3.2.1.1 Higher number of preferential producers

If the WOM scenario covered only those technologies with feed-in tariffs for which at least a decision for temporary preferential producer is issued by the Energy Regulatory Commission of the Republic of Macedonia, then this measure assumes the number of preferential producers to increase. The analysis was based on the decision of the Government which states that by 2016 maximum 50 MW wind PP can be subject to feed-in tariffs, by 2020 - 100 MW and by 2025 - 150 MW. Since the feed-in tariffs for PV, as established in the decision are exhausted, here it is assumed that additional 22 MW PV shall be subject to feed-in tariffs, and added to the 18 MW from the WOM scenario it will be total of 40 MW. The decision of the Government does not determine the total power for small hydropower plants, so it was assumed that additional 100 MW, to the existing 65 MW, shall be subject to feed-in tariffs. Here the possibility for 10 MW of small PP using geothermal energy was also analyzed.

The total costs for the scenario developed in this way, containing all technologies and same assumptions as the WOM scenario, but with additional technologies for feed in tariffs, cumulative and discounted for the period until 2035 amount to 43,437 M€. Compared to the WOM scenario, there is a cost reduction by 392 M€. This reduction, above all is due to the high price of gas in the WOM scenario. The introduction of additional technologies with feed-in tariffs, first replaces the gas PPs from the system because they have the most expensive production from the non-preferential producers on one hand, but on the other hand they are the most flexible ones which causes a very low number of working hours on annual level, thus making them inefficient.

The increase in the number of preferential producers brings a CO_2 emission reduction and compared to the WOM scenario in 2020 there is a reduction by 82 kt, and in 2030 by 214 kt (Table 11). The cumulative CO_2 emission reduction by 2020 amounts to 224 kt, and to 2,338 kt by 2030. With this measure a cost reduction of 3 M€ in 2020 can be achieved, 5 M€ in 2030 or cumulatively by 2020 19 M€, while by 2030 the reduction is 136 M€. The economic and environmental parameters show that this measure has negative specific costs, or that it is a “win-win” measure, which means that it reduces CO_2 emissions with negative costs. The cumulative specific costs until 2030 are -58 €/t

Table 11. Economic and environmental assessment of higher number of preferential producers

Higher number of preferential producers	2020	2030	Cumulative 2020	Cumulative 2030
CO_2 (kt) reduction	82	214	224	2,338
Total cost difference (mil €)	-3	-5	-19	-136
Specific costs (€/t)	-34	-23	-83	-58

3.2.1.2 Implementation of the Large Combustion Plants Directive

Implemented in the WOM scenario

3.2.1.3 Distribution losses reduction

According to information obtained from the World Bank team developing the Green Growth Study for the Republic of Macedonia, the losses in distribution of electricity in the Republic of Macedonia are about 17% and this percentage has been used in the WOM scenario. The same team provided the amounts of investments expected in the following 20 years by the distribution company in Macedonia, in order to reduce loss to 11%. Annual investments range from 25 to 30 M€. Taking into consideration this data, this measure shall contribute to CO_2 emissions reduction by 146 kt in 2020 and by 401 kt in 2030, Table 12. Cumulative emissions by 2020 shall be reduced by 448 kt and until 2030 by 3,261 kt. In the same period of time, the total system costs shall be reduced by 70 M€ and by 290 M€, cumulatively by 2020, 2030 respectively. The specific costs, just like for the previous measure are negative, which means that this measure is also a “win-win” measure. The cumulative specific costs until 2030 amount to -89 €/t.

Table 12. Economic and environmental assessment of distribution losses reduction

Distribution losses reduction	2020	2030	Cumulative 2020	Cumulative 2030
CO_2 (kt) reduction	146	401	448	3,261
Total cost difference (mil €)	-13	-12	-70	-290
Specific costs (€/t)	-90	-30	-156	-89

3.2.1.4 Electricity import (market)

If in the WOM scenario, the Republic of Macedonia is considered to be a closed system, or as a country which satisfies more than 95% of its electricity demand from its own capacities and it imports only a small portion of the electricity used, then this measure envisages electricity import. If the price of electricity on the market is lower than the price of electricity produced by domestic production capacities, then instead of domestic production the electricity will be imported.

As a result of introducing feed-in tariffs on European level, the price of electricity in the European market has significantly dropped and it is assumed that in the following several years, until 2020, it will stay on this relatively low level, after which a specific increase is expected. It is assumed that the imported energy will be of renewable sources because currently they are treated as priority source of energy, so consequently this will cause a GHG emission reduction.

It is necessary to underline that the introduction of this measure contributes for emissions reduction in other sectors as well. This reduction is a result of the lower electricity price and the use of certain electrical appliances becomes less expensive compared to others which use fuel with higher emission factor.

The introduction of electricity import, as a result of the lowered price, shall shutdown the gas PPs which are present in the WOM scenario. It should be noted that the price of natural gas should also be a market price, which currently is high for Macedonia, but it is assumed that in a period of 3 to 4 years the price of gas in Macedonia shall be reduced to the European market price.

The reduction of CO_2 emissions in 2020 is 1,005 kt. In 2030 due to the intensified operation of the coal PPs there will be a slight increase in the emissions and this takes place only in this year (Table 13). Cumulative emission reduction by 2030 is 12,024 kt, and the difference in the total cost is 344 M€. This measure is also a “win-win” measure, because emissions reduction are evident at negative costs. The cumulative costs by 2030 amount to -29 M€.

Table 13. Economic and environmental assessment of electricity import (market) measure

Electricity import (market)	2020	Cumulative 2020	Cumulative 2030
CO_2 (kt) reduction	1,005	4,655	12,024
Total cost difference (mil €)	-20	-125	-344
Specific costs (€/t)	-20	-27	-29

A sensitivity analysis was conducted in case the price of electricity stays on the current level of about 40-50 €/MWh. This shall cause the shutdown of existing coal power plants and no construction of new coal PPss which are projected in the WOM scenario. This will also cause significant reduction in the GHG emissions, because the coal PPs are the ones that emit most CO_2 emissions.

3.2.1.5 Introduction of CO_2 tax and electricity import (market)

As a result of 2003/87/EC Directive on emission trading in the EU, this measure stipulates introduction of CO_2 tax for electricity generated from fossil fuels. At the same time, it provides a possibility for the import of electricity, which means that the domestic production of fossil fuels shall be burdened with a CO_2 tax which shall increase the production price and if this price is higher than the electricity import price, than there will be import instead of domestic production of electricity. The CO_2 tax is set at 20 €/t in 2020, and then it is increased to 25 €/t in 2025 and to 30 €/t in 2030. At this price of CO_2 it is interesting that domestic coal PPs (on domestic and imported coal) can still operate and they are competitive on the market, and the commissioning of new PPs is postponed for two to three years. When there is no sufficient production of electricity by the domestic coal power plants it is supplemented by imported electricity or by domestic natural gas PPs, which at the specified CO_2 price in certain periods are even more competitive than the coal PPs.

This measure causes cumulative savings of CO_2 of 17,988 kt by 2030 and negative costs of 189 M€ although in a certain period of time there are positive costs, as in 2020 when the costs are 9 M€ (Table 14). The specific costs are far lower than in the previously analyzed measures, but are still negative and the cumulative costs by 2030 amount to -10 €/t.

Table 14. Economic and environmental assessment of the measure for introducing CO_2 tax + electricity import (market)

Electricity import (market) +CO_2	2020	2030	Cumulative 2020	Cumulative 2030
CO_2 (kt) reduction	1,370	2,358	3,945	17,988
Total cost difference (mil €)	9	-2	-37	-189
Specific costs (€/t)	7	-1	-9	-10

3.2.1.6 Increased utilization of renewable energy sources

The Renewable Energy Sources Directive (2009/28/EC), impose the introduction of a measure which will show how much the increased utilization of RES really contributes to emission reduction and how much would it cost. Besides the preferntial producers, large hydro PP (Boshkov Most, Lukovo Pole, Chebren, Galishte, Gradec and Veles) have also been included, as well as the second phase of revitalization of existing hydro power plants and revitalization of HPP Shpilje. Besides this, the construction of PV and wind PP without feed-in tariffs is possible. The roof-top PV systems have also been included.

The cumulative CO_2 emission reduction, if all above mentioned technologies are constructed, shall amount to 5,648 kt by 2030, while the costs are negative and they amount to 192 M€, and specific costs are - 34 €/t (Table 15).

Table 15. Economic and environmental assessment of the measure for increased utilization of RES

More RES + FT	2020	2030	Cumulative 2020	Cumulative 2030
CO_2 (kt) reduction	248	1,025	605	5,648
Total costs difference (mil €)	-6	-4	-39	-192
Specific costs (€/t)	-24	-4	-65	-34

3.2.2 Heat

3.2.2.1 Higher penetration of solar collectors

This measure plans for wider application of solar collectors. The WOM scenario assumes that solar collectors can provide for maximum 7% for satisfying the hot water demand in the analyzed period. Wider application of solar collectors means that their participation of 7% is to be increased to 30% during the analyzed period.

In 2020 and 2030 there is a very small increase in the electricity production which brings increase in the GHG emissions. Due to this reason Table 16 does not show the specific costs, but only cumulative emission reductions by 2030 which amount to 550 kt CO_2, while the specific costs are negative and amount to 165 €/t. This means that the introduction of solar collectors is a cost-effective option, however it is preferable to continue with the subsidizing policy because it was shown that this additionally increases national penetration, but it is recommended to subsidize more the socially vulnerable families.

Table 16. Economic and environmental assessment of the measure for wider application of solar collectors

Wider application of solar collectors	Cumulative 2030
CO_2 (kt) reduction	550
Total cost difference (mil €)	-91
Specific costs (€/t)	-165

3.2.3 Transport

3.2.3.1 10% Biofuels

Taking into consideration the Biofuels Directive (2003/30/EC) which stipulates that by 2020 there should be 10% participation of biofuels in the final energy consumption in the transport sector and the Renewable Energy Sources Directive (2009/28/EC), it was necessary to investigate how much biofuels can contribute to CO_2 emission reduction. In 2020 the final energy consumption in the transport sector will be 593 ktoe, which means that the consumption of biofuels will be 59 ktoe. This quantity of biofuels contributes to emissions reduction of 175 kt and at the same time, the costs compared to the WOM scenario are increased by 4 M€ (Table 17). This means that marginal costs are positive and amount to 21 M€. In the period by 2030 the cumulative CO_2 savings amount to 2,747 kt, and the total costs are increased by 29 M€ compared to the WOM scenario. The specific costs during the whole period are positive and amount to 11 €/t.

It is assumed that the percentage of biofuels by 2020 would change similarly to what is shown on Figure 12, starting in 2015 with 0.5%, 1.25% in 2016, reaching 10% in 2020, and after 2020 it is assumed that the participation of biofuels shall remain at 10%.

Table 17. Economic and environmental assessment of the measure for 10% biofuels

10% biofuels	2020	2030	Cumulative 2020	Cumulative 2030
CO_2 (kt) reduction	175	265	504	2,747
Total cost difference (mil €)	4	1	12	29
Specific costs (€/t)	21	4	24	11

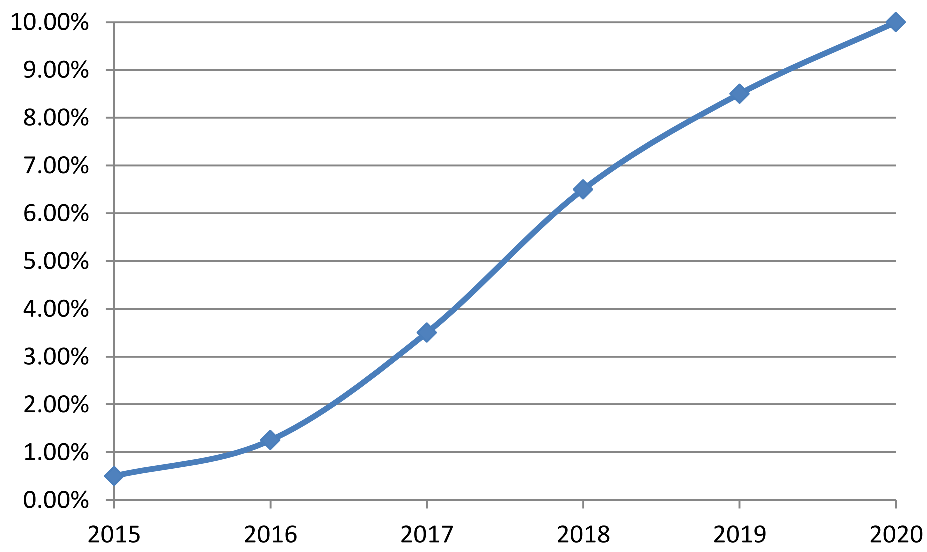

Figure 12. Participation of biofuels until 2020

3.2.3.2 Biofuels – delay until 2025

This measure plans for certain delay in the implementation of the Biofuels Directive, as a result of the financial implications of biofuels on the budget of the Republic of Macedonia. Because of the delay instead of having 10% biofuels in 2020, there is only 5%, and 10% in 2025. Also it is assumed that the participation of biofuels in 2016 shall be 0.5%. Just as with the previous measure, after 2025 the participation of biofuels shall remain at 10%.

With the assistance of this measure, in 2020 the CO_2 savings amount to 89 kt, while in 2030 they are 265kt (Table 18). The cumulative reductions by 2020 and 2030 are 211 kt, and 2,307 kt. The total cumulative costs have increased by 4 M€ in 2020, and by 19 M€ in 2030 compared to the WOM scenario. The specific costs throughout the whole period are positive, but in time they decrease, so cumulatively from 21 €/t in 2020, they decrease to 8 €/t in 2030.

Table 18. Economic and environmental assessment of the biofuels measure – voluntarily

Biofuels voluntarily	2020	2030	Cumulative 2020	Cumulative 2030
CO_2 (kt) reduction	89	265	211	2,307
Total cost difference (mil €)	1.6	1.0	4	19
Specific costs (€/t)	18	4	21	8

4 MARGINAL ABATEMENT COSTS CURVE (MAC CURVE)

From the results presented above, it is evident that highest savings in CO_2 emissions are achieved with the introduction of CO_2 tax and electricity import (market) of about 18,000 kt, while the lowest savings are achieved with the measure for more frequent use of bicycles, walking and introduction of parking policy, of about 38 kt (Figure 13). Besides this, high CO_2 savings are also achieved with the measures for increased utilization of RES (about 5,600 kt CO_2), electricity import (market) (about 12,000 kt CO_2) and the Rulebook on energy performance of buildings (about 16,000 kt CO_2). Each of the other measures generates CO_2 savings lower than 3,300 kt CO_2.

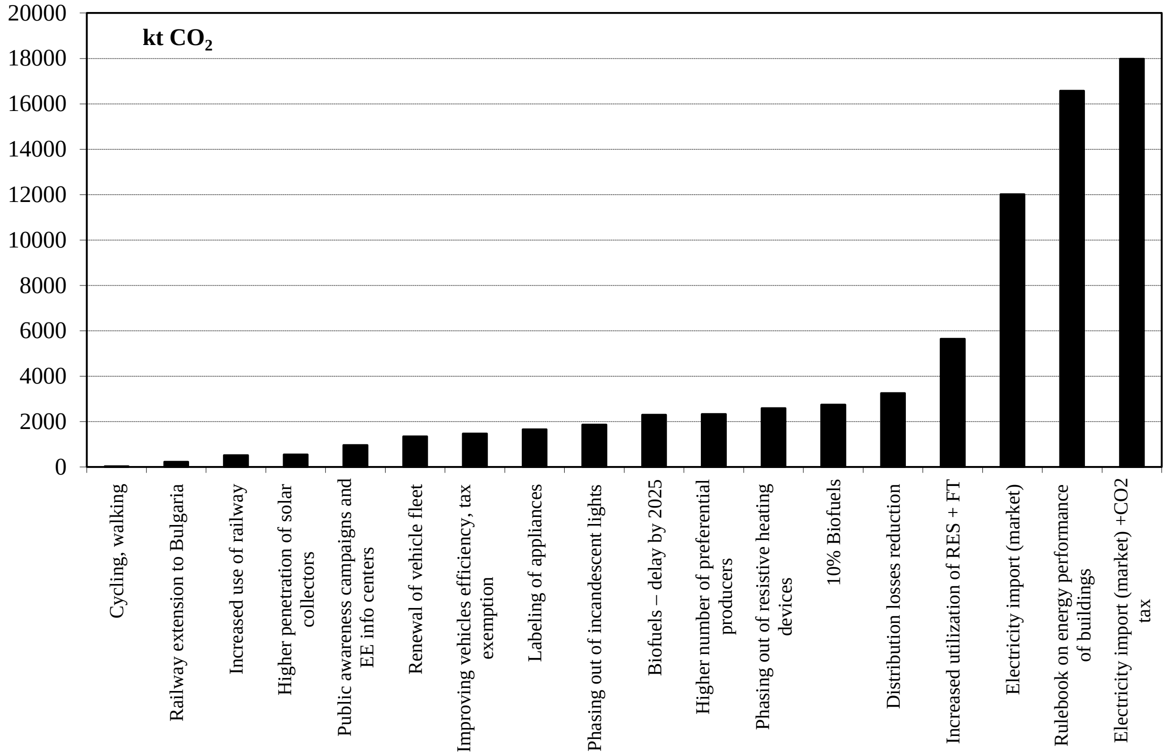

Figure 13. CO_2 emissions reduction, cumulatively by 2030 – aggregate results

In regard to the specific costs, out of 18 measures, 15 are “win-win” measures, which means that besides generating CO_2 savings, they also provide for financial benefits, which actually means that investing in them would reduce costs compared to the reference option. Increased use of bicycles, walking and introduction of parking policy has lowest specific costs (-647 €/t CO_2), followed by the measure for increased use of the railway (-214 €/t CO_2), higher penetration of solar collectors (-165 €/t CO_2), renewal of the vehicle fleet (-161 €/t CO_2) and awareness campaigns and EE info centers (-161 €/t CO_2) (Figure 14). The only measures with positive costs are the biofuels – delay until 2025 (8 €/t CO_2), 10% biofuels (11 €/t CO_2) and extension of railway to Bulgaria (246 €/t CO_2).

