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THE SECOND NATIONAL COMMUNICATION ON CLIMATE CHANGE

February 2015

MONTENEGRO
Ministry of Sustainable Development and Tourism

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MINISTRY OF SUSTAINABLE DEVELOPMENT
AND TOURISM

THE SECOND NATIONAL COMMUNICATION ON CLIMATE CHANGE OF MONTENEGRO TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC)

The Second National Communication on Climate Change was prepared as a joint project by the Government of Montenegro and the Centre for Sustainable Development, Office of the United Nations Development Programme (UNDP) in Montenegro, and was funded by the Global Environment Fund (GEF).

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FOREWORD

The Second National Communication on Climate Change of Montenegro to the United Nations Framework Convention on Climate Change has been produced by the Ministry of Sustainable Development and Tourism, in cooperation with UNDP, i.e. the Centre for Sustainable Development.

Montenegro joined the United Nations Convention (UNFCCC) through succession, in 2006, and on 27 January 2007 it became the full Convention member as a non-Annex 1 country. Also, Montenegro ratified the Kyoto Protocol on 27 March 2007 and on 2 September 2007 became non-Annex B member of the Protocol, which means that it still does not have quantified requirements for reduction of GHG emissions.

As a party to the Convention, Montenegro is required, among other things, to produce, update and publish reports on the national greenhouse gases inventory, in line with the agreed methodology, as well as a report on vulnerability of natural resources and economy caused by climate change. Fulfilling its commitments, Montenegro adopted and delivered the Initial National Communication on Climate Change to UNFCCC Secretariat in May 2010.

Reporting to the United Nations Framework Convention on Climate Change (UNFCCC) is primarily an international commitment of Montenegro, shared by all parties to the international agreement. However, the process of producing the communication can be observed also from the aspect of European integration in the field of climate change, as it actually represents a significant part of necessary capacity building in this field as well as of necessary synergy of key sectors, which is a prerequisite for alignment of the national policy with ambitious EU goals.

This communication is the Second National Communication on Climate Change of Montenegro to UNFCCC and has been produced also with the support from GEF. The purpose of this report is to update and supplement information provided in the Initial National Communication on Climate Change to UNFCCC, and particularly chapters on national circumstances, national GHG inventory, policies and measures for climate change mitigation, vulnerability to climate change and steps taken to adapt to climate change impact, including information that should contribute to raising public awareness on climate change and information related to education, training, research and development in this field and other relevant data.

Preparation of the Second National Communication on Climate Change to UNFCCC has contributed to the strengthening of capacities within Montenegrin institutions for preparation of future communications as well as to the decision-making process in the course of preparation and adoption of policies and measures, not only in the environment sector, but also in other relevant sectors, such as energy, transport, industry, tourism, agriculture, water management, forestry and waste management.

We would like to emphasize that the general public was consulted, numerous local experts participated, a team of scientists from the University of Montenegro was involved, consultations with relevant institutions were held and a public debate was organised in preparation of this complex document.

By fulfilling the commitment of reporting to the key international agreement in the field of climate change, Montenegro is a step closer to definition of the specific climate policy with a clear vision of possibility to reduce emissions of greenhouse gases.

Branimir Gvozdenovic,
Minister of Sustainable Development and Tourism

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ABBREVIATIONS

AMS	Automatic Meteorological Station
AOGCM	Atmospheric-Oceanic General Circulation Model
APEC	Asia-Pacific Economic Cooperation
ASEAN	Association of Southeast Asian Nations
AU	African Union
BAT	Best Available Techniques
BaU	Business as usual
BDP	Gross Domestic Product
CAMP	Coastal Area Management Programme
CNG	Compressed Natural Gas
CBA	Cost-Benefit Analysis
CEM	Clean Energy Ministerial
CF_4	Carbon Tetrafluoride
C_2F_6	Carbon Hexafluoride
CH_4	Methane
CKCG	Montenegro Red Cross
ClimateADAPT	European Climate Adaptation Platform
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_{2eq}	Equivalent Carbon Dioxide
CSLF	Carbon Sequestration Leadership Forum
CTCN	Climate Technology Centre and Network
DMCC	Drought Management Centre for South East Europe
DSM	Demand Side Management
EBRD	European Bank for Reconstruction and Development
EBU-POM	Regional Climate Model
EE	Energy Efficiency
EDSM 2030	Energy Development Strategy of Montenegro until 2030
EQ	Ellenberg Climate Coefficient
EPCG	Montenegrin Electric Enterprise
ESCO	Energy Service Companies
EU	European Union
EU ETS	EU Emission Trading Scheme
EZ	Energy Community
FWI	Fire Weather Index
G20	Group of Twenty
GBEP	Global Bioenergy Partnerships
GCF	Green Climate Fund
GEF	Global Environmental Fund
3GF	Global Green Growth Forum
GGGI	Global Green Growth Institute
GHG	Greenhouse Gasses
GIS	Geographic Information System
GIZ	(Germ. Deutsche Gesellschaft für Internationale Zusammenarbeit) German International Cooperation
HE	Hydropower Plant
HFC	Hydrofluorocarbons
HS	Hydrological Station
IBRD	International Bank for Reconstruction and Development
ICID	International Cooperative Initiatives Database
IEA	International Energy Agency
ILO	International Labour Organisation
IPHM	Institute for Public Health of Montenegro
IMELS	Italian Ministry for Environment, Land and Sea
IPA	Instrument for Pre-Accession Assistance
IPARD	Instrument for Pre-Accession Assistance in Rural Development
IPCC	Intergovernmental Panel for Climate Change
IPEEC	International Partnership for Energy Efficiency Cooperation
IRENA	International Renewable Energy Agency
IHSM	Institute of Hydrometeorology and Seismology of Montenegro
KAP	Aluminium Plant Podgorica

KfW	German Development Bank
LAS	League of Arab States
LEAP	Long-Range Energy Alternatives Planning
LPG	Liquefied Petroleum Gas
LSU	Livestock Unit
LUCF	Land Use Change and Forestry
MEEC	Montenegrin Energy Efficiency Centre
MEF	Major Economies Forum on Energy and Climate
MCAIMP	Montenegrin Coastal Area Integrated Management Plan
mHE	Small Hydro Power Plant
MONSTAT	Statistical Office of Montenegro
MSDT	Ministry of Sustainable Development and Tourism
MARD	Ministry of Agriculture and Rural Development
MASA	Montenegrin Academy of Science and Arts
MRV	Measurement, Reporting and Verification
MUP	Ministry of Interior
NAMA	Appropriate Mitigation Actions
NAO	North Atlantic Oscillation
NFI	National Fforest Iinventory
NMVOC	Non-Methane Volatile Organic Compounds
N_2O	Nitrous Suboxide
NO_x	Nitrous Oxides
NWMP	National Water Master Plan
OAS	Organisation of American States
OLADE	Latin American Energy Organization
PFC	Perfluorocarbons
PPP	Photovoltaic Power Plant
PV	Photovoltaic
QA/QC	Quality Aassurance/Quality Control
QELRC	Quantified Emission Limitation or Reduction Commitment
RCREEE	Regional Centre for Renewable Energy and Energy Efficiency
REEEP	Renewable Energy and Energy Efficiency Partnership
REN 21	Renewable Energy Policy Network for the 21st Century
RES	Renewable Energy Sources
SE4ALL	Sustainable Energy for All
SCS	State Coordinate System
SF_6	Sulphur Hexafluoride
SO_x	Sulphur Oxides
SPI index	Standardized Precipitation Index
TE	Thermal Power Plant
TEC	Technology Executive Committee
TNA	Technology Needs Assessment
UfM	Union for the Mediterranean
UL	Unknown Location
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UN-Energy	UN Eenergy Nnetwork
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organisation
UNISDR	United Nations Office for Disaster Risk Reduction
WHO	World Health Organisation
WINISAREG	Irrigation Planning Model
WIS	Water Information System
WMO	World Meteorological Organisation
WTO	World Trade Organisation
WT	Wind Turbine

EXECUTIVE SUMMARY

National Circumstances

Montenegro is an independent and sovereign state, with a republican form of government. Montenegro is a civil, democratic, ecological country and its state of social justice is based on the rule of law.

State institutions responsible for environment and climate change issues include the Ministry of Sustainable Development and Tourism, the Environmental Protection Agency and the Institute of Hydrometeorology and Seismology. The Ministry is an administrative body, while the Environmental Protection Agency and the Institute of Hydrometeorology and Seismology are executive bodies.

An important role in state policy-making in the field of climate change is also played by the Ministry of Economy, the Ministry of Agriculture and Rural Development, the Ministry of Transport and Maritime Affairs, and by other ministries and institutions. In order to ensure proper inter-sectoral cooperation in the field of climate change, the National Council for Sustainable Development was reorganised and became the National Council for Sustainable Development and Climate Change in 2013.

Scientific research activity in Montenegro has predominantly been carried out at the University of Montenegro, as well as at other scientific research institutes. However, due to certain circumstances over the last 15 years, primarily due to a lack of funds, scientific research has been carried out at a more basic level, not just at the University of Montenegro but at all locations. Higher education curricula do not include specific syllabuses that specialise solely in the phenomenon of climate change.

The total surface area of the state's territory is 13,812 km^2, while its territorial sea surface area is about 2,540 km^2. The total length of the land borders is 614 km, while its Adriatic Sea coastline is 293 km long. According to the 2011 census, the population of Montenegro is 620,029, which gives the population a density of 44.9 inhabitants per km^2. Administratively, the state's territory is divided into 23 municipalities/local government units. 63.23% of the total population lives in urban zones in Montenegro, and 36.77% in rural ones.

Montenegro is a predominantly mountainous country in southeast Europe. The capital of Montenegro is Podgorica, while Cetinje is the historical capital of Montenegro. It borders with Croatia in the west (14 km), with Bosnia and Herzegovina in the west/northwest (225 km), with Serbia and Kosovo in the north and northeast (203 km), and with Albania in the east/southeast (172 km). Its Adriatic Sea coastline is 293 km long.

According to the National Forest Inventory, forests of differing structures and categories cover 59.9% of the Montenegrin territory.

More than 90% of Montenegro's surface area is more than 200 meters above sea level (MASL), 45% of its area is lower than 1,000 MASL, and mountainous areas above 1,500 MASL cover about 15% of the state's territory. The rivers drain into two basins: the Black Sea, which has a total area of 7,260 km^2 (or 52.5% of the territory), and the Adriatic Sea which has a total area of about 6,560 km^2 (or 47.5%). The major rivers which flow into the Black Sea Basin are the Lim (the longest river, 220 km long), the Tara (146 km), the Ćehotina (125 km) and the Piva (78 km); those that flow into the Adriatic Sea Basin are the Morača (99 km), the Zeta (65 km) and the Bojana (40 km) Rivers. Important water resources also include natural lakes, the most significant of which are Biogradsko (0.23 km^2), Plav (1.99 km^2), Black Lake (0.52 km^2), Šasko (3.6 km^2) and Skadar Lake. The surface area of Skadar Lake, depending on its water level, varies from about 360km^2 to over 500 km^2, while the volume of the lake ranges from 1.7 km^3 to 4.0 km^3. The largest artificial reservoir is Piva Lake which has a total accumulation capacity of 880x106m^3. Other significant accumulations include Slano, Krupac and Vrtac Lakes (225 x 106m^3) and Otilovići Lake (18x106m^3).

Montenegro is located in the central part of a moderately warm zone in the Northern Hemisphere (41°52' and 43°32' latitude North and 18°26' and 19°22' longitude East). Owing to its latitude, i.e. the proximity of the Adriatic and Mediterranean Seas, it has a Mediterranean climate with warm and somewhat dry summers and mild and rather humid winters.

During a period in which normal climate trends were experienced (1961-1990), the climate profile of Montenegro was characterised by the following data:

- Mean annual temperature: 11.2°C
- Mean annual precipitation: 1.500,5 mm
- Mean intensity of heavy rain on days with rainfall in excess of 20 mm: 38.2 mm/day
- Mean duration of dry periods: 28.7 days/year
- Mean duration of frosty periods: 71.5 days/year
- Mean duration of heat waves: 7.5 days/year
- Climate classification - three climate types: Cs-Mediterranean, Cf-warm temperate and humid, and Df-snow forest climate.

The Montenegrin Gross Domestic Product (GDP) was about 3.15 billion € (approx. 5,100 € per capita) in 2012. The Montenegrin economy falls into the category of small economic systems and into the group of countries with medium revenues. GDP growth rates were very high during the period 2006–2008 (for example, 10.7% in 2007). However, the economic crisis caused a significant decline (5.7%) in economic activity in 2009. Over the past two years the economy has emerged from recession and GDP growth (realised or estimated) is now at a level of 2.5% per year. Services played a dominant role in the structure of the 2012 GDP (trade represented 12.3%, accommodation and food services around 7%, real estate related activities around 7%, construction around 5%, and transport and storage 4%, etc.), while industrial production (mining, manufacturing and energy generation) accounted for about 8% and agriculture and forestry for about 8%. The public sector's contribution (administration, education, healthcare) to GDP was about 17% during the same year.

The most important source of energy in Montenegro is its hydro-potential and based on data from the 2007 Energy Development Strategy and from studies produced in 2005 and 2006, the overall theoretical hydro-potential is estimated as being about 10.6-10.7 TWh, of which 9.846 TWh relates to main watercourses and 0.8-1 TWh to smaller watercourses. The overall technical hydro-potential is estimated as being in the range of 4.1-5 TWh, of which 3.7-4.6 TWh relates to main watercourses and 0.4 TWh to smaller watercourses.

After hydro-potential, the second most important source of energy in Montenegro is coal. This is located in two separate geographical areas: in the north and in the northeast of Montenegro.

Exploration for other types of renewable energy sources in Montenegro intensified during the period 2007-2012 when estimates were made regarding the potential for electricity production using wind, sun and biomass. The total gross capacity of wind turbines that could be installed amounts to approximately 400 MW, assuming that potential is calculated on the basis of either high or medium level productivity; of this 100 MW refers to areas of high productivity (i.e. with an approximate capacity factor of 30%) and 300 MW refers to areas of medium productivity (i.e. with an approximate capacity factor of 25%). Technical wind potential has been estimated as being approximately 900 GWh/year. Theoretically, the potential of solar radiation could be estimated as being about 20 PWh/year assuming that the average amount of solar insolation in Montenegro is around 1,450 kWh/m^2year. The estimated average consumption of firewood in 2008 was 560 GWh/year and this is expected to increase to 620 GWh/year by 2030.

Key branches of industrial production in Montenegro include the production of electricity, mining and the metal industry. The most important branches of the metal industry are the production of aluminium and steel. Economic development in Montenegro up until 1990 was characterized by intensive industrial production and industry's share in the gross domestic product (GDP) was about 30% until 1991. Since that time there has been a continuous decline in industrial production and in 2011 the level of manufacturing as represented in GDP was only about 5%.

Of the total surface area of Montenegro, 515,740 ha or 37% is suitable for agriculture, and of that amount only 16% is used for agricultural purposes. That equals 0.83 ha of agricultural land per capita.

Tourism is one of the major sources of revenue in Montenegro and economic development in Montenegro is based primarily on the further development of this economic branch. Tourism is most developed in the coastal regions of Montenegro. Over the past 10 years, however, the promotion of tourism in the central and northern mountain parts of the country has increased significantly.

The national road network includes 8 main and 23 regional roads with a total length of 1,860 km; in 2012 there were 197,826 registered road motor vehicles and trailers. Of the total number of registered motor vehicles, 75.4 % were passenger vehicles which were more than 10 years old, and of these, more than one third were more than 20 years old. If categorised by the type of fuel used, 56.6% of vehicles used diesel, 42.6% petrol, and 0.8% of vehicles used other types of motor fuel. The railway infrastructure of Montenegro includes 250 km of railway track and there are 50 railway stations. The current condition of the railway infrastructure is such that it hinders normal transport and its existing volume is inadequate to generate sufficient revenue to cover its costs. Air transport is handled by two international airports: Podgorica and Tivat. There are 4 international sea ports in Montenegro: Bar, Kotor, Risan and Zelenika. The most important of these is the port of Bar, which accounts for 95% of all port activities including the transport of passengers and cargo. While air passenger transport has increased (7.9% in 2012 compared to the previous year), maritime transport has recorded a decrease in volume of 61.1% in cargo and 23.3% in passenger transport during the same period (2011-2012).

The quantity of municipal waste collected in 2012 amounted to 279,667 tons, i.e. 451 kg per capita, which is about 6% less than in 2011. As there is no primary or secondary selection of waste, and given the poor records on the structure and quantity of waste, there is currently no accurate quantitative data on the structure of municipal waste generated on an annual level in Montenegro. 457,610.73 tons of industrial waste was generated in 2012.

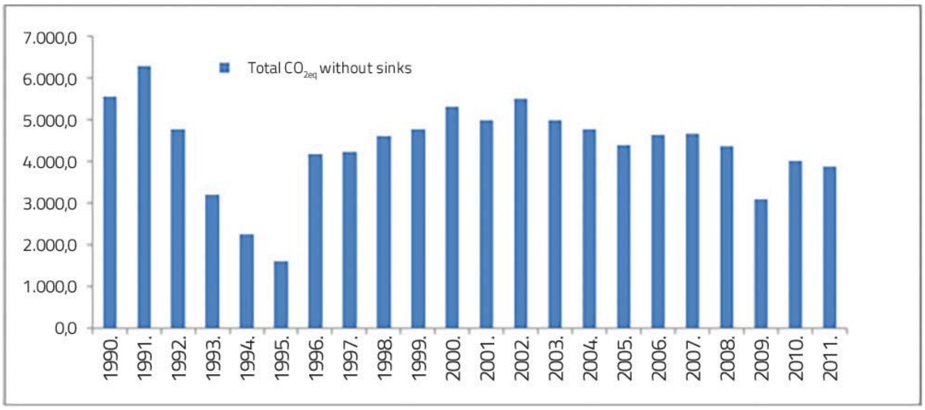
Inventory of Greenhouse Gases

This part of the report shows trends in GHG emissions for the period 1990 – 2011.

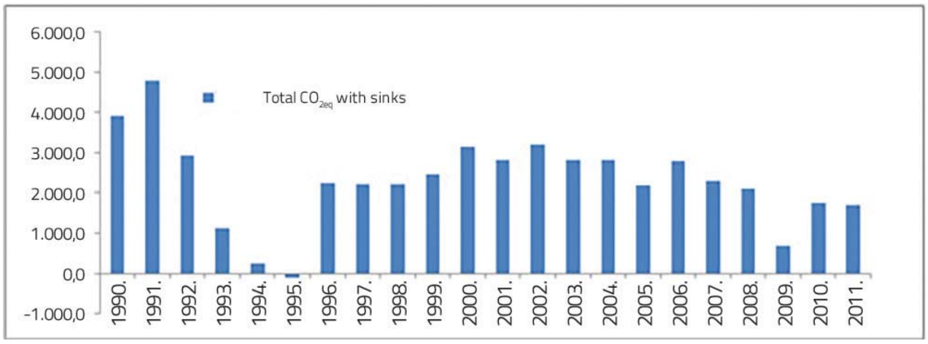
Total direct GHG emissions expressed in CO_{2eq} (1990-2011) (Gg)

CO_{2eq} (Gg)	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
Total CO_{2eq} (Gg) without sinks	5.556,8	6.280,2	4.759,3	3.199,9	2.267,3	1.615,2	4.171,9	4.225,6	4.599,5	4.774,1	5.300,5
Total CO_{2eq} (Gg) with sinks	3.922,2	4.770,9	2.932,4	1.133,1	233,2	-104,1	2232,4	2.201,4	2.213,8	2.456,3	3.146,4
CO_{2eq} (Gg)/year	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.*
Total CO_{2eq} (Gg) without sinks	4.976,4	5.507,1	4.987,0	4.778,0	4.382,6	4.643,9	4.655,7	4.366,5	3.084,5	4.022.3	3.865.71*
Total CO_{2eq} (Gg) with sinks	2.826,5	3.197,8	2.828,7	2.814,5	2.183,5	2.779,3	2.291,4	2.096,8	679,2	1.759.4	1.698,8

*Note: Estimates of direct GHG emissions in 2011 expressed in CO_{2eq} also include SF_6 emissions in accordance with available data. This is not the case for other years included within the observed period.



Total CO_{2eq} emissions without sinks, 1990-2011 (Gg)



Total CO_{2eq} emissions with sinks, 1990-2011 (Gg)

Direct GHG emissions expressed in CO_{2eq}, 1990-2011 (Gg)

Sector	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
Energy	2.360,7	2.466,8	2.057,6	1.698,6	1.349,6	490,3	1.987,7	1.841,9	2.252,2	2.329,0	2.429,7
Industrial processes	2307,7	2.926,5	1.859,2	690,1	96,0	281,3	1.344,8	1.567,6	1.550,7	1.653,2	2.096,2
Agriculture	783,3	781,9	737,4	706,2	716,6	738,5	734,4	711,1	691,6	686,8	669,6
Waste	105	105	105	105	105	105	105	105	105	105	105
Sector	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.*
Energy	2.019,1	2.502,4	2.413,1	2.404,4	2.247,1	2.439,3	2.373,6	2.943,0	2.043,5	2.818,6	2.653,0
Industrial processes	2.202,4	2.250,8	1.812,0	1.629,1	1.556,1	1.635,1	1.747,2	918,2	601,6	741,4	747,3
Agriculture	649,8	648,9	656,9	639,5	474,4	464,4	429,8	421,3	355,3	378,2	380,6
Waste	105	105	105	105	105	105	105	84	84	84	84

CO_2 represents the biggest share of the total CO_{2eq} emissions (31-70%), followed by CF_4 (13-37%), CH_4 (9-34%), N_2O (5-22%) and C_2F_6 (do 6%).

Total CO_{2eq} emissions per capita (1990-2011) (t/per capita)

CO_{2eq} (t)/ per capita	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
Total CO_{2eq} without sinks	9,1	10,6	8,0	5,4	3,8	2,7	6,9	7,0	7,6	7,8	8,7
Total CO_{2eq} with sinks	6,4	8,1	4,9	1,9	0,4	-0,2	3,7	3,6	3,6	4,0	5,1
CO_{2eq} (t)/ per capita	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
Total CO_{2eq} without sinks	8,1	8,9	8,0	7,7	7,0	7,4	7,4	6,9	4,9	6,5	6,2
Total CO_{2eq} with sinks	4,6	5,2	4,6	4,5	3,5	4,5	3,7	3,3	1,1	2,9	2,7

Total CO_{2eq} emissions per GDP unit, (2000-2011) (t/thousand €)

CO_{2eq} (t)/ thousand €	2000.	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
Total CO_{2eq} without sinks	5,0	4,6	4,2	3,6	3,0	2,5	2,4	2,0	1,5	1,1	1,3	1,2
Total CO_{2eq} with sinks	3,0	2,6	2,4	2,0	1,8	1,3	1,4	1,0	0,7	0,2	0,6	0,5

Emissions from the afore-mentioned nine key categories accounted for 95% of total national emissions during the observed period (1990-2011). According to analysed key categories, and when viewed cumulatively, the combustion of lignite in the energy sector represented the largest share (36%) of total emissions during the observed period.

Key categories of GHG inventory (1990-2011)

Categories	Gas	Estimated CO_{2eq} (Gg) emissions for 1990	Estimated CO_{2eq} (Gg) emissions for 2011	Trend assessment	Cumulative share in total emissions (%)
1. Stationary sources- lignite combustion	CO_2	1.147	1.739	0,175	36
2. Aluminium production	PFC	2.077	589	0,153	31
3. Road transport	CO_2	327	502	0,051	11
4. Stationary sources- liquid fuel combustion	CO_2	314	3	0,039	8
5. Enteric fermentation	CH_4	349	160	0,015	3
6. Fuel combustion in industry and construction	CO_2	227	95	0,011	2
7. Fertilizer management	CH_4	74	2	0,009	2
8. Fuel combustion-other	CO_2	178	164	0,008	1
9. Aluminium production	CO_2	189	151	0,004	1
Total					95

Vulnerability and Adaptation to Climate Change

Atmospheric and climate variability in Montenegro is usually influenced by:

- North Atlantic Oscillation (NAO),
- Genoa cyclone and Siberian anticyclone,
- Air depressions in the Adriatic, cyclones with trajectory over the Adriatic or Mediterranean Sea and which are affected by the simultaneous presence of high pressure in North Africa,
- Influence of El Niño, in situations where it is fully developed, and
- Influence of atmospheric blocking systems.

Climate monitoring and assessments show that the Montenegrin climate has changed as a result of global climate change as well as variability. The clearest indicators include: a significant increase of air temperature, an increase in sea surface temperature and in average sea levels, changes in extreme weather and in climatic events.

The following changes in extreme weather and climatic events were observed up to 2010:

1. Frequent, extremely high maximum and minimum temperatures;
2. More frequent and longer heat waves;
3. Increase in the number of very warm days and nights;
4. Fewer frosty days and very cold days and nights;
5. More frequent droughts;
6. Increase in the number of wildfires;
7. Dry periods followed by heavy precipitation;
8. More frequent storms (cyclones) during colder parts of the year;
9. Fewer consecutive days with rain;
10. Fewer days with heavy precipitation;
11. Increase in the intensity of precipitation;
12. Reduced total annual snowfall.

According to available sequences of data for the period 1980-2012 for sea surface temperature from the station in Bar, and for sea level during the period 1965-2011:

- Sea surface temperature rose by about + 0.02°C per year;
- Each decade the temperature was higher than it had been during the previous one; the highest was seen during the last decade with an average annual temperature of 18.3°C;
- Sea level increased, with small year-to-year changes during the first decade of the 21st century.

Climate change is expected to increase the frequency and intensity of many types of extreme events, including floods, droughts, wildfires, storms (i.e. fully developed cyclones), gales, etc. as well as the nature of many other occurrences that are not directly related to weather conditions (such as landslides).

Based on climate monitoring and assessment in Montenegro, and on the analysis of extremes, 5 air temperature and 3 precipitation indexes were selected from the set of climate indexes. These indexes were analysed within the context of normal climate, for which the period 1962-1990 was chosen, and within the context of projected climate, as set out in scenarios A1B and A2 (defined as "medium" and "high" scenarios with regard to GHG concentration) during the periods 2001-2030 and 2071-2100. The regional climate model EBU-POM was applied to the calculations. On the basis of the results obtained, the following sectors were predicted to be vulnerable: water resources, the coastline and the coastal strip, agriculture, forestry and human health. Based on the fact that climate change will have a significant impact on the balance and regime of underground water in Montenegro in the future, a detailed assessment of the water sector was conducted, a Montenegrin water cadastre was created and the impact of climate change on the water regime of the Lim and Tara Rivers was analysed.

Based on observed and projected climate changes and extremes, it can be concluded that the agriculture sector in Montenegro is vulnerable to:

1. Droughts: projected increase in the number of consecutive days without rain, decrease in overall quantity of precipitation and the expectation of a drier climate in the future will result in land erosion and loss of agricultural surfaces;
2. Shift of the vegetation period towards the beginning of the year due to the potential occurrence of frost, especially during the first 30 years of the 21st century. This could stop vegetation from growing and could cause losses in yield, particularly in fruit crops;
3. Increase in the number of warm days during the year, changes in the duration and frequency of heat waves, which could potentially lead to an increase in the activities of pests and insects;
4. Rising sea levels and potential consequential flooding of agricultural land.

In order to assess the impact of climate change on forests in Montenegro, two studies were produced as part of the preparation work for the Second National Communication:

1. Sensitivity of the forestry sector of Montenegro to pests and plant diseases, and
2. Analyses and projections of the impact of climate change; the application of a regional climate model to the future distribution and cultivation of main tree types found in Montenegro.

The occurrence and intensity of wildfires are directly dependent on the typical climate of a certain area, i.e. on maximum daily temperatures and on the duration of dry periods. Bearing in mind environmental and economic damage, wildfires pose the greatest threat to forest ecosystems in Montenegro. Although they currently affect about 0.5% of the total forest area on an annual level, they could be a serious threat in the future, particularly in forests in the south which stretch along the coast and along the karst terrain; in these areas it is very difficult to extinguish wildfires.

Based on comprehensive analyses of rising sea levels in Montenegrin coastal areas, there are two key recommendations which concern the area of flooding zones and the vulnerability of the Montenegrin coastline:

1. To assume that the sea level will rise by 96 cm and to consider both now and in the future, within such terms, the potential coverage by water in flooding zones;
2. For the purpose of estimating vulnerability of the area, in terms of widening the distance from the coast, the most realistic and most probable scenario is a projection of sea level rise by 62 cm by the end of the 21st century.

These recommendations should be used in all spatial plans, including short-term planning, especially considering that urban planning is currently placing considerable pressure on the environment.

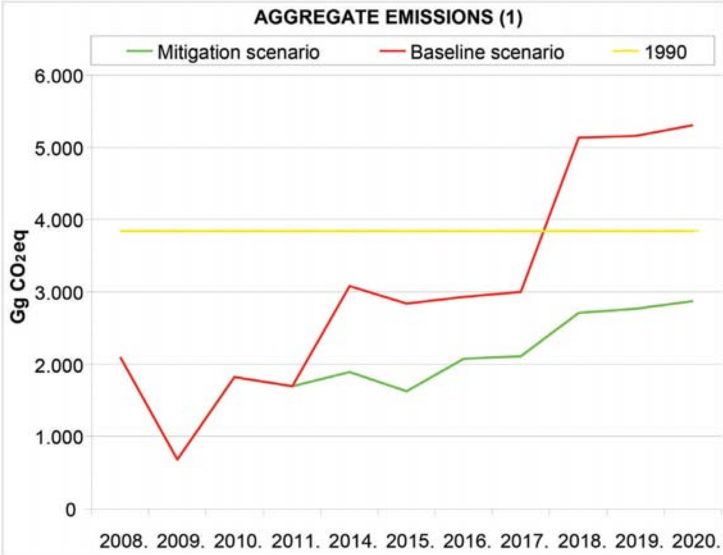
Recommended sector-based adaptation measures:

1. Water resources – efficient water management and water information system
2. Agriculture – introduce a more flexible agricultural system
3. Forestry – forest management system
4. Coast and coastal areas – recommendations regarding the size of flooding zones and the vulnerability of the Montenegrin coast
5. Health – the implementation of a bio-meteorological forecast is necessary to provide early notification of favourable or unfavourable weather conditions which can affect humans, particularly patients with chronic illnesses.

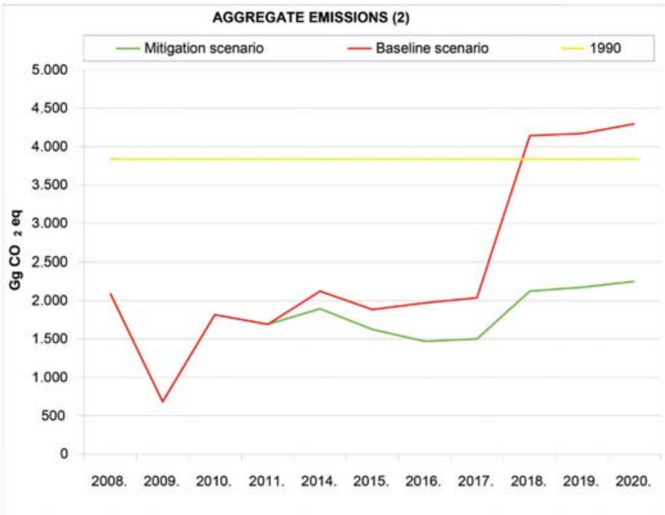
GHG Emission Reduction Policies, Measures and Assessments

An assessment of how to reduce GHG emissions was carried out in two ways: by assuming that the Aluminium Plant Podgorica (KAP) achieves its full production capacity and secondly by assuming that it operates at a reduced level of capacity.

Aggregate GHG emissions for a baseline scenario and GHG emissions reduction scenario (assuming the full production capacity of KAP)



Aggregate GHG emissions in all sectors by analysed scenario (assuming a reduced level of production by KAP)



The first graph shows that, in comparison with 1990, the aggregate level of GHG emissions in 2020 will be:

- Higher by 1,466 Gg CO_{2eq} – in the baseline scenario;
- Lower by 967 CO_{2eq} – in the GHG emissions reduction scenario.

At the end of the observed period (2020), GHG emissions in the baseline scenario are 85% higher than the figures would be in a scenario representing a reduction in GHG emissions.

The second graph, which shows aggregate GHG emissions for a baseline scenario along with a scenario representing a reduction in GHG emissions, and assuming a reduced level of production by KAP, shows that compared with 1990 the aggregate level of emissions in 2020 would be:

- Higher by 455,5 Gg CO_{2eq} – for the baseline scenario;
- Lower by 1587,1 Gg CO_{2eq} – for GHG emissions reduction scenario.

At the end of the observed period (2020), the GHG emissions in the baseline scenario are 91% higher than figures would be in a scenario representing a reduction in GHG emissions.

The chapter "Additional Information" includes, among other things, a small study on underground water in Montenegro; it aims to determine its specific vulnerability to climate change.

This Communication also identifies restrictions and deficiencies of both a technical and of a methodological nature, it identifies institutional constraints and a lack of capacity, as well as a lack of funds required to implement mitigation/adaptation measures. This Communication also provides a brief overview of the complete assessment of technological needs within the context of climate change, of current projects which address the issues of climate change in Montenegro and of proposals that have been put forward for specific projects.

1. INTRODUCTION

No one at an international level asks whether climate change will or will not happen any more. Scientific evidence and facts show that climate change is happening today, and this has been confirmed by the Fifth Report of the International Panel for Climate Change (IPCC).

Based on data collected through direct physical and biogeochemical measurements, through remote censoring from stations on the ground and via satellite, and also by including data from paleoclimate archives, the following can be concluded:

Climate warming is an undisputable fact. Many observed changes during the period dating from the 1950s until today are, without precedent, not only relevant to previous decades but also to previous centuries. The atmosphere and the oceans have become warmer, quantities of snow and ice have declined, sea levels have risen and concentrations of greenhouse gases (GHG) have increased;

During each of the last three decades, temperatures measured on the Earth's surface have become successively higher than those measured in any of the previous decades from 1850 onwards. In the Northern Hemisphere, the period 1983–2012 was probably the warmest 30-year period experienced during the last 1,400 years. Data obtained by combining global sea and land temperatures and expressed through a linear model shows an increase of about 0.89°C (0.69–1.08)°C during the observed period 1901–2012, and an increase of about 0.72°C, i.e. (0,49-0.89)°C during the observed period 1951– 2012;

Increased energy levels stored in the climatic system mainly affect the warming of oceans. More than 90% of this energy was accumulated during the period 1971–2010. It is very likely that the temperature of the oceans' upper layer (0–700 m) rose during precisely this period;

Over the past twenty years, the ice plates in Greenland and Antarctic have reduced in mass, glaciers have shrunk almost all over the world, and ice in the Arctic Sea and spring snow cover in the Northern Hemisphere continue to diminish;

Sea levels have increased at a much faster rate since the mid 19th century; the speed of increase was higher than the average rate recorded during the previous two centuries. During the period 1901–2010, the mean global sea level rose by 0.19 m, i.e. 0.17–021 m;

Concentrations in the atmosphere of carbon dioxide (CO_2), methane (CH_4) and nitrogen oxides (NO_x) have increased to their highest levels over at least the past 800,000 years. Concentrations of CO_2 have increased by 40% compared with the preindustrial age, primarily due to emissions from the combustion of fossil fuels, and also due to emissions resulting from land use change. It is estimated that the oceans have absorbed 30% of the CO_2 that has been emitted causing, in turn, ocean acidification (IPCC, 2013).

Since 1992, 196 countries have joined the United Nations Framework Convention on Climate Change (UNFCCC). Their aim is to commit themselves to limiting the increase of average global temperatures and to mitigate the negative impact of climate change through a common effort. The Kyoto Protocol was signed in 1997 when the first mandatory period requiring a reduction in GHG emissions was set. A commitment to the achievement of this goal was confirmed by the adoption of the Doha Amendments in the Kyoto Protocol from December 2012. Through this the Kyoto Protocol parties agreed to a new/second mandatory period for the Kyoto Protocol (2013–2020).

At the nineteenth session of the Conference of Parties to the UNFCCC that took place in Warsaw (Poland) in November 2013, the importance of an urgent response from all parties to climate change, in compliance with the agreement and necessary for a new universal climate agreement was once again reiterated. The adoption of this agreement is planned for 2015 at the 21st Conference of Parties to UNFCCC in Paris; it includes the adoption of new important decisions that will contribute to the reduction of GHG emissions.

Since it declared its independence, Montenegro has been involved in a twenty-year long effort, along with the international community, to find a solution to reduce the negative impact of climate change.

The preparation of the Second National Communication on Climate Change to UNFCCC has contributed to strengthening capacity in Montenegrin institutions. It is also intended to help institutions to prepare for future Communications and to assist in the decision-making process during the preparation and adoption of policies and measures, not only in the environment sector, but also in other relevant sectors such as energy, transport, industry, tourism, agriculture, water management, forestry and waste management.

2. NATIONAL CIRCUMSTANCES

2.1 Administrative and Institutional Organisation

After the referendum on 21st May 2006, Montenegro became an independent state; it left the state union that had been formed with the Republic of Serbia after the dissolution of the Socialist Federal Republic of Yugoslavia. In 2006, Montenegro became a state with full international and legal subjectivity within its existing state borders.

According to its Constitution, Montenegro is an independent and sovereign state with a republican form of government. Montenegro is a civil, democratic, ecological country and its state of social justice is based on the rule of law.

Municipality is a basic form of local governance. It has the status of a legal entity and adopts its own municipal charter and general documents. Since January 2014, there are now 23 municipalities in Montenegro. Municipalities differ significantly in their demographic characteristics, economic development and organisational structures. In addition to 23 municipalities and according to the 2012 Statistical Yearbook, there are 1,256 settlements, 40 urban centres and 368 neighbourhood districts in Montenegro.

State institutions responsible for the environment and for climate change issues include the Ministry of Sustainable Development and Tourism, the Environmental Protection Agency and the Institute of Hydrometeorology and Seismology (IHSM). The Ministry is an administrative body, while the Environmental Protection Agency and IHSM are executive bodies.

An important role in state policy-making in the field of climate change is also played by the Ministry of Economy, the Ministry of Agriculture and Rural Development, the Ministry of Transport and Maritime Affairs, and other ministries and institutions. In order to ensure proper inter-sectoral cooperation in the field of climate change, the National Council for Sustainable Development was reorganised in 2013 to become the National Council for Sustainable Development and Climate Change.

2.2 Geographic Characteristics

Montenegro is a predominantly mountainous country in southeast Europe. The capital of Montenegro is Podgorica, while Cetinje is the historical capital of Montenegro. It borders with Croatia in the west (14 km), with Bosnia and Herzegovina in the west/northwest (225 km), with Serbia and Kosovo in the north and northeast (203 km), and with Albania in the east/southeast (172 km).

The total surface area of the state territory is 13,812 km^2, while the surface area of its territorial sea is around 2,540 km^2. The total length of land borders is 614 km, while the Adriatic Sea coastline is 293 km long. According to the 2011 census, the population of Montenegro was 620,029; this gives the population a density of 44.9 inhabitants per km^2. Administratively, the state territory is divided into 23 municipalities/local government units. According to data from the Spatial Plan of Montenegro, up until 2020, 6,225 km^2 or 45% of the total surface of Montenegro (13,812 km^2) is covered by forests, about 5,145 km^2, i.e. 37% of its territory is agricultural land, and settlements, roads, waters, rocky terrain and other categories cover about 2,442 km^2 or 18% of its territory. It should be emphasized that the above-mentioned estimate of surface area covered by forests is significantly less when compared with more recent data provided by the National Forest Inventory (NFI). According to this latest data, forests of different structures and categories cover 59.9 % of the Montenegrin territory.

More than 90% of the surface area in Montenegro is over 200 meters above sea level (MASL), 45% is less than 1000 MASL, and mountainous areas above 1,500 MASL cover about 15% of the state's territory. The geological structure of Montenegro is characterised by rocks of different ages. Limestone, dolomite and igneous rocks account for almost two thirds of its surface. Hydro-geological characteristics are determined by the geological structure of the terrain. Due to the composition of the rocks, precipitation quickly penetrates into the ground feeding both confined and unconfined karst aquifers that discharge into the zones of erosion bases, the sea, Skadar Lake and along the rim of the Zeta-Bjelopavlići plain, the Nikšić Field and the area adjacent to the waterbeds.

Figure 2.1 Borders of Montenegro and its neighbouring states – Source: WTTC, Travel and Tourism: Trends and Prospects, 2011

In Montenegro, there are significant differences in the distribution and abundance of water resources ranging from arid karst areas to areas rich in both surface and groundwater. Generally speaking, with an average annual runoff of 624 m^3/s (i.e. the volume of 19.67 billion m^3), the territory of Montenegro is considered to be an area that is rich in water. The average specific runoff is about 43 litres/s/km^2. Of this total runoff, about 95% is from inland water, whilst the remaining 5% is from transit water.

The rivers drain into two basins: the Black Sea which has a total area of 7,260 km^2 (or 52.5% of the territory), and the Adriatic Sea which has an area of about 6,560 km^2 (or 47.5%). The major rivers of the Black Sea Basin are the Lim (the longest river, 220 km long), the Tara (146 km), the Ćehotina (125 km) and the Piva (78 km). The rivers that run into the Adriatic Sea Basin are the Morača (99 km), the Zeta (65 km) and the Bojana (40 km).

Natural lakes are also an important water resource. The most significant of these are Biogradsko (area of 0.23 km^2), Plav (1.99 km^2), Black Lake (0.52 km^2), Šasko (3.6 km^2) and Skadar Lake. The surface area of Skadar Lake, depending on its water level, varies from about 360 to over 500 km^2, while the volume of the lake ranges from 1.7 to 4.0 km^3. The largest artificial reservoir is Piva Lake with a total accumulation capacity of 880x106m^3. Other significant accumulations include the lakes of Slano, Krupac and Vrtac (225 x 106m^3) and Otilovići (18x106m^3). Wetlands can generally be found in areas around the lakes and to a lesser extent in coastal areas. The most important wetland area is located in the vicinity of Skadar Lake, and is listed as an internationally important area (based on the Ramsar Convention).

The entire area of Montenegro, especially its coastal and central areas, is seismically active. More than 450 earthquakes, most of which are weak, (more than 440 earthquakes that measured less than 4 degrees on the Mercalli scale MCS) were recorded in 2010, while in 2011 fewer earthquakes were recorded compared to 2010 when there were only 287; only one measured 7 degrees on the MCS. Only one earthquake that measured 9 degrees on the Mercalli scale has been recorded and that was in 1979; on this occasion the coastal area was particularly badly affected.

2.3 Climate Profile

Montenegro is located in the central part of a moderately warm zone in the Northern Hemisphere (41°52' and 43°32' latitude North and 18°26' and 19°22' longitude East). Owing to its latitude, i.e. its proximity to the Adriatic and Mediterranean Seas, it has a Mediterranean climate with warm and somewhat dry summers and mild and rather humid winters.

Large bodies of water, its altitude and the position of its coastal mountains, along with the relief of its terrain affect both its local and regional climates; thus within a small area there are big differences between the climates in the coastal and high mountains regions. There are also numerous transitional local climates in-between these areas.

The average annual air temperature ranges from 4.6°C in the area of Žabljak which is 1,450 m above sea level, to 15.8°C on the coast. The average annual precipitation ranges from 800 mm in the far north to around 5,000 mm in the far southwest.

On average, the annual number of days with precipitation is about 115-130 on the coast and around 172 in the north of Montenegro. The rainiest month on the coast is November, while July is the driest. Snow cover is formed at altitudes above 400 meters. It is deeper than 50 cm and remains on average from 10 (in Kolašin) to 76 days (in Žabljak). On the high land it snows much more frequently in spring than in autumn.

According to the IHSM's data and taking into account the general climate complexity of the area, the following data was obtained for Montenegro. Results were obtained by calculating the mean value of data from 9 meteorological stations, selected by the quality of the data, the duration of sequence and representativeness. The period represented is one of climate normality (1961–1990):

- Mean annual temperature: 11.2°C
- Mean annual precipitation: 1.500,5 mm
- Mean intensity of heavy rain on days with over 20 mm: 38.2 mm/day
- Mean duration of dry periods: 28.7 days/year
- Mean duration of frosty periods: 71.5 days/year
- Mean duration of heat waves: 7.5 days/year
- Climate classification - three climate types: Cs-Mediterranean, Cf-warm temperate and humid, and Df-snow forest climate.

The following changes in extreme weather and climate events were observed up until 2010:

1. Frequent, extremely high maximum and minimum temperatures;
2. More frequent and longer heat waves;
3. Increase in the number of very warm days and nights;
4. Fewer frosty days and very cold days and nights;
5. More frequent droughts;
6. Increase in the number of wildfires;
7. Dry periods followed by heavy precipitation;
8. More frequent storms (cyclones) during colder parts of the year;
9. Fewer consecutive days with rain;
10. Fewer days with heavy precipitation;
11. Increase in the intensity of precipitation;
12. Reduced total annual quantity of snow.

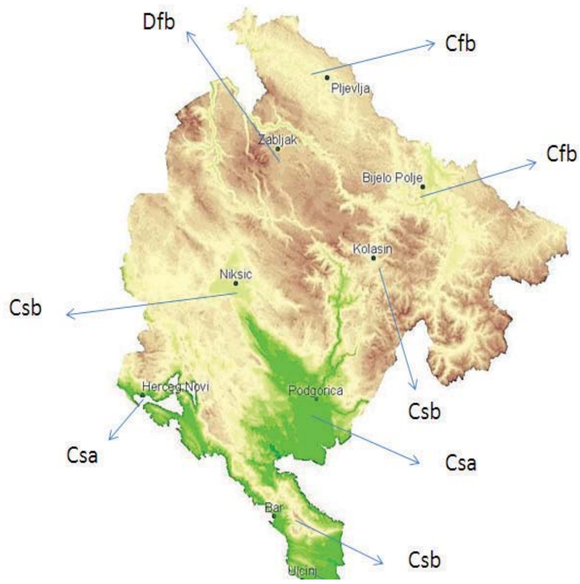


Figure 2.2 Spatial distribution of meteorological stations whose data has been used to update and verify the EBU-POM regional climate model. The figure shows the classification as designated by Koeppen

2.4 Demographic Data

According to the 2011 census, the population of Montenegro was 620,029, which gives the population a density of 44.9 inhabitants per km^2. The age structure of the population is shown in table 2.1. The annual population growth is negative when compared to the 2003 population census; statistics show a negative growth rate of about 0.02%.

Table 2.1 Age structure of the population of Montenegro, period 1971–2011 – Source: MONSTAT

Date of census	Age 0 - 14	Age 15 - 29	Age 30 - 49	Age 50 - 64	Age 65 and older	Unknown
1971.	31,90%	25,74%	24,50%	9,69%	7,63%	0,49%
1981.	27,48%	46,92%	24,63%	11,58%	8,22%	0,40%
1991.	25,28%	24,10%	25,95%	15,43%	8,23%	1,01%
2003.	20,55%	23,11%	27,72%	15,76%	11,96%	0,89%
2011.	19,15%	21,40%	27,41%	19,20%	12,80%	0,04%

External migrations and natural factors have contributed to a slower growth in population. When demographic trends are observed at a local level, it is important to note varying population figures during the period 2003–2011. Only 6 (out of 23) municipalities in Montenegro recorded a growth in population (Bar, Berane, Budva, Podgorica, Danilovgrad and Tivat), while all other municipalities showed a decline in population. This is particularly evident in municipalities in the northern region where population levels declined by up to 29 % (Šavnik).

2.5 Economy and Development Priorities

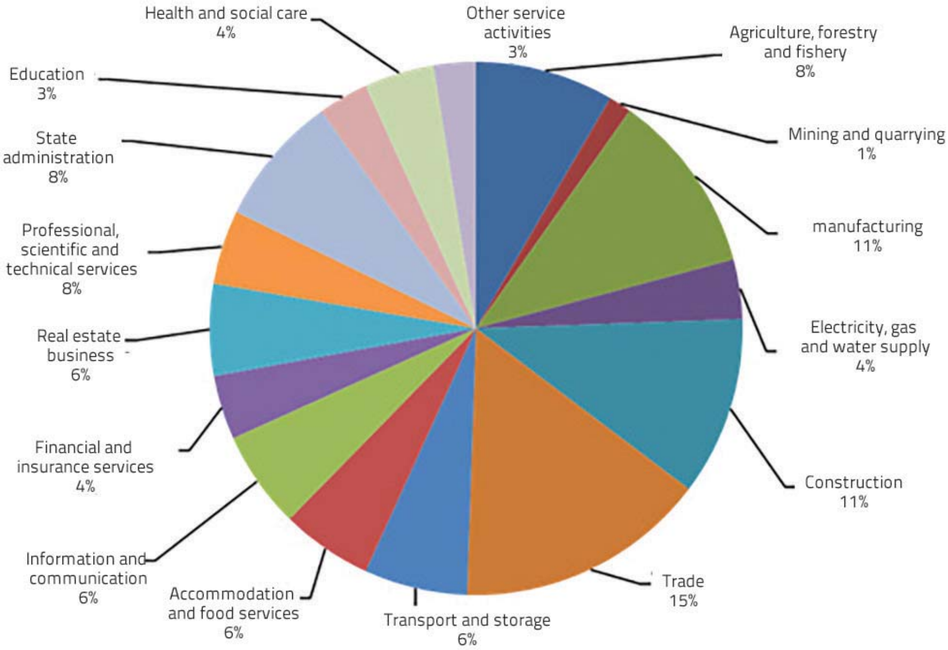
The Montenegrin Gross Domestic Product (GDP) in 2012 was about 3.15 billion € (approx. 5,100 € per capita). The Montenegrin economy falls into the category of small economic systems and into the group of countries with medium revenues. GDP growth rates were very high during the period 2006–2008 (for example, 10.7% in 2007). However, the economic crisis caused a significant decline (5.7%) in economic activity in 2009. Over the past two years the economy has emerged from the recession and GDP growth (realised or estimated) has reached a level of 2.5% per year. Services represented a dominant role in the structure of the 2012 GDP (trade represented a share of 12.3%, accommodation and food services about 7%, real estate related activities about 7%, construction about 5%, and transport and storage 4%, etc.), while industrial production (mining, manufacturing and energy generation) accounted for about 8% and agriculture and forestry for about 8%. The public sector's contribution (administration, education, healthcare) to GDP was about 17% during the same year.

An overview of the important economic and social indicators is shown in table 2.2, while graph 2.1 shows the 2012 GDP structure.

Table 2.2 Gross Domestic Product and employment (2006–2012) – Source: MONSTAT

Year	Gross Domestic Product				Employment (annual average, administrative sources)		Net income (average)
	Current prices	Constant prices	Per capita	Real growth rate	No. of employed	No. of unemployed	
	in thousands €		€	%			€
2006.	2.148.998	1.970.474	3.443	8,6	150.800	43.190	282
2007.	2.680.467	-	4.280	10,7	156.408	34.396	338
2008.	3.085.621	2.866.025	4.908	6,9	166.221	29.535	416
2009.	2.980.967	2.911.070	4.720	-5,7	174.152	28.385	463
2010.	3.103.855	3.054.410	5.006	2,5	161.742	31.864	479
2011.	3.234.060	3.204.056	5.216	3,2	163.082	30.869	484
2012.	3.148.857	3.151.727	5.078	-2,5	166.531	49.400	487

Tourism remains one of the main drivers of the Montenegrin economy. Thus, 1.44 million tourists visited Montenegro in 2012, with a total of 9.15 million overnight stays, an increase of 4.8% compared to 2011. According to data from the Statistical Office of Montenegro, sales of retail goods (according to current prices) in 2012 increased by 6.7% compared with the previous year. This information is important considering the level this business activity represents in the overall GDP (12.1%). Construction related indicators show that this sector has not yet recovered from the negative effects of the economic crisis and, according to MONSTAT data, the value of completed construction works in 2012 was 13.2% lower when compared with 2011. Overall industrial production recorded a decline in 2012, but production in the electricity, gas and steam sectors increased in comparison with 2011. The decline in industrial production of 7.1% in 2012, compared to 2011, is as a result of a decline in production in the mining and quarrying sectors (21.0%) and in manufacturing (10.1%); the electricity sector, however, generation a growth (2.2%) due to favourable weather conditions and low figures recorded in 2011.



Graph 2.1 Structure of 2012 Gross Domestic Product

Table 2.3 Unemployment in Montenegro – Source: MONSTAT

Number of unemployed persons and the unemployment rate as defined by the International Labour Organisation (ILO)

Year	Unemployed			Unemployment rate		
	Total	Men	Women	Total	Men	Women
	in 1.000			in %		
2005.	77,8	37,4	40,3	30,3	26,2	35,5
2006.	74,8	41,2	33,6	29,6	29,1	30,1
2007.	51,1	27,0	24,0	19,4	18,1	20,9
2008.	44,8	24,0	20,8	16,8	15,9	17,9
2009.	50,4	26,9	23,5	19,1	18,0	20,4
2010.	51,3	27,8	23,5	19,7	18,9	20,7
2011.	48,1	26,5	21,6	19,7	19,5	20,0
2012.	49,4	26,8	22,6	19,7	19,3	20,3

Montenegro has made big progress in increasing its income per capita and in reducing poverty over recent years. It has also made progress in its structural reforms, as well as in preparing for EU membership. The Gross National Income has tripled since 2003 and has grown from $2,400 to $7,160, which makes it the highest per capita income compared with the other five countries of Southeast Europe (Albania, Bosnia and Herzegovina, Kosovo, Former Yugoslav Republic of Macedonia and Serbia). According to MONSTAT data, unemployment is still relatively high and was at constant level of 19.7% during the period 2010-2012 (Table 2.3), while poverty reduced from 11.3% in 2006 to 9.3% in 2011 (Table 2.4.). The country maintains a relatively moderate income inequality. In 2011, Montenegro became a member of the World Trade Organisation (WTO), while in June 2012 it opened formal negotiations for accession to the European Union.

Table 2.4 Poverty line – Source: MONSTAT

	National absolute poverty line (in € per month, by equivalent adult)	Poverty rate (%)	Poverty gap (%)	Poverty severity (%)	Gini coefficient (%)
2006.	144,68	11,3	1,9	0,6	24,4
2007.	150,76	8,0	1,4	0,4	26,4
2008.	163,57	4,9	0,9	0,3	25,3
2009.	169,13	6,8	1,4	0,5	26,4
2010.	169,98	6,6	1,1	0,3	24,3
2011.	175,25	9,3	2,0	0,7	25,9

2.5.1 Energy

The umbrella document in the field of energy in Montenegro is its Energy Development Strategy of Montenegro up to 2030. This document recognizes the important role of this sector for the social and economic development of the country and anticipates the, "...sustainable development of the energy sector based on an accelerated, but rational use of its own energy resources in compliance with the principles of environmental protection, increased energy efficiency and increased use of renewable energy sources."

The most important source of energy in Montenegro is its hydro-potential and based on the data from the 2007 Energy Development Strategy and from studies produced in 2005 and 2006, the overall theoretical hydro-potential is estimated as being about 10.6-10.7 TWh, of which 9.846 TWh relates to main watercourses[1] and 0.8-1 TWh relates to smaller watercourses. The overall technical hydro-potential is estimated as being in the range of 4.1-5 TWh, of which 3.7-4.6 TWh relates to main watercourses and 0.4 TWh relates to smaller watercourses.

After hydro-potential, the second most important source of energy in Montenegro is coal; this can be found in two separate geographical areas in the north and northeast Montenegro, in the areas surrounding Pljevlja and Berane. The area of Pljevlja includes 3 basins:

- Pljevlja Basin (deposits: Potrlica with cement factory, Kalušići, Grevo, Komini and Rabitlje) with small basins nearby (deposits: Otilovići, Glisnica and Mataruge)
- Ljuće-Šumani Basin (deposits: Šumani I and Ljuće II)
- Maoče Basin

The level of exploration is high. Total reserves in the Pljevlja area are estimated to be about 188.4 mil. tons, of which 109.9 mil. tons are in the Maoče Basin, 76.8 mil. Tons are in the Pljevlja Basin and 1.7 mil. tons are in the Ljuće-Šumani Basin. Reserves in the Glisnica and Mataruge Basins have been estimated with a significant degree of reliability. Glisnica Basin is in the final stages of exploration and deposit definition, and the Mataruge Basin has already been explored twice (in 1982 and in 1994). According to data, the quantity of coal is not questionable, but detailed geological research is necessary to define the exact quantity and quality of the coal. The area of Berane (deposits: Polica, Petnjik and Zagorje) has not yet been sufficiently explored. There are geological reserves of brown coal of about 158 million tons; however, exploitable reserves were estimated in 2008 as being somewhat less with a maximum quantity of 17.8 mil. tons (IMC study, 2008).

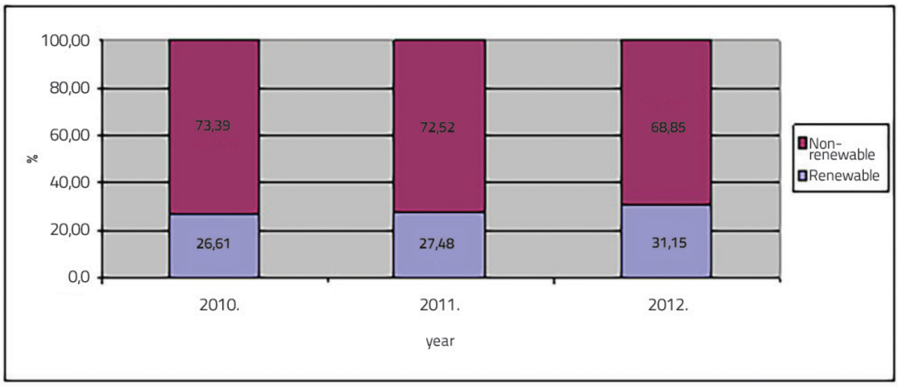
1 Main watercourses in Montenegro are the Tara, the Lim, the Morača, the Zeta, the Piva, the Ćehotina, the Mala rijeka, the Ibar i the Cijevna rivers.

Research on other types of renewable energy sources in Montenegro was intensified during the period 2007-2012 when an assessment of wind, sun and biomass potential for electricity generation was carried out. The wind, sun and biomass potential was analysed for the first time in 2007 in a CETMA study called "Assessment of Potentials of Renewable Energy Sources in the Republic of Montenegro".

The study showed that the total gross capacity of wind turbines that can be installed amounts to approximately 400 MW, and assumes that only high and medium productivity levels of the potential are taken into consideration. Of this, 100 MW relates to areas of high productivity (i.e. with approximate capacity factor of 30%) and 300 MW relates to areas of medium productivity (i.e. with approximate capacity factor of 25%). Technical wind potential is estimated at approximately 900 GWh/year.

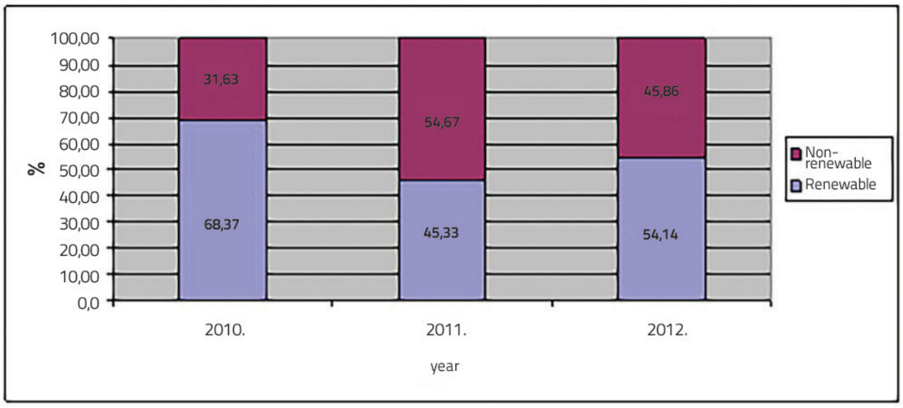
With regard to solar energy, the study estimates that the annual available quantity of solar radiation, as a primary source of energy, per square meter in Podgorica, is about 1,600 kWh/m^2year, and that theoretically solar radiation potential can be estimated at about 20 PWh/year if we assume that the average solar insolation in Montenegro is 1,450 kWh/m^2year.

It is very hard to assess the potential of biomass in Montenegro. The FODEMO study estimates the average consumption of firewood at 560 GWh/year for 2008. However, the Energy Development Startegy up to 2030 (EDS 2030) estimates that this level will remain the same until 2020 but that it will increase to 620 GWh/year by 2030. Graph 2.2. shows shares of renewable energy sources in the overall energy mix, and graph 2.3. shows shares of renewable energy sources within the total amount of electricity generated, while table 2.5. represents percentage shares of renewable energy sources in consumption in other sectors (industry, transport and households).



Graph 2.2 Shares of renewable energy sources in the overall energy mix

The Montenegrin energy sector is characterised by a high level of intensity in energy consumption, primarily due to industry's large share of the total amount of electricity consumed. Additionally insufficient energy efficiency measures have been introduced to households and the service sector. The industry sector's share in the total amount of electricity consumed during the observed period 2010–2012 ranged from 30% to 35%; the Aluminium Plant in Podgorica (KAP) was the largest consumer and represented a share of 28-33% within the total amount of electricity consumed. Electricity consumption in the household and services sectors is also high and ranged from 60.8% to 66%. Table 2.6. shows the energy balance for electricity in Montenegro during the observed period (2010–2012).



Graph 2.3 Shares of renewable energy sources within total electricity generation figures

Table 2.5 Percentage share of renewable energy sources in consumption in other sectors (industry, transport and household)

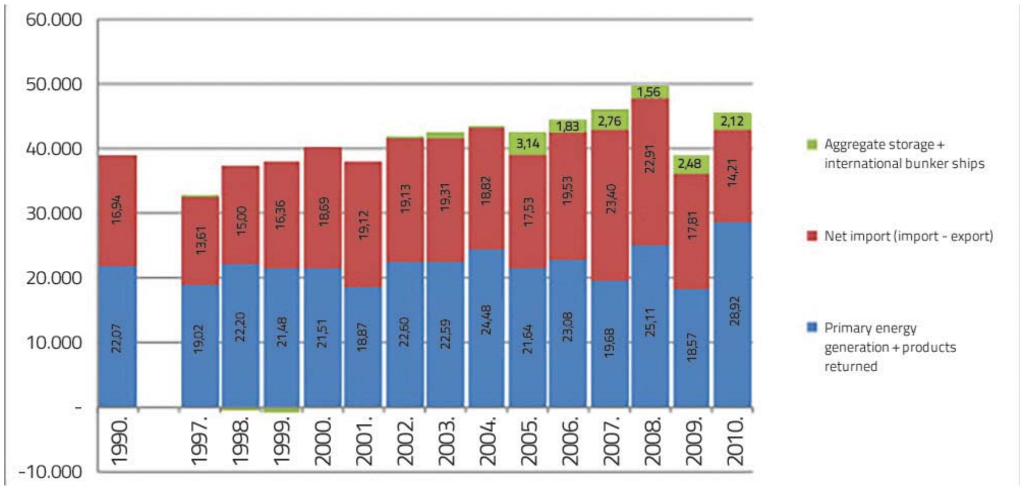
Households, commercial sector and services (%)	2010.	2011.	2012.
Renewable energy sources	62,77	77,18	79,71
Non-renewable energy sources	37,23	22,82	20,29
Industry. agriculture and construction (%)			
Renewable energy sources	45,48	30,29	46,56
Non-renewable energy sources	54,52	69,71	53,44
Transport (%)			
Renewable energy sources	0,47	0,51	0,32
Non-renewable energy sources	99,53	99,49	99,68

Table 2.6. EPCG energy balances for the period 2010–2012 (GWh) – Source: EPCG energy balances for 2011, 2012 and 2013.

BALANCE ELEMENTS	2010.	2011.	2012.
PRODUCTION	4021,3	2.656,14	2.707,70
PURCHASE FROM EPS	1203,6	1.209,67	1.204,00
I M P O R T	731,5	1.382,81	942,95
DIVERGENCE - taking over from EES	11	30,28	23,61
DELIVERY TO EPS-u	1450,7	629,56	725
EXPORT	482,8	431,45	184,26
DIVERGENCE – transmission to EES	12,3	0,2	26,69
AVAILABLE ELECTRICITY	4.021,7	4.217,69	3.942,31
CONSUMPTION	4.021,7	4.217,69	3.942,31
Direct consumers	1341	1.494,52	1.187,20
Aluminium Plant	1.241,2	1.386,86	1.110,00
Ironworks	79,2	85,82	53
Railway Infrastructure MNE	20,7	15,01	15
Thermal Power Plant consumption	0,05	6,83	9,2
Distribution consumers	2.516,2	2.563,71	2.602,11
Transmission losses	164,4	159,46	153

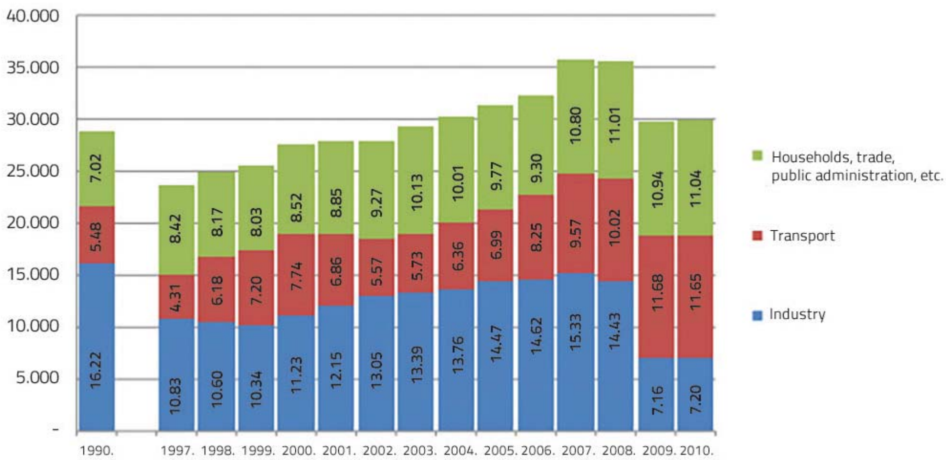
Gross domestic consumption increased during the period 1997–2008, from 32.66 PJ in 1997 to 49.54 PJ in 2008 or 3.86%/year (Graph 2.4.). As a result of reduced production at KAP and difficulties with the Nikšić Ironworks, electricity consumption also significantly declined in 2009 and 2010. Montenegro's energy dependence during this period ranged from 40.5% (1998) to 55.3% (2007) while in 2010 it fell to 29.5% as the net import of electricity was eliminated. During a five-year period (2005–2010), Montenegro imported all of its liquid fuel (100%) and

30.1% (1.322 GWh/year) of its electricity on average, according to its realized energy balance. During the period 1997–2010, electricity generation at a primary level (coal, hydro and biomass) ranged from 17.73 PJ (2007) to 29.77 PJ (2010) and represented between 47% (in 2009) and 65% (in 2010) of the total of all gross domestic energy consumption.



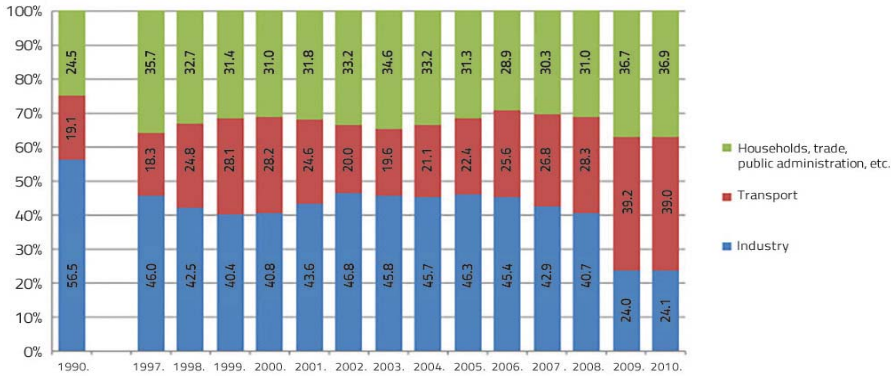
Graph 2.4 Gross domestic energy consumption, (1990–2010) (PJ) – Source: EDS until 2030

Total final energy consumption during the period 1997–2008, as shown in graph 2.5, indicates a permanent growth (3.74%/year on average, from 23.9 PJ in 1997 to 35.7 PJ in 2008). In 2009, consumption figures showed a reduced level of consumption by KAP and the Nikšić Ironworks and an increase in consumption by sectors such as transport, households and other services.



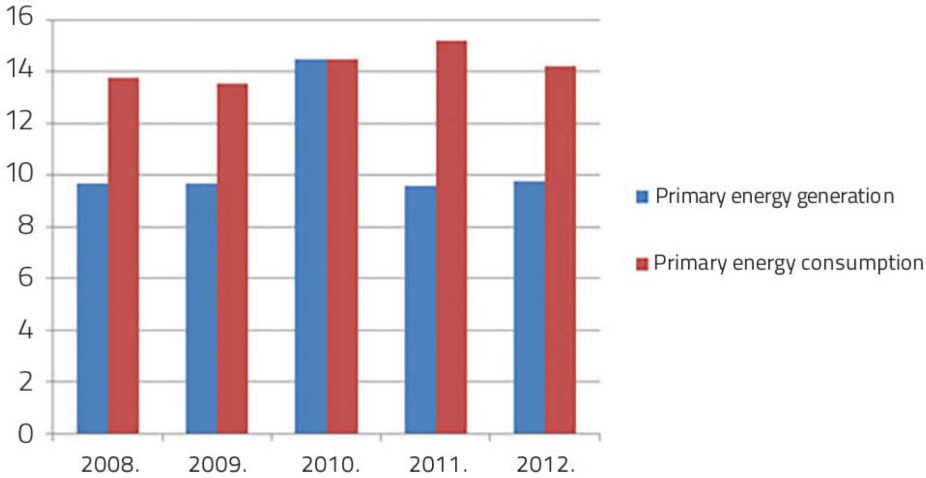
Graph 2.5 Final energy consumption figures by sector (1990–2010) (PJ) – Source: EDS until 2030

When analysing the period 1990–2010, it can be seen that, depending on the year, industry was dominant in the final energy consumption figures and represented 40-46% of the total, followed by other consumers including households and services with a share of 29–36%, and transport with a share of 18–28%. Due to the fact that there was a reduced level of consumption by industries working in the fields of ferrous metallurgy and non-ferrous metals in 2009 and 2010, transport became the dominant sector (39%) compared with other consumption (37%) and with industry (24%). A constant increase in consumption was also recorded in the transport sector, suggesting that the transport sector will play a significant role in the consumption of energy in the future. Graph 2.6. shows an overview of the final energy consumption figures by sector (1990–2010) (%).



Graph 2.6 Final energy consumption figures shown by sector (1990–2010) (%) – Source: EDS up to 2030

Total primary energy consumption in 2008 amounted to 13.74 PJ, and during the period 2008–2011 primary energy consumption rose at an average rate of 34% per year, while in 2012 there was a reduction of 6.5% compared with 2011. Total generation and consumption figures during the period 2008–2012 are shown in Graph 2.7.

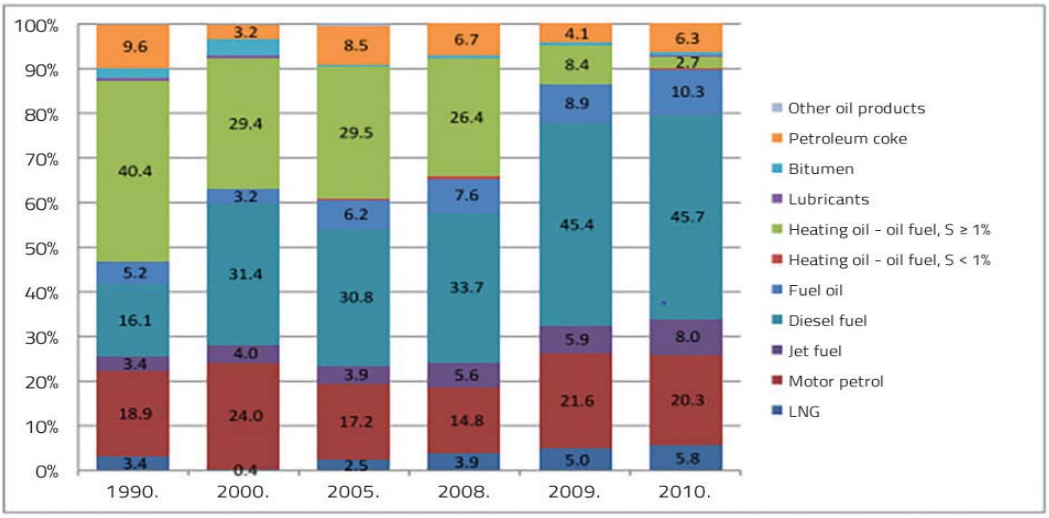


Graph 2.7 Total primary energy consumption and generation figures (2008–2012) – Source: Energy balances

Fossil fuels play a dominant role in the overall consumption of energy-generating products and a break-down of the consumption of fossil fuels is represented in Table 2.7; it shows that solid and liquid fuels are used almost exclusively. All of the country's needs for solid fossil fuels are met from its own resources. Lignite is mostly commonly used, but brown coal was also used to a lesser extent until 2007. Within the usage structure of liquid fossil fuels, motor petrol, diesel and oil fuel dominate (Graph 2.8.), and since Montenegro does not have its own sources of petroleum fuels, its entire supplies of liquid and gaseous fossil fuels are imported.

Table 2.7 Consumption of electricity and fuel in industry – Source: MONSTAT

	Measure unit		2007.	2008.	2009.	2010.	2011.
Electricity	GWh		2.654	26.48	2.232	1.522	2.074
Coke	thousand tons		-	-	-	32	39
Stone coal	thousand tons		-	-	-	-	-
Brown coal	thousand tons		2	-	1	1	1
Lignite	thousand tons		27	29	17	15	12
Liquid fuels	thousand tons		14	15	9	9	11
Oil fuel	thousand tons		110	115	40	22	14
Natural gas	mil. m^3		-	-	-	-	-
Liquid gas	thousand tons		3	2	2	2	3



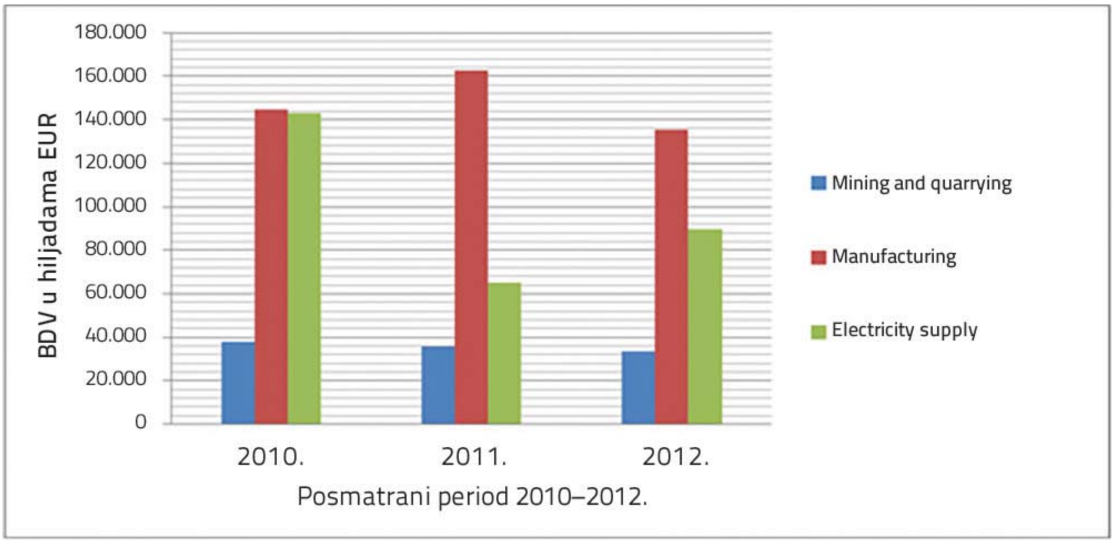
Graph 2.8 Usage structure representing the consumption of oil derivatives
(1990-2010) – Source: Energy database of the Ministry of Economy

An analysis of the usage structure representing the consumption of oil derivatives during the period1990-2010 (Graph 2.8.) shows a reduction in the consumption of heating oil – a type of oil created as a result of reduced levels of production and other operations by KAP. Also, a continuous increase in the level of diesel consumption is obvious, and this corresponds to an increase in the number of vehicles with diesel engines.

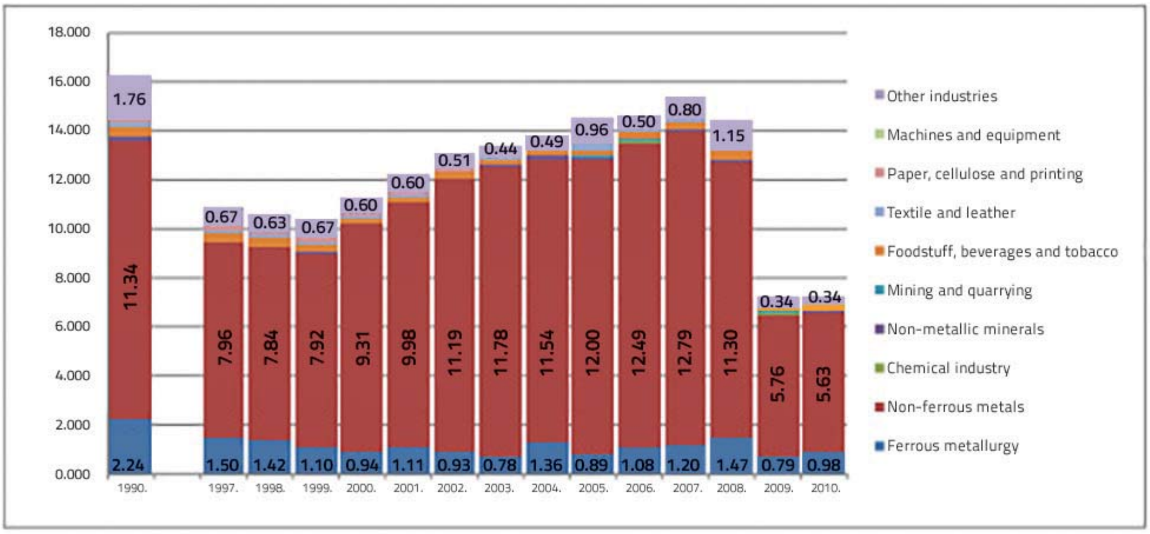
2.5.2 Industry and Mining

A declining trend in industrial production also continued through the period 2010-2012. Generally, industrial production recorded an overall decline in 2012, but production in the electricity, gas and steam sectors increased compared with 2011. The decline in industrial production of 7.1% in 2012, compared to 2011, was the result of declines in the mining and quarrying sectors (21%) and in manufacturing (10,1%). Electricity generation, however, increased (2.2%) due to favourable hydrological circumstances and low figures recorded in 2011.

In line with the aforementioned facts, a declining trend in the gross added value of mining and quarrying, manufacturing and electricity generation and supply is evident during the observed period 2010–2012, as shown in Graph 2.9.

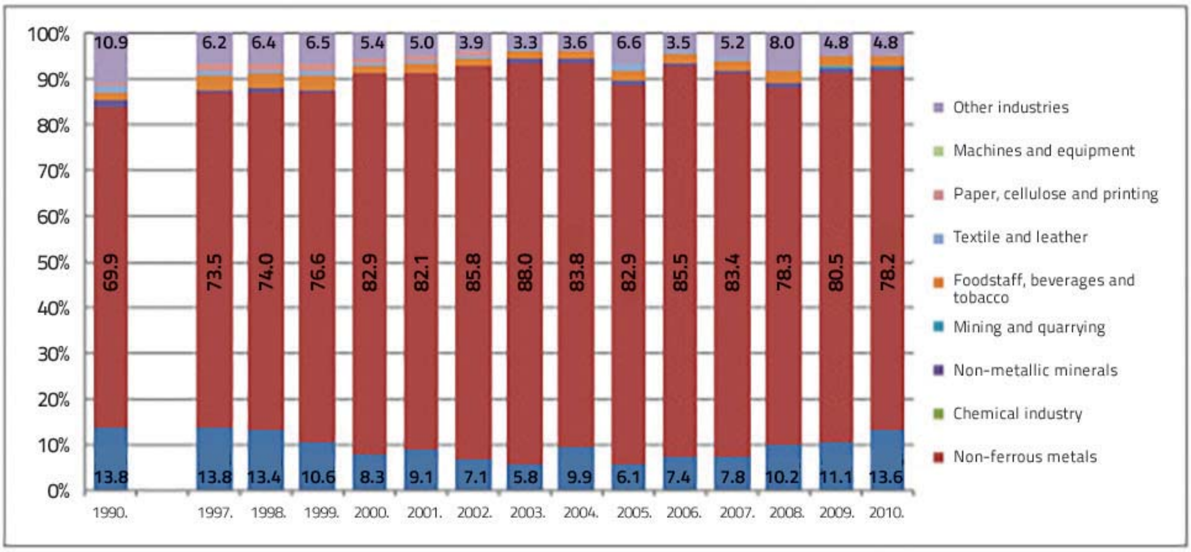


Graph 2.9 Gross added value for mining and quarrying, manufacturing and electricity production and supply, (2010–2012)



Graph 2.10 Final energy consumption by industrial branch (1990–2010) (PJ) – Source: EDS up to 2030

Energy consumption in industry has varied over the last twenty years. Energy consumption figures in industry increased during the period 1997–2008, mainly due to consumption by the ferrous metal industry which accounted for 74-88% of all total consumption. Energy consumption in industry, however, fell by about 50% during the period 2009–2010 (14.4 PJ in 2008, 7.2 PJ in 2010) because of reduced production levels at KAP and at the Nikšić Ironworks. Consumption in the ferrous metallurgy sector accounted for 6–14% of the total final energy consumption figures during the period 1997–2010. During the period1997–2010, however, consumption by the ferrous metallurgy and non-ferrous industries ranged from 6.6 PJ (2010) to 14.0 PJ (2007) and accounted for 87–94% of the total final energy consumption figures in industry. (Graphs 2.10. and 2.11.).