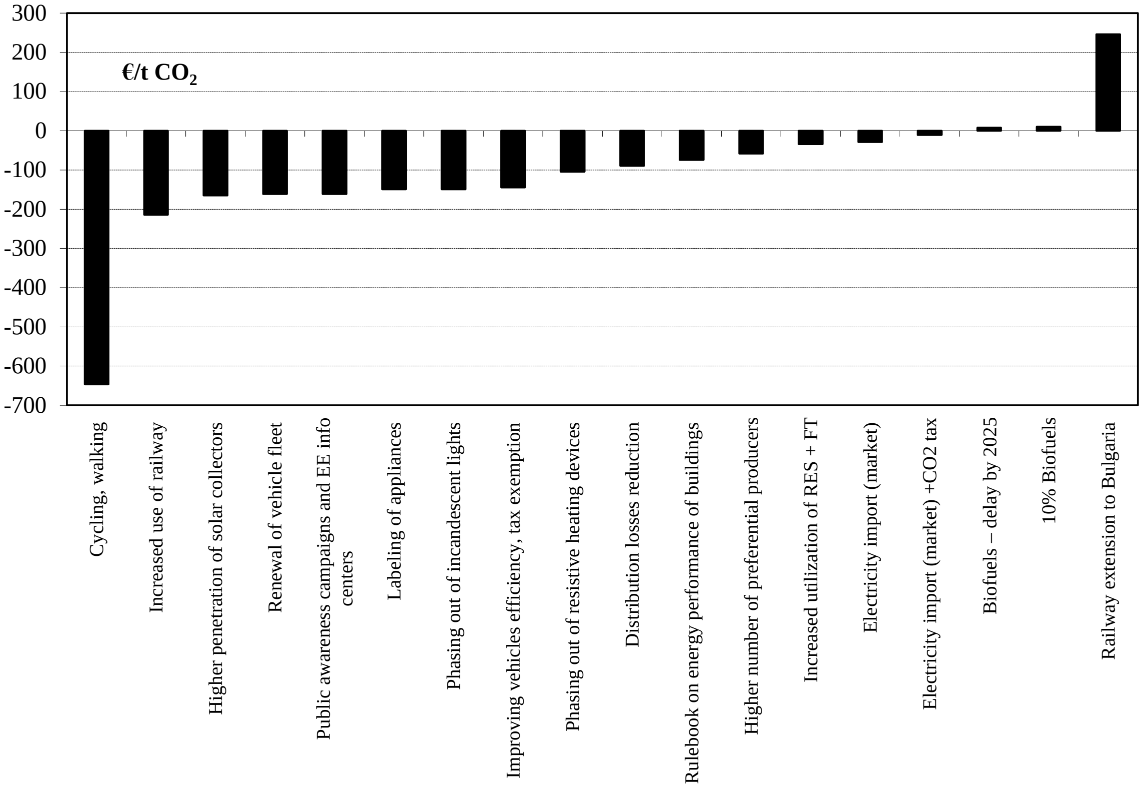

Figure 14. Specific costs cumulative by 2030 – aggregate results

The results obtained concerning specific costs and quantity of emissions saved for each of the measures may be presented visually on a curve called Marginal Abatement Cost Curve (MAC) (Figure 15). On this curve, the x-axis presents CO_2 emission reductions, while the y-axis presents specific costs. From this it is easy to see what measures achieve highest savings of CO_2 at what specific cost and whether a measure is a “win-win” measure. Besides this, this curve can also show the total quantity of emissions reduced, which in this case is 75 Mt. Of course one has to note that this curve is an indicative one, because there are some measures overlapping, such as electricity import and electricity import and introduction of CO_2 tax, so in a real situation the emission reduction of 75 Mt cannot be reached.

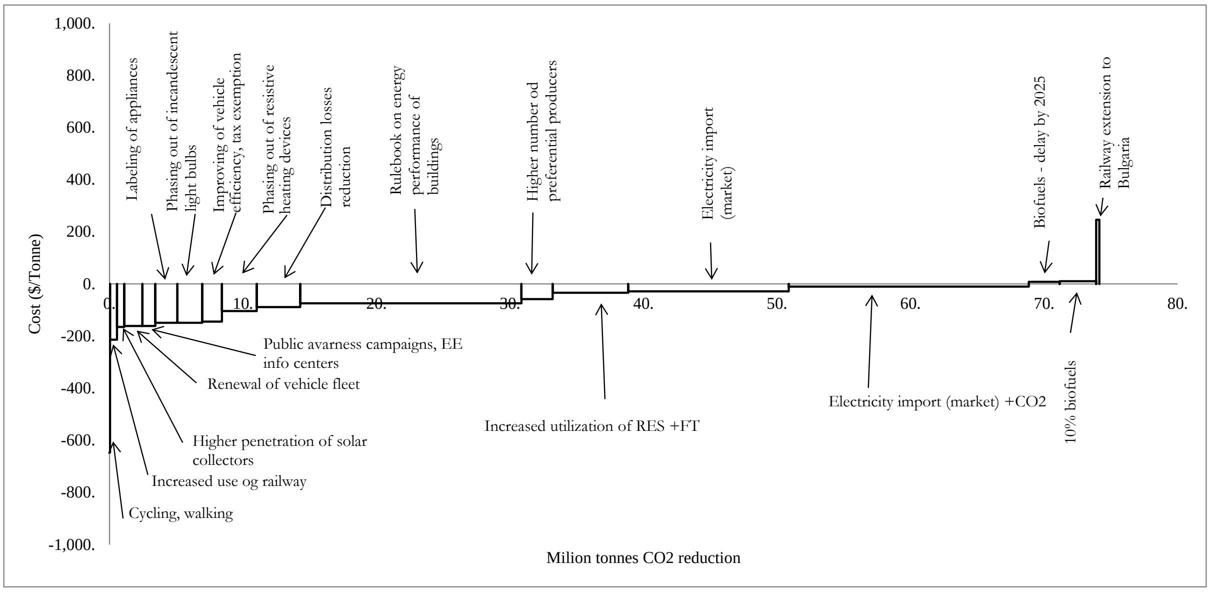

Figure 15. Marginal Abatement Costs Curve based on cumulative reductions and costs cumulatively for 2030

5 MITIGATION SCENARIOS

The measures created and explained above in the text, in this chapter are divided into two groups: measures with relatively high degree of certainty of implementation (their implementation has already started/ are planned for near future, are priority projects/policies in the sector strategic and planning documents or are a result of laws that are already adopted or shall be adopted in future), and other additional measures. The first group of measures are modelled in the scenario with existing measures or WEM scenario, while the second groups of measures (additional ones), are modelled in the scenario with additional measures of WAM scenario.

5.1 SCENARIO WITH EXISTING MEASURES (WEM SCENARIO)

In the WEM scenario, out of the 18 measures previously described 11 have been included and they are as follows:

1. Labeling of appliances
2. Public awareness campaigns and EE info centers
3. Rulebook on energy performance of buildings
4. Increased use of railway
5. Increased use of bicycles, walking and introduction of parking policy
6. Renewal of vehicle fleet
7. Distribution losses reduction
8. Electricity import (market)
9. Increased utilization of RES
10. Biofuels – delay by 2025
11. Higher penetration of solar collectors

With these measures it is possible to achieve maximum emission reduction of about 4,000 kt CO_2 in 2030 (Figure 16), which compared with the WOM scenario generates a reduction of 24% in that year. The highest emission reduction is achieved with the implementation of the Rulebook on energy performance of buildings, and this measure is followed by electricity import (market), increased utilization of RES and distribution losses reduction. The measure for import of electricity provides for highest savings in the period 2016-2023, however as the price of imported electricity grows the domestic production of electricity becomes more competitive which in the end results in a lower import and lower CO_2 emissions savings.

Cumulative CO_2 emission savings by 2020 are about 10,000 kt, and by 2030 they increase for more than four times and amount to 43,000 kt (Figure 17). Cumulative emissions, compared to the WOM scenario, decrease by 11% by 2020, while by 2030 they decrease by 18%. As it was already mentioned the highest reduction is achieved with the implementation of the Rulebook on energy performance of buildings which contributes with 35% in the total emission reduction, followed by the electricity import (market) with 28%, increased utilization of RES with 13% and distribution losses reduction with 7%.

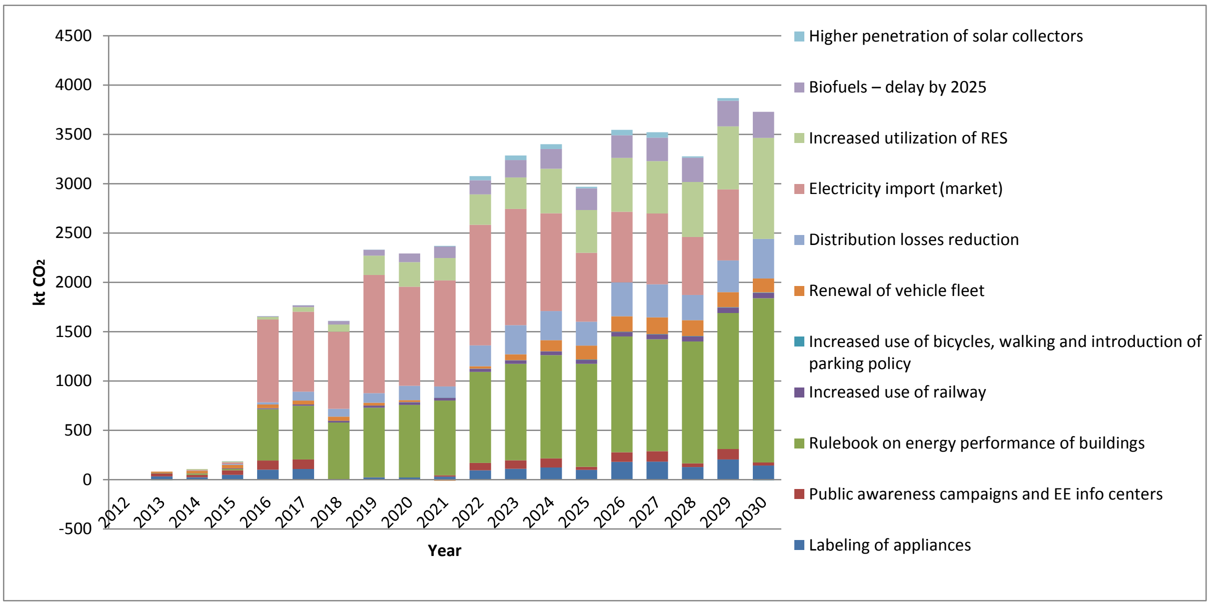

Figure 16. Annual emissions reduction in the WEM scenario

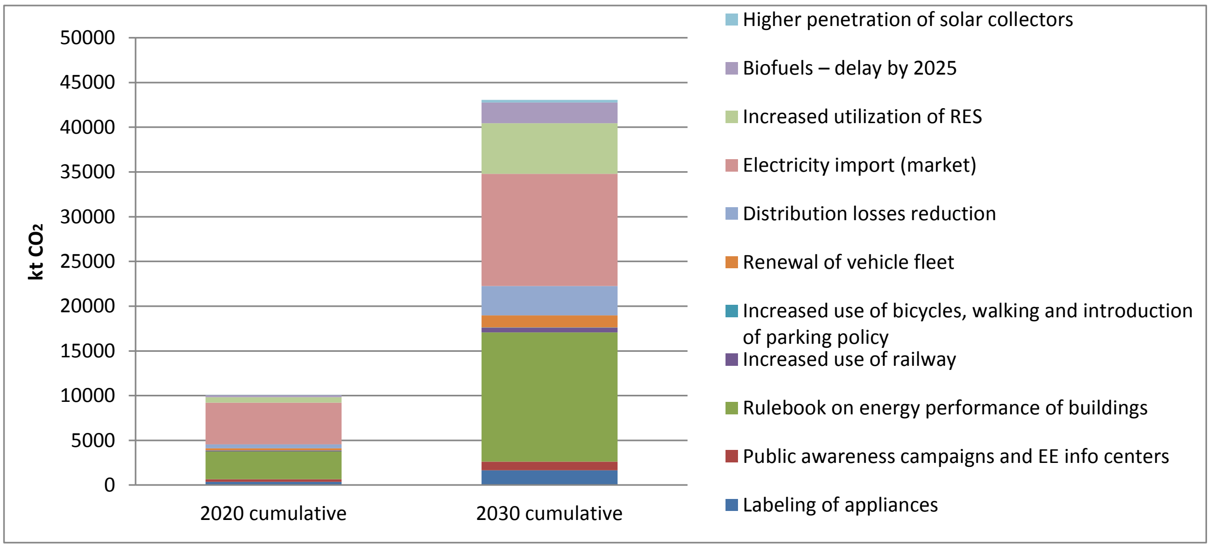

Figure 17. Cumulative savings by 2020 and 2030 in the WAM scenario

5.2 SCENARIO WITH ADDITIONAL MEASURES (WAM SCENARIO)

The scenario with additional measures includes 14 measures, which are as follows:

- **WEM measures**

1. Labeling of appliances
2. Public awareness campaigns and EE info centers
3. Rulebook on energy performance of buildings
4. Increased use of railway
5. Increased use of bicycles, walking and introduction of parking policy
6. Distribution losses reduction
7. Increased utilization of RES
8. Higher penetration of solar collectors

- **Improved WEM measures**

9. Improving vehicles efficiency, tax exemption for hybrid and electrical vehicles
10. Introduction of a CO_2 tax and electricity import (market)
11. 10% Biofuels

- **Additional measures**

12. Phasing out of incandescent lights
13. Phasing out of resistive heating devices
14. Railway extension to Bulgaria

With the assistance of these measures a maximum emission reduction of more than 7,000 kt in 2030 can be achieved (Figure 18), which compared to the WOM scenario presents a reduction of about 40%, in that year. Highest emission reduction can be achieved with the measure for introducing CO_2 tax and electricity import although there are high oscillations in the emission reduction caused by this measure, because they are mainly connected to higher production of gas PPs in the WOM scenario, or to the year when the new coal PPs will be built (domestic or imported).

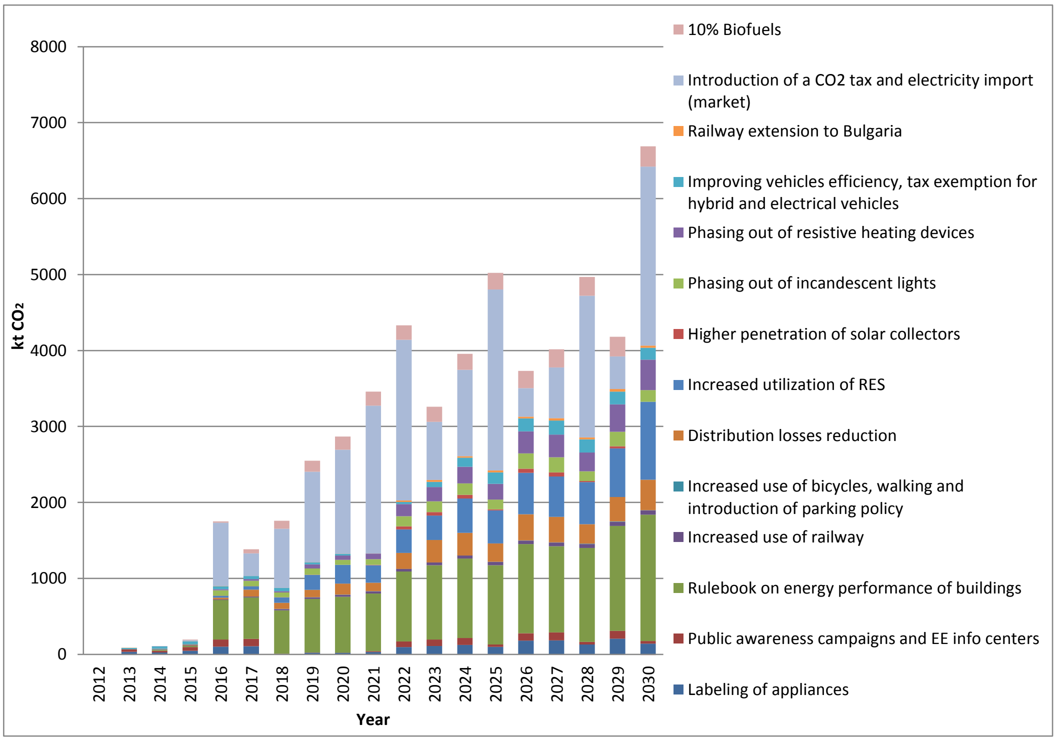

Figure 18. Annual emissions reduction in the WAM scenario

Cumulative CO_2 emissions savings until 2020 amount to about 11,000 kt, and by 2030 they increase for five times and amount to 55,000 kt (Figure 19). Cumulative emissions, compared to the WOM scenario, by 2020 shall decrease by 12%, while by 2030 they decrease approximately by 22%. The highest reduction is achieved by introducing CO_2 tax and electricity import (market) which generates 34%, and next is the Rulebook on Energy Performance of Buildings with 27%, higher participation of RES with 10% and decreasing losses in distribution with about 6%.