Graph 2.11 Energy consumption figures by industry (1990–2010) (%) – Source: EDS until 2030

2.5.3 Agriculture

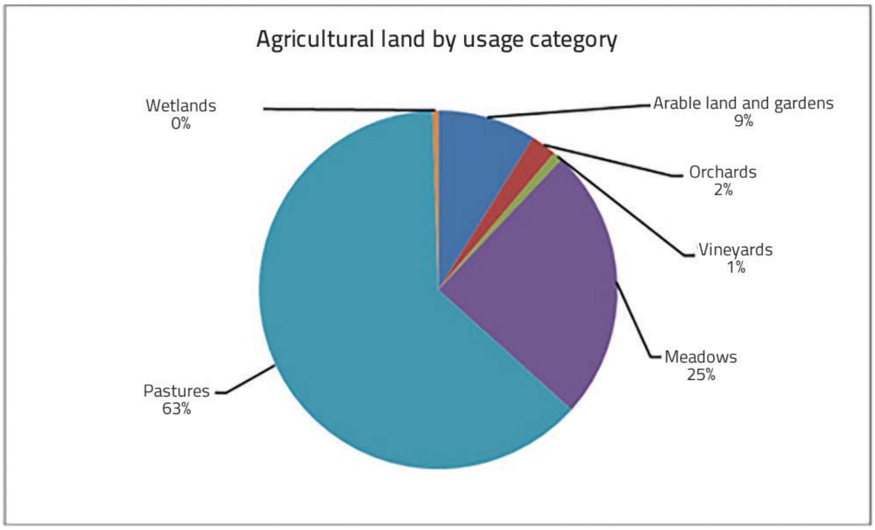
Agriculture continues to be an important strategic sector within the economic development of Montenegro, and has many economic activities that are linked to it, particularly in rural parts of the country. During the observed period 2006-2012, the agriculture, hunting and forestry sectors represented the largest share within GDP in 2009, 8.26%, and the smallest in 2007, 7.21%. The combined share of the agriculture, hunting and forestry sectors in GDP in 2012 was 7.4%, and contribution to overall GDP 70% compared to manufacturing.

Looking at the structure of employees in Montenegro during the period 2006-2011, the overall number of employees in the agriculture, hunting and forestry sectors, as represented within total employment figures in Montenegro, showed a declining trend. These sectors represented a combined share of total employment in Montenegro of 1.73% in 2006, and 1.45% in 2011.

The situation concerning agricultural households is unfavourable considering the fact that there is intensive and competitive production, and given the fact that small farms (less than 5 ha) dominate. On the other hand, there are significant comparative advantages such as, for example, there are more opportunities for diversified production, there is low usage of mineral fertilizers and pesticides, and there is potential for the development of organic production. Montenegro has a significant trade deficit due to food imports (around 150 million € per year).

Of the total surface area of Montenegro, 515,740 ha or 37% is suitable for agriculture, but only 16% is used for agricultural purposes. There is 0.83 ha of agricultural land per capita. According to MONSTAT data, 515,740 ha of agricultural land in 2011 comprised the following (as shown in Graph 2.12.):

- Arable land and gardens (45,748 ha),
- Orchards (12,007 ha) and vineyards (4,399 ha),
- Meadows (126,990 ha),
- Pastures (323,953 ha), and
- Other – wetlands (2,643 ha).



Graph 2.12 Agricultural land by usage category – Source: MONSTAT

A slight decrease in the total area of agricultural land was recorded during the period 1997-2007 and this also continued during the period 2007-2011. The usage structure remained approximately the same, with a slight decrease in the usage of surface areas for arable land, gardens and pastures, and a slight increase in the usage of surface areas for perennial plantations and meadows (Table 2.8.).

Table 2.8 Changes in usage of agricultural land surface areas during the period 2000–2011 (000 ha)– Source: MONSTAT

Land category	2000.	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
Arable land and gardens	49,7	47,4	45,8	44,8	46,9	46,2	44,5	44,9	45,2	45,7	45,5	45,7
Perennial plantations	14,6	13,4	13,4	13,4	13,6	15,2	16,1	16,2	16,2	16,3	16,4	16,4
Meadows	121,5	129,3	130,6	131,5	128,2	127,8	128,6	128,8	127,8	126,9	126,8	126,9
Permanent pastures	327,7	325,3	325,6	325,7	326,6	325,3	325,4	323,9	324,3	324,5	324,4	323,9
Wetlands	4,3	2,7	2,7	2,7	2,7	2,6	2,7	2,7	2,6	2,6	2,6	2,6
Agricultural land	517,8	518,1	518,1	518,1	518,0	517,1	517,3	516,5	516,2	516,1	515,8	515,7

There are 5 distinguishable areas in Montenegro that can be categorised based on their specific characteristics and conditions for the development of agriculture (the data on surface areas and percentage shares in the total agricultural land refer to 2003):

The coastal region with 50,815 ha (9.8% of the total) of fertile agricultural land that consists of deep alluvial – deluvial and brown anthropogenous soils; the region is suitable for fruit and vegetable growing and for breeding of small ruminants, while on the other hand it has an abundance of honey-bearing, aromatic and medicinal herbs and wild fruits (fig, pomegranate, etc.).

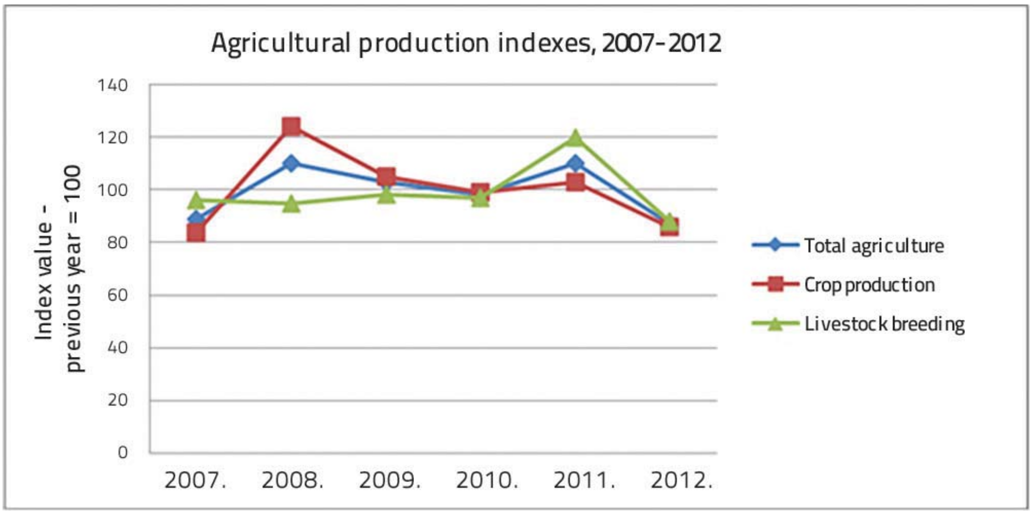
The Zeta-Bjelopavlići region with 78,997 ha (15.3%) is a lowland region with land up to 200 m above sea level - it is suitable for various types of production (crop husbandry, fruits-vineyards, livestock breeding).

The karst region covers 74,320 ha or 14.3% of the total agricultural area and lies at elevations of up to 700-800 m. The arable land is scarce and is mainly located in the karst fields, karst funnel-shaped depressions and small valleys, whereas arid areas dominate. The most important agricultural sectors are livestock breeding (especially goats and sheep, along with some cattle) and beekeeping.

The northern-mountainous region with 184,528 ha (35% of the total area) is characterized by numerous plateaus and highland; it is suitable for growing cereals, potatoes and brassicas, as well as for the development of livestock breeding due to large areas of meadows and pastures.

The Polimsko-Ibar region covers 25% of the total area or 129,804 ha. Fertile land and an abundance of springs and running water make this region important for all three branches of agriculture: crop husbandry with vegetable growing, fruit growing and livestock breeding.

Overall agricultural production recorded variable growth during the period 2007–2011. A greater increase was noticeable in the area of livestock breeding in 2011, while growth in the area of crop production was small, showing some oscillations and a visible trend of a slight decline. Overall, agricultural production in Montenegro in 2012 declined by 12.7% compared to 2011, due to a 13.7% decline in crop production and a 11.4% decline in livestock breeding. The share of crop production represented in the total agricultural production figures in 2012 was 56.6% and the share of livestock breeding was 43.4%.



Graph 2.13 Agricultural production indexes for the period 2007–2011 – Source: MONSTAT

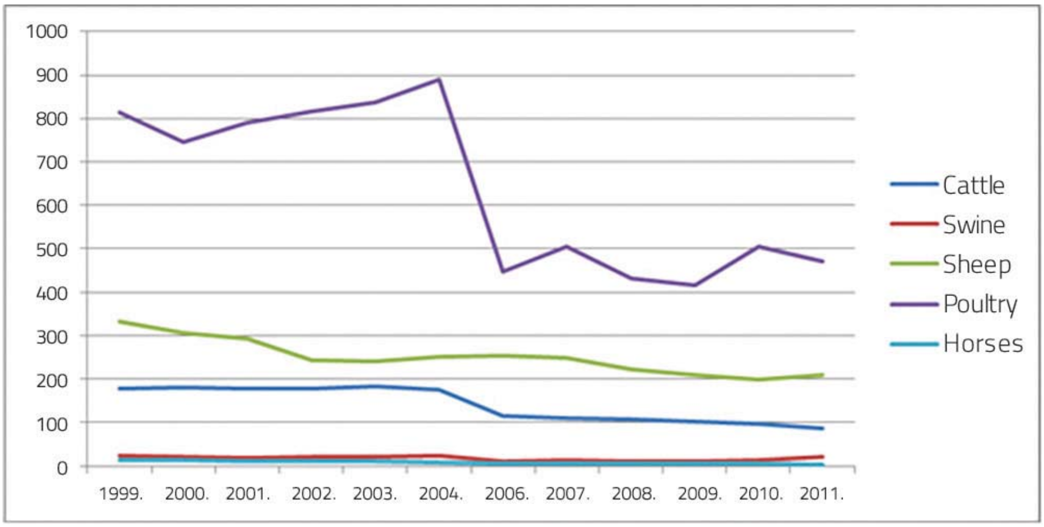
The most important crops are vegetables and fruits, while the commercial production of farm crops (cereals, maize, sugar beet, oilseed)[2] is poorly represented. A slight growth in the production of arable crops is noticeable during the period 2007–2011. The main crops are potatoes (with a yield of about 180,126 t in 2011 and 132,674 t in 2012) and vegetable crops (about 142,700 t of yield in 2011 and 133,487 t of yield in 2012). The most commonly grown fruit crops are plums (about 1,375,100 trees in 2011 and 1,408,130 in 2012), apples (603,805 trees in 2011 and 622,495 in 2012), pears (234,720 trees in 2011 and 235,999 in 2012), peaches (203,642 trees in 2011 and 200,507 in 2012) and also oranges and tangerines in the south (442,960 trees in 2011 and 449,660 trees in 2012) and figs (215,910 trees). There are about 495,200 fruit-bearing olive trees. During recent times the production of grapes and wine has increased, with around 18.4 million of bearing vines in 2011 and 17.5 million of bearing vines in 2012.

Livestock breeding is a significant branch of agriculture. During the period 2007-2011, a drastic decline in the number of heads was generally recorded compared to 1999: cattle (51%), poultry (42%), sheep (37%), pigs (7%), and horses (71%). Official statistics started to be published in 2012 to provide data on numbers and production levels in goat breeding; the current population of goats totals about 23,700 heads, which is much less than previously estimated.

2 In 2011, the crop production was around 11,700 t of corn, 2,400 t of wheat and around 2,000 t of barley.

Table 2.9 Livestock figures during the period 1999–2011 (in 000 animals) – Source: MONSTAT

Livestock	1999.	2000.	2001.	2002.	2003.	2004.	2006.	2007.	2008.	2009.	2010.	2011.
Cattle	178	180	179	178	183	175	115	109,4	106,5	101	96	87
Swine	23	22	19	21	22	24	10,7	13,3	10,4	10	12,4	21,4
Sheep	333	306	293	244	241	252	255	249,3	222,2	209,4	199,7	208,8
Poultry	813	745	791	817	838	890	448,5	505,4	432,3	416,7	506,5	470
Horses	14	12	11	10	10	9	6,2	5,4	5,1	4,9	4,8	4



Graph 2.14 Livestock figures during the period 1990–2011 (in 000 animals)

2.5.4 Tourism

In Montenegro, tourism is one of the most important business activities which has potential for economic growth and development. Tourism is of great importance taking into consideration all of the direct and indirect multiplicative effects. A study carried out by the Central Bank of Montenegro analysed the effect of tourism on the Montenegrin GDP, employment and balance of payment. The report states that the development of elite tourism, the investment of foreign capital in the infrastructure, intensive promotional campaigning in foreign markets and the arrival of world brands in the Montenegrin market have contributed to positive trends in the Montenegrin tourism industry. In 2010, more than a million visits by foreign tourists were registered in Montenegro, which is the highest number in the last ten years. The number of visits by foreign tourists has grown steadily since 2001, with significant growth recorded after Montenegro won its independence.

Tourism is one of the major revenue sources in Montenegro and the economic development of Montenegro is based primarily on the further development of this branch of the economy. Tourism is most developed in the coastal region of Montenegro; this area is characterised by a beautiful jagged coastline, a variety of beaches for swimming and relaxation and cities such as Budva, Kotor, Herceg Novi, Perast, Petrovac which have fortifications dating back to the Middle Ages. Over the past 10 years, however, the promotion of tourism in the central and northern, mountainous part of Montenegro and the development of active tourism for the elderly and the young have been intensified. Special emphasis has been placed on the development of adventure travel, mountaineering and cycling. At the same time, cultural and religious tourism is more present in the central parts of Montenegro, with the historical capital Cetinje and medieval monasteries in Cetinje, Morača and Ostrog being viewed as major tourist attractions.

Tourism has achieved major successes since 2006 and both the total number of visits by tourists and the number of overnight stays have grown continuously. The significant growth in the number of foreign tourists recorded in 2007 was mostly the result of reclassifying tourists from Serbia, who started to be registered as foreign tourists from the time that Montenegro declared its independence. An increase in the number of tourists from other counties also, however, contributed to the growth in numbers recorded. In 2012, 1,439,500 a total of tourists visited Montenegro; this was 4.8% more than had been recorded in the previous year. Most of these tourists stayed on the coast, although there was also a slight increase in the number of tourists visiting mountain locations (Table 2.10.).

Table 2.10 Visits of guests by tourist location types – Source: MONSTAT

Visits by tourists	Year						
	2006.	2007.	2008.	2009.	2010.	2011.	2012.
Total	953.928	1.133.432	1.188.116	1.207.694	1.262.985	1.373.454	1.439.500
Capital city	39.295	45.588	50.393	49.166	54.196	53.480	52.889
Coastal cities	859.904	1.010.742	1.058.825	1.081.805	1.130.832	1.245.340	1.301.396
Mountain locations	26.362	39.158	38.304	41.161	46.545	49.184	52.503
Other tourist locations	28.144	37.642	40.229	34.623	30.540	24.547	30.785
Other locations	223	302	365	939	872	903	1.927

Along with an increase in the number of visits, particularly by foreign tourists, an increase in the number of overnight stays was also recorded. More than 1.2 million foreign tourists were registered in 2012, which was 5.3% more than in the previous year and almost 3.5 times more than in 2006. Table 2.11. shows visits of domestic and foreign tourists recorded during the period 2006–2012.

Table 2.11 Visits by domestic and foreign guests, (2006–2012) – Source: MONSTAT

Structure of tourists	Year						
	2006.	2007.	2008.	2009.	2010.	2011.	2012.
Total	953.928	1.133.432	1.188.116	1.207.694	1.262.985	1.373.454	1.439.500
Foreign tourists	377.798	984.138	1.031.212	1.044.014	1.087.794	1.201.099	1.264.163
Domestic tourists	576.130	149.294	156.904	163.680	175.191	172.355	175.337

Tourism development plans have recognised the fact that the tourism potential of the mountainous area is insufficiently exploited and that the further development of tourism in this area is of major importance, not only for the overall tourism offer of the country but also for the development of the northern region. Current tourism development plans for mountain locations have focused on the development of both summer, winter and ski tourism.

2.5.5 Transport

Road Transport

The national road network includes 8 main and 23 regional roads with a total length of 1,860 km, of which 932 km are main roads and 928 km are regional roads. In addition to the main and regional roads, there are also 4,270.10 km of local roads in Montenegro. The density of the national road network, including main and regional roads, is 13km/100km², and including local roads 44.39 km/100 km². The longest tunnels are Sozina (4,189 meters), which connects the coastal area and the Zeta plain, and Budoš (1.215 meters), which connects the Nikšić Field and the Bjelopavlići Plain.

There were 197,826 registered road motor vehicles and trailers in 2012, which is 0.7% more than in 2011, when there were 196,419 registered motor vehicles and trailers. Of the total number of motor vehicles and trailers registered in 2012, passenger vehicles accounted for 88%, trucks for 6.7% and all other categories of vehicles for 5.6%. Of the total number of registered motor vehicles, 5.6% were passenger vehicles registered for the first time. Regarding the age of passenger vehicles, 9.6% were new vehicles and vehicles up to 5 years old, 15% were vehicles between 5 - 10 years old, and 75.4% were passenger vehicles which were more than 10 years old, of which one third were more than 20 years old. If categorised by type of motor fuel used, 56.6% of vehicles used diesel, 42.6% petrol, and 0.8% of vehicles used other types of motor fuel.

The volume of road transport in 2012 is presented through two indicators: the transport of goods and the transport of passengers. Based on both indicators, the volume of transport declined compared to 2011: the number of passengers transported fell by 8.2% in 2012 compared to 2011, and the volume of goods transported fell by 68.1% in 2012 compared to 2011. Detailed indicators expressing the volume of transport carried out by individual categories is shown in the following table.

Table 2.12 Volume of transport by individual category

Name	Year		Index
	2011.	2012.	2012. / 2011.
Passengers transported in thousands – total	6.240	5.726	91,8
Goods transported in thousands tons	1.247	398	31,9
Buses - mileage –total in thousands	18.700	19.076	102,1
Trucks - mileage – total in thousands	12.108	12.014	99,2

Railway Transport

The railway infrastructure of Montenegro includes 250 km of railway track and 50 railway stations. According to statistical data, the number of passengers transported by rail increased by 12.9% in 2012 compared to 2011, while the quantity of freight transported by rail declined by 35.0% in 2012 compared to 2011. The longest tunnels are Sozina (6,200 m) and Trebješica (5,170 m).

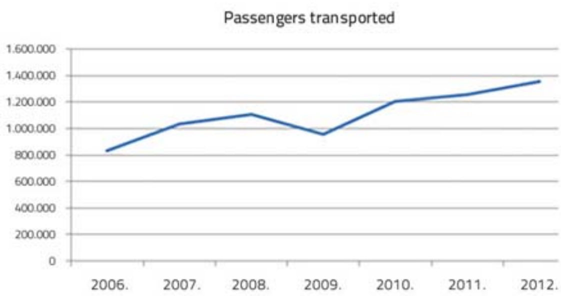
Table 2.13 Volume of railway transport in Montenegro

Name	Year		Index
	2011.	2012.	2012. / 2011.
1. PASSENGER TRANSPORT AND PASSENGER MILES			
Passenger transport, in thousands	692	781	112,9
Passenger kilometres, in thousands	65.100	62.377	95,8
2. FREIGHT TRANSPORT AND TON-KILOMETRES			
Freight, in thousands tons	1.050	683	65
Ton-kilometres, in thousands	135.522	73.337	54,1

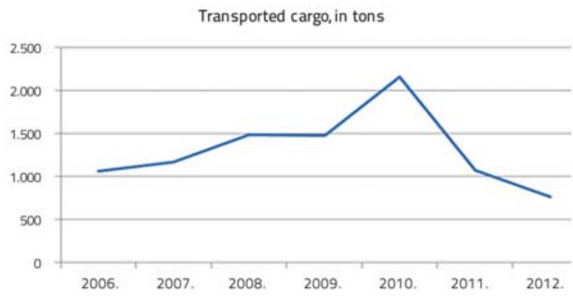
The current condition of the railway infrastructure is such that it hinders normal transport and its existing volume is inadequate to generate sufficient revenues to cover its costs.

Air Transport

Transport by air is handled by two international airports: Podgorica and Tivat. The volume of air transport in Montenegro for the period (2006–2012) is represented by two indicators: cargo transport and the transport of passengers, in Graphs 2.15. and 2.16. According to statistical data, the number of transported passengers has grown continuously. Thus, passenger transport increased by 7.9% in 2012 compared to 2011, and by about 63% compared to 2006 (Graph 2.15). Cargo transported through airports recorded a decline of 28.7% in 2012 compared to 2011, and a decline of 28% compared to 2006 (Graph 2.16).



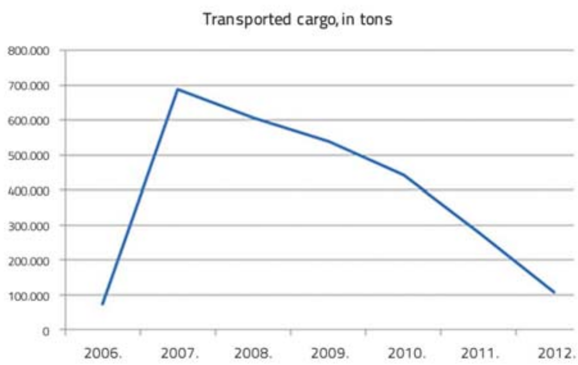
Graph 2.15 Passengers transported during the period 2006–2012



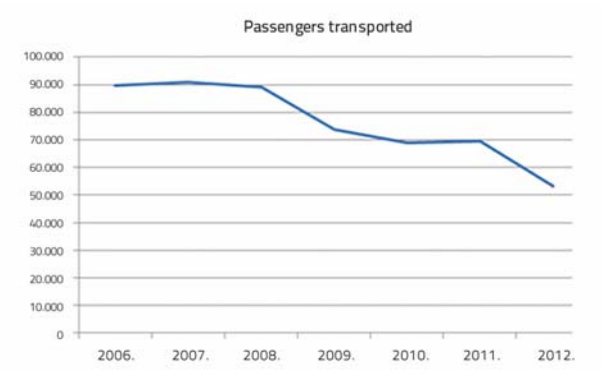
Graph 2.16 Cargo transported during the period 2006–2012 (in tons)

Maritime Transport

There are 4 international ports in Montenegro: Bar, Kotor, Risan and Zelenika. The most important of these is the port of Bar, which accounts for 95% of all port activities and for the transport of passengers and cargo. Statistical indicators show stagnation in the quantity of cargo and in the number of passengers transported by maritime transport. Despite the fact that during the period 2006–2008 a sudden growth was recorded in the transport of cargo, 7 times greater than had been recorded in 2006, a decline in the transport of cargo has been evident since 2009. Thus, the quantity of cargo transported in 2012 fell by 61.1% compared to 2011 (Graph 2.17.). The transport of passengers also recorded a slight decline, 4.2% on average during the period 2007–2012. Thus, for example, the number of passengers transported fell by 23.3% in 2012 compared to 2011 (Graph 2.18).



Graph 2.17 Cargo transported during the observed period (2006–2012) (in tons)



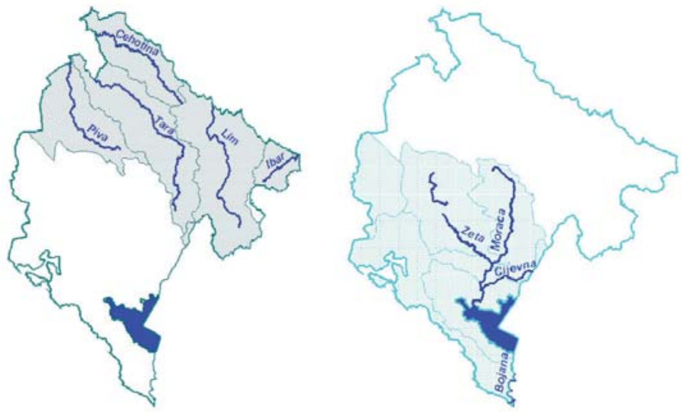
Graph 2.18 Numbers of passengers transported during the observed period (2006–2012)

2.6 Natural Resources

2.6.1 Water Resources

The surface area of Montenegro is 13,812 km^2 and taking into account its corresponding part of the Adriatic Sea (2,540 km^2) it totals 16,352 km^2. Water from the territory of Montenegro drains into two basins: the Adriatic Sea and the Black Sea.

The total surface area of the Black Sea Basin is 7,545 km^2 or 54.6% of the Montenegrin territory. This part of Montenegro drains through the Ibar River and further on to the Zapadna Morava River towards the Danube, as well as through the Tara, Piva, Lim and Ćehotina Rivers towards the Drina and the Danube Rivers. The Montenegrin part of the Adriatic Sea Basin is about 6,560 km^2 or 45.4% of the territory. The biggest watercourses of this basin are the Zeta and Morača Rivers, i.e. the Morača River after the confluence of these two rivers in Podgorica, and the Bojana River, which borders with Albania.



The Black Sea Basin | The Adriatic Sea Basin

Figure 2.3 The Black Sea Basin – the Adriatic Sea Basin

Montenegro's Water Balance

The Adriatic Sea Basin

- The Morača River, the mouth (Lake Skadar) 202 m^3/s
- The Crnojevića River, the mouth (Lake Skadar) 6 m^3/s
- The Orahovštica River, the mouth (Lake Skadar) 3 m^3/s
- Direct precipitation on Lake Skadar 20 m^3/s
- Lake tributaries (the Crmnica, the Seljanštica, the Šegrtnica, the Bazagurska Matica, the Plavnica, the Gostiljska, the Pjavnik, the Velika and Mala Mrka, the Zbelj and the Rujela rivers), total 10 m^3/s
- Inflow from the Albanian side 15 m^3/s.

The water balance of the Adriatic Sea Basin without the Bojana River is 256 m^3/s in total.

The Bojana River is presented separately because of its international character and due to the fact that a significant part of its river basin lies outside of the territory of Montenegro.

- The Bojana River, outflow from Lake Skadar 304 m^3/s
- The Drim River, location "Bahčelek" 306 m^3/s
- The Bojana River, location "Dajči" 610 m^3/s
- Direct tributaries of the Adriatic Sea 25 m^3/s
- Location "Verige", the Boka Kotorska bay 35 m^3/s.

The water balance of the Adriatic Sea Basin together with the Bojana River is 670 m^3/s in total.

The Black Sea Basin

- The Piva River, the confluence 75 m^3/s
- The Tara River, the confluence 77.5 m^3/s
- The Ćehotina River, Gradac 12.5 m^3/s
- The Lim River, Dobrakovo 71 m^3/s
- The Ibar River, Bać 6 m^3/s

The water balance of the Black Sea Basin is 242 m^3/s in total.

Water from Montenegro drains into two basins: the Adriatic Sea and the Black Sea. Potential future changes in the water resources of the Adriatic Sea Basin will impact only on the citizens of Montenegro, while changes in the Black Sea Basin will impact on the countries downstream of the basin and their citizens.

Groundwater

Groundwater in Montenegro is present in rocks of different ages, from the Paeolozoic era to the Quaternary. It is a very important resource that represents the only practical source of water for the population. In addition to supplying water to the population, groundwater is also used in industry as well as in agriculture. Seventy-five sources are used to provide public water supplies to 40 urban settlements; 21 of these are municipal centres and there are also a large number of suburbs. Of the total number of sources, groundwater from karst aquifers is abstracted from 64 of them and groundwater from inter-granular aquifers is abstracted from 11 sources. The chapter "Additional Information" includes a detailed report on reserves, use, protection and other issues related to groundwater.

Water Usage

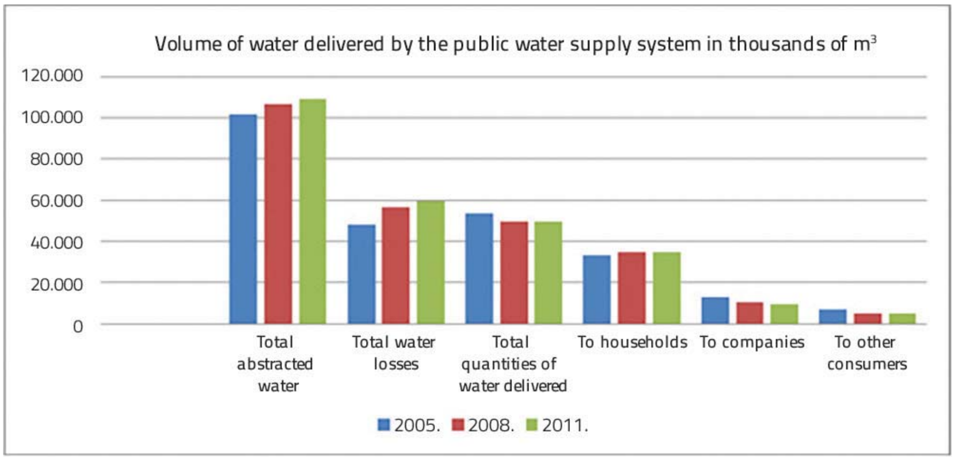
Montenegro has significant surface and underground water resources which are of relatively good quality; this abundance and quality of water resources represents one of the most important comparative advantages of the state.

The largest water consumers are industry and the population. Statistical data[3] shows that the volume of water abstracted during the period 2005-2011 to supply the public water system increased from 101.9 million m^3 in 2005 to 109.5 million m^3 in 2011, i.e. it increased by 7.4%. Of the total volume of water abstracted in 2011, 49.67 million m^3 was delivered to the public water supply system, which is 7.4% less than in 2005 (53.67 million m^3). Of the total delivered volume of water in 2011, 35 million m^3 or 70.4% was delivered to households, 9.6 million m^3 or 19.3% to enterprises and 5.1 million m^3 or 10.3% to other users. Losses in water delivery to the water supply system increased during the observed period (2005-2011), from 48.19 million m^3 in 2005 to 59.77 million m^3 in 2011, i.e. the amount lost increased by 24%. (Graph 2.19.).

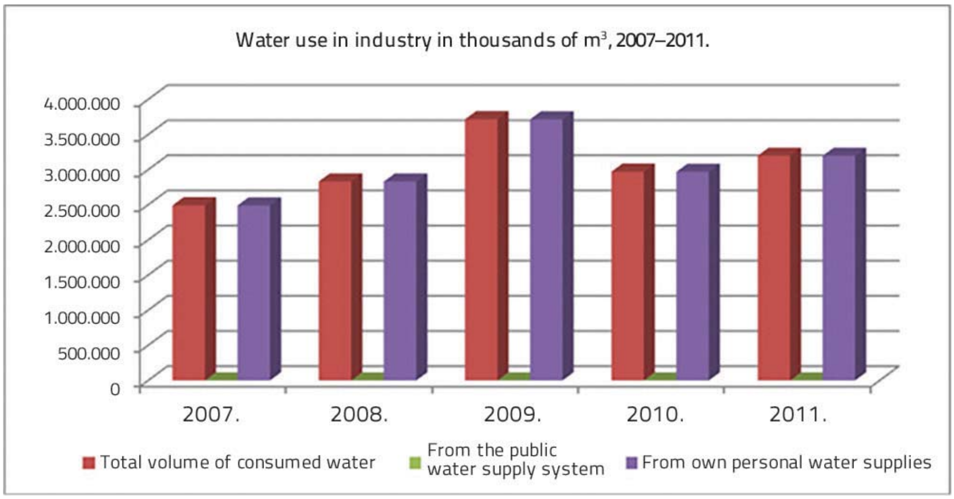
Water consumption levels in industry also increased during the period 2005–2011. Industry is only partially supplied by water from the public water system (only 1.2 million m^3 of water in 2011, i.e. 0.04% of the total volume of consumed water); industry mostly supplies its own water through both surface and underground water (3,1978.8 million m^3 in 2011, i.e. 99.96%). Water consumption in industry during the period 2005-2011 is shown in Graph

3 MONSTAT – data were collected in the annual report on the public water supply system.

2.20. Of the total amount of water used in industry, 99.27% was used by the electricity, gas and steam providing sectors and for air-conditioning, while 0.73% was used by the mining and manufacturing sectors.

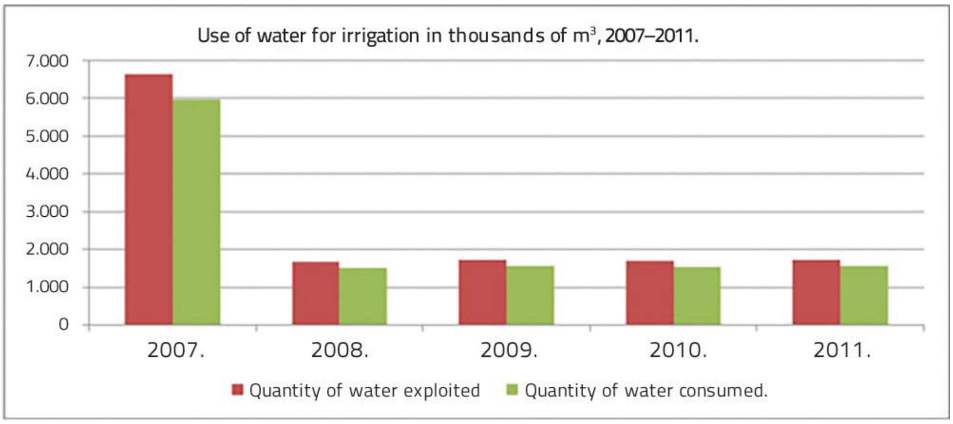


Graph 2.19 Volume of water delivered by the public water supply system in 2005, 2008 and 2011



Graph 2.20 Water use in industry (2007–2011) in thousands of m³

Use of water for irrigation during the observed period (2007–2011) is shown in Graph 2.21. Underground water sources are mainly used for irrigation (96.6% in 2011), while surface sources are used very little (3.4% in 2011).



Graph 2.21 Use of water for irrigation (2007–2011) in thousands of m³

2.6.2 Forests

Forests are one of the major natural resources in Montenegro, because of their natural and diverse structure and because of their natural regeneration.

Orographic features and the refugial character of many habitats have made the abundance and diversity of wildlife (flora and fauna) a quality specific to Montenegro. The floristic diversity comprises 3,250 plant species and the index (S/A-species/area[4]) 0.837 makes Montenegro one of the most important biodiversity centres in Europe. The refugial character[5] of habitats predominates; however, there is also evidence that species of flora and fauna that are endemic in Europe, Alpine and in other Mediterranean regions are also present.

Major diversity in dendroflora is illustrated by the fact that the National Forest Inventory registered 68 species of trees (57 broadleaf and 11 coniferous species). Woody species form pure and mixed forests and cover 59.9 % (832,900 ha), while forest land covers additional 135,800 ha or 9.8%, which represents 69.7% of the territory of Montenegro. When comparing the data from the National Forest Inventory (NFI) with the data from the Spatial Plan of Montenegro up to 2020, which states that forests and forest land covers an area of 738,000 ha or 53.4%, an increase of 16.3% is evident.

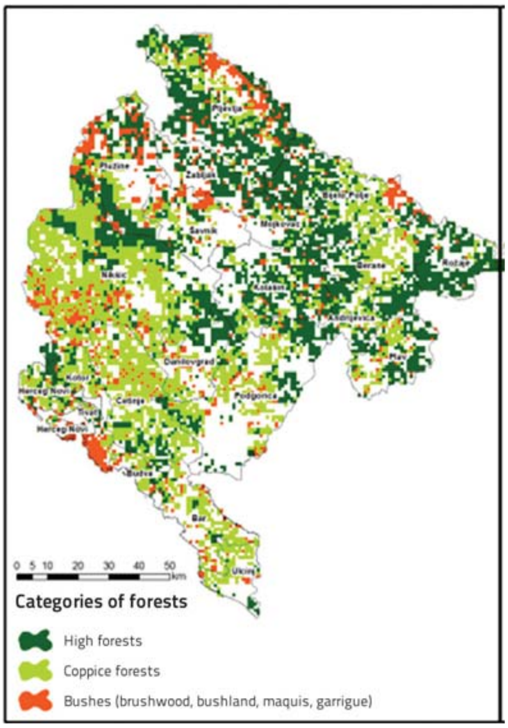
Taking into consideration the area covered by forests (69.7%), as well as the hectare ratio per capita (1.3 ha/per capita), Montenegro is among the top three most forested countries in Europe, falling closely behind Finland (86%; 4.5 ha/per capita) and Sweden (67%; 3.1 ha/per capita). It should be stressed that the forest cover such as this is far above the average European (46%) and world (30%) level of forest cover. A high percentage of forest cover represents a big advantage in terms of environmental protection and improvement, and is also positive in terms of adapting ecosystems to meet future changes.

Data on the estimated standing volume in all forests ranges from 72.8 million m^3, as quoted in the Spatial Plan, to 118 million m^3 according to NFI data, while increment estimates range from 1.5 to 5 according to the Spatial Plan and to 2.82 million m^3 according to NFI data. Dominant species in the forest include beech, spruce, fir, black pine, etc. Graph 2.22. shows the distribution of high forests and coppice forests.

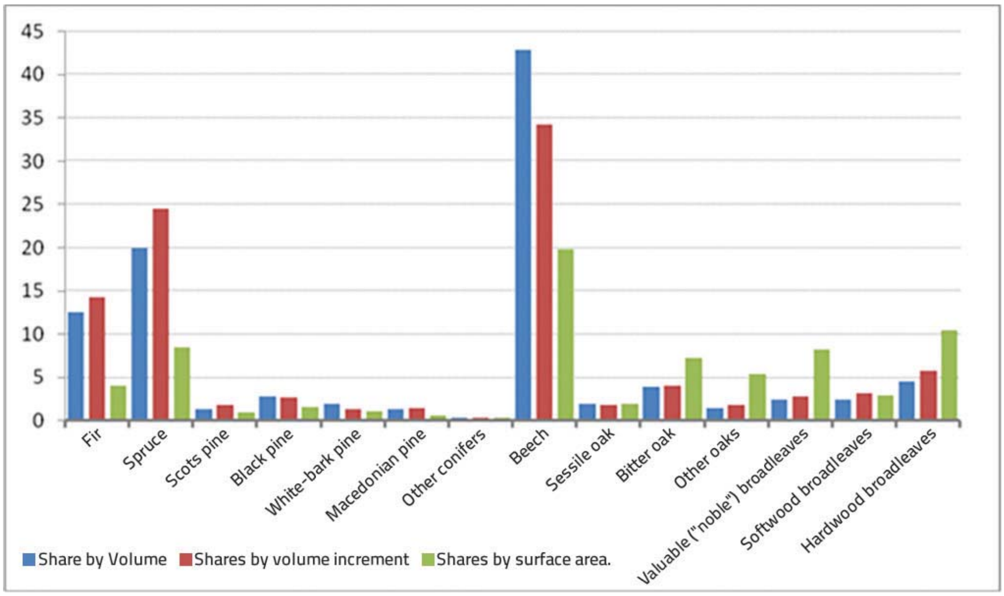
Regarding the share of surface area, beech dominates with 19.8%, then spruce with 8.5%, fir with 4.1%, sessile flowered oak 2.0% and black pine with 1.6% (Graph 2.23). The share of dominant species by volume is as follows: beech 42.6 %, spruce 20 %, fir 12,5 %, which accounts for 75.1 % of the standing volume, then black pine and bitter oak with respective shares of 2.8% and 3.9%. White bark pine and Macedonian pine, which are endemic species in the Balkans, represent significant shares both in surface area with 1.1 % (white bark pine) and 0.6 % (Macedonian pine), and in volume.

According to data from the Spatial Plan of Montenegro, 67% of forests are state owned. However, there are some indications that the balance of ownership has changed in favour of private forest owners, due to updates in the cadastre, and due to restitution, etc. and that 49% of forests and forest land are now privately owned.
Currently, 124,964.24 ha or 9.05% of the Montenegrin territory is protected. The biggest areas are the national parks: Durmitor, Lake Skadar, Lovćen, Biogradska gora and Prokletije which represent a total of 101.733 ha (7.77 %). The next most significant protected areas are natural monuments which total 13,538 ha (0.98%) and nature reserves 650 ha (0.047 %).

4 Index describing biodiversity, i.e. number of species per area unit (Species/Area).
5 A refugial habitat is an area that was suitable for survival of a large number of species during the Ice Age.



Graph 2.22 Distribution of high and coppice forests – Source: NFI (2012)



Graph 2.23 Percentage share of tree species by volume (V), volume increment (Vi) and surface area

The share of forestry in the Montenegrin GDP in 2011 was estimated at 0.3% which is similar to the share of this sector in GDP of other Balkan countries. MONSTAT data for the period 2003– 2010 indicates that the quantity of felled trees varied from year to year (Table 2.14), but that it was less than the annual allowable cut[6] (717.568 m^3), and this is stated in the current planning documents of the Forestry Administration of Montenegro. However, it should be stressed that the felling of trees is not carried out on inaccessible terrain, but is rather concentrated in "open" forest areas where the volume of felling cannot be considered as being sustainable.

6 Annual allowable cut is the volume of growing stock or forest area planned for felling.

Table 2.14 Tree felling in forests and outside forests, produced assortments (m^3) – Source: MONSTAT (2010)

	Gross volume	Felling		Total felling		
		Hardwood	Conifers	Industrial wood and timber	Firewood	Scrap
2003.	485.440	232.131	253.309	235.418	166.006	84.016
2004.	527.165	247.148	280.017	263.880	169.225	94.060
2005.	574.375	260.488	313.887	305.795	163.835	104.745
2006.	631.273	280.760	350.513	338.993	174.282	117.998
2007.	548.162	236.339	311.823	306.944	139.737	101.481
2008.	595.195	242.589	352.606	328.857	156.181	110.157
2009.	444.446	216.640	227.806	208.250	156.341	79.855
2010.	480.396	224.811	255.585	246.699	152.391	81.306
2011.	542.729	-	-	-	-	-

Forest Condition

Factors that threaten forest ecosystems are primarily wildfires, abiotic factors (droughts, floods, frost, snow and high winds, etc.) and pests and diseases. The number of wildfires varies from year to year. Given the ecological and economical damage, wildfires are the biggest threat to forest ecosystems in Montenegro. Although currently their coverage is about 0.5% of the total forest area at the annual level, they could impose a serious threat in the future, especially in the southern forest region, where forests spread along the coast and in karst terrains. Here access is difficult to put out wildfires.

According to available detailed information from Montenegro's national forest monitoring data, which is obtained from 49 locations and covers the entire territory of Montenegro, the average health and condition of forests is satisfactory. In most of the locations, the recorded degree of defoliation is within expected limits (0–25)%. Of all inspected trees (1.176 trees), 43% fell into the no-defoliation category ((0–10)%-no defoliation), 37% showed signs of slight defoliation ((10–25)%-slight (warning defoliation)), and major changes in defoliation were only recorded in 20% of trees ((25–60)%-medium defoliation).

Usual insects and fungi, causing tree degeneration, were identified during tree inspections. It should be stressed that according to the ICP[7] 2011 Report total damage caused by pests and fungi was found in 21% of trees (insects – 181 trees (15.39%); plant diseases – 68 trees (5.78%). Compared to 2010, this damage was identified in 26 additional trees or 2.21% more, which is an insignificant change.

In Montenegro, there are significant forest areas which are in different stages of degradation, and which are planned for reconstruction or conversion, i.e. the removal of the remaining standing volume that does not have silvicultural perspective and the forestation of those areas with new plantations that would guarantee greater standing volume production, and would thus constitute a vegetation cover of larger resilience and capacity for CO_2 absorption.

7 Monitoring of the forest damage situation in Montenegro according to ICP programme for forests (International Co-operative Programme on Assessment and Monitoring of Forest Condition in Europe).

2.6.3 Ores and Minerals

There are numerous ore and mineral deposits which are spread over relatively large areas. For example, occurrences and deposits of white and red bauxite are registered in almost 1/3 of the territory of Montenegro. Peat covers about 1,400 hectares. Coal reserves are located in the Pljevlja and Berane Basins, whereas the opencast mining of lignite in the vicinity of Pljevlja extends to several hundred hectares. Total coal exploitation reserves in the Pljevlja Basin are estimated at 198.9 million tons. In the Berane Basin (Polica, Petnjik and Zagorje Basins), the geological reserves of brown coal are estimated as being about 158 million tons, but due to inadequate research, total assumed exploitation reserves are estimated at only 17.8 million tons (IMC study, 2008).

Table 2.15 Coal reserves in the area of Pljevlja – Source: Coal Mine, Pljevlja, except for Maoče (Fichtner study, 2009)

No.	Basin/deposit	Category	Reserves (t)	Overburden (m^3)	DKV (kJ/kg)	Mean coefficient of overburden (m^3/t)
1	Pljevlja Basin					
	Potrlica (with Cement factory)	A+B+C1	43.393.192	175.522.891	11.048	4,04
	Kalušiči	A+B+C1	13.808.391	34.799.000	8.231	2,52
	Grevo	C1	2.288.757	4.183.000	12.812	1,83
	Komini	C1	7.039.460	8.932.000	11.515	1,27
	Rabitije	C1	5.486.126	40.947.000	13.663	7,46
	Total 1		72.015.926			
2	Ljuče-Šumanski Basin					
	Šumani I	A+B+C1	651.632	1.323.673	7.684	1,15
	Ljuče II	B+C1	1.056.085	500.000	5.572	0,60
	Total 2		114.706.351			
3	Maoče	B+C1	109.900.000	715.300.000	12.504	6,90
4	Otilovići	B+C1	3.490.885	11.887.300	10.510	3,78
5	Bakrenjače	A+B+C1	1.315.466	1.151.000	10.296	0,89
	Total 3-5		114.706.351			
	TOTAL BALANCE		188.429.994			
6	Mataruge	C1	7.500.000	15.500.000	8.000	2,00
7	Glisnica	C1	3.000.000	8.000.000		
	Total 6-7		10.500.000			
	TOTAL FOR ALL DEPOSITS		198.929.994			

2.7 Waste Management

2.7.1 Municipal Waste

Insufficient capacity for safe waste disposal, slow progress regarding waste recycling and poor public awareness regarding reducing the amount of waste produced and conscientious waste disposal are still issues that hinder efficient waste management in Montenegro. Eight Montenegrin municipalities (Budva, Bijelo Polje, Cetinje, Kolašin, Mojkovac, Rožaje, Šavnik and Ulcinj) have not yet adopted waste management plans and a lack of accurate records is another reason for a lack of data on the qualitative and quantitative analysis of waste; this all makes it difficult to assess the total quantity of municipal waste in Montenegro. Currently, there are two regional sanitary landfills in Montenegro and these are in Podgorica –Livade landfill (to meet the needs of the Capital City of Podgorica, the municipality of Danilovgrad and the historical capital of Cetinje) and in Bar (to meet the needs of the municipalities of Bar and Ulcinj, and also most recently the municipalities of Budva, Kotor and Tivat). The regional sanitary landfill site, Možura, in Bar was opened in June 2012. The strategic National Waste Management Plan outlines the construction of an additional five regional centres for waste processing by 2020. Apart from the Primary Recycling Centres in Podgorica and Herceg Novi, where some types of waste are selected and prepared for transportation for further processing purposes, and a small plant in Kotor (for the needs of municipalities of Kotor and Tivat), there are currently no recycling facilities in Montenegro. Nor is there a single composting plant in Montenegro.

According to statistical data, total quantities of collected municipal waste in 2011 amounted to 297,428 tons, i.e. 480 kg per capita, which is 9.8% less when compared to 2010, and 36% less then compared to 2009. In 2012, 279,667 tons of municipal waste was collected, i.e. 451 kg per capita, which is 6% less than compared to 2011. Table 2.16. shows quantities of collected municipal waste in Montenegro during the period 2009-2012.

Table 2.16 Quantities of municipal waste collected in Montenegro (2009–2012)

Montenegro	2009.	2010.	2011.	2012.
Number of municipalities where waste is collected	21	21	21	21
Total annual quantities of collected waste	464.617	329.610	297.428	279.667

Number of households included in municipal waste collection increased by 2.7% in 2011 (153,028 households) compared to 2010 (148,959 households) and by 4% compared to 2009 (147,014 households). As there is no primary and secondary selection of waste, and bearing in mind poor records on the structure and quantity of waste, there is currently no accurate data in Montenegro on the structure of municipal waste produced annually.

2.7.2 Industrial Waste

Although industrial production has stagnated in Montenegro over the past 20 years and has consequently generated less hazardous industrial waste on an annual basis, the total quantity of such waste is still significant and poses a threat to the environment.

Thus, 557,635.81 tons of waste was generated in 2011, of which 1,790.46 tons or 0.3% was in the mining sector, 60,271.81 tons or 10.8% was in the manufacturing sector and 495,573.54 tons or 88.9% was in the electricity, gas and steam supply sectors (Table 2.17). Shares of hazardous and non-hazardous waste by sector were:

- Mining sector – non-hazardous waste 31.4%, hazardous waste 68.6%;
- Manufacturing industry – non-hazardous waste 90,3%, hazardous waste 9.7%;
- Electricity, gas and steam supply sectors– non-hazardous waste 99.9%, hazardous waste 0.1%.

In 2012, 457,610.73 tons of waste were generated in total, of which 923.46 55 or 0.2% were in the mining sector, 105,296.22 tons or 23% were in the manufacturing sector and 351,390.96 tons or 76.8% were in the electricity, gas and steam supply sectors (Table 2.18). Shares of hazardous and non-hazardous waste by sector were:

- Mining sector – non-hazardous waste 75.8%, hazardous waste 24.2%;
- Manufacturing industry – non-hazardous waste 96.7%, hazardous waste 3.3%;
- Electricity, gas and steam supply sector– non-hazardous waste 99.97%, hazardous waste 0.03%.

Table 2.17 Generated industrial waste by sector in 2011

MONTENEGRO	Mining	Manufacturing industry	Electricity, gas and steam supply	Total
Non-hazardous waste	1.227,4	54.446,6	495.385,2	551.059,2
Hazardous waste	563,0	5.825,2	188,4	6.576,6
TOTAL	1.790,4	60.271,8	495.573,5	557.635,8

Table 2.18 Generated industrial waste by sectors in 2011.

MONTENEGRO	Mining	Manufacturing industry	Electricity, gas and steam supply	Total
Non-hazardous waste	699,66	101.790,33	351.301,53	453.791,52
Hazardous waste	223,89	3.505,89	89,43	3.819,21
TOTAL	923,55	105.296,22	351.390,96	457.610,73

Statistical data shows that the quantity of industrial waste generated in 2012 declined by 18% compared to 2011, that non-hazardous waste declined by about 17.6% and that hazardous waste declined by about 42%.

2.8 Physical Planning

The priorities of physical planning are to overcome urban development issues, and relate to clearly defining urban development policies, including stopping illegal construction by fully observing the principles of the Vienna Declaration, by improving the quality of living in urban environments, and by establishing a responsible attitude from citizens towards their urban environment. This is particularly important bearing in mind that 63.23% of the total population of Montenegro lives in urban zones, and 36.77% in rural ones.

The Spatial Reform Agenda, adopted by the Government of Montenegro, discussed the Report on the State of Physical Planning for 2013 and set new goals for the physical planning policy. This is an important and necessary segment of the overall development policy for Montenegro and includes:

- Preservation of spatial potential with sustainable development;
- Preservation of spatial identity and distinctiveness of Montenegrin landscape;
- Physical planning policy reform;
- Land policy reform;
- Solutions for illegal construction problems;
- European spatial integration.

The challenges of the physical planning policy include: spatial limitations and non-renewability, the creation of a modern spatial identity based on the potential and unique nature of the landscape, the relationship between ecology and the economy, defining the difference between growth and development, the differences between physical growth and damage to the environment, the problems of severe pollution, issues arising from climate change, the need to increase public awareness about preserving and planning space usage, education and the strengthening of capacity.

2.8.1 Coastal Area

The coastal area of Montenegro has a land area of 1,591 km^2, i.e. 6 costal municipalities as defined by their administrative borders, and territorial sea and inland water with a total surface area of about 2,540 km^2.

The six coastal municipalities (Herceg Novi, Kotor, Tivat, Budva, Bar and Ulcinj) account for 11% of the national territory, and about1/3 of the total population of Montenegro lives in this region. The coastal area is the most developed and the most populated part of Montenegro and has beautiful nature and a rich cultural heritage. This area is particularly interesting for tourism development – this branch of the economy is viewed as a major factor in the overall economic recovery and development of the country.

The amount of developed land in the coastal municipalities of Montenegro represents 15.5% of the total land available. An analysis of the current spatial planning documents along with an overview of the situation based on orthophoto images from 2011 shows that property development areas are excessive in comparison with the existing population and tourist capacity.

If the Special Purpose Area Special Plan for the coastal area goes ahead with all of the zones that are planned for property development according to existing plans, i.e. construction plans which cover 46% of the surface area of a 1 km wide strip, this would mean that by 2030, within a period of 16 years, that twice as much would be built as has already collectively been built by all previous generations and investors (to date 29% of a 1 km wide strip has been developed). It is more than obvious that a plan like this is neither sustainable nor realistically feasible. It involves extremely high levels of planned property development, even when compared with the much more densely populated coasts of France, Spain and Italy. Additionally, natural, undeveloped coastal areas are an important attraction for tourists and for the general growth of Montenegrin coastal areas.

The irrational expansion of property development is often the result of the conversion of agricultural land. This does not only harm agriculture but also causes other negative effects such as: land erosion, environmental pollution, the destruction of cultural heritage and other areas. In order to accomplish one of the basic goals of sustainable development, related to the preservation of agricultural land as a natural resource, the conversion of agricultural land to urban land requires a responsible approach at both municipal and regional levels. Consistent restrictions are necessary regarding the expansion of existing settlements and regarding construction, including the reduction of property development areas and the direction of construction into urban centres.

Vulnerability of Coastal Areas

An analysis of general vulnerability was conducted based on the vulnerability of individual segments of the environment. However, in doing so the degree of each area's vulnerability was not calculated based on individual operations or actions, but rather on the specific characteristics or values of each area. The current level of pollution affecting individual segments of the environment was also analysed and the results of the analysis were used to define the vulnerability of an area along with rehabilitation measures.

The results of the vulnerability analysis clearly indicate extreme vulnerability of the environment in Montenegro's coastal region; 2/3 of it is deemed to be highly vulnerable. Regarding the size of vulnerable areas, the areas of Bar and Ulcinj (Ulcinj and the Anamal Fields, the area adjacent to the Bojana River) stand out, while most of the other highly vulnerable areas are located close to Budva (naturally preserved hinterland and parts of the coast).

Tables 2.19 and 2.20 give an overview of the size of vulnerable areas and their share of the total surface area within municipalities and within the strip of land that measures 1,000 m from the coastline.

Table 2.19 Size of vulnerable areas and their share within the total surface area of municipalities – Source: Report on the State of Physical Planning for 2013

Degree	Very low vulnerability (1)		Low vulnerability (2)		Medium vulnerability (3)		High vulnerability (4)		Very high vulnerability (5)	
Municipality	ha	%	ha	%	ha	%	ha	%	ha	%
Bar	473	1	482	1	16.236	35	13.336	29	15.380	34
Budva	329	3	51	>1	2.400	19	3.477	28	6.324	50
Herceg Novi	470	2	436	2	7.489	33	7.412	33	6.554	29
Kotor	450	1	198	1	13.793	41	10.066	30	9.143	27
Tivat	256	6	133	3	1.287	28	1.065	23	1.893	41
Ulcinj	66	>1	129	1	3.319	13	10.956	42	11.386	44
Total	2.044	1	1.429	1	44.524	31	46.312	32	50.680	35

Table 2.20 Size of vulnerable areas and their share within the strip measuring 1,000 m from the coastline – Source: Report on the State of Physical Planning for 2013

Degree	Very low vulnerability (1)		Low vulnerability (2)		Medium vulnerability (3)		High vulnerability (4)		Very high vulnerability (5)	
Munici-pality	ha	%	ha	%	ha	%	ha	%	ha	%
Bar	189	6	315	10	840	27	1.133	36	658	21
Budva	190	7	31	1	541	20	957	36	966	36
Herceg Novi	267	7	147	4	1.712	42	1.183	29	794	19
Kotor	9	>1	38	1	2.465	42	1.557	27	1.785	30
Tivat	233	9	131	5	925	37	628	25	614	24
Ulcinj	11	>1	34	1	516	18	1.387	48	933	32
Total	899	5	696	3	6.999	33	6.845	32	5.750	27

2.9 Scientific Research Activity

The Ministry of Science performs activities as detailed in the Decree on Organisation and Manner of Work of State Administration (Official Gazette of Montenegro 5/12, 25/15 and 61/12) and implements research policy in Montenegro, pursuant to the Law on Scientific Research Activity (Official Gazette of Montenegro 80/10, 40/11 and 57/14) and Amendments to the Montenegrin Strategy for Scientific Research Activity in the period 2012-2016, through national programmes of national interest and international cooperation programmes and projects.

The Ministry has defined three strategic goals that will contribute to the development of the Montenegrin scientific research community, as well as to the overall development of the society. The goals are:

- Development of scientific research community in Montenegro,
- Cooperation of the scientific research community with the economy, and
- Strengthening bilateral and multilateral cooperation.

In 2014, scientific research activity in Montenegro was performed by 57 licensed scientific research institutions (universities, institutes, faculties, companies), registered with the Ministry of Science register.

Research and development activity in Montenegro is performed by 1,345 researchers in total, who are registered with the electronic database "Scientific Network" of the Ministry of Science.

The Montenegrin Ministry of Science is a state administration body that implements research and development policy in Montenegro. The Council for Scientific Research Activity prepares and proposes strategies for research and development, follows implementations of strategies, provides technical proposals and plays an advisory role. Scientific research activity is carried out in existing scientific research institutions. These are, primarily:

- The Montenegrin Academy of Science and Arts (MASA);
- Centres of Excellence;
- Scientific research parks;
- Licensed scientific research institutions registered with the Ministry of Science Register (universities/units, institutes, faculties and companies) that perform scientific research activity; and
- Other business entities that perform scientific research activity and are not registered with the Ministry of Science register of licensed scientific research institutions.

The Montenegrin Academy of Science and Arts consolidates research potential in Montenegro, organises, encourages and develops scientific, artistic and cultural work, organises, initiates and conducts scientific research, independently or in cooperation with other scientific research institutions, in line with defined directions of scientific research activity in Montenegro and in accordance with good practice of EU states in this field and contemporary role of science academies in the society.

In accordance with the Law on Scientific Research Activity, the status of a Centre of Excellence may be granted to a scientific research institution or to a group of researchers in an institution that have accomplished, with their originality, significance or actuality of results in the scientific research activity in the period of five years, the highest level and internationally recognized outputs in their field of science.

The Ministry of Science granted the status of the first Centre of Excellence in Montenegro to the University of Montenegro - Electrical Engineering Faculty in Podgorica, for its implementation of the scientific research project "Centre of Excellence in BioICT". This status was awarded for a three-year period, starting from 1st June 2014 and ending on 31st May 2017 and a grant worth 3.42 million € was approved for the implementation of the project. The Centre commenced its operations on 1st June 2014. The Centre of Excellence "BIO-ICT" is a consortium of 8 partners. It is of inter-disciplinary character and is active in the following research fields:

- ICT;
- Agriculture and food;
- Medicine and human health; and
- Sustainable development and tourism.

Research at the Centre is carried out in 6 laboratories (4 existing and 2 new ones). There are 82 researchers at the Centre and they come from many scientific fields. Fifteen of them are young researchers - PhD students and 5 are post-PhD students.

In accordance with the defined speed of implementation of the Strategic Plan for the establishment of the first Science and Technology Park (STP) in Montenegro, activities related to the establishment of the first Innovation and Entrepreneurship Centre "Tehnopolis" in Nikšić were launched in 2014. It is expected that this centre will contribute to: better relations between the science and business sectors, the enhancement of competitiveness by SMEs, the promotion of entrepreneurship and the provision of support for start-up companies.

The Ministry of Science has completed the tender procedure for the development of the main project design for the renovation of the Montenegrin Army House in Nikšić, where "Tehnopolis" will be located. According to the main project design, the activities of "Tehnopolis" will be carried out in the business premises of the renovated Montenegrin Army House in Nikšić which has a total gross surface area of approximately 2,000 m^2. This facility will include offices for up to 20 micro and small enterprises, a big meeting room and 3 laboratories, as follows: biochemical laboratory, laboratory for industrial design and ICT laboratory (ICT data centre). In addition to this, "Technopolis" will also have a Congress Centre where professional conferences, seminars, workshops, press conferences and other similar activities can be held.

National Scientific and Research Projects

In 2014, the implementation of a second research year enabled the continuation of 104 scientific and research projects following the Public Announcement for 2012-2015. These projects are co-financed by the Ministry of Science together with six other ministries: the Ministry of Agriculture and Rural Development, the Ministry of Health, the Ministry for Information Society and Telecommunications, the Ministry of Sustainable Development and Tourism, the Ministry of Education and Ministry of Culture.

The projects are funded within the following priority areas: Energy; Identity; Information and Communication Technologies; Competitiveness of the National Economy; Medicine and Health; Science and Education; New Materials, Products and Services; Sustainable Development and Tourism; Agriculture and Food; and Transport.

The Ministry is involved in the following international projects:

1. FP7 - EU's Seventh Framework Programme for Research and Technological Development;
2. Framework EU Programme for Research and Innovation "Horizon 2020";
3. International Atomic Energy Agency (IAEA);
4. EURECA Programme (Pan – European network for market oriented research);
5. COST Programme (European programme for cooperation in science and technology);
6. NATO Scientific Programme for Peace and Security;
7. International Centre for Genetic Engineering and Biotechnology - ICGEB;
8. Other multilateral programmes and projects.

The Ministry of Science has actively supported the participation of researchers in the JRC (Joint Research Centre), in activities within the Danube Strategy and has also promoted UNESCO science programmes.

Within the IPA IV component and the operational programme "Human Resource Development" 2012-2013, the Ministry of Science is a part of the Operational Structure (the body responsible for measure - BRPM), together with the Ministry of Labour and Social Welfare, the Ministry of Education and the Ministry of Science (CFCU). After the decision was adopted to transfer authority to the decentralised management of IPA IV component from 28th July 2014, the implementation of activities planned within Measure 2.2 "Support to promotion of innovative capacities in higher education, research and economy" started (development of the Service Contract terms of reference and of the Guide for Grant Scheme Applicants).

In order to implement this programme, a system has been set up within the Ministry of Science for the implementation of activities within IPA component IV. After getting official accreditation, the implementation of planned activities within Measure 2.2 "Support to promotion of innovative capacities in higher education, research and economy" will commence.

Also, preparatory activities are underway to programme priorities within new IPA II cycles Financial Perspective 2014-2020. The Ministry of Science is involved in two sectors: "Competition and Innovations" sector and "Education, Employment and Social Policy" sector.

Investment in Science and Research

1.85% of GDP is allocated for research in EU member states, but the ultimate goal is 3%

The Government of Montenegro continuously implements activities aimed at increasing the percentage of GDP allocated for science and research and this has resulted in an increase in allocation of funds for this field from 0.13% of GDP in 2010 to 0.50% of GDP in 2014.

In cooperation with MONSTAT, the Ministry of Science continuously carries out activities related to the statistical processing of data on human resources and on investment in research and development; the aim is to achieve wider coverage of reporting units involved in data collection and processing, which will in turn enable a more realistic account of investments in science by a large number of public and private institutions, as well as by the private sector. A statistical survey was conducted in 2014 and the finalisation of data processing is expected by the end of February 2015. An agreement has been reached between the Ministry of Science and MONSTAT that the Ministry is to be an administrative source of statistical data on science in the future. Technical assistance will be provided for this through a planned project from IPA 2013 Programme – Enhancement of Statistical Capacities and Strengthening of Economic and Social Statistics, which will be operational from early 2016.

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3. INVENTORY OF GREENHOUSE GASES

The calculation of GHG emissions in Montenegro was done for the first time for the purpose of the Initial Communication on Climate Change to UNFCCC, when years 1990, 2003 and 2006 were considered to identify the trend of GHG emissions. This Communication presents the trend of GHG emissions for the period 1990–2011.

3.1 Methodological Approach

The Second National Communication on Climate Change shows the inventory of GHG emissions and sinks in Montenegro for the period 1990–2011. Revised IPCC Guidelines for National GHG Inventories, (1996) and Good Practice Guidance and Uncertainty Management in National GHG Inventories, (2000) were used to produce the inventory of GHG emissions.

The GHG emissions inventory included the calculation of emissions of the following direct greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous suboxide (N_2O), synthetic gases (fluorinated carbon compounds – HFC, PFC and sulphur hexafluoride – SF_6).

This Communication also includes calculations for the following indirect greenhouse gases based on the EMEP/EEA Air Pollutant Emission Inventory Guidebook (2009): carbon monoxide (CO), nitrous dioxide (NO_2), non-methane volatile organic compounds (NMVOC) and sulphur dioxide (SO_2).

Sources and sinks of emissions of direct and indirect GHG are divided into six main categories:

1. Energy
2. Industrial processes
3. Use of solvents
4. Agriculture
5. Land use change and forestry
6. Waste

Results obtained through bilateral cooperation between Italy and Montenegro in the field of the environment, as defined in the Agreement on the Establishment of the Government Environmental Protection System in the field of air quality management, were also used for the purpose of this Communication.

The GHG inventory development process is a dynamic, continuous process which has the potential to include new data on activities in specific sectors, which, according to methodology, requires the recalculation of the entire time series. It is particularly important to mention national energy balances, which were updated according to internationally recognized methodology and as such required the recalculation of the results obtained for the energy sector emissions to date, and consequently of the total emissions at a national level. Data verification and checks were carried out by an external consultant who was hired for the purpose of drafting the Second National Communication on Climate Change for Montenegro.

3.2 Emissions of Greenhouse Gases (by gas)

This part of the Communication offers an overview of GHG emissions in Montenegro during the period 1990-2011. Graphs 3.1 to 3.8 and Tables 3.1 to 3.5 show total emissions of direct GHG (CO_2, CH_4, N_2O, CF_4 and C_2F_6) from six main economic sectors. An estimate of hydrofluorocarbons (HFC) and sulphur hexafkuoride (SF_6) was also made for 2011. Graphs 3.9 to 3.16 and Tables 3.6 to 3.9 offer an overview of total indirect GHG, while Graphs 3.17 to 3.20 and Table 3.10 provide an overview of total CO_{2eq} emissions.

3.2.1 Direct GHG Emissions

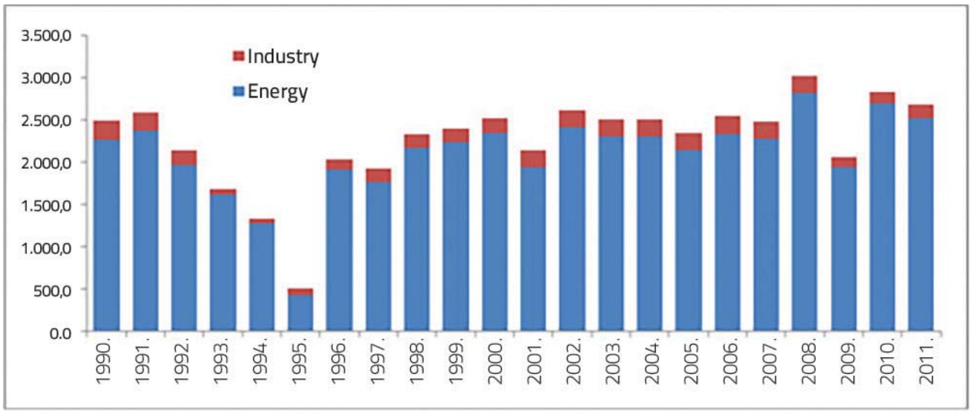
CO_2 Emissions

As shown in Table 3.1 and Graphs 3.1 and 3.2, the energy sector is responsible for the greatest share in total CO_2 emissions (85.5–96.7)%, due to fuel combustion. Industrial processes and production contribute to the total CO_2 emissions to a smaller extent (3.3–14.5)%, while other sectors almost do not contribute at all.

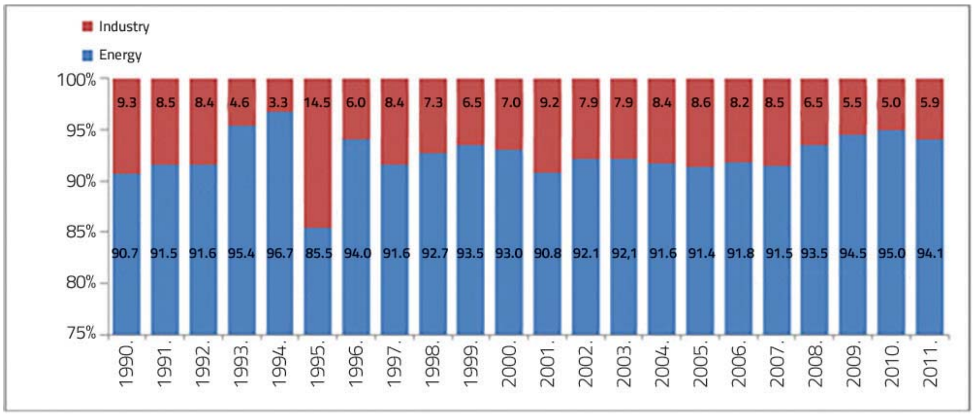
A decline in CO_2 emissions during some years of the observed period (1990-2011) relates mostly to a decrease in electricity generation in the Thermal Power Plant at Pljevlja and to a significant decrease in industrial production.

Table 3.1 CO_2 emissions by economic sector, 1990-2011 (Gg)

Sector/year	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
Energy	2.260,2	2.367,0	1.963,5	1.613,1	1.284,8	431,0	1.908,1	1.759,1	2.165,0	2.241,9	2.345,0
Industry	231,2	218,5	180,2	78,1	44,0	73,3	120,8	161,6	170,7	156,2	175,7
Solvent and similar product use	/	/	/	/	/	/	/	/	/	/	/
Agriculture	/	/	/	/	/	/	/	/	/	/	/
Land use change and forestry	-1.634,6	-1.509,2	-1.826,8	-2.066,8	-2.034,1	-1.719,3	-1.939,5	-2.024,2	-2.385,6	-2.317,8	-2.154,1
Waste											
Other											
Total without sinks	2.491,4	2.585,5	2.143,7	1.691,2	1.328,8	504,3	2.028,9	1.920,7	2.335,7	2.398,1	2.520,8
Total with sinks	856,8	1076,3	316,9	-375,7	-705,3	-1215,0	89,4	-103,5	-49,9	80,3	366,7
Sector/year	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
Energy	1.942,7	2.410,2	2.310,6	2.300,6	2.145,1	2.332,9	2.272,3	2.824,2	1.944,4	2.694,5	2.526,9
Industry	197,4	206,8	198,0	210,1	202,1	209,59	211,23	195,72	113,15	142,41	158,79
Solvent and similar product use	/	/	/	/	/	/	/	/	/	/	/
Agriculture	/	/	/	/	/	/	/	/	/	/	/
Land use change and forestry	-2.149,9	-2.309,4	-2.158,3	-1.963,5	-2.199,2	-1.864,6	-2.364,3	-2.269,7	-2405,3	-2.262,8	-2.166,8
Waste	/	/	/	/	/	/	/	/	/	/	/
Other	/	/	/	/	/	/	/	/	/	/	/
Total without sinks	2.140,1	2.617,0	2.508,6	2.510,7	2.347,2	2.542,5	2.483,5	3.019,9	2.057,5	2.836,9	2.685,7
Total with sinks	-9,8	307,6	350,3	547,2	148,1	677,9	119,1	750,1	-347,7	574,0	518,8



Graph 3.1 CO_2 emissions from economic sectors, 1990-2011 (Gg)

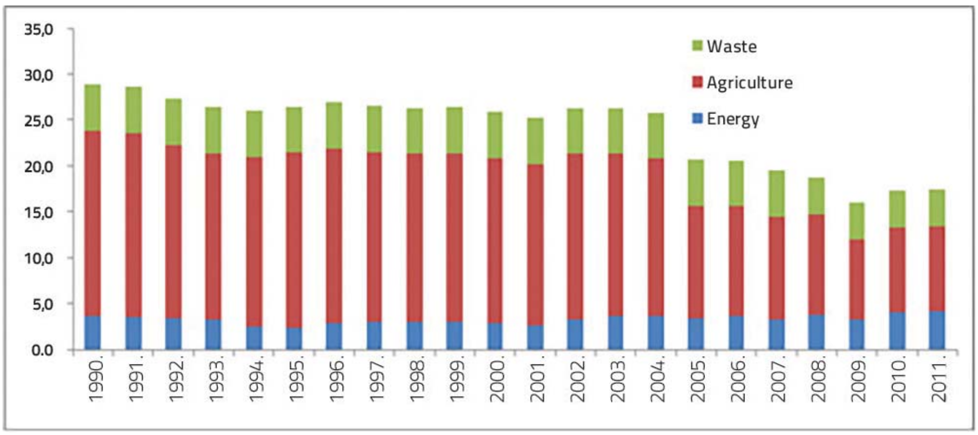


Graph 3.2 Shares of economic sectors in total CO_2 emissions, 1990-2011 (%)

CH_4 Emissions

Table 3.2 and Graphs 3.3 and 3.4 show the total amount of CH_4 emissions from all economic sectors; agriculture is responsible for the greatest share (53–70)%, followed by waste (17–25)% and the energy sector (9–24)%.

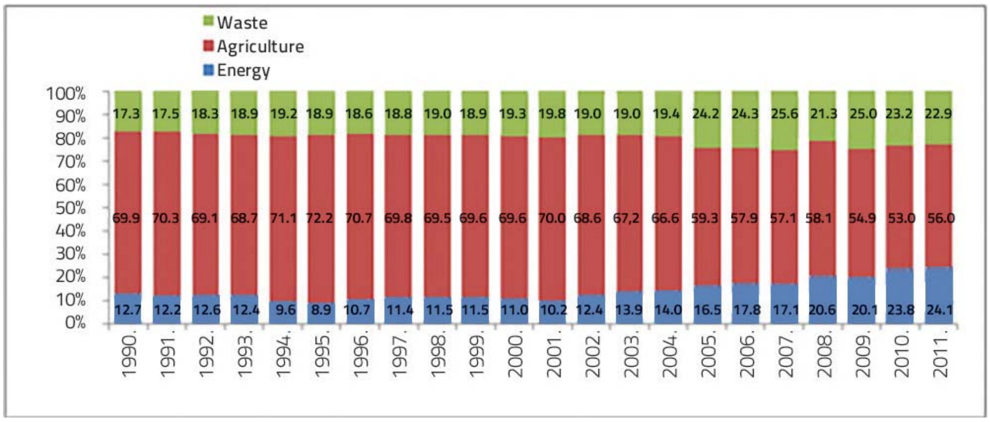
A decline in agricultural production (livestock breeding) caused a significant decline in the level of CH_4 emissions from this sector during the period 2005– 2011.



Graph 3.3 CH_4 emissions by economic sector, 1990-2011 (Gg)

Table 3.2 CH_4 emissions by economic sector, 1990-2011 (Gg)

Sector/year	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
Energy	3,7	3,5	3,4	3,3	2,5	2,3	2,9	3,0	3,0	3,0	2,8
Industry											
Solvent and similar product use											
Agriculture	20,2	20,1	18,9	18,1	18,5	19,1	19,0	18,5	18,3	18,4	18,0
Land use change and forestry											
Waste	5	5	5	5	5	5	5	5	5	5	5
Other											
Total	28,9	28,6	27,3	26,4	26,0	26,4	26,9	26,5	26,3	26,4	25,9
Sector/year	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
Energy	2,6	3,3	3,7	3,6	3,4	3,7	3,3	3,8	3,2	4,1	4,2
Industry											
Solvent and similar product use											
Agriculture	17,7	18,1	17,7	17,2	12,3	11,9	11,2	10,9	8,8	9.2	9,3
Land use change and forestry											
Waste	5	5	5	5	5	5	5	4	4	4	4
Other											
Total	25,2	26,3	26,4	25,8	20,7	20,6	19,5	18,8	16,0	17,2	17,5



Graph 3.4 The economic sector's shares of total CH_4 emissions, 1990-2011 (%)

N_2O Emissions

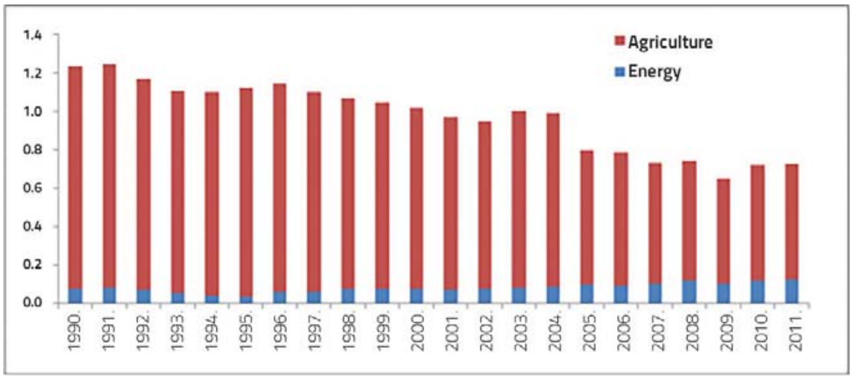
The economic sectors' total N_2O emissions for the observed period are shown in Table 3.3 and in Graphs 3.5 and 3.6. Agriculture represents the greatest share of N_2O emissions, due to the use of nitrogen fertilizers (83–97)%, followed by the energy sector (3–17)%, while the contributions of other sectors is negligible.

A decline in agricultural production, and consequently a reduced use of nitrogen fertilizers, contributed to a decrease in the level of N_2O emissions from this sector, while increased fuel consumption during the observed period contributed to an increased level of pollutant emissions from the energy sector (Graph 3.5).