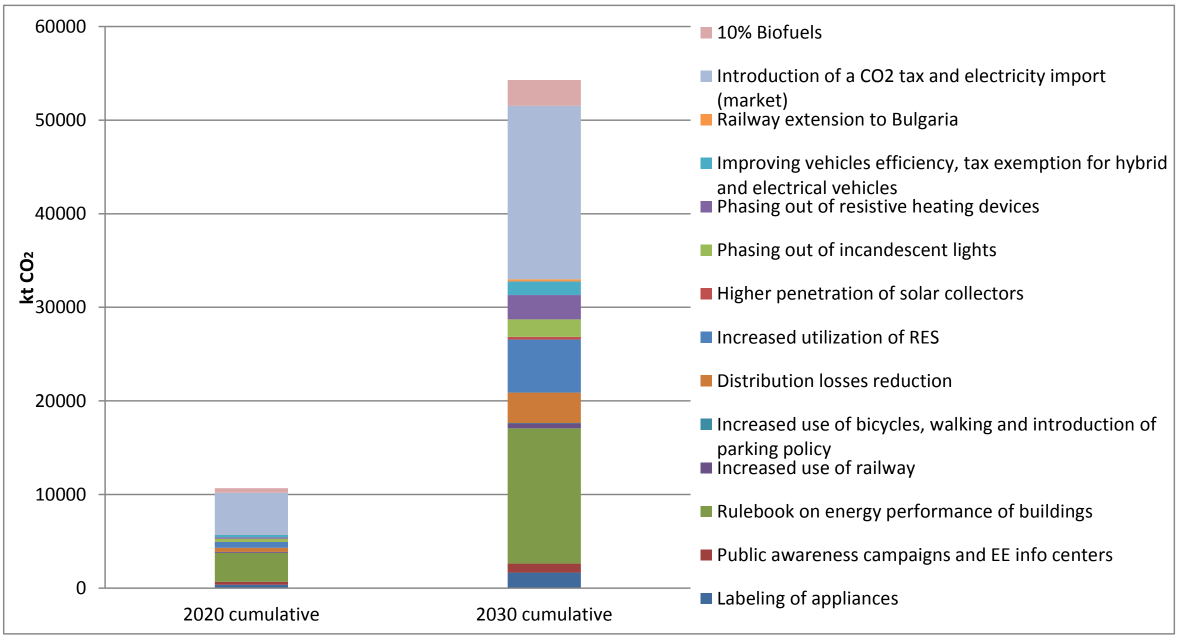

Figure 19. Cumulative savings by 2020 and 2030 in the WAM scenario

6 CONCLUSION

Cumulative emissions in the WOM scenario by 2030 amount to 212,634 kt CO_2, in the WEM scenario 173,301 kt CO_2, and in the WAM scenario they are 165,032 kt CO_2 (Table 19). In percentages, cumulative emissions by 2030, in the WEM scenario compared to the WOM scenario, decrease by 18%, while in the WAM scenario they decrease by 22%.

Table 19. Summary CO_2 emission results in 2020, 2030 and cumulatively by 2020 and 2030 in WOM, WEM and WAM scenarios

	WOM	WEM	WAM
CO_2 emissions in 2020 (kt)	11,561	9,269	8,694
CO_2 emissions in 2030 (kt)	17,891	12,124	11,214
Cumulative CO_2 emissions by 2020 (kt)	90,033	80,007	79,348
Cumulative CO_2 emissions by 2030 (kt)	212,634	173,301	165,032
Reduction compared to WOM (CO_2 emissions in 2020)		20%	25%
Reduction compared to WOM (CO_2 emissions in 2030)		32%	37%
Reduction compared to WOM (cumulative CO_2 emissions by 2020)		11%	12%
Reduction compared to WOM (cumulative CO_2 emissions by 2030)		18%	22%

By comparing CO_2 emissions in all scenarios (Figure 20) it can be concluded that measures with relatively high probability of implementation (WEM scenario) significantly contribute to CO_2 emission reduction, so their introduction is very important in order to achieve specific national targets. The influence of additional measures is also important, especially in the period after 2020, when greater reductions of CO_2 emissions are visible, additional to the ones caused by the existing measures.

However, taking into consideration the fact, that these two scenarios can be improved, that there are other measures in these sectors, and in other sectors as well which could be analyzed additionally (as part of the WEM and WAM scenarios), it should be underlined that the results of the study are indicative and should be used for defining national contributions in the global GHG emission reduction efforts.

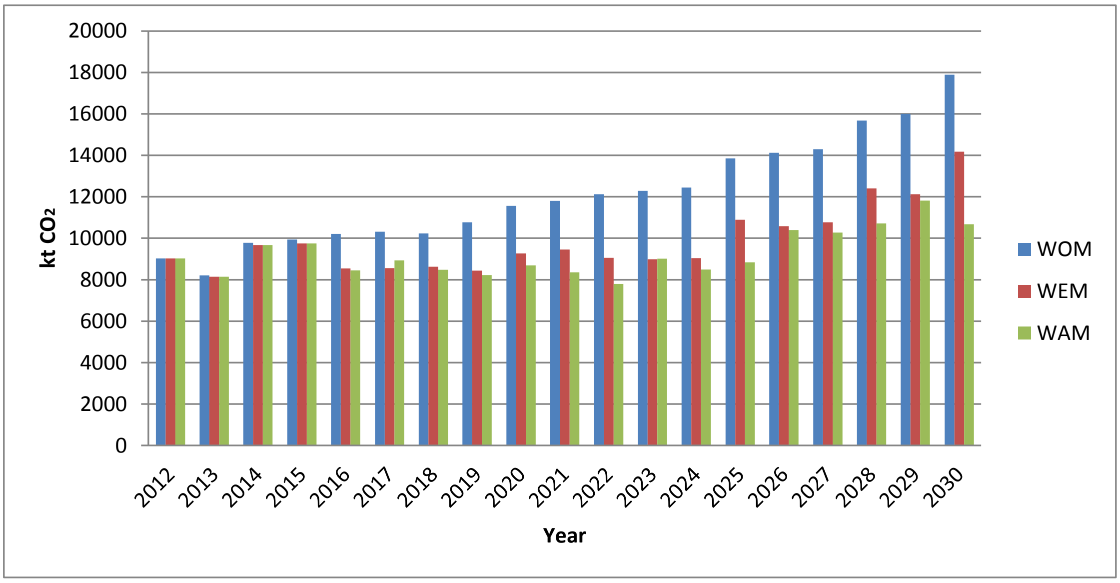

Figure 20. Comparison of GHG emissions in the WOM, WEM and WAM scenarios

ANNEX 1. SCENARIO WITH EXISTING MEASURES– ACTION PLAN

Measure	Type	Stakeholders	Timeframe	Funding (Euros where mentioned)	CO2 emission reduction cumulatively by 2030 in kt
Labeling of appliances	Regulation	Ministry of Economy, Energy Agency, manufacturers and appliances vendors	Short term	Small budget	1,659
Public awareness campaigns and EE info centers	Capacity building, public awareness	Ministry of Economy, Energy Agency	Short term	Medium budget	967
Rulebook on energy performance of buildings	Regulation	Ministry of Economy, Energy Agency	Long term	Small budget	14,982
Increased use of railway	Policy	Ministry of Transport and Communications	Long term	Medium budget	525
Increased use of bicycles, walking and introduction of parking policy	Policy /Regulation / Public awareness	Ministry of Environment and Physical Planning, local self-government	Long term	Small budget	38
Renewal of the vehicle fleet	Policy, technical	Ministry of Transport and Communications, Ministry of Interior	Long term	Large budget	1,345

Measure	Type	Stakeholders	Timeframe	Funding (Euros where mentioned)	CO2 emission reduction cumulatively by 2030 in kt
Distribution losses reduction	Technical	Distribution companies for transmission of electricity	Long term	Large budget	3,261
Electricity import (market)	Policy /Regulation	Energy Regulatory Commission, network transmission operator	Short term	Large budget	12,024
Increased utilization of RES	Policy	Ministry of Environment and Physical Planning, Ministry of Economy, Energy Agency	Long term	Large budget	5,648
Biofuels – delay until 2025	Policy	Ministry of Economy	Long term	Large budget	2,307
Higher penetration of solar collectors	Policy, technical	Ministry of Economy	Long term	Medium budget	550

ANNEX 2. ANALYSES AND PROPOSED ACTIONS FOR REFINING THE MITIGATION SCENARIOS DEVELOPED WITHIN THE THIRD NATIONAL COMMUNICATION

A2.1. INTRODUCTION

The Republic of Macedonia has recently submitted its Third National Communication on Climate Change (TNC) where mitigation analyses has included a development of three groups of scenarios reflecting three types of possible targets for GHG emissions reduction/limitations. The mitigation scenarios have been developed using MARKAL model for energy planning and targets were imposed in a top-down manner in order to understand the appropriate level of ambition regarding the emissions reduction/limitations and to identify the optimal type of target taking into account also the economic aspects. Along that line, the TNC mitigation analysis has shown "where the country is and where it can go" regarding mitigation and represents an excellent analytical base for devising the national position in the post-Kyoto negotiation process.

On the other side, having in mind the latest UNFCCC and EU requirements for reporting mitigation policies and measures and their modelling, a refining of the mitigation scenarios developed under the TNC is needed in order to enable them to correctly capture and represent the implemented measures and policies. That generally means that most important mitigation actions should be modelled bottom up, taking into account conversion efficiencies and new technologies needed to satisfy useful demand. For example, useful demand for heating should be defined at useful household and services area that has to be kept conditioned for human use and not at total sectorial heating demand level. Thus, while useful area can still be calculated using top down macroeconomic approach, the heating and cooling demand needed to condition useful area would depend on the insulation technology being used for new buildings and for retrofitted buildings. The supply of those energy needs and also for hot water, cooking, lighting and other uses would then depend on the phase in of available new and more energy efficient technologies.

The refining mentioned above is needed in order to enable developing the following three scenarios:

- With existing measures - **WEM scenario** which is the one with measures that are either implemented or will certainly happen, either because of the spill over effect (Republic of Macedonia is a small market, and even if it does not always apply EU standards, the local market will tend to follow since it might be too expensive to have special standards), or because it is planned to implement them.

- With additional measures – **WAM scenario** which is the one that will have additional measures that are not yet implemented, or not even seriously contemplated, in order to see their effect on the climate change mitigation, local economy and employment.

- Without measures – **WOM scenario** which assumes no mitigation action is undertaken and serves as a reference when identifying the achievements (mainly emissions reduction) of the other scenarios;

Scenarios should in general be accompanied with the analysis of the cost of each measure per ton of CO_2 avoided and if possible also with the number of jobs created.

The main goal of this assignment is to provide guidance on the refining in order to make the MARKAL Macedonia model to capture the implemented and planned measures in a number of demand sectors mostly buildings and transport, as well as at supply side taking into account the relevant sectoral planning documents (strategies and plans) primarily in the area of energy efficiency (EE) - Strategy and Second National EE Action Plan –NEEAP2 , and renewable energy sources (RES), the RES strategy and the plan. Furthermore, some other governmental policies and plans in the transport sector have been examined and included in the bottom-up list of measures which are to be modelled.

A2.2. PROPOSED ACTIONS FOR REFINING THE MITIGATION SCENARIOS DEVELOPED WITHIN THE TNC

The proposed actions will be divided between demand side modelling and supply side modelling, even though some of the measures may have influence on both sides. That is because special attention has to be given to long term demand in buildings (both residential and commercial sectors) and transport.

A2.2.1. Energy demand modelling

Top down energy demand modelling based on using elasticity factors between energy consumption and gross domestic product growth is good for energy planning in the times without significant technological change. Small improvements in efficiency can be captured by learning curve factors. Meanwhile, when one wants to calculate the effect of demand side technical policies and measures, that approach cannot capture the effect of policies and is thus useless. Sectoral top down macroeconomic models are only little bit better, since they allow for different learning curves in different sectors.

In order to properly model the effects of policies and measures on demand side, it is necessary to model not energy demand, but to model the demand of useful need, either measured in area to be inhabited, or goods and people to be transported. These needs could be modelled using macroeconomic elasticity. Even then, some voluntary policies, like “live in smaller houses”, or “turn off the light”, or “live close to your work place” may influence these needs. Also, some other policies, like expensive fuel, may make people and business decide to cluster more closely. Or a policy of smart urban planning, with mixed residential-commercial areas, may significantly decrease the number of km travelled per person per year. Nevertheless, these policies and measures may be best modelled by convergence assumption, meaning that Republic of Macedonia will follow the path at given future GDP/capita level of countries that now have that GDP/capita. With this assumption the long term changes to behaviour and clustering will be lost and model will have to be recalculated every 5-10 years. But since these processes are long term, that is acceptable.

Once the useful need trend is established the way how this need is supplied by energy will depend on policies and measures and one only has to take into account the population of old conversion technologies, their retiring and a phase in of new ones in order to obtain the useful energy needed to satisfy those needs (building envelope loss, energy to move vehicles) and then once technologies supplying the useful energy (heating/cooling appliances, IC, HEV, PHEV or BEV vehicles) demand are taken into account, also final energy demand.

Demand has to be defined based on its time criticality. Some type of electricity demand, as lightning, TV, has to be delivered at the moment, while other demands can be moved in time, like resistance heating, vehicle charging etc. Other demands, as heating and cooling or water pumping are more flexible in time, due to their inherent storage capacity. Also, some industrial processes may be flexible. Fuel demand is more flexible due to fuel storage. Generally, demand should be defined as time critical and flexible, so that the supply model can find best way to supply it. Time flexible demand has flexibility that is in itself time dependent.

Energy storage plays important role in our energy systems. Currently the fossil fuel are cheapest option to store, but as the energy systems move towards more renewable energy sources, new storage options will come. The cheapest option is storing heat, which can later be used for heating, cooling or as hot water. Electric vehicle will come with necessary batteries which could be used as storage. Reversible hydro, pumped hydro storage, compressed air storage and other such technologies offer options of storing electricity as potential energy. All such storages have flexible demand side and thus increase the flexible demand, and have supply side which may be the same energy as they consumed, or may be different. Thus, it is important to model all the energy subsystems together.

Buildings

Having in mind Buildings Directive and its recast, and huge change to the way buildings will be build and retrofitted in the future, the model has to be based on useful area approach, while the heating and cooling demand have to depend on the insulation technology being used in the planned year of construction. The model can be applied to both residential and commercial sectors, while the industrial sector has special needs for conditioning area. The mode has to follow buildings population based on its construction or last major retrofit year, since that year dictates the insulation technology applied. Different scenarios rates of retrofitting buildings will be one of possible policies. For example, it would be logical to expect that each building has to be retrofitted once every 30 years, which would imply very high retrofitting rate of 3%. Meanwhile, it would be more realistic to expect 1-1.5% retrofit rate.

The rate will depend very much on the strength of the energy certification scheme applied nationally. If the scheme is well applied, then it will influence property markets and differentiate the property prices, forcing higher retrofit rate. For example the policy that allows only sale of buildings that have energy certificate would hasten the process strongly.

One also has to bear in mind that Buildings directive and current measures are only applied for buildings with more than 1000 m^2, while starting in 2018 in EU, and when implemented in Republic of Macedonia it will apply to buildings with more than 50 m2. Smaller buildings will continue with older rules, but will also be influenced by new technologies being used.

Conversion factors between useful area and envelope, and heat losses through the envelope are rather standardized, although one should take into account local specificities, as share of area of the building actually heated, actually cooled, typical shape of buildings and typical size of buildings.

Hot water demand for residential and commercial sector should be modelled based on standardized values, and added to the heat needed for heating space.

The total heating/cooling demand in new and retrofitted buildings has to be supplied by renewable energy sources or waste heat produced at or near the building site, allowing for plethora of technologies that may be used to supply residual demands. Old buildings may continue to use old supply technologies until their next retrofit.

Lightning needs should be modelled based on the actual need for lightning, since different technologies may be used to supply them, mainly much more efficient LED supplanting incandescent bulbs, but also other technologies.

Cooking needs as well as needs for other appliances may be modelled on the useful need level, or may be modelled with elasticity to GDP growth, taking into account increased energy efficiency with learning curves. This is especially important if the energy labelling policy is applied.

Total electricity demand for lightning, cooking and appliances for new and retrofitted buildings may also have to be produced from renewable energy source at or near the building, depending on the local interpretation of zero energy building. For old buildings it will continue to be supplied in the old way, through the grid. Also, since the grid will be preferable balancing tool for local electricity generation, the need for local distribution capacity may be only slightly decreased in time.

One should also take into account appliances used by services which may need much more energy than can be produced on site.

The locally supplied demand can be either modelled by the demand side, thus reducing the demand that has to be supplied by the supply sector, or one can include it in the supply sector, but forcing certain amount of small scale supply technologies. One has to be careful to define demand that has to be supplied by supply sector on hourly basis, since otherwise the result will have significant error.

Transport

In order to properly model modal shift policies as those related to public transport, construction of railways, roads, waterways, bicycle and walking routes , it is necessary to model useful demand in km-tons and passenger km, which then can be satisfied in various ways.

Meanwhile, this approach will not capture policies aimed at reducing the demand for these in the first place, as for example high taxes on fuels which will not only bring modal shift, but will also force clustering of production in order to reduce the number of ton-km. Also, good urban planning may significantly reduce the number of passenger km travelled. By planning for combined residential and business areas, one may reduce need for commuting and shopping. Also, switching to more online business may reduce the need for km-tons and passenger-km. It would be possible to model that also, but then one would need to add also urban planning which would be way to complicating. Thus, assessing these needs and taking into account policies that influence those needs in the first place, should be done through out of model coefficients.

Once the passenger-km and km-tons are established, depending on the policies applied, the modal shit policies and measures should be modelled. Measures like more railways built, higher price of fuels, higher taxes for cars and fuels, more bicycle and walking paths, more public transport, higher parking fees, city entrance fees, road pricing, dynamic road pricing, will all try to decrease the individual car as transport mean, and move persons towards walking, bicycling and using public transport, while they will also move cargo transport from road haulage to railways and waterways.

Some policies and measures will increase efficiency, like those that reduce congestion. Reducing congestion can save up to 15% of the fuel spent. Better traffic management system will primarily try to increase efficiency by reducing congestion. Modal shift will have secondary influence on reducing congestion, as measures as higher parking fees, city entrance fees, road pricing, dynamic road pricing. This should be only investigated in cases that it is a major problem in some cities. HEVs, PHEVs and BEVs do not have the problem, since they do not use additional energy for congestion. Also, newer vehicle models that have stop go technology have much lower potential efficiency gain.

Better railways will also help move people and cargo from energy intensive air transport to more energy efficient rail and water transport. Since water transport is not applicable to Macedonia, only railway transport is relevant. Generally, transport up to 600-1000 km distance may be shifted from airways to railways.

Once the mode of transport has been established for each passenger-km and km-tons, individual technologies have to be calculated.

Walking will not use any energy, while bicycling depends on if it is electrical bicycle or manual one.

Individual cars technology has started to get much more efficient recently with EU regulating CO2 emissions of new cars per km. This measure has already significantly reduced demand for motor fuels in Europe. It will have a spill over effect in the Republic of Macedonia even if EU regulation is not implemented through two mechanisms. One is the fact that car industry will most probably not produce lesser quality cars for Macedonian market, but market its wares considering it part of wider European market. The other is that import of second hand cars from EU will bring more efficient cars with certain delay. This is a very significant issue, which may be mitigated by adopting a yearly registration incise tax based on CO2 emissions, which would decrease the attractiveness of using inefficient cars. The tax has to take into account social sensitivity and be aimed mainly at highly polluting cars.

Some policies will help increase efficiency of current vehicle stock, as for example increasing the use of low viscosity lubricant and low rolling resistance tires.

In the longer run, part of the vehicles market will be taken by hybrid vehicles (HEV), plug-in hybrid vehicles (PHEV), and battery electric vehicles (BEV). HEVs do not use grid electricity but have improved energy efficiency, especially if used in the cities. PHEVs and BEVs use partially or fully fuelled by electricity from the grid, and are much more efficient than ICE (internal combustion engine) vehicles. Even if the electricity is produced from coal, at reasonable efficiency, this measure will help mitigate the climate. The actual effect should be calculated based on the national or European electricity emission factor. Such vehicles are more economically viable at higher yearly usage, so it is necessary to model vehicle population as at least two classes by km per year.

Switching to LPG is generally not considered to have climate change mitigation effect but it is often promoted by countries with old refineries which are unable to produce high standard fuel. Unfortunately it also works as a mechanism for loosing tax income, since LPG has to be taxed at lower rate in order to make it economically viable. Generally it can be modelled as part of petrol vehicle fleet, or separately.

Switching to CNG has mitigation effect, but depends on developing new infrastructure and dedicated vehicles, usually buses. It makes sense as transitory measure towards introducing to biogas to public transport. It should be modelled as a separate fleet.

Biofuels was designed as an important EU mitigation policy but it came out that its mitigation effect are limited, when also indirect emission change is taken into account. Biofuels demand can be modelled as energy share, up to the limit of blending which does not require special vehicles. Above that level has to be modelled as a dedicated vehicle fleet. There is huge room for flexibility here, since various standards will allow different levels of blending. The highest level technically feasible are B100 for Diesel engine and E25 for Otto engine, but in most countries legal level is lower and since legal level is important for marketing and services purposes, it is not advisable to set the technical limit above the legal one.

Industry

It is much more difficult to model industry in a proper way. It is quite possible to do a good bottom up representation of existing industry, and to model its transition to best available technologies.

The problem is that in a small country as Republic of Macedonia it is difficult to predict closures and openings of individual installations.

Using macroeconomic approach will also not yield good results, since it also cannot predict closures and openings of individual installations.

The best way would be to predict production of most energy intensive products, as cement, lime, metals etc. using macroeconomic top down model, and then to model the measures needed to bring it to best available technology for final to useful energy conversion, and also to check measures of fuel substation. It is important to separate energy efficiency measures from fuel switching measures to get good results.

The rest of industry should be modelled macroeconomically on final energy level with learning curve, with option of fuel switching measures.

A2.2.2. Energy supply modelling

When modelling supply there are several timescales that have to be correctly captured. One is daily scale. Technologies installed at any given time have to be able to satisfy the demand, at the exact time of it happening, or must have storage to move the supply in time. When most of supply technologies are fully controllable (accumulation hydro, gas) or partially controllable (nuclear, coal) then either small number of typical days or load duration curves approaches maybe used. When higher penetration of weather controlled supply technologies are used (wind, solar, run-of-the-river hydro) then it is usually better to use full time series, in order to check on all possible situations that may appear during a year. It is very difficult to define the border between the two cases, since it also depends on the shares of fully controllable technologies, storages, and integration of various energy systems. The seasonal effect can be captured by use of typical days. Yearly variations of precipitation have to be checked for, in such a way that the system will work for both very dry year and very wet year.

The other important time scale is usually yearly retirement of old capacities and construction of new ones, as well as retrofitting the old ones and extending their lives.

The modellers usually limit the size and number of new capacities, what forces often wrong solutions. All available capacity should be listed, and only by use of policy decisions in given scenarios certain technologies should be positively or negatively discriminated. For example, there is usually no practical limit wind or solar potential, since their potential is usually much higher than needed to cover all the energy needs of any given country. Only very densely populated countries with high energy needs may have problems to achieve that. The various scenarios should be then run by pollution limitations and pricing, or targeted shares of various or groups of technologies, in order to reach a certain energy mix, or security of energy supply level, or emission level. In all cases the final solution should then be left to the cost benefit analysis performed by the modelling algorithm.

Since energy planning is done from the national point of view, the correct pricing of various technologies should ideally include national external costs. That is due to the fact that national economy will have to cover those costs also. External costs can be found in Study on the Need for Modernization of Large Combustion Plants in the Energy Community[9].

Storage capacity should be carefully modelled. Since storage capacity can significantly change the way merit order of technologies works on the daily basis, more important storage is to the system, more important it is to perform a full time series analysis. If storages are used mainly for daily arbitrage then careful choice of typical days can perform well. If the storage is seasonal, then full time series analysis is necessary.

Good modelling of integration of power and heating/cooling systems is very important. Since electricity is widely used for space heating and cooling as well as hot water in the Republic of Macedonia, the planners already have some experience with it. While demand for electricity for cooling depends mainly on temperature and only at high price changes on cost, demand for

[9] South East European Consultants, Ltd., Study on the Need for Modernization of Large Combustion Plants in the Energy Community, November 2013

electricity for heating depends on temperature but also very much on price. When price hits a certain threshold, and biomass becomes significantly cheaper, those that have wood stove (and ¾ of population has) switch to it.

In order to model heating subsystem one has to properly capture price differentials between biomass (which may be cheap or free for some who have own production) and electricity, as well as other alternatives like heat pumps, gas, district heating and solar thermal heating. Switching from electric resistance space heating to heat pumps is very good mitigation policy, due to much higher efficiency.

Small scale photovoltaic electricity is economically viable when grid parity is reached. That means that PV electricity costs should be benchmarked against daily residential retail electricity price, and not against wholesale market price. Similarly, another class of PVs, small scale photovoltaic integrated into commercial buildings should be benchmarked to daily commercial retail electricity price. Grid parity is usually difficult to model, so a special attention should be placed on this. The best way is to model residential and commercial small scale PV as negative load technology. Once the grid parity is reached, a good policy will aim at having a constant market of PV installations in order to maximize value added and jobs sustained locally. A 10 MW per year PV market would probably be order of magnitude of sustainable market for small PV systems. The integration capacity should be taken at half of the transformation capacity of medium-low voltage without any additional investment, while it may be significantly higher with investment into local voltage control. Both of values may also be studied in more detail.

Regarding integration capacity of bigger variable renewable energy sources, there are two limitations. One is evacuation capacity which is related to the transmission grid capacity to evacuate additional capacity connected to grid and bring it to the demand areas or to neighbouring markets. This capacity is usually high in countries in which power plants are built in different locations than population and industrial centres, at least at the level of base load. The other is balancing and backup capacity, which depends on the flexibility of the system. Since the backup capacity depends on the flexibility of power plants, in a system centred on base load power plants that may be rather low. The increased need for balancing power will be at tertiary reserve level and hour ahead intraday level[10]. Since the weather forecast in an important part of demand forecasting anyway, it will now have to be extended to also supply forecasting. Well organised system will not need additional primary or secondary reserve for balancing variable renewable energy sources. Integrating capacity may be additionally studied to take into account local specificities. Retrofitting base load power plants to be more flexible may be one of the technologies proposed[11]. The rationale is that replacing electricity with higher variable with one with lower variable costs is economically beneficial for response to future electricity markets, as well as environmentally sound. It may also produce higher employment. All these issue may be additionally studied.

When taking into account technology prices, it is important to use realistic prices, taking into account hidden subsidies. Prices should reflect realistic number of hours which is expected that

[10] Erik Ela, Michael Milligan, and Brendan Kirby, Operating Reserves and Variable Generation, Technical Report NREL/TP-5500-51978, August 2011

[11] Jaquelin Cochran, Debra Lew, Nikhil Kumar, Flexible Coal - Evolution from Baseload to Peaking Plant, NREL/BR-6A20-60575 | December 2013

technology will work in future energy system. The best approach is if actual merit order to calculate for future years, and cost function calculated based on that. If that is not feasible, then realistic LCOE should be estimated, based on merit order stemming from variable cost.

A2.2.3. Scenarios

Generally, there should be 3 scenarios modelled, with measures, with additional measures and for comparison purposes scenario without measures.

The scenario with measures should include all the measures already implemented, or being in the process of being implemented. It is in a way baseline scenario, but the problem with using that term is that with more and more measures being implemented, such baseline cannot be used any more as a reference scenario.

The scenarios with additional measures should include all possible measures that could be feasibly devised. Such measures should then be compared on cost per ton of CO2 reduced and jobs creation basis. The costs of various measures should be visualised by a mitigation cost curve. Jobs per ton of CO2 mitigated may also be visualised by a similar curve.

The scenario without measures is only calculated for reference purposes. Such a scenario is not a possible one, since the measures that have already been implemented, but is important to show the effectiveness of the implemented measures. The scenario without measures will be a scenario as if all the mitigation measures previously implemented or in the process of implementation will not be having any impact.

The scenario with existing measures (WEM scenario)

After having studied all relevant documents following measures have been noted as already implemented or in the process of being implemented:

Demand

Buildings

- Buildings directive implementation, energy efficiency standard for new and retrofitted buildings with area > 1000 m2
- NEEAP2, Rulebook on energy performance in buildings
- NEEAP2 measure, Retrofit existing residential buildings, multi apartment buildings
- NEEAP2 measure, Retrofit existing commercial buildings
- NEEAP2 measure, Retrofit existing public buildings
- Energy certificates for buildings
- NEEAP2 measure, Labelling electric appliances
- NEEAP2 measure, Information campaigns, EE info centres

- NEEAP2 measure, Energy management
- NEEAP2 measure, Heat allocators
- NEEAP2 measure, Intelligent network, suppliers obligations to introduce energy savings

Transport

Modal shift

- Railway extension to Bulgaria
- Public transport improvement (tramway in Skopje)
- More bicycle and walking paths
- Better parking policy
- NEEAP2 measure, Sustainable urban transport
- NEEAP2 measure, Car free days
- NEEAP2 measure, Increased use of railways

Fuel economy improvements by vehicle replacement

- NEEAP2 measure, Renewal of vehicle fleet
- No tax for buying hybrid and electrical cars

Fuel economy improvements for old vehicles

- Traffic management system
- Low viscosity lubricant
- Low rolling resistance tires

Industry

- Labelling - appliances
- LCPD implementation
- NEEAP2 measure, Improvements of process performance
- NEEAP2 measure, Energy management
- NEEAP2 measure, Efficient electrical motors
- NEEAP2 measure, Waste heat utilisation
- NEEAP2 measure, Co-generation

Other

- NEEAP2 measure, Energy management

- NEEAP2 measure, Municipal street lighting
- NEEAP2 measure, Green procurement

Supply

Electricity supply

- Feed-in tariff, cap per technology
- Large Combustion Plant Directive (LCPD) implementation
- Decreasing losses in distribution
- 21% RES obligations by 2020

Heating supply

- NEEAP2 measure, Thermal solar collectors, heating pumps
- NEEAP2 measure, RES applications in commercial sector (for hot water)
- District heating extension in Bitola
- 21% RES obligations by 2020

Transport fuel

- Biofuels - voluntary
- CNG – no tax, 2 filling stations
- 21% RES obligations by 2020

Other

- NEEAP2 measure, Wider application of RES
- NEEAP2 measure, Green procurement

The scenario with additional measures (WAM scenario)

The additional measures may include the following policies and measures:

Demand

Buildings:

- New buildings directive - nearly zero energy buildings
- Energy efficiency directive - 3% yearly rate of public buildings retrofit
- Energy certificates for buildings required when selling
- Phase out of incandescent bulbs
- Phase out of resistive heating in residential sector

Transport:

- No tax for registration of hybrid and electric cars
- Free parking and tolls for hybrid and electric cars
- Incise taxes based on CO2 and not power
- More railway
- Regional railway

Industry:

- IED

Supply

Electricity

- Day ahead market
- More renewables
- CO2 tax for businesses
- Energy Community RES obligations by 2020
- IED

Heating

- More heat pumps
- More district heating
- Hot water supplied by district heating
- More solar collectors
- District heating on biomass, waste heat and power to heat
- Energy Community RES obligations by 2020

Transport:

- Energy Community RES obligations by 2020
- Biofuels 10%in total transport fuels by 2020

It should be noted that a participatory prioritization should be initiated for the possible measures from the WAM scenario. When selecting demand side policies and measures for modelling, a priority should be given to the sectors of buildings and transport given their long-term mitigation potential.

A2.3. CONCLUSIONS

In order to model correctly the GHG mitigation scenarios, three scenarios should be devised. The scenario with existing measures is a scenario including all the implemented measures and policies, and also those with high certainty and preparation level, so that they can be considered certainly implemented in future. This scenario is a baseline, but it is better not to use that term, since the scenario with measures will be constantly changing with new policies and measures being implemented. All the envisioned policies and measures that might be implemented in future should be modelled as part of scenario with additional measures. Such measures should be then compared on the basis of price and where possible with the number of jobs created per ton of CO2eq mitigated and priority list of policies and measures suggested.

For the purpose of comparing mitigation potential of entire scenarios, the third scenario should be devised, scenario without measures, based on technologies and trends which would be extension of those used before the mitigation policy started. This scenario is not a realistic scenario - it is only used for reference purposes.

Care should be taken to model policies and measures in a way that their effect on demand and supply is correctly captured, and generally not estimated by macroeconomic means. That is so since in the periods of technology change the link between energy demand and economy is clearly decoupled, and economic growth may be consistent with the stagnation or fall in energy use. Thus, demand should be modelled at use level, and not on useful energy level. The conversion between use and useful energy will depend on conversion technologies being used in future based on policies and measures. Also, the conversion technologies supplying useful energy will be changing, and the transitional effect has to be modelled in detail.

APPENDIX A2.1. UNFCCC REPORTING REQUIREMENTS REGARDING PAMS AND MODELLING

In preparing their National Communications (NCs), Annex I Parties should follow the UNFCCC guidelines for reporting and review. These guidelines have been revised twice, at COP 2 (Geneva, July 1996) for the preparation of the second round of communications, and again at COP 5 (Bonn, Oct./Nov. 1999), where revised reporting guidelines[12] were adopted for the preparation of third NCs and continued to be applied. In the following an extract from the guidelines is provided according to relevance to PaMs and projections.

App. A2.1.1. Reporting in relation to Policies and Measures

A. Selection of policies and measures for the national communication

13. In accordance with Article 12.2, Annex I Parties shall communicate information on policies and measures adopted to implement commitments under Article 4.2(a) and (b). These need not have the limitation and reduction of GHG emissions and removals as a primary objective.

14. In reporting, Parties should give priority to policies and measures, or combinations of policies and measures, which have the most significant impact in affecting GHG emissions and removals and may also indicate those which are innovative and/or effectively replicable by other Parties. Parties may report on adopted policies and measures and those in the planning stage, but should clearly distinguish these from implemented policies and measures throughout. The national communication does not have to report every policy and measure which affects GHG emissions.

15. Policies and measures reported on should be those planned, adopted and/or implemented by governments at national, state, provincial, regional and local level. Furthermore, policies and measures reported may also include those adopted in the context of regional or international efforts. Policies and measures influencing international transport GHG emissions should be reported in the transport sector.

16. Parties should report on action taken to implement commitments under Article 4.2(e)(ii) of the Convention, which requires that Parties identify and periodically update their own policies and practices which encourage activities that lead to greater levels of anthropogenic GHG emissions than would otherwise occur. Parties should also provide the rationale for such actions in the context of their national communications.

B. Structure of the policies and measures section of the national communication

17. Parties shall organize the reporting of policies and measures by sectors, subdivided by greenhouse gas (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulphur hexafluoride). To the extent appropriate, the following sectors should be considered:

[12] UNFCCC. Secretariat, Review of the implementation of commitments and of other provisions of the Convention. UNFCCC guidelines on reporting and review, FCCC FCCC/CP/1999/7, http://unfccc.int/documentation/documents/advanced_search/items/6911.php?priref=600001361#beg [accessed on May 11, 2014]

energy, transport, industry, agriculture, forestry and waste management. Each sector shall have its own textual description of the principal policies and measures, as set out in section D below, supplemented by table 1. Parties may include separate text and a table describing cross sectoral policies and measures.