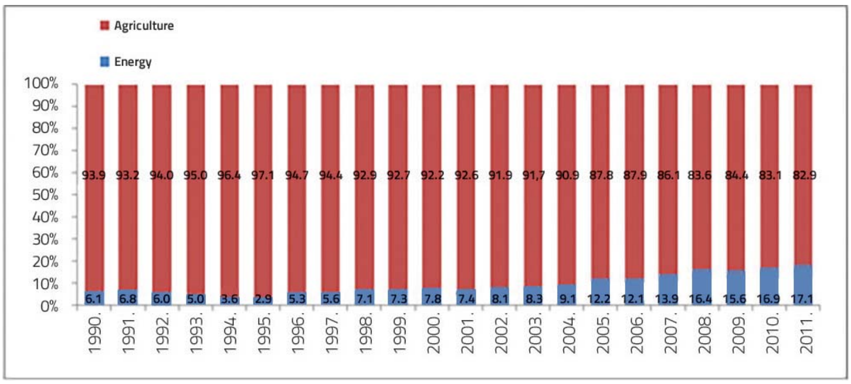
Table 3.3 N_2O emissions by economic sector, 1990-2011 (Gg)

Sector/year	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
Energy	0,1	0,1	0,1	0,1	0,0	0,0	0,1	0,1	0,1	0,1	0,1
Industry											
Solvent and similar product use											
Agriculture	1,2	1,2	1,1	1,1	1,1	1,1	1,1	1,0	1,0	1,0	0,9
Land use change and forestry											
Waste											
Other											
Total	1,2	1,2	1,2	1,1	1,1	1,1	1,1	1,1	1,1	1,0	1,0

Sector/year	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
Energy	0,1	0,1	0,1	0,1	0,1	0,095	0,102	0,122	0,102	0,122	0,124
Industry											
Solvent and similar product use											
Agriculture	0,9	0,9	0,9	0,9	0,7	0,69	0,63	0,62	0,55	0,6	0,6
Land use change and forestry											
Waste											
Other											
Total	1,0	0,9	1,0	1,0	0,8	0,8	0,7	0,7	0,7	0,7	0,7



Graph 3.5 N_2O emissions by economic sector, 1990-2011 (Gg)



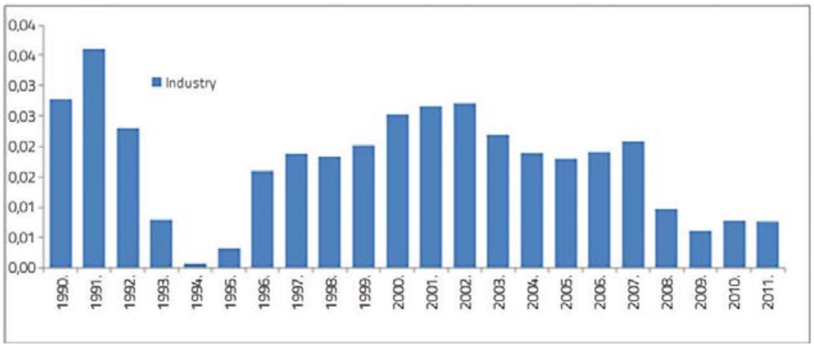
Graph 3.6 The economic sector's shares of total N_2O emissions, 1990-2011 (%)

CF_4 and C_2F_6 Emissions

Tables 3.4 and 3.5 and Graphs 3.7 and 3.8 show the total emissions of synthetic gases CF_4 and C_2F_6 arising exclusively from the production of aluminium at KAP. Emission levels of this gas depends on the volume of aluminium produced, and on the number and duration of anode effects. Until the mid 1990s, anode effects were controlled manually and as a result they lasted for about 10 minutes. A decline in CF_4 and C_2F_6 emissions in 1994 and 1995 is linked to the period of economic sanctions and low production levels. After that period, the decline in emissions is linked to the introduction of automatic controls for the anode effects and their subsequent shorter duration, and from 2009 onwards a significant decline in production is also relevant.

Table 3.4 CF_4 emissions by economic sector, 1990-2011 (Gg)

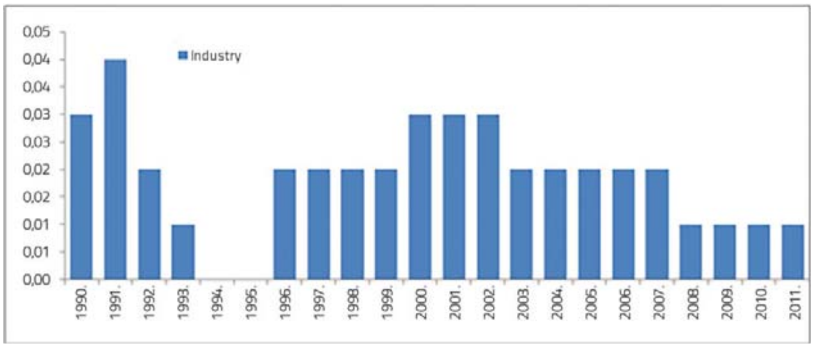
Sector/year	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
Industry	0,3	0,4	0,2	0,1	0,0	0,0	0,2	0,2	0,2	0,2	0,3
Total	0,3	0,4	0,2	0,1	0,0	0,0	0,2	0,2	0,2	0,2	0,3
Sector/year	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
Industry	0,3	0,3	0,2	0,2	0,2	0,19	0,21	0,09	0,06	0,08	0,07
Total	0,3	0,3	0,2	0,2	0,2	0,19	0,21	0,09	0,06	0,08	0,07



Graph 3.7 CF_4 emissions by economic sector, 1990-2011 (Gg)

Table 3.5 C_2F_6 emissions by economic sector, 1990-2011 (Gg)

Sector/year	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
Industry	0,03	0,01	0,01	0,00	0,00	0,00	0,00	0,02	0,02	0,02	0,03
Total	0,03	0,01	0,01	0,00	0,00	0,00	0,00	0,02	0,02	0,02	0,03
Sector/year	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
Industry	0,03	0,03	0,03	0,02	0,03	0,02	0,02	0,02	0,01	0,01	0,01
Total	0,03	0,03	0,03	0,02	0,03	0,02	0,02	0,02	0,01	0,01	0,01



Graph 3.8 C_2F_6 by economic sector, 1990-2011 (Gg)

SF_6 Emissions

According to data made available by the Montenegrin Electric Enterprise and the Montenegrin Electrical Transmission System, and after a detailed analysis, only estimates of SF_6 emissions for 2011 were made. The level of those emissions was 0.108 Mg, and due to high global warming potential, the level of CO_{2eq} amounted to 2.581 Gg, which did not significantly contribute to the level of emissions in 2011.

HFC Emissions

Based on the Montenegrin Environmental Protection Agency's database on issued licences for HFC use, an assessment of this pollutant's emissions for 2011 was produced. The level of HFC emissions in 2011 was 0.008 Mg.

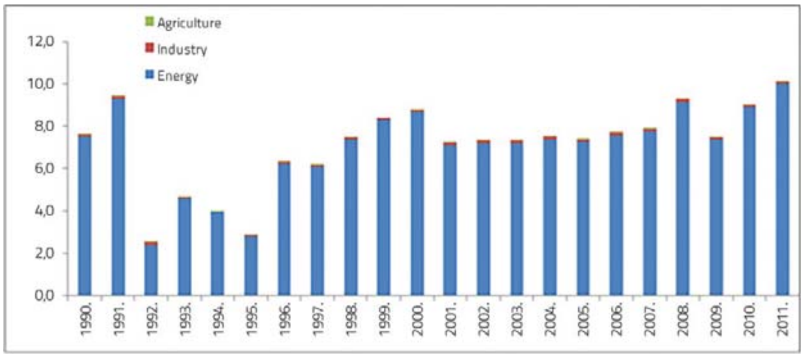
3.2.2 Emissions of Indirect Greenhouse Gases

NO_x and SO_x Emissions

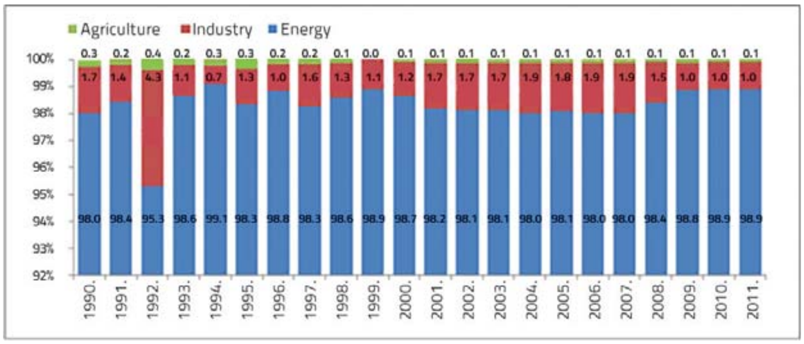
Due to fuel combustion, the energy sector represented the largest share of total NO_x and SO_x emissions (over 90%) during the observed period. The share of this pollutant emitted by the industrial production sector is only about 5%, while contributions of other sectors are insignificant (Tables 3.6 and 3.7, Graphs 3.9, 3.10, 3.11 and 3.12). Due to a reduced level of consumption of energy-generating products, as well as reduced electricity production from TPP Pljevlja in the 1990s, levels of NO_x i SO_x emissions also dropped. In 2009, TPP Pljevlja was out of service for 6 months due to an overhaul, and thus the level of emissions was lower. According to the energy balance data, the consumption of lignite by TPP Pljevlja increased significantly in 2010 and 2011 and consequently levels of indirect GHG emissions in those years were higher (Tables 3.6 and 3.7, Graphs 3.9 and 3.10).

Table 3.6 NO_x emissions by economic sector, 1990–2011 (Gg)

Sector/year	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
Energy	7,5	9,3	2,4	4,6	3,9	2,8	6,2	6,1	7,4	8,3	8,7
Industry	0,13	0,13	0,11	0,05	0,03	0,04	0,06	0,10	0,10	0,09	0,11
Solvent and similar product use											
Agriculture	0,02	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,00	0,01
Land use change and forestry											
Waste											
Other											
Total	7,66	9,45	2,51	4,65	3,98	2,87	6,32	6,21	7,48	8,39	8,80
Sector/year	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
Energy	7,1	7,2	7,2	7,4	7,3	7,571	7,745	9,153	7,39	8,918	10,041
Industry	0,12	0,13	0,13	0,14	0,13	0,14	0,15	0,14	0,08	0,09	0,10
Solvent and similar product use											
Agriculture	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01
Land use change and forestry											
Waste											
Other											
Total	7,25	7,34	7,36	7,54	7,42	7,72	7,90	9,30	7,48	9,02	10,15



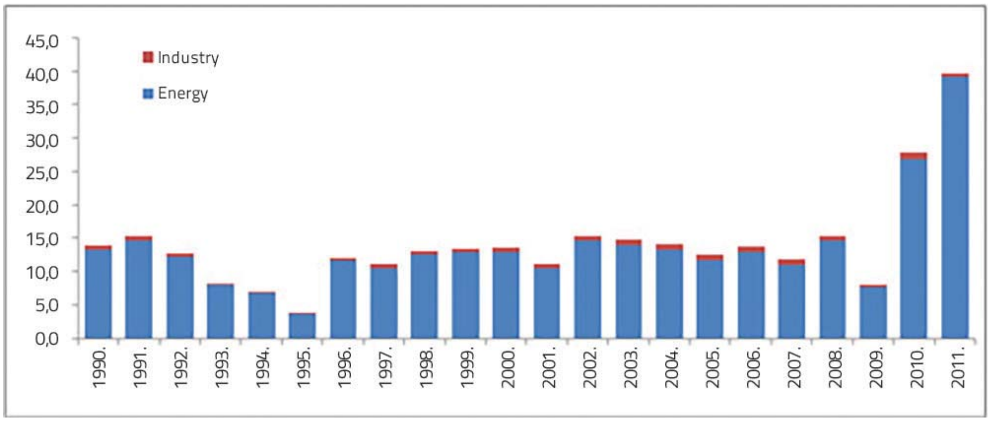
Graph 3.9 NO_x emissions by economic sector, 1990-2011 (Gg)



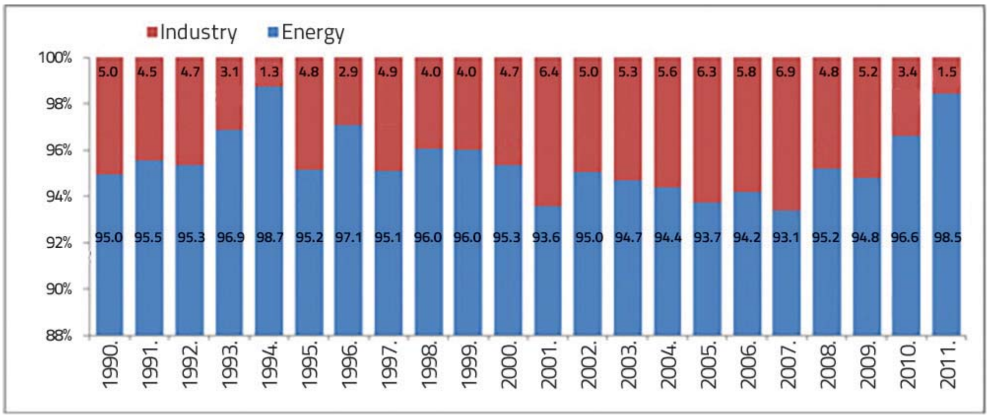
Graph 3.10 The economic sector's shares of total NO_x emissions, 1990-2011 (%)

Table 3.7 SO_x emissions by economic sector, 1990-2011 (Gg)

Sector/year	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
Energy	13,3	14,6	12,1	8,0	6,8	3,6	11,7	10,5	12,6	12,9	12,9
Industry	0,70	0,68	0,60	0,26	0,09	0,18	0,35	0,54	0,52	0,54	0,63
Solvent and similar product use											
Agriculture											
Land use change and forestry											
Waste											
Other											
Total	13,95	15,29	12,73	8,21	6,91	3,77	12,03	11,07	13,12	13,45	13,52
Sector/year	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
Energy	10,4	14,6	14,0	13,3	11,7	12,945	10,971	14,607	7,656	26,863	39,117
Industry	0,71	0,76	0,78	0,79	0,79	0,80	0,81	0,74	0,42	0,94	0,61
Solvent and similar product use											
Agriculture											
Land use change and forestry											
Waste											
Other											
Total	11,09	15,38	14,80	14,10	12,50	13,74	11,78	15,34	8,08	27,80	39,73



Graph 3.11 SO_x emissions by economic sector, 1990-2011 (Gg)

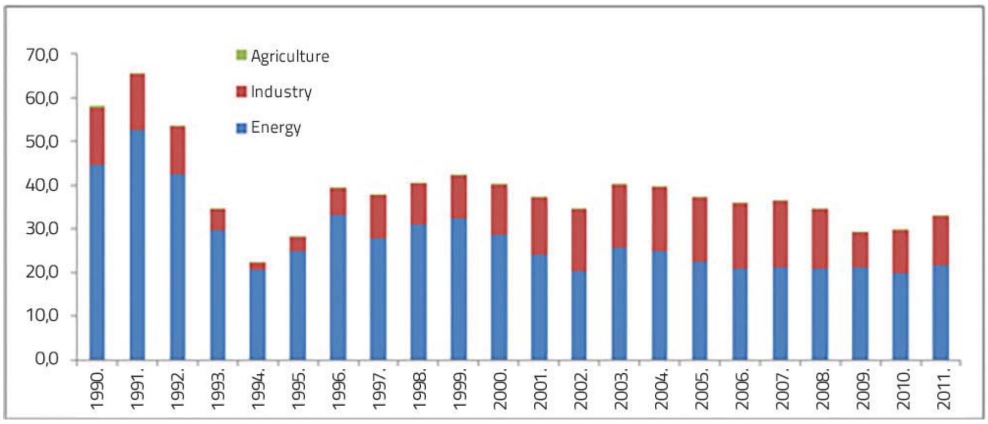


Graph 3.12 The economic sector's shares of total SO_x emissions, 1990-2011 (%)

CO Emissions

Table 3.7 and Graphs 3.13 and 3.14 show total CO emissions from all of the economic sector; the energy sector has the largest share (58-92)%, followed by the industrial production sector (12–42)%. Other sectors hardly contribute to CO emissions at all.

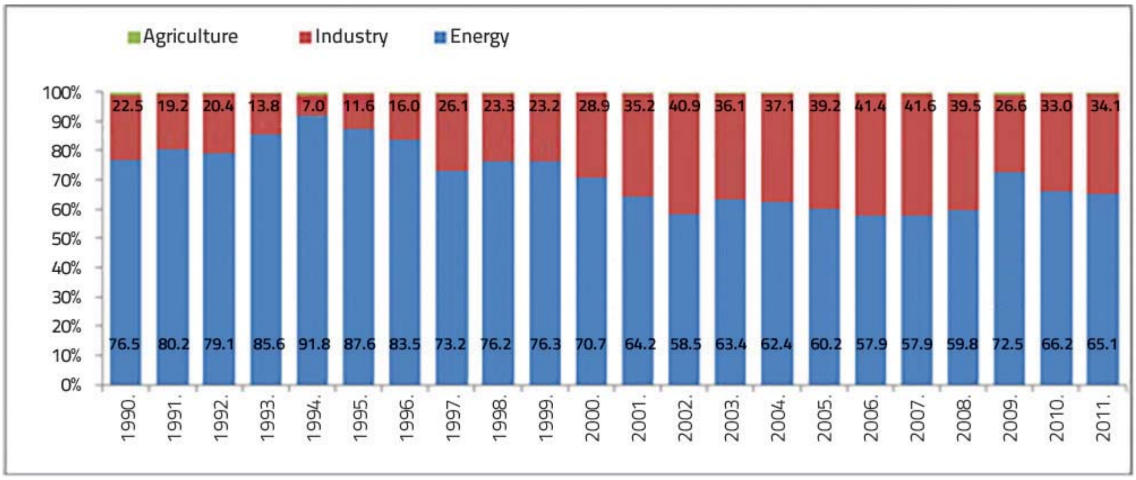
The reduction of electricity generation at TPP Pljevlja and the decline in industrial production during the mid nineties resulted in a decrease of CO emissions during those years.



Graph 3.13 CO emissions by economic sector, 1990-2011 (Gg)

Table 3.8 CO emissions by economic sector, 1990-2011 (Gg)

Sector/year	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
Energy	44,5	52,8	42,5	29,6	20,7	24,9	33,1	27,8	30,9	32,4	28,5
Industry	13,1	12,6	11,0	4,8	1,6	3,3	6,3	9,9	9,5	9,9	11,6
Solvent and similar product use											
Agriculture	0,6	0,4	0,2	0,2	0,3	0,2	0,2	0,3	0,2	0,2	0,2
Land use change and forestry											
Waste											
Other											
Total	58,2	65,8	53,7	34,6	22,5	28,4	39,6	38,0	40,6	42,5	40,3
Sector/year	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
Energy	24,0	20,2	25,6	24,8	22,5	20,825	21,175	20,799	21,266	19,883	21,604
Industry	13,2	14,1	14,6	14,8	14,6	14,9	15,23	13,73	7,79	9,9072	11,314
Solvent and similar product use											
Agriculture	0,2	0,2	0,2	0,2	0,2	0,23	0,17	0,24	0,26	0,25	0,28
Land use change and forestry											
Waste											
Other											
Total	37,4	34,6	40,3	39,8	37,3	36,0	36,6	34,8	29,3	30,0	33,2



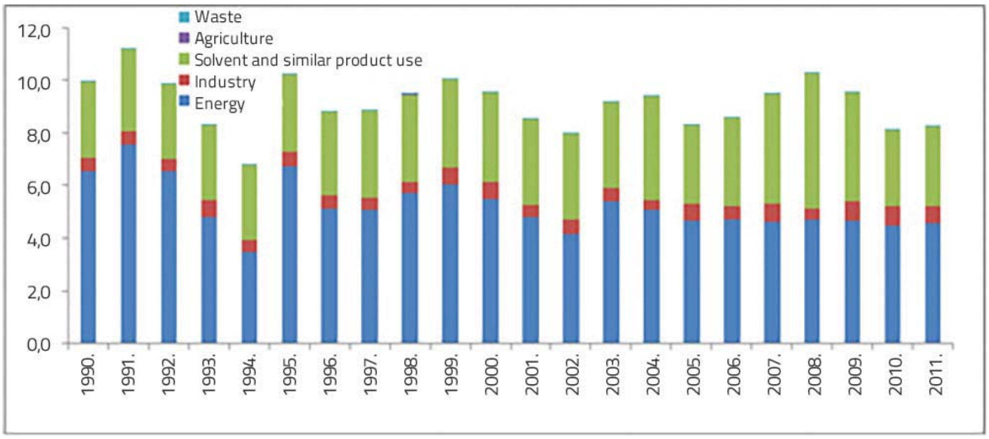
Graph 3.14 The economic sector's share of total CO emissions, 1990-2011 (%)

NMVOC Emissions

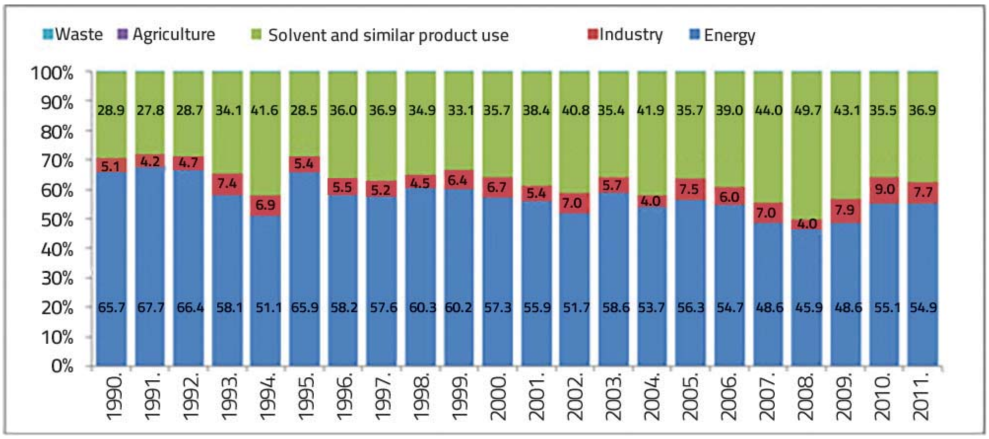
The economic sector's total NMVOC emissions are shown, by individual sector, in Table 3.8 and in Graphs 3.15 and 3.16. The energy sector with its fuel consumption is the biggest contributor to the total amount of NMVOC emissions (46–66)%, followed by the use of solvents sector (28–50)% and by industrial production (4–9)%. During the observed period, NMVOC emission levels varied depending on fuel consumption, on industrial production levels, and on the consumption of solvents and other similar products by the economic sector.

Table 3.9 NMVOC emissions by the economic sector, 1990-2011 (Gg)

Sector/year	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
Energy	6,5	7,6	6,5	4,8	3,5	6,7	5,1	5,1	5,7	6,1	5,5
Industry	0,5	0,5	0,5	0,6	0,5	0,6	0,5	0,5	0,4	0,6	0,6
Solvent and similar product use	2,9	3,1	2,8	2,8	2,8	2,9	3,2	3,3	3,3	3,3	3,4
Agriculture	0,007	0,006	0,005	0,005	0,006	0,004	0,004	0,004	0,004	0,003	0,003
Land use change and forestry											
Waste	0,024	0,024	0,025	0,025	0,026	0,026	0,027	0,027	0,028	0,028	0,029
Other											
Total	9,96	11,18	9,86	8,29	6,82	10,23	8,81	8,85	9,48	10,06	9,56
Sector/year	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
Energy	4,8	4,1	5,4	5,1	4,7	4,695	4,621	4,727	4,659	4,476	4,557
Industry	0,5	0,6	0,5	0,4	0,6	0,512	0,665	0,41	0,759	0,731	0,643
Solvent and similar product use	3,3	3,3	3,3	3,9	3,0	3,347	4,184	5,119	4,129	2,881	3,063
Agriculture	0,002	0,002	0,002	0,002	0,002	0,001	0,002	0,001	0,001	0,001	0,002
Land use change and forestry											
Waste	0,029	0,029	0,03	0,031	0,031	0,032	0,032	0,033	0,033	0,033	0,033
Other											
Total	8,57	8,01	9,18	9,42	8,31	8,58	9,50	10,29	9,58	8,12	8,29



Graph 3.15 NMVOC emissions by the economic sector, 1990-2011 (Gg)



Graph 3.16 The economic sector's shares of total NMVOC emissions, 1990-2011 (%)

3.2.3 Total Emissions of Direct Greenhouse Gases in CO_{2eq}

Tables 3.9 and 3.10 and Graphs 3.17 to 3.19 show the total GHG emissions expressed in CO_{2eq}. The economic sector's shares of the total CO_{2eq} emissions are shown in Graph 3.18, with the biggest contribution coming from the energy sector (32–69)%, followed by industrial production (4,5–44)%, by agriculture (10–48)% and by the waste sector (2–7)%. Shares of gas emissions expressed in CO_{2eq} relating to the total amount of CO_{2eq} emissions are shown in Graph 3.20, from which it is clear that the CO_2 share is the largest and that this ranges from 31–69.5%.

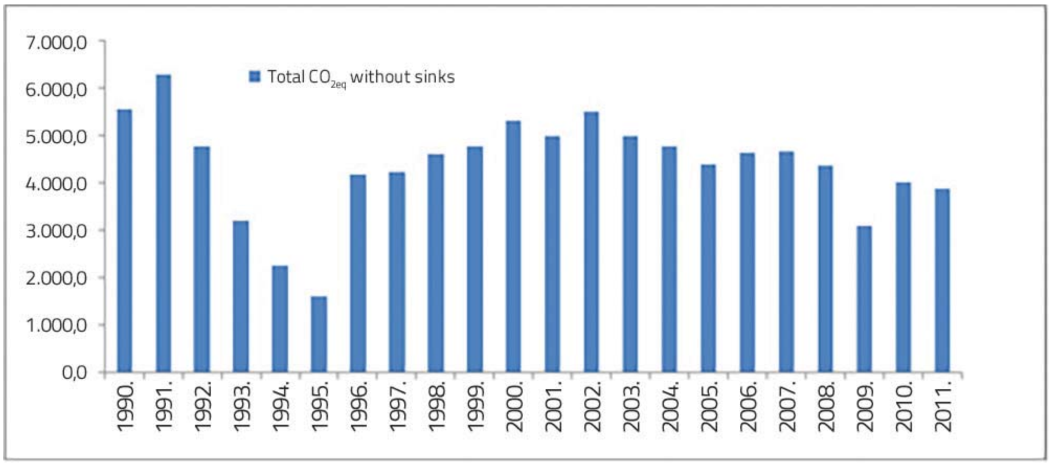
Table 3.10 Total direct GHG emissions expressed in CO_{2eq}, (1990-2011) (Gg)

Total CO_{2eq} (Gg) without sinks	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
Total CO_{2eq} (Gg) with sinks	5.556,8	6.280,2	4.759,3	3.199,9	2.267,3	1.615,2	4.171,9	4.225,6	4.599,5	4.774,1	5.300,5
CO_{2eq} (Gg)/ year	3.922,2	4.770,9	2.932,4	1.133,1	233,2	-104,1	2232,4	2.201,4	2.213,8	2.456,3	3.146,4
Total CO_{2eq} (Gg) without sinks	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.*
Total CO_{2eq} (Gg) with sinks	4.976,4	5.507,1	4.987,0	4.778,0	4.382,6	4.643,9	4.655,7	4.366,5	3.084,5	4.022,3	3.865,71*
Total CO_{2eq} (Gg) without sinks	2.826,5	3.197,8	2.828,7	2.814,5	2.183,5	2.779,3	2.291,4	2.096,8	679,2	1.759,4	1.698,8

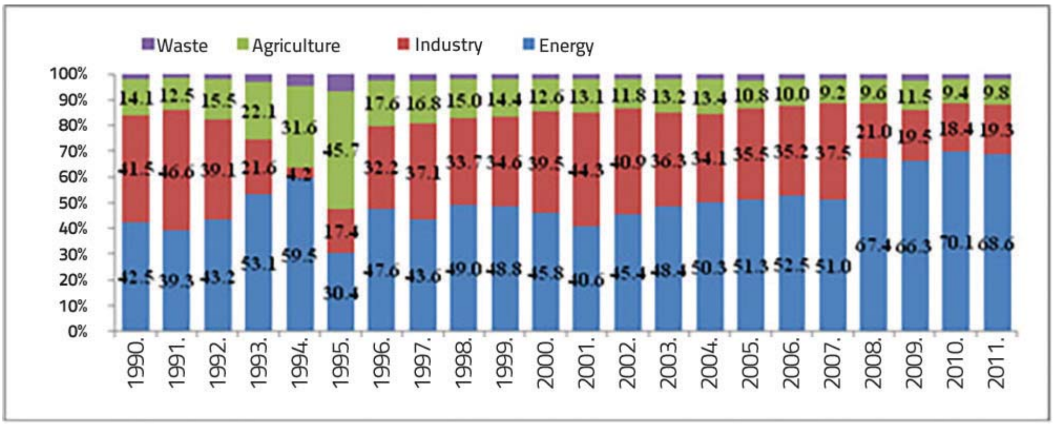
Estimates of direct GHG 2011 emissions expressed in CO_{2eq}; this also includes SF_6 emissions in line with available data. This is not the case for other years within the observed period.

Table 3.11 Direct GHG emissions by economic sector expressed in CO_{2eq}, (1990-2011) (Gg)

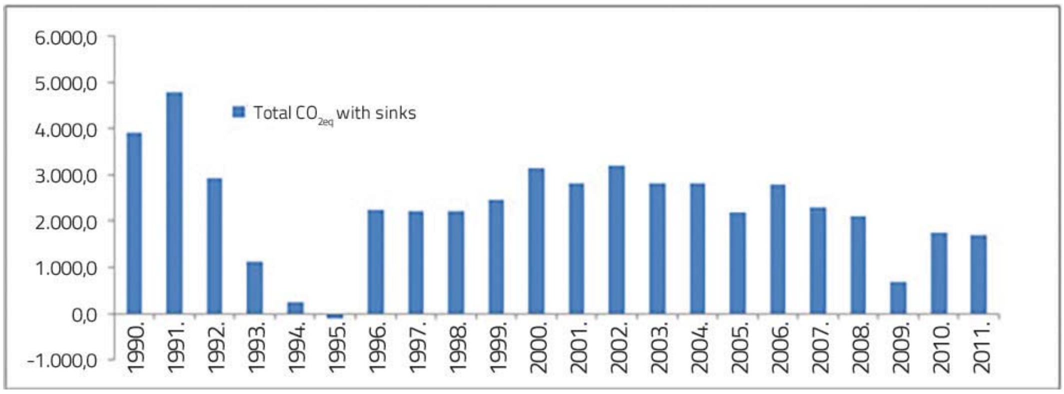
Sector	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
Energy	2.360,7	2.466,8	2.057,6	1.698,6	1.349,6	490,3	1.987,7	1.841,9	2.252,2	2.329,0	2.429,7
Industrial processes	2307,7	2.926,5	1.859,2	690,1	96,0	281,3	1.344,8	1.567,6	1.550,7	1.653,2	2.096,2
Agriculture	783,3	781,9	737,4	706,2	716,6	738,5	734,4	711,1	691,6	686,8	669,6
Waste	105	105	105	105	105	105	105	105	105	105	105
Sector	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.*
Energy	2.019,1	2.502,4	2.413,1	2.404,4	2.247,1	2.439,3	2.373,6	2.943,0	2.043,5	2.818,6	2.653,0
Industrial processes	2.202,4	2.250,8	1.812,0	1.629,1	1.556,1	1.635,1	1.747,2	918,2	601,6	741,4	747,3
Agriculture	649,8	648,9	656,9	639,5	474,4	464,4	429,8	421,3	355,3	378,2	380,6
Waste	105	105	105	105	105	105	105	84	84	84	84



Graph 3.17 Total CO_{2eq} emissions without sinks, 1990-2011 (Gg)



Graph 3.18 Economic sector's shares of total CO_{2eq} emissions without sinks, 1990-2011 (%)



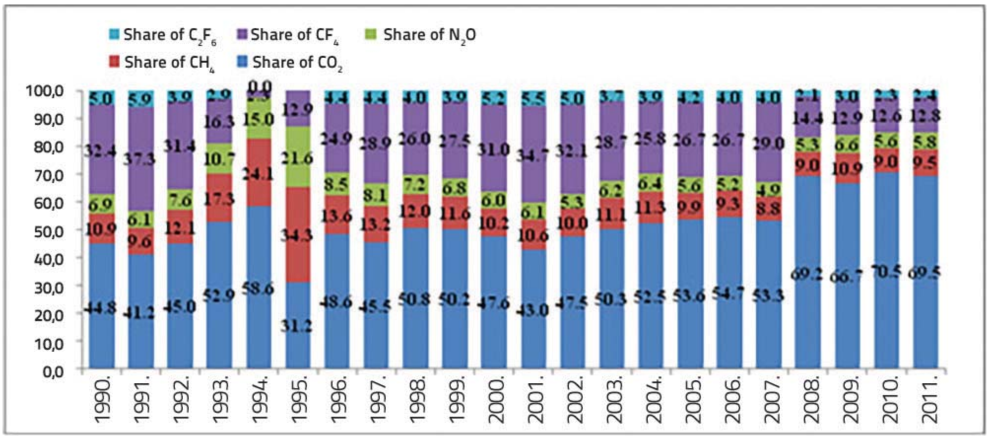
Graph 3.19 Total CO_{2eq} emissions with sinks, 1990-2011 (Gg)

Table 3.12 shows individual GHG emissions expressed in CO_{2eq} during the period 1990-2011.

Table 3.12 Direct GHG emissions expressed in CO_{2eq}, 1990-2011 (Gg)

GHG - CO_{2eq} (Gg)	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
CO_2	2.491,4	2.585,5	2.143,7	1.691,2	1.328,8	504,3	2.028,9	1.920,7	2.335,7	2.398,1	2.520,8
CH_4	606,0	600,7	573,9	554,2	545,5	554,8	565,3	557,3	553,3	554,7	543,0
N_2O	382,9	386,0	362,7	342,6	341,0	348,1	353,7	341,6	330,5	324,3	316,2
CF_4	1.800,5	2.340,0	1.495,0	520,0	52,0	208,0	1.040,0	1.222,0	1.196,0	1.313,0	1.644,5
C_2F_6	276,0	368,0	184,0	92,0	0,0	0,0	184,0	184,0	184,0	184,0	276,0
GHG - CO_{2eq} (Gg)	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
CO_2	2.140,1	2.617,0	2.508,6	2.510,7	2.347,2	2.542,5	2.483,5	3.019,9	2.057,5	2.836,9	2.685,7
CH_4	530,0	552,6	553,5	541,4	434,3	432,6	409,4	394,1	336,4	362,6	367,0
N_2O	301,3	293,6	310,9	306,9	247,1	243,4	226,9	230,0	202,1	223,8	224,4
CF_4	1.729,0	1.768,0	1.430,0	1.235,0	1.170,0	1.241,5	1.352,0	630,5	396,5	507,0	494,0
C_2F_6	276,0	276,0	184,0	184,0	184,0	184,0	184,0	92,0	92,0	92,0	92,0

CO_2 represents the biggest share in all total CO_{2eq} emissions (31–70)%, followed by CF_4 (13–37)%, CH_4 (9–34)%, N_2O (5–22)% and C_2F_6 (up to 6 %). (Graph 3.20).



Graph 3.20 GHG shares in total CO_{2eq}, 1990-2011 (%)

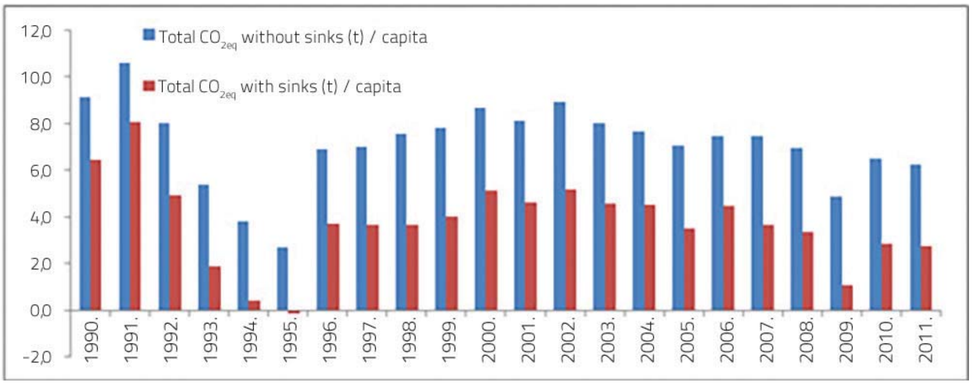
Table 3.13 Population, 1990-2011

Year	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
Population	608.816	591.843	594.137	596.432	598.727	601.022	603.317	605.611	607.906	610.201	612.496
Year	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011
Population	614.791	617.085	620.279	622.118	623.277	624.241	626.188	628.804	631.536	617.304	620.029

Table 3.14 and Graph 3.21 show the total CO_{2eq} emissions per capita for the period 1990-2011. It can be concluded from the data presented that Montenegro is among the countries with the lowest emission levels when compared with emission levels in developed countries.

Table 3.14 Total CO_{2eq} emissions per capita, 1990-2011 (t/per capita)

CO_{2eq} (t)/ per capita	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
Total CO_{2eq} without sinks	9,1	10,6	8,0	5,4	3,8	2,7	6,9	7,0	7,6	7,8	8,7
Total CO_{2eq} with sinks	6,4	8,1	4,9	1,9	0,4	-0,2	3,7	3,6	3,6	4,0	5,1
CO_{2eq} (t)/ per capita	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
Total CO_{2eq} without sinks	8,1	8,9	8,0	7,7	7,0	7,4	7,4	6,9	4,9	6,5	6,2
Total CO_{2eq} with sinks	4,6	5,2	4,6	4,5	3,5	4,5	3,7	3,3	1,1	2,9	2,7



Graph 3.21 Total CO_{2eq} emissions per capita, 1990-2011 (t/per capita)

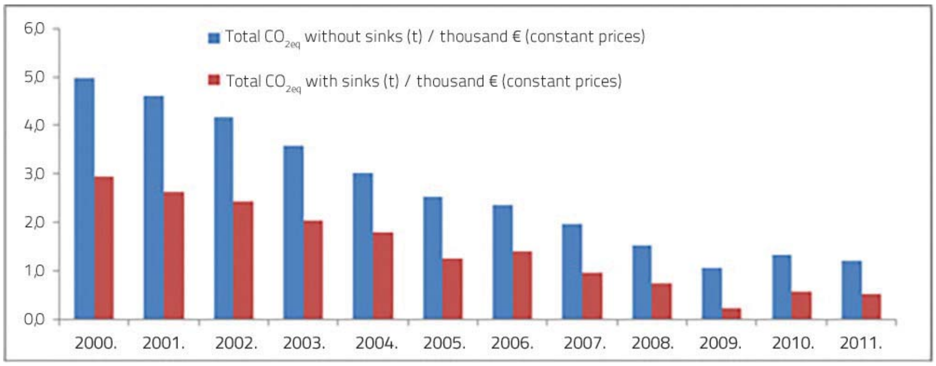
Table 3.15 Gross Domestic Product, 2000-2011 (thousand €)

Year	2000.	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
Gross Domestic Product-GDP in thousand € (constant prices)	106.500,0	107.700,0	131.900,0	139.400,0	157.700,0	173.900,0	197.000,0	237.800,0	286.600,0	291.100,0	305.400,0	320.400,0

Table 3.16 and Graph 3.22 show CO_{2eq} emissions per GDP unit for the period 2000-2011, expressed in t/thousand €.

Table 3.16 Total CO_{2eq} emissions per GDP unit, (2000-2011) (t/thousand €)

CO_{2eq} (t)/ thousand €	2000.	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
Total CO_{2eq} without sinks	5,0	4,6	4,2	3,6	3,0	2,5	2,4	2,0	1,5	1,1	1,3	1,2
Total CO_{2eq} with sinks	3,0	2,6	2,4	2,0	1,8	1,3	1,4	1,0	0,7	0,2	0,6	0,5



Graph 3.22 Total CO_{2eq} emissions per GDP unit, 2000-2011 (t/thousand €)

3.3 Greenhouse Gas Emissions (by sector)

3.3.1 Emissions From the Energy Sector

Energy is a strategically important branch of the Montenegrin economy. According to official data, Montenegro has significant coal reserves and renewable energy potential, while possible reserves of oil and gas are still at an exploratory stage. Hydro potential and coal are the most important sources of energy.

The energy sector is the major source of GHG emissions and these result from human activities. GHG emissions from the energy sector include emissions from activities involving the consumption of fossil fuels (fuel combustion and its non-energy use), as well as fugitive emissions from fuels. Fugitive emissions take place during the production, transmission, processing, storage and distribution of fossil fuels.

Processed Data

Data relating to the consumption, importation and distribution of fuels in Montenegro was provided by the Ministry of Economy, the Statistical Office – MONSTAT and the Energy Regulatory Agency. This data was processed and systematised within energy balances to represent a basis for estimating GHG emissions from the energy sector.

In order to estimate the consumption of oil derivatives in the subsector of transport, the Ministry of Interior provided data on the number and types of vehicles, while data on the frequency of vehicles on Montenegro's busiest roads was received from the Transport Directorate.

The combustion of fossil fuels also takes place at industrial facilities, and accurate records are kept regarding this; these records were provided for the purpose of this GHG Inventory and for the Inventory of Polluting Gases Emissions.

Of Montenegro's total needs which amounted to 4.2 TWh in 2011, 1.5 TWh was generated by TPP Pljevlja. Hydroelectric power plants (HPP) Perućica, with a capacity of 285 MW, HPP Piva, with a capacity of 342 MW and other distributed HPPs collectively generated 1.2 TWh. The remaining 1.4 TWh was imported.

The energy sector includes the following energy subsectors:

- Energy transformation and electricity generation;
- Industry and construction;
- Transport;
- Households and services;
- Agriculture, fishery and forestry.

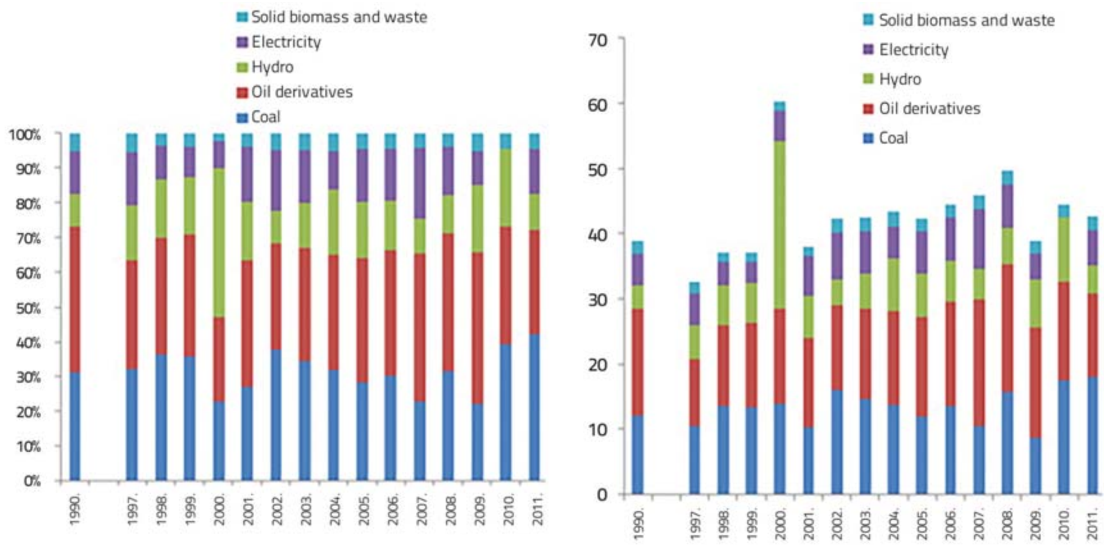
Graph 3.23 shows the total energy and fuel consumed by Montenegro's energy sector during the period 1990-2011.

Energy transformation and electricity generation at TPP Pljevlja is the most important subsector within the energy sector. TPP Pljevlja is a condensation thermal power plant with an installed capacity of 218.5 MW. In 2011, TPP Pljevlja used 1,900.5 t of lignite with a calorific value of 9,190 kJ/jg, sulphur content of (0,8–1)% and ash content 25% to generate 1.5 TWh.

Industry and construction is a subsector in which significant quantities of fossil fuels are consumed. The Aluminium Plant Podgorica and the Nikšić Ironworks are the largest consumers of fuel in this sector.

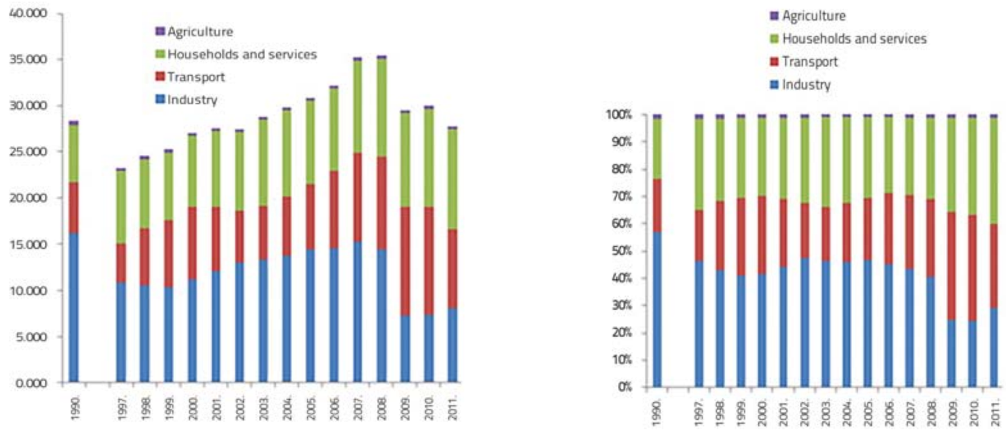
Subsector of transport includes road, air and maritime transport. In Montenegro, the largest quantities of oil derivatives are consumed in road transport, and hence it is the biggest contributor to GHG emissions from the transport sector.

Households and services subsectors are smaller consumers of fossil fuels than the aforementioned subsectors, but their consumption should not be disregarded. Accordingly, they are a small but still significant contributor to GHG emissions from the energy sector.



Graph 3.23 Gross domestic consumption of energy and fuel, 1990-2011 (% i PJ)

Subsector of agriculture, fishery and forestry represents the smallest share in total fuel consumption. Thus, the level of GHG emissions from this subsector is very low.



Graph 3.24 Energy consumption by energy subsector, 1990-2011 (PJ and %)

Fugitive emissions were also taken into consideration when estimating GHG emissions. In Montenegro, fugitive emissions mostly originate from lignite extraction processes in open pits. Coal is currently only mined at the Coal Mine at Pljevlja; the exploitation of coal in Berane did not start after privatisation in 2007.

Graph 3.24 shows final energy consumption figures in Montenegro, expressed by energy sector, for the period 1990-2011.

GHG Emissions

Direct GHG emissions from the energy sector were estimated in accordance with the Revised IPCC Guidelines for National GHG Inventories (1996) and Good Practice Guidance and Uncertainty Management in National GHG Inventories (2000). In line with available national data (lower calorific values and specific carbon emissions from fossil fuels), it was possible to apply Tier 2 approach to estimate emissions.

Indirect GHG emissions were estimated in accordance with EMEP/EEA Air Pollutant Emission Inventory Guidebook (2009).

In the absence of official energy balances for the period 1991–1996, GHG emissions from the energy sector were estimated approximately, and were based on data concerning lignite consumption by TPP Pljevlja, production levels in industry and on the number of vehicles on the road. GHG emissions from other subsectors are approximate and are compared with emissions from 1990 and from the period 1997–2011.

Estimates included GHG emissions from the following subsectors: energy transformation and electricity generation, industry and construction, transport, households and services, agriculture, and calculations also took into consideration fugitive emissions from production (coalmines), transmissions, processing, storage and distribution of fossil fuels.

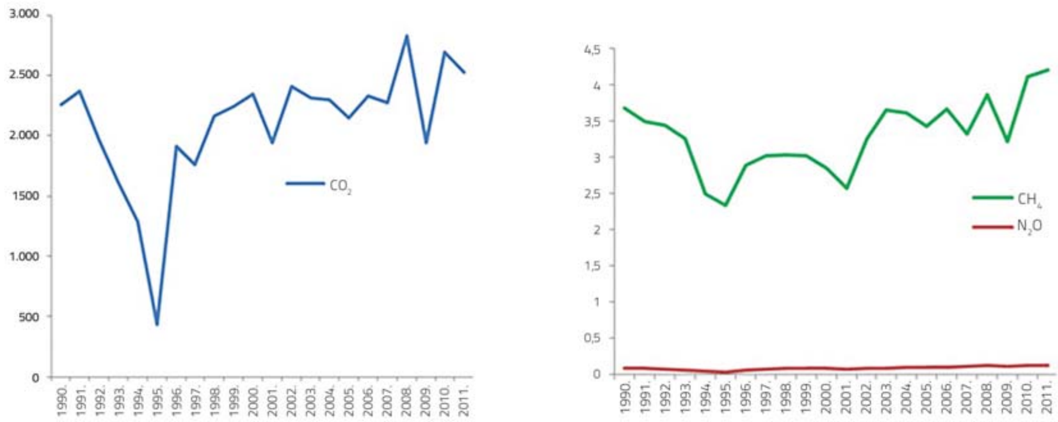
CO_2 represents the greatest share of direct GHG emissions in the energy sector, most of it coming from the subsector of energy transformation and electricity generation (TPP Pljevlja).

A recorded fall in the level of this pollutant during the period 1991–1995 and in 2009 resulted from reduced electricity generation at TPP Pljevlja, as well as an economic crisis in the country.

Table 3.17 Direct GHG emissions from the energy sector, 1990-2011 (Gg)

Direct GHG emissions (Gg)	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
CO_2	2.260,21	2.367,04	1.963,49	1.613,09	1.284,80	431,01	1.908,10	1.759,08	2.165,01	2.241,87	2.345,04
CH_4	3,679	3,494	3,447	3,261	2,496	2,338	2,89	3,026	3,029	3,026	2,849
N_2O	0,075	0,085	0,07	0,055	0,04	0,033	0,061	0,062	0,076	0,076	0,08
Direct GHG emissions (Gg)	**2001.**	**2002.**	**2003.**	**2004.**	**2005.**	**2006.**	**2007.**	**2008.**	**2009.**	**2010.**	**2011.**
CO_2	1.942,69	2.410,15	2.310,57	2.300,58	2.145,14	2.332,87	2.272,22	2.824,15	1.944,37	2.694,45	2.526,92
CH_4	2,58	3,25	3,66	3,61	3,42	3,67	3,32	3,86	3,22	4,12	4,21
N_2O	0,07	0,08	0,08	0,09	0,09	0,09	0,10	0,12	0,10	0,12	0,12

CH_4 emissions from coal mines represented the greatest share of fugitive emissions which amounted to (0,8–1,65) Gg during the observed period.

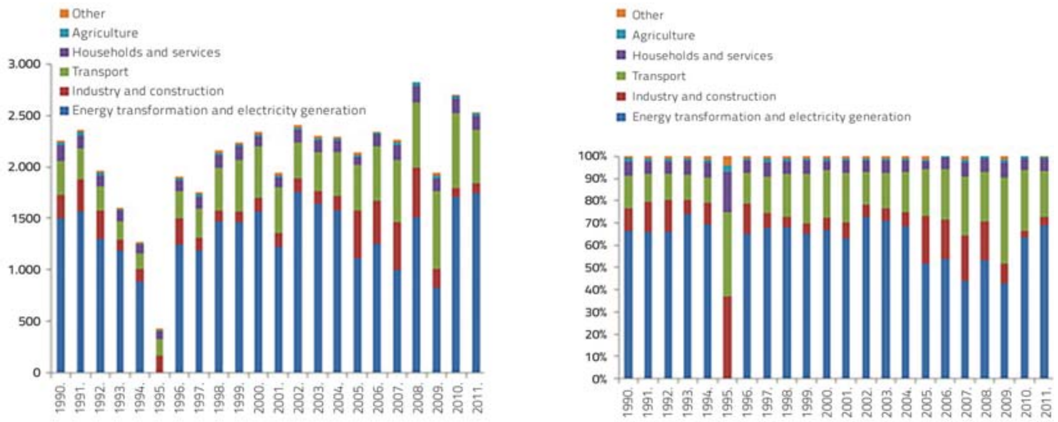


Graph 3.25 CO_2 , CH_4 and N_2O emissions from the energy sector, 1990-2011 (Gg)

Table 3.18 CO_2 from energy subsectors, 1990-2011 (Gg)

CO_2 emissions (Gg)/year	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
Energy transformation and electricity generation	1.502,4	1.562,5	1.296,9	1.187,6	885,8	0,0	1.243,9	1.191,2	1.473,6	1.463,8	1.569,8
Industry and construction	226,7	321,4	282,7	100,3	120,4	159,8	258,2	114,8	105,1	98,8	125,5
Transport	334,5	294,5	231,5	180,6	149,2	162,3	263,0	293,3	412,3	502,9	503,2
Households and services	147,2	130,2	108,0	102,7	85,7	78,7	104,9	113,9	121,7	131,6	94,1
Agriculture	30,9	35,0	24,3	13,4	15,9	12,4	19,4	24,7	24,1	21,6	22,8
CO_2 emissions (Gg)/year	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
Energy transformation and electricity generation	1.224,4	1.751,7	1.643,7	1.574,3	1.107,2	1.253,6	1.001,3	1.507,2	830,3	1.707,5	1.741,8
Industry and construction	137,6	133,6	124,4	143,3	464,9	415,9	457,9	488,4	173,3	83,2	96,6
Transport	437,7	357,0	373,1	423,0	451,6	533,0	609,0	634,9	758,6	737,7	520,3
Households and services	101,5	117,2	120,0	119,8	69,6	110,3	139,1	162,8	128,3	139,2	139,7
Agriculture	20,3	21,2	19,4	19,7	21,9	19,7	34,9	30,9	23,8	26,6	24,2

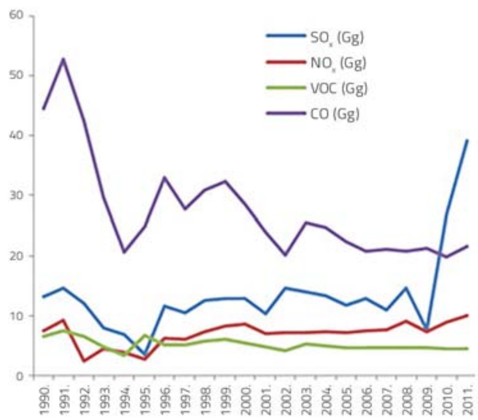
Table 3.19 and Graph 3.27 show indirect GHG emissions from the energy sector during the period 1990-2011. As in the case of direct GHG emissions, indirect gas emissions were mostly due to operations at TPP Pljevlja. Accordingly, lower levels of SO_x, NO_x and CO emissions were recorded in 1995 and in 2009; this was directly related to reduced electricity generation at the thermal power plant. According to data from the energy balance, the consumption of lignite at the thermal power plant significantly increased in 2010 and 2011, and this resulted in a significant increase in indirect GHG emissions. It is important to mention that the power plant (technical steam generation) at the factory for the production of aluminum (Aluminium Plant Podgorica) was closed in mid 2009, which led to a decline in SO_x and NO_x emissions that year. When working at full capacity (1990–1992 and 1997–2008), the power plant used about 60,000 t/year of oil fuel whose sulphur content varied from 0.79–3.03 w/w.



Graph 3.26 CO_2 from energy subsectors, 1990-2011 (Gg and %)

Table 3.19 Indirect GHG emissions from the energy sector, 1990-2011 (Gg)

Year	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
SO_x (Gg)	13,25	14,60	12,14	7,95	6,82	3,58	11,67	10,52	12,60	12,91	12,89
NO_x (Gg)	7,51	9,30	2,39	4,59	3,95	2,82	6,24	6,11	7,38	8,29	8,68
NMVOC (Gg)	6,55	7,57	6,55	4,82	3,48	6,74	5,12	5,09	5,72	6,05	5,48
CO (Gg)	44,53	52,77	42,46	29,65	20,66	24,91	33,06	27,83	30,90	32,43	28,51
Year	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
SO_x (Gg)	10,37	14,62	14,01	13,30	11,71	12,94	10,97	14,61	7,66	26,86	39,12
NO_x (Gg)	7,12	7,19	7,22	7,38	7,27	7,57	7,75	9,15	7,39	8,92	10,04
NMVOC (Gg)	4,78	4,14	5,38	5,06	4,68	4,69	4,62	4,73	4,66	4,47	4,56
CO (Gg)	24,01	20,23	25,57	24,83	22,47	20,83	21,18	20,79	21,26	19,88	21,60



Graph 3.27 Indirect GHG emissions from the energy sector, 1990-2011 (Gg)

3.3.2 Emissions From the Industry Sector

Crucial branches of industrial production in Montenegro include the generation of electricity, mining and the metal industry. Aluminium and steel production are key branches of the metal industry. Other industrial facilities are in the business of producing: food, beverages, tobacco, textile, products made of leather, paper, medicines and rubber and plastic products.

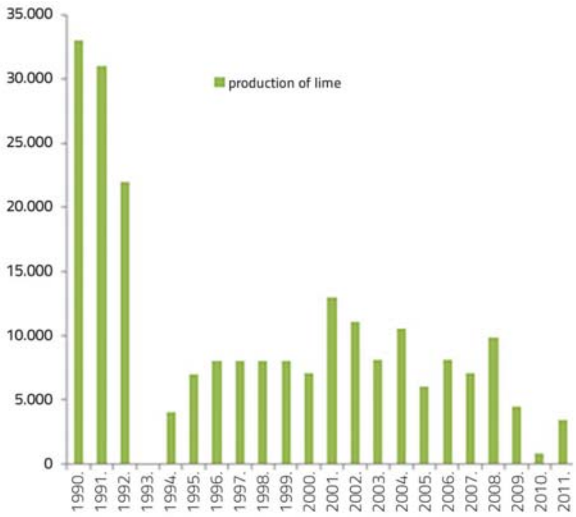
Processed Data

The data on industrial production was provided by: Statistical Office – MONSTAT, Aluminium Plant Podgorica, Nikšić Ironworks, 13. jul - Plantaže Podgorica and Trebjesa Brewery.

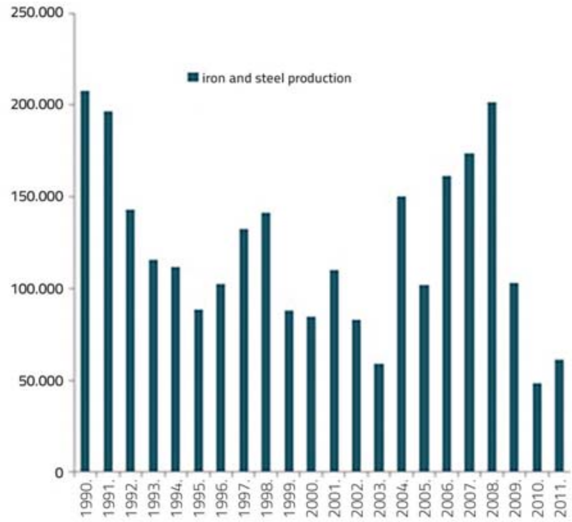
The economic development of Montenegro during the period up to 1990 was characterised by intensive industrial production, and thus the industry's share in GDP until 1991 was about 30%. After this period, industrial production continuously declined and as a result its share in GDP was only 5% in 2011.

Production Levels

The production of lime, as was the case with all other industries in Montenegro, recorded a drastic decline in the 1990s due to the adverse economic situation (Graph 3.28). The production of lime has not recovered in recent years and the demand for lime, therefore, is met through imports.



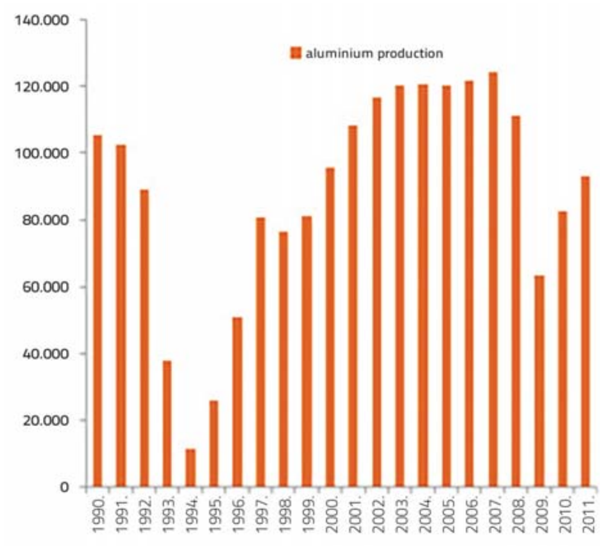
Graph 3.28 Production of lime, 1990-2011 (t)



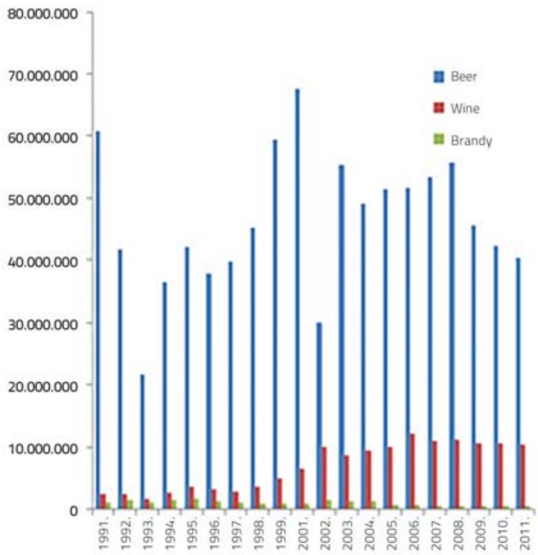
Graph 3.29 Iron and steel production, 1990-2011 (t)

After a decline in production in the early 1990s, the iron and steel industry recovered; in 2008 it reached the same level of production as in 1990. After that period of recovery, the world economic crisis contributed to a new decline in production (Graph 3.29).

Aluminium is the country's main industrial product and generates half of the country's total export revenue. During the period 2000–2008, the aluminium industry managed to reach and exceed its 1990 production level, after which the production of aluminium stopped and the quantity of aluminium produced was reduced due to low aluminium prices in world markets (Graph 3.30).

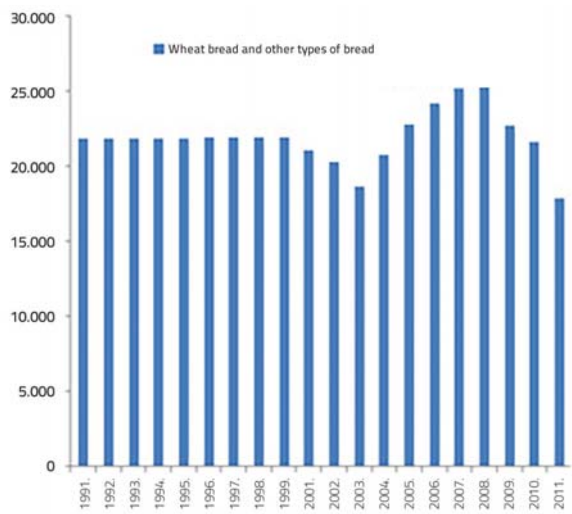


Graph 3.30 Aluminium production, 1990-2011 (t)



Graph 3.31 Production of beer, wine and brandy, 1990-2011 (l)

In Montenegro, beer is produced by the Trebjesa Brewery; the brewery achieved a stable level of production during the period 1990-2011, except for a couple of years. Although wine and brandy are produced in private wine-cellars in Montenegro, larger quantities are produced by the 13. jul - Plantaže plant (Graph 3.31). The production of wheat bread and other types of bread is mostly stable during the period (1990-2011) (Graph 3.32).



Graph 3.32 Production of wheat bread and other types of bread, 1990-2011 (t)

GHG Emissions

The estimate of direct GHG emissions was made in accordance with IPCC methodology (1996) and was based on data from production processes. Due to the data provided on the number and duration of anode effects it was possible to estimate the CF_4 and C_2F_6 emissions resulting from aluminium production at the electrolysis plant according to a Tier 2 approach. The estimates of the other direct GHG emissions from production processes were made according to a Tier 1 approach.

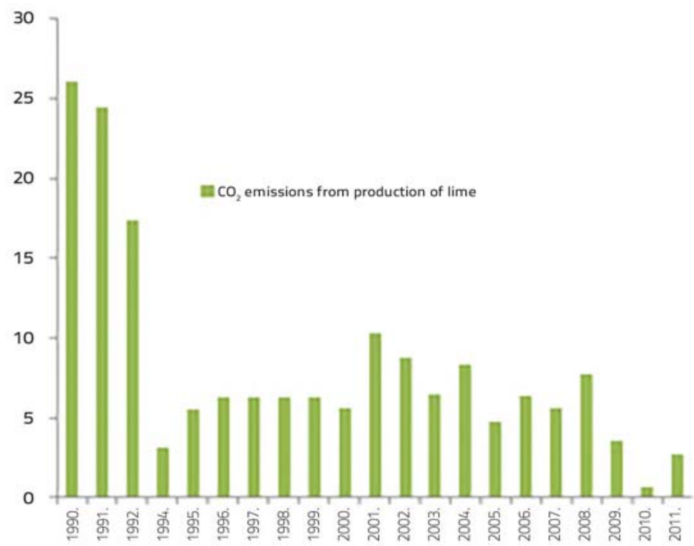
The estimate of indirect greenhouse gases was made in accordance with the EMEP/EEA Air Pollutant Emission Inventory Guidebook from 2009.

It can be seen that the level of direct GHG emissions, as well as the level of indirect gas emissions, strictly follows production volume levels during the period 1990-2011.

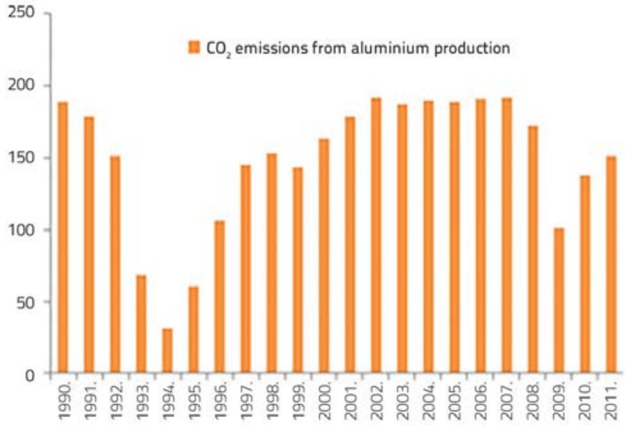
The estimate of CO_2 emissions included the industrial subsectors that produce lime, iron and steel and aluminium (Table 3.20 and Graphs 3.33, 3.34 and 3.35).

Table 3.20 CO_2 emissions from industrial subsectors, 1990-2011 (Gg)

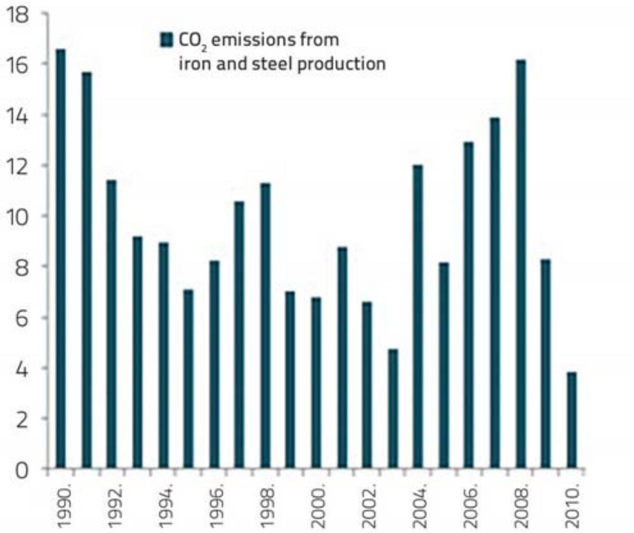
CO_2 emissions (Gg)/ year	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
Production of lime	26,1	24,5	17,4	/	3,2	5,5	6,3	6,3	6,3	6,3	5,6
Iron and steel production	16,6	15,7	11,4	9,2	8,9	7,1	8,2	10,6	11,3	7,0	6,8
Aluminium production	188,5	178,3	151,4	68,8	31,9	60,7	106,3	144,7	153,0	142,8	163,3
CO_2 emissions (Gg)/ year)	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
Production of lime	10,3	8,8	6,4	8,4	4,7	6,4	5,6	7,7	3,5	0,7	2,7
Iron and steel production	8,8	6,6	4,7	12,0	8,2	12,9	13,9	16,1	8,3	3,8	4,9
Aluminium production	178,4	191,4	186,8	189,7	189,2	190,3	191,7	171,8	101,3	137,9	151,2



Graph 3.33 CO_2 emissions from the production of lime, 1990-2011 (Gg)

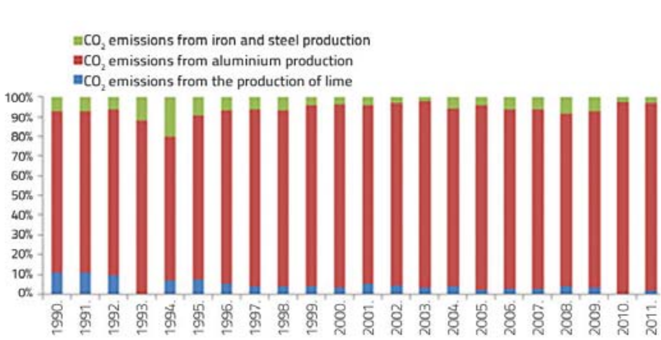


Graph 3.34 CO_2 emissions from the production of aluminium, 1990-2011 (Gg)



Graph 3.35 CO_2 emissions from the production of iron and steel, 1990-2011 (Gg)

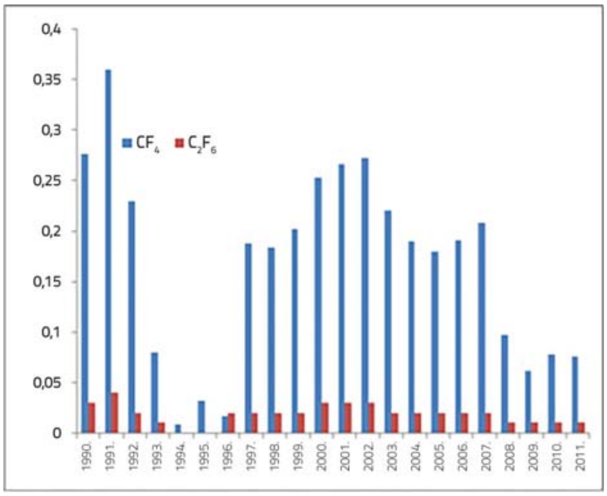
The most significant emissions of CO_2 within the industrial sector come from the aluminium industry due to its technological processes of anode baking and electrolyte aluminium melting. Of the total amount of CO_2 emissions created by the industrial sector, the Aluminium Plant Podgorica is responsible for 95%, the Nikšić Ironworks for about 3%, and the production of lime for about 2% (Graph 3.36).



Graph 3.36 Shares of CO_2 emissions resulting from production processes in industrial subsectors, 1990-2011 (%)

Graph 3.37 and Table 3.21 show emissions of synthetic GHG (CF_4 and C_2F_6) resulting from the production of aluminium at the electrolysis plant. The emission of these pollutants is caused by the anode effect in electrolytic cells. Emission levels depend on production levels during the observed period and on the number and duration of anode effects. The number and duration of anode effects depend on the efficient control of voltage on the electrolytic cells; this has been carried out automatically in sequence "A" since 1997 and in sequence "B" since 2008.

Although emissions of synthetic gases are low compared with other GHG, their very high global warming potential indicates that their pollutants represent a large share of the total GHG emissions.



Graph 3.37 CF_4 and C_2F_6 emissions from aluminium production, 1990-2011 (Gg)

Table 3.21 CF_4 and C_2F_6 emissions from aluminium production, 1990-2011 (Gg)

Year	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
CF_4 emission (Gg)	0,3	0,4	0,2	0,1	0,0	0,0	0,2	0,2	0,2	0,2	0,3
C_2F_6 emission (Gg)	0,03	0,04	0,02	0,01	0,00	0,00	0,02	0,02	0,02	0,02	0,03
Year	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
CF_4 emission (Gg)	0,3	0,3	0,2	0,2	0,2	0,191	0,208	0,097	0,061	0,078	0,076
C_2F_6 emission (Gg)	0,03	0,03	0,02	0,02	0,02	0,02	0,02	0,01	0,01	0,01	0,01

HFC and SF_6 Emissions

The estimate of HFC emissions in 2011 was made based on data provided by the Environmental Protection Agency of Montenegro and was based on licences issued for the use of that pollutant. Levels of HFC emissions in 2011 were 0.008 Mg.

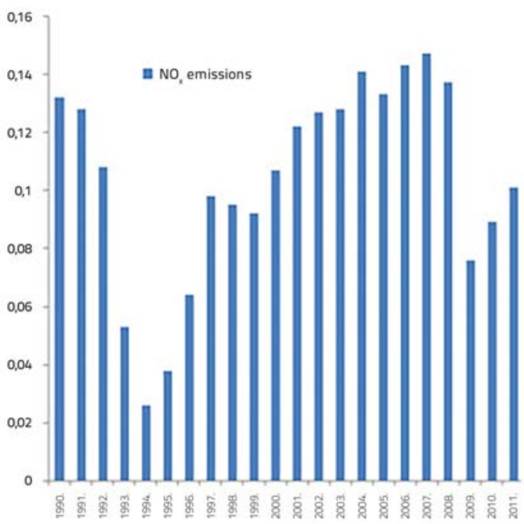
According to the data that was made available by the Montenegrin Electric Company and the Montenegrin Electrical Transmission System, and after a detailed analysis, only SF_6 emissions for 2011 were estimated. The level of these emissions was 0.108 Mg, and due to its high global warming potential the level of CO_{2eq} was 2.581 Gg, which did not significantly influence the overall level of emissions in 2011.

Emissions of Indirect Gases

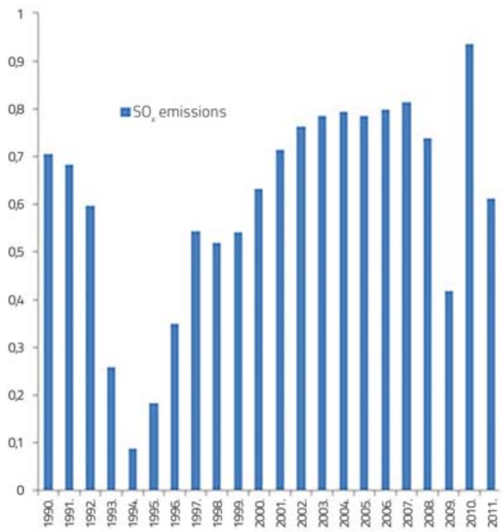
SO_x, NO_x and CO emissions from the industrial sector during the observed period (Table 3.22 and Graphs 3.38, 3.39 and 3.40) refer almost entirely to the aluminium industry. Thus, levels of emissions from these pollutants depend on applied technological solutions and on the level of aluminium production. As already mentioned, the aluminium industry went through a period of low production in the nineteen-nineties and consequently the level of indirect GHG emissions was lower than it had been in 1990. The same situation was recorded in 2009.

Table 3.22 Indirect GHG emissions in the industrial production sector, 1990-2011 (Gg)

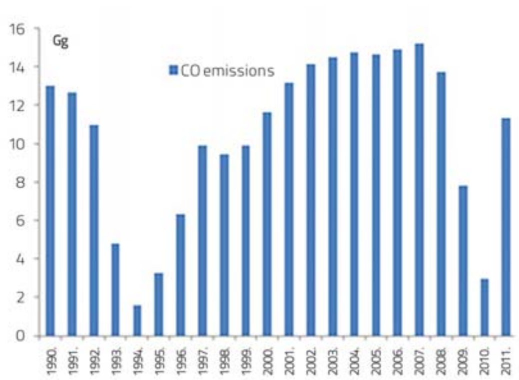
Year	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
SO_x emission (Gg)	0,704	0,683	0,595	0,258	0,088	0,182	0,35	0,543	0,519	0,54	0,631
NO_x emission (Gg)	0,132	0,128	0,108	0,053	0,026	0,038	0,064	0,098	0,095	0,092	0,107
CO emission (Gg)	13,029	12,638	10,965	4,778	1,575	3,29	6,32	9,92	9,45	9,88	11,631
Year	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
SO_x emission (Gg)	0,714	0,763	0,784	0,793	0,785	0,799	0,813	0,737	0,419	0,935	0,611
NO_x emission (Gg)	0,122	0,127	0,128	0,141	0,133	0,143	0,147	0,137	0,076	0,089	0,101
CO emission (Gg)	13.188	14,145	14,522	14,777	14,645	14,916	15,23	13,73	7,796	2,972	11,314



Graph 3.38 NO_x emissions from the industry sector, (1990-2011) (Gg)

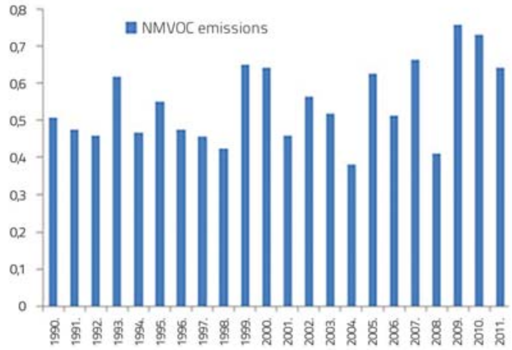


Graph 3.39 SO_x emissions from the industry sector, 1990-2011 (Gg)



Graph 3.40 CO emissions from the industry sector, 1990-2011 (Gg)

NMVOC emissions occur during the processes of beverage and food production. Levels of this pollutant depend almost entirely on the production of bread, beer, wine and brandy (Graph 3.41, Table 3.23).



Graph 3.41 NMVOC emissions from the production of bread, beer, wine and brandy, 1990-2011 (Gg)

Table 3.23 NMVOC emissions from the production of bread, beer, wine and brandy, (1990-2011) (Gg)

Year	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
NMVOC Emission (Gg)	0,51	0,47	0,46	0,62	0,47	0,55	0,47	0,46	0,42	0,65	0,64
Year	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
NMVOC Emission (Gg)	0,46	0,56	0,52	0,38	0,63	0,51	0,66	0,41	0,76	0,73	0,64

3.3.3 Emissions From the Sector of Solvents and Other Similar Products

Solvents and other compounds are mostly used in industry, shipbuilding and construction in Montenegro. Significant amounts of these products, including fungicides, are used in households. NMVOC emissions, which belong to the group of indirect GHG, occur when these compounds are used.

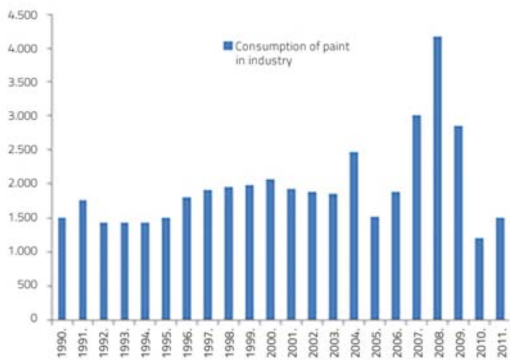
Processed Data

Data on quantities of organic solvents, thinners, paints, varnishes, coatings, printing inks, India ink, regular ink, degreasers and pesticides were used to estimate emission levels of non-methane volatile compounds. The data was provided by MONSTAT, Customs Administration and the Adriatic Shipyard Bijela.

Consumption of Solvent and Similar Products

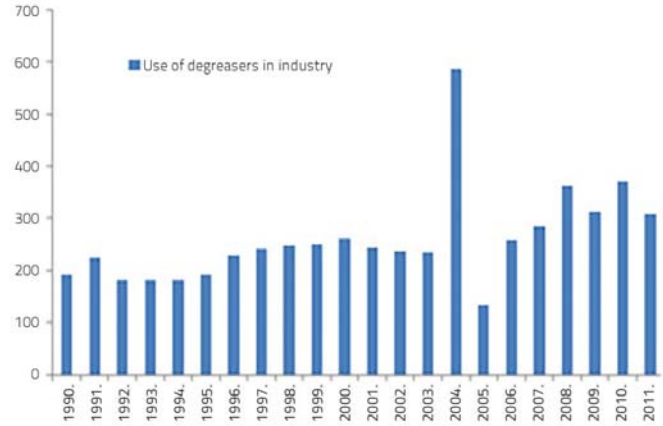
Construction in Montenegro stagnated in the 1990s. Since the beginning of this century until now, construction has been growing, and as a result of that the use of construction materials has increased. This includes the use of paint (Graph 3.42).

Graph 3.42 Consumption of paint in construction, 1990-2011 (t)



Graph 3.43 Consumption of paint in industry, (1990-2011) (t)

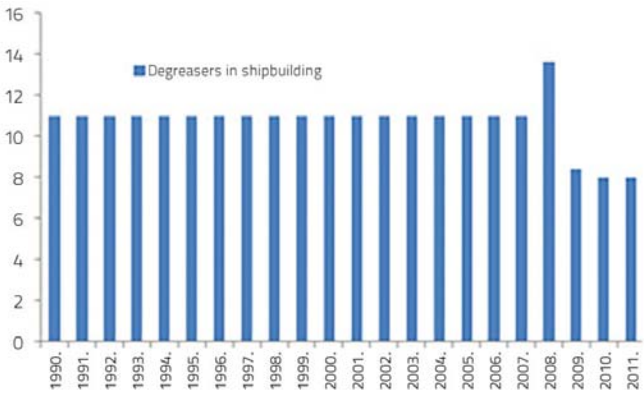
In line with the growth of industrial production, there was also an increase in the consumption of paints and degreasers in the industry sector during the period 2004-2011 (Graphs 3.43, 3.44).



Graph 3.44 Use of degreasers in industry, (1990-2011) (t)

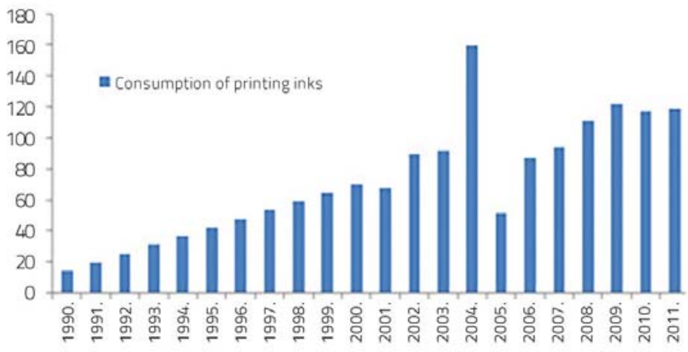
Graphs 3.43 and 3.44 refer to the consumption of paints and degreasers in shipbuilding; a significant increase was recorded in 2006.