18. In cases where a policy or measure has been maintained over time and is thoroughly described in the Party's previous national communication, reference should be made to this and only a brief description contained in the latest national communication, focusing on any alterations to the policy or measure or effects achieved.

19. Some information such as the effect of policies and measures may be presented in aggregate for several complementary measures in a particular sector or affecting a particular gas.

C. Policy-making process

20. The national communication should describe the overall policy context, including any national targets for greenhouse gas mitigation. Strategies for sustainable development or other relevant policy objectives may also be covered. Relevant inter-ministerial decision-making processes or bodies may be noted.

21. The national communication should provide a description of the way in which progress with policies and measures to mitigate GHG emissions is monitored and evaluated over time.

Institutional arrangements for monitoring of GHG mitigation policy should also be reported in this context.

D. Policies and measures and their effects

22. The presentation of each policy and measure shall include information on each of the subject headings listed below. The presentation should be concise and should include information on the detail suggested after each subject heading:

(a) Name and short description of the policy or measure;

(b) Objectives of the policy or measure. The description of the objectives should focus on the key purposes and benefits of the policies and measures, including a description of activities and/or source and sink categories affected. Objectives should be described in quantitative terms, to the extent possible;

(c) The greenhouse gas or gases affected;

(d) Type or types of policy or measure. Use, to the extent possible, the following terms: economic, fiscal, voluntary/negotiated agreements, regulatory, information, education, research, other;

(e) Status of implementation. It should be noted whether the policy or measure is in the planning stage or is adopted or whether it is under implementation. For adopted and implemented measures, additional information may include the funds already provided, future budget allocated and the time-frame for implementation;

(f) Implementing entity or entities. This should describe the role of national, state, provincial, regional and local government and the involvement of any other entities.

23. In addition, the description of each policy and measure reported should include, as appropriate, a quantitative estimate of the impacts of individual policies and measures or collections of policies and measures. Such information includes estimated changes in activity levels and/or emissions and removals due to adopted and implemented policies and measures reported and a brief description of estimation methods. Information should be presented as an estimate for a particular year such as 1995, 2000 and 2005, not for a period of years.

24. Parties may also provide information under the headings below for each policy and measure reported:

(a) Information about the costs of policies and measures. Such information should be accompanied by a brief definition of the term ‘cost’ in this context;

(b) Information about non-GHG mitigation benefits of policies and measures. Such benefits may include, for example, reduced emissions of other pollutants or health benefits;

(c) How the policy or measure interacts with other policies and measures at the national level. This may include a description of how policies complement each other in order to enhance overall greenhouse gas mitigation.

25. Parties shall provide information on how they believe their policies and measures are modifying longer-term trends in anthropogenic GHG emissions and removals consistent with the objective of the Convention.

E. Policies and measures no longer in place

26. When policies and measures listed in previous national communications are no longer in place, Parties may explain why this is so.

App. A2.1.2. Projections and the total effect of policies and measures

A. Purpose

27. The primary objective of the projections section of the national communication is to give an indication of future trends in GHG emissions and removals, given current national circumstances and implemented and adopted policies and measures, and to give an indication of the path of emissions and removals without such policies and measures.

B. Projections

28. At a minimum, Parties shall report a 'with measures' projection, in accordance with paragraph 29 and may report 'without measures' and 'with additional measures' projections.

29. A 'with measures' projection shall encompass currently implemented and adopted policies and measures. If provided, a 'with additional measures' projection also encompasses planned policies and measures. If provided, a 'without measures' projection excludes all policies and measures implemented, adopted or planned after the year chosen as the starting point for this projection. In reporting, Parties may entitle their 'without measures' projection as a 'baseline' or 'reference' projection, for example, if preferred, but should explain the nature of this projection.

30. Parties may report sensitivity analysis for any of the projections, but should aim to limit the number of scenarios presented.

C. Presentation of projections relative to actual data

31. Emission projections shall be presented relative to actual inventory data for the preceding years.

32. For the 'with measures' and 'with additional measures' projections, the starting point should generally be the latest year for which inventory data are available in the national communication. For the 'without measures' projection, the starting point may be 1995, or Parties may provide a 'without measures' projection starting from an earlier year such as 1990 or another base year, as appropriate.

33. Parties may use 'normalized' data in making their projections. However, Parties should present their projections relative to unadjusted inventory data for the preceding years. In addition, Parties may present their projections relative to adjusted inventory data. In this case, Parties shall explain the nature of the adjustments.

D. Coverage and presentation

34. Projections shall be presented on a sectoral basis, to the extent possible, using the same sectoral categories used in the policies and measures section.

35. Projections shall be presented on a gas-by-gas basis for the following greenhouse gases:

CO2, CH4, N2O, PFCs, HFCs and SF6 (treating PFCs and HFCs collectively in each case). Parties may also provide projections of the indirect greenhouse gases carbon monoxide, nitrogen oxides and non-methane volatile organic compounds, as well as sulphur oxides. In addition, projections shall be provided in an aggregated format for each sector as well as for a national total, using global warming potential (GWP) values agreed upon by the Conference of the Parties.

36. To ensure consistency with inventory reporting, emissions projections related to fuel sold to ships and aircraft engaged in international transport shall, to the extent possible, be reported separately and not included in the totals.

37. In view of the objective of the Convention and the intent to modify longer-term trends in emissions and removals, Parties should include projections on a quantitative basis for the years

2005, 2010, 2015 and 2020. Projections should be presented in a tabular format by sector and gas for each of these years, together with actual data for the period 1990 to 2000 or the latest year available. For Parties using a base year different from 1990 for their inventories, in accordance with Article 4.6 of the Convention, actual data for that year shall be given.

38. Diagrams illustrating the information in paragraphs 34 to 37 should be presented showing unadjusted inventory data and a 'with measures' projection, for the period 1990 (or another base year, as appropriate) to 2020. Additional diagrams may also be presented. Figure 1 illustrates the presentation of a hypothetical Party's projection for a single gas. It shows unadjusted inventory data for the period 1990 to 2000. It shows 'with measures' and 'with additional measures' scenarios starting from 2000, and a 'without measures' scenario starting from 1995.

E. Assessment of aggregate effects of policies and measures

39. The estimated and expected effects of individual policies are addressed in the policies and measures section of the national communication. In the projections section of the national communication, Parties shall present the estimated and expected total effect of implemented and adopted policies and measures. Parties may also present the total expected effect of planned policies and measures.

40. Parties shall provide an estimate of the total effect of their policies and measures, in accordance with the 'with measures' definition, compared to a situation without such policies and measures. This effect shall be presented in terms of GHG emissions avoided or sequestered, by gas (on a CO2 equivalent basis), in 1995 and 2000, and should also be presented for 2005, 2010, 2015 and 2020 (not cumulative savings). This information may be presented in tabular format.

41. Parties may calculate the total effect of their measures by taking the difference between a 'with measures' and 'without measures' projection. Alternatively, Parties may use another approach, for example individually assessing the effect of each significant policy and measure, and aggregating the individual effects to arrive at a total. In either case, when reporting, it should be clear from what year onward it is assumed that policies are implemented or not implemented in making the calculations.

F. Methodology

42. When projecting greenhouse gas emissions and removals and estimating the total effects of policies and measures on emissions and removals, Parties may use any models and/or approaches they choose. Sufficient information should be reported in the national communication to allow a reader to obtain a basic understanding of such models and/or approaches.

43. In the interests of transparency, for each model or approach used, Parties should briefly:

(a) Explain for which gases and/or sectors the model or approach was used;

(b) Describe the type of model or approach used and its characteristics (for example,

top-down model, bottom-up model, accounting model, expert judgement);

(c) Describe the original purpose the model or approach was designed for and, if applicable, how it has been modified for climate change purposes;

(d) Summarize the strengths and weaknesses of the model or approach used;

(e) Explain how the model or approach used accounts for any overlap or synergies that may exist between different policies and measures.

44. Parties should provide references for more detailed information related to (a) to (e) above.

45. Parties should report the main differences in the assumptions, methods employed, and results between projections in the current national communication and those in earlier national communications.

46. The sensitivity of the projections to underlying assumptions should be discussed qualitatively and, where possible, quantitatively.

47. To ensure transparency, Parties should report information about key underlying assumptions and values of variables such as GDP growth, population growth, tax levels and international fuel prices, using table 2. This information should be limited to that which is not covered under paragraph 48, i.e. it should not include sector-specific data.

48. To provide the reader with an understanding of emission trends in the years 1990 to 2020, Parties shall present relevant information on factors and activities for each sector. This information on factors and activities may be presented in tabular format.

APPENDIX A2.2. EU REPORTING REQUIREMENTS FOR PAMS AND MODELLING[13]

The Member States' reporting on projections is crucial in the process of:

- tracking of progress by MS and EU towards UNFCCC based targets (annual report by the Commission, biennial projections submissions by MS)
- tracking progress towards headline targets under the Europe 2020 strategy (especially the Effort Sharing Decision (406/2009/EC) targets)

The Effort Sharing Decision (ESD) sets annual emission reduction and limitation targets for the Member States in the Non-ETS sector for the period 2013 – 2020. Its implementation requires an enhanced quality and transparency of Member States' actual emission reports for the compliance assessment at the end of each year. Projections and their quality are important in the compliance action plan to be developed in cases of non-compliance with the targets. The overall organisation of the GHG reduction commitments in the recent EU legislation requires a split of total GHG emissions between the ETS emissions and non-ETS emissions in terms of projections due to the scope of the decision.

The EU's current and future mitigation actions will be facilitated through the enhanced monitoring and reporting system being put in place. The system supersedes the system which was established in 1993 and revamped in 2004.

Enhanced reporting is essential for the recognition of the Union's and the Member States' efforts in fulfilling their commitments on the provision of financial, technological and capacity-building support to developing country Parties as agreed at the 2009 and 2010 UNFCCC conferences. In this context the particularity of the EU reporting system must also be taken into consideration which necessitates ensuring quality reporting at both the EU and the Member State level, and consistency of reporting between the EU and the Member States. This need necessitated the elaboration of the new Monitoring Mechanism Regulation, which came into force in 2013.

The overall objectives of the new Monitoring Mechanism Regulation are:

- to assist the Union and its Member States to meet their mitigation commitments and to implement the climate and energy package;
- to improve the timeliness, transparency, accuracy, completeness, comparability and comprehensiveness of the data reported by the Union and its Member States;
- to ensure that the Union and its Member States comply with international monitoring and reporting obligations and commitments, including the reporting on financial and technical support provided to developing countries;
- to facilitate the development of new Union climate change mitigation and adaptation instruments;
- to provide a legal basis for the implementation of future reporting requirements and guidelines pursuant to Union legislation or international agreements and decisions.

It covers emissions of six greenhouse gases from all sectors (energy, industrial processes, land use, land use change and forestry (LULUCF), waste, agriculture, etc). It is based on methodologies established under the Intergovernmental Panel on Climate Change (IPCC) and existing aggregated statistical data at the national level.

[13] European Commission, Directorate-General for Climate Action, Development of GHG projection guidelines, ML-32-13-425-EN-N, 2012, http://bookshop.europa.eu/en/development-of-ghg-projection-guidelines-pbML3213425/ [accessed on May 11, 2014]

The new Regulation implements the monitoring and reporting requirements of the Effort Sharing Decision and the revised EU ETS Directive through:

- establishing a review and compliance cycle under the Effort Sharing Decision;
- incorporating the reporting requirements for the use of revenues from auctioning carbon allowances, as stipulated in the revised ETS Directive;
- enhances the current monitoring and reporting framework so as to meet the needs of future EU and international legislation through establishing a basis for monitoring and reporting emissions from maritime transport, non-CO2 climate impacts from aviation, LULUCF, and adaptation;
- enhances EU and Member State reporting on financial and technology support provided to developing countries, thereby ensuring adherence to international commitments under the UNFCCC;
- enhances consistency of reporting under this Decision with reporting under other EU legal instruments that address air pollutants;
- enhances reporting of actual emissions, projections, policies and measures taking into account lessons learned from past implementation.

App. A2.2.1. Low-carbon development strategies

Member States, and the Commission on behalf of the Union, shall prepare their low-carbon development strategies in accordance with any reporting provisions agreed internationally in the context of the UNFCCC process

Member States shall report to the Commission on the status of implementation of their low-carbon development strategy by 9 January 2015 or in accordance with any timetable agreed internationally in the context of the UNFCCC process.

App. A2.2.2. Reporting on PaMs and on projection of GHGs

By 9 July 2015, Member States and the Commission shall set up, operate and seek to continuously improve national and Union systems respectively, for reporting on policies and measures and for reporting on projections of anthropogenic greenhouse gas emissions by sources and removals by sinks. Those systems shall include the relevant institutional, legal and procedural arrangements established within a Member State and the Union for evaluating policy and making projections of anthropogenic greenhouse gas emissions by sources and removals by sinks.

Member States and the Commission shall aim to ensure the timeliness, transparency, accuracy, consistency, comparability and completeness of the information reported on policies and measures and projections of anthropogenic greenhouse gas emissions by sources and removals by sinks,

By 15 March 2015, and every two years thereafter, Member States shall provide the Commission with the following:

(a) a description of their national system for reporting on policies and measures, or groups of measures, and for reporting on projections of anthropogenic greenhouse gas emissions by sources and removals by sinks pursuant to Article 12(1), where such description has not already been provided, or information on any changes made to that system where such a description has already been provided;

(b) updates relevant to their low-carbon development strategies referred to in Article 4 and progress in implementing those strategies;

(c) information on national policies and measures, or groups of measures, and on implementation of Union policies and measures, or groups of measures, that limit or reduce greenhouse gas emissions by sources or enhance removals by sinks, presented on a sectoral basis and organised by gas or group of gases (HFCs and PFCs) listed in Annex I. That information shall refer to applicable and relevant national or Union policies and shall include:

(i) the objective of the policy or measure and a short description of the policy or measure;

(ii) the type of policy instrument;

(iii) the status of implementation of the policy or measure or group of measures;

(iv) where used, indicators to monitor and evaluate progress over time;

(v) where available, quantitative estimates of the effects on emissions by sources and removals by sinks of greenhouse gases broken down into:

— the results of *ex ante* assessments of the effects of individual or groups of policies and measures on the mitigation of climate change. Estimates shall be provided for a sequence of four future years ending with 0 or 5 immediately following the reporting year, with a distinction between greenhouse gas emissions covered by Directive 2003/87/EC and those covered by Decision No 406/2009/EC;

— the results of *ex post* assessments of the effects of individual or groups of policies and measures on the mitigation of climate change, with a distinction between greenhouse gas emissions covered by Directive 2003/87/EC and those covered by Decision No 406/2009/EC;

(vi) where available, estimates of the projected costs and benefits of policies and measures, as well as estimates, as appropriate, of the realised costs and benefits of policies and measures;

(vii) where available, all references to the assessments and the underpinning technical reports referred to in paragraph 3;

(d) the information referred to in point (d) of Article 6(1) of Decision No 406/2009/EC;

(e) information on the extent to which the Member State's action constitutes a significant element of the efforts undertaken at national level as well as the extent to which the projected use of joint implementation, of the CDM and of international emissions trading is supplemental to domestic action in accordance with the relevant provisions of the Kyoto Protocol and the decisions adopted thereunder.

A Member State shall communicate to the Commission any substantial changes to the information reported pursuant to this Article during the first year of the reporting period, by 15 March of the year following the previous report.

Member States shall make available to the public, in electronic form, any relevant assessment of the costs and effects of national policies and measures, where available, and any relevant information on the implementation of Union policies and measures that limit or reduce greenhouse gas emissions by sources or enhance removals by sinks along with any existing technical reports that underpin those assessments. Those assessments should include descriptions of the models and methodological approaches used, definitions and underlying assumptions.

App. A2.2.3. Projections

1.By 15 March 2015, and every two years thereafter, Member States shall report to the Commission national projections of anthropogenic greenhouse gas emissions by sources and removals by sinks, organised by gas or group of gases (HFCs and PFCs) listed in Annex I and by sector. Those projections shall include quantitative estimates for a sequence of four future years ending with 0 or 5 immediately following the reporting year. National projections shall take into consideration any policies and measures adopted at Union level and shall include:

(a) projections without measures where available, projections with measures, and, where available, projections with additional measures;

(b) total greenhouse gas projections and separate estimates for the projected greenhouse gas emissions for the emission sources covered by Directive 2003/87/EC and by Decision No 406/2009/EC;

(c) the impact of policies and measures identified pursuant to Article 13. Where such policies and measures are not included, this shall be clearly stated and explained;

(d) results of the sensitivity analysis performed for the projections;

(e) all relevant references to the assessment and the technical reports that underpin the projections referred to in paragraph 4.

2. Member States shall communicate to the Commission any substantial changes to the information reported pursuant to this Article during the first year of the reporting period,

3. Member States shall report the most up-to-date projections available. Where a Member State does not submit complete projection estimates by 15 March every second year, and the Commission has established that gaps in the estimates cannot be filled by that Member State once identified through the Commission's QA or QC procedures, the Commission may prepare estimates as required to compile Union projections, in consultation with the Member State concerned.

4. Member States shall make available to the public, in electronic form, their national projections of greenhouse gas emissions by sources and removals by sinks along with relevant technical reports that underpin those projections. Those projections should include descriptions of the models and methodological approaches used, definitions and underlying assumptions.

App. A2.2.4. Biennial report and national communications

The Union and the Member States shall submit biennial reports in accordance with Decision 2/CP.17 of the Conference of the Parties to the UNFCCC (Decision 2/CP.17), or subsequent relevant decisions adopted by the bodies of the UNFCCC, and national communications in accordance with Article 12 of the UNFCCC to the UNFCCC Secretariat.

ANNEX 3. CRITERIA FOR PRIORITIZATION OF THE PROPOSED MEASURES AND ACTIONS FROM THE CLIMATE CHANGE MITIGATION ACTION PLAN

A3.1. INTRODUCTION

The national mitigation action and planning in the Republic of Macedonia, either developed through National Appropriate Mitigation Actions (NAMAs) as part of the UNFCCC process as non-annex I country, or through taking over more ambitious targets through acceding to Annex I and Doha amendment as part of EU negotiation process, will have to be selected and measured based on criteria relevant to the local circumstance. Properly implementing measures and actions will enable recognition of the mitigation efforts of the country, as well as will link the national mitigation action to international support. The results would also support competent and wise policy making in the field of climate change and will enhance the positions of the Republic of Macedonia in the climate change negotiation process at international, as well as at European level. Meanwhile, clever choice of proper actions and measures may also result in creation of new economy sectors, increase of employment, beneficial results to regional development, decrease of health costs, tempering the adaptation costs etc.

The measures can be divided into existing measures and additional measures. Existing measures are those already implemented, planned to be implemented or that will certainly happen, either because of the spill over effect (Republic of Macedonia is a small market, and even if it does not always apply EU standards, the local market will tend to follow since it might be too expensive to have special standards), or due to planned political process of integration. Existing measures cannot be prioritised since they are already ongoing. Additional measures are those measures that are not yet implemented, or not even seriously contemplated, and the criteria are most relevant to their eventual selection. These are the measures that have to be prioritized.

These measures can be thus lumped into following three scenarios:

- With existing measures - **WEM scenario** which is the one with measures
- With additional measures – **WAM scenario** which is the one that will have additional measures
- Without measures – **WOM scenario** which assumes no mitigation action is undertaken and serves as a reference when identifying the achievements (mainly emissions reduction) of the other scenarios

The criteria for prioritization of proposed measures and actions should include the following:

- Environmental effectiveness (abatement volume per measure)
- Economic effectiveness (measure specific abatement cost)

- Feasibility (measure easiness of implementation)
- Measurability (measurability and verifiability of the measure emissions reductions)
- Co-benefits (health benefits, diversification of income, new jobs, life quality, economic growth potential)

The main goal of this assignment is to provide guidance and criteria for prioritization of proposed additional measures from the climate change mitigation action plan.

A3.2. CRITERIA FOR PRIORITIZATION OF THE PROPOSED MEASURES AND ACTIONS FROM THE CLIMATE CHANGE MITIGATION ACTION PLAN

The most important criterion for measures will be **environmental effectiveness**, or abatement potential given in volume of GHG reduction achieved annually with implementation of the given measure/practice, expressed in t_{CO2eq}. The criterion will enable to understand how much can be reduced by a particular measure or action. Some measures may be negligible in their environmental effectiveness, and not being worth to consider regarding climate change mitigation action plan.

The implementation of measures and actions will have different specific abatement cost (cost per mitigated t_{CO2eq}). This specific cost would then constitute the second criterion, **economic effectiveness** of measures and actions. Some measures may actually have negative specific cost, and should be given priority. Nevertheless, some measures with lower economic effectiveness should also be implemented up to a level, since that may influence the learning curve of the proposed measure, improving the economic effectiveness of a particular measure later on. Also, some may be much easier to implement. Also, the criterion may take into account not only the specific cost of measure to the investor, but also those external costs and benefits which can be easily internalised, as for example system costs, external costs related to health, global warming etc. This analysis may end up being rather complicated, so a set of simplifications are possible.

These two criteria may then be visualized using abatement cost supply curve methodology to decide which measures and actions have higher environmental and economic effectiveness. Although highly important, these two criteria are not sufficient for comprehensive assessment. Indeed, to better inform policy and strategic action it is critical to explore and evaluate the abatement measure **feasibility**, since there might be cases when mitigation efforts with high economic and/or environmental effectiveness cannot be realized due to country-specific barriers, be they financial, institutional, legislative, administrative or technical ones (infrastructures and supply chain gaps, involvement of many stakeholders with different interests, as well as, lack of relevant data, studies and knowledge in general). The feasibility may also depend on timing, some measures and actions becoming feasible at later time.

Furthermore, in light of the Measuring, Reporting and Verification (MRV) as an essential element of NAMAs, **measurability** of the achieved emissions reductions should act as a partial determinant of the policy decisions that are guided and bolstered by the mitigation achievements (including policy decisions for appropriate country specific emission reduction/limitation targets). Moreover, associating measurement methodologies to the mitigation action will open possibilities for linking the national mitigation actions to international support (which is among the topics of the international negotiations about the future of the climate regime). Meanwhile, a measure and action whose results cannot be properly measured and verified may also be implemented, due to other possible benefits, or long term benefits.

Finally, it is becoming clear that **co-benefits** can help to make the economic case for climate change mitigation measures. Hence, some of the co-benefits associated with climate change mitigation strategies are directly related to human health, including:

- Improved air quality due to reduced emissions of air, water and soil pollutants from agriculture, mining, industry, power generation, transport, households, services, waste and waste water treatment
- Increases in the amount of physical exercise carried out by the population in general due to a shift to non-motorised transport modes (cycling and walking)
- Reductions in the number and/or severity of traffic accidents (e.g. through speed reduction policies)
- Reduced ambient noise levels due to quieter low-carbon vehicles (e.g. electric vehicles)
- Indirect effects related to the life cycle effects of vehicles, energy carriers or infrastructure

Some of the health benefits may be internalised through external costs methodology, but some may not have enough data available. Those benefits that are not internalised have to be taken into account in other ways.

Other co-benefits associated with climate change mitigation strategies, particularly the reinforcement of low carbon fuels, include diversification of income in rural areas and creating of new jobs, as well as enabling new economy sectors, reduction of subsidies, more equity based society, etc. These co-benefits may be very significant because they may answer to the issue stemming from sustainable development, economic and social policy. These co-benefits should be taken into account although their internalisation may be difficult.

Thus, the criteria may be grouped as following:

- Environmental effectiveness (mitigation volume per measure)
- Economic effectiveness (measure specific cost of mitigation)
- Feasibility (measure easiness of implementation)
- Measurability (measurability and verifiability of the measure emissions reductions)
- Co-benefits (health benefits, diversification of income, new jobs, life quality, economic growth potential)

The criteria will be more thoroughly analysed in this chapter.

A3.2.1. Environmental effectiveness

It should be possible to estimate the abatement potential or the volume (t_{CO2eq}) of greenhouse gas (GHG) emission reductions per each action and measure to be considered in each of the scenarios. The volume of emission reduction of a particular measure will be calculated on the basis of comparing scenario without a particular measure and with, and the difference in emission will constitute the reduction volume.

The potential reduction volume may vary in time, usually increasing as the time goes. Some measures may have only temporary mitigation impact though. For example, measures advancing energy efficiency may create rebound effect where there will be increase of use of activity, cancelling the mitigation effect.

The environmental effectiveness of each individual measure — that is, the quantity of GHG emissions saved as a result of its implementation — can be estimated in relation to a logical baseline (assuming that the measure in question has not been implemented). Specifically, the released amounts of a GHG gas *g* in a year *i* from a specific emission source can be calculated using the following general equation:

$$E_{g,i} = A_i \cdot EF_g \qquad (1)$$

where:

- $E_{g,i}$ is the emissions of a GHG gas g in year i associated with the emissions source in question;
- A_i are the activity data that refer to the source of GHG emissions in question in the corresponding year y; and
- EF_g is the emission factor of the GHG gas g attributed to the source of emissions in question.

The total emission reduction of the measure is thus:

$$E = \sum_g \sum_{i=1}^{n} E_{g,i} \qquad (3)$$

The average yearly emission reduction E_0 of the measure is:

$$E_0 = E / n \qquad (4)$$

Any measure planned for reducing GHG emissions from a particular source aims to reduce the activity data (e.g. energy conservation measures in buildings) and/or the corresponding emission factors (e.g. the substitution of fossil fuels with renewable energies). The effectiveness of an intervention planned for reducing GHG emissions can therefore be estimated by implementing equation (1) twice: the first run assumes that the measure in question is not implemented and constitutes the baseline of the analysis (without measure); while the second run assumes a specific degree of implementation of the measure in question affecting the activity data and/or the emission coefficients (with measure). The difference between these two runs shows the GHG emissions abatement potential that can be achieved.

A reduction in activity data associated with a specific source of GHG emissions can be achieved through interventions that aim to increase the efficiency of existing technologies, enhance the penetration of clean and more efficient technologies, improve the implemented processes, reduce demand through behavioural changes, etc.

On the other hand, a reduction in emission coefficients can be achieved primarily through the promotion of cleaner fuels and renewable energy sources, and secondarily through the exploitation of advanced technologies.

Information on how a specific intervention influences activity data is strongly dependent on the technical characteristics of the measure, the level of its implementation/penetration, as well as national circumstances in the sector. Very often, certain assumptions must be made in order to estimate quantitative changes in activity data as a result of the implementation of a specific measure. Emission coefficients are differentiated on the basis of the fuel (particularly CO_2, but also other GHGs) and the technology (mainly non-CO_2 gases) used, as well the emissions source concerned (mainly non-CO_2 gases). Information on emission coefficients can be derived from national inventory report (NIR) as well as from the IPCC guidelines and guidelines on the EEA's Core Inventory Air Emissions (CORINAIR).

A3.2.2. Economic effectiveness

Each measure should have its specific cost calculated (cost per reduced t_{CO2eq}). In general, the economic evaluation of individual GHG emissions abatement measures comprises of calculation of specific or levelized abatement cost of measure:

$$C = \frac{C_0}{E_0} \tag{5}$$

where C_0 is annualised cost of the measure and E_0 is average yearly emission reduction.

In order to calculate the annualised cost of the measure, following procedure may be taken:

The definition of technological project parameters and evaluation assumptions. All the technical characteristics of the project under evaluation, such as capacity, efficiency, the qualitative and quantitative characteristics of inputs and outputs, etc., are recorded in detail. In addition, the evaluation period is specified and a discount rate is selected in order to reduce the various cost and benefit elements to a common base.

The determination of the project cost and benefit components. This analysis involves the recording of all the cost and benefit components that determine the financial return of the project/measure examined. Specifically, these cost components usually refer to initial (investment) expenditures, maintenance and operation costs, the cost of labour, costs of replacement etc. Similarly, the benefit components comprise potential revenues arising from the operation of the project, such as energy savings in the case of energy conservation measures, etc. It is usually relatively easy to determine both these components on the basis of market data and existing experience. Costs and benefits resulting from changes in environmental quality, health expenditure or from impacts on other social goods due to the implementation of the project in question can also be taken into account, so called external costs and benefits. However, their quantification presents significant methodological difficulties.

The calculation of net present value. The time allocation of cost and benefit components over the lifecycle of the project under examination greatly affects the analysis results. An evaluation can only be made by incorporating timing considerations, which is done by tracing the incidence over time of costs and benefits and by using an appraisal method that takes this into account. In this context, the economic evaluation of a GHG emissions abatement measure under involves a comparison of financial cost/benefit flows and GHG emission reductions occurring at different points in time. The cost and benefit flows can be compared through the net present value (NPV):

$$\mathrm{NPV} = \sum_{i=0}^{n} \frac{C_i}{(1+r)^i} \qquad (6)$$

where r is the discount rate, C_i is the net cost (i.e. costs reduced by benefits) in year i, and n is the evaluation period of the project in number of years.

In order to obtain annualised cost of the measure following formula may be used:

$$C_0 = \mathrm{NPV}\frac{r}{1-(1+r)^{-i}} \qquad (7)$$

Sensitivity analysis. Sensitivity analysis tries to identify the parameters that most affect the outcome of project evaluation. Experience shows that very often the final project outcome differs significantly from the outcome initially expected. Usually, the parameters that can significantly alter the overall attractiveness of the project are the discount rate adopted; the investment costs, which in many cases increase due to unexpected transaction costs; the projected benefits after the operation of the project, etc. For all these factors, detailed sensitivity analyses should be undertaken in order to examine the reliability of the analysis.

The measure or action may be constituted of various individual projects, which may have different costs and benefits. If that variation is significant, it may make sense to calculate levelised abatement separately for different projects.

Visualisation of results. The environmental and economic effectiveness may be visualised using different graphs. A very useful one is marginal abatement cost curve, or just abatement cost supply curve, in which levelised abatement costs of measures are plotted against abatement potential. See the one produced my McKinsey in Figure 21.

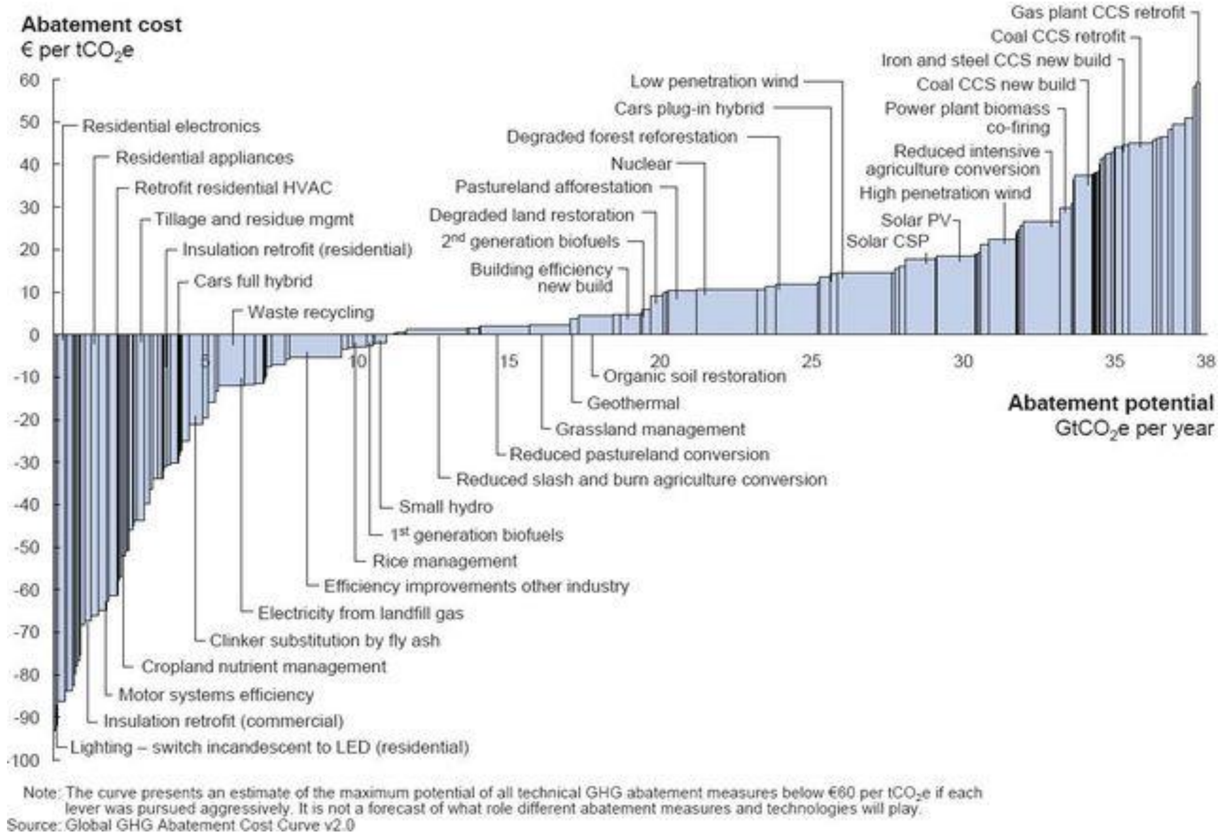

Figure 21. Abatement Cost Curve. Global GHG Abatement Cost Curve, v2.0. Source: WRI, Stabilization Wedges: Technologies and Practices for Climate Stabilization Transition Plan. After McKinsey & Co, Pathways to a Low-Carbon Economy, 2009.

The way that abatement cost curves are usually built has been criticized for its lack of transparency and the poor treatment it makes of uncertainty, inter-temporal dynamics, interactions between sectors and ancillary benefits. These may be added into calculation, but this may significantly complicate the process. For example, integration up to 15-20% of variable renewable energy sources (VRES) into power system fuel mix, may be adding little to the system costs, while adding more will add significant system costs, unless there is enough of flexible demand to match the variability of supply.

Another way of visualisation of environmental and economic effectiveness may be done by using sectoral potential for mitigation, as for example in Figure 22 or as in Figure 23.

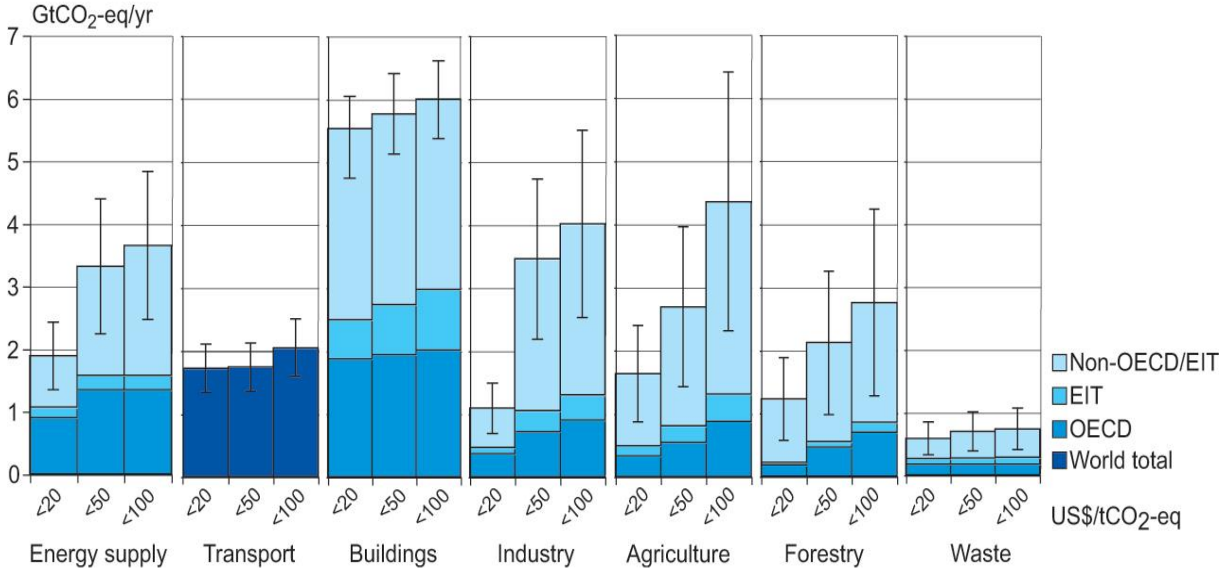

Figure 22. Sectoral potential for global mitigation for different regions. Source: Intergovernmental Panel on Climate Change (IPCC). IPCC Fourth Assessment Report: Climate Change 2007, Working Group III: Mitigation of Climate Change.