Graph 3.45 Consumption of paint in shipbuilding, 1990-2011 (t)



Graph 3.46 Consumption of degreasers in shipbuilding, 1990-2011 (t)

The consumption of printing inks grew constantly in line with the intensification of printing activities in Montenegro during the period 1990-2011 (Graph 3.47).



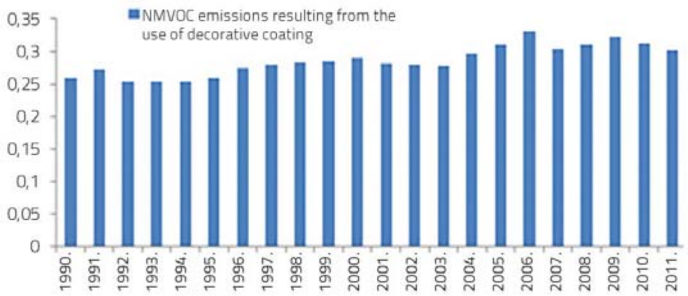
Graph 3.47 Consumption of printing inks, (1990-2011) (t)

The consumption of solvents and similar products in households relates directly to population figures. Therefore, this data has also been used to estimate NMVOC emissions.

GHG Emissions

The estimate of NMVOC emissions was made in accordance with the EMEP/EEA Air Pollutant Emission Inventory Guidebook (2009).

NMVOC emissions, which are a consequence of the use of decorative coatings, produce the same pollutants as the paints and varnishes that are used in construction and in shipbuilding. During the observed period (1990-2011), there was a significant increase in the consumption of paint at the Shipyard in Bijela. This data was recorded in 2006 and was responsible for the increase in NMVOC emissions (Graph 3.48).

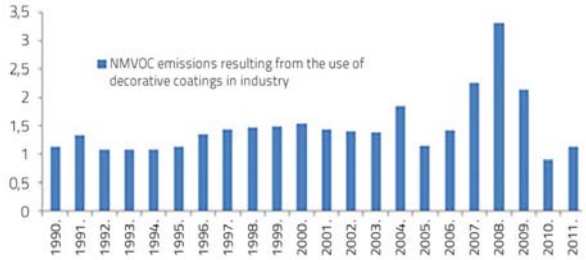


Graph 3.48 NMVOC emissions resulting from the use of decorative coatings in construction and in shipbuilding, 1990-2011 (Gg)

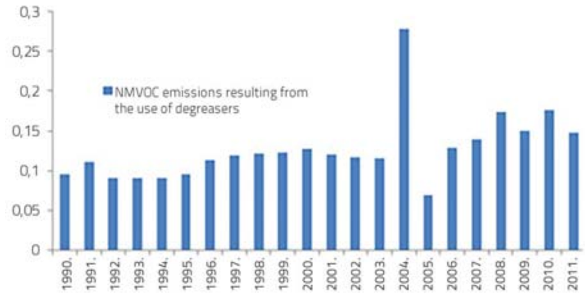
In 2008, the industrial sector recorded higher production levels and, therefore, the consumption of coatings for general and plant maintenance reached its highest level during the observed period. Accordingly, the level of NMVOC emissions also rose in 2008 (Graph 3.49).

The consumption of degreasers is mostly present in industry and shipbuilding. In line with high consumption levels of these products in 2004 (particularly in the industrial sector), NMVOC emissions were also the highest that year (Graph 3.50).

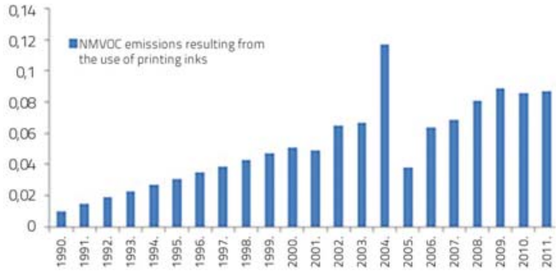
The levels of NMVOC emissions resulting from printing activities were in line with consumption levels of printing inks during the observed period (Graph 3.51).



Graph 3.49 NMVOC emissions from decorative coatings used in industry, 1990-2011 (Gg)

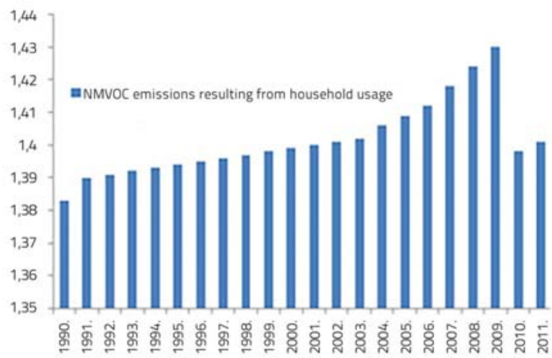


Graph 3.50 NMVOC emissions from degreasers used in industry and shipbuilding, 1990-2011 (Gg)



Graph 3.51 NMVOC emissions resulting from the use of printing inks, 1990-2011 (Gg)

The level of NMVOC emissions grew proportionally with the increase in consumption of solvents and similar products in households (Graph 3.52).

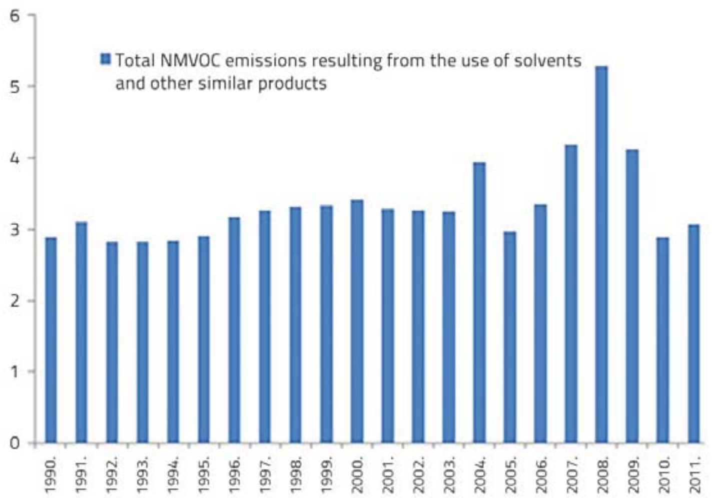


Graph 3.52 NMVOC emissions from solvents and similar other products used in households, 1990-2011 (Gg)

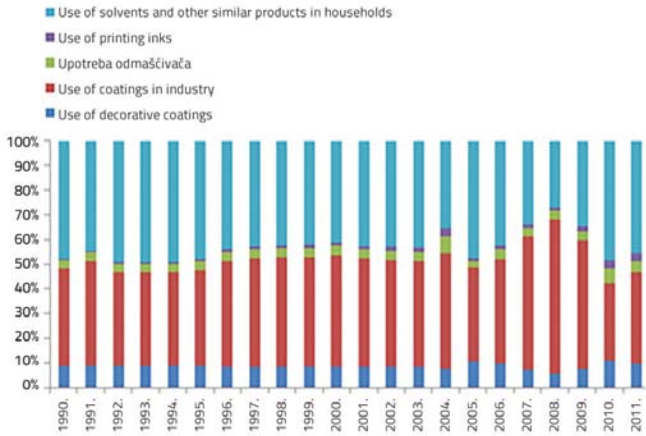
In conclusion, industry and shipbuilding are responsible for the greatest share of all total NMVOC emissions which result from the use of solvents and other similar products.

Table 3.24 Total NMVOC emissions from the use of solvents and other similar products, 1990-2011 (Gg)

NMVOC emissions (Gg)	Decorative coatings use	Use of coatings in industry	Degreasers use	Printing inks use	Solvent and similar product use in households	Solvent and similar product use
1990.	0,258	1,136	0,096	0,01	1,383	2,883
1991.	0,272	1,322	0,111	0,015	1,39	3,11
1992.	0,253	1,073	0,091	0,019	1,391	2,827
1993.	0,253	1,072	0,091	0,023	1,392	2,831
1994.	0,253	1,072	0,091	0,027	1,393	2,836
1995.	0,258	1,132	0,096	0,031	1,394	2,911
1996.	0,274	1,351	0,113	0,035	1,395	3,168
1997.	0,28	1,429	0,119	0,039	1,396	3,263
1998.	0,283	1,467	0,122	0,043	1,397	3,312
1999.	0,284	1,481	0,123	0,047	1,398	3,333
2000.	0,289	1,546	0,128	0,051	1,399	3,413
2001.	0,281	1,44	0,12	0,049	1,4	3,29
2002.	0,279	1,408	0,117	0,065	1,401	3,27
2003.	0,277	1,39	0,116	0,067	1,402	3,252
2004.	0,296	1,849	0,278	0,117	1,406	3,946
2005.	0,31	1,143	0,07	0,038	1,409	2,97
2006.	0,331	1,411	0,129	0,064	1,412	3,347
2007.	0,303	2,255	0,139	0,069	1,418	4,184
2008.	0,31	3,31	0,174	0,081	1,424	5,299
2009.	0,322	2,138	0,15	0,089	1,43	4,129
2010.	0,312	0,909	0,176	0,086	1,398	2,881
2011.	0,302	1,125	0,148	0,087	1,401	3,063



Graph 3.53 Total NMVOC emissions from the use of solvents and other similar products, 1990-2011 (Gg)



Graph 3.54 Share of emissions by individual activity within total NMVOC emissions due to the use of solvents and other similar products, 1990-2011 (Gg)

3.3.4 Emissions From the Sector of Agriculture

Agricultural land covers about 37% of the territory of Montenegro. According to data from MONSTAT, there were 517,136 ha of agricultural land in 1990, while in 2011 there were 517,740 ha; of this 349,708 ha were private holdings and 166,032 ha were owned by companies and cooperatives.

Of all the big agricultural producers owned by the state, the only one that still remains is 13. jul Plantaže a.d.; it owns vineyards and peach plantations as well as extensive processing facilities.

Processed Data

MONSTAT data was used to estimate direct and indirect GHG emissions from the sector of agriculture.

The statistical yearbook's introductory section describes the methodology of data collection and processing for agriculture; this includes livestock breeding and crop production.

After the agricultural census in 2010 (MONSTAT, 2010), conditions were created to commence the alignment of crop production and livestock breeding statistics with EUROSTAT recommendations and EU standards.

In late 2012, MONSTAT started to draft a new methodology and new forms for the collection and statistical processing of data. These changes will have a significant impact on time series; recalculations will be carried out during the forthcoming period. It is hoped that the time series recalculated on the basis of the 2010 agricultural census data will be published in the Statistical Yearbook for 2013.

Data recalculated in this manner will serve as the basis for the recalculation of the entire GHG emission time series provided in this Communication for the agriculture sector.

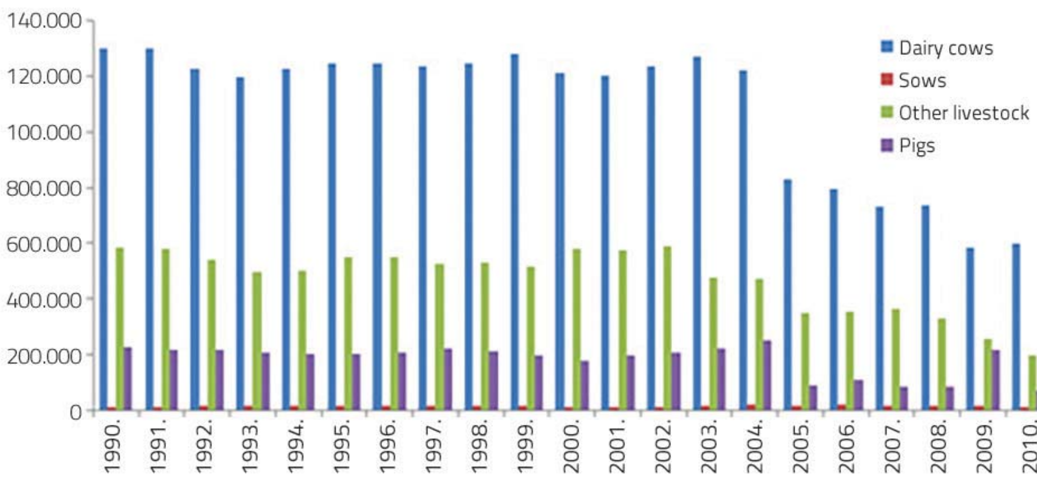
Livestock Breeding and Crop Production

During the observed period (1990-2011), agricultural production declined in almost all segments (Tables 3.25 and 3.26, Graphs 3.55 – 3.58). The crisis of the 1990s and subsequent low investments in agricultural production caused the stagnation of this economic sector.

Data on the consumption of nitrogen fertilizers varies (Table 3.27, Graph 3.52) during the observed period; a clear picture of the consumption levels of this fertilizer will only be evident after the full harmonisation of national statistics with the EUROSTAT methodology.

Table 3.25 Livestock production, 1990-2011 (number of units)

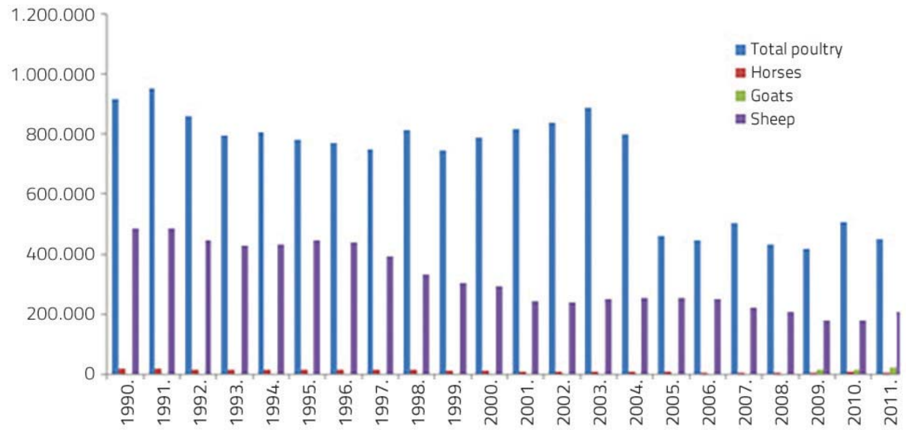
Number of units/ year	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
Total poultry	917,084	953,273	859,543	794,435	806,196	781,265	770,826	750,074	813,358	745,017	790,577
Horses	19,914	19,318	16,864	16,160	16,209	16,327	15,812	14,997	14,182	12,474	10,703
Goats											-
Sheep	486,634	487,500	448,543	430,498	430,847	447,909	438,881	392,058	332,795	305,707	293,.197
Dairy cows	130,144	129,926	122,763	119.702	122,704	124,567	124,457	123,473	124,373	128,179	121,060
Sows	1,397	1,323	1,777	1,577	1,762	1,605	1,622	1,529	1,564	1,664	1,370
Other livestock	58,365	57,980	54,183	49,622	50,135	54,957	55,124	52,570	53,320	51,527	58,011
Pigs	22,831	21,941	21,779	20,624	20,510	20,219	20,855	22,107	21,078	19,852	17,896
Number of units/ year	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
Total poultry	817,445	837,542	890,045	799,839	462,149	448,502	505,355	432,264	416,737	506,520	449,058
Horses	9,967	9,568	9,028	7,447	7,119	6,.260	5,463	5,124	4,342	7,904	4,035
Goats	-	-	-	-	-	-	-	-	16,175	14,427	23,377
Sheep	243,524	240,531	252,007	254,406	254,898	249,281	222,244	209,354	180,228	177,808	206,746
Dairy cows	120,427	123,534	126,987	122,035	82,851	79,553	73,142	73,477	58,495	60,133	59,532
Sows	1,212	1,369	1,785	2,076	1,555	2,395	1,593	1,676	1,537	1,391	2,802
Other livestock	57,637	59,146	47,967	47,305	34,991	35,369	36,236	33,017	25,551	19,664	27,641
Pigs	19,663	20,548	22,094	25,165	9,142	10,899	8,781	8,341	22,014	7,302	14,711



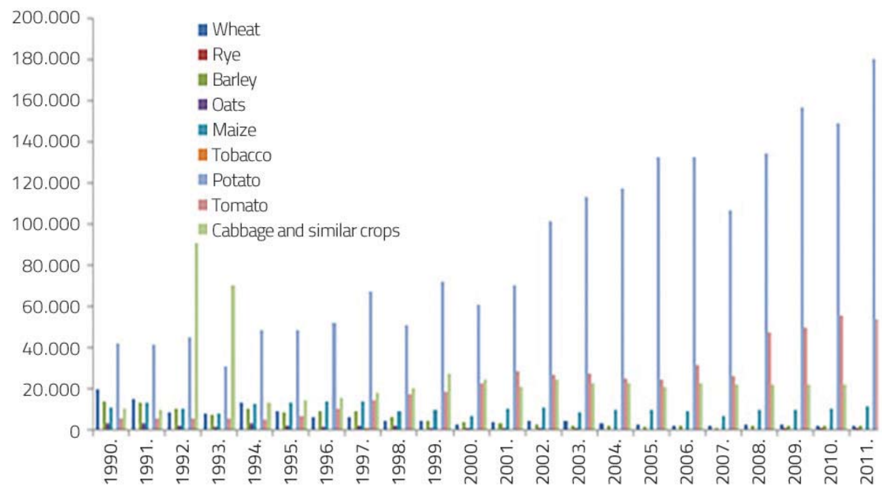
Graph 3.55 Livestock production, (1990-2011) (number of units)

Table 3.26 Crop production, 1990-2011 (t)

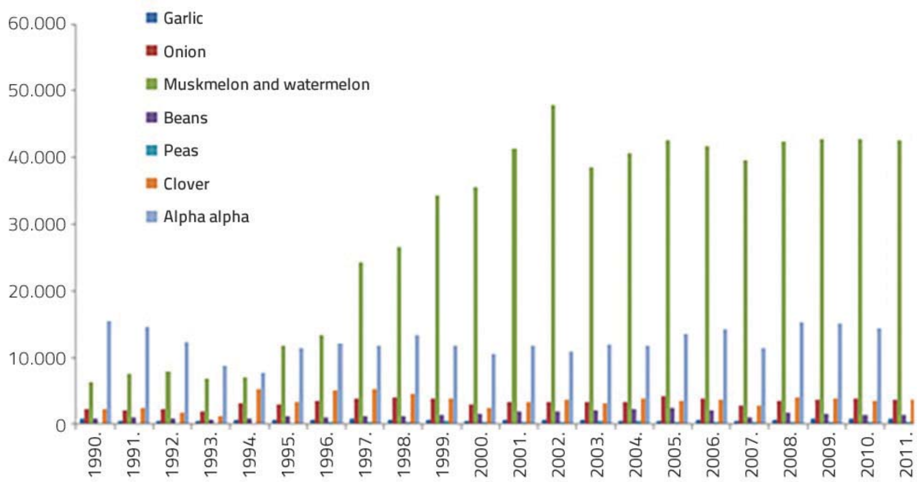
Crop (t) /year	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
Wheat	19,838	15,217	8,940	8,142	13,580	9,201	6,397	6,637	4,615	4,452	2,888
Rye	458	450	314	281	277	249	175	275	102	81	80
Barley	14,007	13,653	10,699	7,317	10,329	8,768	9,163	9,069	6,448	4,618	4,060
Oats	3,536	3,128	2,389	1,866	3,215	2,309	1,925	2,294	2,015	1,201	889
Maize	11,111	13,188	10,433	8,155	12,899	13,176	13,797	14,184	9,360	9,585	6,665
Tobacco	609	676	712	680	430	364	739	795	623	373	274
Potato	42,047	41,776	45,204	30,901	48,783	48,871	52,171	67,618	51,156	72,139	60,787
Cabbage and kale	5,538	5,720	5,802	5,770	5,437	6,977	10,515	14,572	17,706	18,901	22,651
Tomato	10,479	10,109	9,615	7,377	13,378	14,478	15,800	18,356	20,582	27,331	24,604
Garlic	768	579	573	473	661	654	748	861	745	686	499
Onion	2,262	2,116	2,212	1,964	3,123	2,999	3,517	3,907	3,940	3,792	2,972
Muskmelon and watermelon	6,291	7,556	7,878	6,749	7,076	11,689	13,439	24,283	26,540	34,335	35,577
Beans	926	1.041	927	658	862	1,126	1,070	1,253	1,257	1,440	1,488
Peas	101	84	110	106	184	229	244	274	396	510	265
Clover	2,298	2,380	1,743	1,246	5,166	3,227	5,035	5,178	4,475	3,897	2,422
Alpha Alpha	15,504	14,623	12,212	8,806	7,693	11,413	12,144	11,731	13,429	11,686	10,608
Crop (t) /year	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
Wheat	4,051	4,851	4,422	3,437	2,632	2,497	1,969	2,856	3,044	2,465	2,446
Rye	124	78	83	256	242	394	214	577	1000	799	826
Barley	3,376	2,976	2,201	1,960	1,561	1,966	1,058	2,244	2,227	2,011	1,955
Oats	1,081	1,069	843	666	516	428	240	524	494	499	586
Maize	10,290	10,781	8,600	9,641	9,668	9,066	6,937	9,625	10,009	10,484	11,688
Tobacco	342	384	398	419	416	431	358	324	272	270	258
Potato	70,421	101,288	113,290	117,039	132,830	132,783	106,909	134,106	156,380	149,252	180,126
Cabbage and kale	28,574	26,782	27,209	25,015	24,408	31,813	26,297	47,334	50,062	55,557	53,631
Tomato	21,220	24,374	22,790	22,818	20,853	22,507	22,084	22,165	22,091	22,430	23,074
Garlic	684	703	681	501	554	685	523	725	784	850	922
Onion	3,234	3,319	3,334	3,261	4,127	3,928	2,793	3,576	3,752	3,816	3,740
Muskmelon and watermelon	41,303	47,886	38,567	40,647	42,644	41,765	39,672	42,449	42,702	42,687	42,601
Beans	1,894	1,869	2,165	2,218	2,364	2,152	1,066	1,684	1,492	1,340	1,331
Peas	281	262	436	578	371	329	258	285	274	287	310
Clover	3,311	3,702	3,060	3,802	3,427	3,633	2,800	3,959	3,925	3,414	3,638
Alpha Alpha	11,846	10,892	11,962	11,784	13,477	14,176	11,474	15,358	15,126	14,446	14,980



Graph 3.56 Livestock production, 1990-2011 (number of units)



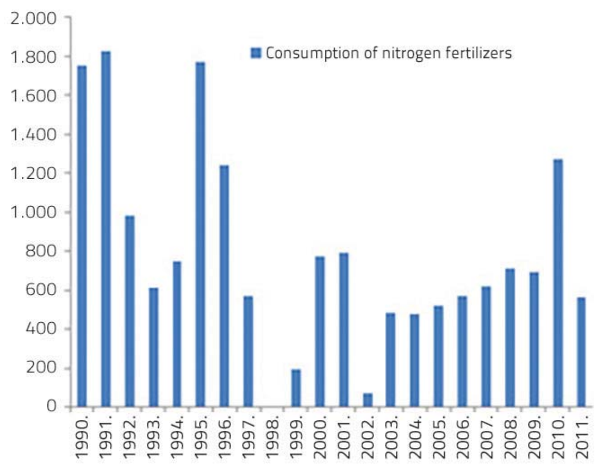
Graph 3.57 Crop production, 1990-2011 (t)



Graph 3.58 Crop production, 1990-2011 (t)

Table 3.27 Consumption of nitrogen fertilizers, 1990-2011 (t)

Year	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
Consumption of nitrogen fertilizers	1,750	1,830	983	614	748	1,773	1,243	571	/	197	776
Year	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
Consumption of nitrogen fertilizers	789	68	482	480	521	569	620	710	693	1,270	563



Graph 3.59 Consumption of nitrogen fertilizers, 1990-2011 (t)

GHG Emissions

The estimate of direct GHG emissions from the sector of agriculture was made in accordance with IPCC methodology (1996), by applying a Tier 1 approach and based on data from agricultural production.

The estimate of indirect GHG emissions was made in accordance with the EMEP/EEA Air Pollutant Emission Inventory Guidebook (2009).

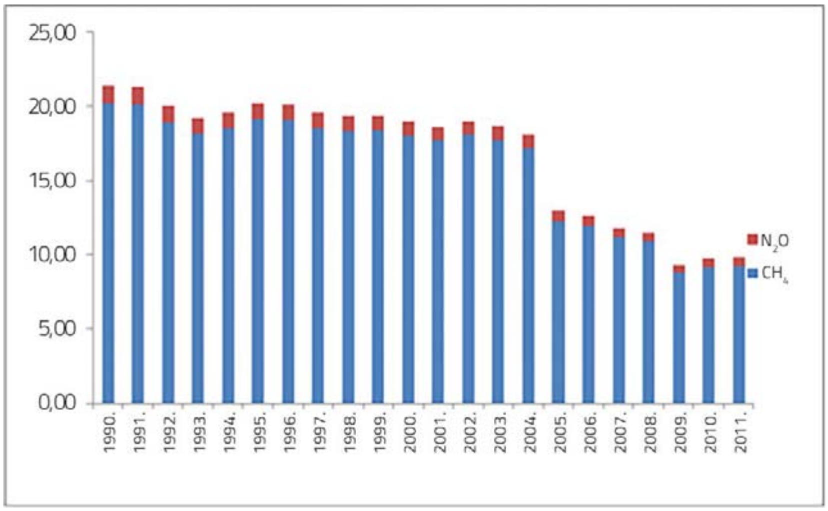
Direct GHG Emissions

Total direct GHG emissions from the sector of agriculture are shown in Table 3.28 and Graph 3.60, where a constant decline in CH_4 and N_2O emissions can be observed; this is in line with the continuous decline seen in agricultural production. Methane represents the biggest share of total direct GHG emissions.

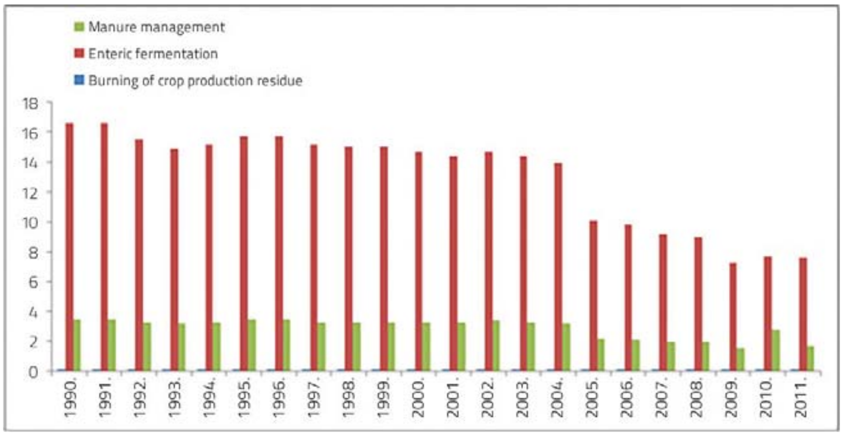
Table 3.28 Total direct GHG emissions from the sector of agriculture, 1990-2011 (Gg)

Year	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
CH_4 (Gg)	20,18	20,11	18,88	18,13	18,48	19,08	19,03	18,51	18,32	18,39	18,01
N_2O (Gg)	1,16	1,16	1,10	1,05	1,06	1,09	1,08	1,04	0,99	0,97	0,94
Year	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
CH_4 (Gg)	17,66	18,06	17,70	17,17	12,26	11,93	11,17	10,91	8,80	9,15	9,27
N_2O (Gg)	0,90	0,87	0,92	0,90	0,70	0,69	0,63	0,62	0,55	0,61	0,60

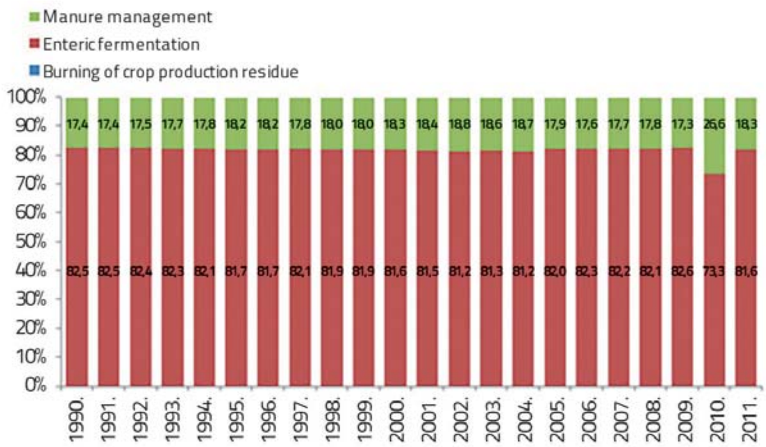
Graphs 3.54 and 3.55 show CH_4 emissions from agricultural activities where enteric fermentation is responsible for the largest share (73–83)%, followed by manure management (17.3–26.6)%. The burning of crop production residue hardly has any impact on CH_4 emissions from agricultural production.



Graph 3.60 Total direct GHG emissions from the sector of agriculture, 1990-2011 (Gg)

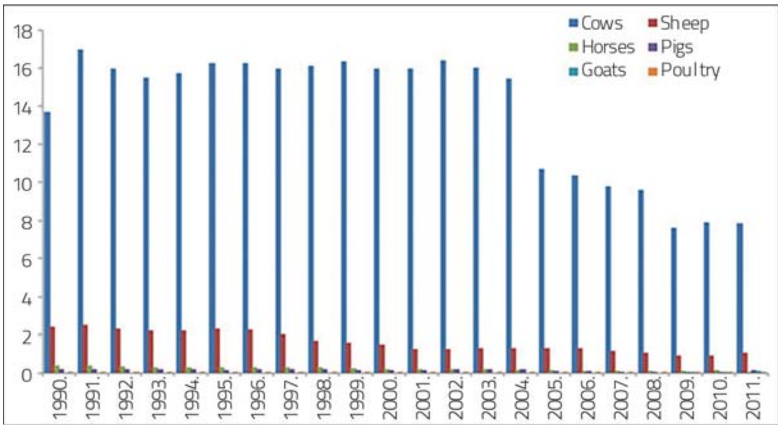


Graph 3.61 CH_4 emissions from agricultural activities, 1990-2011 (Gg)

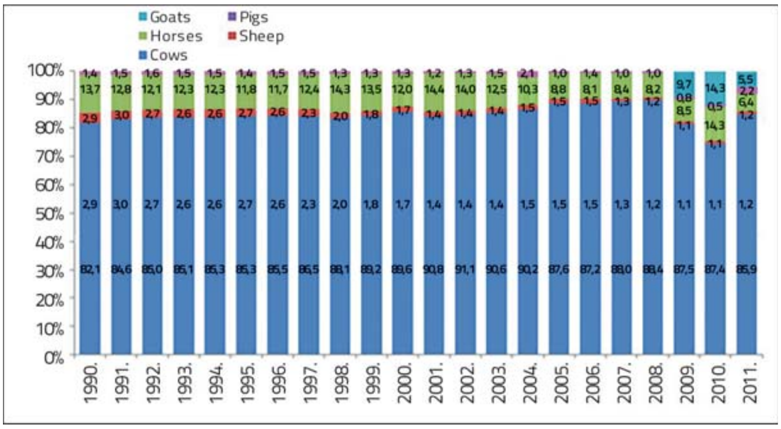


Graph 3.62 Shares of activities comprising total CH_4 emissions from the sector of agriculture, 1990-2011 (%)

The breeding of cows represented the biggest share in CH_4 emissions (82–90)%, due to enteric fermentation. This was followed by horse breeding (6.5–14)%, while the breeding of other animals had an insignificant impact. The collection of statistics and data regarding the number of goats has been started in recent years, and this data has consequently been updated in inventories relating to 2009, 2010 and 2011.



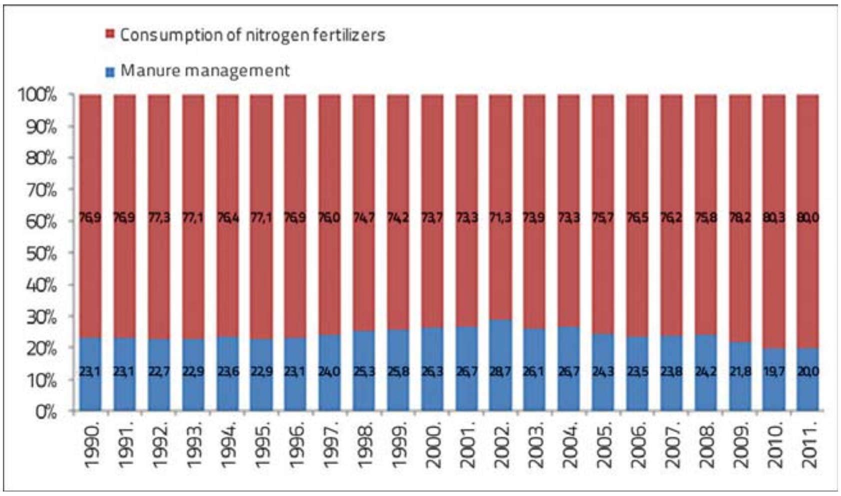
Graph 3.63 CH_4 emissions from enteric fermentation by bred livestock, 1990-2011 (Gg)



Graph 3.64 Livestock representing CH_4 emissions from enteric fermentation, 1990-2011 (%)

N_2O emissions from the sector of agriculture mostly include emissions from the use of nitrogen fertilizers (70–80)%, and to a lesser extent emissions from manure management (20–30)%. (Graphs 3.65 and 3.66)

Graph 3.65 N_2O emissions from agricultural activities, 1990-2011 (Gg)



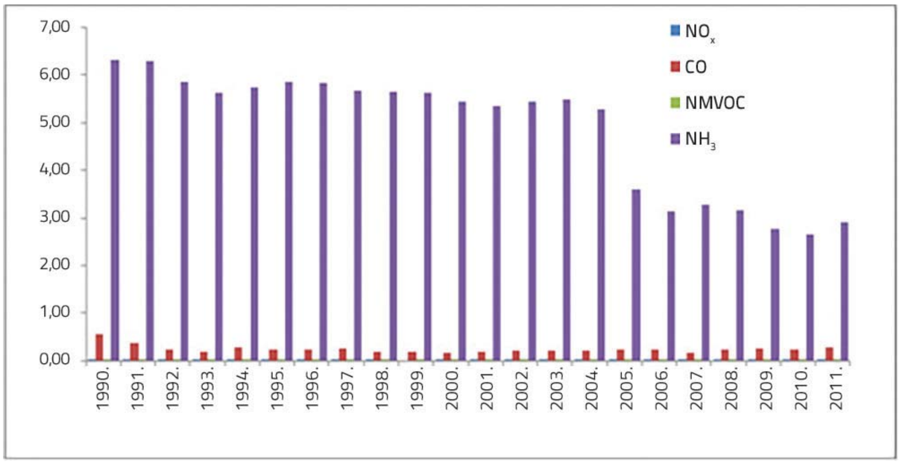
Graph 3.66 Shares of activities in total N_2O emissions from the sector of agriculture, 1990-2011 (%)

Indirect GHG Emissions

Total indirect GHG emissions from the sector of agriculture are shown in Table 3.21 and in Graph 3.67, where a constant decline of NH3 emissions can be observed; this is in line with the continuous decline seen in agricultural production.

Table 3.29 Total indirect GHG emissions from the sector of agriculture, 1990-2011 (Gg)

Year	1990.	1991.	1992.	1994.	1995.	1996.	1997.	1993.	1998.	1999.	2000.
NO_x (Gg)	0,02	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01
CO (Gg)	0,57	0,38	0,24	0,28	0,24	0,23	0,26	0,19	0,20	0,20	0,16
NMVOC (Gg)	0,007	0,006	0,005	0,006	0,004	0,004	0,004	0,005	0,004	0,003	0,003
NH3 (Gg)	6,31	6,29	5,86	5,73	5,86	5,84	5,68	5,63	5,64	5,63	5,44
Year	2001.	2002.	2003.	2005.	2006.	2007.	2008.	2004.	2009.	2010.	2011.
NO_x (Gg)	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01
CO (Gg)	0,20	0,23	0,22	0,23	0,23	0,17	0,24	0,22	0,26	0,25	0,28
NMVOC (Gg)	0,002	0,002	0,002	0,002	0,001	0,002	0,001	0,002	0,001	0,001	0,002
NH3 (Gg)	5,35	5,43	5,48	3,61	3,14	3,28	3,16	5,29	2,77	2,66	2,90



Graph 3.67 Total indirect GHG emissions from the sector of agriculture, 1990-2011 (Gg)

3.3.5 Emissions From the Land Use Change and Forestry Sector (LUCF)

Processed Data

The estimate of GHG sinks in Montenegro for the period 1990-2011 was made in accordance with IPCC (1996) and with GPG (2003) manuals.

Data from statistical yearbooks (MONSTAT), records of the Forestry Administration of Montenegro and data from the National Forest Inventory of Montenegro (2010) were used to estimate sinks.

The National Forest Inventory of Montenegro provides a fundamental basis for data on forestry in Montenegro in line with standards applied by other countries that have a long tradition of forestry management. The key quantitative findings of NFI are that forests cover 59.9% of the total land surface area, that forest land covers 9.8% of the land surface area, and that forests and forest land together cover 69.7% of the land surface area of Montenegro.

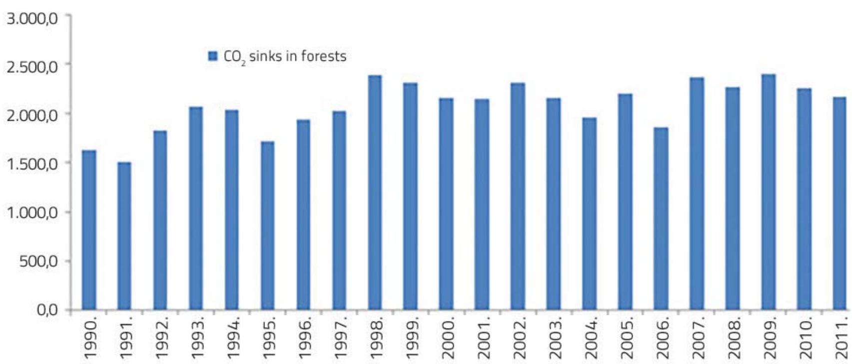
Sinks of GHG Emissions

The estimate of sinks for 2010 and 2011 was made exclusively in accordance with NIS (2010) data; in previous years sinks were estimated approximately in cooperation with an external consultant. Historical statistical data on Montenegrin forests (MONSTAT) was used for approximation, taking into consideration certain quantitative differences between the data from the Statistical Yearbooks (2010 and 2011) and the NFI. Data on wood felling during the observed period (1990-2011) was also used to estimate sinks, in accordance with the relevant methodology.

Table 3.15 and Graph 3.68 show sinks, i.e. the amount of absorbed CO_2 in Montenegrin forests during the period 1990-2011.

Table 3.30 Sinks of CO_2 emissions in the forestry sector, 1990-2011 (Gg)

Year	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
CO_2 (sinks) (Gg)	-1.634,6	-1.509,2	-1.826,6	-2.066,8	-2.034,1	-1.719,3	-1.939,5	-2.024,2	-2.385,6	-2.317,8	-2.154,1
Year	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
CO_2 (sinks) (Gg)	-2.149,8	-2.309,4	-2.158,3	-1.963,5	-2.199,2	-1.864,6	-2.364,3	-2.269,7	-2.405,3	-2.262,8	-2.166,8



Graph 3.68 Sinks of CO_2 emissions in the forestry sector, 1990-2011 (Gg)

3.3.6 Emissions From the Waste Management Sector

Processed Data

Montenegro still does not have reliable data regarding its generated quantities of waste. Therefore, estimates of GHG emissions (1991-2011) were made based on estimated quantities given in the Waste Management Plan for the period 2008-2011 (Table 3.31), and assumed the composition of municipal waste (Table 3.32) and population figures for the observed period (Table 3.33).

Table 3.31 Produced quantities of waste – Source: Montenegro Waste Management Plan (2008-2011)

Region	Waste producer			Projections
	Population	Tourists (number of overnight stays)	Number of refugees	Projected volumes (tone/year)
Northern	194.879	119.626	13.601	46.877
Central	279.419	124.874	15.947	85.598
Coastal	145.847	5.691.770	17.336	60.673
Montenegro (total)	620.145	5.936.270	46.884	193.148

Table 3.32 Assumed composition of municipal waste in Montenegro

Region	Paper and cardboard (%)	Glass (%)	Metal (%)	Plastics (%)	Textile (%)	Organic matter (%)	Other (%)	Total (%)
Central region	17	7	4	10	5	25	32	100
Coastal region	25	10	5	15	5	25	15	100
Northern region	15	7	4	12	5	35	22	100
Average value	18	8	4	12	5	28	25	100

According to data from the above mentioned document for the period 2008-2012, the quantity of waste produced by the urban population was 0.8 kg/person/day, while according to data from the Initial Communication on Climate Change of Montenegro for the period 1990–2007 it was 1 kg/person/day. Population figures for the period 1990-2011 were provided by MONSTAT.

Table 3.33 Population, 1990-2011

Year	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
Population	608.816	617.144	625.630	633.443	639.542	601.020	644121	642.533	639.309	635.689	632.606
Urban population	358.175	358.175	360.311	362.447	364.583	366.719	368.855	370.991	373.128	375.264	377.400
Year	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
Population	630.299	628.594	627.500	626.912	626.739	627.074	627.962	629.185	630.435	630.435	620.029
Urban population	379.536	381.672	383.808	385.740	387.672	389.604	391.536	393.468	395.400	397.332	399.264

Currently, there are two regional sanitary landfills in Montenegro: one is in Podgorica (Livade landfill Podgorica, opened in 2007) and serves as a regional sanitary landfill for Podgorica, Cetinje and Danilovgrad, and the second one is near Bar (Možura Landfill Bar, opened in 2012) and serves as an inter-municipal sanitary landfill for Bar and Ulcinj. Since 2008, landfill gas has been flared at the landfill site Livade, at the so-called "torch". Landfill gas is a mixture of methane (CH_4) and carbon dioxide (CO_2), in which methane accounts for about 55% of the volume. According to data delivered by the landfill, 1,917,250 m^3 of landfill gas, i.e. 1,054,486 m^3 of methane was flared during the period 2008-2011 (Tables 3.34 and 3.35).

Table 3.34 Flared quantities of landfill gas during the period 2008-2011

Year	Quantities of flared landfill gas at the torch (m^3)
2008.	271.326
2009.	493.806
2010.	601.614
2011.	550.504
Total	1.917.250

Table 3.35 Flared quantities of methane during the period 2008-2011

Year	Flared CH_4 (m^3)	Flared CH_4 (kg)	Flared CH_4 (Gg)
2008.	149.229	107.146,4	0,107,146
2009.	271.593	195.003,8	0,195,004
2010.	330.887	237.576,9	0,237,577
2011.	302.777	217.393,9	0,217,394
Total	1.336.157	959.361	1

GHG Emissions

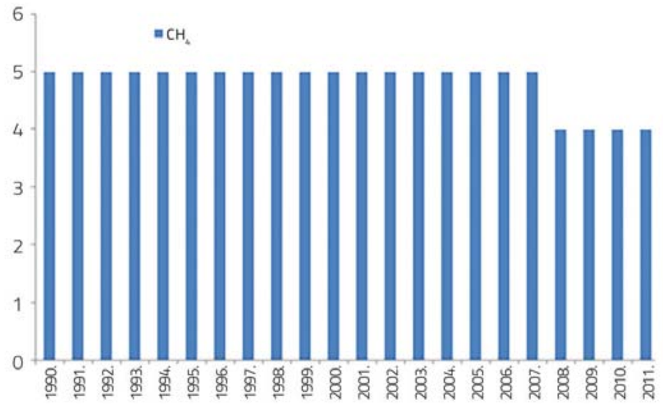
The estimate of direct GHG emissions in the waste sector in Montenegro for the period 1990-2011 was made in accordance with IPCC (1996) methodology and by using a Tier 1 approach.

The estimate of indirect GHG emissions was made in accordance with the EMEP/EEA Air Pollutant Emission Inventory Guidebook (2009).

Direct GHG Emissions

Table 3.36 Total CH_4 emissions from the waste sector, 1990-2011 (Gg)

Year	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
CH_4 emission (Gg)	5	5	5	5	5	5	5	5	5	5	5
Year	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
CH_4 emission (Gg)	5	5	5	5	5	5	5	4	4	4	4

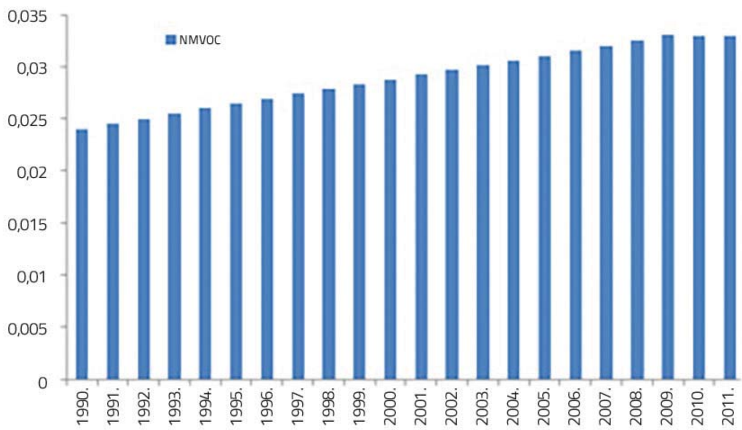


Graph 3.69 Total CH_4 emissions from the waste sector, 1990-2011 (Gg)

Indirect GHG Emissions

Table 3.37 Total NMVOC emissions from the waste sector, 1990-2011 (Gg)

Year	1990.	1991.	1992.	1993.	1994.	1995.	1996.	1997.	1998.	1999.	2000.
NMVOC emission (Gg)	0,024	0,024	0,025	0,025	0,026	0,026	0,027	0,027	0,028	0,028	0,029
Year	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
NMVOC emission (Gg)	0,029	0,030	0,030	0,031	0,031	0,032	0,032	0,033	0,033	0,033	0,033



Graph 3.70 Total NMVOC emissions from the waste sector, 1990-2011 (Gg)

3.4 Analysis of Key Categories for the Period 1990–2011

The identification of key categories was carried out in accordance with the Good Practice Guidelines (IPCC – GPG 2000) and by using a Tier 1 approach. According to UNFCCC recommendations for the calculation of key categories and the measurement of uncertainties, a software tool was used (EPA's Key Category Calculation Tool – USA).

Key categories are those that, summed up together in descending order by value, make up more than 95% of the total CO_2 equivalent emissions.

Table 3.17 shows the sum of 9 key categories that, during the observed period (2008-2011), represented 95% of all total national GHG emissions. According to the analysed key categories and when observed cumulatively, the combustion of lignite in the energy sector represented the largest share of all total emissions during the observed period (36%).

Table 3.38 Key categories of the GHG inventory, 2008-2011

Categories	Gas	Estimated CO_{2eq} (Gg) emissions for 1990	Estimated CO_{2eq} (Gg) emissions for 2011	Trend estimate	Cumulative share in total emissions (%)
1. Stationary sources - lignite combustion	CO_2	1.147	1.739	0,175	36
2. Aluminium production	PFC	2.077	589	0,153	31
3. Road transport	CO_2	327	502	0,051	11
4. Stationary sources- liquid fuel combustion	CO_2	314	3	0,039	8
5. Enteric fermentation	CH_4	349	160	0,015	3
6. Fuel combustion in industry and construction	CO_2	227	95	0,011	2
7. Manure management	CH_4	74	2	0,009	2
8. Fuel combustion - other	CO_2	178	164	0,008	1
9. Aluminium production	CO_2	189	151	0,004	1
Total					95

3.5 Uncertainty Calculations for the Period 1990-2011

The analysis of measurement uncertainty is one of the key activities carried out in the annual inventory of GHG emissions; it consists of identifying sources of uncertainty quantifying them. The purpose of estimating measurement uncertainty is not to deny the validity of the GHG emissions study, but rather to assist in improving the accuracy of calculations regarding GHG emissions. The identification of sources of uncertainty is the first step to assessing the uncertainty of a study. Often there is no complete information available, or the measurement cannot be repeated, so many calculations of measurement uncertainty provide the best estimate.

Estimates of measurement uncertainties relating to GHG emissions for the period 1990-2011 were made on the basis of an analysis of all typical available data for Montenegro. In cases where there was no national data, results from literature were used. First, the sources were identified, and then an assessment of measurement uncertainties was made for individual gases and sectors in the inventory of greenhouse gases. The assessment of measurement uncertainty was made for key sources of gases.

Identification and Quantification of Measurement Uncertainty

The analysis of measurement uncertainty for the Inventory of Greenhouse Gases in Montenegro is based on Tier 1 methodology as described in the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories and in Good Practice Guidance and Uncertainty Management in the National Greenhouse Gas Inventories; 1990 was taken as a baseline. The estimate of measurement uncertainty for an individual gas is the combination of information obtained from IPCC data and from information taken from national sources.

Measurement Uncertainty of Key Categories

The key categories of the national inventory contain 9 factors that generate more than 95% of all total GHG emissions. Therefore, special attention has been paid to the assessment of measurement uncertainty in key categories of the inventory (1991-2011). Estimates of measurement uncertainties have been made for emissions of individual gases and key categories.

1. The main factors that contribute to measurement uncertainty in determining CO_2 emissions from lignite combustion in stationary sources include the quantity of combusted lignite and the emission factor for CO_2. In Montenegro, lignite is produced in the coal mine at Pljevlja, and the measurement uncertainty of the quantities of lignite produced can be estimated based on data obtained from the mine; this represents the initial data used in the calculations for carbon dioxide emissions by combustion. The measurement uncertainty estimated in this manner equals 1%. The total measurement uncertainty of CO_2 emissions resulting from lignite combustion equals 7.1%.
2. The main factors contributing to measurement uncertainty when determining emissions of PFC (CF_4 and C_2F_6) gases from aluminium production are the volumes of aluminium produced and the measurement uncertainty of emission coefficients. Measurement uncertainty of aluminium related activities, based on the data obtained, is estimated at 2%. Measurement uncertainty for emission coefficients is 7.0% for CF_4 and 22.2% for C_2F_6 emissions. Therefore, the total estimated measurement uncertainty of PFC gas (CF_4 + C_2F_6) emissions is 7.0%. The measurement uncertainty of the emission factor is 7.3%.
3. The identified sources of measurement uncertainty for CO_2 emissions during the combustion of petrol and oil derivatives are the quantities of imported fuel and associated emission factors. The combined measurement uncertainty is 9.9% for CO_2 emissions from petrol; this is the same as for its emission value from oil derivatives.
4. CO_2 emissions from stationary sources and from the combustion of oil fuel, have an estimated combined measurement uncertainty of 9.9%. The combined measurement of uncertainty is obtained through measurement uncertainties for the activity and from the emission factor taken from scientific literature; this amounts to 7.0%.
5. The parameters that influence the measurement uncertainty of methane emissions from internal fermentation in domestic animals include the "correct" number of domestic animals and emission factors for different types, etc. The combined measurement uncertainty for methane emissions from the internal fermentation process in domestic animals is estimated at 58.3%.
6. The combined measurement uncertainty of CO_2 emissions in the subsector of fuel consumption in industry and construction, based on measurement uncertainty of the activity (7%) and uncertainty of emission factors (7 %), is 9.9%.
7. The combined measurement uncertainty of CH_4 emissions from manure management is 58.3%.
8. The combined measurement uncertainty of CO_2 emission from fuel combustion in other sectors is 9.9%.
9. The combined measurement uncertainty of CO_2 emissions from aluminium production is 9.9

Table 3.39 shows the estimated measurement uncertainties (without sinks) for key categories of GHG.

Table 3.39 Estimates of measurement uncertainties (without sinks) for key categories of GHG emissions (1990-2011)

Categories	Gas	Estimated CO_{2eq} (Gg) emissions for 1990	Estimated CO_{2eq} (Gg) emissions for 2011	Estimated uncertainty of activity (%)	Estimated uncertainty of emission factors (%)	Combined measurement uncertainty (%)
Stationary sources - lignite combustion	CO_2	1.147	1.739	1	7	7,1
Aluminium production	PFCs	2.077	589	2	7	7,3
Road transport	CO_2	327	502	7	7	9,9
Stationary sources - liquid fuel combustion	CO_2	314	3	7	7	9,9
Enteric fermentation	CH_4	349	160	50	30	58,3
Fuel combustion in industry and construction	CO_2	227	95	7	7	9,9
Manure management	CH_4	74	2	50	30	58,3
Fuel combustion-other	CO_2	178	164	7	7	9,9
Aluminium production	CO_2	189	151	7	7	9,9

The total measurement uncertainty of GHG emissions from the entire inventory is calculated according to Tier 1 methodology; for 2011 it is 8%. Measurement uncertainty for the period 1990-2011 is 4%.

3.6 Recommendations on How to Improve Estimates of Measurement Uncertainty and Inventory Verification

As noted above, the calculation of measurement uncertainties for GHG emissions of greenhouse gases was made according to the simplest Tier 1 methodology. Active input data obtained from various national sources was used for the calculation of combined measurement uncertainties, while the emission factors were taken from scientific literature.

In order to improve estimates of measurement uncertainty for GHG emissions, it is necessary to:

- Revise the data on activities,
- Calculate national emission coefficients, if possible,
- Change the calculation methodology to multiple Tier, i.e. do an estimate of measurement uncertainty by also using Tier 2 methodology, which is based on a simulation in Monte Carlo,
- Continue applying and working in accordance with quality assurance and quality control practices (QA/QC).

Calculations were only verified in the case of CO_2 for the energy sector and this was done by comparing the values obtained through reference and sectoral approaches. The values of emitted CO_2 obtained through these approaches differ by less than 3%, thus indicating that the calculations are reliable.

Literature:

- National Forest Inventory of Montenegro, 2010, Ministry of Agriculture and Rural Development
- Montenegro Energy Development Strategy until 2030, 2014, Ministry of Economy
- Waste Management Plan for Montenegro for the period 2008-2012, 2008, Government of Montenegro
- The Initial National Communication on Climate Change of Montenegro to the UNFCCC, 2010, Ministry of Spatial Planning and Environment
- Statistical Yearbooks (1990-2011), Statistical Office of Montenegro MONSTAT

4. VULNERABILITY AND ADAPTATION TO CLIMATE CHANGE

There are various definitions, opinions and interpretations regarding vulnerability to climate change, depending on what is deemed to be vulnerable and why. For example, IPCC treats vulnerability as the function of exposure of a system (geo-physical, biological, social and economic) to climate change, as well as its sensitivity or susceptibility to damage and its adaptive capacity, including the ability to recover from consequences.

This is why the term "vulnerability" can refer to the vulnerability of the system itself, for example due to the low level of islands or coastal towns; it can refer to influences on such systems - like the flooding of coastal areas and agricultural lands, forced migration; or it can refer to the mechanisms that cause such influences. Thus, the vulnerability of systems to climate change, variability and extremes, refers to their physical, social and economic prospects. Therefore we can say that greater levels of exposure or sensitivity cause greater levels of vulnerability. Adaptive capacity is inversely proportionate to vulnerability; the higher it is, the lower is vulnerability. Given such relationships, reducing vulnerability would include reducing exposure through the application of specific measures or would involve the strengthening of the adaptive capacity through activities closely related to the development priorities.

Thus, the key vulnerabilities are connected to numerous climate-sensitive systems, like food supply, infrastructure, health care, water resources, coastal systems, etc.

Seven recognized criteria that can be used for establishing the key vulnerabilities are:

1. size of impact (defined by proportion (e.g. the territory or the number of persons that might be affected) and intensity (level of caused damage), expressed in quantitative terms - in money or in the number of persons affected by, for example water shortages or diseases; or described in qualitative terms);
2. time of occurrence of the impact (the faster they are the more important they are);
3. sustainability and reversibility of impact (e.g. droughts and floods);
4. probability of impact and vulnerability and reliability of estimates;
5. ability to adapt (the lower the availability and feasibility is regarding efficient adaptation, the higher is the probability for such an impact to be characterized as "key vulnerability");
6. widespread views of impact and vulnerability;
7. importance of a vulnerable system (various societies and people can assess in different ways the importance that a particular impact and vulnerability have on human and natural systems (e.g. ecosystems with unique habitats of numerous endemic species or endangered species.

Although, for a long time, technical preparedness for hazards and climate impact has been considered important, over the last decades attention has focused more on vulnerability and particularly on the role that adaptation and disaster risk reduction play in reducing vulnerability to climate change, hazards and extreme events.

The chapter Vulnerability and Adaptation to Climate Change consists of 4 parts. The first part analyses the variability of climate and the changes observed in Montenegro up to 2010. In the second part this chapter analyses the vulnerability of Montenegro to climate change and extreme events. This is done using a set of indicators based on the impact of climate change (the so called impact indicators) and projections of extreme climate events using the EBU-POM model. The third part of this chapter uses the indicators of impact and future exposure to climate change and extreme events to analyse vulnerability on a sector by sector basis. Finally, the fourth part of this chapter proposes appropriate adaptation measures.

In the Initial National Communication to UNFCCC Montenegro tackled the issue of vulnerability and adaptation to the conditions of changes in climate. One of the goals of the Second Communication is to use modelling to get quantitative estimates of vulnerability; the focus, as defined by the Initial National Communication as priority areas, is on water resources, agriculture and forestry, public health and the coastal areas. It is important to note that the quantitative vulnerability assessments provided take into account the observed and projected changes in extreme weather and climate events; thus they ensure the availability of necessary information for opening a new chapter based on understanding and managing risks.

4.1 Variability of the Climate and of Climate Changes Observed up to 2010

The variability of climate and climate change have been analysed in line with the IPCC definitions provided in the boxes:

climate variability – the way in which the climate fluctuates (above or below climate normals) on all spatial and temporal scales beyond that of individual weather events. Such variability may be due to natural (internal and external) processes and anthropogenic factors;

climate change – changes in the average climate situation or its variability over a longer period of time (typically for several decades or more). Changes may be due to natural and anthropogenic factors (changes in the composition of the atmosphere or use of land).

Given the above definitions, we can say that the atmosphere and climate variability in Montenegro are usually affected by the following:

- North Atlantic Oscillation (NAO),
- Genoa cyclone and Siberian anticyclone,
- Air depressions in the Adriatic, cyclones with trajectory over the Adriatic or Mediterranean Sea and which are affected by the simultaneous presence of high pressure in North Africa,
- Influence of El Niño, in situations where it is fully developed, and
- Influence of atmospheric blocking systems.

Monitoring and evaluation of climate shows that the Montenegrin climate has changed due to global climate changes and variability. The clearest indicators include: a significant increase in air temperature, an increase in both surface and mean sea level temperatures, and changes in extreme weather and climatic events.

Since climate change refers to long-term consecutive changes (increase or decrease) of average atmospheric conditions and since one of the clearest signals of the climate change is a change in air temperature, this analysis covers:

- changes in annual temperature during the period 1951–2012;
- mean decadal values of annual air temperature;
- mean values for the period 1961–1990, and
- decadal deviations (Δ) from the climate normals.

Due to the fact that they belong to different climatic zones, the analysis selected 4 representative municipalities in Montenegro (Žabljak, Pljevlja, Podgorica and Bar). The quality of data was also taken into account when making this choice.

Table 4.1 Mean annual air temperature for 4 municipalities that represent different climate types

	Climate normal	DECADE						
REGIONS	1961-1990[8]		'61–'70.	'71–'80.	'81–'90.	'91–'00.	'01–'10.	Δ
Municipality of Žabljak	DECADE	5,1	4,7	4,5	4,7	5,4	6,0	+1,4
Municipality of Pljevlja	8,1	8,6	8,1	7,9	8,2	8,8	9,1	+1,0
Municipality of Podgorica	15,3	15,5	15,4	15,0	15,4	15,8	16,3	+1,0
Municipality of Bar	15,5	15,7	15,7	15,3	15,6	15,9	16,8	+1,3

(Δ - deviations of annual temperature from climatic normals during 2001–2010)

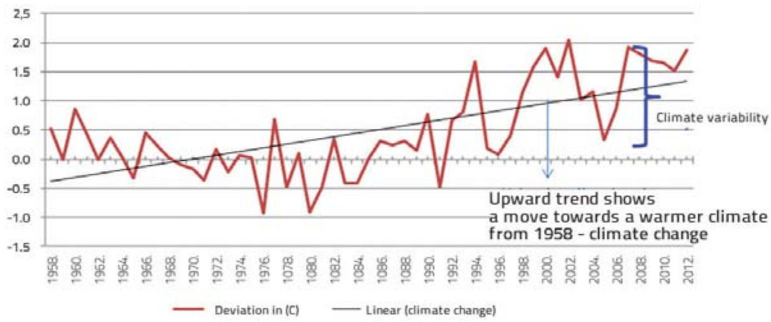
8 The period 1961-1990 presents climate normals against which climate changes are observed. The period was selected by WMO and refers to the climate as described by the mean values provided by the meteorological office and collected over a 30-year period. At the end of 2020 the period 1991-2020 will be used as the next baseline period in place of the current one. More information on the selection of the baseline period can be found on the WMO website: http://www.wmo.int/pages/themes/climate/statistical_depictions_of_climate.php

The results presented in Table 4.1 show:

- mild cooling during 1971–1980;
- changes toward a warmer climate since the 1990s (particularly noticable in the northern mountainous region);
- the 2001–2010 decade was the warmest since records began (49/51),
- the most prominent changes were in the northern mountainous region of +1.40C and in the coastal region of +1.30C during the period 2001–2010.

In the graph below, to portray the results visually, we presented deviations from the mean annual air temperature in Žabljak during the period 1958–2012 in comparison with the period 1961–1990 and explained both the variability and the climate changes (Graph 4.1).

This part of the northern mountainous region is 1,450m above sea-level. It was selected because its climate interestingly showed the largest changes in annual temperature including the largest levels of snow drifting (Debelog Nameta) in the Durmitor National Park; this area is being studied as a possible endangered system. The graph shows that variability has increased since the beginning of the 1990s.



Graph 4.1 Deviations of the Žabljak mean annual air temperature from climate normals

Regarding precipitation, as described in the Initial National Communication of Montenegro to UNFCCC:

- there has been no significant reduction in the total level of annual precipitation;
- the precipitation levels have increased during the autumn and have fallen during the spring, summer and winter but have remained within normal ranges;
- statistically speaking, there has been a significant increase in the quantity of precipitation in September in the Zeta-Bjelopavlići region.

Generally speaking, these changes show changes in precipitation that are becoming more extreme. Table 4.2 offers the following conclusions:

- figures recorded between 2001–2010 break existing records for mean annual precipitation recorded between 1971–1980 in the northern-mountainous region (up to 1,000m above sea-level) and in the coastal region,
- In 2010 the highest level of annual precipitation was recorded in the northern-mountainous region of Zeta-Bjelopavlići (over 1,000m).

Table 4.2 Decadal annual quantity of precipitation (mm)

	Climate normal	DECADE						
REGIONS	1961–1990.	‘51–’60.	‘61–’70.	‘71–’80.	‘81–’90.	‘91–’00.	‘01–’10.	Δ
Municipality of Žabljak	1.455,4	-	1.514,2	1.564,4	1.287,5	1.370,1	1.610,6	+155,2
Municipality of Pljevlja	796,5	735,7	783,8	865,4	740,4	733	839,86	+43,4
Municipality of Podgorica	1.657,9	1.632,1	1.756,7	1.695,2	1.521,7	1.593,7	1.781,6	+123,7
Municipality of Bar	1.390,9	1.414,1	1.473,2	1.480,5	1.218,9	1.241,9	1.463,9	+73

(Δ - deviations of annual precipitation levels from climate normals 2001-2010)

According to data available from IHSM for the period 1980-2012, the station in Bar recorded that the surface sea temperature and the mean sea level during the period 1965-2011 were as follows:

- surface sea temperature increased by about + 0.02°C a year;
- decade after decade temperatures are higher, and the highest levels were recorded during the last decade with an average temperature of 18.3°C (Table 4.3);
- the sea level is rising with minor year-to-year changes evident during the first decade of the 21st century.

Table 4.3 Decadal values of annual sea surface temperature in Bar

Decade	Sea surface temperature (°C)
1981–1990.	17,9
1991–2000.	18,1
2001–2010.	18,3

A more detailed analysis of the changes in the sea surface temperature and its level, due to climate changes and variability, was conducted within the CAMP project (Coastal Area Management Programme). This segment of the project revealed the following serious issues:

- problematic quality of meteorological and hydrographic data;
- poor availability of data sets, and
- the observance network in the coastal area does not provide sufficient coverage and thus provides a poor basis for the assessment of current and future changes in the sea level.

Climate changes and variability affect the frequency and intensity of many types of extreme events like heat waves, droughts, storms, and floods and also influence many other hazards (e.g. landslides, forest fires) that are not directly linked to weather conditions. It is worth noting that the consequences of climate change have been visible in the recent past in the territory of Montenegro and that they have led to heavy and destructive floods that have affected the territory of 12 municipalities (Podgorica - town municipalities Golubovci and Tuzi, Ulcinj, Bar, Cetinje, Nikšić, Danilovgrad, Bijelo Polje, Berane, Plav, Andrijevica, Kolašin and Mojkovac) in 2010 (January, November and December 2010). The consequences of extreme meteorological events - in the form of heavy snowfalls- were recorded in February 2012. This led to the state of emergency being proclaimed in Montenegro at the time.

On a global level, extreme weather and climate events were particularly frequent and intensive during the last decade of the 21st century. Therefore, the World Meteorological Organization (WMO) named the period 2001 - 2010 as the decade of climate extremes.

The WMO report says that the 2001-2010 decade was not only the warmest decade since modern records began (in 1850), but that, on a global level, it was a characteristic trend as precipitation was above average, including the annual precipitation recorded in 2010 which exceeded records for all other years. The situation recorded in Montenegro was almost the same.

It is considered that many of the events and trends of the last decade can be explained by natural climate variability and an increasing concentration of the greenhouse gases; the key challenge is to identify the roles played by climate variability and individual anthropogenic factors within climate change.

4.2 Analysis of the Extreme Events Observed by 2010

Climate change is expected to increase the frequency and intensity of many types of extreme events, including floods, droughts, forest fires, storms (i.e. very strong cyclones), storm winds, etc. as well as the nature of many hazards that are not directly related to weather conditions (e.g. landslides).

A decadal climate picture has been used to assess climate trends and to warn of future climatic changes. All efforts are being made to develop operational climate services to help with decision making regarding agriculture, health, risk reduction, water resources and other sectors, as started in the previous decades. The coordination of such services is currently being worked on by the Global Framework for Climate Services of the World Meteorological Organization (WMO Report).

An intergovernmental panel for climate change published a detailed assessment of increases in the frequency of extreme events in 2011; it emphasised that fast action is required to reduce GHG emissions and that adaption measures relating to changes in climate should be applied quickly.

The climate has been analysed on a decade by decade basis. Table 7.8 presents a summary of the extreme events that have been observed over the last 15 years in Montenegro and in parallel with that it presents projections according to the EBU-POM regional model. One thing that can immediately be noticed is that there is a good level of correlation between the trends of the observed and of the projected climate changes.

4.2.1 Maximum Daily Temperatures (absolute records)

According to WMO climate status reports, 44% states reported that their highest observed temperatures occurred during the period 1961-2010, and that these were registered during the last decade. The WMO report shows that the influence of a human factor probably contributed to the increase in the maximum daily temperatures of the warmest days and nights as well as to the minimum temperatures of the cold days and nights, all of which reached their most extreme values in the last decade.

The decadal presentation of maximum temperatures in Table 5 shows that in Montenegro:

- highest recorded maximum temperatures were recorded during between 2001-2010 in the region of Zeta-Bjelopavlići and in the northern mountainous region;
- slightly higher maximum temperatures were recorded in the northern mountainous region of up to 1,000m above sea-level between 1991–2000;
- in the coastal region the highest maximum temperatures were recorded between 1981–1990

Table 4.4 Decadal records of the highest maximum air temperatures during the period 1951–2010

	DECADES					
REGIONS	'51–'60.	'61–'70.	'71–'80.	'81–'90.	'91–'00.	'01–'10.
Municipality of Žabljak		30,4	28,2	30,6	31,3	32,4
Municipality of Pljevlja	38,0	35,0	33,2	36,2	38,2	38,1
Municipality of Podgorica	41,2	40,6	39,2	41,4	41,6	44,8
Municipality of Bar	35,4	35,9	36,8	37,7	37,0	36,6

4.2.2 Minimum Daily Temperatures (absolute records)

Results presented in Table 4.5. show:

- that there was a difference between the regions regarding the lowest minimum temperatures - mostly, they were observed during the periods 1951- 1960 and 1961-1970;
- that there was an increase in minimum temperatures during 1991-2000 except in the coastal region;
- that in all regions in Montenegro the lowest minimum temperatures increased the most during the last decade with the exception of the northern mountainous region (above 1,000m);
- that there was an increase of about +3°C to + 6°C in the lowest minimum temperatures during the last decade compared with the lowest values recorded between 1951-1960 and 1961 - 1970.

Table 4.5 Decadal records of the lowest minimum air temperatures during the period 1951–2010

	DECADE					
REGIONS	'51–'60.	'61–'70.	'71–'80.	'81–'90.	'91–'00.	'01–'10.
Municipality of Žabljak		-26,4	-22,7	-26,4	-25,7	-24,6
Municipality of Pljevlja	-29,4	-29,0	-27,0	-29,2	-26,7	-23,5
Municipality of Podgorica	-9,7	-9,2	-8,5	-9,6	-8,4	-6,7
Municipality of Bar	-7,0	-7,2	-4,9	-4,4	-5,3	-4,3

4.2.3 Maximum Daily Precipitation (absolute records)

Results presented in Table 4.6 show:

- that the recorded daily amounts of precipitation in the largest part of Montenegro were registered between 1981-1990;
- that the exception is the northern mountainous region (above 1,000m above sea-level), where the record values were recorded between 1961-1970;
- that in the coastal region and in the Zeta-Bjelopavlići region the second decade by the extreme amount of precipitation was the one 2001-2010;

Table 4.6 Decadal records of the highest maximum daily precipitation during the period 1951–2010

	DECADE					
REGIONS	'51–'60.	'61–'70.	'71–'80.	'81–'90.	'91–'00.	'01–'10.
Municipality of Žabljak		207,4	146,5	122,6	144,2	141,3
Municipality of Pljevlja	55,5	79,4	90,2	123,5	77,9	81,1
Municipality of Podgorica	128,4	128,2	133,7	226,8	108,4	145,9
Municipality of Bar	180,8	135,4	157,1	224,0	124,2	200,7

According to available data, i.e. a number of cases from the time records started in 1949 (in some stations in 1958) until today, it is obvious that extreme heat has become more frequent since 1998 and that the heat is particularly strong in August when it also lasts the longest.

Table 4.7 Summary presentation of the observed and projected changes of extreme events in relation to the climate normals (1951–2010) – Source: IHSM observations and results from the EBU-POM regional climate model

Existing situation – observed extreme events

1. more frequent extremely high maximum and minimum temperatures;
2. more frequent and longer heat waves;
3. a larger number of very hot days and nights;
4. a smaller number of days with frost and very cold days and nights
5. more frequent droughts;
6. higher number of forest fires;
7. interruption of dry periods followed by strong precipitation;
8. more frequent storms (cyclones) during the colder half of the year;
9. a decrease in the number of consecutive rainy days
10. a decrease in the number of days with heavy precipitation;
11. an increase in the intensity of precipitation
12. a decrease in the overall annual amount of snow

Projected extreme events according to the regional EBU-POM climate model

Index/variable	Expected qualitative change	Quantitative change			
		Unit of change	A1B 2001–2030.	A1B 2071–2100.	A2 2071–2100.
Number of frosty days	*Decrease in all locations*	days/year	-1 to -16	-5 to -43	-6 to -61
Last spring frost	*Move towards the beginning of the year*	days/year	-0,6 to -13	-13 to -30	-19 to -36
First autumn frost	*Moving towards the end of the year*	days/year	0 to 9	5 to 22	8,9 to 28
Number of very hot days	*Significant increase throughout the year even several times by the end of the 21st century*	days/year	33 to 48	110 to 182	144 to 239
Average length of heat waves	*Extension in all locations*	days/year	0,5 to 2	2 to 9	4 to 15
Frequency of heat waves	*Significant increase in all locations*	days/year	2 to 3,8	7 to 10	9 to 10
Length of the vegetation period	*Extension*	days/year	0 to 16	3 to 56	3 to 70
Number of consecutive days without rain	*Increase*	days/year	1 to 5	3 to 6	5 to 7
Number of consecutive days with rain	*Decrease*	days/year	0,5 to -0,7	-0,2 to -2	-0,1 to -2,4
Number of days with pre-cipitation of over 20mm	*Decrease*	days/year	0 to -3,6	-0,5 to -10	0 to -7
Average intensity of precipitation in days with over 20mm	*Mostly increase*	mm/day	0,9 to 4,1	-2,4 to 1,3	0,9 to 4,7
Annual accumulated snow	*Decrease, more significant in the northern regions*	%	-25	-50	-50
Mean maximum daily wind speed	*Decrease on an annual level.*	%	-5	-5	-5
	Increase on the level of season and in the south-east part of Montenegro during the summer season	%	+2	+2	+3

4.2.4 Droughts

Before the 2012 IPA project Drought Management Centre for South East Europe, DMCC, co-financed by the European Commission, Montenegro had not carried out any established permanent drought monitoring. This project brought to:

- homogenization of data on precipitation;
- development of an archive on drought impact since 2000;
- establishment of permanent drought monitoring through SPI[9] index;
- testing of the application of WINISAREG model for irrigation planning;
- testing of the application for remote drought monitoring (i.e. satellite model),
- development of a Montenegrin drought vulnerability map.

Since the region of the Southeast Europe is a region vulnerable to droughts and since Montenegro is not an exception in that respect, this report shows typical drought years by decades in chronological order (Table 4.8). The results in Table 4.8 show that droughts have been more frequent since the period 1981-1990.

Table 4.8 Typical drought years in Montenegro by decade

'51–'60.	'61–'70.	'71–'80.	'81–'90.	'91–'00.	'01–'10.
1953.	1962, 1967, 1969.	1978.	1981, 1982, 1985, 1988, 1989.	1993, 1994, 1996, 1999.	2003, 2007, 2008, 2011.

The 2003 drought evolved to the level of an agricultural drought which most severely affected the following: • coastal region, Zeta-Bjelopavlići plain and the northern mountainous region up to 1,000m above sea-level
The 2007 drought lasted a long time and evolved not only to the level of an agricultural drought but also to the level of hydrological drought and most severely affected the following: • all regions of Montenegro bust most particularly the karst regions in the North-west and the northern mountainous region
The 2011 meteorological drought also lasted for a long time and evolved not only to the level of an agricultural and hydrological drought but also to the level of a social and economic drought and most severely affected the following: • all regions of Montenegro, most specifically resulting in an extreme hydrological deficit in the region of Zeta-Bjelopavlići in November, • the meteorological and hydrological conditions present were ideal for the occurrence of forest fires of large proportions; these did occur in 2012 and included human victims.

9 SPI – Standardized Precipitation Index

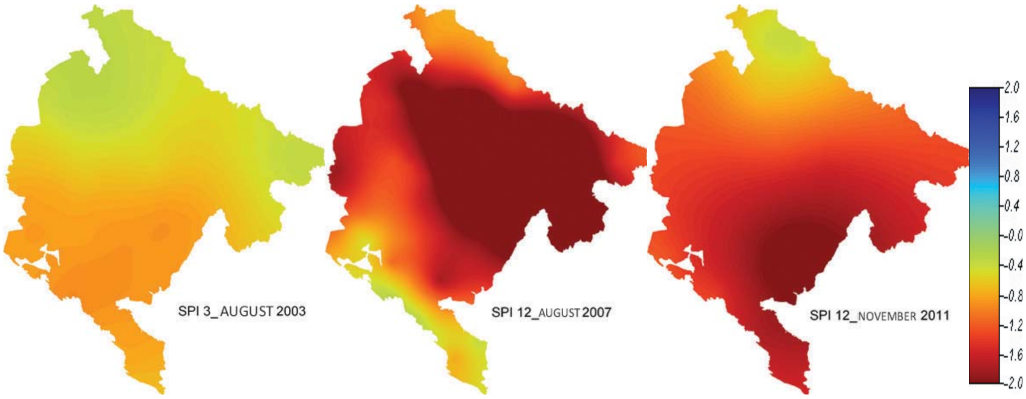
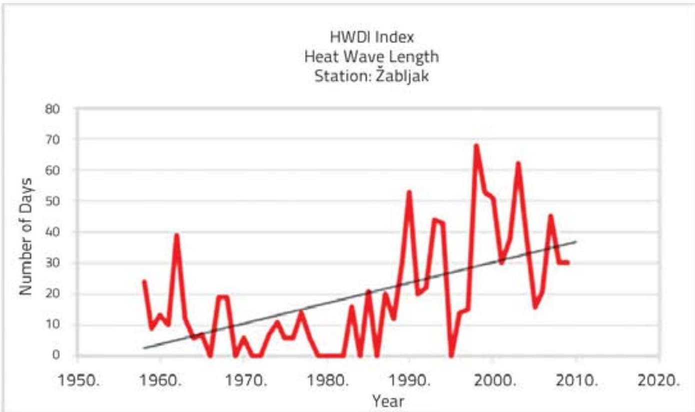


Figure 4.1 Map of Drought Intensity 2003, 2007 and 2011 expressed through anomalies of the SPI index: SPI3 – agricultural drought 2003, SPI12 – hydrological drought 2007 and 2011.

4.2.5 Heat Waves

The monitoring and evaluation of the climate in Montenegro shows that heat waves are increasingly frequent and their length shows a high year-to-year variability. From a long-term perspective, there is a trend of continuous increases in the length of heat waves. The figure below shows the situation in the station in Žabljak. It is particularly interesting since it is located in the northern mountainous region of Montenegro at a level of 1,450 m above sea-level and has a predominantly snow-forest climate.



Graph 4.2 Annual variability in the length of heat waves at the Žabljak station

Analyses for Montenegro have shown that long heat waves predominate in August, while in June and July Montenegro experiences more frequent but shorter heat waves.

Frequent long heat waves have contributed to a higher frequency of extreme temperatures and a warmer climate in Montenegro.

4.2.6 Heavy Rains

Heavy rains can also occur within a well-developed cyclone (so called storm) or as a consequence of strong local air instability.

Heavy rains that lead to floods most frequently affect the Tara and Lim areas during their seasons of colder weather (October-March). During that period the area of low air pressure develops in the coastal region of

Montenegro and has a wide impact causing maximum precipitation in the southern areas. In the karst areas, during spring, there are periodic floods due to longer periods of precipitation, melting snow and reserves of water in the ground. Such floods have hit the Cetinje plain several times and have caused serious damage to the buildings there.

Research within the CAMP project used observed data and data on the damage caused by storms, to show that the storms (strongly developed cyclones) have become more frequent and more intensive since 1998, bringing with them huge amounts of precipitation, storm to hurricane gusts of wind, high waves and flooding in significant areas along the coast.

Series of cyclones and local instabilities were registered between 2001-2010. They came together with strong rains, floods, snow precipitation and storm winds.

The results presented in Table 4.9. show that:

- the intensity of heavy precipitation showed decadal variability except for in the northern mountainous region above 1,000 m above sea-level, where it was recorded as increasing over the last two decades;
- the heaviest precipitation was recorded between 2001-2010 on the coast and in the Zeta-Bjelopavlići region, as well as in the northern mountainous region up to 1,000 m above sea-level, where records showed similar intensity as during the period 1981-1990;
- long term changes in relation to climate normals are positive and are in line with the qualitative changes predicted in the EBU-POM model.

Table 4.9 Average intensity of precipitation on the days with heavy precipitation.[10]

	Climate normal	DECADE					
REGIONS	1961–1990.	'51–'60.	'61–'70.	'71–'80.	'81–'90.	'91–'00.	'01–'10.
Municipality of Žabljak	37,4	38,9		39,3	36,5	37,3	38,2
Municipality of Pljevlja	29,2	30,7	27,1	29,9	29,4	30,9	29,1
Municipality of Podgorica	39,8	50,0	34,6	38,1	39,7	41,6	40,1
Municipality of Bar	38,8	63,3	36,7	38,6	39,3	38	37,1

The WMO report states that it is probable that climate change has influenced the occurrence and the intensity of extreme amounts of precipitation and the acceleration of the hydrological cycle, which is reflected in both heavy precipitation and by the evaporation of snow cover.

In the mountainous regions, over time, the overall amount of snow cover will decrease in relation to climate normals. Variability was particularly prominent on a year-to-year basis during the 2001-2010 decade where more frequent extreme snowfalls were recorded both in higher and in lower regions.

According to Table 4.10:

- in the northern mountainous region the annual amount of the snow cover has decreased in relation to climate normals since 1971-1980;
- there was an obvious impact resulting from the extreme snow falls during the period 2001-2010 and this affected the total annual amount of snow cover in the northern mountainous region
- in the Zeta-Bjelopavlići region the total annual snow cover decreased on a year-to-year basis in relation to climate normals over the last two decades. The impact of extreme precipitation during the period 2001-2010 increased the overall annual snow cover which was still almost 2 times lower than usual.

10 Heavy precipitation - precipitation in the amount of more than 20 mm/day
* Influence of the extremes in 2003, 2005 and 2006 on the overall annual amount of snow cover.

Table 4.10 Annual amount of the snow cover (cm)

	Climate normal	DECADE					
REGIONS	**1961–1990.**	**'51–'60.**	**'61–'70.**	**'71–'80.**	**'81–'90.**	**'91–'00.**	**'01–'10.**
Municipality of Žabljak	8.707		10.025	7.901	8.194	6.400	6.642*
Municipality of Pljevlja	790	940	876	755	723	706	800*
Municipality of Podgorica	31	59	24	30	39	7	14*
Municipality of Bar	-	-	-	1	2	2	0

4.3 Vulnerability of Montenegro to Climate Change and Climate Extremes

This chapter uses indicators to describe the state of the Montenegrin climate and the impact of its changes on various natural and social systems which are exposed to it. The use of indicators provides us with an insight into the character, scope and level of climate change, including the variability of the climate and the extremes of climate that the social system is exposed to, its sensitivity and adaptability. Thus, indicators can be helpful in assessing the vulnerability of both natural and social systems to climate change, the variability of the climate and climate extremes, as well as the process of developing adaptation measures.

The indicators have been grouped into 6 different categories as follows:

1. atmosphere and climate (e.g. increase in air temperature, reduction in the number of days with frost, reduction in the amount of precipitation, reduction in snow cover);
2. coast and the coastal region (e.g. increase in the sea surface temperature, rising sea level);
3. water resources (e.g. river flow);
4. agriculture (e.g. productivity of plants due to temperature increase);
5. forestry (e.g. development of different pests and diseases due to increases in temperature and reduction in the amount of precipitation, index of distribution of forest tree types);
6. health (e.g. more frequent heat waves, floods, respiratory tract allergies caused by pollen particularly in children, more frequent cardiac arrests and strokes during periods of low air pressure, large fluctuations of temperatures and sultry days).

These impact indicators have been selected due to the following reasons: they are measurable; they have causal links with climate change; they are politically relevant/applicable due to the length of their sequence and their transparency since they are easily understood.

An observed increase in mean air temperature, particularly during the last decade, is one of the clearest indicators of global climate change. Consequences of increases in temperature include the increased risk of floods and droughts, the loss of biodiversity, the withdrawal of glaciers, as well as an impact on human health. In addition to this, the increase in temperature can have a negative impact on the economy, e.g. forestry, agriculture, tourism and insurance companies. Some sectors like forestry or tourism can sometimes even benefit from more favourable life conditions, but it all ultimately depends on location.

Changes in the mean values of precipitation parameters can have far-reaching consequences for ecosystems and biodiversity, food production, the water industry and rivers. Changes in the precipitation regime during the period of a year can lead to more frequent flooding in certain areas and seasons and to more droughts in others, or to more landslides and land erosion. Floods and droughts can also exist in the same area in different seasons (e.g. a region can be exposed to droughts in spring and summer and yet be flooded in the autumn). Projections of future precipitation levels are largely uncertain, particularly due to different regional characteristics and seasonal distributions.

Snow cover influences river drain, vegetation (through thermal insulation) and wild life. The withdrawal of snow has had an unfavourable influence on snow sports and winter tourism, as well as on the output of hydropower plants that use melted snow. Conversely, the withdrawal of snow cover could reduce complications related to the maintenance of roads and the railway and could thus improve matters concerning transport.

Extreme levels of snow cover and frequent occurrences of its fast formation in the northern areas and higher southern areas of Montenegro have led to long term interruptions of transport operations on many roads and have caused links with many villages to be completely broken, most specifically with towns such as Šavnik and Žabljak. Combined with windstorms, huge snowdrifts have formed and these are difficult to remove to make roads operational. Snow avalanches also play an important role in steep mountainous areas where certain key Montenegrin roads are located.

Since many sectors show high levels of vulnerability to situations concerning extreme events (IPCC, 2012), this chapter offers an assessment of the possible changes which could occur due to extreme events in Montenegro. This assessment has taken into account the fact that observations have already provided us with an awareness of clear and significant trends in the changes of frequency and intensity of certain extreme events.

This part of the chapter focuses on vulnerability to climate and water extremes and their negative consequences for human safety and sustainable development. Vulnerability is treated in line with the IPCC definition, i.e. as a function of exposure, sensitivity and adaptation capacity.

4.3.1 Climate Extreme Scenarios

Methodology

A typical breakdown of the Atmospheric-Oceanic General Circulation Model (AOGCM) used today for studying climate and climate change ranges from 100 to 200 km. Models demonstrating this breakdown show satisfactory success levels in simulating observed climate conditions by using both planetary and continental proportions and by using an increase in the mean global temperature, as observed over the last decades and as conditioned by the anthropogenic emission of greenhouse gases.

Conversely, some local climate characteristics specific to certain regions depend to a large extent on their local physical features such as complex orthography or land and vegetation types, as well as on their distribution, their relationship between land and sea etc. This is also typical for Montenegro. Most of these local characteristics cannot be well presented in global models, since the proportions of the local features within a specific area are frequently several times smaller than is the distribution of the global model of ~100 km.

Most of the models used for studying the impact of climate change on certain society segments, economy or ecosystems (the so called impact models) assume input parametres at a much "higher" level of breakdown (usually 10 km or several km) than does the typical breakdown of the global model. As a consequence, the results of the global models have to be modified to scale results in order to obtain satisfactory information on proportions that are evidently much lower than those of the global model. The two most widely used methods are the statistical method and the dynamic method. The dynamic downscaling method requires the introduction of a Regional Climate Model - RCM of high resolution that uses the results of the global model as the side marginal conditions, producing through its own integration the results of the breakdown at a level of 10 km of the selected area. Figure 4.2. shows the schematic presentation of the regionalization process.

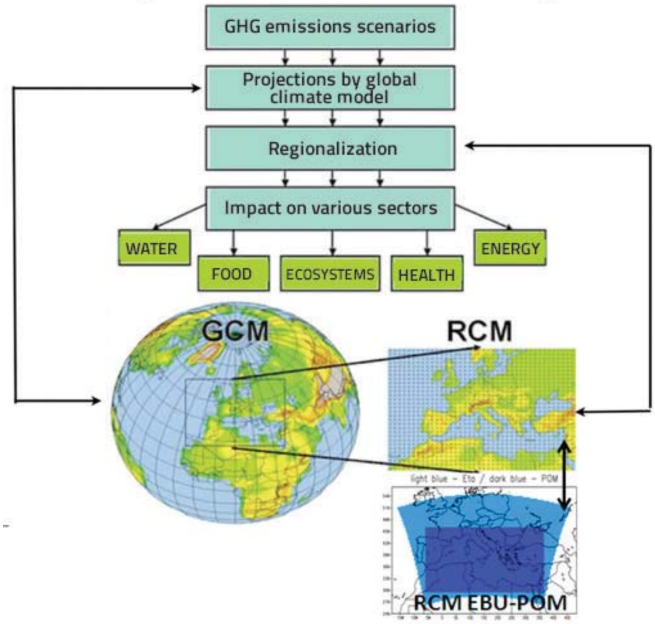


Figure 4.2 The schematic presentation of the process of regionalisation of climate change scenarios

Estimating future changes in extreme events in a changed climate is very difficult. This is primarily due to the high level of vulnerability of sectors to changes resulting from these events, but also due to the specific features of the measures of adaptation to these phenomena. Therefore the World Meteorological Organization (WMO, 2009) has given recommendations for monitoring and for the identification of changes regarding extreme weather and climate events.

During the second half of the 20th century we observed changes in the frequency and features of extreme weather and climate events. These extreme events cannot be attributed to long-term climate change but through climate models they can provide us with an idea of what the future might look like. According to the climate models, namely, the frequency and intensity of extreme events will most likely increase as a result of climate change; further changes are likely to happen in this century.

In order to monitor and evaluate the climate in Montenegro and to analyse the extremes, 5 climate indices for air temperature and 3 for precipitation have been selected from the set of climate indices. These are: the number of frosty days, the date of the last day with frost (in the first half of the year) and the date of the first day with frost (in the second half of the year), the number of very warm days, the length of heat waves and the length of vegetation periods, the number of consecutive days without rain, the number of consecutive days with rain and the number of days with heavy precipitation (more than 20 mm).

These indices have been analysed within the conditions of a normal climate (the climate of 1961-1990 is considered normal) and within the conditions of a projected climate, as shown in scenarios A1B and A2 during the periods 2001–2030 and 2071–2100. The regional climate model EBU-POM was used for such calculations. Its results were also used during the process to develop the Initial National Communication on Climate Change of Montenegro to the UNFCCC.

In addition to these 8 indices, changes in the overall annual amount of snow and changes in the mean daily maximum wind speed were also analysed. These changes were calculated from the results of the direct outputs of the EBU-POM model and are expressed in percentages in relation to the baseline period 1961–1990.

Model

EBU-POM is the regional climate model. It is a system of two connected regional models, one for the atmosphere and one for the ocean.

Due to the complexity of the climate system, all climate models, including EBU-POM contain a certain level of approximation regarding various geophysical processes; due to this the model results contain certain errors/deviations from observed conditions. These deviations from the model are verified through the simulation of existing climate conditions for the period deemed as being climate normal (1961-1990). This method of quintiles was applied to achieve a significant reduction in the number of errors. It ensures that results are adjusted and that meteorological stations are selected on the basis of the quality of the observed data, and on the completeness of their sequence and spatial distribution (Figure 2.2). Thus, 9 meteorological stations have been selected: Bar, Herceg Novi, Kolašin, Nikšić, Pljevlja, Podgorica, Ulcinj and Žabljak, as well as the station in Bijelo Polje in order to ensure completeness of the sequence and due to its geographic position, although it works according to a lower level of the work programme (Figure 2.2). The measurements and observations in all of these stations are continuous.

Presumptions

The key presumption is based on various long-term trends in the greenhouse gas emissions that actually result from various economic and demographic trends and from various interests related to sustainability.

According to the special IPCC report on the emission scenarios, the so-called SRES scenarios, four groups of scenarios were identified: A1, B1, A2 and B2. Each of these includes appropriate descriptive parts of the scenarios. This report focuses on the results obtained from the experiments/scenarios A1B and A2 that, based on the concentration of greenhouse gasses, have been defined as “medium” or “high” scenarios.

Thus, the medium scenario A1B presumes a balanced combination of technology and the use of basic resources with technological improvements to avoid the use of only one energy source. The presumption is that the greenhouse gas emissions will range from very intensive carbon emissions to the possible decarbonisation of emissions, at least to the extent to which other factors affecting this SRES scenario are variable.

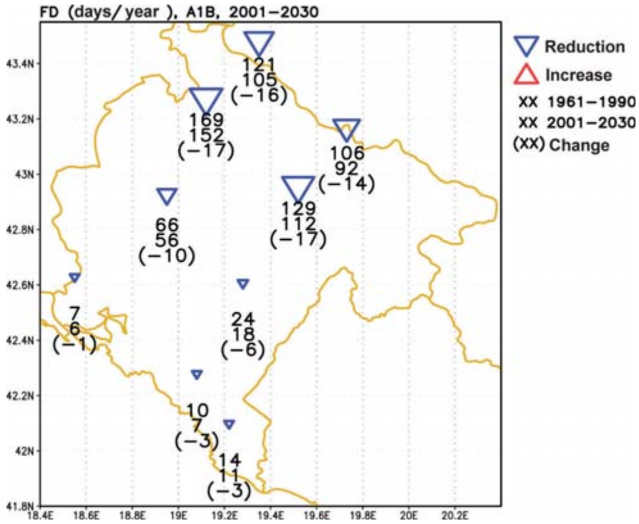
The high A2 scenario assumes a very heterogeneous society that relies on local resources and on the preservation of the identity of local communities. Due to a very slow enlargement of material goods and even regional distribution, a significant increase in population would be expected in such a scenario. Economic development would be primarily regionally orientated, while technological exchanges would be much slower and more locally oriented than in other scenarios.

Results of the Model

Days with Frost (Index of the number of frosty days -FD)

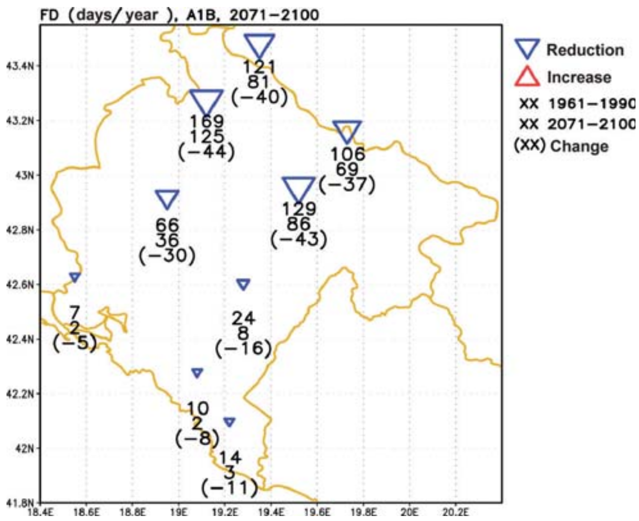
As a phenomenon related to temperature, frost is a good indicator for the frequency of extreme cold. However, there is a large spatial volatility connected to this phenomenon.

Projections of the EBU-POM model show that the number of frosty days will reduce in the future. In the A1B scenario (2001-2030) this reduction ranges from 1-3 days in the coastal region to 17 days in the high mountainous region in the north.



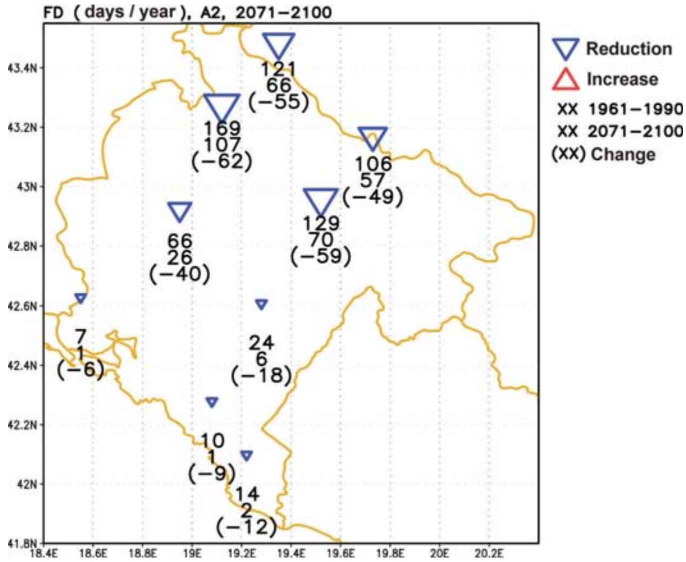
Graph 4.3 Mean annual value of the FD index, for the period 1961–1990, and for scenario A1B for the period 2001-2030 with changes in this index compared to the period 1961–1990

During the period 2071–2100, the number of frosty days will continue to decrease, on average by as many as 5-10 days on the coast and by 30, even 44 days in the northern mountainous region.



Graph 4.4 Mean annual value of the FD index for the period 1961–1990 and for scenario A1B for the period 2071–2100 with changes in this index compared to the period 1961–1990.

The largest changes can be observed in scenario A2. This is expected since this scenario is more "aggressive" than A1B in terms of increases in the concentration of greenhouse gasses and also in terms of temperature increases. On the coast the number of frosty days on average is one per year, while the number of frosty days in the northern mountainous region could reduce by up to 62 days.



Graph 4.5 Mean annual value of the FD index for the period 1961–1990 and for scenario A2 for the period 2071–2100 with changes in this index compared to the period 1961–1990

Duration of Frosty Periods

Predictions say that the frosty periods will gradually reduce to a certain degree depending on the analysed scenario and time period. This means that the last frost (the spring frost) will tend to move towards the beginning of the year, while the first frost (the autumn frost) will tend to move towards the end of the year. Therefore in the future we can expect to have longer periods without any frost.

Thus, for scenario A1B, during the period 2001-2030 the spring frost will be 1-13 days shorter in comparison to the climate normal, while the autumn frost will be 3-10 days shorter. The largest shift of the first frost towards the end of the year will happen on the Zeta-Bjelopavlići plain and the south eastern coastal region, while it will be less noticable in the areas that are more northern and are at a higher altitude above sea-level. However, in the northern mountainous regions the shift of the spring frost towards the beginning of the year is expected to be the greatest.

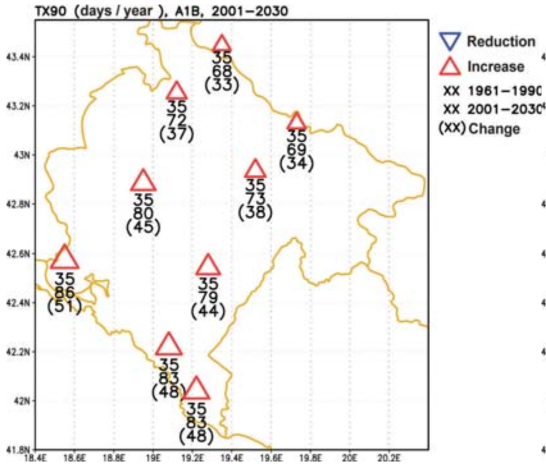
During the period 2071 - 2100, according to the conditions of the A1B scenario, the spring frost will end about 20 days earlier in the northern mountainous regions, and about 13-18 days earlier in the central regions. It will last the shortest time on the coast.

The shortest spring frost during the defined time period occurs in scenario A2, according to which the spring frost will move towards the beginning of the year by about 17-23 days in the northern regions and by about 37 days on the coast.

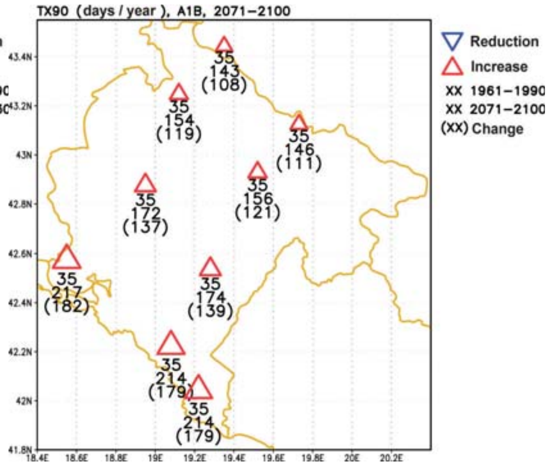
The difference between scenarios A1B and A2 is a couple of days in favour of the A2 scenario. On average, in both of the scenarios it is expected that the total period without any frost i.e. from the last spring frost to the first autumn/winter frost will be about a month longer.

Warm Days (Index of the number of warm days -TX90p) will significantly increase during the year, maybe even several times by the end of the 21st century.

According to the A1B scenario and during the period 2001–2030, the number of warm days will increase by as many as 2 times in all regions of Montenegro, and by 3-5 times in the period 2071–2100. This increase will be the highest on the coast – by as many as 5 times.

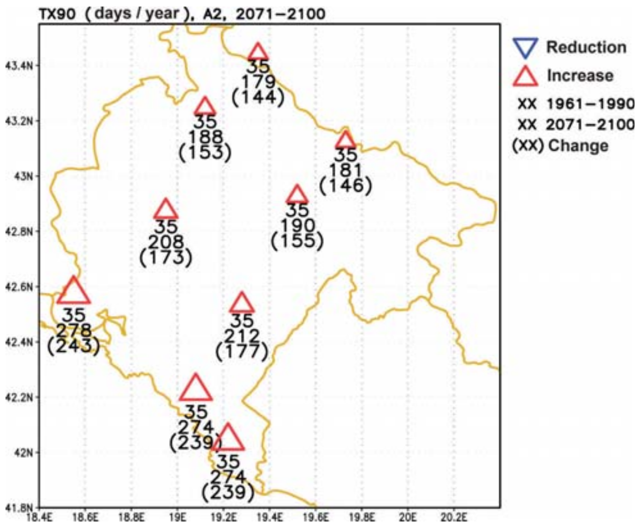


Graph 4.6 a) Mean annual value of the TX90p index for the period 1961–1990 and for scenario A1B for the period 2001–2030 with change in the index compared to values from the period 1961–1990;



b) Mean annual value of the TX90p index for the period 1961–1990 and for scenario A1B for the period 2071–2100 with changes in this index compared to values from the period 1961–1990.

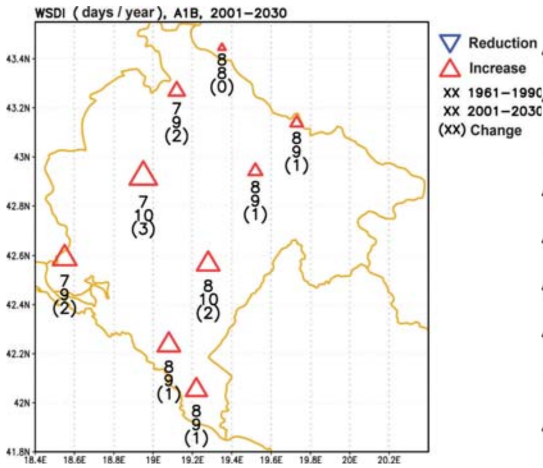
In the conditions of scenario A2, the central and northern mountainous areas will have about 4 times more warm days while the number of warm days will increase by as many as 7 times on the coast. On the coast, during almost 3/4 of the year, the maximum daily temperatures might be higher than the high temperatures in the period 1961–1990. Thus, if the climate change follows current trends, during this century we can expect significant shifts in temperatures to reach values that are higher than climate normals.



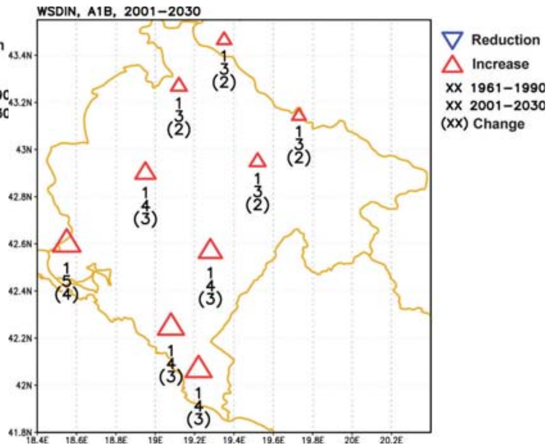
Graph 4.7 Mean annual value of the TX90p index for the period 1961–1990 and for scenario A2 for the period (2071–2100) with changes in this index compared to values from the period 1961–1990

Heat Waves (Warm Spell Duration Index -WSDI) will be more frequent and will last longer in all Montenegrin regions, particularly on the coast.

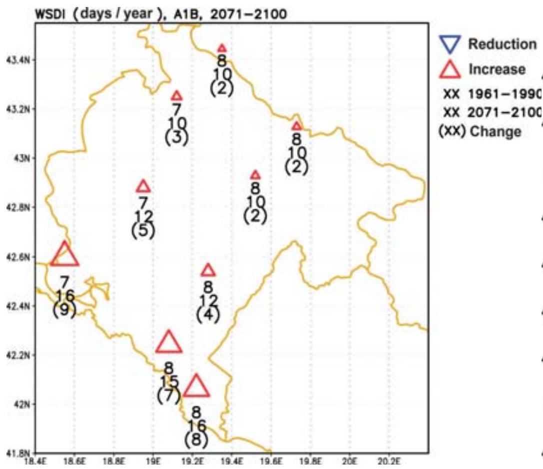
According to the conditions of the scenario A1B, during the period 2001–2030, heat waves will on average be about 1 day longer in the northern mountainous regions and about 2 days longer in the central and coastal regions. During the year more frequent heat waves can be expected, particularly in the central and northern regions, 3-4 times more frequently than experienced during the period 1961-1990 and as much as 7 times more frequently as previously on the coast.



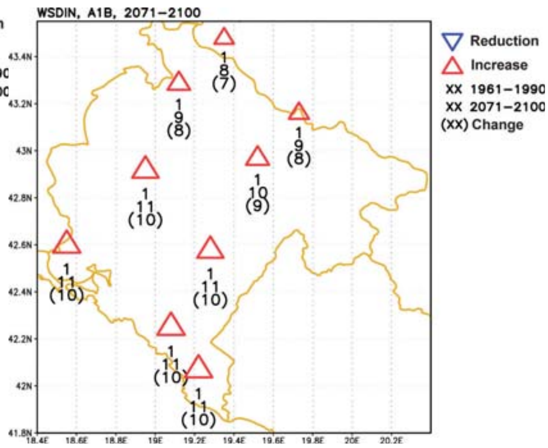
Graph 4.8 a) Mean annual value of the WSDI index for the period 1961–1990 and for scenario A1B for the period 2001–2030 with changes in this index compared to values from the period 1961–1990;



b) Mean annual value of the number of heat waves (WSDIN) during the year, for the period 1961–1990 and for scenario A1B for the period 2001–2030 with changes in this index compared to values from the period 1961–1990



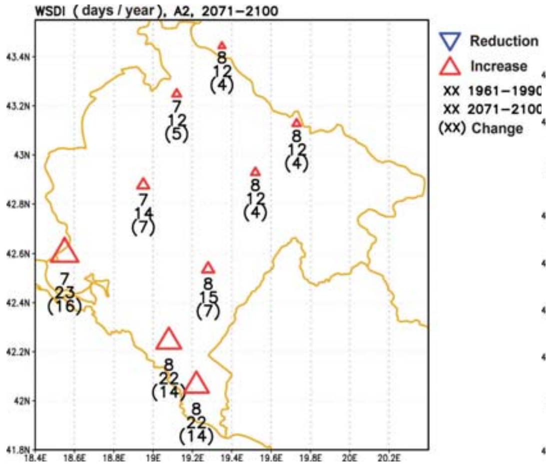
Graph 4.9 a) Mean annual value of the WSDI index for the period 1961–1990 and for scenario A1B for the period 2071–2100 with changes in this index compared to values from the period 1961–1990;



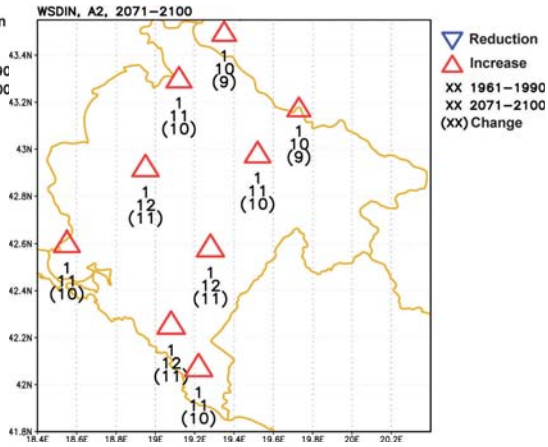
b) Mean annual value of the number of heat waves (WSDIN) during the year, for the period 1961–1990 and scenario A1B for the period 2071–2100 with changes in this index compared to values from the period 1961–1990.

During the period 2071–2100, heat waves will on average last a bit longer than two weeks on the coast. It is expected that in the locations that are further in the north, heat waves will last for 10 days on average. The number of heat waves in the northern mountainous regions is expected to increase by 7 to 9 heat waves more than was experienced during the period 1961-1990, while it is expected that there will be 10 more heat waves on the coast.

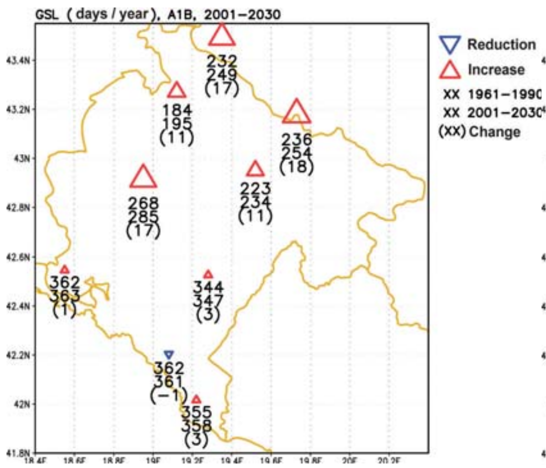
According to the A2 scenario, the mean length of a heat wave will probably range between 11 days to 2 weeks in the northern and central areas, to about 3 weeks on the coast in relation to the climate normal. On average, all regions in Montenegro are expected to have about 10 heat waves a year.



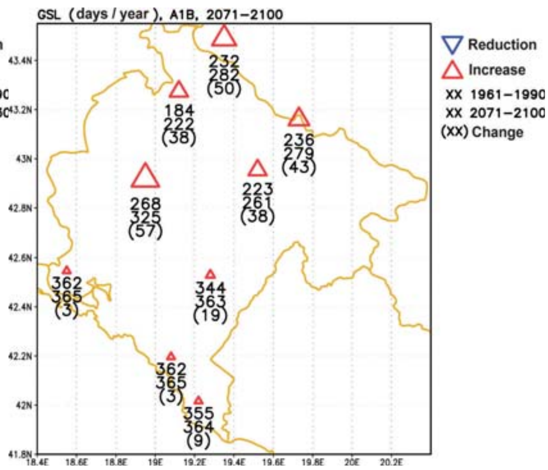
Graph 4.10 a) Mean annual value of the WSDI index for the period 1961–1990 and for scenario A2 for the period 2071–2100 with changes in this index compared to values from the period 1961–1990;



b) Mean annual value of the number of heat waves (WSDIN) during the year, for the period 1961–1990 and scenario A2 for the period 2071–2100 with changes in this index compared to values from the period 1961–1990



Graph 4.11 a) Mean annual value of the GSL index for the period 1961-1990 and for scenario A1B for the period 2001-2030 with changes in this index compared to values from the period 1961–1990;

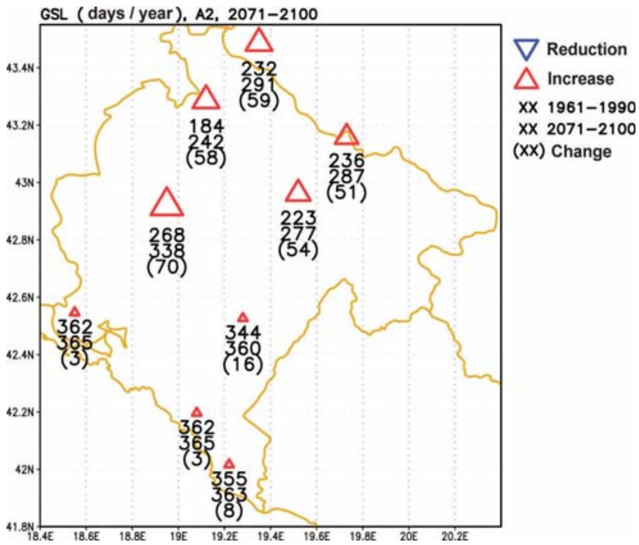


b) Mean annual value of the GSL index for the period 1961–1990 and for scenario A1B for the period 2071–2100 with changes in this index compared to values from the period 1961–1990.

Length of the Vegetation Period (Growing Season Length index - GSL) is longer in the 21st century in both scenarios. The changes are more significant at the beginning of the vegetation period than at its end.

For scenario A1B and for the period 2001–2030, the change in the length of the growing season is most significant in the north and ranges from an average of 11 days in the higher mountainous regions to 18 days in lower areas. On the coast, the changes are for up to three days, which means that the vegetation period will last for the whole year. During the period 2071 - 2100 the vegetation period will increase by about 38 days in the higher mountinous areas in the north and by up to 57 days in lower areas. This means the length of the vegetation period could be as long as 324 days a year.

According to the A2 scenario, conditions favourable for the development of plants will increase by as much as two months in the northern areas in comparison to the period 1961-1990. These favourable conditions will start already during the second and third week of February in the lower northern regions, while in the higher regions they will start in mid March. The end of the vegetation period is expected to occur at the end of November.

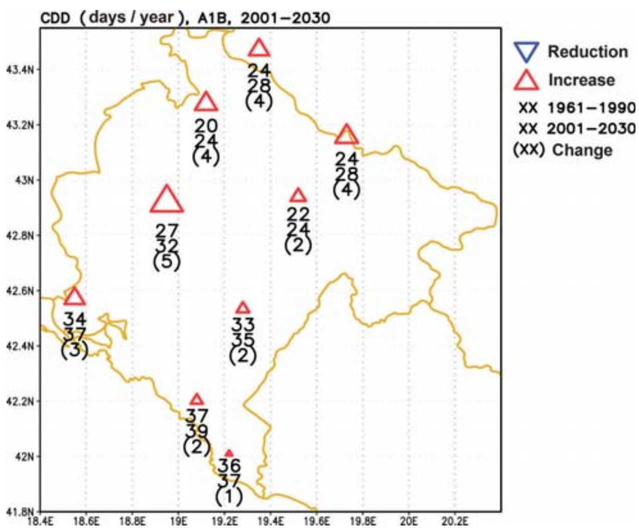


Graph 4.12 a) Mean annual value of the GSL index for the period 1961–1990 and for scenario A2 for the period 2071–2100 with changes in this index compared to values from the period 1961–1990.

However, the shift of the vegetation period towards the beginning of the year is not only positive, for example that it will allow the earlier development of plants. It could also have negative elements such as possible frosts and the fact that such a sharp interruption to the vegetation process could lead to losses in yield (e.g. with fruit cultures). The probability of such occurrences is more likely during the first 30 years of the 21st century.

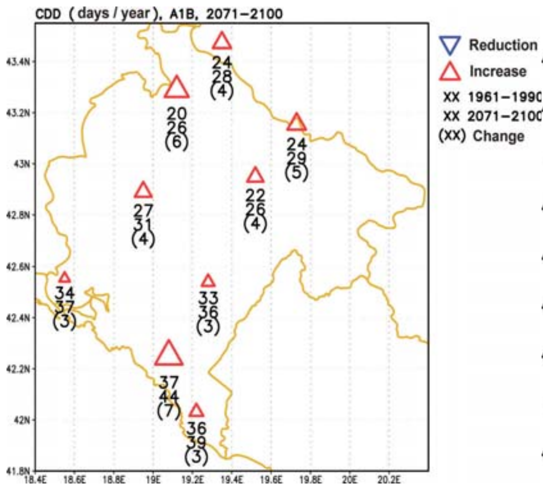
Dry Periods (Consecutive Dry Days Index - CDD) dare longer in both of the observed scenarios, particularly in the north.

In scenario A1B during the period 2001–2030 the extension of dry periods ranges on average from 1 to 5 days. It is predicted to be the longest in the karst region of the north-west of Montenegro where it is expected to last 5 days longer than the climate normal. This is followed immediately by the northern mountainous region where dry periods are expected to be about 3 - 4 days longer than during the period 1961–1990.

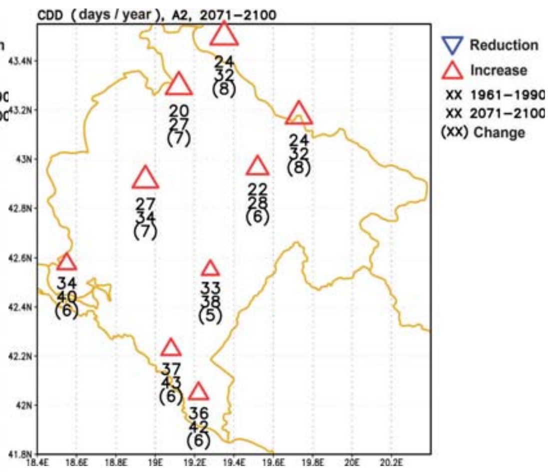


Graph 4.13 Mean annual value of the CDD index for the period 1961–1990 and for scenario A1B for the period 2001–2030 with changes in this index compared to values in the period 1961–1990.

In the period 2071–2100 (scenario A1B), dry periods are several days longer than in the period 2001–2030. Scenario A2 predicts even longer dry periods. Although these changes do not seem to be significant, it is important to notice that they are positive for all areas of Montenegro. This signifies a reduction in the overall amount of precipitation and the formation of a drier climate in the future.

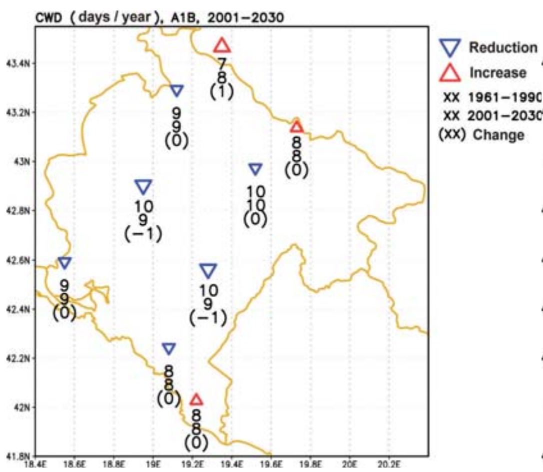


Graph 4.14 a) Mean annual value of the CDD index for the period 1961–1990 and for scenario A1B for the period 2071–2100 with changes in this index compared to values in the period 1961–1990;

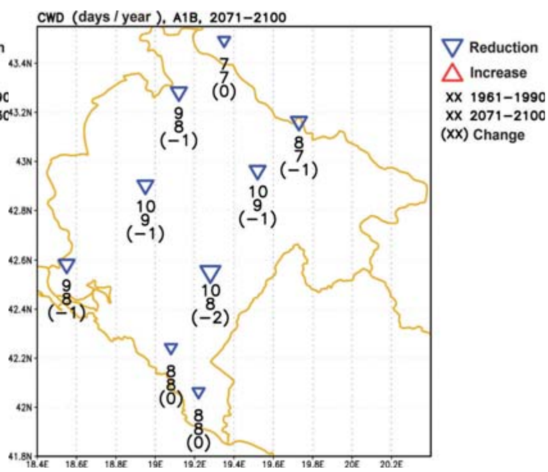


b) Mean annual value of the CDD index for the period 1961–1990 and for scenario A2 for the periods 2071–2100 with changes in this index compared to values in the period 1961–1990.

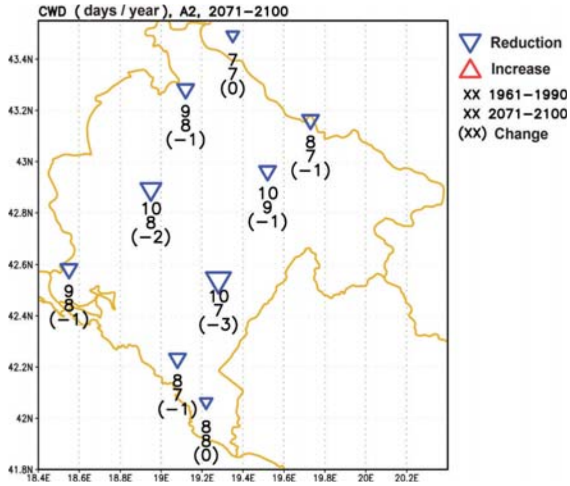
Rainy Periods (Consecutive Wet Days (CWD) index shows consecutive days that have rainfall of more than 1 mm per day) are decreasing in both scenarios and time periods; this is in line with the fact that dry periods are getting longer and it also supports the thesis that the climate will be more arid in the future.



Graph 4.15 a) Mean annual value of the CWD index for the period 1961–1990 and for scenario A1B for the period 2001–2030, with changes in this index compared to values in the period 1961–1990;



b) Mean annual value of the CWD index for the period 1961–1990 and for scenario A1B for the period 2071–2100, with changes in this index compared to values in the period 1961–1990;

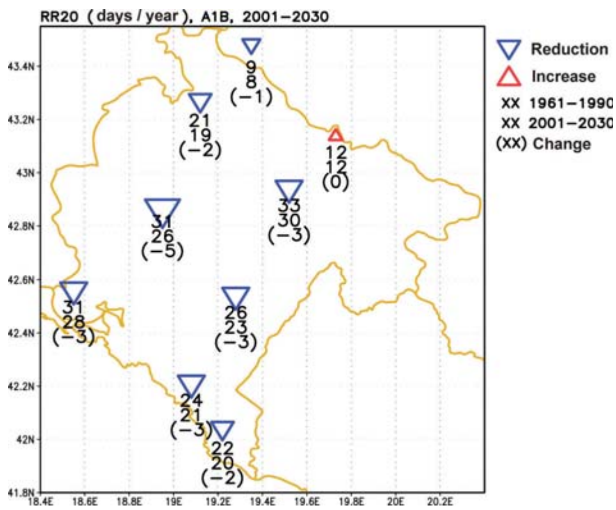


c) Mean annual value of the CWD index for the period 1961–1990 and for scenario A2 for the period 2071–2100, with changes in this index compared to values in the period 1961–1990.

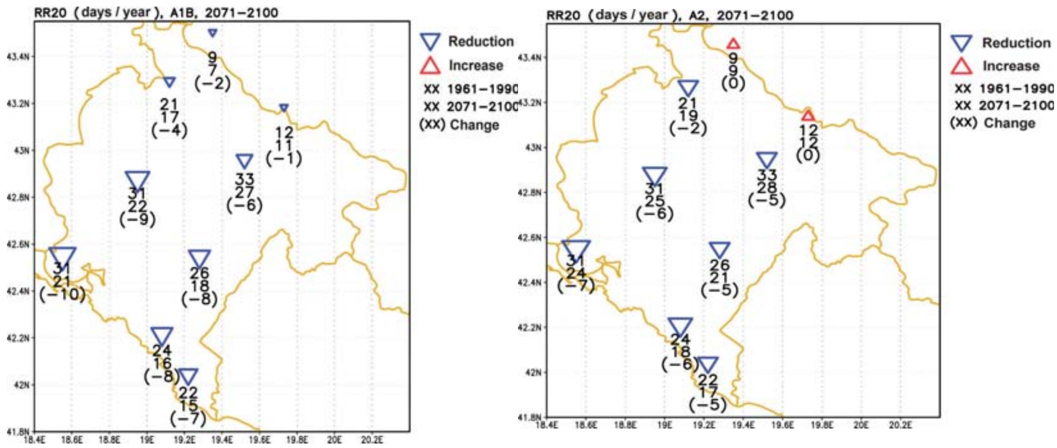
Number of Days with Heavy Rain (Index of the number of days with the precipitation levels that are higher than 20 mm -RR20mm) are decreasing or are very slightly increasing in a very small number of cases.

The most significant decrease is recorded on the coast, particularly in the municipality of Herceg Novi for both scenarios A1B and A2 during the period 2071-2100. This result is in line with the results presented for the other two indices (CDD and CWD) and supports the thesis that the climate will be drier in the future, i.e. that precipitation levels will change.

A reduction in the number of days with heavy precipitation and an increase in the amount of precipitation on such days indicates a higher intensity of precipitation in the future, which is in line with the results of the SRES report, as well as the results of other research related to the possible intensification of the bad weather, like intensive convective weather, multi-cell and super cell events etc. This increase in the intensity of precipitation could cause extreme events (e.g. floods).



Graph 4.16 Mean annual value of the RR20mm index for the period 1961–1990 for scenario A1B for the period 2001–2030, with changes in this index compared to values in the the period 1961–1990



Graph 4.17 a) Mean annual value of the RR20mm index for the period 1961–1990 for scenario A1B for the period 2071–2100, with changes in this index compared to values in the period 1961–1990;

b) Mean annual value of the RR20mm index for the period 1961–1990 for scenario A2 for the period (2071–2100), with changes in this index compared to values in the period 1961–1990.

Changes in the total annual amount of snow are negative in both of the scenarios and time periods. The reduction in the annual amount of snow is larger than the reduction in the total amount of precipitation; this is to be expected considering the fact that due to an increase in air temperature, snow precipitation would still be present but would fall in the form of rain.

During the period 2001–2030 and in scenario A1B, these changes are predicted to be about 10% less in the central and northern regions of Montenegro and about 30% less in the coastal region than was seen during the period 1961–1990.

During the period 2071–2100 changes are expected to become more significant. In the northern parts of Montenegro the amount of snow is predicted to be 30-50% less, while this reduction is expected to be about 30% in the most eastern areas. The amount of snow will be halved in the south, while in the furthest south-east part of the coastal region it is expected that there will be almost no snow. The baseline for comparison is the period 1961–1990.

According to the A2 scenario, areas expected to have 40–50% less snow per year will be further up in the north than predicted in the A1B scenario, while areas expected to have 90% less snow than the climate normal, will spread up from the coastal area towards the north-west.

Changes in the Mean Daily Maximum Wind Speed – According to EBU-POM projections, the mean daily wind speed will decrease annually by 5% in comparison to the period 1961–1990; this is more or less uniform for both scenarios and time periods in all Montenegrin regions.

In scenario A1B in summer, during the period 2001-2030, the maximum wind speed is expected to increase on average by more than 2% in the coastal regions, while it is expected to drop in other areas and during other seasons.

In summer during the period 2071–2100, in both scenarios, the areas which experience the greatest wind speeds is expected to decrease and to move more to the south-eastern part of the coastal region. In the A2 scenario, maximum wind speeds in the Skadar Lake[11] area expected to be 3% higher than they were during the period 1961–1990.

11 Note: the increase of several percentages in the wind speed can cause the increase in the wind power of several tens of percentages

It is worth noting that in Ulcinj, Bar and Herceg Novi, the A2 scenario shows less days with heavy precipitation, but actually shows larger amounts of precipitation; together with possible increases in mean maximum wind speed, this could indicate intensive local summer bad weather events with storm winds and heavy short rains. This also indicates a high level of vulnerability in these areas resulting from damage caused by strong winds and heavy rains.

Floods

Floods are among the most common natural disasters and they cause the greatest damages. They have direct and indirect effects. The direct effects are human loss and damage to households, while indirect losses include increased exposure to other hazards such as, for example, polluted water reserves, landslides and chaos in transport and trade.

Given the geo-morphological characteristics of the territory of Montenegro, floods could jeopardize settlements, agricultural areas, forests and other land and transport routes in river plains and valleys. We should particularly bear in mind that in their upper streams, and in some cases in their overall streams, all of the rivers in Montenegro have varying currents. This means that there are large differences between the flow of higher and lower waters and that there are regular current waves which have significant concentrations of sediments.

In this respect there are 2 problems that are particularly prominent and that make Montenegro highly vulnerable to floods:

1. a large number of towns and settlements are located on large river banks which makes them potentially more vulnerable to overflow of water from watercourses;
2. there are problems around Skadar Lake and the Bojana River, as well as on the Cetinje and Nikšić plains where large areas of agricultural land, material goods and urban zones can easily be jeopardized.

In Montenegro, protection from floods has not been given much attention so far, although the consequences are frequently fatal. Solving this issue would significantly contribute to the stabilization of the area, to the safety of transport and to the enlargement of arable agricultural land surfaces.

Protection from floods in the territory of Montenegro has to be based on the following:

- permanent improvements in the forecast hydrological service of the Institute of Hydrometeorology and Seismology of Montenegro (IHSM), so that it could quickly and properly issue flood warnings and so that it could forecast the trends and duration of floods, at least couple a days in advance, which would then ensure the timely preparation and implementation of protection measures;
- protection from floods should be implemented through the use of all available capacities, starting from passive protection, the use of accumulation as a measure of active protection, all the way up to the strict definition of and compliance with regulations for defence from floods;
- regular maintenance and reconstruction of constructed flood protection structures;
- endangered areas should be defined on appropriate maps and plans and the flood defence elements should be defined in spatial plans;
- work on protection from erosion and currents in the upper streams of river basins should be implemented:
- exploitation of material from river watercourses should be planned and used in line with the characteristics of watercourses, so that damaging impact on watercourses and constructed structures can be prevented.

An integrated approach to the development of currents and to protection from erosion in the territory of Montenegro assumes:

- coordination and synchronization of all activities and measures, taking into account the development of a concept for the whole territory. Such a framework should also envisage changes in land use for some parts of the territory;
- turning areas of low productivity and degraded surfaces into forest complexes. The forestation of these surfaces as well as the irrigation of degraded forest surfaces would lead to significant anti-erosion effects. The most efficient and most economic solutions to the anti-erosion development of an area consists of an optimum balance of biological, bio-technical and technical measures and works.

4.4 Vulnerability by Sectors and Adaptation Measures

Impacts of climate change on natural and social systems have already been observed both at global and regional levels. They have been manifested as losses in the yield from agricultural crops, the reduced availability of drinking water and its poorer quality, the increase and spread of diseases, the increased danger from floods, droughts etc.

Projections of future climate change indicate the further growth of these impacts, particularly if the anthropogenic emissions of the greenhouse gasses continue to grow. Some of these future impacts are already inevitable because of the life span of GHG and because of the nature of the climate system.

The fact that southern parts of Europe have been recognized as the most vulnerable areas in addition to the Arctic, makes the analysis of vulnerabilities and the definition of measures for adaptation to meet climate changes, and the analysis of variability and extreme events even more important. The text below offers an indicator-based analysis of vulnerability in the following sectors:

- water resources;
- coast and the coastal area;
- agriculture and forestry;
- human health.

4.4.1 Water Resources

Annual river flow can be used as an indicator of climate change since it represents a response from the river basin to meteorological factors such as precipitation and temperature.

Annual flow is an indicator of the availability of fresh water in river basins, and it is also the first assessment of whether a river flow is low or high. If the annual flow grows, the risk of floods also grows. Low annual flow could lead to a series of dependant events that could have a negative impact on e.g. the possibility of river navigation.

The most important political framework in Europe for river flow is the Framework Water Directive. According to this Directive every EU member state has to establish a programme for monitoring water flows and volumes of water in key basins. With this data, information observed from a river flow could be connected with climate data and thus projections of future trends caused by climate change could be provided.

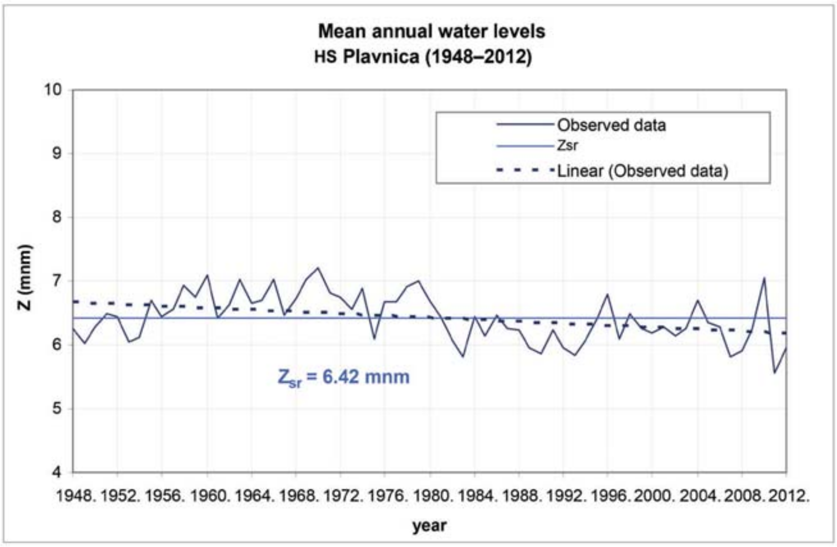
Hydrology – Analysis of Trends

Using the analysis of hydrological records, like river watercourses, water levels etc. hydrologists can assess future hydrological phenomena. This means that the characteristics of the process remain unchanged. Observations of hydrological processes are primarily used for predicting future trends and amounts of water.

Such hydrological analyses have been done for Skadar Lake, the most important hydrological entity in Montenegro. The analysis used data from the period 1948- 2012.

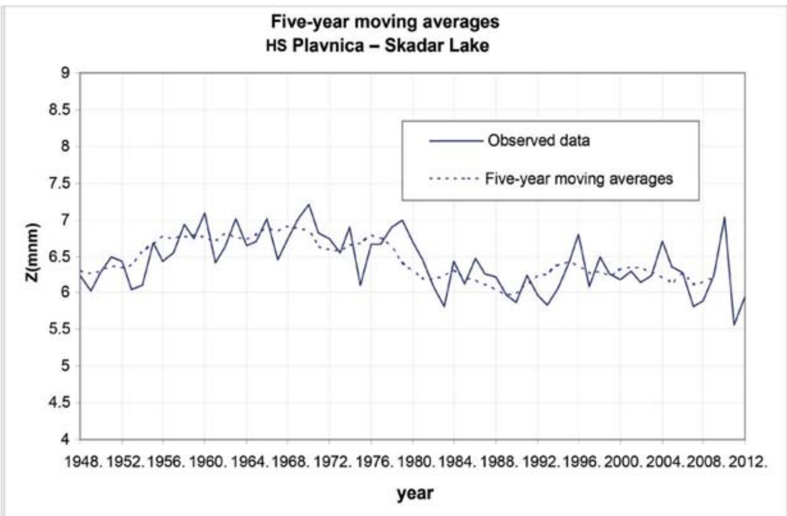
The hydrological analysis for Skadar Lake, the most important hydrological entity in Montenegro, is presented here to ensure a better overview of the current state of play and a better insight into the hydrological regime over the last 60 years. Assessments and analyses of the impact of envisaged climate change on water resources will, however, require continuous and high quality hydrological observation and measurement in the future.

The trend of the mean annual water levels (Graph 4.18.) at the hydrological station (HS) Plavnica on the Skadar Lake for the analysed period is negative.



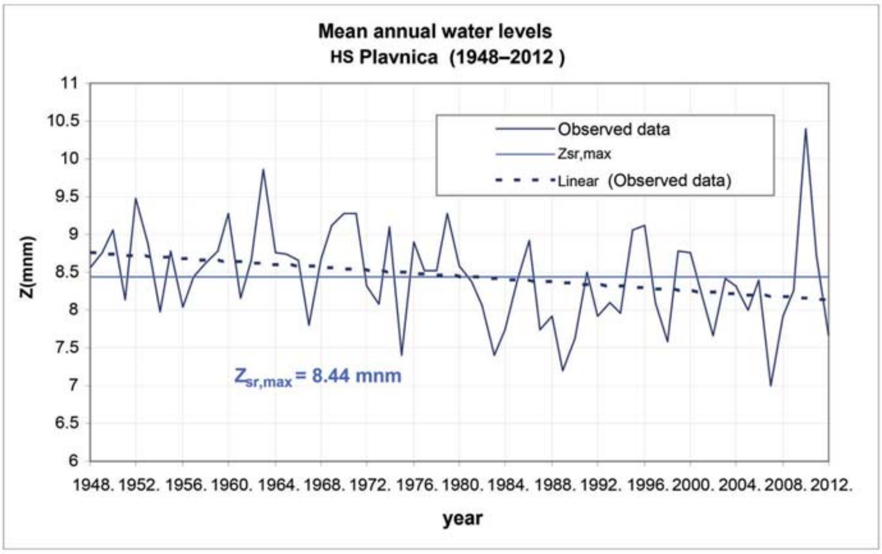
Graph 4.18 Analysis of the trend of mean annual water levels at HS Plavnica

Five-year moving averages (the point denoting the mean value for the last 5 years is inserted in the graph) vary in the range of 0.932 m. The lowest average was recorded during the period 1989–1993 and amounted to 5.971 mnm, while the highest average was registered during the period 1968–1972, and amounted to 6.903 mnm (Graph 4.19 Five-year moving averages).

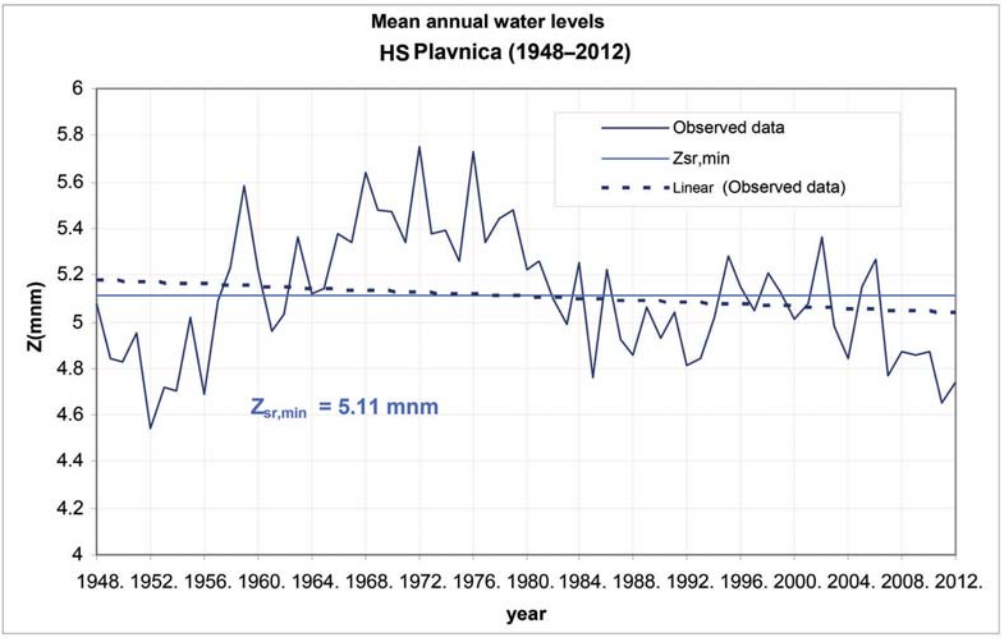


Graph 4.19 Five-year moving averages

Maximum and minimum annual water levels of the Lake at HS Plavnica (Graphs 4.20 and 4.21) have a slightly negative trend.



Graph 4.20 Analysis of the trend of maximum annual water levels at HS Plavnica.



Graph 4.21 Analysis of the trend of minimum annual water levels at HS Plavnica

An analysis of the trends of the medium, maximum and minimum levels of Skadar Lake has shown that during the entire period that was observed, there was a negative trend for all three analysed sets of characteristic waters. It was not very explicit, so we can say that there are no significant deviations from the usual periodic exchanges of dry and wet periods. The maximum that was recorded in 2010 was a consequence of a combination of several factors that happened at the same time - from extreme rains to the inadequate management of the Drim resevoir.

4.4.2 Climate Change Impact on Water in Montenegro

Just like most of the countries in South-East Europe, Montenegro is highly exposed and sensitive to climate change. Increased temperatures, reduced water resources and larger extremes seem to be inevitable. Sensitivity can be reduced through the programmes for reduction of water consumption in households and agriculture, but the methodology for the fastest resilience lies in the ability to adapt. Information technology, including the development of a high quality national ecologic database (cadastre of water and information systems) is considered to be a critical tool in developing the ability to adapt - adaptability. The Initial Communication on Climate Change produced by the Government in 2010 identified a significant lack of national willingness and ability to adapt: *"At this point there are no national strategies or adaptation measures and estimates of the expected mechanisms of self-adaptation."; "For now, there is no formal strategy or government policy which treats this problem integrally and provides recommendations for adaptation"*

Aware of the fact that climate change will in the future have a significant influence on the balance and regime of its surface and ground waters, Montenegro has conducted several activities related to its water resources:

- a detailed assessment of the water sector has been done and a proposal for a water cadastre has been prepared;
- the impact of climate change on the water regime of the Lim and Tara Rivers was analysed.

Detailed Assessment of the Water Sector and Proposal of the Water Cadastre

On the basis of an overview of needs in the water sector and on issues concerning coordination in Montenegro, with a particular focus on the required data and data management systems, Montenegro made a detailed assessment of the water sector and prepared a proposal for a water cadastre which contains four chapters: 1) overview of the hydro-meteorological networks, 2) overview of availability of necessary geographic data, 3) conceptual design for a national water information system (national water cadastre) and 4) overview of data coordination in the water sector and the process of work.

Overview of the Hydro-Meteorological Network

Since the time of the former Yugoslavia, Montenegro has had a very broad and high-quality network of meteorological stations for observing precipitation. The earliest data was recorded in 1949 and some of the systematic daily archives from that period are still available. Since 2008 the real time data on the water levels from 19 automatic meteorological stations (AMS) has been stored in the HYDRAS software that ensures examinations/queries for data etc. Still, most of the archive data on the national flow is not available in any easily accessible form.

In 2010 Montenegro had 20 climate stations (the number was reduced to 15 in 2012).

Before 2006 there were almost 80 WMO standard stations for measuring precipitation that were observed on a daily basis. This important network of stations for measuring precipitation has been in operation since the early 50s. The network was much larger in the past. It had more than 100 stations. In 2006 the network was reduced further from 80 to 65 stations, and another 48 stations were closed after that. Since 2012 there are only 18 stations that remain for measuring precipitation (not taking into account the automatic and climate stations).
As for the meteorological network, since 2012, the network for meteorological observations in Montenegro has had 9 automatic meteorological stations, 15 climate stations and 18 independent measuring instruments for measuring precipitation. The nine automatic meteorological stations work in real time for the needs of monitoring weather conditions, and the data is published on the website of the Institute of Hydrometeorology and Seismology (IHSM).

This significant reduction in the number of stations means that the errors in the interpolation[12] of precipitation for basins that are not measured can increase significantly, with unpredictable outcomes for modelling water resources, assessment of hydropower and ecology of waters in general.

- Station for the automatic measuring of water levels that does not monitor water quality
- Station for the automatic measuring of water levels that monitors water quality
- Non-automatic station for the measuring of water levels that monitors water quality

Figure 4.3 Network for monitoring water quality

The network for monitoring water quality has been developed well, but several significant problems have been noted. First of all, the active correlation between sampling for quality examination and continuous flow measuring is not satisfactory. Secondly, the programme of monitoring is mostly based on physical-chemical parameters. Thirdly, a significant deficiency is storage and the availability of data on water quality.

Overview of Availability and Need for Geographic Data

Integrated water resource management is one of the key principles of the Water Framework Directive which emphasizes spatial connections and integration at all levels of analysis, from one point such as the source of pollution to e.g. all the capacities of water resources of the entire river basin. The geographic information system (GIS) is considered to be a key tool that can be used to meet the requirements of the Water Framework Directive. The analysis that was carried out identified two key drivers relating to spatial-referenced data in Montenegro:

- Montenegro's operational issues in terms of managing the environment, legislation and disaster risk reduction, should be expressed in functional maps and as spatial data;
- development of the National Waters Master Plan (NWMP) and reporting to the European Commission on plans for managing river basins in line with Water Framework Directive requirements.

It is of highly concern that Montenegro currently does not have any developed maps of protected water source areas. Such maps define surface zones where the impact of construction and pollution must be strictly controlled with a view to preserving the quality of the chemical status of ground water that is used for public water supplies; these are numerous in Montenegro. The development of such maps is a priority.

12 Interpolation is a convenient way to obtain a value of a spacial variable in the location in which measurements are impossible, on the basis of the data obtained by measuring the same variable in pre-defined locations (e.g. meteorological or precipitation stations).

Conceptual Design for the National Water Information System (Water Cadastre)

The Government of Montenegro has identified the need to develop a national water cadastre. The primary purpose of such a cadastre would be the following:

- water resources that are of fundamental importance, like water supplies, should be identified and protected from uncontrolled exploitation and negative effects such as climate change;
- to establish a high level of information exchange between various institutions that deal with water with a view to ensuring the timely identification of any changes in water resources and to undertaking adequate protection measures.

Conceptual design for a water information system includes three key components:

1. a database for monitoring the condition of the environment (that consists of the numerical values of parameters as per figures obtained from the time series obtained from biological, meteorological, hydrological and water quality networks);
2. properly structured and computerised water licences of databases with the licences, and
3. a comprehensive set of geo-spatial data that can be combined in GIS to produce any kind of ecological map.

Overview of Coordination of Data in the Water Sector and Process of Work

In Montenegro the water sector is managed by the following institutions: the Institute of Hydrometeorology and Seismology, the Physical Planning Sector, the Environment Protection Agency, the Ministry of Agriculture and Rural Development - Water Administration and the Ministry of Interior.

The coordination of data in the water sector and the process of work includes hydro meteorological forecasting and alerting services, ensuring the provision of data for the study and identification of long term trends in terms of climate change, as well as strategic elements of coordination and the processing of data to generate results that can be used in the context of the Water Framework Directive and plans for managing river basins and measures for mitigating disaster risks such as the advanced mapping of flooding hazards.

Eight areas that could be considered as key resources and that could represent technical or communication bottlenecks in the future coordination have been identified as: 1) the collection of data by several institutions, 2) a transparent regulatory framework for the environment, 3) the efficient and coordinated process of licensing, 4) the development of plans for the management of river basins, 5) the mapping of risks concerning droughts and water shortages, 6) the mapping of potential flooding risks, 7) the mapping of basins and the introduction of a national system for coding water bodies, 8) the collection of biological data and regular records showing the ecological status. In line with the identification of potential bottlenecks in the future coordination of institutions, the report offers specific recommendations to solve these issues.

4.4.3 Impact of Climate Change on the Water Regime of the Lim and Tara Basins

The key reason for working on a model was to create an overview of the impact of climate parameters (primarily temperature and precipitation) from the climate projections obtained from the water regimes of the Lim and Tara Rivers. The activities implemented during the process of developing of this model included: i) the development and calibration of a hydrological model of the Tara and Lim Basins; ii) the production of a series of the mean daily flows from selected hydrological profiles; iii) the analysis of water regimes; and iv) the definition of water levels of high water from relevant flows, derived from an analysis of the water regime, as well as defining and mapping flooding surfaces, i.e. identifying geographic locations within the area of the Lim and Tara Basins that are most sensitive to floods.

The development of hydrological models for the Lim and Tara basins to meet the needs for analysis regarding the impact of climate change on water resources was done using the Swedish (HBV) (Hydrologiska Byråns Vattenbalansavdelning) conceptual model of time resolution for one day, for the selected hydrological profiles of Plav and Bijelo Polje on the Lim River and for Crna Poljana (Black Plain) and Trebaljevo Polje (Trebaljevo Plain) on the Tara River, with available hydrological and climatological data. This conceptual approach presents complex hydrological processes through simplified equations and with parameters that are set during the process of the calibration of the model, i.e. by the comparison of produced and observed physical values. The selected hydrological stations also identify the surfaces of the basins that were used to establish the model.

The calibration of the model of river basins was done according to criteria to achieve the best possible match between the observed and calculated flows, and to minimise errors in water balance. Satisfactory assessment values were obtained from the results of the model regarding both calibration and verification periods, and thus the Tara and Lim Basins can be used for the analysis of climate change impact on water regime. The formed, calibrated and verified models of the Tara and Lim River Basins were subsequently used to simulate flow on the basis of daily accumulated amounts of precipitation and mean daily temperatures obtained from the EBU-POM regional climate model. The input data for the hydrological model was available for both the A1B and A2 climate scenarios. The simulation of mean daily flows and the accumulation of snow was carried out for three time periods - 1961-1990, 2001-2031 and 2071-2100. The period 1961–1991 is the baseline period to which all the simulated values were compared: the period of the near future 2001-2031 according to the A1B climate scenario and a more distant future period 2071-2100 for the A1B and A2 climate scenarios. Following this, an analysis of the water regime was carried out. It assumed the use of statistical methods with a view to analysing droughts and the probability of high water and defined the water level of high water from the level of credible flows derived from results obtained from the water regime analysis.

Vulnerability of Surface Water to Climate Change

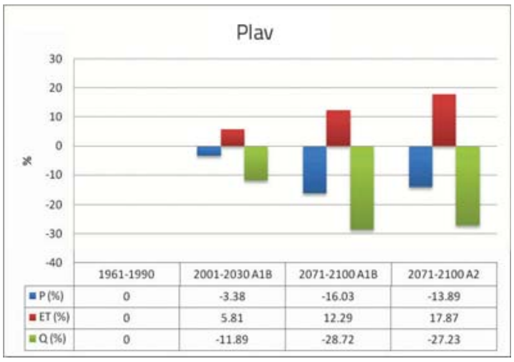
A high degree of karstification leads to large watercourses drying up in certain areas. For example, the Morača River, between the Duga Monastery and Zlatica almost dries up during dry periods of the year. The Zeta dries up in Zavrh. The section of the Cijevna from Dinoša to its delta into Morača dries up in the summer. The extension of dry periods would definitely have a negative impact on the already fragile flow of karst rivers.

Vulnerability of Ground Water to Climate Change

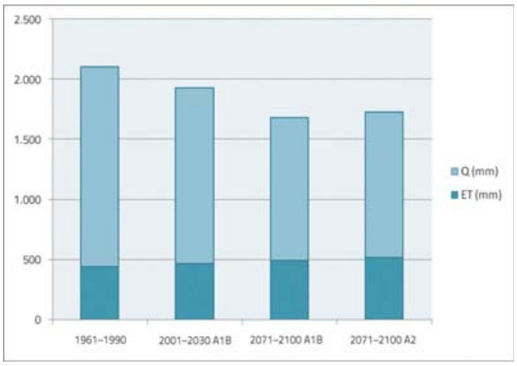
Watershed recharge in the karst areas directly depends on the amount of precipitation. It is well known that a large number of karst springs, even some that are used for water supplies (e.g. the well at Risanska špilja) dry up during summer. A reduction in the annual amount of snow could have a negative impact on water supplies because snow cover causes the later occurrence of low hydrological levels in the springs. Still, the most of karst watersheds play a very useful role, since they accumulate water taken in during the rainy period of the year and release it during the dry period when water is most needed (springs Mareza, Oraška Jama, etc.)

Analysis of the Water Balance

Analysis of the water balance in all river basins shows a reduction in the amount of precipitation on average of 4% during the period 2001-2030 and a reduction in the amount of precipitation on average of 14% during the period 2071-2100 in comparison to the period 1961-1990. It can be expected that the average increase of evapotranspiration in the near future will be around 8.5% and that it will reach 25% by the end of the 21st century, compared to the baseline period. On the basis of both climate scenarios, by the end of the 21st century we can expect a reduction in average annual flow of 27% in comparison to the period 1961-1990. Graphs 4.22 and 4.23 show the values obtained for the sub-basin Plav of the river Lim.



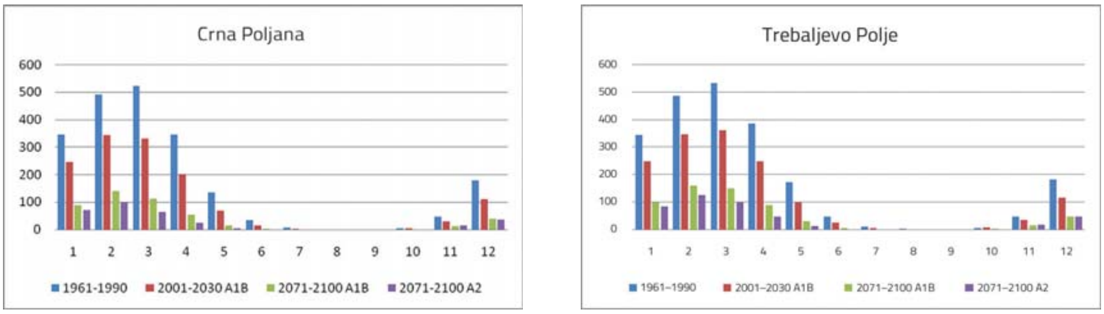
Graph 4.22: Expected changes in the components of the water balance for the sub-basin Plav in comparison to the values from the baseline period (P-precipitation, ET-evapotranspiration, Q-flow)



Graph 4.23 Mean multi-annual water balance for the baseline and the future period for the sub-basin Plav (P-precipitation, ET-evapotranspiration, Q-flow)

Analysis of Snow

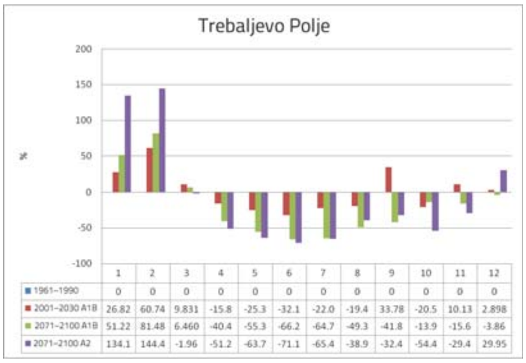
Both climate scenarios for the Tara River Basin and for the Lim River Basin indicate a reduction in the amount of snow cover as a result of future climate changes. Expected changes are presented in the March figures as that month in the baseline period showed the largest amount of water present in snow. Projected changes in the amount of water in snow in March during the period of the near future in the Lim River Basin amounts to about 25%, while in the Tara River Basin it amounts to 36%. By the end of the 21st century, according to both climate scenarios, we can expect to see a reduction in the amount of water present in the snow cover of about 70-80%. Graph 4.24 shows the changes in the average monthly amount of water present in snow for the sub-basins Crna Poljana and Trebaljevo Polje.

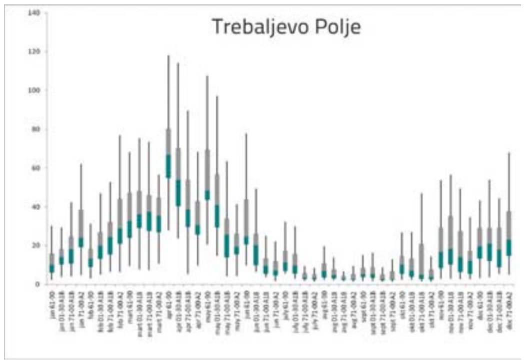


Graph 4.24 Projections of the mean monthly values of the contents of water in snow in the sub-basins of the Tara River for the periods 1961-1990, 2001-2031 and 2071-2100

Analysis of Median Water

During the period (1961-1990), during the winters, significant amounts of accumulated snowfalls were recorded. Due to the projected increase in temperatures for the future period more precipitation in the form of rain will be recorded during winter months as well as smaller accumulations of snow. Thus, it is expected that during the period from January to March the mean monthly flows of the Tara and Lim Rivers will rise in comparison to figures recorded during the baseline period. During the period from April to August, i.e. to November for the Tara River, a reduction is expected in the mean monthly flow; this would be a direct consequence of small accumulations of water in snow during winter. Examples of percentage changes in mean monthly flow values for the sub-basin of Trebaljevo Polje, for the periods 2001-2031 and 2071-2100, according to both climate scenarios in comparison to the period 1961-1990, is presented in Graph 4.25.





Graph 4.25 Changes (%) in mean monthly flow values for the periods 2001-2031 and 2071-2100 in comparison to the baseline period 1961-1990 for the sub-basin Trebaljevo Polje, Tara River

Analysis of High Water

Series of maximum annual flows for the periods 1961-1990, 2001-2031 and 2071-2100 for both basins and both climate scenarios were used to calculate the maximum annual flow of various return periods[13].

In the Plav profile a reduction of values for maximum annual flows of all return periods of 2% is expected during the period 2001-2031 and of about 12% by the end of the 21st century, while in the Bijelo Polje profile it is expected that the near future will see an increase of 5% in flow values in all of the observed return periods. In the future, flow values are expected to be greater or at least equal to the flows recorded in the periods that are 25, 50 and 100 years from the baseline period. Table 4.11 shows the value of the maximum annual flows in various return periods.

Table 4.11 Maximum annual flow values in m^3/s for the various return periods - Lim River

Plav					Bijelo Polje				
Return period (year)	61-90	01-30 A1B	71-00 A1B	71-00 A2	Return period (year)	61-90	01-30 A1B	71-00 A1B	71-00 A2
10000	545	538	572	495	10000	1776	1902	2230	1788
2000	470	463	487	423	2000	1522	1626	1889	1524
1000	437	431	450	392	1000	1413	1508	1742	1410
500	405	398	413	362	500	1303	1389	1595	1297
200	362	355	365	321	200	1159	1232	1400	1147
100	329	323	328	290	100	1049	1112	1253	1033
50	296	290	291	259	50	939	993	1105	918
40	286	280	279	249	40	903	954	1057	881
25	263	257	254	228	25	828	872	956	803
20	252	247	242	217	20	792	833	908	766
10	219	213	205	186	10	678	710	756	648
5	183	178	166	153	5	559	581	597	525

For all flows in the near future relating to Crna Poljana there is an increase in values (12-15)%, while the flow value at the end of the 21st century is expected to be equal or higher than the flows recorded during the period 1961-1990. In the Trebaljevo Polje figures a slight increase in flow values is evident in all return periods. Table 4.12 shows maximum annual flow values for various return periods.

13 Defined as a reciprocal value of the probability of a critical event and expressed in years

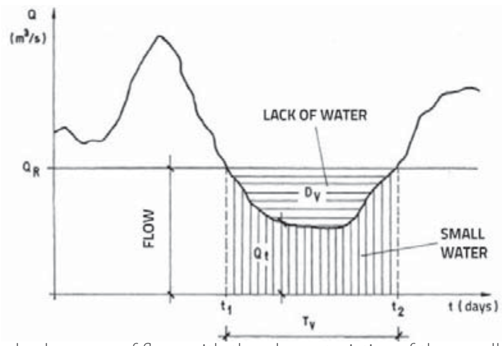
Table 4.12 Maximum annual flow values in m^3/s for various return periods - Tara River

Crna Poljana				
Return period (year)	61-90	01-30 A1B	71-00 A1B	71-00 A2
10000	522	664	716	576
2000	448	559	600	487
1000	417	514	550	449
500	385	469	500	411
200	343	410	434	361
100	311	365	385	323
50	279	321	336	286
40	269	307	321	273
25	247	277	288	248
20	237	263	272	236
10	204	218	224	198
5	170	173	175	159

Trebaljevo Polje				
Return period (year)	61-90	01-30 A1B	71-00 A1B	71-00 A2
10000	1046	1111	1225	1142
2000	897	947	1034	968
1000	832	876	951	893
500	768	805	869	818
200	683	711	761	720
100	618	640	680	646
50	553	570	598	571
40	532	547	572	547
25	488	498	517	497
20	467	475	491	473
10	400	403	409	397
5	330	328	325	320

Analysis of Small Water

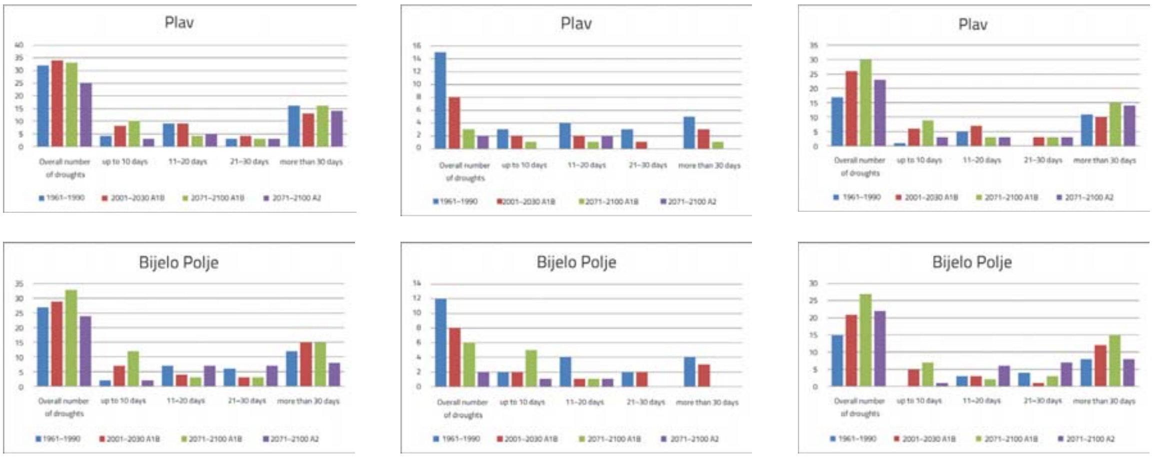
In the analysis of the impact of climate change on small waters the methodology of E. Zelenhasić was used; this method has been used in many countries. In addition to the flow values of small waters this method also takes into account the length of dry periods. To apply this method it is important to define the threshold, as expressed by the flow, that defines the start of a dry period. Based on the goals of this analysis, only flow values of less than 10% of the flows registered in the period 1961-1990 were used. This value was obtained from the curves of the length of flow for all four hydrological profiles (Graph 4.26)



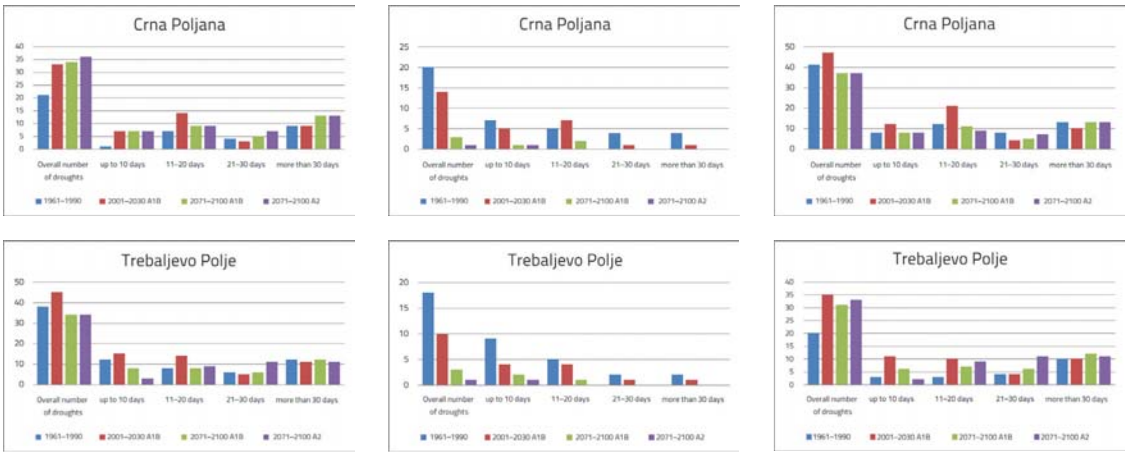
Graph 4.26 Image of the hydrogram of flow with the characteristics of the small water period above the defined baseline flow, water deficit and the length of a hydrological drought

In the Lim River Basin during the period 2001-2031 it is not expected that there will be a significant increase in the total number of hydrological droughts in comparison to the period 1961-1990, but there is a noticeable explicit migration of dry periods from winter to summer. This is a consequence of the transformation of snow into rain precipitation and because of reductions in snow accumulations; these factors were the cause of hydrological droughts in the baseline period. There is a slight increase in the number of droughts that last for more than 30 days. By the end of 21st century there is a significant increase (in comparison to the baseline period) in the number of droughts of various length that are recorded in the Tara River Basin and in the sub-basin Crna Poljana.