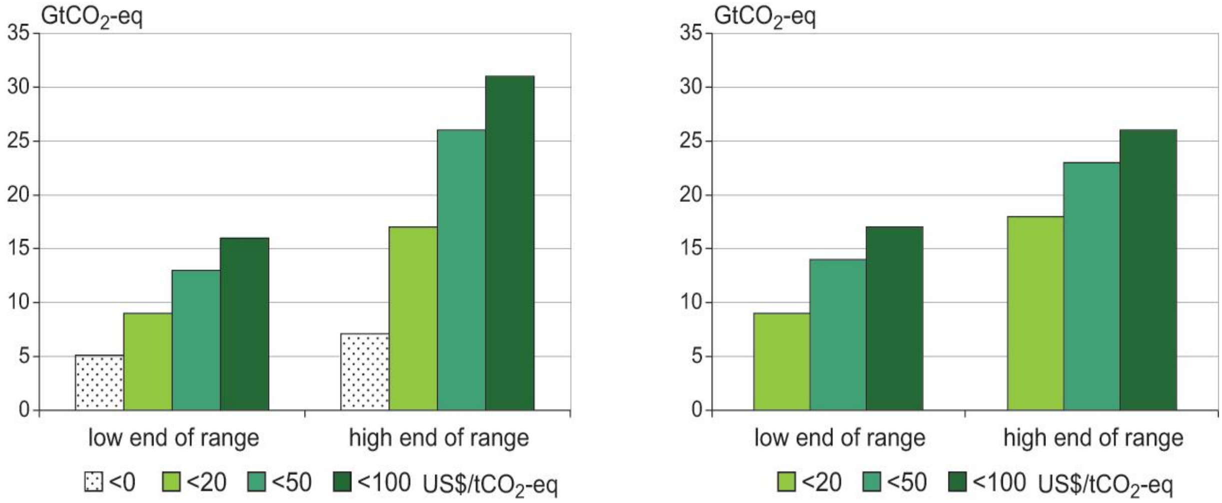

Figure 23. Global mitigation potential in 2030. Source: Intergovernmental Panel on Climate Change (IPCC). IPCC Fourth Assessment Report: Climate Change 2007, Working Group III: Mitigation of Climate Change.

A3.2.3. Feasibility

In order to better inform policy and strategic action it is critical to explore and evaluate the abatement measure feasibility, since there might be cases when mitigation efforts with high economic and/or environmental effectiveness cannot be realized due to country-specific barriers, be they financial, institutional, legislative, administrative or technical ones (infrastructures and supply chain gaps, involvement of many stakeholders with different interests, as well as, lack of relevant data, studies and knowledge in general). The feasibility may also depend on timing, some measures and actions becoming feasible at later time.

Currently unfeasible measures and actions may be then recalculated with the additional cost of making them feasible, or they can be given priority conditional on certain assumptions and conditions. Some measures and actions may be feasible up to a certain level, while higher volume may be depending on certain predisposition.

For example, coal for gas fuel substitution may be feasible up to the level of the capacity of the current pipeline capacity, while higher level of substitution is conditional on increased capacity of interconnectors. Similarly, coal for VRES fuel substitution can be feasible up to certain penetration of VRES, while the higher one is conditional on wholesale market higher system costs and more flexible demand.

In the long run all the measures are feasible in general, unless the unfeasibility is of physical nature, in which case they should not have been considered in the first case (for example considering hydro power where there is no hydro potential).

A3.2.4. Measurability

Measuring, Reporting and Verification (MRV) as an essential element of NAMAs the measurability of the achieved emissions reductions should act as a partial determinant of the policy decisions that are guided and bolstered by the mitigation achievements (including policy decisions for appropriate country specific emission reduction/limitation targets). Moreover, associating measurement methodologies to the mitigation action will open possibilities for linking the national mitigation actions to international support (which is among the topics of the international negotiations about the future of the climate regime). Meanwhile, a measure and action whose results cannot be properly measured and verified may also be implemented, due to other possible benefits, or long term benefits.

Typical measures that are difficult to measure and verify are voluntary measures and awareness raising measures. They should be probably anyway implemented due to cross-cutting benefits, but they will be difficult to count as NAMAs.

Also, modal shift measures may be difficult to assess prior to the implementation, because they also partially involve voluntary character of the shift.

Measures that are due to technology spill over effect are easier to measure and verify, but are usually difficult to predict. For example, improvement of EU car fuel economy standards will eventually have a spill over effect also on a neighbouring country, but the delay of transition may be difficult to plan for. Anyway, such measures do not have to prioritized, since they will happen anyway.

A3.2.5. Co-benefits

The **co-benefits** resulting from implementing measures and actions may help to make the economic case for climate change mitigation measures more attractive, balancing the additional costs with additional benefits. The co-benefits may include decrease of air, water and soil pollutants, improved treatment of waste, less noise pollution, which will improve health, environmental protection, biodiversity etc., but also improved energy security of supply, increased economic development, new employment, more balanced regional development, sustainable development etc.

Decrease of air pollution. Improvement of energy efficiency in transport, power generation, industry, and heating, substitution solid fuels with renewables and gas in power generation, industry heating, introducing alternative fuels in transport, improved waste and waste water recycling and treatment will decrease air pollution, including particulate emissions, CO, NOx, SOx, volatiles, etc. This will have significant financial results on health avoiding deaths and illnesses, decreasing the health cost, disablement benefits, early retirements etc. Also, it will effect on nature protection and to some species survival which are vulnerable to air pollution, thus improving the biodiversity. Also, reduction of SOx will reduce the negative effect of acid rains. These additional and external costs of air pollution are reasonably well documented, so they can be taken into account.

Decrease water and soil pollution. Improvement in power generation and waste and waste treatment will decrease the water pollution, decreasing the cost of fresh water treatment, irrigation water use, and increasing the biodiversity of rivers and the their value to the nation, since they can be used for other purposes. Less soil pollution increases the usable land coverage.

Improvement of waste and waste water treatment. Apart from reducing GHG emissions, proper waste recycling and treatment scheme will also generate significant additional income based on secondary materials, energy use of waste, and by decreasing the amount of waste ending in environment decreasing air, water and soil pollution.

Other health related co-benefits. Some other of the co-benefits associated with climate change mitigation strategies for the transport are directly related to human health, including:

- Increases in the amount of physical exercise carried out by the population in general due to a shift to non-motorised transport modes (cycling and walking)
- Reductions in the number and/or severity of traffic accidents (e.g. through speed reduction policies)
- Reduced ambient noise levels due to quieter low-carbon vehicles (e.g. electric vehicles)
- Indirect effects related to the life cycle effects of vehicles, energy carriers or infrastructure

Table 20. Estimated external costs of emissions in 2014 in Republic of Macedonia. South East European Consultants, Ltd., Study on the Need for Modernization of Large Combustion Plants in the Energy Community, November 2013

Code	Plant name	Fuel type	Power MW	Energy GWh/a	Emission - BAU			External costs – BAU				
					Pollutants emiss, t/year			Total costs, million €/year				Unit cost
					Dust	NO_x	SO_2	Dust	NO_x	SO_2	Sum	€c/kWh
1	Bitola 1	L	233	1,387	2,571	5,629	33,359	1.2	26.9	189.2	217	15.7
2	Bitola 2	L	233	1,387	4,448	5,699	27,104	2.0	27.3	153.7	183	13.2
3	Bitola 3	L	233	1,387	4,448	5,699	27,104	2.0	27.3	153.7	183	13.2
4	Oslomej	L	125	604	1,722	1,087	12,383	0.8	5.2	70.2	76	12.6
5	Negotino	FO	210	17	0	0	0	0.0	0.0	0.0	0	0.0
6	Skopje CHP	NG	227	1394	28	456	2	0.0	2.2	0.0	2	0.2
7	Kogel CHP	NG	30	185	4	72	0	0.0	0.3	0.0	0	0.2
Total			1,291	6,362	13,222	18,642	99,953	6	89	567	662	10.4

Some of the health benefits may be internalised through external costs methodology, but some may not have enough data available. Those benefits that are not internalised have to be taken into account in other ways. A very good source for assessing the external cost of current power generation sector per plant can be found in reference given in Table 20.

The specific external costs as calculated for Macedonian power plants are much higher than global value, what is the consequence of very high SOx emissions from those plants. Figure 24 gives values for EU for various power generation technologies.

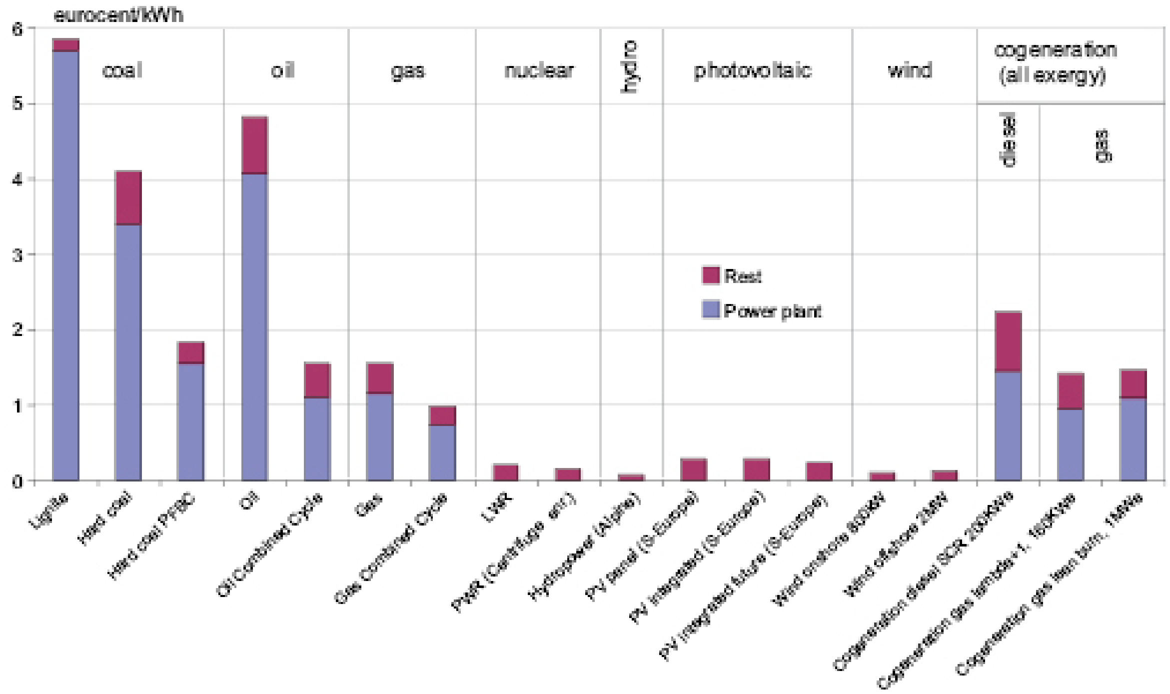

Figure 24. External costs (€/MWh) of current and more advanced electricity systems associated with emissions from the operation of the power plant and the rest of the fuel-supply chain (EU, 2005). 'Rest' is the external cost related to the fuel cycle (1 € = 1.3 US$ approximately). IPCC Fourth Assessment Report: Climate Change 2007

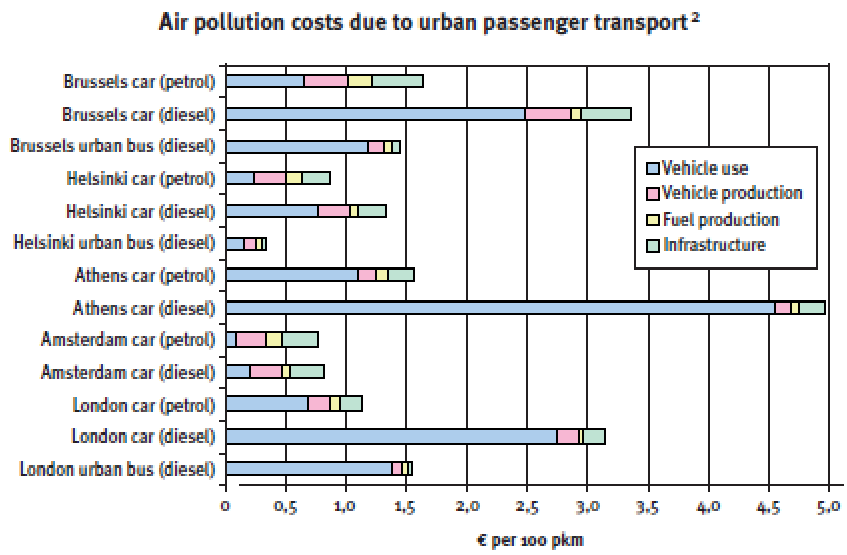

Figure 25. Air pollution costs due to urban passenger transport. European Commission, Directorate-General for Research, External Costs - Research results on socio-environmental damages due to electricity and transport, 2003

The specific external costs of different options for urban (Figure 25) and interurban (Figure 26) transport can visualize the significance of the issue.

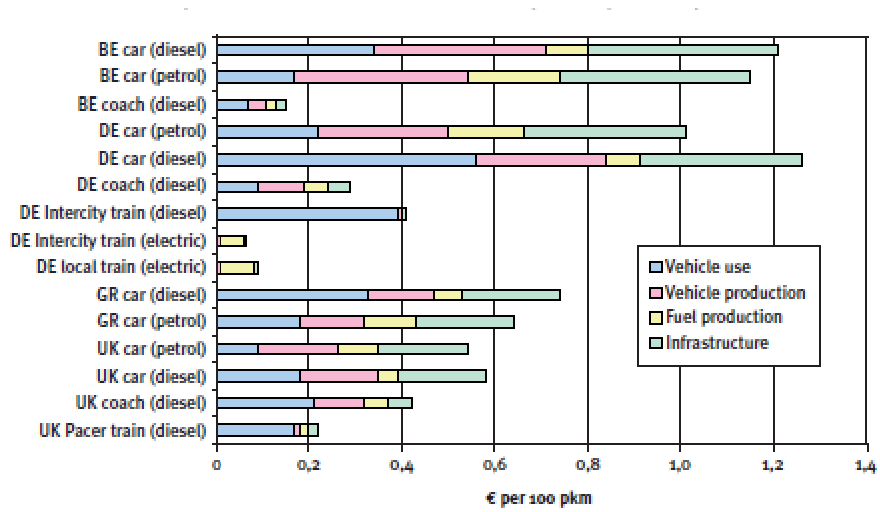

Figure 26. Air pollution external costs due to interurban passenger transport. European Commission, Directorate-General for Research, External Costs - Research results on socio-environmental damages due to electricity and transport, 2003

Other co-benefits associated with climate change mitigation strategies, particularly the reinforcement of low carbon fuels, include diversification of income in rural areas and creating of new jobs, as well as enabling green growth, creating entirely new economy sectors, reduction of subsidies, more equity based society, etc. These co-benefits may be very significant because they may answer to the issue stemming from sustainable development, economic and social policy. These co-benefits should be taken into account although their internalisation may be difficult.

	Average emplyment over life of facility (Jobs per megawatt of average capacity)		
	Manufacturing, construction, instalation	Operating & maintenance/ fuel processing	Total
Solar PV	5.76-6.21	1.20-4.80	6.96-11.01
Wind power	0.43-2.51	0.27	0.70-2.78
Biomass	0.40	0.38-2.44	0.78-2.84
Coal-fired	0.27	0.74	1.01
Natural gas-fired	0.25	0.70	0.95

Note: Based on findings from a range of studies published in 2001-04. Assumed capacity factor is 21% for solar PV, 35% for wind, 80% for coal, and 85% for biomass and natural gas.

Figure 27. Average employment over life of facility (jobs per MW of average capacity). UNEP, Green Economy Report, Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication, Chapter Renewable energy, Investing in energy and resource efficiency, 2011,

Employment. Some energy conversion technologies are more capital intensive, some have higher fuel costs, and some employ more people. The employment that is most relevant for the Republic of Macedonia is the local one, in operation and maintenance, fuel handling, project development, installation, investment and servicing. Only for some technologies the conversion equipment will be produced locally.

Meanwhile, some old technologies may actually employ more than new, but such employment is precarious, and with low productivity. European coal sector is in general much less productive then one in US, South Africa, Australia and Canada, as shown in Figure 28. The consequence is that domestic coal is being often replaced by imported one, which improves productivity, but replaces most of local jobs with foreign ones.