In Graphs 4.27 and 4.28, the graph on the left shows the overall number of droughts during the observed period. The graphs in the middle and on the right show the distribution of summer and winter droughts and the distribution of their length.



Graph 4.27 Overall annual number of droughts during the observed period (left), distribution of winter (in the middle) and summer droughts with their distribution by length – Lim River



Graph 4.28 Overall annual number of droughts during the observed period (left), distribution of winter (in the middle) and summer droughts with their distribution by length – Tara River

Projected changes in temperature and in precipitation will inevitably impact on and create changes in the water balance in both river basins. A reduction in the amount of precipitation in comparison to the period 1961-1990 would cause a significant decrease in the average annual flow value by the end of the 21st century in comparison to flows observed during the baseline period. Due to an envisaged increase in temperature by 2100 in both climate scenarios, the precipitation that fell as snow in winter months would fall as rain and would result in an increase in mean monthly flows values during that period, while reduced accumulations of snow would result in a decrease in mean monthly flow values during spring months. The analysis of maximum annual flows has not produced a uniform change, but rather has resulted in a different set of results for each of the hydrological stations. The overall number of hydrological droughts is not expected to increase during the period before 2100 in the Lim River Basin, but is expected to increase in the upper stream of the Tara River Basin. Changes in precipitation during the winter are expected to lead to a re-distribution of the number of summer and winter droughts and to change to number of periods with the small water periods. It is expected that the number of winter droughts will decrease, while the number of summer droughts will increase. A slight increase in the number of droughts of over 30 days in length is also expected.

Analysis of high water carried out using the hydrological models of the Lim and Tara Basins within the selected profiles

An analysis of high waters carried out using the hydrological models of the Lim and Tara Basins in the selected profiles was done using the Swedish semi-distributed conceptual HBV model, along with the available hydrological and climate data.

Data obtained from the model for the adopted A1B and A2 climate scenarios, and the input parameters from the EBU-POM regional climate model in the form of flow in the zone of the selected profiles did not contain a z component (water level) for the given conditions. It was therefore necessary to translate the flow Q (m^3/s) to the appropriate water level - H (mnm). This was done on the basis of the existing data of the hydrological service for the given profiles, by using the analysis of the defined curve of flow Q=f(H) (rating curve). The data on water levels obtained in such a way was "located" in space in order to define the zones of impact (flooding) of the possible extreme waters. That was done through a geodetic survey of the field and by identifying the possible areas prone to flooding on the basis of the hydrological data obtained through hydrological modelling.

For the municipality of Bijelo Polje (Image 4.5) a stretch along the Lim River at a level of 595 m above sea-level, adjacent to the former Wool plant (Vunarski kombinat) and close to to the settlement Sutivan, was identified. Measurements were carried out on both sides of the river. In the municipality of Kolašin (Figure 4.4) a slightly smaller zone in the area of the settlement Rovačko Trebaljevo was chosen, an area downstream along the Tara River at a level of 900 m above sea-level. Surveys were also done on both sides of the river.

The survey used a GPS Leica GS09 which ensured centimetre precise positioning for the network of the permanent stations in the RTK measuring mode. For both locations the transformation parameters (we did not use the parameters of the Real Estate Directorate) were calculated in order to ensure the highest possible level of accuracy of the Z coordinate. The data was then transposed into the State Coordinate System (DKS). Geodetic surveys were done on 21st and 22nd December 2013 in favourable weather conditions, so that none of the meteorological parameters could hamper the work process. The survey were each carried out from 100 to300 m, depending on the configuration of the terrain.

The data from the field surveys was transposed onto maps of appropriate proportions and high water catchment areas were identified in the some of the selected hydrological profiles.

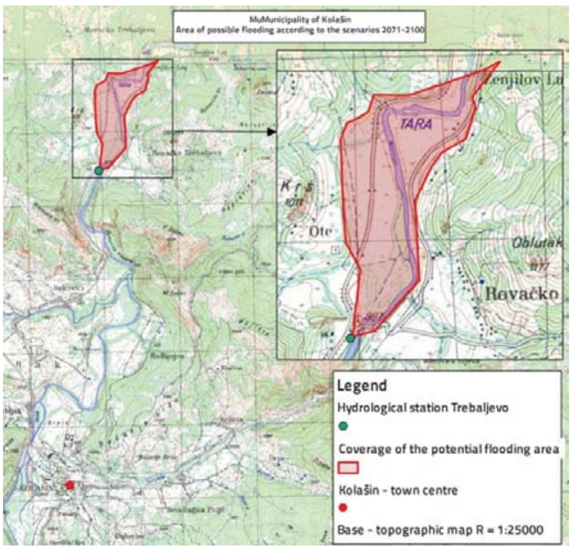


Figure 4.4 Municipality of Kolašin – possible flood plain according to the proposed scenarios (2071-2100)

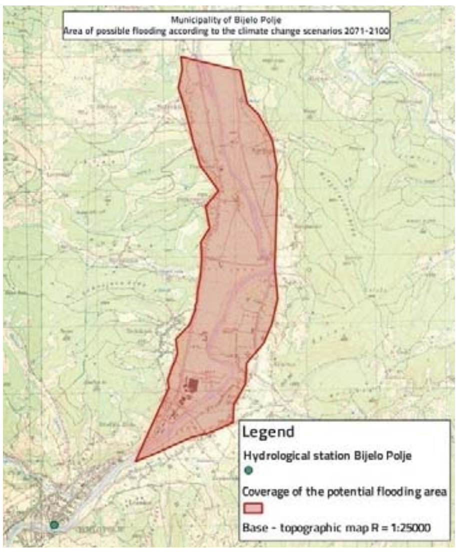


Figure 4.5 Municipality of Bijelo Polje – possible flood plain according to the proposed scenarios (2071-2100)

4.4.4 Agriculture and Forestry

Agriculture

Agriculture is very sensitive to climate change since climate is one of the most important natural factors for agricultural production. An increase in the concentration of CO_2 can stimulate photosynthesis, increase the production of biomass and increase a more efficient use of water (Pinter et al., 1996; Kimball et al., 1993). This is most favourable for wheat, barley, rye, potato and rice. Other products like corn benefit less.

Increases in temperatures can have various effects. They can increase the productivity of plants and reduce the risk of freezing. On the other hand, in warm and dry conditions, increases in temperature can lead to water shortages and to decreases in yield. Changes in the amount and distribution of precipitation can have positive and negative impacts on agriculture, depending on regional conditions and regional trends in precipitation.

Other impacts of climate change include: higher risk of poor harvest due to more frequent and more intensive weather extremes like droughts, floods, favourable conditions for development of plant pests and diseases, decrease in the quality of yield due to higher concentration of CO_2 (IPCC, 2001b). On the other hand, the effect of climate change on crop yields is subject to high uncertainty due to the complex interaction between technical progress, political measures and crop yields.

Vulnerability of the Agriculture Sector to Climate Change

Agriculture is one of three priority development branches in Montenegro. Although in 2012 the total agricultural output in Montenegro recorded a 12.7% fall in comparison to the year before, the share of agriculture, fishery and forestry in Montenegrin gross domestic product is still significant at 7.4%.

Montenegro has a very small amount of arable agricultural land, which is the reason that certain commercial arable crops are not grown. Crops such as small grains, corn, sugar beet and oilseeds all require large areas of land. The area of pasture land in Montenegro is significantly larger, which gives Montenegro greater potential for livestock breeding, particularly cattle, sheep and goats.

In its chapter entitled Environment, Biodiversity, Forestry, Climate Change and Use of Resources, the Strategy of Development of Agriculture and Rural Areas for the Period 2015-2020 recognizes that climate change presents a threat to the preservation of the environment, economic development and society. The strategy recognizes that the agriculture sector produces a significant amount of plant and animal waste and that due to the absence of a system for the collection of agricultural waste (with the exception of some individual households), emissions of GHG occur. Climate change can also have a negative impact on the fertility of land, in form of an increased level of vulnerability to organic matter in the soil and an increased risk of erosion due to the increases in temperature, and more frequent droughts and precipitation. The strategy also recognizes that climate change will have a significant impact on agriculture due to changes in water levels; the strategy expects to see a reduction in the annual amount of water available to agriculture in many areas due to an expected reduction in the amount of summer precipitation, primarily in the southern parts of Europe.

Montenegrin agriculture is very diverse and the fact that it represents such a large number of branches is conditioned primarily by its various natural preconditions for agriculture. Thus, in the coastal region olive growing is very developed, as well as citrus and sub-tropical fruit growing. The central region is known for growing early vegetables, fruit, and grapes, and for producing eggs, meat and milk. In the karst region, livestock breeding predominates, particularly goat breeding, while the north is mainly know for potatoes, fruit growing and extensive livestock-breeding (breeding of cattle and sheep). The Montenegrin strategy for developing food production and rural areas recognizes that this broad range of production can be an advantage on one hand, but that due to the fact that the market cannot sustain large quantities of products it is also a disadvantage. Compensation for this disadvantage can be found in the fact that the land, generally speaking, has not been overexploited and that farmers in Montenegro still do not use a high level of mineral fertilizers (in excess of 10 times less than the EU average) and plant protection substances.

Given the above, Montenegro has recognized that it has a comparative advantage in organic production. Favourable and varied climate conditions ensure the production of various agricultural products, although in limited quantities. Generally, Montenegro has a well-preserved nature and a significant number of traditional products. In Montenegro, the extensive system of agricultural production prevails with the limited use of pesticides and artificial fertilizers, which makes a transfer to organic production easier. Montenegro has recognized that a transfer to organic agriculture would generate new jobs in farms and would contribute to slowing down the negative trend of depopulation and desertion of rural areas, which is currently a huge challenge for Montenegro.

Surfaces used for organic production in 2011 made up 0.6% of the total agricultural land. In total 3,068.07 ha of agricultural land were registered as being used for organic production. Of this 200.29 ha were arable land (arable crops and grown medicinal herbs - 119.81 ha; vegetables - 2.29 ha; orchards 75.52 ha, vineyards - 2.67 ha), while 2,867.78 ha were meadows and pastures. In addition to this, medicinal herbs and forest fruits were collected from a total of more than 139,000.00 ha.

However, Montenegro belongs to the region of South-East Europe, in which, according to the projections of climate models, increases in air temperature and reductions in the amount of precipitation are expected, as well as more frequent and more intensive droughts, particularly in summer.

More frequent and more intensive droughts would have a negative impact on the quality of yields, on incomes, on the cost of protecting plants from diseases, weeds and insects and on irrigation prices. Regarding livestock breeding it would have a negative impact due to a reduction in yields of hay, the production of milk and a reduction of the livestock.

Furthermore, projections for Montenegro indicate shifts in the growing (vegetation) period by up to 30 days towards the beginning of the year, and also a greater possibility of frost at the beginning of the period, particularly during the first 30 years of the 21st century. These combined factors could sharply interrupt vegetation periods and cause the loss of yields.

A projected increase in the number of warm days per year, as well as changes in the length and frequency of heat waves could lead to the acceleration of pest and insect activities.

In order to reduce the negative effects of existing drought risks, along with other projected impacts from climate changes, the countries of South-East Europe (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Former Yugoslav Republic of Macedonia, Greece, Hungary, Moldova, Romania, Serbia, Slovenia and Turkey) decided to establish the Drought Management Centre of South-East Europe (DMCSEE).

The key goal of the centre, implemented through an IPA[14] project with the same name - DMCSEE - is to improve preparedness for droughts by conducting vulnerability and risk assessments and by establishing an early warning system aimed at reducing the impact of droughts.

Since agriculture is the first to be hit by droughts, the assessment of vulnerability to droughts for the agriculture sector has been done on the basis of the observed climate and geomorphological data. Vulnerability is classified in five categories: not vulnerable, slightly vulnerable, moderately vulnerable, vulnerable and highly vulnerable. The results for the region of South-East Europe are presented in the website of the project www.dmcsee.org/GISapp/, while the vulnerability map for Montenegro is presented in the Figure 4.6.

The vulnerability map actually serves as an indicator for the areas that require a more detailed assessment of drought risks, which could help the decision makers in identifying appropriate mitigation measures before the onset of the next drought; thus this would reduce the consequences of droughts and would ensure the sustainable development of the agriculture sector.

The Figure 4.6 shows that 3 key agriculture areas, i.e. the Zeta River Valley, the Bjelopavlići Plain and the coastal

14 IPA – Instrument for Pre-Accession Assistance of the EU

area are slightly to moderately vulnerable, that the south-west part of the coast is moderately vulnerable while some of its areas are vulnerable, and even highly vulnerable to drought, which is particularly contributed to by a sharp inclination of the terrain (very steep mountain slopes along the coast) and exposure to the sun radiation.

Within the DMCSEE project the WINISAREG model for irrigation planning was applied, and the project also included the assessment of the impact of climate change on irrigation within the context of the future climate. For Montenegro, tests were done for Podgorica and Berane in the short term and in the long-term for growing certain types of corn. The results of the simulations show that the WINISAREG model is an efficient and very practical tool in planning the use of water for agriculture.

The results of the 30-year simulation in the Podgorica region indicate that irrigation would be necessary for both types of corn. It would also be possible to move the short corn-growing season to early spring to avoid the long-term summer dry period.

Relative yields have grown over the last 30 years for both long-term and short-term cultivars in the Podgorica region. On the other hand, in the Berane region they are declining. Thus, climate change has different effects depending on climate - Mediterranean or Continental.

The project also included an assessment of the monitoring of drought in Montenegro through remote detection. The results showed that the remote monitoring is very volatile. The key factor is the inclination of the mountains rather than their height. The best results were obtained for the coastal region, the Zeta-Bjelopavlići Plain and the Ulcinj Field, where the use of satellite drought monitoring was recommended. It is also worth noting that these are also the 3 key agricultural areas in Montenegro.

It is very important that the Drought Management Centre of South-East Europe materialises as it would ensure that, on the basis of identification and on the awareness of vulnerability, risk advice could be given with a view to improving drought management. It would be particularly important to identify the research, institutional and operational capacities that exist at both national and sub-national levels.

A comprehensive plan of response/adaptation to droughts should focus on existing schemes for drought control measures. Currently there are numerous possibilities that can help in the process of facing drought risks. In that respect it is worth noting that permanent drought monitoring in Montenegro was established after the IPA project DMCSEE was implemented. It is based on monitoring the standard precipitation index (SPI). However, it is a problem that the observation network appears to have been getting increasingly weaker, particularly since 2011 due to a reduction in the number of active precipitation stations from 67 to 20. This will have a negative impact on the quality of data that is required for setting the intensity and frequency of weather and climate events, for forecasting weather characteristics and potential damage, and for providing information on weather and climate for the needs of agriculture, transport, and energy production.

Given the existing situation in the field of agriculture in Montenegro, as described above, and also the observed and projected climate changes and extremes, it can be concluded that the agricultural sector is vulnerable to:

1. droughts - due to the projected increase in consecutive dry days, a reduction in the total amount of precipitation and the establishment of a drier climate where in the future land is eroded and agricultural land is lost;
2. shift of vegetation periods towards the beginning of the year and due to the possible appearance of frosts, particularly during the first 30 years of the 21st century. This could cause sharp interruptions in the vegetation process and cause losses in yield, particularly in fruit growing cultures;
3. increase in the number of hot days per year, and of the duration and frequency of heat waves and due to the possible acceleration of pest and insect activities;
4. rise in sea level and the possible flooding of agricultural surfaces.

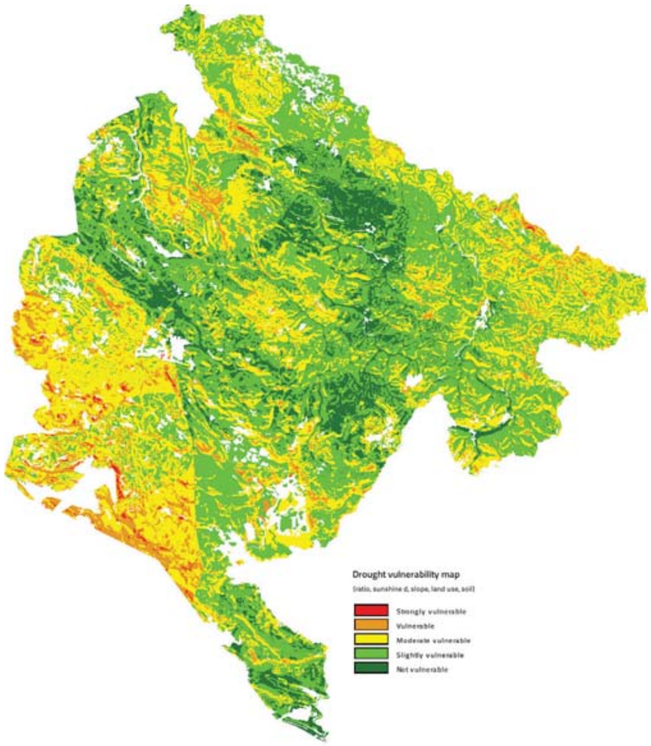


Figure 4.6 Vulnerability of agricultural areas to drought during the period observed (1971-2000) – Source: IPA DMCSEE, 2011

Impact of Climate Change to Livestock Breeding

Livestock breeding still contributes greatly to Montenegrin agriculture. The leading livestock breeding sectors are cattle, sheep, goat and poultry breeding. The amount of livestock and pigs significantly declined over the last couple of years. During the period 2007-2011, Montenegro recorded a dramatic decline in the number of heads of cattle (51%) and poultry (42%), but also of sheep (37%) and pigs (7%) in comparison to 1999.

In 2010 an agricultural census was organized and its results showed that Montenegro had:

- 24,616 farms that breed cattle, 78,633 heads of cattle and 50,888 dairy cows;
- 6,082 farms that breed sheep and 130,459 ewes for milk;
- 13,465 farms that breed pigs and 280 sows of the first farrow;
- 16,304 farms that breed poultry and 411,086 heads of poultry.

The total number of farms breeding livestock was 32,675, while the total number of livestock units (LSU) was 117,753.1. The structure of livestock production is not proportionate between family agricultural holdings and business entities. The characteristic of family agricultural holdings is that they possess a relatively low and mixed livestock production with 3.6 LSU per holding, while business entities possess 257.4 LSU per holding. According to data from Census of Agriculture the average area of perennial meadows and pastures per agricultural holding is 4.87 ha, and per livestock unit 1.78 ha. The greatest number of agricultural holdings 24,624 breed cattle, where an average number of bovines per agricultural holding is 3.3 heads. On average, there are 38 heads of poultry per agricultural holding rearing poultry, there are 3.5 pigs per those rearing pigs, and there are 9.9 goats per those rearing goats. Number of holdings moving sheep to mountain land is 3,512, i.e. 57.7% of the total number of agricultural holdings breeding sheep. Livestock resources in Montenegro lie in rearing sheep, which is also confirmed by the data that every agricultural holding on average has 37.62 heads of sheep.

Starting from the possible climate change impact on livestock breeding described in the Initial National Communication on Climate Change of Montenegro to UNFCCC, the state of play in livestock breeding and the results of the regional climate model, we can conclude that the livestock-breeding sector is vulnerable to:

1. droughts and thus a reduction in the production of animal foodstuffs;
2. an increase in the number of hot days during the year, the length and frequency of heat waves and thus to heat stress which influences milk production, gain in muscle mass and reproduction;
3. floods and thus the vulnerability of livestock because of more difficult evacuation which assumes the use of the appropriate means of transport.

Forestry

With a view to assessing the impact of climate change on forests in Montenegro, two studies have been carried out during the preparation process for the Second National Communication: (1) vulnerability of forestry in Montenegro to pests and plant diseases and (2) analyses and projections of the impact of climate change by the use of regional climate models on the future distribution and growth of key tree species in Montenegro. We would like to note that the working data from the National Forest Inventory was used for these two studies.

Vulnerability of Forests to Diseases and Pests Resulting From Climate Changes

According to available detailed information from the national forestry monitoring for Montenegro, which is being conducted at 49 stations and which includes the entire territory Montenegro, the average health condition of forests is at a satisfactory level. At the largest number of stations the registered degree of defoliation was within the range of 0-25%. Of all the controlled number of trees (1,176) 43% were in the category without defoliation (0-10% no defoliation at all), 37% had low defoliation (10-25% - low (warning) defoliation), while more significant changes in defoliation were registered only in 20% of trees (25-60% - medium defoliation).

The data of the National Monitoring of the Health Condition of Forests (ICP Programme[15] - International Cooperation Programme for monitoring status of forests in Europe) shows that there are negative trends in terms of lower resistance to forest pests, although the general condition of forests is deemed to be at a satisfactory level.

The process of inspecting trees identified the common insects and fungi that cause degradation (Table 4.13). It is important to emphasise that according to the ICP[16] report for 2011 the overall amount of damage caused by pests and fungi was recorded as being present in 21% of trees (insects–181 trees (15,39%); plant diseases–68 trees (5,78%). In comparison to 2010 there was an increase in this damage in 26 or 2.21% of trees, which is an insignificant amount.

Table 4.13 The most frequent pests and diseases in Montenegrin forests – Source: ICP, 2011

Type of forest	Host	Pests and diseases
Beech forests	*Fagus moesiaca*	*Rhynchaenus fagi, Mikiola fagi, Cryptococcus fagisuga, Operophtera brumata, Nectria spp., Fomes fomentarius, Trametes versicolor*
Oak forests	*Quercus spp.*	*Altica quercetorum, Scolytus intricatus, Lymantria dispar, Operoptera brumata, Fomes fomentarius, Micosphaera alphitoides*
Spruce forests	*Picea abies*	*Iplps typographus, Pitiogenes chalcographus, Heterobasidion annosum, Fomitopsis pinicola, Chrysomyxa abietis, Lophodermium piceae, Herpotrichia nigra*
Silver fir forest	*Abies alba*	*Melampsorella caryphyllacearum, Armillaria mellea*
Pine forest	*Pinus spp.*	*Diprion pini, Ips sexdentatus, Heterobasidiono annosum, Phellinus pini, Mycosphaerella pini, Cenangium ferruginosum*

15 Monitoring the status of forests in Montenegro according to the ICP for forests (International Cooperation Programme for Monitoring the Status of Forests in Europe)

16 Monitoring the status of damage to forests in Montenegro according to the ICP forest programme (International Cooperation Programme for Monitoring Forest Status in Europe).

On the basis of the above data it can be concluded that forest stands at monitoring station locations at level I were in a stable state and that any damages was within the range of normal changes within the dynamics of harmful insects and fungi.

Harmful insects, as poikilotherm animals, are very sensitive to any changes in the environment. According to knowledge acquired so far, warming will influence this in terms of increased food consumption, development stadiums, length of the generation, mobility of insects and their distribution, which will mean a higher level of danger for forest resources. In parallel with the accelerated metabolism of insects during vegetation their mortality will decline as a consequence of milder winters.

According to the Initial National Communication of Montenegro on Climate Change to UNFCCC, i.e. according to the regional climate EBU-POM model, existing temperature changes range between 0.1-1.0 ºC, while some scenarios for the period up to 2100 envisage changes of up to 4.8ºC These values are much greater than the ones that are needed for changes in areas and gradation to occur[17].

However, it must be emphasised that insects and diseases are just one part of the ecosystem and that the changes that relate to insects will certainly cause a larger number of changes within the entire complex system. The insects that spend winter in litter will face a higher mortality rate if the level of snow cover falls. At the same time, changes related to increases in the number of insects will influence their predators and the parasitoids that can control the number of the most important gradogenic insects[18].

Climate change will probably cause an increase in the growth of fungal organisms as well as an increased level in reproduction capacity. It will bring about changes in infections and in wintering. Changes in the physiological condition of hosts will have an indirect impact on the life cycle of fungi, on their spread and, of course, on the distribution of primary and secondary hosts. There will also be some changes in the resilience of certain local host populations to pathogens. Similar processes happen when new pathogens are brought into areas where they were not present before; consequently there are no populations resilient to the host due to the intensive death of sensitive individuals. In the end, it cannot be forgotten that certain pathogens play a role in the improvement of diversity in phytocenosis since they eliminate certain types or individuals and create space for the development of other resilient species.

Organisms that have the capability to wait for the right time - opportune organism (Armillaria and Heterobasidion species), will benefit the most from the forthcoming climate changes. Insects, as organisms that depend on temperature, will have better conditions for their development due to the warming process (e.g. increase in the number of generations). The dying out of trees, due to climate changes, will lead to an increase in the population of saprophyte fungi, and of insects that feed on dying and dead matter. On the other hand, a greater growth (increase in CO_2) and longer vegetation periods will make it possible for the trees to fight diseases and pests more actively.

In Montenegro, pests and diseases appear in small amounts and mostly lead to the degradation of individual trees or smaller groups of trees. The pathogens that are more intensive are conditioned by changes in temperature and precipitation, i.e. by their impact on physiological condition of trees. However these more frequent appearances of gradogenic types of insects (like gipsy moth and bark-beetle) lead to the significant weakening of the physiological condition of trees, which over a longer period of time can cause the degradation of significant surfaces in forests.

Forest Fires

The occurrence and intensity of fires is directly dependant on the climate that prevails in a certain area, i.e. on the occurrence of maximum daily temperatures and the length of dry periods. Given the ecological and economic

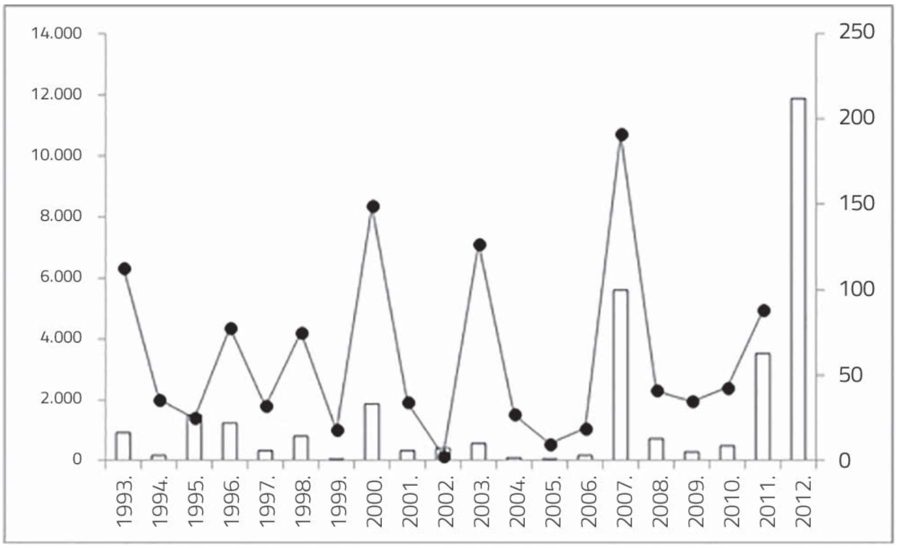
17 Insect gradations - a mass appearance of certain types of insects in a large territory, followed by large economic damages.
18 Gradogenic insects - insects that come in gradations.

damage they produce, forest fires can be described as the most serious threat to forest ecosystems in Montenegro. Although they currently destroy about 0.5% of the total surface of forests annually, they could pose a serious threat in the future, particularly in forests in the south forest zone that stretches from the coast to the karst area as here it is difficult to access and extinguish fires.

The number of fires varies from year to year. During a period of 19 years (1993 - 2011) there were a total of 1,444 registered fires that ignited the surface of 19,173 ha, while the burnt wood volume was assessed to be 352,340 m^3. The average number of fires per year was 60, and about 18,500 m^3 of wood was burned. This means that 2.3% of forests were ignited during the observed period. In 2012 a total of 11,858 ha caught fire and ~500.000 m^3 of wood volume was burned, while the loss of yield was estimated as being around 500,000 m^3. Damage worth approximately 4,268,099 € occurred and represented a 30-year loss in yield. The material damage is much larger if we costs are also included for loss of quality, extinction and sanation. The ecological damage is two to three times higher. The number of fires during the period researched (1993-2012), both in number and in area, pose a key threat to forest ecosystems. Their frequency and intensity are directly linked to maximum temperatures and longer dry periods. On the basis of the analysis of fires in the Mediterranean area, it can be concluded that fires will become more frequent in the future and that the damages they cause will be more significant.

The observed period is not yet sufficient to show a clear trend regarding the occurrence of fires. The only conclusion that can be made is that there are years that provide more favourable conditions for fires, like 2007 or 2011 (Graph 4.29) and that in those years, fires develop over large surface areas and cause significant economic damage. More precise conclusions would require a deeper analysis of the causes of fires and of the ecological, primarily climatic, factors that were present in the specific areas.

It can still be concluded, however, that forest fires pose a particular risk that is on the increase as the intensity of climate change increases.



Graph 4.29 Number of forest fires and surfaces ignited by fires during the period (1993-2012) in the territory of Montenegro. The dots (•) show the number of fires, the pillars (▯) show the surfaces ignited.

Impact of Climate Change on the Distribution and Growth of Forests

Together with orthographic[19] and edaphic factors[20] climate factors define the habitats of both forest trees and other tall plants. For some tree types that show certain indifference to orthographic and edaphic factors, cli-

19 Orographic factors include the relief features: allevation above the sea, inclination of the terrain, level of indentation of relief, ect.
20 Edaphic factors include the physical, chemical and biological features of the land and rocks the land is developed on.

mate factors largely define their growth and distribution. The observed extreme weather and climate events and the identified changes in the basic climate parameters during the period 1949-2010 could, in the long run, have a negative impact on the distribution and growth of the largest number of key types of forest trees in the territory of Montenegro.

Quality and quantity of wood volume, i.e. the level of vitality and resilience of forests to negative impacts directly depends on their structure and on the types of trees and on optimum mixes in mixed forests. These are the key parameters for the vulnerability of individual trees and ecosystems, as well as for the intensity of reactions to negative impacts caused by physical moves and extent to which certain tree types have spread.

In order to analyse and project the impact of climate change on the future distribution and growth of key tree types, the regional climate model EBU-POM and biometeorological indices were used. The Ellenberg climate coefficient (EQ) and FAI index are scientifically verified indicators used for the assessment of the long-term impact of climate factors and climate change on the distribution of individual types of trees.

The Ellenberg index showed unreliable results for the territory of Montenegro. The problem was due to the fact that the areas that have a Mediterranean climate, and which represent the largest part of Montenegro, have large amounts of precipitation outside of their vegetation periods; thus this does not have any direct impact on the growth of forest trees and the values of the Ellenberg index are therefore systematically reduced.

The FAI index[21] proved to be a much more objective index for the assessment of the potential spread of key tree types in the area that has a Mediterranean climate. Its value is obtained as a ratio of the average temperatures of the warmest months in a year (July and August) and the sum of precipitation during the vegetation period (May-August), so that the highest levels of precipitation that occur outside the vegetation period do not influence the FAI index at all.

Calculations of the Ellenberg and FAI indexes were done using the data of mean monthly temperatures and monthly precipitation figures taken from 21 meteorological stations in Montenegro for the baseline period (1961-1990). The data from the National Forest Inventory was used to assess the accuracy of the current distribution of the key tree types.

On the basis of the distribution of the FAI index, value for the baseline period (1961-1990) were set regarding upper and lower limits for the potential distribution of key tree types (beech, spruce, silver fir, black pine and Aleppo pine) and a group of oak species (Table 4.14.).

Table 4.14 Upper and lower limits for the potential distribution of key tree types and groups of oak species

FAI index	Beech	Spruce	Silver fir	Black pine	Aleppo pine	Prim. Oaks	Pubescent oak	Sessile flowered oak/ Hungarian oak/bitter oak
Lower limit	2,50	2,49	2,45	2,97	2,80	4,90	3,45	3,00
Upper limit	5,70	4,52	4,51	6,10	4,10	10,80	10,00	10,00

The lowest variation spread between the set limits was the Aleppo pine, which means that it grows in very similar climatic conditions in Montenegro; the greatest variation spread was the black pine and oak, which means that they grow in very different climatic conditions.

With a view to predicting the impact of climate change on the distribution of species, the FAI index was calculated on the basis of climate data taken from scenarios A1B for the time periods 2001-2030 and 2071- 2100 and for scenario A2 for the time period 2071-2100.

21 FAI=100*$_{TVII-VIII}$/(P_{V-VII}+$P_{VII-VIII}$); where: $T_{VII-VIII}$–mean monthly temperatures for July and August, PV-VII–total amount of precipitation for May, June, and July, and $P_{VII-VIII}$–total amount of precipitation for July and August.

According to scenario A1B for the period 2001-2030, it was established that there would be no significant change in distribution for any of the analysed tree types in comparison to the baseline period (1961-1990). However, on the basis of further analyses and projections it can be concluded that the potential climate change by the end of the 21st century will have a very different impact on key tree types in Montenegro.

The climate change is expected to have a negative impact on the distribution of most of the key tree types in Montenegro. This primarily refers to the distribution of spruce (Figures 4.7 and 4.8), silver fir (Figures 4.9 and 4.10) and Aleppo pine. It can be expected that the climate change will have a negative impact on the distribution of these types of trees on larger surfaces, primarily in the furthest eastern part of Montenegro, in the territory of lower Prokletije, Mokra Planina, Hajla, Suva Planina, Mokra Gora and in all the mountain areas north of Berane and Rožaje. It can also be expected that these species will become endangered in larger lower mountain areas around Pljevlja. Conversely it is possible that certain tree types will spread such as: spruce, silver fir and Aleppo pine in the mountain pasture areas of the high mountains (Maglić, Volujak, Bioč, Planina Pivska, Durmitor, Ljubišnja, Sinjavina, Maganik, Bjelasica, Komovi, Prokletije, Hajla, Mokra planina). Here, other habitat conditions are favourable, primarily the quality of the soil.

On the basis of the projections, beech will preserve the largest part of its current area, with the exception of in some border habitats like the areas of Rumija, the coast and Polimlje (Figrues 4.11. and 4.12.). There is a possibility of beech spreading into the mountain pasture areas[22] of the high mountains where other conditions are favourable, primarily the quality of the soil. Generally speaking, the territory of Montenegro will not see any significant reductions or increases in the surfaces covered by beech forests if the existing climate predictions materialise.

Black pine and the oak types analysed will become endangered in small parts of their current coastal habitats (black pine in the entire area, and oaks in the region north-west of Ulcinj). Conversely, it is possible that they will spread to cover broader regions of the continental part of Montenegro and may well dominate over beech, spruce, silver fir and Aleppo pine.

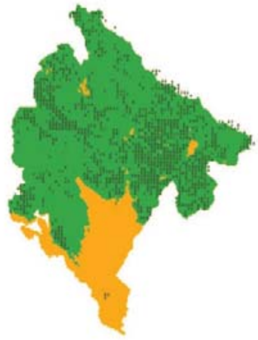
Figure 4.7 Spruce spread estimate (2071-2100 A1B)

Figure 4.8 Spruce spread estimate (2071-2100 A2)

Figure 4.9 Silver fir spread estimate (2071-2100 A1B)

Figure 4.10 Silver fir spread estimate (2071-2100 A2)

21 Mountain pastures (suvati) are areas of high mountains that are above the upper limits of the spread of forest trees and that are frequently covered in dense grass vegetation.

	
Figure 4.11 Beech spread estimate (2071-2100 A1B)	Figure 4.12 Beech spread estimate (2071-2100 A2)

The green area shows the potential spread of the analysed species as becoming dominant or admixed species, while the yellow area shows where the analysed species will not appear either as dominant or as admixed species. When looking at the map, map attention should be paid to the overlap of the yellow areas and the exemplary surfaces of the National Forest Inventory (dark green spots); these areas may potentially suffer from the highest level of endangered tree types when considering the future spread of analysed tree types.

Adaptation of Forest Ecosystems to Climate Change

Measures of adaptation have to be in line with strategic and regulatory forestry documents in Montenegro. The key strategic and regulatory (law) forestry documents that define the development of forests as a natural resource and forestry as a branch of the economy and that analyse aspects of climate change and define measures for its mitigation include the Law on Forests (2010), the National Forestry Policy of Montenegro (2008), the Operational Criteria and Indicators of Sustainable Forest Management in Montenegro (2011) and the strategy which plans the development of forests and forestry – the National Forestry Strategy (2014). Planning documents have also been defined (Plan for the development of forests, programmes of forest management and the implementation plan) that are used for planning the usage of forests and for establishing guidelines for managing forest resources.

A synthesis of the measures for the adaptation of forests to climate change, as proposed in the strategic forestry document in Montenegro, provides the conclusion that most of the measures relate to the future management of forests. In essence, the method of management is also a basic instrument that can be used in forestry management to alleviate the negative impact of potential climate change as envisaged in the various climate models.

Regarding the contents of the key documents that regulate the forestry sector in Montenegro along with the existing research findings, Montenegro has defined its measures for forestry management that will alleviate the negative impact of climate change on its forests. Table 4.15 shows a summary of the findings.

4.4.5 Coast and Coastal Area

Another consequence of global warming is a rise in sea level. There are several causes of this, the primary cause being the thermal expansion of water due to sea temperature increases (Gregory et al., 2001). According to the last IPCC report (IPCC 2007, Chapter 10), 75% of the projected sea level rises by the end of the century will be as a consequence of the thermal expansion of water, while 25% will be caused by the melting of glaciers and ice fields (Arctic, Antarctic, Greenland).

In addition to rising sea levels and the melting of the glaciers, an increase in sea temperature will influence sea ecosystems, fish, aquaculture, the level of damage to algal bloom, the threat to human health from epidemiological bacteria, and the development of pathogenic bacteria that have a negative impact on human health.

Rising sea levels will be particularly significant in terms of flooding, the erosion of the coast and the loss of the flat areas of karst like Ada Bojana in the furthest south-eastern area of the Montenegrin coast. The rise in sea level will also increase the probability of storm waves, the penetration of salty water into the land and the endangerment of coastal ecosystems and marshlands.

High flood risks do not only threaten natural systems, but also human lives, property, tourism, the infrastructure and transport etc. On a global level the projections for rising sea levels during the 21st century, mostly deemed to be due to the thermal expansion of the ocean, range between 9 and 88 cm.

The two-year CAMP project[23] will, by the end of 2013, result in the development of an Integrated Coastal Zone Management Plan for Montenegro (ICZM). This will be compatible to the National Integrated Coastal Zone Management Strategy, the drafting of which is planned in parallel with the implementation of CAMP. The key results of the ICZM plan will include a proposal for a model to develop an institutional structure for integrated coastal zone management with clearly defined responsibilities and showing the requirements for institutional development.

The study within the CAMP project that deals with climate change impact and vulnerability to climate changes includes an analysis of increases in sea level along the Montenegrin coast. The analysis used global projections according to IPCC, but without using the technique of downscaling to a regional level. These projections are based on semi-empirical methods. A digital terrain model (DTM) was used and the impact of storms (cyclones) and storm waves was not taken into account.

Four possibilities for a rise in sea level have been analysed for scenarios A1B and A2 up to 2100; various projections of sea level rises were taken into account. The thermal expansion of the sea was also taken into account, along with the melting of glaciers and the highest local sea levels recorded during the period 1978-2013.

On the basis of these comprehensive analyses, two key recommendations were given in terms of estimating the size of flood plains and to assess the vulnerability of the Montenegrin coast:

1. To apply a figure of 96cm, currently and in the near future, in terms of calculating the coverage of potential flood plains (Image 4.13.). This projection matches mareographic data provided by the Institute for Hydrometeorology and Seismology, measured at the station in Bar, where rises in sea level have already been recorded as being 69 cm during storms (cyclones), i.e. 96 cm if we take into account the calibration of the sea level in comparison to the normal zero of Trieste which is 27 cm.
2. For the purposes of assessing vulnerability of an area in terms of the expansion of coastal delineation, the CAMP project recommends, as the most realistic and the most probable, a scenario according to which the sea level rise is projected to rise by 62 cm (Figure 4.13) by the end of the 21st century. This recommendation should be applied to all spatial plans, including short term planning, particularly in the context of the fact that urbanization plans are placing a high level of pressure on the environment.

The results show a correlation between the possible flooding of locations due to rises in sea level and the intensity of flooding on one side, and the impact of storm winds in real time, i.e. by applying real data on the other side. Thus, the possible locations that, according to the CAMP project, can be indicated to as the most vulnerable include:

- the areas represented by measurements at the meteorological stations in Herceg Novi, Bar and Ulcinj;
- Buljarica Lagoon, Jaz Lagoon, Sutorina River Delta, Solila and Kotor (particularly the southern part), Čanj Lagoon, Ulcinj Beach and the Bojana River Delta to the Porto Milena Channel;
- Coastline of Montenegro's open sea because it does not have any natural protection from waves in the form of island chains and underwater cliffs, and
- the major part of the Boka Kotor Bay

23 http://www.camp.mrt.gov.me/index.php/o-camp-u

Experience from the CAMP project shows that there is a small amount of available and high-quality data and that there is a need to establish local meteorological, hydrological and hydrographic observation programmes as a basis for risk assessment and for the development of a plan to mitigate the consequences of a changed climate.

In terms of the risk assessment of the coastal area and mitigation due to climate changes, the CAMP project corresponds to the integrated THESEUS project financed by the European Commission.

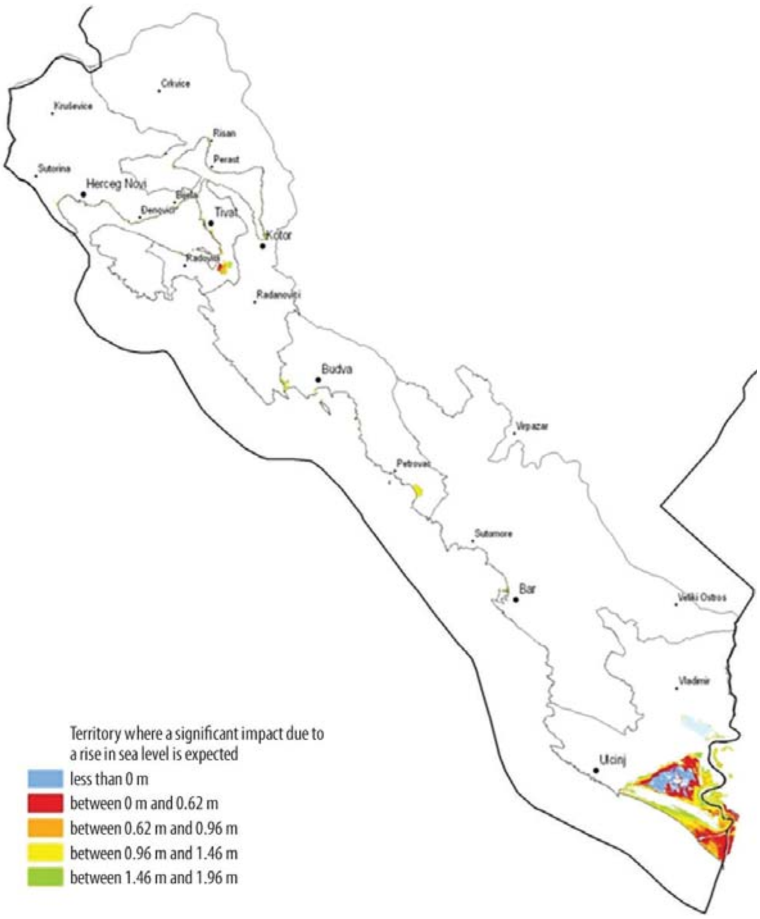


Figure 4.13 Sea level rise

Basic Features of Small Watercourses along the Montenegrin Coast

The Montenegrin coast is a basin for about 70 currents and channels, 40 of which are active. The surface of the basin for the currents amounts to about 350 km^2. The watercourses' flow regime is characterised by a large amplitude of flow and water level, which is manifested in the long periods with low water levels and a lack of flow, as well as by short-term heavy flows due to heavy precipitation. Extreme precipitation causes an overflow of water from the watercourses which in turn cause short-term floods. These floods belong to a category of flash floods and are characterized by flood waves, the response-time of which is 6 hours from the occurrence of intensive precipitation.

Specific hydrological features of the Montenegrin coast are reflected in numerous occasional and permanent watercourses, as well as a lack of basic hydrological parameters in a large number of watercourses have led to the development of a study of key characteristics of small watercourses along the Montenegrin coast. The initiative arose due to a lack of hydrologic data, pressure on water resources and the absence of a unique data base regarding activities associated with these water courses; the study aims to create a picture of the current situation in the watercourses and to create appropriate conditions for the high-quality management of this resource, bearing in mind expected climate changes and their influence on water levels in these temporary watercourses. In order to achieve this, Montenegro analysed 42 watercourses in the territory of 6 coastal municipalities. These watercourses cause damage during periods of extreme precipitation (Image 4.14). Most of them have flooded the area over the last ten years during times of heavy precipitation.

Through the analytical and comparative methods that were combined during the development of the study, the results were analysed and all of the parameters relevant for the territory were presented. An analysis that defines the catchment areas of all of the small watercourses along the coast has been conducted, as well as an analysis of their basic physical-geographic characteristics; this is a first step and forms the basis for the future activities of protection from water along the Montenegrin coast as well as creating conditions for the high-quality monitoring of changes in the water of this region. The study shows the importance of the watercourses in the areas through which they flow as well as the urban zones and bathing areas that they affect. The key physical-geographic characteristics that were analysed in the study include: surface, scope and basin length, maximum and minimum basin levels, medium basin dimensions and the air distance between the centre of basins and the delta.

The analysis delineated all of the small watercourses and included definitions of the basin areas along with their key physical and geographic characteristics; this provides a basis for future activities regarding the protection of high water levels and for the protection of water along the Montenegrin coast. It also enables the creation of conditions for the high quality monitoring of changes in the water in this area.

The analysis covered 42 small watercourses along the Montenegrin coast. It presented the watercourses that, on the basis of our knowledge, are important in terms of the territory through which they flow. Attention was paid to the watercourses that flow into the sea via urban communities and bathing areas.

The contents of the study are useful for monitoring, planning and managing watercourses both at a local and at a national level.

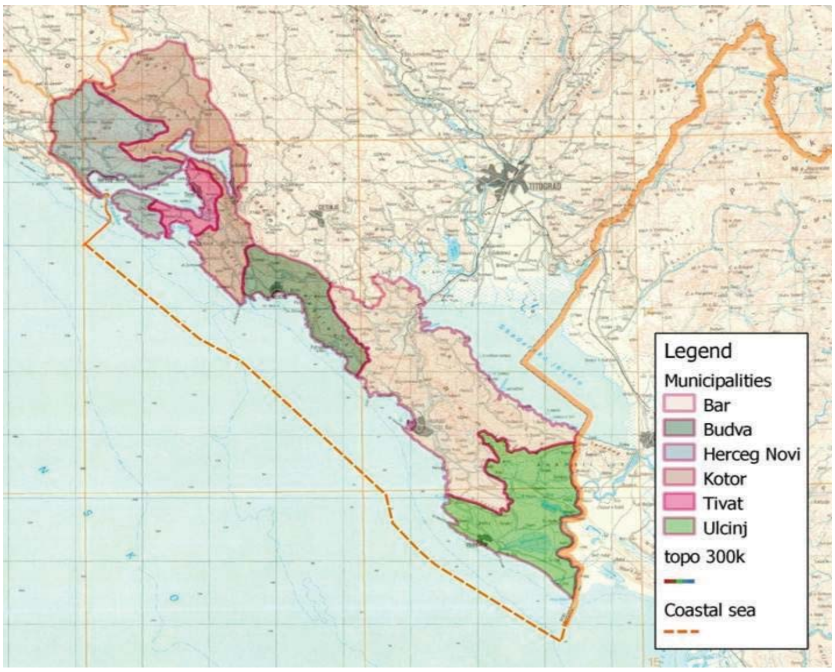


Figure 4.14 Coastal municipalities in which the delineation of small watercourses was carried out

4.4.6 Health

As stated in the Initial National Communication on Climate change to UNFCC, there is no reliable data on the impact of climate change on human health, as this data has not been integrated with compulsory health records. The Second National Communication, however, supports the strengthening of this capacity and consequently has put forward a proposal to introduce bio-forecasting in order to quantitatively assess the impact of weather and climate on human health in Montenegro.

It is important to establish such a system of bio-forecasting and this is supported by both direct indicators (e.g. more frequent heat waves, floods, droughts, forest fires) and indirect indicators (increased frequency of food- and water-borne diseases, allergy and other respiratory tract diseases caused by pollen, particularly in children; more frequent heart attacks and strokes due to low air pressure, large fluctuations in temperature and sultry days).

The aim is to prevent and adapt to changes in climate; with the support of a bio-meteorological forecasting system, Montenegro will establish a database which provides data on the impact of weather and climate on morbidity and mortality in Montenegro. Two ways of collecting data have been defined: using questionnaires with questions about meteoropathic reactions and using a list of specific diseases that are affected by weather. All of the collected data will be archived and analysed by the Public Health Institute of Montenegro (PHI). At the beginning, data collection and research will only be carried out for the capital city of Montenegro, Podgorica.

In addition to this, in order to inform the public and to raise the awareness of the general public about the impact of heat waves on the health of general population and vulnerable groups (children, the elderly, persons with chronic illnesses, pregnant women), PHI implemented a public campaign in July 2013 with the support of the Government of the Republic of Germany through the office of the German organization for international cooperation (GIZ) in Montenegro and in cooperation with the Institute of Hydrometeorology and Seismology and the Red Cross of Montenegro. Figure 4.15 shows one example from the campaign: a leaflet which contains recommendations for the protection of the elderly from high temperatures. This leaflet was distributed during the campaign. All of the materials are available at the Public Health Institute website: www.ijzcg.me.

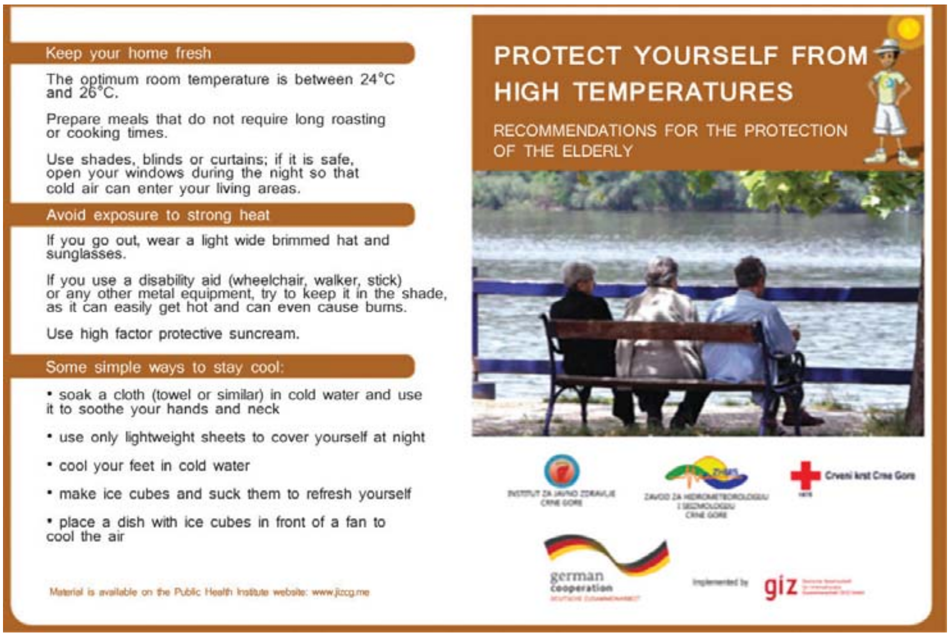


Figure 4.15 The cover page of the leaflet on the protection of the elderly from high temeperatures – Source: www.ijzcg.me

Upon the preliminary announcement of the possible continuation of cooperation in the field of climate change by GIZ, the Public Health Institute, with the technical assistance of WHO made a project proposal aimed at the following:

- conducting a study to assess the vulnerability of the health sector to climate change;
- preparing and composing a draft national strategy for the adaptation of the health sector to climate change on the basis of the results of the vulnerability assessment;
- developing a national action plan for heat waves and
- implementing new activities with a view to improving the adaptation of the health sector to climate change.

IAt the local WHO office a round table meeting on climate change and health was organized in December 2013 in Podgorica. It was attended by representatives from the relevant institutions in the country and by experts in the field of climate change and health from WHO.

4.4.7 Urban Areas

There is one fact that is very obvious: through their activities human beings have modified the climate on a local basis in cities (e.g. due to an increasingly large number of surface covered in pavements and concrete buildings, the daily accumulation of heat in cities is higher than in an environment with grass; there is larger surface drain off during precipitation, there is higher air pollution etc.) City climate and the impact of climate change in urban areas have not been thoroughly studied in Montenegro to date.

A step forward in this field is the GIZ project "Climate Change Adaptation in Urban Areas in the Western Balkans", where, in addition to the capitals of Serbia, Macedonia and Albania, the project has also analysed the urban structure of Podgorica, the capital city of Montenegro, its climate, the so called "islands of heat", its future climate projections, its potential adaption measures, and its recommendations for support by GIZ in terms of adaptation measures.

4.5 Recommended Adaptation Measures by Sector

Table 4.15 Recommended adaptation measures by sector

Water resources	**Efficient water management and the introduction of a water information system** • Strengthening the network of measuring stations for monitoring hydrology and meteorology in Montenegro is necessary; • There is a need for better coordination between the government, the Environment Protection Agency and the Institute of Hydrometeorology and Seismology in order to ensure the development of a system of quality national water archives to store and make available data; • There is a need to encourage relevant agencies to use GIS tools and to identify all GIS needs relating to the environment in Montenegro; • There is a need to harmonize data set standards and to clearly define responsibilities and "ownership" regarding specific sets of data, as well as defining procedures for controlling data versions managing data exchanges between institutions; • Exploring ground water in Montenegro and carrying out GIS mapping of hydrogeological boundaries of ground water used to supply water; • There is the need for a water information system; options for the implementation of a better software information system for a water/cadastre should be considered (e.g. WaterWare, WISYS or WISKI) and decisions should be made about the structure of an information system for a water/cadastre.

Agriculture	• The impact of climate change on agriculture and on various cultures should be researched; • Breeds and hybrids of different ripening periods should be introduced in order to avoid the least favourable parts of the year; • Irrigation and drainage systems are needed to regulate the content of water in root systems; • A reduced level of cultivation is necessary as well as deep cultivation, covering the surface with harvest remains, changes in the density of sowing and planting, with a view to preserving certain levels of moisture in root systems; • The early application of pesticides and insecticides is necessary; • Changes should be made in the use of fertilizers, i.e. their quantity and time of application; • A more flexible agriculture system should be established in order to reduce climate change consequences; • A national forestry management policy is required.
Livestock breeding	• Montenegro needs to carry out research on the impact of climate change on livestock breeding and on which regions are best for certain breeds and types of livestock; • In livestock breeding attention should be paid to breeds that are less sensitive to warmer weather and to possible thermal stress; • Adequate conditions for growing plants in new climate conditions should be ensured and new technology should be used. It should include direct management and should focus particularly on systems for ventilation, the control of temperature and humidity in buildings; • Advisory activities should be organized with a view to educating producers to apply new techniques; • With a view to preventing or slowing down climate change, proposals should be made for the construction of pits and digestors in farms; these would use fertilizers from the production process as biomass for energy generation - composting waste on farms; • Material support should be given to research programmes.
Forestry	Measures for forest management: • Nature friendly forest management should be the basis for the stability of forest stand; • Increase in the share of high natural forests in comparison to the low-productive ones; • natural regeneration as the basis for forest growth, adequate support through afforestation if the natural process of forest regeneration fails; • indigenous tree types should be used in afforestation; • Encouragement of a mixed forest stand, particular attention should be given to the preservation of selected stands of beech, silver fir, spruce (stands of various ages); • Preservation of the forest genofund, particularly through the protection of key habitats and varieties, and of trees, plants and animals. Organisational and technical measures: • Fire-protection measures should be developed (with an emphasis on prevention and fast response in the case of fire); • Work on the improvement of logistics for fire extinction: road infrastructure, fire breaks, the removal of easily flammable material from forests; establishment of hubs with fire extinguishing materials, closer control of activities in forests during dry periods; • Re-establishment of forest order after harvesting; adequate and timely rehabilitation of surfaces damaged by fire; • Adequate reporting-forecasting services for forest protection, establishment of ecological indicators indicating current changes in forest ecosystems.

Coast and coastal area	**CAMP - Recommendations for the size of the flooding zones and the vulnerability of the Montenegrin coast:** • Regarding flooding zones, in the present and in the near future, Montenegro should assume that the sea level will rise by 96 cm; • In terms of assessing areas regarding coastal delineation, the CAMP project should recommend, as the most realistic and the most probable, a projection of a rise in sea level of 62 cm by the end of the 21st century **Analysis of small watercourses in the Montenegrin coastal region** • Further analyses of high waters in watercourses in the Montenegrin coastal region are required; • Mapping of surfaces endangered by high waters is needed, as well as an analysis of options enabling the hydrological service of IHSM and the relevant municipal services to organise and monitor networks in priority watercourses; • Particular attention should be paid to defining the erosion potential of these watercourses, both due to the protection of the sediment and due to the possible impact of this sediment on the preservation of beaches in the Montenegrin coastal region.
Health	• Implementation of bio-meteorological forecasting is necessary in order to ensure early warning about the favourable or unfavourable impact of weather on human beings, particularly on people with chronic diseases; • It is necessary to establish an early warning system for heat waves and periods of cold weather; • It is necessary to implement the bio-classification of various weather conditions, to collect data and to archive it; to collect data from questionnaires on bio-meteorological responses and also from ambulance service records for diseases linked with biometeorology. The Public Health Institute should collect, sort and analyse data and together with the IHSM it should work on its validation.

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5. POLICIES, MEASURES AND ESTIMATES OF THE REDUCTION IN GHG EMISSIONS

The key goal of the analysis of the reduction of the emission of greenhouse gasses is to assess the potential to which climate change impact can be alleviated at a national level in line with economic development goals. This goal will be implemented through the recognition of appropriate measures, practical examples, projects and/or interventions in all sectors where GHG emissions can be reduced and that can be implemented during the period 2014-2020. In addition to this, historical GHG emissions are presented on the basis of the GHG emissions inventory for the period 2008-2010. Projections of GHG emissions were made with the help of methodology adopted by the Secretariat of the UNFCCC Convention, taking into account all of the relevant official documents (those adopted and those that are still in the adoption procedure) in the sectors that are of major importance for the reduction of GHG emissions (energy sector, industry, agriculture, forestry and waste). In line with methodology, the reduction estimates for GHG emissions were done separately for the energy sector and non-energy sectors (industry, agriculture, use of land, changes in the use of land, forestry and waste).

The chapter "Policies, Measures and Estimates of the Reductions in GHG Emissions" includes:

1. a detailed insight into the adopted (and draft) sectoral strategy development plans, with a view to recognizing the possibilities for reducing GHG emissions and to implement their analysis on the basis of various scenarios. Proposed measures for a reduction in GHG emissions include the use of technology that has been commercially recognized and has already been applied, and that is already available and has been recognized in the market;
2. an overview of key sectors that emit GHG: energy, industry, agriculture, use of land, changes in land use, forestry and waste, that are the anthropogenic sources of GHG emissions or sinks;
3. an analysis of previous GHG emissions on the basis of the national inventory of GHG emissions for the period 2008-2011, on the basis of which a model has been "calibrated" to obtain the projections of GHG emissions in line with various scenarios defined in advance;
4. projections of GHG emissions, according to pre-defined scenarios for the period 2014-2020 that are based on presumptions regarding economy growth rates that have been applied to various strategies used in the development of the document (e.g. Economic Development Strategy 2030). The predicted reduction in GHG emissions would influence the alleviation of the impact of climate change and would consequently influence social and economic factors;
5. recognising possible obstacles and uncertainties that could prevent the effectiveness of the implementation of proposed measures to reduce GHG emissions. The afore-mentioned obstacles and uncertainties made the work on the analysis more difficult and increased the uncertainty of the estimated projections of measures.

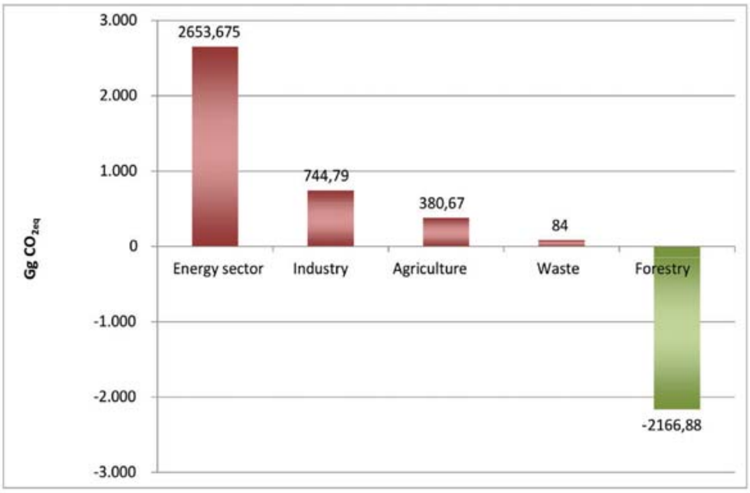
One of the largest obstacles identified during the course of work in the analysis related to the uncertainty of the situation in the largest industrial plant in the state, as well as the non-existence of a strategic framework for production in the sector of agriculture.

The national inventory of GHG emissions for the period 1990-2011 clearly shows that the energy sector is a key source of GHG emissions (dominantly CO_2). This is actually the result of electricity generation and the use of energy products in industry and transport. The second most important source of GHG emissions (synthetic gasses) is the industry sector. The above indicates that efforts to reduce GHG emission should primarily be focused on these two sectors. Table 5.1 shows GHG emissions and sinks by key sector in 2011.

Montenegro has great potential for using renewable energy sources for electricity generation. This potential comprises primarily small watercourses, wind, sun and biomass. This potential is represented in Table 5.2 and would contribution greatly to a rapid reduction of GHG emissions into the atmosphere.

Table 5.1 GHG emissions and sinks by sector in 2011 - Source: GHG inventory (Environment Protection Agency)

Emissions (sinks) of GHG (Gg) / sector	CO_2	CH_4	N_2O	CF_4	C_2F_6	CO_{2eq}
Energy sector	2.526,93	4,205	0,124			2.653,68
Industry	158,79			0,076	0,01	744,79
Agriculture		9,27	0,6			380,67
Waste		4				84,00
Forestry	-2.166,88					-2.166,88



Graph 5.1 Emissions and sinks of GHG for 2011

Table 5.2 Potential for using renewable energy sources for the generation of electricity - Source: Economic Development Strategy 2030

Theoretical hydropotential	Technical hydro-potential
Main watercourses: 9.8 TWh 1)	Main watercourses: (3.7-4.6) TWh 2)
Smaller watercourses: 0.8-1.0 TWh	Small watercourses: 0.4 TWh
Total: 10.6 – 10.8 TWh	**Total: (4.1-5.0) TWh**
	Technical wind potential (on the continent)
Theoretical potential of the sun radiation	900 GWh/god
20 PWh/god	
	Technical potential of biomass
	389 GWh/god – wooden biomass
	580 GWh/god – agricultural crops
	57 GWh/god – plant and animal remains

Note: Major watercourses that are ideal for the construction of large hydro-power plants: Tara[24] *(2.255 TWh), Zeta (2.007 TWh), Morača (to Zeta) (1.469 TWh), Lim (1.438 TWh), Piva (1.361 TWh), Ćehotina (0.463 TWh), Mala Rijeka (0.452 TWh), Cijevna (0.283 TWh) and Ibar (0.118 TWh) without transfer, with transfer 22.2 m^3/s from Tara to Morača (4.6 - 5.3) TWh.*

24 Parliament of the Republic of Montenegro adopted on 14th December 2004 the Declaration on the Protection of the Tara River. According to this declaration, a solution for future improvement lies in electricity sources that will not disturb the balance of nature, and that will not cause any dramatic commercial loss

Renewable energy sources are the best and the fastest way to reduce emissions of GHG into the atmosphere. These emissions are mostly produced through the combustion of fossil fuels in the production of electricity and thermal energy. In addition to this, better use of renewable resources would ensure:

- certain transfer to low-carbon economy
- reduced dependence on imported fossil fuels, which would increase certainty of supply;
- much lower environmental impact;
- generation of new "green" jobs;
- better energy mix.

Better insulation of residential and business buildings, better use of efficient appliances in households, more efficient heating and the cooling of premises and heating of sanitary water in all sectors, more efficient street lighting, and lighting in public and residential buildings, industry and services would significantly contribute to a reduced level of GHG emissions.

A reduction in the number of vehicles and in the size of vehicles, the intensity and manner of using motor vehicles and a transfer to alternative forms of mobility, greater use of biofuel, hybrid and electric vehicles or hydrogen powered and fuel cells vehicles, if widely used, would significantly reduce the overall level of GHG emissions. In that respect, it should be emphasized that the potential for reducing emissions through the use of hybrid and electric vehicles could be partly reduced depending on the way that electricity for their usage were produced.

In addition to a high level of consumption of fossil fuels, the associated industrial technological processes present a significant source of synthetic gas emissions, whereas it should be taken into account that the introduction of new technology could bring about a reduction in GHG emissions.

Agriculture is a significant source of methane and nitrogen sub oxide and therefore the treatment of animal waste, as well as a lower use of artificial fertilizers could potentially reduce the level of GHG emissions.

The capacity of carbon dioxide sinks in the land use sector, and changes in land and forestry use could be increased through the improvement of forest areas through sustainable management, increased initiatives for afforestation, repair planting and the tending of coppice forests, fire protection, and the sustainable and efficient use of wood in the processing industry. This strategy along with the plan for the development of forests and forestry, i.e. the national forestry strategy, indicate positive moves in this field.

An insight into the national inventory of GHG emissions in Montenegro concluded that the combustion of fossil fuels for energy is present in various sectors:

- electricity generation;
- production of thermal energy in industry;
- vehicles in transport;
- heating and other needs in services and households.

The second most dominant contribution to the total amount of GHG emissions in Montenegro comes from the emission of synthetic GHG in the production process at the aluminium plant (KAP). Since most of the GHG emissions are produced through the combustion of fossil fuels, it is clear that measures to reduce GHG emissions should be based on a reduction in the amount of fuel used. Ways in which this can be achieved include:

- rational energy use (saving energy);
- efficient energy conversion;
- using renewable energy sources (RES);
- using alternative fuels (including the ones from RES).

5.1 Methodology

The methodology requires reduction estimates for GHG emissions to be based on a minimum of two defined scenarios, for each individual sector: (1) basic scenario stating measures for the reduction of GHG emissions (BaU- business as usual) and (2) mitigation, with various levels of interventions in terms of the reduction of GHG emission levels in certain sectors. Scenarios for assessing GHG emissions include the same preconditions (the level of development, GDP, transfers of technology), on the basis of which official documents were prepared in key sectors for the reduction of GHG emissions. The base scenario for GHG emissions is characterised by a continuation current activities along with the political measures that partly support activities relating to a reduction in GHG emissions. In contrast to the base scenario, the scenario which assumes measures for the reduction of GHG emissions predicts the gradual introduction of measures that would lead to a significant reduction in GHG emissions.

During the process of developing a scenario for the energy sector, the drafters used Long-range Energy Alternatives Planning (LEAP) simulation software. It is inter alia designed for the assessment of the policies and measures in the energy sector that are necessary for the development of national reports in countries that are not listed in Annex I of the Convention. With the support of LEAP, the scenarios that are created simultaneously analyse the production and consumption of energy products, whilst paying particular attention to the calculation of GHG emissions according to IPCC methodology.

Future requests for energy-generating products have been projected individually for each of the sectors regarding final consumption (industry, transport, households and services).

Projections of GHG emissions in non-energy sectors (industry, agriculture, use of land, changes in the use of land, forestry and waste) were made using revised IPCC methodology from 1996.

After the scenarios were defined, calculations were made regarding the effects of the proposed measures expressed in GHG units started for the cases of application of the proposed measures, practical examples, projects and/or interventions. In the presented scenario it is desirable to propose measures, activities and projects that could lead to the reduction or limitation of the GHG emissions or enlargement of GHG sinks, particularly in sectors which do not have sectoral development plans, relevant data or relevant national studies, as is the case with the sectors of processing industry and agriculture.

The analysis that follows presents the estimated potential of a reduction of GHG emissions in Montenegro. This analysis should be continuously revised, taking into account all relevant events in the national economy. It is important to mention that the uncertain future of large industrial plants in the state has affected the accuracy of the analysis.

5.2 Sectorial Analysis

5.2.1 Energy Sector

Energy Policy

Based on its obligations as defined in the current legislative and regulatory framework and in accordance with the documents of the EU, the Energy Community, the World Energy Council and the International Energy Agency, and aware of the fact that the energy sector is a pillar of the overall, sustainable and long-term stable development of the state and clearly has a positive macroeconomic effect, the Government of Montenegro adopted its Energy Policy (EP) in 2011 by setting goals for developing the energy sector in Montenegro by 2030.

The EP defines three key priorities of the energy sector that are to achieved through the key established strategic commitments. The three key priorities in the process of development of the energy sector in Montenegro are:

- certainty of energy supply;
- development of the competitive energy market, and
- sustainable energy sector development.

On the basis of the set priorities Montenegro has defined twenty commitments, i.e. goals that will ensure the development of the energy sector within a set of defined priority directions, including the following:

- the maintenance, revitalization and modernization of existing services and the construction of a new infrastructure for the generation, transmission and distribution of energy on the principles of meeting international technical standards, energy efficiency (EE), reduction of losses and negative impact on the environment;
- a gradual reduction of dependence on energy imports (i) a reduction in the specific consumption of final energy, (ii) an increase in the generation of energy (primary and secondary) using own resources and (iii) a reduction in energy losses from the point of generation to final consumption. Montenegro plans to turn from being a net electricity importer, which it currently is, to a net electricity exporter by 2020;
- energy efficiency is a priority in the energy policy in Montenegro in terms of:
    a) ensuring institutional conditions and financial incentives for improving energy efficiency and a reduction of energy intensity in all sectors, from generation to final energy consumption;
    b) achieving a national indicative goal for increasing energy efficiency which represents a saving of 9% of the average final energy production in the country (without KAP) by 2018. The interim indicative objective by the end of 2012 amounted to 2%. Average annual savings after 2018 will be harmonized with targets set at a level comparative with that of the EC or the EU;
    c) a rational use of energy in transport also through the promotion of EE measures (improving public transport including the railway transport, promotion of energy efficient and low-emission vehicles, integration of the EE criteria into the projects of transport infrastructure).

Using renewable energy sources (RES) has been identified as a priority of the Montenegrin energy policy through:

- the creation of a favourable environment for the development and use of RES and for the achievement of a national target for RES in final national energy consumption figures;
- continued research on the potential of RES and other studies exploring the possibilities for using remaining available RES potential;
- increasing the share of RES use in transport, with a view to ensuring the achievement of the targeted share of RES within the total energy consumption figures in transport, in line with state commitments;
- the improvement of heating and/or cooling systems in buildings: (i) through the substitution of direct transformation of electricity into heat and (ii) by using new technologies that are acceptable in terms of environmental protection, which means using more RES and using highly efficient co-generation;
- the sustainable development of the energy sector in comparison to environmental protection and international cooperation in this field, particularly regarding the reduction of GHG emissions;
- encouraging research, development, transfer and application of ecologically sustainable new technologies in the energy sector; increasing investment in education and research projects and encouraging international cooperation in the field of environmentally sustainable new technologies in the energy sector, as well as introducing classes about the energy sector into the education system;
- the harmonization of the legislative-regulatory framework in line with EU requirements and ensuring support to develop and accelerate the implementation of programmes and projects using RES and to accelerate the implementation of energy efficiency measures, the substitution of energy products and the development of the local energy sector (combined production of electricity and thermal energy);

- achieving agreement with neighbouring states regarding optimum levels of exploitation regarding shared hydro potential and water management, as well as planning and constructing new interconnection lines for electric power transmission connecting Montenegro with these countries;
- achieving active international cooperation in the energy sector.

This document also defines the methods and measures for achieving these goals; these will be elaborated upon in more detail during the process of developing the action plan over a five year period (2012-2016).

By signing the Treaty Establishing the Energy Community, Montenegro committed to apply certain directives in the field of energy, i.e. electricity, gas, RES and EE, as well as in the field of environment and competitiveness. By adopting new directives in cooperation with the countries signatories and with the EU, the Energy Community makes decisions on extending the obligations to the new directives in these fields.

The Energy Law (Official Gazette of Montenegro, 28/10) was adopted in 2010. It defines in a better way the duties and rights of various agents in the energy sector and opens up possibilities particularly in the sector of renewable energy sources and regarding the implementation of the latest EU Directive 2009/28 EC.

Montenegro, as one of the signatories of the Treaty Establishing EC, is obliged to harmonize its legislation with EU directives in the energy sector. In the field of RES the most important directive is Directive 2009/28/EC on the promotion of use of energy from renewable sources. This directive is important because it defines individual national targets for all EU-27 countries. National targets are defined in such a way that the EU as a whole can by 2020 achieve a RES share of 20% in the final energy consumption figures.

National targets are set on the basis of a baseline year that was defined by EU 27 in a Directive from 2005. National targets can be separated into three components: targets for shares of RES in the final electricity consumption figures, targets for shares of RES in the final consumption of energy figures for heating and/or cooling and targets for shares of RES in the energy figures for transport.

In the X Ministerial Meeting the Energy Community obliged member states, including Montenegro, to implement Directive 2009/28/EC. At the same time it defined targets for shares of RES in the gross final energy consumption figures of 33% by 2020 for Montenegro. This target was defined on the basis of the methodology of the Directive and on the baseline year 2009.

The Energy Development Strategy of Montenegro up to 2030 (EDSM) was adopted in mid 2014. The new draft Law on Efficient Energy Use was published recently, as well as a set of adopted rulebooks that govern the energy efficiency of buildings.

Presumed Inputs for the Energy Sector

The analysis of the reduction of GHG emissions in the energy sector is based on the EDSM 2030 and takes into account all the forecasts and calculations from the strategy against the adopted baseline year, i.e. development planning of the electricity generation sector, development scenarios for consumption in all energy sub-sectors, energy efficiency measures and savings, as well as the demographic data and assessment of increases in GCP per capita. For the purposes of the EDSM drafting process, three basic scenarios for the development of key factors of energy consumption in Montenegro were analysed.

High Level Scenario

- Political context:
  - EU has the key initiative and the role in the permanent solution of the political issues in South-East Europe;
  - Strong institutionalization of Montenegrin society aimed at accelerated economic, but also environmentally and socially sustainable growth;

  - Montenegro will become an EU member in 2020;
- Development of the market and competition:
  - Globalization has a significant impact on market development;
  - Energy markets in the region are open and very active;
- Growth and structure of Montenegrin economy:
  - accelerated post 2015 economic growth;
  - economic growth based on the intensive development of the processing industry and the service sector;
  - growth of the processing industry is based on the production of durable goods;
  - agriculture is still an important sector in the economy;
- Energy Supply Certainty:
  - Contribution from the European area is significant;
  - By 2020 Ionian Adriatic Pipeline will be constructed;
  - Intensive use of RES and EE;
- Environment protection and climate change:
  - At a high level and at local and regional levels;
- Energy structure and technology:
  - Structure of final consumption will change: more higher-quality energy sources will be used: natural gas, heat from remote heating, electricity, motor fuels and less coal and firewood will be used;
  - More explicit influence of RES and EE;
  - Relatively low energy intensity in all consumption sectors in comparison to the medium and low level scenarios.

Medium Level Scenario

- Political context:
  - Montenegro becomes an EU member after 2020;
- Growth and structure of Montenegrin economy:
  - Growth and structural changes from the high level scenario are slower;
- Energy Supply Certainty:
  - Construction of Ionian Adriatic Pipeline before 2025;
- Energy structure and technology (compared to the High Scenario)
  - slower introduction of RES and EE;
  - slightly higher energy intensity in all consumption sectors in comparison to the high level scenario;

Low Level Scenario

- Political context:
  - EU is slower in undertaking determined and clear decisions;
  - Montenegro becomes an EU member after 2025;
- Development of the market and competition:
  - slower and structurally oriented to energy intensive industries of basic materials;
  - dominated by small entrepreneurs;
  - energy markets are formally liberalized, but their realistic openness and efficiency is low;
- Growth and structure of Montenegrin economy:
  - growth and structural changes from the medium level scenario are slower;
- Energy supply certainty:
  - Ionian Adriatic Pipeline not before 2030;
- Environment protection and climate change:
  - Area that is insufficiently present in international and national initiatives;
- Energy structure and technologies:
  - Energy intensity is at the highest boundary level for an area demonstrating characteristics typical for transition and development countries.

Size of Population and GDP

The size of the Montenegrin population is expected to grow from 629,603 in 2010 to an approximate 645,000 in 2020, while the GDP of 2,414 EUR_{2000} per capita in 2010 is expected to grow to about 4,000 EUR_{2000} in the medium level scenario by 2020.

Types of EE Measures and Timelines for Their Introduction into Energy-Consumption Sectors

The medium and high level scenarios provide two alternatives: (1) without national measures and (2) with national measures aimed at increasing EE with a higher use of RES. The low level scenario does not envisage any national measures and therefore does not contain alternatives. Therefore, the scenarios where national measures are envisaged assume that the intervention and activity of the state will ensure additional energy measures throughout the entire energy system. This implies the establishment of concrete energy prices which will provide opportunities for *Energy Service Companies*[25] (ESCO) to supplement existing providers and with a view to reducing the consumption of electricity and other energy products. The presumed framework opens up possibilities for companies to undertake activities aimed at increasing their own EE, individually or with the support and organization of national and regional energy agencies or centres. These activities could be more significant if special instruments or organizations like e.g. EE Fund were established.

Measures in Industry (medium and high level scenarios with measures)

The scenarios without measures (medium and high levels) assume that growth in industrial activity would be accompanied by production levels based on tested and adequate technological solutions. This means that the technical level of EE in new industrial processes would already be at a relatively high level in the baseline scenario.

Thus, the energy intensity of electricity consumption and thermal energy in Montenegrin industry would decline even in the scenarios that have no measures. This would as a result of structural changes, better quality and value of industrial products and due to technical improvements regarding energy efficiency, i.e. market mechanisms. This includes a higher use of technology for the production of thermal energy, increased cogeneration in the production of thermal energy and electric power, with biomass as a fuel, and the certain use of sun radiation energy in the food industry.

Energy consumption in the processing industry for other companies, except for KAP and the Steel Plant is extremely small. In 2010 their electricity consumption was below 50 GWh. In the case of investments by foreign investors, clearly all of the plants will use new technology. Of course, a larger part of these new production lines would be imported from economically developed countries. Due to the uncertain future of KAP and the Steel Plant the scenarios do not take into account any possible measures in those industrial plants.

Measures in Transport (medium and high level scenarios with measures)

For all transition countries, including Montenegro, the level of technical efficiency in industrial technological processes and in transport are directly linked with the quality of the technology and transport means that are imported or produced, based on the licences of economically developed countries. Institutional measures, legislative and organizational measures could additionally improve energy efficiency. Reduction in the specific consumption of motor fuel for private vehicles in the baseline scenarios without measures results from technological progress in the economically developed world where vehicles are imported, or whose licensed production is organized in the region. The average consumption of fuel in the EU-27 is presently just 7 l per 100 km. As

25 ESCO (energy service company or energy savings company) – a commercial organisation that provides a wide range of comprehensive energy solutions, which include project design and implementation of energy saving projects, energy generation, energy supply and risk management.

for new cars, the average level of consumption is 6 l per 100 km. These trends have already been included in the scenarios without measures.

Furthermore, the scenarios also assume a transport policy that supports public transport, and an improved level of use of alternative energy sources (liquefied petroleum gas - TNG and compressed natural gas - CNG) and electricity in transport. The greatest changes to the consumption of fuel in the Montenegrin transport could be achieved by the introduction of a transport policy that directed a larger part of transit cargo transport to the railway system. There are a number of measures that could be organised in the transport sector that are not capital intensive but that could achieve visible effects. In the medium and high level scenarios with measures, the envisaged measures are: eco driving, bonus-malus system and speed limits on roads. The estimate is that some of these measures could reduce energy consumption in the transport sector by 6% by 2020.

The intensive substitution of diesel coaches with coaches that use CNG is also envisaged for areas where gas will be available, as well as a gradual increase in the presence of biodiesel as a fuel for coaches.

Household Measures (medium and high level scenarios with measures)

The highest part of energy consumption in households goes on heating. Therefore the highest reduction in household energy consumption could be achieved by measures aimed at improving thermal insulation in buildings and heating systems. There is a difference between the possibilities of reducing heat loss in the newly constructed buildings and in buildings constructed before 2010. Heat loss in newly constructed buildings can be limited by legislation; compliance with the implementation of legislation is more easily controlled in newly constructed residential buildings than in newly constructed family houses. The further reduction of heat loss in existing buildings in the future will be the most difficult task, but it also has the greatest potential.

The medium and high level scenarios with measures assume the application of very strict regulations regarding the thermal insulation of residential buildings. Regarding newly constructed buildings, the presumption is that already after 2012, legislation allowing a maximum heat loss of 80 kWh/m^2 will be implemented. For existing buildings, i.e. old flats, the presumption is that from 2014 onwards, every year 1% of these flats will be refurbished. Of course, this will require legislation, organisation and financial incentives. A significantly higher presence of solar collectors for heating water is also envisaged. This would require larger incentives and only a small amount can be achieved without incentive measures.

The medium and high level scenarios without measures envisage growth in electricity consumption for non-heating needs (all the needs apart from heating of premises and water) in the household sector, but technical progress regarding household appliances has been taken into account. However, implementing consumption measures as described in Demand Side Management (DSM) and creating consumption categories for domestic appliances could also result in additional reductions in consumption during the same period. These elements mostly refer to the faster introduction of more efficient appliances along with encouragement to replace old and classic technology with new and more efficient measures. This mostly refers to energy saving bulbs and the replacement of old refrigerators, freezers and washing machines. The markets already offer significantly more efficient household appliances than those that were used previously, and replacement is gradually taking place. Promotion measures and incentives are accelerating replacement. Measures are also being implemented by distribution network operators and by national, regional and local EE and RES agencies or centres.

Measures in the Service Sector (medium and high level scenario with measures)

By 2020 we can expect to see the construction of new buildings and at the same time can expect to see an increase in heating standards; thus the scenario with measures estimates that additional measures for improving thermal insulation would bring about a reduction in the use of energy for heating. It is estimated that the implementation of DSM measures would bring about a reduction in the consumption of electricity for non-heating purposes. These results could be achieved by efficient organisation by distribution network operators and all types of energy agencies, including the ESCO companies. Organised campaigns would ensure the achievement of results in the commercial field and also in public sector services.

The high level scenario with measures was selected as the baseline scenario for final energy consumption figures for the detailed analysis in the EDSM 2030 on the basis of the following:

- due to delays in construction, a new energy infrastructure in the region and in Montenegro, along with a strong need for the timely construction of energy buildings, Montenegro has proposed a scenario with a more optimistic GDP growth. With a faster GDP growth, final energy consumption figures are higher. The advantage of this approach is that in the case of a slower rate of growth in energy consumption, there will be a reserve in the case of problems and delays in the preparation of the construction of the planned energy buildings and measures for increasing the use of EE and RES.
- the proposed scenario is also the scenario with the most intensive EE measures and RES use which, as such, additionally motivates the state to use active energy policy and to mobilize the entire society for urgent action. This approach is also fully in line with the EP that recognizes EE and RES as two key priorities for the development of the energy sector in Montenegro by 2030.

Electricity Consumption Growth Rate

The demand for electricity in Montenegro for a long time (by 2009) exceeded the maximum generation capacity of the national power plants. The large consumption of electricity and other energy products was due primarily to energy inefficient technological plants in metallurgy: KAP and the Steel Plant at Nikšić. These are inefficient in comparison to advanced technology in developed countries, although in the last couple of years both of these plants, now privatized, reduced their energy consumption but they still represent a large share in the national energy consumption. However, the situation has partly changed since 2010 when the metallurgy plants (KAP and the Steel Plant) significantly reduced their production activities.

The prolonged and undefined status of the largest electricity consumer (KAP) currently does not provide us with a clear operational picture nor of the further development of KAP in the future. In July 2013 KAP went bankrupt and in December 2013 an advertisement was published to invite bids to puchase the property of KAP AD which was going through bankruptcy procedures.

Data from the first year of this analysis (2008) shows that total energy consumption was 3,816GWh. In an optimistic scenario for the period 2008-2020, final energy consumption in Montenegro would increase by 1.4 times, while electricity consumption would increase by 1.36 times. During that period total GDP would increase by 1.8 times. These presumptions are based on an annual economic development rate of 5%. Although the current growth rate is about 2.5% it is difficult to estimate its future trends. Electricity generation, which is the basis for economic development, should follow the pace of development of industry and other economic branches.

Liberalisation in the electricity market, as an administrative change in the energy sector set new rules for the electricity supply of all industrial producers; this relieved the national electricity company Elektroprivreda Crne Gore (EPCG) of its obligation to provide an electricity supply to industrial producers.

Industry

a) Processing industry

Final energy consumption in the processing industry are expected to be 1.48 times lower in 2020 than in 2008. Oil derivatives are expected to remain the key energy products used for heating. The largest impact on the future consumption of energy is expected to come from the future activities of KAP and from the Steel Plant at Nikšić. EDSM 2030 starts from the assumption that both KAP and the Steel Plant will continue working (KAP with a reduced capacity) up to the end of the observed period and that their plants will use new technologies.

b) Agriculture, non-energy mining and construction

Consumption of final energy in this sector is expected to increase by about 3.5 times by 2020 in comparison to 2008. The dominant energy product will most probably be diesel.

Transport

Consumption of final energy in the subsector of transport is expected to increase by only 13% by 2020 in comparison to 2008. The dominant energy product is expected to be diesel, whilst some biodiesel will also be used.

Households

Consumption of final energy in the sub-sector of households is expected to increase by 62% by 2020 in comparison to 2008. The dominant energy product is expected to be electricity. The consumption of firewood is anticipated to remain at the same level and the consumption of oil derivatives and biomass are expected to increase.

Services

Consumption of final energy in the sub-sector of services are expected to increase by 10% by 2020 in comparison to 2008. The dominant energy product is expected to be electricity.

Energy Efficiency Measures

In Montenegro some initiatives for energy savings and EE improvements have already been implemented, are being implemented or have been planned. They include:

- EE in Montenegro – International Bank for Reconstruction and Development (IBRD) loan worth 6.5 million Euros. This project envisaged energy efficiency improvements in education and health institutions. The implementation of the project was finished in June 2013. According to unofficial data energy savings after the implementation of measures in the concerned institutions amounted to about 8.400 MWh;
- Programme of EE in public buildings is being implemented in cooperation with the German Development Bank (KfW). The goal of the programme is to improve EE and comfort in target buildings that are within the competencies of the Ministry of Education and Sports (primary, secondary and special schools, kindergartens and dormitories for students);
- MONTESOL – financial mechanism for ensuring favourable loans to households to install solar collectors for heating water (in cooperation with the United Nations Environment Programme - UNEP and the Italian Ministry for the Environment, Land and Sea (IMELS)). A total number of 105 solar systems have been installed;
- Solar summer pasture areas (katun) (in cooperation with the Ministry of Agriculture and Rural Development) – creating better conditions for life and work, providing electricity supply by installing photovoltaic systems in summer pasture areas. So far 87 photovoltaic systems have been installed;
- Development of a legal framework for the establishment of ESCO concept in Montenegro - within the Regional Programme of Energy Efficiency in the Western Balkan Countries, supported by the European Bank for Reconstruction and Development (EBRD);
- Project of the Ministry of Foreign Affairs (platform for the integrated monitoring and verification of the

implementation of energy efficiency action plans) in cooperation with the Open Regional Energy Efficiency Fund for SEE of the German Development Cooperation (GIZ ORF EE);

- Programme Energy Wood in cooperation with the Lux-Development – Luxembourg agency for development cooperation. The goal of the programme is to establish an attractive and sustainable financial mechanism for ensuring interest-free credit to households to install heating systems using modern biomass products (pellets and briquettes). The project is in its initial stage, and so far 82 furnaces/boilers using pellet/briquettes have been installed.
- Seminar on Solar cooling: overview of technology, trends in the market and example of the Princess hotel was organized by the Montenegrin Energy Efficiency Centre (CCEE);
- The project Solar Energy in Montenegrin Tourism Sector, implemented by CCEE with the support of grant funds from the German Government through the German organization for international cooperation (GIZ). The goal of the project is to create an IT base for investing in solar thermal systems in the tourism sector in Montenegro with a view to helping with the development of solar thermal systems for heating and/or cooling;
- UNDP project Beautiful Cetinje deals with the economic revitalization of the historic capital of Montenegro, through the urban reconstruction of the cultural heritage with energy efficient solutions; through vocational training, support to small entrepreneurs and by encouraging the ideas and innovations of green design in overall urban development. According to calculations made in the project, investment worth 100,000 Euros has been made in the reconstruction of buildings protected as cultural heritage buildings; it is expected that the project will result in savings of 20,000 Euros for energy and in a parallel reduction in terms of CO_2 emissions into the atmosphere, about 30 t;
- UNDP project Legalisation of informal settlements in Montenegro through the implementation of the EE measures: according to estimates, there are about 100,000 illegally constructed buildings in Montenegro, although there is no official data confirming this. The idea is, and recently conducted research and prototypes show the same, that the legalization of informal settlements through the introduction of EE measures, could also result in the increase of revenue for central and local budgets, along with a reduction in negative impact on the environment, an increase in employment figures, an increase in economic activities, a reduction in electricity consumption, and a reduced need for imported electricity, which would ultimately contribute to improvements in living standards. According to rough estimates made on the basis of the energy audits of several illegal buildings, the retrofitting of all illegal buildings (100,000 of them) would lead to a total reduction in the energy consumption of about 3,476 GWh during a period of 10 years, i.e. 347 GWh annually. This would also lead to a significant reduction in GHG emissions. The implementation of this project is waiting for the approval of the grant for technical assistance of WBIF which is a precondition for the EBRD credit line.

Key EE goals within 20 years which were used in the simulation are:

- Industry:
  - introduction of co-generation, including biomass as fuel and meeting up to 20% of the total needs for steam and hot water.

- Transport:
  - Support and promotion of public transport, and higher use of gas and electricity;
  - Redirection of 50% of cargo transport to railways using electricity;
  - Implementation of capital non-intensive measures: eco driving, bonus-malus system and the speed limits on roads;
  - Increase in the share of private vehicles using liquefied petroleum gas;
  - Substitution of diesel fuel by compressed natural gas in coaches.

One example of positive practice in the implementation of measures relating to the reduction of GHG emissions in the transport sector is evident in the capital city of Podgorica. As an optimum measure for making transport more green it started to develop a network of cycle tracks. The Secretariat for Communal Activities and Transport and the Secretariat for Planning and Physical Development and the Environmental Protection of Podgorica, in cooperation with the local association of cyclists, "biciklo.me", defined priority routes for the construction of cycle tracks in the centre of the city: 1) along the Bulevar Mihaila Lalića and Bulevar Svetog Petra Cetinjskog, and 2) along the Crnogorskih Serdara Street, Bulevar revolucije and George Washington Bulevar. As the result of this joint initiative a conceptual design for the project has been prepared. It analyses existing planning documents, the position of the routes, and offers a signalisation plan, along with characteristic cross sections and details of the route. The project also analyses how the various sections fit into existing planning documents that led to the conclusion that they were compatible with the proposed zoning plan which is presently in its final stage of development. A conceptual design for the construction of these cycling tracks was submitted to the capital city of Podgorica which expressed an interest in continuing to work on the development of the project documentation, and to subsequently construct the cycle tracks. These tracks will connect the key routes used by cyclists in the city and will present a huge step forward in the development of a cycling network that could, in the future, be extended to other parts of the city.

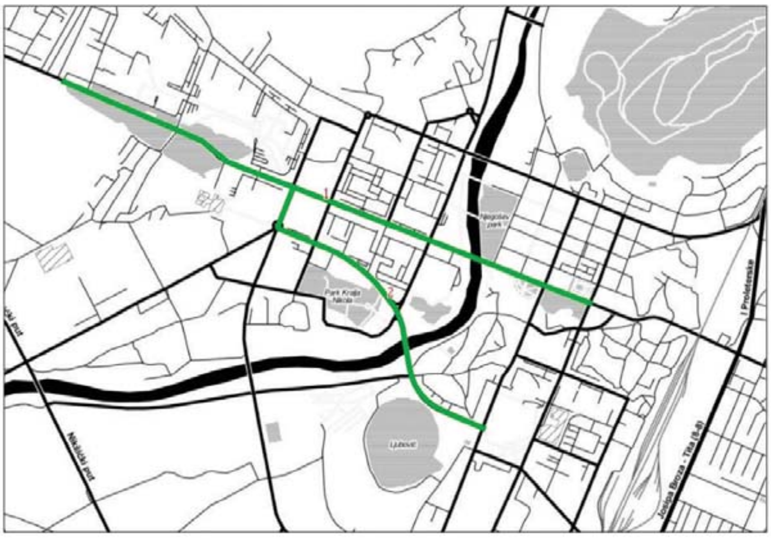


Image 5.1 Map of Podgorica with cycling routes (marked in green) introduced by the conceptual desig: 1) along Bulevar Mihaila Lalića and Bulevar Svetog Petra Cetinjskog, and 2) along the Crnogorskih Serdara Street, Bulevar Revolucije and George Washington Bulevar.

- Households:
  - Implementation of legislation on thermal protection in newly constructed buildings, which will reduce the consumption of useful thermal energy for heating to a level of 80 kWh/m^2 of the heated surface from 2014 on;
  - Refurbishment of 28,000 housing units by 2020 i.e. 4,000 housing units a year starting from 2015 with a 60% reduction in heat loss in refurbished housing units;
  - Reduction of non-thermal consumption of energy per household by 150 kWh a year by 2020, as a result of the classification of household appliances and other measures.

- Services:
  - Just as for the household sector, the implementation of legislation regarding thermal protection in newly constructed buildings will reduce the consumption of thermal energy for heating to a level of 80 kWh /m^2 for heated surfaces by 2014;
  - Refurbishment of one third of the surfaces in buildings in the service sector based on information from 2010 to achieve a level of consumption of 80 kWh/m^2 by 2020;
  - Reduction in the consumption of electricity for non-heating needs of up to 10% through the activities of energy agencies and ESCO companies.

On the basis of the above preconditions, total energy savings in 2020 will amount to 4,49 PJ.

Generation of Electricity

Existing Electricity Generation Capacity

There has been a period of stagnation that has lasted for more than 30 years regarding the construction of facilities for the generation of electricity in Montenegro. Existing facilities have, however, been partly refurbished. During the next 2-3 years further improvements can be expected, i.e. an increase in installed power (i.e. produced electricity).

Refurbishment of the hydro-power plant at Piva will be completely finished by the end of 2017, which will increase the installed power from the current 342 MW (3x114 MW) to 363 MW) and the planned generated electricity from 762 GWh to 800 GWh a year.

After the recently finished refurbishment of the hydro-power plant at Perućica, the installed power of the plant increased from 285 MW to 307 MW, while the average annual production amounted to 958 GWh. EDSM 2030 envisages the instalment of an additional generator no. 8 (65 MVA/58,5 MW, to increase annual production to about 20 GWh) by 2016.

After the successful large-scale refurbishment of the thermal power plant at Pljevlja in 2009 (replacement of the management system of the electro-filter and turbine plant with a view to increase the power and efficiency of the plant), this power plant still has to do some work on the reconstruction of its cooling tower, landfill and new transport system for slag and ash, along with the stabilization and recultivation of its landfill and the instalment of a new deSO_x[26] system. A conceptual design and feasibility study for a new landfill site and new transport system have been prepared; the development of the main project for the stabilization and recultivation of the existing landfill for slag and ash is also in progress.

The finalization of refurbishments of the small hydropower plants at Glava Zete and Slap Zete, that are owned by Zeta Energy DOO are expected by the end of March 2014.

After the refurbishment of the small hydropower plant at Slap Zete, installed power is expected to increase from the current 1.2 MW to 3.2 MW, while the annual production should increase from the current 3.5 GWh to 14.6 GWh. At the small hydropower plant at Glava Zete, power is anticipated to remain the same - 5 MW, but generation levels should increase from the current 12 GWh to 15 GWh due to the refurbishment and the replacement of electrical engineering equipment along with subsidiary equipment.

The remaining 5 small hydro-power plants owned by EPCG will be gradually refurbished during the period up to the end of 2014, and this will lead to an increase in installed power from the current 2.5 MW to 3.2 MW and an increase in production from 5.5 GWh to 7.8 GWh.

There is an obvious increase in the need for this type of power; this relates to economic growth and thus there is a continuous increase in difference between generation and consumption. According to the energy balance (EB, the final consumption of electricity during the period 1997-2008 increased (1.93%/year from 3,091 GWh in 1997 to 3,816 GWh in 2008) but has grown at a slower pace than has the gross rate of energy consumption (3.86%/year in the period 1997-2008)).

The electricity that Montenegro cannot generate for itself is imported. Therefore intensive investment is necessary to construct new capacity. The most recently constructed power plant is the Thermal Power Plant at Pljevlja which meets more than 30% of Montenegrin electricity needs. It has been in operation for more than 30 years. The import of electricity during the period 2005-2012 is represented in Table 5.3.

26 Process of de-sulfuring–reducing SO2 in smoke from thermal power plants and from other plants that are active in coal combustion.

Table 5.3 Import of electricity

Year	2005.	2006.	2007.	2008.	2009.	2010.	2011.	2012.
GWh	1.543	1.656	2.059	1.463	979	249	952	736

Candidates for New Production Capacities

Taking into account the abundance of renewable energy sources, primarily the hydrological ones, but also fossil fuel lignite, the realistic options for development of production capacities in Montenegro by 2020 are the following:

- Hydro-power plant on the Morača and hydro-power plant at Komarnica;
- Thermal power plant Pljevlja II and/or the thermal power plant at Maoče;
- renewable energy sources (small HE, WE, FE, etc.).

With a view to using the available coal reserves from the territory of Pljevlja, EDSM 2030 envisages the implementation of a construction project to develop the second block of the thermal power plant at Pljevlja (TE Pljevlja II).

A consortium of Slovenian companies hired by EPCG prepared the main design and a feasibility study for the construction of the thermal power plant Pljevlja II (2012). A study to assess the impact on the environment of the project of the Thermal Power Plant at Pljevlja was also done (2012).

On the basis of the conceptual design and on the results of the feasibility study prepared by the Slovenian consortium, the key technical parameters for the future block 2 have were identified as follows:

- the level of power would be the same as for block 1 - 220 MW;
- efficiency would be about 40%;
- the calorific value of the coal was calculated at a level of 9,560 kJ/kg (current value is 9,211 kJ/kg);
- it has been confirmed that around the existing coal mine pits in Pljevlja there are sufficient amounts of coal. The most distant new pit is Otilovići;
- the second block of the thermal power plant is anticipated to solve heating issues at Pljevlja.

Domestic lignite is mostly exploited in the Pljevlja basin; the coal deposit Potrlica/Cementara which has about 43.39 milion tons of coal makes up 60% of the coal reserves in the Pljevlja Basin. Exploitation of the coal deposits in Kalušići, and also in the Pljevlja Basin, which total about 13.81 million tons or 19% of the reserves, could prove to be unprofitable due to the lower calorific value of the coal and due to the emigration of the population from the area. Coal supplies for the new thermal power facility have to come from existing coal mines and through the opening of a new one, the most important of which is the coal deposit at Maoče, also in the Pljevlja Basin. Its usable coal reserves have been estimated as being 103 million tons. As the only fossil fuel in the country is lignite, Montenegro should use its hydro-energy potential to the maximum and in line with sustainability standards and standards of environmental protection. New candidates for hydropower plants have demonstrated a relatively good technical and hydrological basis. Initial activities for the construction of these plants has already started through the preparation of technical documentation and the publishing of tenders; interested investors were offered to start the construction of the power plants through concessions using natural resources.

Using renewable resources for the electricity generation is rather limited and is based on existing small hydropower plants that are very old. So far construction permits have been issued to 8 small hydropower plants, while procedures for issuing construction permits for several small hydropower plants and two large wind power plants are in progress. The use of solar energy for the generation of electricity has hardly started to date but there is still significant potential for this. The annual available amount of solar radiation as a primary source of energy per square metre in Podgorica amounts to about 1,600 kWh/m² (CETMA, 2007). This form of electricity generation is still seen as expensive, so it consequently lags behind the exploitation of wind on a world-wide basis.

National Activities in the Field of the Development of Renewable Energy Sources

The UNDP project, financed by GEF: The Reform of the Energy Sector Policy With a View to Promoting Development of Small Power Plants in Montenegro, which recently finished, aimed at reducing emissions from 402,360 CO_{2eq} to 536.480 during a period of 20 years of work at the new small hydro-power plants, and provided support to the government in the following ways:

- establishing and simplifying procedures for small and independent renewable energy producers;
- collecting basic data for rendering investment decisions;
- establishing attractive but competitive business conditions for investors; and
- supporting renewable energy sources in tender process procedures and ensuring their transparency.

One of the results of the project was the announcement of 3 public advertisements for granting concessions for the use of watercourses for the construction of the small hydropower plants in Montenegro. The third public advertisement (July 2013) regarding concessions for the use of watercourses for the construction of small hydropower plants in Montenegro included 8 watercourses (Bukovica, Bijela, Bistrica, confluent of Ljuboviđa, Kraštica, Velička Rijeka, Đurička Rijeka with confluents, Kaludarska and Vrbnica).

So far Montenegro has issued 8 energy licences for RES power plants with power of up to 1 MW - 7 for small hydro power plants (Raštak, Vrelo, Ljeviška Rijeka, Bradavac, Piševska Rijeka, Raštak 2 and Rijeka Reževića) and one licence for a biogas power plant (Mataguži).

EBRD financed the following projects:

- The development of a Cadastre of Small Watercourses with the potential to construction small hydro power plants up to 1 MW in the territory of 13 Montenegrin municipalities including: Kolašin, Mojkovac, Andrijevica, Berane, Bijelo Polje, Plav, Rožaje, Pljevlja, Žabljak, Šavnik, Plužine, Nikšić and Danilovgrad. This cadastre covers more than 70 watercourses;
- Pre-feasibility studies for the construction of small hydropower plants in local water-supply systems (for 5 municipalities in the North of Montenegro: Mojkovac, Plav, Andrijevica, Rožaje and Berane). The main projects of the mini hydro-power plants in the water-supply systems of the municipalities of Andrijevica (50 kW) and Berane (160 kW) are already in progress;
- The Programme of Development and Use of Renewable Energy Sources defines the pace at which natural potential is used as well as the planning the use of technology necessary to meet the national targets within the share of the energy generated from renewable sources in the total final energy production figures. Although the development of this programme was envisaged for late 2012, it has not yet been finished;
- Improvements in the regulatory framework (recommendations for setting the purchase price for electricity; overview of the state of play in the field of connections for small hydro power plants in terms of the electric power system; economic influence of achieving national targets and the purchase prices of electricity; overview of current concessions; possibilities for the use of summary procedures for the authorization of energy projects; recommendations for incentives in heat generation projects) and
- seminar: Investing in Renewable Energy Sources.

The World Bank financed the development of a study entitled Public-Private Partnerships for New Forms of Generation of Electricity in Montenegro.

The project Sustainable Energy Development of the Municipality of Kolašin, which was implemented during the period 2012-2014 in cooperation with the company Gaudal from Norway aimed to prepare a sound basis and to develop the technical studies necessary for planning the energy development of the Municipality of Kolašin and to create the possibility to implement small hydro-power plants projects.

There are 2 registered CDM projects (a small hydro power plant at Otilovići and a wind power plant at Možura) that were approved by the UNFCCC Secretariat but have not been implemented yet. The expected average reduction of GHG emissions from the power plant at Otilovići amounts to 13,200 tCO_2/year. With a view to stimulating preparation and registering CDM projects in Montenegro, this project included the process for calculating the value of the emission factor for the electric-power system of Montenegro in 2012. IT amounted to: $EF_{EESCG,2012}$ = 0,334.

Using wind for the generation of electricity pays off if, inter alia, the speed of wind measured at a location is above 8 m/s. This value has so far been measured in Montenegro in two locations: Možura and Krnovo, where during the next couple of years the construction of wind power plants is expected.

Measuring wind potential through the regional project Coastal Wind Power Plants: Research and Development - POWERED was financed through IPA Adriatic. The goal of the project was to analyse current legislation and the procedures for the construction of wind power plants and to carry out the measurements and research required for creating a wind map for the territory of the Adriatic Sea and to identify the locations where wind power plants might be built in the sea. The project started in February 2011 and it finished in February 2014.

In Montenegro there are 2,000 -2,500 sunny hours a year; solar energy use is limited to use in solar heating systems for water in the residential, public and service sectors. This type of use of solar energy is treated as an energy efficiency measure. The number of installed photovoltaic modules in the state is negligible. Within the project Integrated and Sustainable Transport in Perast, financed by the Italian Ministry of Environment, Land and Sea (IMELS), the photovoltaic power plant wuith a power of 5 kW was built. It will be used for charging electric bicycles - segways[27] and electric cars. In addition to this, a photovoltaic power plant with a peak power value of 130 kW has been planned to meet the needs of the new UN building in Podgorica.

DPG project – Distribution of Energy Generation and Smart Management of Isolated Regions of Montenegro is being implemented by the Italian company D'Appolonia.

The project aims to analyse the current situation in Montenegro and to define regions with low quality and a low certainty of energy supply; it aims to analyse the potential for renewable energy sources in the regions, the impact of its use on the environment and the technical options available for improving the existing supply. The project will define procedures for implementing these options, and will implement a pilot project in the territory of Montenegro which will be used as an example of good practice. The key goal of the project is to define conditions for a secure and continuous energy supply in remote areas, with a view to improving living conditions and encouraging the continuous efforts of the Government of Montenegro to ensure the sustainable economic development of the country. Implementation of the project started in July 2012 and it will continue to mid 2014.

Through the project Forestry Development in Montenegro - FODEMO (implemented by Lux Development - Luxembourg Agency for Development Cooperation), the Government of the Grand Duchy of Luxembourg, since 2003, has provided support to Montenegro in reforms in the forestry sector. This project is being implemented in cooperation with the Ministry of Agriculture and Rural Development in Montenegro.

The project was implemented in two stages. The first stage that was implemented during the period 2003-2006 focused on support to the national forestry sector starting with the institutions that work on planning and the

27 Segway – personal vehicle for one person, self-galanced two wheels, driven by electricity, charged from accummulators

management of forestry resources, through the production and development of seeds and seedlings right through to the final stages of wood production, including marketing in the wood industry. The second stage that was implemented during the period 2007-2011 focused on the strengthening of the operational capacity of institutions in the Montenegrin forestry sector, the introduction of an improved system of planning in forestry and the introduction of a strategic and more comprehensive framework for the development of the forestry sector and the use of investments in programmes (forest inventory, geographic-information system, growing stock, planning, national forestry policy) and the introduction of significant changes in legal and institutional frameworks with a view to getting closer to the EU standards and legislation.

In 2011 the project was extended to include the period 2011 - 2013 with a view to starting and developing a sustainable market for wood biomass as a renewable energy source. During this period the most significant activities that were completed or are currently in progress and relate to the development and use of renewable energy sources include:

- development of a study on the options and obstacles present in the development of a biomass market;
- preparation of an action plan for Biomass;
- changes in methodology for collecting data on the consumption of biomass.

An annual survey regarding the consumption of wood fuel was conducted in 2011 in cooperation with the Montenegrin Statistics Office (MONSTAT). The goal of the survey was to collect data on types, amounts and values of wood fuel that is produced, imported and consumed in Montenegro, as well as on amounts that are exported from Montenegro.

In addition to this, the survey collected data on sources of wood fuel supplies, as well as data on devices used for their combustion. Data was collected from households, public buildings, and industrial companies involved in processing wood in Montenegro, as well as from significant commercial institutions.

In addition to the implemented survey, on the basis of recommendations from the statistical institutions of the international organizations UNECE/FAO/EUROSTAT, a methodological concept was defined for the development of achieveing an energy balance for wood fuel. The energy balance for wood fuel in Montenegro was defined in 2011.

At the end of the survey, the publication 'Consumption of Wood fuel for 2011 in Montenegro - New Energy Balance for Wood fuel' was issued. According to this publication, the total use of individual types of wood fuel for energy needs in 2011 in Montenegro amounted to the following:

- firewood – 732,911 m^3
- large wood remains from industry (slabs from sow mills) – 79,498 m^3
- small remains of wood in industry (sawdust) – 6,695 m^3
- remains from forestry, fruit growing – 251 m^3
- wood briquettes – 106 tons
- wood pellets – 692 tons
- waste wood in the construction industry – 5,254 m^3
- wood charcoal – 1.039 tons.

The Dutch development organization SNV financed the development of the following publications:

- Manual Wood fuel, Types, Characteristics andBbenefits for Heating, which is a short overview of the potential and use of wood biomass in Montenegro, the contribution of wood biomass to the rural development of Montenegro, the impact of the use of biomass on the mitigation of climate change, a short description of units used for measuring wood fuel, their energy values depending on the type of the wood and moisture levels, their ratio along with their energy measurement units and a detailed description of the types and characteristics of wood fuel as well as the economic efficiency of their use in Montenegro.

- Separate local studies analysing the value of biomass for the municipalities of Rožaje, Bijelo Polje and Pljevlja along with the analyses from the research conducted with target groups (concessionaires, private owners, wood processors). The results of these analyses were presented at the workshop: Possibility to Produce and Use Biomass as a Renewable Energy Source. During this workshop, relevant institutions were given the opportunity to hear about the key findings of the studies.

The IPA 2012-2013 project: Optimum use of Resources with a View to Reducing the Impact of Climate Changet and the Nnegative Influence of Natural Disasters shows the possibilities of multi-sectorial cooperation and is aimed at solving common problems.

Montenegro is a country that is rich in natural resources; on one hand these should be used in a sustainable way, and on the other they should be preserved from natural disasters. Therefore, the purpose of this project is to ensure sustainable energy development through the development of local energy sectors and to improve institutional capacity and the quality of equipment available. The goal is to ensure the development of sustainable energy with the lowest levels of risk and to minimise negative consequences in terms of natural disasters such as floods. The implementation of this project has not yet started.

IPA 2011 project: Sustainable Development of the Energy Sector (Transport) is aimed at the development of a relevant regulatory framework with a view to increasing sustainable energy use, particularly in the transport sector. Implementation of the project has not yet started.

The work of the National Strategy - Assessment of Technological Needs for Mitigating Climate Change and for the Adaptation to Climate Change in Montenegro (TNA), financed by the Dutch Agency of the Ministry of Economy (October 2012) included the development of an action plan for prioritising technologies for mitigating climate changes and for the adaptation to climate change in Montenegro in all sectors. The development process in this strategy was extremely participatory and it required that priority was given to low-carbon technologies. The conclusions from this strategy were also taken into account in this analysis. According to this strategy, priority technologies included the following:

a) in the sector of electricity production:
    - small hydro power plants;
    - solar photovoltaic panels;
    - large hydro power plants;
    - solar thermal power plants,
b) in the sector of energy consumption:
    - solar water heating systems;
    - insulation of buildings;
    - highly efficient air conditioners in households and in the services sector;
    - automatized energy management in buildings,
c) in the transport sector:
    - improving public transport;
    - liquefied petroleum gas;
    - cycling tracks;
    - electric vehicles;
    - plug-in hybrids;
    - intelligent transport system,

d) in the aluminium production sector:
   - increasing efficiency and working temperature in electrolyzers;
   - dot dosage of alumina and biter process control;
   - using inert anodes.

Recently UNDP has started the project Towards the Development of Tourism with Low CO_2 Emissions; this is aimed at reducing GHG emissions in Montenegrin tourism through:

- the promotion and adoption of policies and legislation aimed at reducing CO_2 levels
- establishing sustainable mechanisms for financing, and
- providing support in developing and implementing key investments in the tourism infrastructure which have low levels of CO_2 emissions. .

Investments in renewable energy sources are naturally much more expensive options than are investments in conventional thermal-energy and hydro-energy capacities, but the construction of such capacities significantly contributes to the reduction of GHG emissions and to the reduction of the dependence on the import of fossil fuels. According to EDSM 2030, by 2020 the total installed power/planned generation of new small hydro power plants will amount to: 120.9 MW/388.1 GWh; new wind power plants: 151 MW/347.8 GWh, and new photovoltaic power plants: 10 MW/16,5 GWh. According to the analyses that have been developed so far, the estimates say that in Montenegro the greatest potential for development within available renewable energy sources is in the building of large hydropower plants, small hydropower plants and wind power plants.

Table 5.4 Planned construction of small hydropower plants with the signed concession agreements – Source: Ministry of Economy

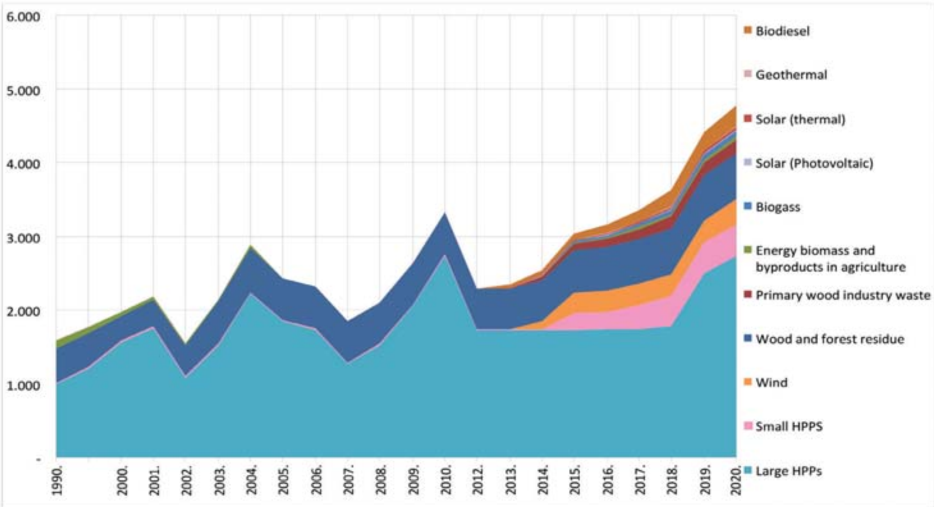
Watercourse	Municipality	Number of small hydro-power plants	Installed power (MW)	Planned electricity generation (GWh)
Bistrica	Berane	8	10,00	37,00
Sekularska	Berane	5	5,00	21,00
Bistrica	Bijelo Polje	2	17,00	50,00
Bjelojevićka	Mojkovac	2	15,00	48,00
Crnja	Kolašin	3	5,00	15,00
Zaslapnica	Nikšić	2	1,00	3,60
Grlja	Plav	1	1,70	5,70
Babinopoljska	Plav	2	9,45	24,20
Vrbnica	Plužine	2	12,00	27,00
Tušina	Šavnik	4	6,00	16,45
Trepačka Rijeka	Andrijevica	1	8,30	33,10
Murinska Rijeka	Plav	2	2,36	9,45
Komarača	Plav	1	4,00	10,60
Total		35	~100	~300

At the moment Montenegro has concession agreements that have been signed for concessions on 13 watercourses with the planned construction of 35 small hydro power plants giving a total installed power of approximately 100 MW and with planned production levels estimated to be approximately 300 GWh a year (Table 5.4.). The concessions were agreed through two competition procedures that were completed in 2008 and 2010. So far only the only small hydro-power plant "Jezerštica" (844 kW) on the confluence of the watercourse Bistrica in Berane started working; next year the commissioning of another 5 small hydro-power plants is expected. Regarding the Tušina watercourse, an amicable termination of the Concession Agreement has been signed.

EDSM 2030 assumed a moderate level scenario regarding the construction of a biomass driven plant by 2020 with a total installed power/planned production of (29.3 MW/101 GWh). Table 2.2.3 shows data on installed power/ planned production for new renewable energy sources in Montenegro by 2020. Graph 2.2.2 shows data on the overall use of RES in the past (1990-2012) and the use of RES envisaged in EDSM 2030 by 2020 (GWh).

Table 5.5 New renewable energy sources by 2020 (MW/GWh year)

RES	mHE	VE	FE	Biomass
MW/GWh year.	120,9/388,1	151/ 347,8	10/16,5	29,3/101



Graph 5.2 Total use of RES in the past (1990–2012) and envisaged in EDSM 2030 for the period up to 2020 (GWh)

Electric Power Losses

According to official data from the electric power balance of Montenegro for the period 2005–2012, losses, particularly in distribution, are still significantly above acceptable international standards (Table 5.6.).

Table 5.6 Losses in the electric-power system during the period 2005-2012 (GWh, %)

Losses	2005.	2006.	2007.	2008.	2009.	2010.	2011.	2012.
Electricity transmission (GWh)	175	157	157	157	148	164	159	153
Electricity distribution(GWh)	600	693	531	568	570	503	492	494
Total (GWh)	775	850	688	725	718	667	651	647
Total (% gross consumption)	17,10%	18,20%	14,90%	15,80%	19,20%	16,60%	15,40%	16,40%

Analyses of Scenarios and Projections of GHG Emission Reductions in the Energy Sector

To assess reductions in GHG emissions, this analysis used the LEAP software tool; with the help of this, projections of GHG emissions were calculated for each of the scenarios included in this analysis. On the basis of the presumptions listed above, two scenarios regarding future capacities for the generation and consumption of energy were developed: a basic scenario (BaU[28]) scenario and a mitigation scenario.

28 BaU – Business as Usual

The following scenarios were taken into account:

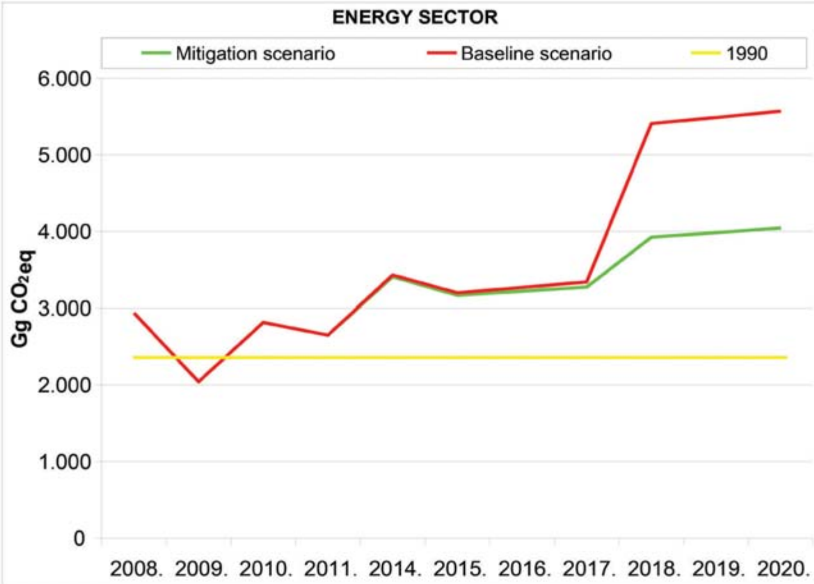
- Baseline - BaU scenario starts from the assumption that current economic and technological trends in energy production and the consumption habits of the population will continue. This scenario envisages investment in new production capacities for the generation of electricity (thermal power plant Pljevlja II), as well as the refurbishment of existing hydropower capacities. In line with the decision of the Council of Ministers of the European Energy Community, the work on the first block of the thermal power plant at Pljevlja is limited to 20,000 hours during the period 2018-2024. This scenario envisages that the first block of the thermal power plant at Pljevlja will operate for the allocated 20,000 working hours during the period 2018–2020. Regarding energy consumption, the basic scenario in this analysis has assumed a high level of consumption regarding final energy, based on the optimistic scenario of an increase in the gross domestic product per capita, without any measure of active policy and without the use of state measures in the field of energy efficiency that would result in savings in the consumption of energy, but as a result of energy savings created due to the transfer of technologies (primarily in the transport sector, households and services and due to the market improvement of energy efficiency). In other words, this scenario starts from the assumption that all sectors will continue using energy in the same way as in the baseline year, 2008 (the same fuel mix, the same specific consumption per GDP unit and the same level of energy efficiency).
- Reduction in GHG emissions – this scenario envisages the construction of new production capacities for the production of electricity (hydro power plant at Morača, hydro power plant at Komarnica and all RES from the baseline scenario of EDSM SRE 2030). It includes the refurbishment of existing hydropower capacities and the operation of block I at the thermal power plant at Pljevlja for 2,857 hours a year during the specified period. As for energy consumption, this scenario assumes a high level of consumption regarding final energy based on an optimistic scenario showing an increase in the gross domestic product per capita with active policy measures and state measures in the field of energy efficiency that would bring about savings in energy consumption, including savings in energy that would be made due to transfers in technologies..

Table 5.7 shows the analysed scenarios - the development of future production capacities keeping pace with construction projects.

Table 5.7 The development of future production capacities keeping pace with construction projects

Power plant → power (year of release)	Basic scenario	Scenario of reductions in GHG emissions
Revitalisation:		
TE Pljevlja I (218,5 MW) → 225 MW (2015)	X	X
HE Perućica (307 MW) → 372 MW (2017)	X	X
HE Piva (342 MW) → 363 MW (2018)	X	X
7 mHE (8,5 MW) → 11.4 MW (2015)	X	X
Construction:		
TE Pljevlja II → 220 MW (2018)	X	X
HE on Morači → 238 MW (2019)		X
HE Komarnica → 168 MW (2020)		X
mHE → 120,9 MW (2015 – 2018)		X
WE Možura → 46 MW (2014)		X
WE Krnovo → 72 MW (2015)		X
WE UL* → 33,2 MW (2016 – 2020)		X
FE UL* → 10 MW (2014 – 2020)		X
Power plants that use other forms of biomass → 29.3 MW (2013 – 2020)		X

*UL-unknown location



Graph 5.3 Total GHG emissions in the energy sector by analysed scenario

The energy sector used to be the largest source of GHG emissions in the past. In the future this sector will continue to provide the largest contributions to total GHG emissions in Montenegro. This primarily refers to the sector of electricity generation, where adopted strategic documents plan new thermal power plants. Figure 2.2.3 shows the following increases in the level of GHG emissions in the energy sector in 2020 in comparison to 1990:

- 3211,8 Gg CO_{2eq}, i.e. 2.4 times – for the basic scenario;
- 1686 Gg CO_{2eq}, i.e. 1.7 times – for the scenario of a reduction in the level of GHG emissions;

At the end of the observed period (2020), GHG emissions in the basic scenario are 38% higher than in the scenario which envisages a reduction in GHG emissions.

5.2.2 Industrial Processes

Industrial Policy

In Montenegro there is no policy that deals with the detailed analysis of the industrial sector. The Strategy for the Development of the Processing Industry 2014-2018, along wuith its action plan was adopted in January 2014. It includes an analysis of the current situation and shows the structure of industrial production in Montenegro, with particular reference to the metal and wood industry sectors (viewed as strategic sectors).

The analysis of the existing strategic and planning documents (Recommendations of the Government for Economic Policy in 2013 in the Field of Industry and Predictions and Expectations Regarding Trends in the Processing Industry on the Basis of the Pre-Accession Economic Programme for the Period 2011-2014 , under current conditions, leads to the definition of the following guidelines and predicted directions of industrial development:

- An increase in the technological level of processing industries and the development of new industries with the creation of conditions for developing entrepreneurship (ecological entrepreneurship) and in-

novative economic potential (investments in new technology, innovations, sustainable development, meeting high ecological requirements etc.);
- Modernisation of existing industry and the development of new industry that will primarily be based on knowledge and innovation using domestic resources and raw mineral materials whilst respecting environmental standards;
- Modernisation of production, increase in the level of final production, introduction of new technologies and quality systems with changes and improvements in product ranges (promoting modernisation and restructuring industry and individual sectors);
- Attraction of foreign investment and development of industrial zones to use and practice all available potential in the field of industry, relying particularly on small and medium sized enterprises (establishing industrial cooperation between economic entities with a view to strengthening the private sector);
- Introduction of incentive measures for investing in the cleaning industry, increase in the energy efficiency of industrial production with a view to improving the impact of industry on the environment.

With the aim of improving industrial development and structural adaptation, Montenegro should aspire to:

- encouraging investment in the development of the industrial sector;
- developing the industrial sector based on innovation and new technologies;
- export industrial products with a high level of final quality.

Some of the following operational measures have been defined on the basis of the Recommendations for Economic Policy in 2013:

- modernisation of production equipment and technology to achieve efficient production that meets standards and is competitive within the international market in terms of price; solving electricity supply issues (KAP);
- modernisation of production equipment in the field of production of high-alloy steel according to the strictest world standards and with the aim of becoming profitable and successful in international markets - replacement of out-dated technology with modern equipment to achieve the production of high-quality products that can be marketed in European markets where high demand for such products is perceived (steel plant).

Strategic Development Directions:

- modernisation of the metal industry to comply with high environmental standards, in line with the needs of domestic demands and for export using energy efficient production methods;
- resolving current illiquidity and the lack of functional assets to ensure the continuity of production.

Analyses of Scenarios and Projections of GHG Emission Reductions in the Sector of Industrial Processes

Currently, GHG emissions from the industrial sector have been reduced to emissions of synthetic GHG resulting from the technological processes carried out by the largest industrial plant in the country, the Aluminium Plant Podgorica (KAP); other industrial processes in the manufacturing industry (Niksic Iron and Steel Works and the production of lime) emit less than 2% of all GHG. During the melting of aluminum, the electrolytic process results in the emission of two gases from the group of perfluorohydrocarbons: carbon tetrafluoride (CF_4), and carbon hexafluoride (C_2F_6). These gases are formed during the phenomenon known as "anode effect", when the content of aluminium in an electrolytic cell is low; thus PFC emissions increase with in frequency, intensity and duration of anode effects. In the National Emissions Inventory of 2011, the relevant synthetic gases are listed immediately after the carbon dioxide emissions, and equal a total of 586 Gg CO_{2eq}.

When operating at full capacity, KAP is a major consumer of electricity and fossil fuels. The KAP aluminium plant has already been in a state of reduced production capacity for more than five years. The decreasing trend of production at KAP started in 2008 and has continued to date. As the situation at KAP is presently uncertain, two approaches have been considered and are as follows:

- KAP operates at full installed production capacity (120,000 tons of cast aluminum per year);
- KAP operates at reduced installed production capacity (70,000 tons of cast aluminum per year).

Measures to reduce synthetic GHG in the technological process of the aluminum industry are as follows:

- Increasing efficiency and operating temperatures during electrolysis;
- Spot alumina feeding and improved process control;
- The use of inert anodes.

Technological Clarifications

- The goal of technology is to increase efficiency and operating temperatures in electrolyzers by interventions in the composition of the electrolyte and to increase their electrical conductivity, reduce viscosity, reduce operating temperature and heat losses, and increase the solubility of alumina. This is accomplished by increasing the content of lithium fluoride (LiF), a very high content of aluminum fluoride (AlF3), using graphitized cathode blocks with trim panels at the level of silicon carbide (SiC) cathodes, automatic feeding and control of AlF3 feeding in the electrolyte.
- Spot alumina feeding and improved process control is one of the most widely accepted technologies for the increased operational and environmental efficiency of electrolyzers with pre-baked anodes. The aim of technological improvement is to introduce better process control regarding the operation of electrolyzers, automation of alumina feeding to the electrolyzer (central dotted punching), and reducing the need and duration of electrode replacement; all due to a reduction in the number and duration of anode effects along with an uncontrollable increase in voltage, increase in consumption of electricity and increase in oxidation of the anode mass. Synthetic gases PFC (CF_4, C_2F_6) are generated as a result of these shortcomings.
- Inert anodes are the so-called "low-consumable" anodes that do not lead to the oxidation and consumption of anode tissue, and thus the generation of GHG emissions. Electrically active inert surfaces of such anodes are made of oxide with semiconducting properties. Nowadays oxyfluoride coatings and a group of materials called "cermets" Ni-Fe-Cu are in use. The advantages of these anodes are their low electrolyte solubility, their high electrical conductivity, their lightweight power supply, their simple production methods which do not cause pollution, their low contamination levels during production, their increased energy efficiency of up to 25%, their reduced operational costs of up to 10%, their significantly reduced levels of CO_2 and PFC emissions, their increased productivity of up to 5%, their reduced emission levels of polycyclic compounds which is typically generated during the production and consumption of anodes, their reduced emission levels of carbonyl sulfide which is generated during electrolysis, and their reduced cost in terms of the price of the anode, their reduced labor costs, their reduced need for the replacement of electrodes, and their reduction in heat losses.

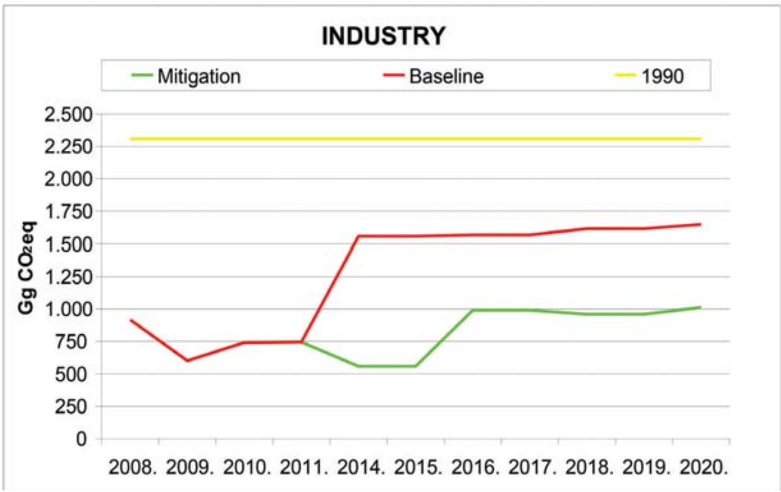
For both approaches, calculations for the reduction of GHG emissions have been made according to the following scenarios:

- Baseline (BAU) – this scenario assumes that no changes will occur during the technological process at KAP;
- Reduction in GHG emissions - this scenario assumes that selected measures will be applied to reduce GHG emissions during the technological process at KAP.

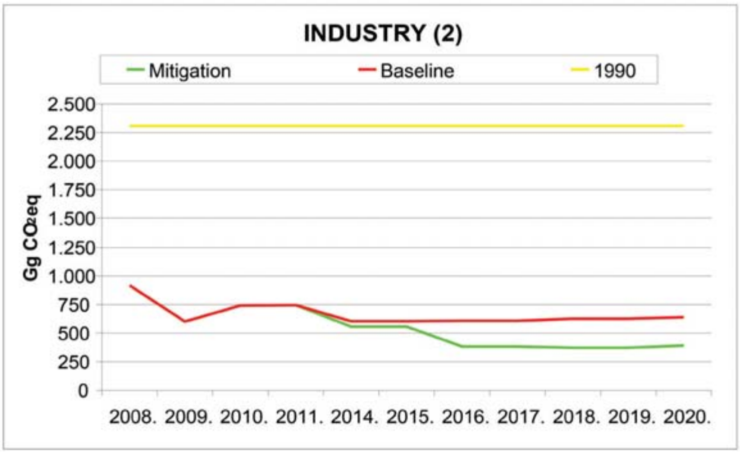
As shown in Graph 5.4, in 2020, the level of GHG emissions in the industrial sector (with full production capacity in KAP) is expected to have been reduced by 658 Gg CO_{2eq} compared with the 1990 level in the baseline scenario, and to have been reduced by 1296 Gg CO_2 eq in the scenario where GHG emissions are reduced. Also, at the end of the period under review (2020), GHG emissions in the baseline scenario increased by 63% compared with the scenario where there is a reduction in GHG emissions.

As shown in Graph 5.4, the level of GHG emissions in the sector of industrial processes (assuming a reduced production capacity at KAP) would be reduced in 2020 compared to 1990 by:

- 1916 Gg CO_2 equivalent - in the baseline scenario;
- 1669 Gg CO_2 equivalent - in the scenario showing a reduction in GHG emissions;



Graph 5.4 Total GHG emissions in the industrial sector by the scenarios analyzed (with full production capacity in KAP)



Graph 5.5 Total GHG emissions in the industrial sector by analysed scenario (assuming reduced production capacity at KAP)

At the end of the reporting period (2020), GHG emissions in the scenario assuming a reduction in GHG emissions increased by 62% compared to the baseline scenario when assuming a reduction in production capacity at KAP.

5.2.3 Agriculture

Agricultural Policy

Strategic documents in the agricultural sector are as follows:

- Strategy for the Development of Agriculture and Rural Areas (2015-2020);
- National Programme for Food Production and Rural Areas (2009-2013);
- Organic Agriculture Development Program (2009-2012);
- National Strategic Plan to Develop the Fisheries Sector (2009-2013).

Analyses of Scenarios and Projections of GHG Emission Reductions in the Agricultural Sector

Animal Husbandry

Of all the individual branches of agriculture, animal husbandry has the greatest economic importance in the Montenegrin agriculture. The special importance of animal husbandry is that less productive areas (pastures and meadows), which are predominant within the total agricultural area, are exploited by ruminant breeding. Regarding livestock production, Montenegro is not a major producer in the region. Over the coming years, livestock production is expected to grow, and this may very well generate more GHG emissions.

Population density in the EU is 1 CH/ha (conditional head of cattle per hectare), while in Montenegro it is 0.53 CH/ha. Extensive animal husbandry is locally present, but it cannot compete with the intensive animal breeding market in the EU. Given that the country is implementing the project IPARD (Instrument for Pre-Accession Assistance and Rural Development), households will own a lot more livestock. Also, bearing in mind that 88% of the total agricultural land consists of meadows and pastures, livestock will increase.

Farming

Any significant increase in grain production is not realistic due to the limited capacity of arable land. However, increasing demands in the milling and baking industries for specific types of cereals (buckwheat, durum wheat, a variety of local varieties of barley and rye) and for the production of various types of bread and rolls may have an stop the current trend of reduction in productivity and may possibly start an increase in certain areas of cereals. Also, in order to meet the demands of livestock for concentrated food, and to alleviate existing deficits in cereals, it will be necessary to increase the areas used for growing cereals.

The agricultural sector is a source of methane (CH_4) and nitrous oxide (N_2O), which mainly originate from livestock and from the use of nitrogen fertilizers in crop production. As shown in the inventory of GHG emissions, these two gases are most present in agriculture, but agriculture contributes very little to direct CO_2 emissions.

Possible measures that may be implemented in order to reduce GHG emissions in the agricultural sector are:

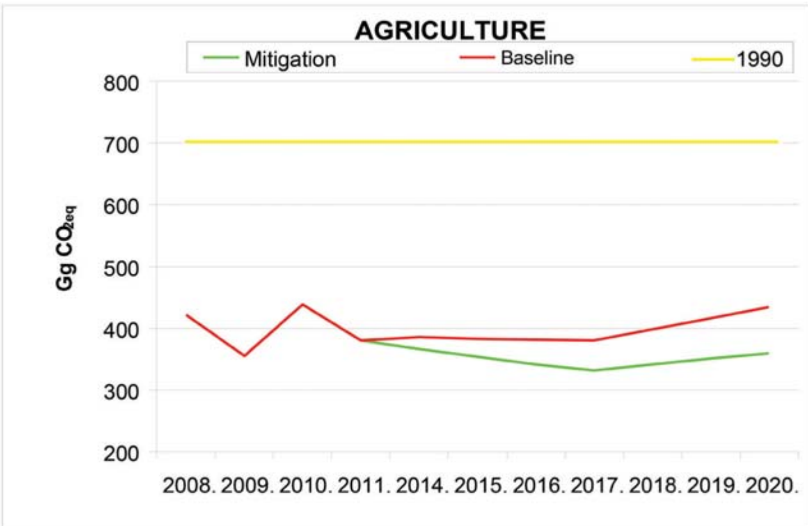
- Reduced land burning after harvest, i.e. implementation of land ploughing or "resting" practices;
- Organic agricultural production;
- Management of agricultural waste (i.e. its use for energy purposes, e.g. biogas from pig and cow farms, or biomass).

A considerable amount of waste is produced by the agricultural sector (straw, of which a part is used for animal husbandry; cuttings from vines and other types of fruit growing; but also a certain amount of animal waste from livestock farming). The absence of a system to collect agricultural waste (with the exception of some individual households) leads to uncontrolled GHG emissions. The current waste management practices are diverse, but most often the waste from cow farming piles up and is then burned, to reduce moisture, and is then used as a fertilizer; waste from pig farms is generally collected in pits (which are not managed properly). This is in case of keeping the cattle on protective floor coverings.

When cattle grids are used to contain cattle (mainly on dairy farms which have channels for manure), solid and liquid manure is deposited in pits which are often not treated properly (waste is deposited in various places where it should not be). The remains from grain are used as animal feed or as floor cover in the livestock living areas, and crop residues are burned or used for heating. Modern management practices include systems for the collection of agricultural waste and its use for energy purposes, e.g. biogas from pig and cow farms, or biomass from cuttings from vines and other types of fruit growing.

In order to reduce N_2O emissions, due to the application of mineral and organic fertilizers, particular attention should be paid to the correct use of nitrogen fertilizers. Agricultural production, without the use of mineral fertilizers, would have positive effects on the environment, and would also reduce production costs. However, in order to ensure the production of agricultural products at current levels or even higher levels, as is planned in the future, organic fertilizer production should be significantly greater; this is impossible to achieve under the current conditions of livestock production.

Organic farming is certainly the best way in terms of environmental protection and product quality. Before starting with organic production, its economic justifiability should be examined and the principles of production should be well understood. Given that organic production only uses organic fertilizers, somewhat lower yields should be expected; the economic impact is, however, positive as production costs are lower. Organic production means lower energy consumption (about 10-15%, according to IPCC), and thus lower emissions of N_2O and CO_2, and greater accumulations of organic matter in soil, along with the exclusion of protective agents and chemicals from production processes.



Graph 5.6 Total GHG emissions from the agricultural sector by analysed scenarios

Currently the country has no precise data which can be used for calculating estimates of CH_4 and N_2O gases in the agricultural sector for the period (2014-2020). In order to be able to plan measures in this respect, it is necessary to give an expert assessment of possible future developments in agricultural production, i.e. its main sub-sectors. The analysis here is based on the experiences of other countries, such as Slovenia and Croatia, and on the expectations of the European Commission regarding the development of agriculture, and by using above measures for a reduction in GHG emissions from this analysis.

As shown in Graph 5.6, in 2020 the level of GHG emissions in the agricultural sector will be lower by 266 Gg CO_{2eq} compared to the 1990 level, in the baseline scenario, or will have reduced by 340 Gg CO_{2eq} in the scenario of reducing GHG emissions. Also, at the end of the period under review (2020), GHG emissions in the baseline scenario have increased by 21% compared with figures in the scenario showing a reduction in the level of GHG emissions.

5.2.4 Land Use Change and Forestry

Forest Policy

The National Forest Inventory for Montenegro (2010) was created in Montenegro for the first time and it provides important information on the status of forests, forest cover, population growth and carbon stocks. The political basis for the inventory is set in the National Forest Policy of Montenegro (2008). The most significant quantitative findings of the National Forest Inventory are that forests cover 59.9% of the total land area of Montenegro, forest land covers 9.8% of the land area of Montenegro, and together forests and forest land cover 69.7% of the land area of Montenegro. The total volume of forest and forest land is estimated at 118 million m^3 with an annual increment of 2.8 million m^3. Analysis of the CO_2 emissions abyss in the forestry sector is based on this document and on the National Forest Strategy and the Forest and Forestry Development Plan up to 2023.

The National Forest Strategy along with the Forest and Forestry Development Plan up to 2023 define two broad objectives relating to forests as ecosystems and natural resources and the economic sector in terms of forestry and the wood industry:

1. *Improving the sustainability of forest management and an increase in growing stock in commercial forests from 104 to 115 million m^3 gross wood mass*
   Montenegro has enough forests that are natural and healthy, but many of these forests, particularly coppice forests that are privately owned, do not yet achieve full productivity. Management of planning, care and breeding should increase the quality, stability, resilience and productivity of forests, and thus provide the basis for long-term sustainable use of all forest functions.
2. *Increase the GDP of the forestry sector, timber industry and other industries that depend on the forest from 2% to 4% of GDP*
   The sectors of forestry and wood industry do not reach economic effeciveness in accordance with their potential. Using investments in forest and rural infrastructure, development activities associated with the forest and timber industry, diversification of the timber market and cooperation within the sector, will increase the number of jobs, socio-economic status of the rural population, the volume of company business, including government revenues from forestry and wood industry.

Analyses of Scenarios and Projections of GHG Sink Increases in the Forestry Sector

Forests are one of the major natural resources in Montenegro, due to their natural and diverse structure as well as their natural renewal. The main species found in forests in Montenegro are mainly beech, fir, spruce, pine, oak and different types of deciduous trees. Due to activities such as illegal logging, construction of buildings on forest land and forest fires, forest areas are reduced, however, there are many areas of land that are overgrown with trees, primarily by the natural reforestation of abandoned agricultural land.

As shown in the inventory of GHG emissions, in 2011 CO_2 removals amounted to 2166.90 Gg CO_2. There are a number of measures which would surely increase the capacity of forests, and thus the absorption of CO_2 emissions in the forestry sector; these were taken into account in the calculations, and include:

- Practical ways of applying silvicultural methods, increasing carbon storage in tree biomass;
- Expansion of forest areas through afforestation of bare lands, increasing overall annual biomass increment;

- Sustainable planning and the management of forests, including the permanent control of forest health and monitoring, in addition to the increase of fire protection measures;
- The use of biomass for energy purposes.

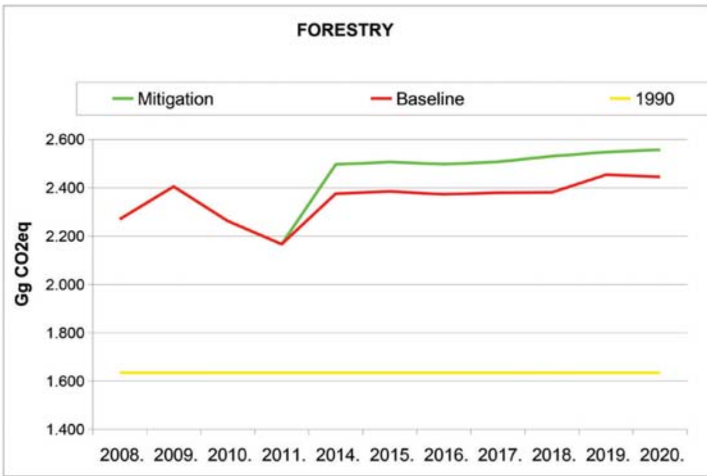
Carbon storage in tree biomass is implemented by maintaining and improving forest conditions, applying silvicultural methods which involve converting the low forests in the higher silvicultural form, in areas where there are pedological conditions (land of sufficient quality), then maintaining high forest fit by regular thinning, thus increasing the quality of thinned wood, its stability and productivity, and also improving the biodiversity.

The increase in the total annual increment of biomass, or better coverage of forests by afforestation of bare land, is carried out by planting on degraded forest lands and restoring forest cover. The analysis of new forests needs to determine which species demonstrate the best growth and in which areas of growing, and which species would better adapt to climate change.

Increasing carbon storage is achieved through forest conservation, reinforced fire protection measures and the permanent supervision of forest health. Potential threats to forest ecosystems are represented by outbreaks of pests and diseases, which have been particularly prominent during the last few decades due to increasing anthropogenic pressures and inadequate silvicultural measures. Increasing the potential abundance and number of species of harmful insects causes significant economic losses and the accumulation of combustible materials (dead biomass) in forests, especially in coniferous forests. Therefore, it is important to improve systems for monitoring disorders caused by biotic pests and to provide adequate sanitation (periodic removal of infested trees) and general control over areas. Another significant threat to forest ecosystems is forest fires; the risk of forest fires is increasing due to increases in temperature which are already evident, especially during the summer months and this situation requires preventive action such as increasing the capacity for the protection of forests against fire. By intensifying efforts to prevent forest fires, the accidental release of CO_2 into the atmosphere is reduced, as well as economic loss, and forest cover is maintained. The risk of fire is increased also due to the remains of the dead wood biomass after harvest, as well as in areas with higher population density; for this reason it is necessary to improve sanitary practices by increasing fire protection measures and the restoration of burnt areas after forest fires. Wood is the main fuel for heating in most rural households. Increasing the production of wood pellets and briquettes from wood waste would reduce the consumption of electricity and fossil fuels for heating in the household sector and the service sector.

In the forestry sector, the following two scenarios were considered:

- Baseline scenario (BAU), which assumes that no changes will occur in the forestry sector;
- Scenario of increasing GHG sinks which proposes the use of these measures in the forestry sector.



Graph 5.7 Total GHG sinks in the forestry sector by scenario

As shown in Graph 5.7, in 2020 the level of GHG sinks in the forestry sector compared to 1990 will be higher by:

- 811 Gg CO_{2eq} –in the baseline scenario;
- 923 Gg CO_{2eq} – in a scenario of increasing GHG sinks.

At the end of the period (2020), GHG sinks in the scenario where GHG sinks are increased is 5% greater when compared with the baseline scenario.

5.2.5 Waste

Waste Management Policy

The most important strategic document governing the field of waste management is the Strategic Master Plan for Waste Management (2005). By the end of 2011, an assessment reviewing the Strategic Master Plan for Waste Management in Montenegro was prepared; this included recommendations for the organization of waste management activities in the period up to 2030, and aimed to assess the conformity of the Strategic Master Plan with the relevant EU acquis. This feasibility study concerning the Strategic Master Plan provided an analysis of applied technology in the field of waste management in the EU, and recommendations regarding technological and economic analyses and starting points for an action plan.

Since the end of 2011, a new Law on Waste Management ("Official Gazette" 64/11) has been in force; it regulates the types and classification of waste, planning, conditions and method of waste management and other issues of importance for waste management. In accordance with the law, waste management means preventing the occurrence of waste, reducing the amount of waste or re-use of waste and collection, transportation, the treatment and disposal of waste, control over the processes and subsequent maintenance of landfills, and includes the activities of waste dealers and brokers.

Objectives and measures for waste prevention, as well as indicators for monitoring and evaluating the progress achieved by applying these measures, are specified by the Waste Prevention Programme. The Waste Prevention Programme is an integral part of the draft National Waste Management Plan for the period 2014-2020; it is expected that this will be adopted during 2015.

A relevant issue that relates to the field of waste management is energy recovery from residual waste after the prevention of waste, maximum waste reduction recovery and treatment of materials, taking into account only materials of high and medium calorific value. In 2020, the potential for energy recovery from residual waste will be in the range of 73 000 t of waste of high calorific value and 12,000 t of waste of medium calorific value (sludge) of materials for thermal treatment. The Draft National Waste Management Plan for the period 2014-2020 provides for the development of a feasibility study at a national level in order to review potential, viable technologies and locations for the construction of a plant for the recovery of energy from waste.

The Biodegradable Waste Disposal Programme will specify measures to reduce the amount of biodegradable waste that is to be disposed of, and will include measures for recycling, composting, biogas production and material and /or energy processing, in order to ensure that the amount of biodegradable municipal waste going to landfill reaches a target figure equivalent to 35% of the total mass of biodegradable waste that was produced in 2010. The Biodegradable Waste Disposal Programme is an integral part of the Draft National Waste Management Plan for the period 2014-2020.

The Draft National Waste Management Plan for the period 2014 to 2020 and the Study on the Biodegradable Disposal of Waste, both form part of the Draft Waste Management Strategy (adoption is planned during 2015) and are in accordance with the Waste Management Law.

The National Waste Management Plan for the period (2014-2020) will also specify the exact number of regional centers for waste treatment (including sanitary landfills) in Montenegro. In accordance with the plan, all sanitary landfills will be equipped with a system for the collection of landfill gas by 2020, for the purpose of electricity generation. Each of the landfill sites will have the potential to collect landfill gas at a level of approximately 450-600 m^3 per hour, and which will represent an average value of 55% of the content of methane in landfill gas.

Analyses of Scenarios and Projections of GHG Emission Reductions in the Waste Sector

GHG emissions in this sector include CH_4, which is released during the decomposition of organic waste in anaerobic conditions. As shown in the 2011 review of the inventory of GHG emissions, the contribution of the waste sector in total CO_{2eq} emissions is around 2%. Taking into account that most of the emissions are released from municipal solid waste in landfills, this analysis will focus only on that sub-sector.

Measures to reduce GHG emissions in the waste sector are the following:

- Construction of regional centers for waste treatment (including sanitary landfill) and the burning of landfill gas;
- The degree of reducing the amount of biodegradable waste.

In order to reduce GHG emissions, which arise due to the decomposition of organic waste, new technology for collecting landfill gas at regional landfills has been introduced, and landfill gas has been burned, thus converting the methane content into carbon dioxide.

Two sanitary landfills have been built in Montenegro so far:

- Podgorica (Podgorica, Cetinje and Danilovgrad) - built in 2006 (includes a plant for landfill gas burning);
- Bar (Bar and Ulcinj) - built in 2012.

Estimates for reducing the share of biodegradable waste in the overall composition of municipal waste have been made on the basis of data obtained from the assessment reviewing the Strategic Master Plan for Waste Management in Montenegro and from recommendations obtained from the Organization of Activities of Waste Management for the period up to 2030.

In order to achieve the desired level of biologically degradable municipal waste going to landfill, the percentage shares of biodegradable waste produced were calculated as follows:

- 75% of the total mass of biodegradable waste produced in 2010 shall go to landfill no later than 2017;
- 50% of the total mass of biodegradable waste produced in 2010 shall go to landfill no later than 2020;
- 35% of the total mass of biodegradable waste produced in 2010 shall go to landfill no later than 2025.

Biodegradable constituents in household waste include:

- Waste paper, cardboard and textiles,
- Green biomass and natural wood waste (waste in gardens, parks, and waste from processing plants which are not intended for eating),
- Waste food and organic waste generated in the production and preparation of food (kitchen waste from households, kitchens and restaurants; biologically degradable waste, generated in the preparation of food from plants, and biologically degradable waste generated in the preparation and processing of meat, fish and other animal source foods), and
- Waste from wood, cork and straw processing.

Reduction levels in the amount of biodegradable waste shall be determined on the basis of data defining the composition of municipal waste in 2009. The amount of biologically degradable components in municipal waste is shown in Table 5.8.

In the waste sector, the following two scenarios were considered:

– Baseline scenario (BAU), which assumes that no changes will occur in the waste sector and that the amount of waste will increase in accordance with the demographic growth rate.

This option implies that the content of biodegradable waste from landfilled municipal waste decomposes in landfills, so that in the absence of a system for collecting landfill gas, methane is emitted into the atmosphere, and that the share of biodegradable waste in the overall composition of municipal waste will not be reduced.

– GHG emissions reduction scenario which proposes the implementation of a system for collecting and burning landfill gas at regional landfills in the country and for reducing the annual amount of landfilled biodegradable municipal waste, calculated as a percentage reduction of biologically degradable component parts of municipal waste that was generated in 2009.

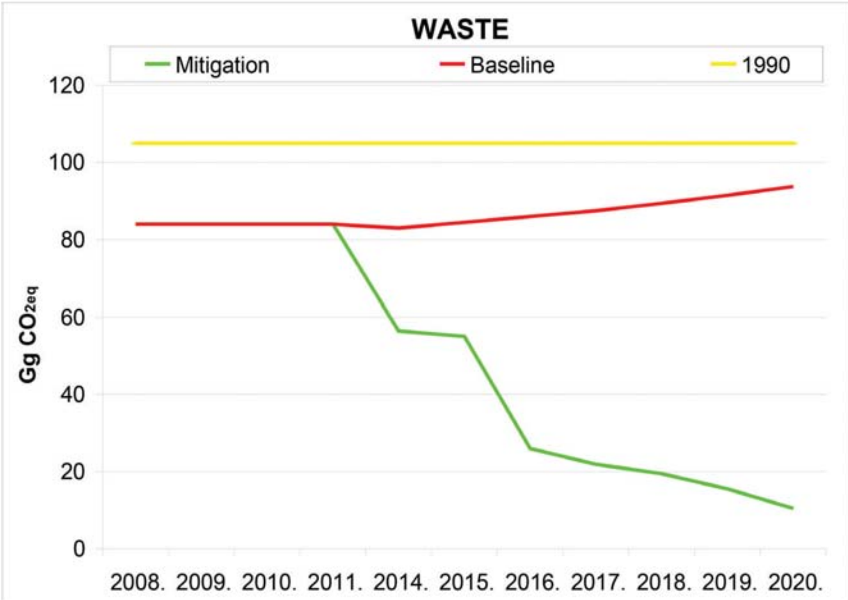
As shown in Graph 5.8, in 2020 the level of GHG emissions in the waste sector compared to 1990 will be reduced by:

– 11.2 Gg CO_{2eq} – for the baseline scenario;
– 94.6 Gg CO_{2eq} – for the scenario showing a reduction in GHG emissions.

At the end of the reporting period (2020), GHG emissions in the scenario of reducing GHG emissions were nine times higher compared to the baseline scenario.

Table 5.8 Quantity of bio-degradable components in deposited communal waste

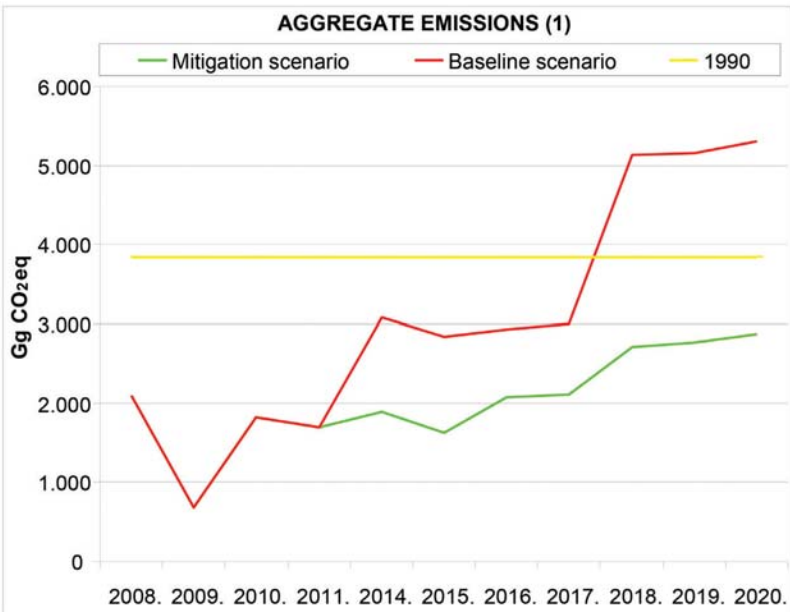
Year/s	Reduction of annual quantities of deposited biodegradable communal waste, calculated as a reduced share of biodegradable components in communal waste produced in 2009 (%)	Annual quantity of biodegradable components in communal waste, calculated as a share in total communal waste produced in 2009 (%)	Annual quantities of bio-degradable components in deposited communal waste (1,000 t)
Baseline year 2009**		63	145
2010.	0	63	145
2011.	5	60	137
2012.	5	57	130
2013.	5	54	123
2014.	5	50	116
2015.	5	47	109
2016.	5	44	101
2017.	10	38	87
2018.	10	32	72
2019–2021.	5	28	65



Graph 5.8 Total GHG emissions in the waste sector by analysed scenario

5.2.6 Total GHG Emissions

Graph 5.9. shows total GHG emissions for the baseline scenario and for the scenario assuming a reduction in GHG emissions (assuming that KAP is working at full production capacity, by analysed scenario at the end of reporting period).



Graph 5.9 Total GHG emissions in all the sectors by analysed scenario (assuming KAP is working at full production capacity)

Graph 5.9. shows that total GHG emissions in 2020, as compared to 1990, will be as follows:

- higher by 1 466 Gg CO_{2eq} – in the baseline scenario;
- lower by 967 CO_{2eq} – in the scenario that assumes a reduction in the level of GHG emissions.

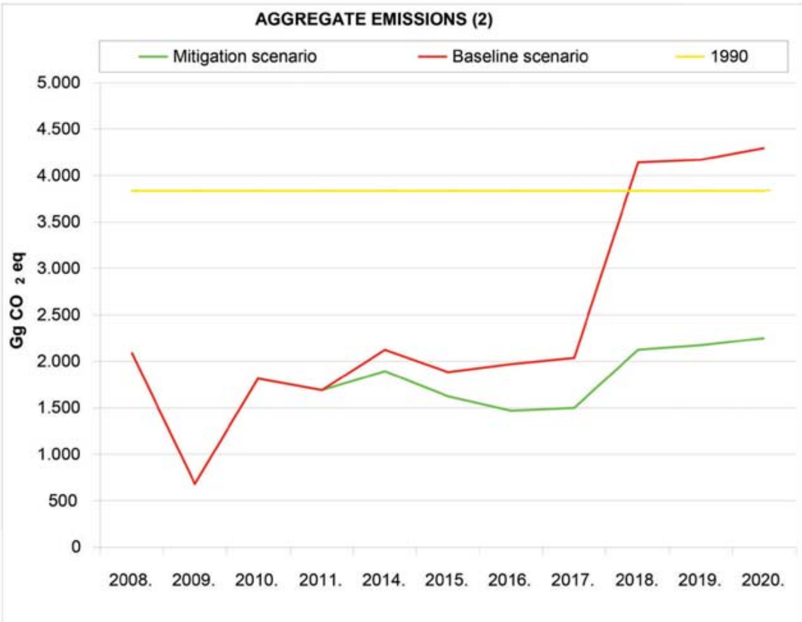
At the end of the reporting period (2020), GHG emissions in the baseline scenario of GHG emission reduction are 85% higher when compared with those in the scenario which assume a reduced level of GHG emissions.

Graph 5.10. shows total GHG emissions for the baseline scenario and for the scenario assuming a reduction in GHG emissions (assuming a reduced level of production capacity at KAP, by analysed scenario at the end of the reporting period).

Graph 5.10. shows that the level of GHG total emissions in 2020, over 1990, will be:

- higher by 455.5 Gg CO_{2eq} – for the baseline scenario;
- lower by 1587.1 Gg CO_{2eq} – in the scenario that assumes a reduction in the level of GHG emissions.

At the end of the reporting period (2020), GHG emissions in the baseline scenario are higher by 91% compared to the scenario that assumes a reduction in the level of GHG emissions.



Graph 5.10 Total GHG emissions in all sectors by analysed scenario (assuming a reduced level of production capacity at KAP)

5.2.7 Montenegro's Low Carbon Development

So far, not a single strategic document in Montenegro has been launched to define national climate change policy nor to set GHG reduction targets, or to define activities relating to such an objective. Work has recently started on drafting a National Climate Change Strategy up to 2030. There are, however, other already adopted (or soon to be adopted) national and sectoral strategies that partly address climate change mitigation issues, such as the Energy Sector Development Strategy up to 2030, The Strategy and Plan for Forests and Forestry Development – The National Forestry Strategy up to 2023, The Agriculture Development Strategy (2014-2018) and a draft for The Waste Management Strategy.

Montenegro is currenly in a specific position given that it is a Non-Annex I party to UNFCCC, it is a party to the Energy Community Treaty and, finally, is a candidate country for EU membership.

As a Non-Annex I party to UNFCCC, Montenegro does not have any quantified obligations regarding GHG emission reductions, at least until 2020. At this moment, there is no definite solution regarding a political framework for regulations concerning GHG emissions at an international level. UN negotiations are now underway regarding a new global climate agreement, and it is expected thatthis will be adopted in late 2015 (while the implementation of convention commitments will be defined for a period after 2020).

As a party to the Energy Community Treaty, Montenegro has already undertaken to harmonise its legislation with the EU legislation (acquis communautaire) in the energy sector; this includes a national target for OIE share in gross final energy consumption (33% by 2020), the introduction of EE standards in building construction and products, the inclusion of EE in public procuremenet, and restrictions on emissions for certain pollutants (e.g. SO_x i NO_x) from thermal-power plants using fossil fuels.