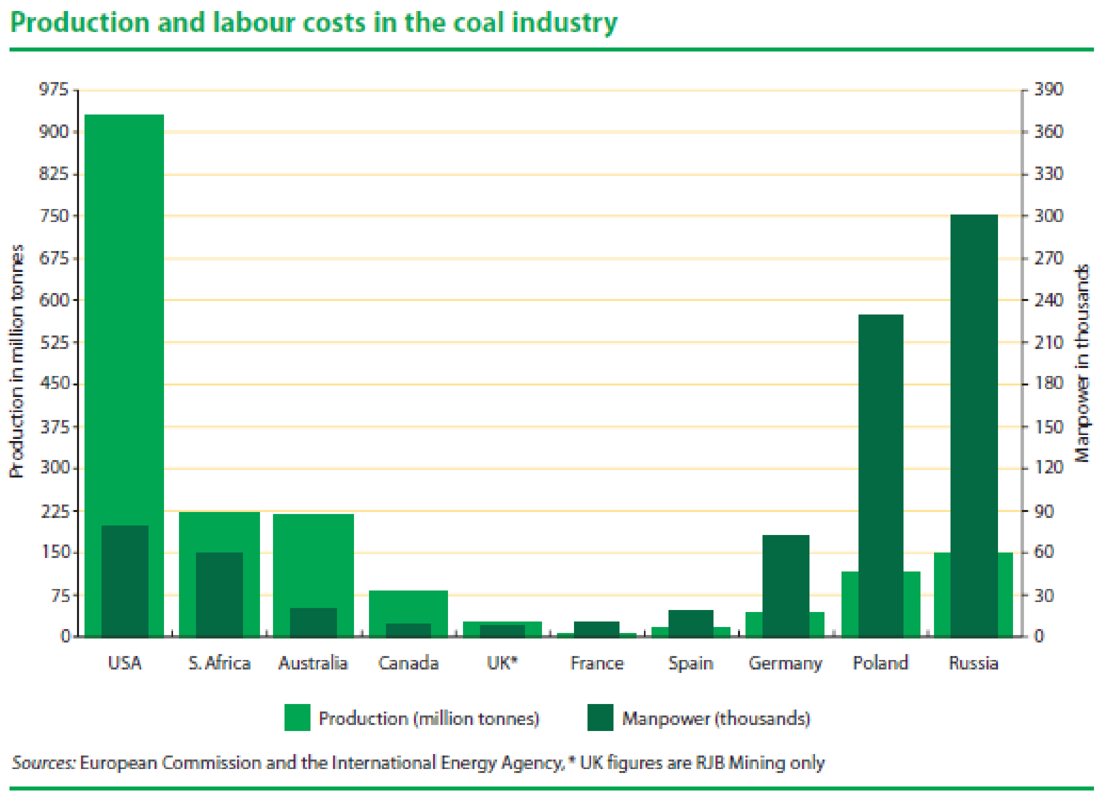

Figure 28. Production and labour costs in the coal industry. EU Green Paper on the security of energy supply, 2000

Creating more jobs will be good for equity. Biomass will for example be good for rural jobs, more regional development and more sustainable development. Renewables will create wholly new economic sectors. More equity will enable to reduce the energy subsidies.

Energy security of supply. Having in mind that any measure action should not be significantly detrimental to energy security of supply. Energy security of supply has several time categories, the instantaneous, medium term and long term. The instantaneous enables secure delivery of electricity by frequency control, and which is a technical issue that can be easily solved, but has its costs. The medium term is linked with fuel delivery chains, and is a logistical one which can be easily solved, but again has its costs. The one that is of huge importance to the national development and even sovereignty is the long term energy security of supply which involves local primary energy production and import capacities. While the diversified imports may help the energy security of supply up to a point, depending too much on imported energy may be seriously detrimental to long term development. So, local coal and renewables are beneficial to energy security of supply, while imported coal is not.

A3.2.6. Procedure for prioritization of the proposed measures and actions from the climate change mitigation action plan

The measures are divided into existing measures and additional measures. Existing measures are those already implemented, planned to be implemented or that will certainly happen. **Existing measures cannot be prioritised since they are already ongoing.**

Additional measures are those measures that are not yet implemented, or not even seriously contemplated, and the criteria are most relevant to their eventual selection. **These are the measures that have to be prioritized.**

The abatement cost supply curve should be compiled for 5 or 10 year period until 2030, taking into account known external costs, and not including those actions and measures that are not feasible. The actions and measures that are more feasible should be given priority, even at higher specific abetment cost. Also, actions and measure that are measurable and verifiable should be given priority over those that are not. Measures and actions that are producing higher co-benefits, especially in employment and health (the part that is not internalised), should be given higher priority, even when having higher specific costs.

Possible new value chains based on low carbon economy should be devised. The potential of the green growth should be estimated.

A3.3. CONCLUSIONS

The national mitigation action and planning in the Republic of Macedonia, either developed through National Appropriate Mitigation Actions (NAMAs) as part of the UNFCCC process as non-annex I country, or through taking over more ambitious targets through acceding to Annex I and Doha amendment as part of EU negotiation process, will have to be selected and measured based on criteria relevant to the local circumstance. Properly implementing measures and actions will enable recognition of the mitigation efforts of the country, as well as will link the national mitigation action to international support.

The measures are divided into existing measures and additional measures. Existing measures are those already implemented, planned to be implemented or that will certainly happen. **Existing measures cannot be prioritised since they are already ongoing.**

Additional measures are those measures that are not yet implemented, or not even seriously contemplated, and the criteria are most relevant to their eventual selection. **These are the measures that have to be prioritized.**

The criteria for prioritization of proposed measures and actions should include the following:

- Environmental effectiveness (abatement volume per measure)

- Economic effectiveness (measure specific abatement cost)
- Feasibility (measure easiness of implementation)
- Measurability (measurability and verifiability of the measure emissions reductions)
- Co-benefits (health benefits, diversification of income, new jobs, life quality, economic growth potential)

This assignment has provided guidance and criteria for prioritization of proposed additional measures from the climate change mitigation action plan.

The abatement cost supply curve should be compiled for 5 or 10 year period until 2030, taking into account known external costs, and not including those actions and measures that are not feasible. The actions and measures that are more feasible should be given priority, even at higher specific abetment cost. Also, actions and measure that are measurable and verifiable should be given priority over those that are not. Measures and actions that are producing higher co-benefits, especially in employment and health (the part that is not internalised), should be given higher priority, even when having higher specific costs. Possible new value chains based on low carbon economy should be devised. The potential of the green growth should be estimated.

ANNEX 4. PROPOSAL FOR SOCIALLY SENSITIVE MITIGATION MEASURE IN ROAD TRANSPORT – CO2 BASED EXCISE TAX FOR PASSENGER CARS

A4.1. INTRODUCTION

The registration excise tax proposal for old passenger cars prepared by the car sellers association was studied and found to be rather socially insensitive. Distinguishing tax mainly by the car production year the proposed methodology will disproportionately hit the poorer segments of population, taxing with much higher rate smaller passenger cars than bigger cars. Furthermore, although use of production year and engine size is used as proxy for environmental friendliness of the car, this methodology does not take into account appropriately the actual quality of technology implemented in the car, since it is better represented by Euro standard and CO_2 emission per km. On the other side, the proposed methodology recognizes hybrid and electric vehicles, but this aspect is not so relevant given the prospective relatively low breakthrough of these technologies in in the Republic of Macedonia in foreseeable future.

Basing excise tax on CO_2 emissions is more environmentally and socially sensitive, since it does place higher tax on stronger cars which pollute more even if the best technology is employed. It is also environmentally beneficial to combine CO_2 emission criterion with Euro standard criterion, taxing more the cars without Euro standard and the ones with older standards. Apart from this, the combination of CO_2 emission and Euro standard criteria also serves well as a proxy for vehicle production year.

Passenger car excise tax is a tax levied on the car at the time of registration, best applied on yearly basis. The tax may serve administering the registration system, building roads and mitigating the local pollution and climate change effects caused by transportation. Passenger car excise tax should be devised in a way that it is proportional to the vehicle value, its use of roads, and its environmental impact. Also, it should be socially sensitive so that it enables car ownership of a wider community. The government should use the tax as a tool to influence the car ownership pattern in concordance with the national development, energy and environmental strategies, but also to support local jobs in sales and service network. On one hand it is in the interest of country to increase the affordable car ownership, in order to enable more economic activity, on the other hand, these cars should not have detrimental impact on environment and security of energy supply. A significant phenomenon of importing used cars is understandable with regards to the level of GDP and incomes in the Republic of Macedonia. Meanwhile, the excise tax may be used to streamline these imports towards more efficient cars emitting less carbon dioxide and other pollutants, while in the same time staying socially sensitive.

This chapter will propose such a passenger cars excise tax, to be levied on all passenger cars at the point of yearly registration. It will take into account 4 criteria, vehicle CO_2 emission per km, exhaust emission level standard, engine size and vehicle value. The model is open to fine-tuning. It may later be easily extended to motorcycles and light duty commercial vehicles.

The report is accompanied with a xls table calculator for passenger car excise tax calculations and fine-tuning. Yellow highlighted cells may be used to fine tune model, while green highlighted cells should be used to check on the excise tax of a particular car model.

A4.2. PASSENGER CAR EXCISE TAX

The proposed passenger car excise tax, to be levied on all passenger cars at the point of yearly registration, is based on having an absolute maximum motor vehicle excise tax, denoted here as tmax. Depending on the proposed criteria, each vehicle will only have to pay a fraction of this amount.

It is proposed to take into account 4 criteria: vehicle CO_2 emission [g_{CO2}/km], exhaust emission level standard [level], engine size [cm^3] and vehicle value [MKD]. Each criterion should be given weighting factor. It is proposed to weight vehicle CO_2 emission with 50%, exhaust emission level (Euro standard) with 25%, vehicle value with 15% and engine size with 10%, but these may also be fine-tuned. Each of the criteria carry a value between 0 and 1, or between 0% and 100%, smaller value meaning that those vehicles should be less taxed for this criterion, and higher value that they should be higher taxed for that particular criterion.

If we denote component factor related to criteria with f, f_{CO2} standing for vehicle CO_2 emission, f_{Euro} for exhaust emission level standard, f_s for engine size and f_v for vehicle value, and weighting factors w_{CO2}, w_{Euro}, w_s and w_v, we obtain the actual excise tax t for an individual car:

$$\mathbf{t = t_{max} \times (f_{CO2} \times w_{CO2} + f_{Euro} \times w_{Euro} + f_s \times w_s + f_v \times w_v)\ [MKD]}$$

where:

t	- amount of passenger car excise registration tax [MKD]
t_{max}	- maximum passenger car excise registration tax [MKD]
f_{CO2}	- vehicle CO_2 emission component factor
w_{CO2}	- vehicle CO_2 emission weighting factor
f_{Euro}	- exhaust emission level standard component factor
w_{Euro},	- exhaust emission level standard weighting factor
f_s	- engine size component factor
w_s	- engine size weighting factor
f_v	- vehicle value component factor
w_v,	- vehicle value weighting factor

Proposed value of maximum passenger car excise registration tax is 10000 MKD.

A4.2.1. Passenger car CO_2 emission

Passenger car CO2 emission value is available for most of models since 2001, based on such a car being sold (make, model, year) in the Republic of Macedonia or declaration from the producer, which should then be delivered by the car owner. In case of imported cars without such a declaration it is assumed that the vehicle has emission of 301 g_{CO2}/km, which is the maximal value It is the responsibility of the owner to prove that the car has lower emissions than that. If he is unable to prove it with legally acceptable documentation, he will be charged the maximum rate.

The government may decide to build a catalogue in order to simplify the taxation. Such catalogue should have each make, model and year included with the CO_2 emission.

The government may also decide to use such online catalogues compiled by other governments.

Table 21 gives the values of proposed factor for this criterion. All the values may be fine-tuned.

Table 21. Vehicle CO_2 emissions [gCO_2/km], weighting factor, w_{CO2} = 50%

From [gCO_2/km]	Till [gCO_2/km]	f_{CO2}
0	90	0%
91	100	3%
101	110	7%
111	120	10%
121	130	21%
131	140	34%
141	160	48%
161	180	55%
181	200	62%
201	225	72%
226	250	79%
251	300	93%
301		100%

A4.2.2. Exhaust emission level standard

Exhaust emission level standard, as defined by Euro standard, should strongly penalize older car models. Especially vehicle produced before (1993) or outside the Euro standard should be highly taxed. Also, those produced under Euro 1 (before 1996), Euro 2 (before 2000), Euro 3 (before 2005) should be additionally taxed. Those produced under later standards (Euro 4-6) should not be additionally taxed.

Table 22 shows proposed values of component factor related to the car Euro standard level.

Table 22. Exhaust emission standard [Euro level], weighting factor, wEuro = 25%

Euro standard level	f_{Euro}
Euro 6	0%
Euro 5	0%
Euro 4	0%
Euro 3	17%
Euro 2	33%
Euro 1	50%
non Euro	100%

A4.2.3. Engine size

Engine size [cm^3] is a criterion that takes into account the higher environmental impact of larger vehicle, even when they are new and up to date technologically. This criterion is also socially sensitive, since smaller vehicles will be less taxed.

Table 23. Engine size [cm3], weighting factor, ws = 10%

From [cm^3]	Till [cm^3]	f_{CO2}
0	750	25%
751	1400	50%
1401	2000	75%
2001		100%

A4.2.4. Passenger car value

The passenger car value should be an important criterion for excise tax, since it is fully socially sensitive, and also maximizes tax collection without reducing economic activity.

Car value is a price of new such vehicle sold in the Republic of Macedonia. If such car is not sold in Macedonia, then a price of similar car, based on Customs office estimate should be used. The source of the data for estimation of such values should be the responsibility of car dealers, even for the models and years not sold in Macedonia. They will generally have interest in reporting correct values for the particular car make, since they usually also service them. Only vehicle makes not sold as new in the Republic of Macedonia will have to be established by Customs office, or may also be established by the association of car dealers and service.

It would not be good to use the current value of the vehicle, as it is done in some countries, since that would be too beneficial for old discounted vehicles which are less environmentally favourable.

Table 24. Vehicle value [MKD], weighting factor, wv = 15%

From [MKD]	Till [MKD]	f_v
0	800000	7%
800001	1200000	14%
1200001	1600000	29%
1600001	2000000	43%
2000001	2400000	50%
2400001	2800000	57%
2800001	3200000	64%
3200001	3600000	79%
3600001	4000000	86%
4000001		100%

A4.3. CONCLUSIONS

A new passenger car excise tax is proposed, based on vehicle CO_2 emission per km, exhaust emission level standard, engine size and vehicle value. The model is open to fine-tuning. It may later be easily extended to motorcycles and light duty commercial vehicles.

Basing excise tax on CO_2 emissions is more environmentally and socially sensitive, since it does place higher tax on stronger cars which pollute more even if the best technology is employed. It is also environmentally beneficial to combine CO_2 emission criterion with Euro standard criterion, taxing more the cars without Euro standard and the ones with older standards. Apart from this, the combination of CO_2 emission and Euro standard criteria also serves well as a proxy for vehicle production year, taxing very old cars on the basis of their Euro standard, and medium old cars on the basis of CO_2 emissions.

APPENDIX A4.1. VEHICLE CO_2 EXCISE CALCULATOR (EXCEL TOOL)

Maximumexcise tax	10000	MKD

Four parameters are taken into account, vehicle value, vehicle CO2 emissions, engine size and exhaust emission level standard.
Each is given fractual importance, from 0%-100%, so that the sum all importance of all 4 parameters must be 100%.
Each parameter is scale, and the scale is given tax weight from 0% to 100%.

Vehicle CO2 emissions, gCO2/km

Weighting factor, wCO2		50%
from	till	fCO2
0	90	0%
91	100	3%
101	110	7%
111	120	10%
121	130	21%
131	140	34%
141	160	48%
161	180	55%
181	200	62%
201	225	72%
226	250	79%
251	300	93%
301		100%

Vehicle CO2 emission value based on
such a car being sold (make, model, year)
in Macedonia or declaration from producer.
Imported cars without such a declaration
are assumed to have emission of 301 gCO2/km.

Exhaust emission level, standard

Weighting factor, wEuro		25%
	fEuro	
Euro 6	0%	
Euro 5	0%	
Euro 4	0%	
Euro 3	17%	
Euro 2	33%	
Euro 1	50%	
non Euro	100%	

Engine size, cm3

Weighting factor, ws		10%
from	till	fs
0	750	25%
751	1400	50%
1401	2000	75%
2001		100%

Vehicle value, MKD

Weighting factor, wv		15.00%
from	till	fv
0	800000	7%
800001	1200000	14%
1200001	1600000	29%
1600001	2000000	43%
2000001	2400000	50%
2400001	2800000	57%
2800001	3200000	64%
3200001	3600000	79%
3600001	4000000	86%
4000001		100%

Vehicle value is a price of new such car
sold in Macedonia. If such car is not sold
in Macedonia, then a price of similar car,
based on Customs office estimate.

Calculator

Vehicle value	MKD	1800000	43%	6.45%
CO2 emission	gCO/km	301	100%	50%
Engine size	cm3	2000	75%	8%
Exhaust emission	standard	Euro 3	17%	4%
Total	MKD	6820		68.20%

Previous proposal for excise tax was based on model production year, engine size and engine type.
Using CO2 and other emissions can replace model production year and engine type in a more environmentally
friendly way. Euro standard will strongly penalize older car models, while CO2 emissions will penalize
all cars which are not really new.

While engine size is a good proxy for social acountability, even better one is price of a car of the particular model.
The price of a car can be based on a price of a new car of the model sold in Macedonia, or previously sold.
Distributors for makes (for example VW, Toyota, etc) that are sold in Macedonia will provide those prices.
For makes that are not sold in Macedonia Customs office will estimate price on the basis of similar cars sold in Macedonia.

Alternatively, the price of car can be based on actual car value as estimated by Customs office at import time.
Such an approach would lower the car for old used cars.

Yellow highlighted cells may be used to fine tune model.
Green highlighted cells should be used to check on the excise tax of a particular car model.