As a future EU member state, Montenegro will be under an obligation to implement a set of measures from an ambitious energy-climate package (better known as 20-20-20). Through the implementation of policies and climate change mitigation measures it will contribute to the overall reduction of GHG emissions by participating in the EU emissions trade scheme (EU ET) and in other joint efforts with other EU member states if it becomes an EU member state by 2020. Furthermore, the EU continues to move towards low-carbon economy, and the European Commission has defined a framework for a future energy-climate policy 2030 (the period after 2020), which sets targets for reducing GHG emissions at 40% compared with 1990 levels.

Even if Montenegro does not join the European Community by 2020, it is possible that international negotiations under the auspices of UNFCCC will result in Montenegro's accession to Annex I of UNFCCC. Depending on the outcomes of the negotiations, there are two potential models for Montenegro's participation in UNFCCC implementation:

– Accession to Annex I, which entails the commitment to submit to the UNFCCC Secretariat for approval the specific targets for GHG emission reduction, the so called QELRC – (Quantified Emission Limitation or Reduction Commitment),
– Maintaining the status of a Non-Annex I party to UNFCCC also entails a potential commitment in the form of the so called intended nationally determined contributions, in line with the expected new global climate agreement.

Given the present uncertainty regarding the future pace of international UNFCCC negotiations, and the dynamics and date of Montenegro's EU accession, the analysis presented here for the period until 2020 is based on the assumption that Montenegro will not become an EU member state by that date. The accession process, however, will be followed by the continuous harmonisation of national regulations with committments from the energy-climate package, which will gradually take effect; this means that some of the measures for GHG emission reduction will be implemented even before Montenegro's accession to the EU.

After it has established a monitoring, reporting and vertification system for GHG emissions and defined its national and/or international obligations to reduce GHG emissions and institutional pre-requisites for the fulfilment of these obligations, a state becomes entitled to funding from the Green Climate Fund for the implementation of Nationally Appropriate Mitigation Actions - NAMA. This is following its registration with NAMA register, which is administered by UNFCCC Secretariat.

The analysis up to 2020 is indicative in character and shows the present situation and what steps need to be taken next with respect to measures for the reduction of GHG emissions and concerning potential future policies; it can certainly help in defining Montenegro's negotiating position at an international level.

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- POWERED – Project of Offshore Wind Energy: Research, Experimentation, Development (http://www.powered-ipa.it/)
- Rulebook on detailed characteristics of location, construction requirements, sanitary and technical requirements, method of operation and closure of landfills, professional qualifications, landfill manager qualifications and types of waste and requirements to accept waste at the landfill (Official Gazette of Montenegro 46/11)
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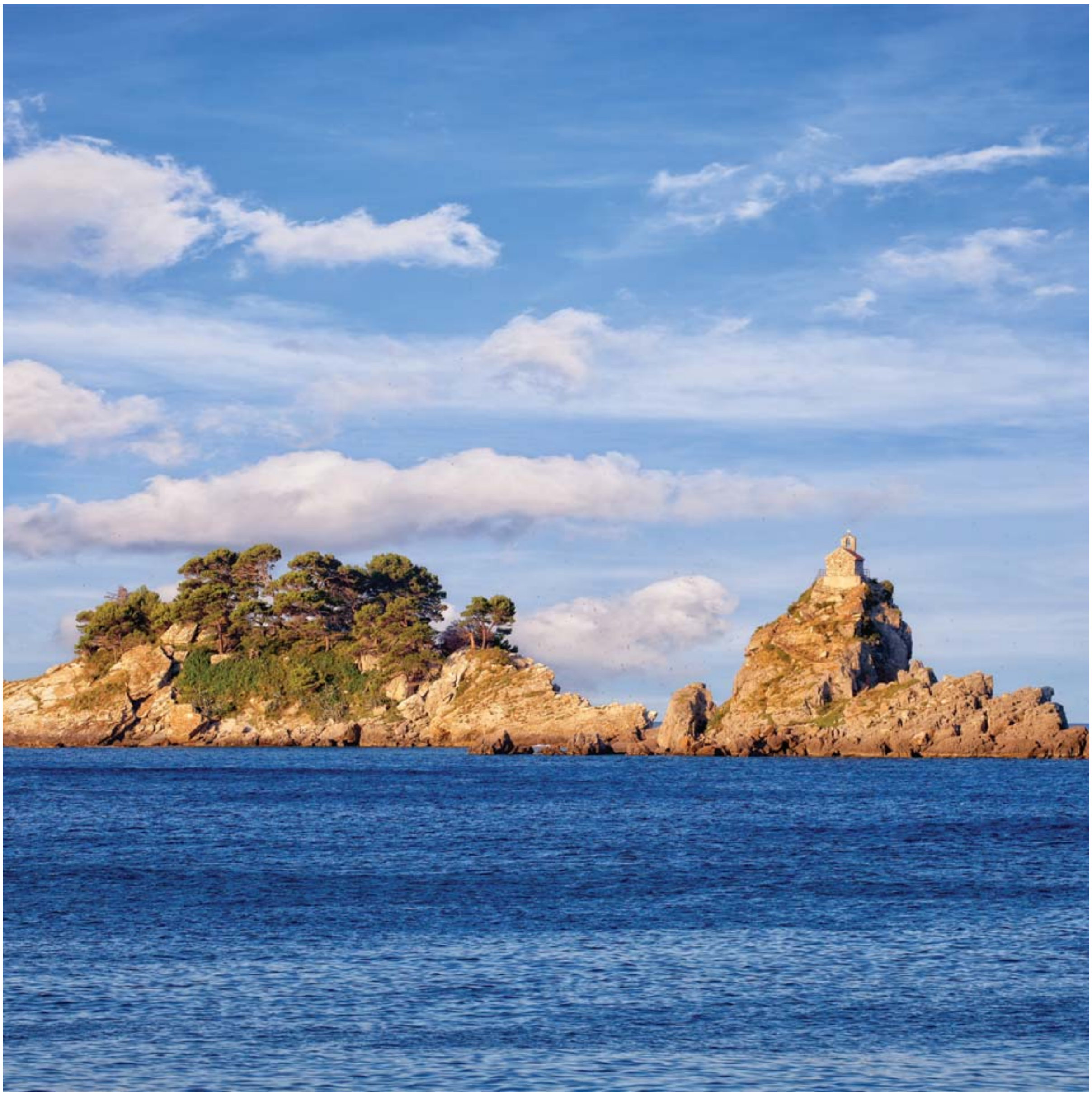
6. ADDITIONAL INFORMATION



6.1 GROUND WATER (Reservoirs, Usage, Protection, Problems)

The territory of Montenegro is part of the South-East Dinarides, which, as a result of the intense geological evolution of the terrain, is marked by the complex lythofacial composition of its terrain (sediment, metamorphous and volcanic rocks) which is of tectonic origin.

Carbonate rocks represented by limestone, dolomite limestone and Palaeozoic and Mesozoic dolomites make up over 60% of the terrain in Montenegro. Karstification has significantly affected these rocks, which is manifested in many surface and ground karst forms, and in complex and specific hydrogeological relations and phenomena, particularly in karst fields and coastal karst.

Less represented in the composition of the terrain, but still relevant to the subject are the following:

- clastic (mechanical) sediments from Palaeozoic, Triassic, Paleogenic and Neogenic age, represented in claystone, sandstone and marlstone acting as full, lateral or hanging barriers to ground waters;
- Palaeozoic metamorphic rocks which are represented by slate of low or no permeability, high and low crystallinity, found in north-eastern part of Montenegro;
- volcanic rocks were detected in several locations along the coast of Montenegro, as well as in the central and northern parts of the country; most often theses act as lateral barriers to ground waters;
- quartar sediments (clay, sands, gravel) deposits in the karst fields and in major depressions with ground water which are represented as confined aquifers.

The territory of Montenegro is marked by the following major geotectonic units: Para-Autochtonous and Budva-Bar coastal zone, Visoki Krs and the Durmitor tectonic unit in the continental part of Montenegro. All of these tectonic units are of complex geological composition. They run following the line of the Dinaric Range. Tectonic movement in geological evolution in this region has resulted in numerous reverse faults - overthrust and bores, while at the same time the tectonics have created conditions for the formation of Cetinje, Niksic and Grahovo plains, as well as of Zeta-Skadar depression.

6.1.1 Hydrogeological Watershed and Direction of Aquifer Flows

Hydrogeological Watershed

Defining hydrogeological watershed, basins and direction of aquifer circulation is one of the most complex tasks in holokarst of South-East Dinarides. In spite of dye surveying, watershed among individual basins in the karst of Montenegro is still hypothetical. This particularly applies to underground watersheds, or those parts of the terrain where watersheds are in a broad and changeable zone, which shifts depending on the hydrological status throughout the year. This is the case of the karst areas between the basins of Zeta and Moraca rivers, the Banjani area and Katun plain, which is a watershed between the basins of Niksic Field, Tresnica, and Boka Bay, as well as the area of Rumija Mount whose ground waters circulate towards Skadar Lake, and the sea.

Beside this type of zone watersheds in the karst of Montenegro, there are also line watersheds, characterised by the contact of permeable and nonpermeable rocks, and, more rarely, topographic watersheds.

Topographic (surface, geomorphologic) watersheds are found only in those parts of the terrain that are made of nonpermeable rocks (Palaeozoic slates, chalk-paleogenic age flysh sediments) as is the case with Tara River Basin upstream from Matesevo, Komarnica River Basin upstream from Savnik, Moraca River Basin upstream from Medjurijecje, Komaracka and Trokuska River Basins (Lim River tributaries) upstream from the town of Plav.

There are many factors that have an impact on the location and type of watersheds in the karst of South-East Dinarides. These primarily include lythofacial composition, structure, hydrological and geomorphological features of the terrain, hydrogeological functions of the rocks, and the direction and hydrogeological functions of faults. A significant role in the general distribution of ground waters in the karst terrain of Montenegro is played by anticline structures; it has dolomites of Late-Triassic and Early-Jurassic age in its core, as well as nonpermeable flysh sediments of Triassic and Chalk-Paleogenic age.

Watershed between the Black Sea and Adriatic Sea Basins match, for most of its part, the topographic watershed from Rikavacko Lake close to the Albanian border to Krnovo Glavica. This part of the terrain is mainly composed of nonpermeable flysh sediments of Chalk-Paleogenic and Permo-Triassic age, and of volcanic rocks from the Middle-Triassic age.

From Kronovo Glavica to Gatacko field the watershed is subterranean, while the hydrogeological watershed, is marked by anticlinal structure of Vojnik Mount (k.l. 1,9998m) with dolomites of Late-Triassic and Jurassic age in its core.

Unlike I order hydrogeological watershed, which is quite reliable and definite, smaller basins are much more problematic, particularly in typical holokarst terrains. Particularly problematic is the watershed between the basins of Trebisnica River and Boka Bay on the one hand, and the basin of Niksic Field on the other; between the basins of Zeta and Moraca Rivers, Crnojevica Rijeka, and Adriatic Basin, the Piva and Tara Rivers, etc. These terrains are made of carbonate rocks that during their geological evolution were tectonically broken and intensively karstified, to great depths.

In the coastal confinement zone, folds of Dinaric direction and overthrust structures were formed, while in the Zeta River Valley, and on the Niksic and Bjelopavlici Plains, the dominant structures are those of splitting, represented by faults in different directions, mostly northwest-southeast and northeast-southwest.

In these typical karst terrains (rimmed by deep canyons or karst fields), where surface discharge is most often absent, watersheds are not only under the ground, but cover a wider zone that shifts depending on the intensity, quantity and distribution of precipitation throughout the year.

Hydrogeological watersheds in this part of terrain have been defined on the basis of numerous dyeing surveys, temporary sinks, and the analysis of hydrometeorological and geomorphological data, geological composition, tectonic structure, and hydrogeological functions of rock mass.

Specific watersheds in the karst terrains are illustrated by the results of dye surveys carried out in the karst terrains of Montenegro, as follows:

- where a sink represents a watershed between hydrogeological units of I order, i.e. between the basins of the Adriatic and Black Sea. By dyeing the undercurrents in Caradje, a link was established after 30 days with the source of the Piva / Sinjac (Black Sea basin), and after 42 days with temporary sources of the Baba and Jama in the Fatnik Plain (basin of Trebjesnica and of the Adriatic Sea);
- where a river bed represents a watershed between smaller catchment areas. (By dyeing the undercurrents in the Cijevna River bed, a link was established with the sources of the Miles, Krvenica and Vitoja : Skadar Lake, and with Ribnicka Vrela - a tributary of the Moraca River);
- where a lake is a watershed between river basins. (By dying the waters of Black Lake, a link was established with Bijela Vrela in the Tara Canyon, as well as with Dubrovska Vrela in the Komarnica Canyon);
- where dyed waters circulate under the deep canyons of the Tara and Cijevna Rivers and show up in sources on the other side of the watershed,
- where dyed ground waters circulate under artificial accumulations or circumvent them. (By dyeing the sink in Trepca, a link was established with the Drenovstice Vrela in Bjelopavlici plain although it was

logical for the dyed waters to show up in the sources along the rims of Slansko accumulation in Niksic Valley);

- where dyed waters circulate deep under or through anticlinal structures with nonpermeable sediments in their core. (By dyeing the sinks in Bare Bojovica and Liverovici a link was established with the sources in Bjelopavlici Valley (Glava Zete, etc);
- where dyed waters show up at the same time or in certain intervals in several springs or cave springs in Skadar Lake that are far from one another, which points to a wide distribution of karst channels, or to karstification of limestone rock mass,
- where dyed waters of a whole series of sinks lying along the edge of karst plains, over 14 km in length, circulate towards one karst well. (By dyeing numerous sinks along the southern rim of Niksic valley a link was established with a strong karst well - Glava Zete in Bjelopavlici Valley.

Direction and Movement of Aquifers

Several conclusions can be drawn from the numerous experiments carried out with groundwater dyeing, geological structure and rock hydrogeological functions on the direction and speed of groundwater circulation.

Fragmented structures have a particularly important impact on the direction of karst aquifers, through which the karstification process is intensified. There are many examples where faults represent main aquifer drainage. For example:

- The Cetinje fault predisposes the development of a system of Cetinje Caves, and directs aquifer water from the valley basin to the Crnojevica River;
- The Gornjopolje fault, lying in the direction northwest-southeast generally directs aquifer waters from the Srijeda area towards the Gornjopoljski Maelstrom estavel;
- The faults in the Boka Bay hinterland, lying northwest-southeast, direct ground water from the Grahovo area, along the disintegrated flows of the Grahovska and Bokeljska Rivers, towards Risan Cave (running parallel to this one is the fault which directs aquifer waters from the sink in Tresnjevo towards Orahovacka Ljuta. J. Cvijic (1924) and emphasizes that after the depression of the terrain in the Quaternary Period, along Orahovo-Kotor Bay, in the Morinj-Kotor depression, and the appearance Orjen and Krivosija, there followed the karstification of the Bokeljska River.

The direction of aquifer waters in typical karst terrains is affected not just by the position of nonpermeable rocks but also by the route of stratification of carbonate rocks. Since the Dinaric direction is dominant, it is not surprising that in the Visoki Krs zone, the direction of ground water is mostly northwest-southeast.

Generally speaking, the direction of aquifer waters in the Adriatic basin is typically from north to south, from northwest to southeast, and from northeast to southwest. Exceptions are the northern slopes of Rumija and Gluhi Do where cave springs drain along the edges of Skadar Lake, and karst springs along the edge of the Crmnica Valley, where the direction of aquifer waters is generally from the south to the north.

The opposite is the case with the karst terrains in Black Sea Basin, where the most frequent direction of aquifer waters is from the south to the north.

However, other directions of aquifer waters have often been recorded (from north to south, and from east to west), which is the result of the deep canyons of the Piva, Tara and Cehotina Rivers. As has already been mentioned, there are records which show a case where the waters from one sink lying on a watershed can circulate in two opposite directions, towards the basis of the Adriatic and of the Black Sea.

Most ground water dyeing experiments have been conducted using sodium fluorescene in the Karst terrains of the Skadar Lake Basin, and the sinks in the Niksic and Cetinje valleys.

The experiments were mainly conducted as a part of the regional hydrogeological surveys, during the design of the hydrogeological map and as a part of the detailed surveys conducted for accumulation purposes in the karst fields.

The hydrogeological characteristics of the terrain result primarily from lythofacial composition, tectonic structure, the position of porous and nonporous rocks and the structural type of porosity of rock masses.

6.1.2 Major Water-Bearing Formations (Inter-Granular and Karst Aquifers)

Light Mineral Water

Ground water in Montenegro's terrain is mainly found in:

- carbonate rock masses with plentiful crevices and cavernous porosity;
- quartar glacio-fluvial and alluvial sediments of inter-granular porosity.

a. Karst Water-Bearing Formations (Karst Aquifer)

Over 60% of Montenegro's territory is made from carbonate rock (limestone and dolomite) as characterised by the significant reserves of quality ground water. Ground water from karst water-bearing formations drains through numerous wells mostly located along the watercourse of the canyon, along the rims of karst fields and depressions, along the sea-coast and in higher elevation points, in places of contact between porous and non-porous rocks.

The total minimum water yield of karst wells in the territory of Montenegro is around 50 m^3/s, while the average is around 600 m^3/s. The strongest are those in the Skadar Lake basin and have a minimum yield of around 21.0 m^3/s, followed by the wells in the Piva, Tara and Cehotina River Basins which have a yield of around 17.0 m^3/s. The minimum yield of wells in the immediate Montenegro Coast Basin is around 5.0 m^3/s, and for the Lim and Ibar River Basins it is around 8.0 m^3/s.

Basic characteristics and specific features of karst aquifer waters in the territory of Montenegro are as follows:

- Karst regime of flow, or a high amplitude of variations in karst well yield, where Qmin:Qmax is often over 1:400 (Qmin Crnojevića River is 0.383 m^3/s and Qmax 188 m^3/s etc.);
- High amplitude of water level variations in karst terrains particularly in karst fields (in the Cetinje valley from 80 - 100 m, in the Niksic valley from 4 m in the northern part of the valley to over 90 m in the southern part of the valley);
- High speed of circulation of aquifer waters, which according to the dye test results varies from 0.10-13.8 cm/s, which has an impact on the occasional bacteriological contamination of karst wells;
- Flowing out of significant volumes of aquifer waters into coastal karst areas below sea level (Qmin > 4,0 m^3/s), which limits the possibility for their exploitation;
- Flowing out of significant volumes of aquifer waters in the form of sublacustic wells, below the level of Skadar Lake. For example, the yield of Sinjacka and Karuce wells alone is Qmin> 8.0 m^3/s;
- Numerous karst wells were flooded by the Piva accumulation lake which has a minimum yield of Qmin> 4.0 m^3/s;
- Some wells were flooded by the Otilovici accumulation lake (Qmin = 0.1 – 0.2 m^3/s);
- A large number of wells were flooded by the Krupac and Slano accumulation lakes (Qmin> 1.5 m^3/s).
- Overall yield of the wells flooded by the sea and by lakes Qmin> 20.0 m^3/s.

The above specific features relating to the regime of yield and the location of wells is a significant factor which limits the possibility of catchment for the necessary quantities of water from local springs in the coastal area. That is why, until recently, the majority of settlements in the Montenegrin coastal area have not been able to find a quality solution to their water supply problems. This problem has now been resolved by the construction of a regional water supply which catches karst aquifers from the Bolje Sestre spring in Skadar Lake and whose minimum yield is around 2.0 m^3/s.

b. Quartar Water-Bearing Formations (Inter-Granular Aquifer)

In quartar water-bearing formations of inter-granular porosity, significant volumes of ground waters are found in:

- glacio-fluvial sediments of the Zeta Valley (over 200 km^2 in area and average aquifer thickness of 35m) which is the area richest in aquifer waters in Montenegro, with dynamic reserves in hydrological minimum of Qmin> 15.0 m^3/s;
- glacio-fluvial sediments of Niksic Valley (Qmin> 1.0 m^3/s);
- alluvial sediments of Grbalj, Sutorina, Budva, Bar and Anomal Vallies, with overall reserves of Qmin> 1.5 m^3/s;
- terrace sediments in the basins of Tara i Lim Rivers and their tributaries (Qmi>1.0m^3/s).

Mineral and Thermal-Mineral Waters

Based on the location and presence of mineral and thermal waters, their chemical composition, abundance and hydrogeological structures where their presence is recorded in the territory of Montenegro, the following zones stand out:

- Coastal zone;
- Central zone, and
- Inner Dinarides zone.

Coastal Zone – This zone includes the terrains of the Montenegrin coast, or geotectonic units of Parahton and Budva Cukali zone. Mineral springs in this province have been identified in the surroundings of Ulcinj. These waters stem from sand or lump limestones of the Miocen age at sea and undersea levels in the localities of Orasac, Zenska Plaza, Stari Grad and Valdanos.

According to its gas composition, it belongs to hydro-sulphur, and according to its ionic composition, to sulphate-chloride-sodium types of water.

Mineral waters also appear in the surroundings of Igalo. There is a mineral water spring located just below the road leading to Njivice. It appears alongside the fault running from Sutorina to Njivice, at the point of contact between the limestone and Eocenic flysh. The temperature of these wells ranges from 14-20°C. Igalo mineral water belongs to the class of muriatic (NaCl) hypothermal waters. The water is slightly salty and mildly radioactive, which is linked to the presence of bauxites.

Central Zone – The central zone records just one thermal zone, located in the Komarnica Canyon some 5km upstream from the point where it joins Piva River. This is the Ilidza spring, which was flooded by the Piva accumulation lake. The temperature of this spring flowing out of alluvial river deposit is around 26oC in summer, whilst the Komarnica River temperature is 11oC and is characterised by an increased fluoride and silicon-dioxide content. According to its gas composition it belongs to the carbon-dioxide type, while according to its ionic composition it belongs to the magnesium-calcium-sulphate hydrocarbonate type of waters. There is no reliable data on the genesis of this spring. These are most probably atmospheric waters that have contact with eruptive rocks of Middle Triasic period.

Zone of Inner Dinarides – The presence of mineral waters in the Inner Dinarides zone, i.e. in the north-eastern zone, is recorded in the basins of Lim and Ibar Rivers. This part of the terrain is made from slate (argelosist, phylite), sandstone and limestone from the Palaeozoic period.

Mineral Waters of Bijelo Polje – The best known locations for mineral waters in the surroundings of Bijelo Polje are those between the Ljubovidja and Sljepasnica Rivers. These are found in the village of Nedakusi (Sljepasnica valley) in the Lipnica River valley, in the villages of Ljesnica and Ceoce (Ljesnica River valley) in the villages of Modri Do, Pape, Dubrave, Jabucno and Bucje. They appear in the form of weak springs at elevations of around 570-1,100m, most often along faults with a NW-SE axis, which lie along the valleys of Ljubovidja, Ljesnica and Sljepasnica.

The springs with biggest yield are Ceoce spring (Qmin = 0.5 l/s), Banje Selo spring (Qmin = 0.02 l/s) and the "Kisjela Voda" spring in Sljepasnica valley, near Nedakusi (Qmin = 0.05 l/s). According to their physical characteristics, they are of bitter taste, with no colour or scent, with temperatures ranging from 9-12°C, and according to their chemical composition they belong to the hydrocarbonate class of sodium type.

The Ceoce Spring in the Ljesnice valley has the biggest yield of all mineral water sources in the wider Bijelo Polje area. This spring is some 6km away from Bijelo Polje, at an elevation of 650m. According to available data, the natural yield of this source is around 0.5 l/s.

In this area, made from Palaeozoic slate, an exploitation well measuring 1982, 220mm in diameter and 29m deep was made; its optimum yield is Q = 1.4 l/s, and maximum yield is Q = 5.6 l/s.

This spring is used by the Rada mineral water bottling plant, located in the industrial zone of the town.

According to earlier analyses, its total mineralisation ranges from 2,100 mg/l to 2,730 mg/l. According to Klute classification, it belongs to the category of hard water, with pH values ranging from 6.05–6.82.

According to Alekin's classification, it belongs to the hydrocarbonate, sodium class, while according to its physical features and chemical composition, it belongs to the class of alkaline-ground-alkaline salinic mineral waters.

The Banje Selo Spring is located some 2.5km away from Bijelo Polje. The terrain is of similar geological composition to the Ceoce spring, i.e. it is made from slate and sandstone. It flows out at the point of crossing of the faults of N-W and NE-SW axis. The spring's yield is 0.02 l/s and its mineralisation is 1.875 mg/l. Its temperature is around 11oC and it has a pleasantly bitter taste.

The Donji Nedakusi Springs are located in Sljepasnica valley, some 4km from Bijelo Polje. They come out at an elevation of 570m. One of them is located next to the Kisjela Voda motel and the other is some 400m upstream. This terrain is dominantly made from Early Paleosoic slate and sandstone. The flow of mineral water is predisposed by the fault whose trajectory matches that of the Sljepasnica valley. These also belong to the hydro-carbonate classes of water, i.e. they belong to cold alkalic-salinic mineral waters. Mineral water from this spring is ferrous water because of its high content of ferrum.

Mineral Water of Rozaje – The best known presence of cold mineral carbon-mineral water in the Rozaje region is found in the Zupanica, Dunerovića Luka, Kalaci and Bogajski springs. There are two additional localities with mineral water: Basca and Lucice.

Mineral waters from this region spring from Paleosoic slates, along faults, and under the influence of gas. They belong to the hydrocarbonate class, the sodium class, and according to their gas content, to the carbon-dioxide class.

6.1.3 Utilisation of Ground Water

Ground waters from karst and quartar water-bearing formations are used for:

- water-supplies in human settlements;
- irrigation of arable land;
- industry;
- bottling.

Water-Supplies

The overall capacity of karst aquifer water springs used for water-supply of settlements and smaller industrial plants in the territory of Montenegro is around 5.0 m^3/s at hydrological minimum, which makes under 10% of the overall hydrological potential of springs at their hydrological minimum.

Since 2010, the problem of water-supply for the Montenegrin coast has been resolved by a regional water-supply system which catches water from the Bolje Sestre spring in Malo Blato Basin of Skadar Lake.

The results of numerous analyses (CETI; FIHM; S. Stanković Institute of Belgrade etc.) indicate that the waters from Bolje Sestre springs are of good quality in terms of both their physical-chemical parameters, and micro-biological features (A1 class). The regional water-supply system, which is already in operation, is key to the future development of tourism and of the economy in Montenegro and is designed for a maximum capacity of 2,000 l/s. This spring supplies Budva, Tivat, Kotor, Bar and Ulcinj with the necessary quantities of water, and activities are now underway to connect the spring to the water-supply system of Herceg Novi.

The entire system is around 140 km long and comprises two subsystems: continental and coastal parts. The continental part begins from Bolje Sestre catchment, passes through the hydrotechnical tunnel Sozina and ends at the Djurmani reservoir; it is 10,000 m^3 in capacity and serves as the main accumulation facility for the system.

The heart of the system is the Bolje Sestre spring in Malo Blato. Water flows from the spring at a depth of some 5-6m and from the surrounding multi-layered limestone, is caught by a cylinder concrete dam and excess water flows over into the lake. A water plant has been constructed at the Bolje Sestre spring along with a catchment area, a pump station and ultraviolet reactors for water disinfection.

Water is transported by pressured water-pipes from the well to the surge tanks near the catchment area; these are located in such a way as to allow for gravitation to transport the water to the edges of Crmnica Field, and to the Reljici pumping station. Once the water has been transported through the 4.2 km long Sozina hydrotechnical tunnel to the 10,000 m^3 Djurmani reservoir, the coastal section is then divided into southern and northern branches. The northern branch from the Djurmani reservoir is 62km long and runs all the way to the municipalities of Budva, Kotor, Tivat and Herceg Novi. The southern branch which is 35 km in length, is used to supply water to the Bar and Ulcinj municipalities.

To allow the ongoing monitoring of water quality at both the well and in locations where the water is delivered to coastal municipalities, the regional water-supply system has a modern laboratory with the capacity to measure all of the key physical and chemical parameters in water.

The municipalities in the continental part of Montenegro do not face any problems with water-supply. The exception is Pljevlja which is partly supplied from the Otilovici accumulation, while other settlements mainly use quality karst spring waters. Most springs that are incorporated into the water-supply systems meet strict international standards and requirements and can be used as potable water through bottling. As for the water quality, Vidrovan wells stand out and makes up part of the Niksic water-supply system; the same applies to the Mareza well which is part of the Podgorica water-supply system, Podgorska Well which is part of the Cetinje water-supply system, Bistrica which is part of the Bijelo Polje water-supply system, etc. However, it is worth noting that all of the afore-mentioned karst wells are sensitive to climate change. This particularly applies to the Vidrovan Wells which suffers from with major reductions in yield during the dry months of the year, which means that in summer months other wells need to be incorporated into the water-supply system, mainly by pumping water out of karst aquifers, and via exploitation wells.

Irrigation and Industry

As a technical measure for the regulation of water regime, irrigation is used in only 18,000ha, which accounts for around 3% of overall agricultural land.

Modern irrigation systems are used for agricultural land at the following locations:

- The Ćemovsko Field, with vine and peach plantations covers an area of around 2,400ha, the system used includes artificial rain and drop by drop irrigation. The system uses ground water from the Zeta Valley aquifers, with the company Plantaze AD using Qmin> 2.0 m^3/s during summer season through over 20 drilled wells which are 50-100m deep, and 600-1,000mm in diameter;
- The Tivat Field covers an area of 20 ha, partly under glasshouses and greenhouses, with a water-supply from micro-accumulation on the Gradiosnica River (60,000 m^3 in volume);
- The Grahovo Field has an area of around 400 ha that requires irrigation; this is irrigated by water from the Grahovo accumulation, around 1,000,000 m^3 in volume.

In the central and northern parts of Montenegro, water used for irrigation includes ground water and the surface water from the Zeta, Moraca, Gracanica, Tara, Cehotina and Lim Rivers.

Irrigation projections include plans to construct irrigation systems by 2021 which should cover 80% of the overall land area that requires irrigation, or some 60,000 ha.

The Aluminium Works in Podgorica uses over 10 drilled wells which are 50m deep on average and catches for its own needs some 1.1 m^3/s;the Steel Works in Niksic uses some 0.5 m^3/s from Liverovici surface accumulation in its technological process, while the Otilovici accumulation lake was made to satisfy the needs of HPP Pljevlja, with an average catchment of 375 l/s.

Bottling of Karst Aquifer Waters

During the past 10 years there has been a growing interest in bottling karst aquifer waters.

Regarding bottling aquifer waters, Montenegro has several different types of springs which vary in the type and character of their water-bearing formations.

The first type includes springs in karst aquifers (Mareza, Rezevica Rijeka, Ravnjak, Ropusnica, etc).

The second type includes springs in karst-crevice aquifers which flow from dolomites (Uganjska Vrela, Rastovacka Vrela, etc).

The third type are springs in water-bearing formations of inter-granular porosity (glacial, glacio-fluvial, and alluvial sediments).

The fourth type includes springs in water-bearing formations with complex (combined) porosity structures (inter-granular and karst-crevice porosity) and with secondary types flowing from glacial and glacio-fluvial sediments, primarily related to carbonate rock masses of crevice-cavernous porosity.

The fifth type is found in the north of Montenegro and is related to Palaeozoic period formations.

In spite of their significant potential, quality aquifer waters are under-utilised for bottling in Montenegro.

The Rada mineral water plant is under construction in Bijelo Polje, four plants (technological lines) of table mildly-gassed mineral potable water operate in the surroundings of Kolasin (Monteaqua, Aqua Bianca, Suza and Gorska), Durmitor spring water Diva is located near Zabljak, and there is one more plant in Zupa Dobrska, between Podgorica and Cetinje.

The preparations for several technological pipelines are underway: from Zaslapnice spring near Grahovo, Alipasini Springs near Gusinje, and from a number of springs in the areas of Niksic and Savnik.

6.1.4 Current Karst Problems in Montenegro

Utilisation of Remaining Watercourse Hydroenergy Potential

In spite of favourable natural conditions, when it comes to its utilisation of water potential Montenegro is severely lagging behind not just developed European countries but also its neighbours. However, special attention should be paid to harmonising the exploitation of water potential with environmental protection, which means that hydro-energy facilities should be carefully integrated into the environment.

The Water Management Plan of Montenegro (2011) mentions two possible options for the integral exploitation of the hydroenergy potential of the Moraca watercourse.

Both options are based on the concept of building the Andrijevo Dam in the Platije Canyon, with downstream cascades (HE Raslovici, HE Milunovici, HE Zlatica).

The first option includes a plan to construct a 150m high dam with a normal accumulation elevation stall of 285 m, and a useable of volume of 249 hm^3, while the second option includes a 115m high dam with a useable volume of 100 hm^3 and an elevation stall of 250m.

The accumulation resulting from the High Andrijevo dam construction entails a certain threat to the stability of the sides in the valley located in Djudjevine fossil landslide and to the river terrace plateau where the Moraca Monastery was erected.

Before the final decisions are made on the construction of accumulation lakes on the Moraca River, their location and dimensions, the elevations of normal and maximum stalls, the following must be undertaken:

- Thorough and equal consideration to option 2 - Low Andrijevo (Water Management Plan, 2001) with a normal stall elevation of 250m, which would not threaten the Moraca Monastery, and would not have a significant effect on potential landslides at Djudjevina, and would not flood the Mrtvica Canyon. Energy losses could be compensated for by the construction of upstream terraces, primarily the following: HPP Grlo, with a normal stall elevation of 335m and HPP Dubravica, with normal stall elevation of 500m, and a useful volume of 100 hm^3
- The hydro-power plants at Low Andrijevo, Raslovici and Milunovici do not have a significant impact on the activation of engineering-geological processes and events, or on the regime of ground and surface water, which is not the case with HE Zlatica.

The hydrostatics of Zlatica's accumulation pool cannot be guaranteed between the Duga Monastery and Smokovac, where surveys have so far registered numerous sinks and sink zones (Monastery Mills, Lazbe Kolovratske, etc). These could lead to significant losses of water close to Drezga and the Straganicko Field which would then flow down the Siralija River towards the Zeta River, and partly by underground route towards the Zeta Valley; this must be the subject of a more extensive analysis during the next stage of exploration.

The Niksic Field has artificial accumulations of Krupac, Vrtac and Slano, and HE Perucica has 307MW of installed power and an average generation level of 907 GWh. However, it must be emphasised that the waters from the Gornja Zeta catchment area are still not being used sufficiently or rationally, and steps must be taken to optimise the use of this hydroenergy system.

The hydrogeological basin of Gornja Zeta, some 895 km^2 in area, with an average precipitation of 2,000 mm, makes an average inflow into the Niksic Field of around 40 m^3/s, which allows for the production of some 1,562 GWh. Today, the useful volume flow rate is deemed to be around 23 m^3/s. The problem is that the Niksic Field accumulations are not watertight, particularly the Slano and Vrtac accumulations, and the Liverovici accumulation is not used at all. The water losses from the Slano accumulation at normal stall elevation are over 7.0 m^3/s, from the Krupac accumulation they are around 1.3 m^3/s and from the Vrtac retention they are in excess of 20.0 m^3/s.

Disintegration of Watercourses in Karst Terrains

The terrains within the Skadar Lake Basin are mainly composed of carbonate rock masses; here it is possible to witness the disintegration of water courses and their gradual disapperance underground. This is the result of intense karstification and climate change in the past. Some rivers have already lost their hydrological functions, and what remains from their former courses is just dry karstified valley.

This is the case with the Cetinje and Karuc Rivers, both of which are tributaries to Skadar Lake. The Cetinje River used to flow through the Cetinje Field, to Dobrsko village and on to Rijeka Crnojevica; it has now disintegrated and flows at some 80-100 m underground.

The remains of former rivers are now marked by systems of caves: Cetinjska, Lipska and Obodska caves, all of which are geologically connected.

Something similar may soon happen with other watercourses in the Skadar Lake Basin: the Zeta, Moraca and Cijevna Rivers, which all dry out in some sections during the summer season.

It is for these reasons that research needs to be carried out to discover more about these phenomena, along with repairing some of the karst sections along the beds of the rivers that are threatened. In addition, the remaining hydroenergy potential of karst watercourses must be utilised by constructing dams and accumulation lakes, with the application of appropriate injection techniques.

Flooding and Drainage of Karst Fields

One of the problems facing karst terrains in Montenegro is frequent flooding primarily in karst fields, but also in the plains of the Zeta Valley, the area surrounding Skadar Lake, and along the courses of the Bojana and Lim Rivers.

Extreme floods were registered in late 2010 in the Zeta Valley and along the course of the Bojana River, with maximum levels of Skadar Lake registered as reaching an elevation of 10.44m. The floods were not just caused by record precipitation levels but also by accumulations in the Drim River in Albania (Vaus Deis, Kumana, Fierza), that released some 3,000 m^3/s of water. The capacity of the Bojana River bed is around 1,700 m^3/s and the overall flow from the Skadar Lake Basin was around 7,000 m^3/s.

A similar situation was registered in the Niksic Field, where there is no set regime for accumulation exploitation, and thus the capacity of sinks was not sufficient to cope with the entire flow. In this field in addition to full accumulation lakes Krupac, Slano and Vrtac, with a total volume of around 240x106 m^3, some 60x106 m^3 was accumulated in the area of Slivlja.

The problem of floods in the Cetinje Field was temporarily resolved by creating a 150m long underground canal in Jurassic karstified limestone which intercepted the system of Cetinje caves, from which point water flows towards Rijeka Crnojevica.

In 1986 floods, water in Cetinje reached the level of the roofs of private houses; however, during the period of extreme precipitation and flooding in December 2010 water did not accumulate at all in this area of Cetinje. A permanent solution to flooding and for the protection of ground and surface water in the basin of Rijeka Crnojevica is planned; the Belveder evacuation tunnel and wastewater treatment facility will soon be built to solve this issue.

Pollution and Protection of Aquifer Waters

With the exception of large karst fields and ravines, karst aquifer water zones are usually away from the reach of major polluters.

In terms of potential pollution hazards, the elements that are most exposed to threats are the aquifer waters within the limestone paleo-relief of the Niksic and Cetinje Fields which are drained by the karst wells of Glava Zete and Obosnicko Mountain Pond, as well as by the Rijeka Crnojevica well. Given the intense karstification of Budos (the southern edge of the Niksic Field) and the Cetinje fault, pollution coming from communal and industrial water spreads easily through underground routes, by way of numerous sinks, through karst channels and through caverns.

The urban and industrial development of major settlements in the Skadar Lake Basin (Niksic, Danilovgrad, Cetinje) was not accompanied by adequate protection measures; the result of this is that industrial facilities and urban settlements pollute aquifer waters and surface courses with their communal and industrial waste.

Skadar Lake water is polluted by:

- Waste water and material from settlements and industry in Niksic, Danilovgrad, Cetinje and Rijeka Crnojevica;
- Industrial waste water from Podgorica (KAP-Factory for the production of aluminium with red mud pools, an electrolysis plant, etc.);
- Pesticides and herbicides used in large vineyards in Cemovsko.

In addition, coal exploitation in the neogen basins of Pljevlja and the existing technology at TPP Pljevlja along with its adjoining facilities (Maljevac ash and slag landfill) do serious harm to the quality of surface watercourses at Cehotina and Vezisnica, as well as damaging compressed aquifers in the quartar alluvial sediments downstream from the thermal power plant.

The implementation of the proposed BAT technology for the second block at TPP Pljevlja, along with the impact of the TPP on the pollution of surface water should be reduced to a minimum. Namely, along with the appropriate storage of coal in surfaces supplied with the drainage systems, the collection and treatment of surface waters flowing from the landfill as a result of precipitation, waste water treatment (technological waters, atmospheric waste waters, sanitary sewage waters), conditions would be created to enable the direct discharge into the environment without creating any additional harm to the quality of ground and surface waters.

In order to obtain reliable data on the existing level of pollution of ground water, of compressed aquifers in alluvial sediments in the valley of Cehotina River and its left tributary Vezisnica, a monitoring network of piezometers should be set up to measure baseline values along with the subsequent monitoring of oscillation of the regime and the quality of ground water.

In order to protect aquifer waters in karst fields and ravines in the territory of Montenegro, a series of protection measures should be carried out to include:

- Defining and setting up sanitary protection zones for all major wells;
- Implementing measures for the ongoing monitoring of the quality of aquifers and surface water;
- Removing hazardous matter as a source of pollution before it is released into the water system, i.e. installing efficient wastewater treatment plants;
- Constructing communal wastewater treatment facilities for all larger settlements in the territory of Montenegro;
- Regulating, rehabilitating and conserving the space in major industrial waste landfills;
- Planning and constructing sanitary landfills for all municipalities in the territory of Montenegro;
- Regulation (protection) of sink zones in Niksic, Cetinje, Grahovo, Njeguse fields, i.e. the prevention of uncontrolled discharge of hazardous materials into the ground,
- Eliminating the use toxic pesticides with longer degradation periods that could jeopardise the quality of aquifer waters, particularly in karst fields, with the fast circulation of ground water.

6.1.5 Recommendations

Karst aquifer waters are still under-utilised and under-protected. For the rational utilisation and protection of ground waters a more intensive basic and detailed exploration must be conducted in the karst terrains of Montenegro and in the entire territory.

For this purpose, the following must be undertaken:

- To fully complete field and desk work regarding hydrogeological exploration; to date this work has been carried out as part of a decade long project 'Basic Hydrogeological Map of Montenegro 1:100.000'. Although the work on this important project is in its final stage, only the "Bar" and "Ulcinj" papers have been completed so far. These maps, with their maps of water quality, pollution hazards for water-bearing formations, etc. and the accompanying cadastre of hydrogeological phenomena are a significant foundation on which to find solutions to the numerous and complex problems in the field of water management. These maps, therefore, should be printed and digitalised immediately following their review and approval, so that they can be used in a timely manner;
- To complete and update the cadastre of hydrogeological phenomena and speleological units and to categorise them by different catchment units;
- To restore the existing monitoring network of piezometers and to expand it further, primarily in the Zeta Valley, and in the Niksic and Cetinje fields in order to monitor oscillation regimes and the quality of ground water. (Such data would be useful for finding solution for supplying water to the communities in the Zeta Valley, draining water from the Cetinje Field, and ensuring that accumulations in the Niksic Field are watertight);
- To initiate the thematic hydrogeological exploration of karst aquifers in coastal karst as well as examining the impact of the sea on changes in the quality of aquifer waters, as well as studying the hydrogeological functions of flysh in the coastal zone;
- To continue speleological exploration (14km long Djalovica cave, potholes in Vjetrena Brda on Durmitor Mount whose explored depth is 894 m) and speleodiving exploration (Boka Bay cave springs and Skadar Lake ponds) in order to create conditions for their utilisation for water-supplies and tourism;
- To restore, modernise and densify the network of water-measurement stations on karst watercourses,

particularly in areas with registered sinks and sink zones along their beds;

- To restore and modernise meteorological and rainfall measurement stations and organise quality precipitation regime monitoring;
- To take steps to prepare quality hydrogeological and geotechnical bases in order to plan the utilisation of the remaining hydroenergy potential of the Zeta, Moraca, Piva, Tara, Lim and Cehotina River watercourses. When making such plans, every effort should be made to adapt the planned facilities to the environment;
- By way of legislative framework and spatial plans, to protect all major potential wells of quality aquifer waters, which may be significant to the organised water-supplies of major settlements;
- To intensify complex exploration in order to find a solution to the problem of the water-supplies of the karst plains and higher elevation pasture settlements in the terrains of Sinjajevina, Pivska Mount and Banjani;
- To intensify exploratory work on wells for the purpose of using karst springs for bottled water under concession agreements since Montenegro has numerous abundant quality springs that fully meet requirements in terms of their chemical composition and microbiological status;
- To take steps towards the implementation of the inter-state project, 'Regulation of Skadar Lake, Drim and Bojana Rivers', as well as towards the establishment of an appropriate operation regime for hydro-power plants on the Drim River and in the Niksic Field in order to prevent frequent flooding in the territories of Montenegro and Albania (Zeta Valley, Skadar Valley, valleys along the Bojana River, etc). Projects for this purpose have already been designed to implement emergency measures including the cleaning of the Bojana River bed and the building of an embankment along the watercourse bed;
- To intensify work on preparing a basis for the implementation of the projects intended to construct municipal sanitary landfills and wastewater treatment facilities.

Table 6.1 Overview of wells and springs in karst water-bearing formations

I. Adriatic Sea Basin				
a) Skadar Lake Basin				
No.	Name of well/spring	Name of location	Minimum yield (l/s)	Utilisation of well/spring
1.	Vidrovan Wells	Vojnik	350	Niksic Water-supply
2.	Vidrovan artif. wells (B1, B2)	Vojnik	60	Niksic Water-supply
3.	Vukova Wells	Vojnik	200	no catchment
4.	Gornjepoljski Maelstrom	Golija	400	no catchment
5.	Rastovacka Wells	Studena	200	no catchment
6.	Glibavacka Wells	Tović	10	no catchment
7.	Uzduv	Tović	10	no catchment
8.	Poklonci	Golija	200	Vodovod Nikšić
9.	Blaca	Golija	100	flooded by Krupac
10.	Krupacko Mt. Pond	Zla Gora	130	flooded by Krupac
11.	Zabica	Zla Gora	50	flooded by Krupac
12.	Zminac	Zla Gora	50	flooded by Krupac
13.	Cetkovi Springs	Jakalj	5	flooded by Krupac
14.	Slano Springs	Njegoš i Rudine	450	flooded by Slano
15.	Lukavice Springs	Žurim	10	Vodovod Župe
16.	Morakovska Wells	Prekornica	10	Vodovod Župe
17.	Crni Ostak, Zurovica	Seoca	10	Vodovod Župe
18.	Drilled Wells, Trebjesa, Nikšić	Nikšićko Field	100	Trebjesa Nikšić
19.	Studenačka Wells	Studenačke glavice	50	Studenci Community
20.	Glava Zete and Obošničko Mt. Pond	Nikš. polje, Budoš	3.200	no catchment

21.	Bašina voda	Ostroške grede	10	Povija Community
22.	Dobropoljski Springs	Prekornica, Župa	1.000	no catchment
23.	Milojevica vrela, Svinjacka Wells, Dobrik and Smrdan	Garca and Starocrnog. Plain	>200	catchment, 20 l/s for Danilovgrad
24.	Slatinski Springs	Prekornica	10	Danilovgrad
25.	Zarica Pit	Prekornica	50	Danilovgrad
26.	Oraska Pit	Starocrnog. Plain	200	Danilovgrad
27.	Orlujina	Starocrnog. Plain	1	Čevo Community
28.	Iverak	Prekornica	5	planned for Piperi
29.	Viška Wells, Tamnik, Lalevica Spring, Moravica, Bijeli studenci etc	Karst edge Bjelopavlici Valley	10	no catchment
30.	Springs alongside the edge of the Bjelopavlici Valley (Vrela, Ziva Voda, etc.)	Karst edge Bjelopavlici Valley	20	primitive catchment
31.	Studenci and Bubuljin	Velje and Malo Hills	5	no catchment
32.	Other springs in Zeta Valley Basin (Šabovo oko, Grgurovo oko etc.)	Starocrnog. Plain and Prekornica	500	no catchment
33.	Mareza	Prekornica Velje brdo	2.000	Podgorica and Danilov. 1100 l/s
34.	Kraljičino oko, Vriješko vrelo Blizanci	Bataljonska Komun	50	no catchment
35.	Vučji studenci	Markovina and Starocrnog. Plain	30	Komani
36.	Ribnička Wells	Kuci and Cijevna riverbed	10	no catchment
37.	Izvor pod Vjetrinom	Bijele Rocks	10	no catchment
38.	Bijeli Nerini	Maganik (Mrtvica Basin)	500	no catchment
39.	Other Wells in Moraca	Kamenik, Broćnik Žijovo	1.000	no catchment
40.	Svetigora –Moraca Monastery	Gornja Morača	30	Moraca Monastery
41.	Straganičko Mt. Well	Karst terrains between Zeta and Moraca rvs.	10	Drezga Community
42.	Vitoje and Podhum Wells	Decic and Cijevna basin	10	Podhum Community
43.	Podgorska Wells	Orahovstica Basin	200	Cetinje, Budva
44.	Obzovica	Ljubotinj	1	Cetinje
45.	Uganjska Wells	Konak	5	Cetinje
46.	Velje Mt. Pond	Sozina	50	Bar
47.	Malo oko and Okruglica (drilled well)	Sozina	10	utilised for Sozina Tunnel
48.	Karuci Cave Spring	Starocrnog. Plain	2.300	no catchment
49.	Bolje sestre (Malo blato)	Starocrnog. Plain	2.000	Regional w-supply
50.	Other Sinjacka Cave Springs (Malo Blato)	Starocrnog. Plain	5.000	no catchment
51.	Wells of Crnojevića River	Cetinje Field Basin	380	no catchment
52.	Raduško oko	Rumija	60	no catchment
		b) Montenegrin Coast Basin		
1.	Sač	Možura	2	Ulcinj
2.	Gač	Možura	30	Ulcinj
3.	Donja Klezna	Šasko brdo and Cok	15	Ulcinj
4.	Mide	Rumija	10	Ulcinj

5.	Kaliman	Rumija	5	Ulcinj
6.	Brajša	Rumija	5	Ulcinj
7.	Brca	Sozina	40	Bar
8.	Kajnak	Rumija	40	Bar
9.	Zaljevo	Lisinj	16	Bar
10.	Sustaši	Rumija	2	Bar
11.	Turčini I and II	Mikulići – Đerinac	11	Bar
12.	Well in Canj	Veligrad	5	Bar
13.	Artif. Wells in Canj	Srednje Hill	12	Čanj
14.	Rezevica River	Paštrovska Mount	55	Budva
15.	Smokov vijenac	Paštrovska Mount	5	Budva
16.	Zagradac	Zagrad	40	Budva
17.	Sopot	Bijelo Polje	7	Budva
18.	Lončar	Bijelo Polje	2	Budva
19.	Piratac	Cukali zona	3	Budva
20.	Well at the Foot of Piramida	Brajići and Hum	5	Budva
21.	Loznica	Brajići and Hum	3	Budva
22.	Topliš	Lovćen	15	Tivat-salt content
23.	Plavda	Lovćen and Vrmac	20	Tivat-salt content
24.	Češljari	Vrmac	3	Tivat
25.	Vrmac	Lovćen and Vrmac	20	Kotor
26.	Gornjogrbaljski Springs	Lovćen	17	Kotor
27.	Škurda	Lovćen and Njeguši	40	Kotor-salinated
28.	Orahovac Springs	Lovćen and Njeguši	110	Kotor-salinated
29.	Risan Cave	Grahovsko polje	4	Kotor-salinated
30.	Morinjski Springs	Mokrine	600	salinated
31.	Opačica	Glavice and Lazine	80	Herceg Novi
32.	Lovac	Mojdež	10	Herceg Novi
33.	Other springs – wells in Boka Bay	flow under the Orjen and Lovćen	> 2.000	flow under the sea level
		c) Trebisnjice Basin		
1.	Zaslapnica	Mirotinjske grede	35	Zaslap
2.	Rečevina	Mirotinjske grede	20	no catchment
3.	Šavnik	Nudolska River Basin	50	no catchment
4.	Trebisnjice Springs	Banjani	> 1.000	flooded by Bilecka
		II. Black Sea Basin		
		a) Basin of Piva, Tara and Cehotina Rivers		
1.	Wells in Gornja Tara Basin	Širokar	> 200	no catchment
2.	Wells of Bistrica in Pcinje Basin Vučje	Vučje	200	no catchment
3.	Mušovica Wells	Bjelasica	170	Kolašin
4.	Vojkovica Wells	Sinjajevina	100	no catchment
5.	Wells in Plasnica Basin (Migalivica, Ropušica, Plasnica Well, Djev. well)	Sinjajevina	> 100	planned for bottling
6.	Ravnjak	Sinjajevina	1.150	planned for bottling
7.	Bjelovac Spring	Sinjajevina	1.500	no catchment
8.	Corbudzak Spring	Sinjajevina	100	no catchment

9.	Ljutica	Sinjajevina	2.000	no catchment
10.	Musova Well	Kosanica	100	no catchment
11.	Bijela Well	Njegovuđa	100	no catchment
12.	Sige	Pivska Mount	100	no catchment
13.	Kucista	Pivska Mount	1.500	no catchment
14.	Kaluđerovača	Pivska Mount	1.500	no catchment
15.	Sige Bailovića	Pivska Mount	100	no catchment
16.	Nozdruc and Vukovica Well	Pivska Mount	100	no catchment
17.	Bukovicka Well	Durmitor	200	no catchment
18.	Boanska Well	Sinjajevina	50	no catchment
19.	Springs of Grabovice and Komarnice	Ivica and Durmitor	> 200	no catchment
20.	Šavnička glava	Sinjajevina	100	Šavnik
21.	Krnovska Well	Krnovska glavica	10	no catchment
22.	Oko Bijele	Ostrvica	80	no catchment
23.	Duski Springs	Pivska Mount	200	flooded by Piva
24.	Dubrovska Well	Pivska Mount	> 500	flooded
25.	Vrela Dube	Brezna	500	flooded
26.	Bezujski mlini	Pivska Mount	500	flooded
27.	Nozdruć	Pivska Mount	500	flooded
28.	Jakšića Well	Pivska Mount	100	flooded
29.	Međeđak	Pivska Mount	500	flooded
30.	Rastioci	Pivska Mount	200	flooded
31.	Sutulija	Bioč	50	Plužine
32.	Pivsko oko – Sinjac	Golija – Čarađe	1.000	flooded
33.	Cokova Well	Pivska Mount	100	no catchment
34.	Kaluđerova Well	Pivska Mount	100	no catchment
35.	Other Sources in Piva Riverbed flooded by accumulation	Pivska Mount	> 2.000	flooded
36.	Wells in Maocnica Basin (Manito Well, Vlaovska Well)	Bujaci, Krupice	150	no catchment
37.	Mataruga Springs	Mataruga Basin	30	no catchment
38.	Springs in Cehotina Basin (between the mouth of Kozicke River and Durutovića)	Katabun Mataruge Otilovići	200	no catchment
39.	Springs in Potpece (Zmajevac, Mandovac, Vrelo i dr.)	Cehotina Riv. Basin Pljevlja Basin	35	Pljevlja
40.	Breznica	Pljevlja Basin	30	Pljevlja
41.	Joguštica	Pljevlja Basin	5	Pljevlja
42.	Tvrdaš	Pljevlja Basin	65	no catchment
43.	Vrioci and Well at the Foot of Poros	Gradac	1	Gradac
44.	Sumansko Well	Vezišnice Basin	10	no catchment
45.	Bjelosevini Well	Bjeloševina	100	no catchment
46.	Other Wells in Cehotina Basin (between Pljevlja and Gradac)	Krće, Plješevina Brvenica, Potoci	600	no catchment
		b) Basin of Lim and Ibar Rivers		
1.	Alipasini Springs	Prokletije	2.000	no catchment
2.	Bajrovica Springs	Prokletije	20	Gusinje water-supp.

3.	Springs in Djuricka and Jasenička River Basins	Prokletije	50	Plav
4.	Velička River Springs	Mokra Mount	> 1.000	no catchment
5.	Murinski Springs	Visitora	50	Murino
6.	Krkori	Sliv Kutskog polja	100	Andrijevica
7.	Other Springs in Lim Basin, between Plav and Andrijevica	Visitor, Željetin Sjekirica	> 100	no catchment
8.	Vinicko Springs	Beranska Ravine	> 100	no catchment
9.	Dapsica Well	Beranska Ravine	20	Berane
10.	Manastirsko Well	Beranska Ravine	80	Berane
11.	Merica Well	Bjelasica	100	Berane
12.	Other springs in the Lim River Basin between Andrijevica and Berane	Beranska Ravine	2.000	no catchment
13.	Bistrica Spring	Bjelasica	300	Bijelo Polje
14.	Bistricko Well – Djalovica Gorge	Korita	300	no catchment
15.	Other Springs in the Lim Basin between Berane and Bijelo Polje	Kurilo, Bjelasica Mušnica	> 1.000	no catchment
16.	Ibar Well	Hajla and Zljeb	100	Rožaje
17.	Grlje Well	Hajla and Zljeb	5	Rožaje
18.	Other Springs in the Ibar Basin	Hajla and Zljeb	> 100	no catchment

Table 6.2 List of major water-bearing formations of intergranular porosity

No.	Name of well/spring	Name of location	Minimum yield (l/s)	Utilisation of well/spring
I. Adriatic Sea Basin				
a) Skadar Lake Basin				
1.	Milocansko Field	glacio-fluvial potential spring sediment of Pjenavca	50	potential spring for Nikšić
2.	Niksic Field	glacio-fluvial potential spring sediment of Kapina polja	50	potential spring for Nikšić
3.	Bioče	glacio-fluvial potential spring sediment of Morače i M. Rijeke	50	spring for Bioče and Kuče
4.	Zagorič	glacio-fluvial potential spring sediment of Zagorič	360	Podgorica
5.	Konik – Stari aerodrom (group of drilled wells	glf-Cemovsko Field	250	Podgorica
6.	KAP Podgorica (9 drilled wells)	glf-Cemovsko Field	1.100	KAP
7.	Agrokombinat „13.jul" (21 drilled wells)	glf-Cemovsko Field	2.000	irrigation Cemovsko field
8.	Farmaci (3 drilled wells)	glf-Farmaka	40	Lješanska nahija
9.	Milješ – Tuzi (3 wells)	glf-Rogamsko Field	60	Milješ and Tuzi
10.	Tuško Field	gfl-Tuškog polja	> 1.500	potential spring for Tuzi and Podgorica
11.	Orahovsko Field	al-Orahovsko Field	170	Bar
12.	Sjenokos	al-Velje river	70	Budva
b) Basin of Montenegrin Coast				
1.	Grbaljsko Field	al-Grbaljsko Field	30	Tivat
2.	Sutorinsko Field	al-Sutorinsko Field	20	H. Novi
3.	Orahovac Wells (3 wells)	quartar sediments	50	Kotor

4.	«Merkur» Wells - Budva	al-Budvansko Field	30	Budva
5.	Lisna – Bori – Ulcinj (drilled wells)	al-Anomalsko Field	250	Ulcinj
II. Black Sea Basin				
a) Piva and Tara River Basins				
1.	Brezna – catchment	neogen and glf sediments	1	Brezna
2.	Black Lake (drilled well)	al-Mlinski Spring	20	Žabljak
b) Lim River Basin				
1.	Jasenica	al-Jasenicka River	20	Plav

6.2 Ground Water Vulnerability to Climate Change

Most settlements in Montenegro rely on karst aquifer waters that are extremely vulnerable to climate change. This is true of the Vidrovan Wells that make up part of the Niksic water-supply system, the Uganjski Wells that make up part of the Cetinje water-supply system, the karst springs of Breznica that are used for the Pljevlja water-supply system, and a number of other wells in the coastal karst areas (Rezevici River, Risan Cave, Skurda).

More pronounced climate changes have manifested themselves over the past decade in the form of increases in air temperatures, the prolongation of dry periods, uneven precipitation, precipitation intensity, occasional record stormy precipitation during dry periods of the year lasting for several days, reductions in annual snowfall, have all lead to the disruption of aquifer courses, turbidity in wells, and the forming of torrential streams, floods, landslides and rockslides.

In low coastal karst aquifers long term drought leads to a disbalance of borderlines between salt and fresh waters and eventually the salinisation of wells. This is the case with the karst well of Skurde, which makes up part of the Kotor water-supply system, Spilja which is part of the Risan water-supply system, and Plavda which is part of the Tivat water-supply system.

A reduction in snowfall, as predicted by IPCC experts, may also have a negative impact on water-supply. As a result of abundant snowfall in the catchment areas of some wells, they reach their hydrological minimum later (September) in comparison with wells whose catchment areas typically have less abundant snowfall (in the latter, hydrological minimum can be reached as early as at the beginning of August which is the time when the most water is consumed).

Confined aquifers are also partly vulnerable to climate change; they are hydraulically linked to the surface courses of the Zeta, Moraca, Cijevna, Lim and Tara Rivers and are also partly filled by karst aquifers.

In the richest confined aquifer in the territory of Montenegro, i.e. the Zeta Valley, some 200 km^2 in area, the ground water volume flow rate is measured at around 15 m^3/s, and the amplitude of the aquifer water fluctuations range from 3-5m annually.

This affluent water-bearing formation of inter-granular porosity, which may be particularly significant in the context of climate change, should be given special attention. It must be protected from various forms of pollution (waste-waters from Niksic, Danilovgrad and Podgorica towns, KAP red mud storage lake, vine plantation in Cemovsko Field) and from the limitations of space due to poor urban planning.

6.3 Adaptation to Climate Change in Terms of Water Resources

All climate change has an impact on water resources, particularly on karst watercourses and karst aquifers, because of their vulnerability to climate change.

This is why a number of activities must be taken into consideration, including the following:

- Analysis of accessibility of water for future water-supply systems for larger settlements and summer pastures in the karst terrains of Montenegro;
- Detection and protection of new alternative wells;
- Changes in the urban planning strategies with a greater focus on the protection of arable land and potential ground water sediments;
- Establishment of an adequate monitoring system for the quantitative and chemical status of water in accordance with Directive 2000/60/EC (in case of good water status measures must be taken to preserve it, and where it is bad, measures must be taken to improve it);
- Establishment of water utilisation controls to prevent excessive exploitation;
- Sanation of river beds in risk areas in order to prevent further sinking;
- Regulation of aquifers with limited yields at the times of their hydrological minimum levels;
- Use of artificial supplements for those aquifers that are used for water-supplies and that would face significant losses in yield;
- Establishment and expansion of sanitary protection zones for all wells included in water-supply systems, as well as for potential wells within karst and inter-granular water-bearing formations;
- Drafting and harmonisation of regulations and instructions that may contribute to the mitigation of potential negative effects of climate change and the better use of such areas for water-supplies;
- Regulation of water-supply management systems;
- Restoration and improvement of hydrological and meteorological monitoring networks;
- Selection of test areas in the karst terrains of Montenegro for the monitoring of climate change (air temperature, precipitation, evapotranspiration, etc);
- Creation and development of regional climate models as instruments for the simulation and projection of future climate changes;
- Assessment of available water resources at present and in the future based on the results obtained from test areas to represent the territory of Montenegro and the broader region.

To both stabilise and improve the yield of some karst wells, measures must be taken to regulate aquifers at time when there are favourable geological and hydrogeological conditions. Examples of some successful regulations in Montenegro's karst include the karst aquifers of the Rezevica River (Budva) and Uganjski Wells (Cetinje), as well as the compressed aquifers in the glacial sediments of Bare Bojovica.

6.4 Status of Projects Illustrating the Need to Integrate Spatial Planning and Climate Change Policies

Spatial planning seems to be particularly important given its regulatory role in the area of land use. Among other things, it provides a necessary forum for the participation of many factors and creates possibilities for the implementation of long-term strategies. All of this is very important for the development and improvement of certain mechanisms for climate change adaptation.

The sector of spatial and urban planning has been growing in importance in the context of climate change for a number of reasons. Some of the reasons relate to the fact that the adaptation capacity of towns depends mainly on the spatial planning systems and the fact that urban planning issues are becoming key issues in facing climate changes.

There are many reasons why spatial planning may be seen as a discipline or process with special potential for climate change adaptation. Some of the reasons are:

Integral and Cross-Border Character of Spatial Planning

There are many examples which show the need for a comprehensive and integral approach to the challenges of climate change by way of intervention concerning space to reduce damage in towns. It is for this reason that spatial planning offers a comprehensive set of tools for the systemic treatment of these issues. The flood risk in the Skadar Lake Basin points to a need for the integrated and planned analysis of potential and risk in the space between Montenegro and Albania.

Long-Term Character of Spatial Planning

Long-term planning is essential to the growth and development of towns, particularly when it comes to infrastructure given that it is often designed to last for 70 years or more. Given the significance of infrastructure in a broader sense, including transport, energy, communication, water supply, such investment is clearly long-term. Spatial planning has an impact on a large number of decisions relating to locations for new development projects and also has an impact on new requests for infrastructural facilities. If these decisions take into account the risks of climate change, it is clear that spatial planning has great potential in this respect. Through adequate zoning, spatial planning can ensure that infrastructure routes or corridors are not located in zones which have a greater risk of flooding or in other areas where there may be threats due to climate change. In addition to the above, spatial plans allow for a comprehensive overview of the future situation (15-20 years), which results in useful knowledge.

Impact of Spatial Planning Through Improved Design

Given the expected dynamics of future climate changes, numerous interventions will almost certainly be required to adapt design principles and concrete design solutions which adapt to new needs. Among other things, the use of new elements to allow greater absorption, as well as extensive use of green areas on roofs, along the streets etc will be required. This means that new standards will be applied to both planning and building construction.

Impact of Spatial Planning Through the Application of New Urban Forms

Spatial planning has an impact on the development and definition of land purpose in towns and in broader areas. With respect to adaptation processes, planning plays a key role in ensuring that space is assigned adequate purpose by allowing or not allowing certain land usage in certain zones. Zoning, for example, can be used to protect the green corridors that allow for refreshment, airing, and the absorption of storm water. It can also prevent the further densification of vulnerable urban areas. Urban planning can be of help in developing capacity by protecting space which has been recognised as having adaptation potential and by reducing at the same time the exposure of existing urban areas to the impact of climate change.

Forum for Participation and Coordination of a Large Number of Stakeholders and Policies that May be Relevant to Climate Change

Extreme weather conditions with all their risks and threats directly jeopardise urban areas. The territory of Montenegro is often faced with such situations. The impact of such phenomena is relevant to many sectors and policies. Spatial planning that traditionally includes the purpose of space, housing, transport, public services, environment protection, and economic development has the potential to integrate different sectors and so plays an important role in responding to many challenges posed by adapting to climate changes. The system of spatial planning must, therefore, offer the chance to all concerned to take part in the decision making so that the final result is of proper quality and is viewed in a broader context

6.5 List of Potential Measures and Actions in the Area of Spatial Planning with Respect to Adaption to Climate Change

In Montenegrin practice, just like in the global context, there is manifest discrepancy between the potential and the role of spatial planning in the area of adapting to climate change on one hand, and the implementation of such potential in practice on the other. With growing awareness regarding climate change, growth in administrative capacity at both national and local levels can be expected with a view to establishing a comprehensive and synchronised response to climate change. The following is a list of potential measures and actions in the area of spatial and urban planning in relation to climate change adaptation.

1. Development of planning techniques and methods and implementation of these plans

a) Impact assessment and data collection:
- strategic environmental impact assessment
- identification of space particularly vulnerable to climate change
- analysis of vulnerability
- mapping of zones of great vulnerability
- setting up comprehensive and detailed records.

b) Participation and communication:
- creation of scenarios
- setting of long-term goals
- participation in initiatives relating to spatial planning
- communication and regular panels regarding climate change adaptation
- presentation of good practice in spatial planning with a special focus on adaptation measures
- regular exchange of information
- participation in international activities and research programmes.

c) Policy of integrated approach and setting up of adaptation plans:
- integration of adaptation action plans within the existing system of planning and spatial plans
- creation of action plans for future action regarding space, particularly at a local level
- harmonisation of spatial plans with adaptation strategies
- transposition of climate change adaptation principles to national policy.

d) Setting up standards and rules:
- adjusting national legislation and secondary legislation to achieve quality analyses of climate change issues
- setting up standards in the area of planning and building construction as a response to climate change challenges.

2. Systemic measures as a response to climate change adaptation needs

- Raising awareness with the general public and decision makers regarding the role, benefits and limitations of spatial planning within the context of climate change adaptation;
- Setting up a broader planning horizon to offer a quality response to the threat of long-term climate changes;

- Establishing stronger institutional and practical links between the need to mitigate the impact of climate change and to adapt to climate change, all within the frame of spatial planning;
- Promoting and developing regional plans that could provide a comprehensive and integrated response
- Promoting the planning, development and protection of regions;
- Encouraging joint participation in the planning of all sectors and policies that may contribute to quality insight into climate change issues;
- Encouraging joint participation and cooperation at both state and local levels;
- Ensuring adequate financial support for programmes encouraging strategic planning in adaptation measures;
- Creating political support for adaptation activities at both local and regional levels;
- Setting up methods and practices that illustrate manifold positive effects resulting from adaptation measures;
- Setting up national level guidelines that illustrate objectives, principles and methods for all the concerned with spatial planning;
- Collection of reliable and accessible spatial data on climate change, scenario, impact and vulnerability
- Strengthening international exchange in order to convey and apply good practice;
- Strengthening mechanisms to assist in setting up responses to market and capital impacts, the effects of which could be opposed to climate change adaptation objectives;
- Strengthening and elaboration of cause-effect links between climate change and future economic prosperity, emphasising that sustainable development agendas do not mean economic stagnation, quite the opposite;
- Development of national legislation and policies that emphasise the themes of adaption to climate change and links to spatial planning;
- Strengthening the role of educational and research institutions and providing education on the importance of spatial planning and climate change.

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7. LIMITATIONS AND GAPS AND RELATED FINANCIAL, TECHNICAL AND INSTITUTIONAL NEEDS

This chapter provides an overview of the limitations, gaps, and needs relating to the preparation of technical components for both this and future National Reports, and for implementation of recommended measures for reducing GHG emissions and for adaptation to climate change. Some of the proposed measures imply stimulating different forms of research, the collection of data necessary for monitoring the impact of climate change, the development of models and projections, as well as strengthening inter-institutional cooperation.

Lack of data poses the main limitation for drafting the Second Report, as well as insufficient capacity for the preparation of NAMA, and the development of a cost-benefit analysis regarding proposed measures for reductions in GHG emissions, as well as limited information and knowledge about vulnerability and adaptation to climate change. For the sake of detailed considerations in this report, limitations and gaps have been grouped into three categories as follows:

- Limitations and gaps of a technical and methodological nature,
- Institutional limitations and lack of capacity,
- Lack of financial resources for implementing mitigation/adaptation measures.

The identified needs relate to further efforts in terms of institutionalising of work for national reports as well as capacity building for monitoring and reporting on all the elements within the report, raising awareness on climate change at all levels, and finally strengthening mechanisms for developing integrated responses to climate change.

7.1 Technical and Methodological Limitations and Gaps

Greenhouse Gas Inventory

Regarding technical and methodological limitations in the work on the GHG Inventory for the Period 1990-201, a lack of data in certain categories of the inventory was the most prominent issue. In the sector of industrial processes, there is no data for the production of asphalt. Incomplete data is also evident in the areas of changes in land use, forestry, and waste and this data should be interpreted with a high level of uncertainty.

Generally speaking, in most of the cases, data uncertainty is the result of the fact that Montenegro was part of a federal state during the period 1990-2006, and this is reflected, in particular, in determining the quantity of oil derivatives consumed in the Montenegrin territory. It is also worth noting that statistical methodology is different in certain sectors (MONSTAT is harmonizing its operations in line with EUROSTAT standards), and that this will require a recalculation of the inventory for the entire time series. This problem has been identified in the agriculture sector, where in 2010 the census was carried out in line with EUROSTAT standards, and therefore it is expected that in the near future recalculations of the historic data in this sector will be available. The assumption is that similar processes will also take place in other sectors.

Vulnerability and Adaptation Measures

When it comes to vulnerability assessment and determining adaptation measures, the following limitations and gaps have been identified:

- Lack of an adequate strategic framework, lack of expert and scientific research, lack of data (there is no database for determining the impact of climate change on different sectors/areas, for example weather and climate impacts on human health, because mandatory health statistics are not managed in a way that enables the simple extraction of data adequate for that type of analysis);
- Lack of technical and scientific research on the vulnerability of human health to climate change;
- There is no national strategy to mitigate the effects of climate change on water resources, agriculture and the coastal area;

- A state policy on the impact of climate change on agriculture has not been defined;
- Low level of confidence of global and regional models - very small degree of confidence in global and regional models when it comes to the projection of rises in sea surface temperature in smaller local basins such as the Mediterranean and Adriatic Sea. The global models have relatively small levels of disaggregation to properly explain such small basins, and regional models such as EBU-POM are not able to properly factor increases in sea level as a result of melting glaciers and eternal ice that are global and not regional issues.

Estimation of Reduction in GHG Emissions

Similar gaps and limitations have been identified for estimating the reduction in GHG emissions:

- Development plans do not consider climate change - sectoral development plans and strategies in most cases do not consider the issues of climate change and consequently do not define measures for the reduction of emissions;
- Lack of expert and scientific research in the field of climate change - the number of studies and research dealing with these issues is small, and, for certain sectors, such research and analyses do not exist at all;
- Lack of data – there is a lack of relevant data for certain categories of the GHG inventory, and for projections of GHG emissions due to a lack of strategic documents, i.e. uncertainty regarding the development of certain sectors. This is especially evident in the sectors of processing industry and agriculture, which has caused the quantification of measures used to reduce GHG emissions in the industrial sector, to be based on projections from the previous National Report on Climate Change and estimates of technological needs to be used for the mitigation of climate change; in the agricultural sector they have been based on the experiences of other countries such as Slovenia and Croatia, as well as on the expectations of the European Commission regarding the development of agriculture.

7.2 Institutional Limitations and Capacity Gaps (Human, Technical, Financial)

Regarding institutional constraints and capacity gaps in the GHG inventory, it should be emphasised that the Montenegrin Environmental Protection Agency, as the competent institution for the GHG inventory, during 2013, expanded its organizational structure to include the Emission Inventory Team which consists of three officers. During the forthcoming period, it will be necessary, by means of numerous training sessions to empower staff to work independently to update the inventory and relevant reports, to meet the needs of the general public, and of national and international institutions.

By transposing international legislation into national law, the methodology for the collection and compilation of GHG inventory will be prescribed, thus improving cooperation with institutions and broadcasters.

We can identify, in particular, the following limitations and gaps:

- Insufficient technical and human capacity for addressing the impact of climate change on different sectors:
  - MONSTAT'S technical and human resources are not sufficient for the collection and processing of data in the manner and to the level of detail required for GHG inventories; this assessment applies, in particular to those segments of MONSTAT dealing with environmental statistics;
  - the Environmental Protection Agency plays a key role in the preparation of future GHG inventories; however, a young institution in which capacity building is at the very beginning is at stake here;
  - cooperation between the research sector and decision-makers is not satisfactory - administrative bodies should effectively make use of the information regarding the impact of climate change on various sectors;

- a lack of capacity is also evident in institutions that play an important role in the preparation of the GHG inventory - whether in terms of collecting and forwarding data, or whether at in terms of coordination and policy-making (ministries and administrative bodies - competent bodies for the development of information systems in the areas of transport, industry, agriculture, waste, spatial planning and forestry; professional institutions);
- insufficient capacity for assessing the impact of weather and climate on human health;
- sharing of information among different institutions is still not satisfactory; there are no expert / advisory bodies regarding vulnerability and adaptation;
- regarding the assessment of the reduction of GHG emissions, the main gaps are as a result of lack of experience and inadequate capacity to integrate climate change issues and to develop measures to reduce GHG emissions by institutions responsible for the creation of sectoral policies and their implementation (Ministry of Economy, Ministry of Agriculture and Rural Development, etc);
- there are significant limitations regarding the accessibility of knowledge, technologies, financial resources when it comes to the implementation of reduction measures for GHG emissions.

- Insufficient financial resources:
  - Are a limiting factor for the establishment of an efficient system for monitoring GHG emissions and periodic reporting;
  - In the area of research programs and vulnerability and adaptation, as well as support to professional/advisory bodies in this area;
  - When it comes to the implementation of reduction measures for GHG emissions;
  - For the implementation of scientific research, strengthening institutional capacity for monitoring the impact of climate change and for implementing mitigation measures in Montenegro.

It is evident that there are a large number of initiatives when it comes to the implementation of measures in the field of energy efficiency, and the establishment of the Energy Efficiency Fund, which has been in the pipeline for some time now, should contribute to work on overcoming financial constraints in this field. The largest industrial plants have exhibited weaknesses in their financial operations over the last few years and have consequently putting into question the matter of reducing GHG emissions.

7.3 Needs

Greenhouse Gas Inventory

In connection with the preparation of a GHG inventory (bearing in mind the fact that the establishment of a greenhouse gas inventory represents a significant obligation within the context of EU accession) the following needs have been identified:

- It is necessary to improve the accessibility of data for the sectors of agriculture, changes in land use, forestry, and waste for the sake of updating the National GHG Inventory;
- To identify historical data, per sector; the systematic collection of data; the proper archiving of data and its transposition into electronic form in line with EU standards;
- To identify other possible sources of data per sector, for Montenegro (web-based EU databases, UN, EIONET, EEA, etc.); the systematic collection of data; proper archiving and the processing of data;
- To develop and apply national methods in order to improve the accuracy of the inventory, especially for the energy sector and for areas of industrial processing by:

  (i) determining national CO_2emission factors for the thermal plant 'Pljevlja', and for big energy facilities in area of industry that use oil as a fuel;

  (ii) determining national CO_2 emission factors for metal production (tons of CO_2/tons of reduction agent).

- Strengthening MONSTAT's and the Environmental Protection Agency's capacities in terms of further updating of the GHG inventory, in line with their roles and competencies;
- Identifying institutions, within public administration, that have the capacity to develop GHG emission projections.

Vulnerability and Adaptation Measures

In order to improve vulnerability assessment and the drafting of adaptation measures for the next report it is necessary to:

- Strengthen early warning system for extreme weather and hydrology events;
- Strengthen support for scientific-research work and to improve inter-institutional cooperation;
- Establish databases per sector and to secure their regular updating.

For implementing adaptation measures, it is necessary to:

- Strengthen and improve the existing public health information system and risk management system (especially in out-patient health care);
- Train agricultural producers and disseminate information on adequate adaptation measures;
- Introduce modern technologies (example, GIS and various software) in the planning of forest management;
- Introduce and monitor a Fire Warning Index (FWI) in forestry, as a threat indicator for certain areas during the fire season;
- Improve communication and the sharing of information among relevant stakeholders in the forestry sector;
- Implement forest management, development plans and programs, and to supervise their implementation in practice;
- Improve the forestry fund, especially for karst forests;
- Secure adequate conditions in the forestry sector for permanent work on establishing a sustainable basis for forest management, and also to stimulate natural regeneration, mixed stands, to transform low forests into high ones, to introduce balanced use, forest protection, rehabilitation of degraded forests, etc;
- Continuous training of forestry professionals and the development of international and regional co-operation along with an exchange of information in forestry related fields (environmental protection, climate change, etc);
- Implementation of forest protection, improvement and development of resistance levels for devastated and degraded forest areas;
- To encourage the drafting of studies, analyses, projections of the impact of climate change on priority sectors.

Assessment of the Reduction of GHG Emissions

In order to improve the analyses of measures to reduce GHG emissions and to assess their impact, it is necessary to work on development plans, capacity building for the application of methods and models for assessing the impacts of measures, on formulating and prioritizing programs and measures, and on evaluating the cost of measures aimed at reducing GHG emissions.

- Develop legislative framework and strategic documents for climate change:
  - Align regulations with EU legislation in the area of climate change (transposition of EU directives) and strengthen legislative implementation;
  - Develop appropriate strategic frameworks (strategy, action plan, etc.) that will define roles, responsibilities and activities to mitigate the impact of climate change.

- Integrating mitigation measures into strategic documents:
  - In future strategic documents define measures for the reduction of GHG emissions in industry;
  - In future strategic documents define measures for the reduction of GHG emissions in agriculture;
  - Sustainable forest managemen and the exploitation of biomass potential;
  - Increase waste recycling and reduce quantities of disposed bio-degradable waste, and start collecting land-field gas;
- Designate national body (National Designated Entity – NDE), as a focal point for technology transfers, regarding UNFCCC and CTCN (Climate Technology Centre and Network);
- Define goals for the reduction of GHG emissions- overall and per sector;
- Draft instructions for the implementation of NAMA projects;
- Analyse possibilities for and develop NAMA projects;
- Select and promote the best NAMA projects;
- Introduce and promote the best available techniques (BAT) for mitigation measures regarding climate change, especially in the energy sector (when selecting technological process for the new thermal plant 'Pljevlja' II), industry sector (technological improvements in Aluminium plant (KAP) and Steel Mill, as well as regarding new future industrial capacities), but also regarding other key sectors in terms of GHG reduction.

Assessment of Technology Needs in the Context of Climate Change

The TNA project was implemented by the Ministry of Sustainable Development and Tourism (Department for support to the National Council for Sustainable Development) with the support of the Dutch Ministry of Housing, Spatial Planning and the Environment through the Environment Fund program G2G.NL (the Dutch Government program- "Government to Government") during the period May 2011- November 2012. This program aims to help candidate countries to fulfill criteria for EU membership.

The project is being implemented on the basis of the revised TNA Handbook prepared by UNDP and UNFCCC, and with the help of tools such as program TNAssess and online database ClimateTechWiki. The TNA process has a multi-sectoral approach and as a starting point it takes into account a long-term, national vision of development and related economic, social and environmental priorities. Involvement of different social stakeholders is also one of the basic premises of the process.

The overall objective of this project was to strengthen the capacity of Montenegrin Government and other stakeholders to develop growth strategies based on low emissions and adaptation to climate change so as to identify technologies, measures and approaches required to provide: i) the greatest benefits in terms of economic, social and environmental improvements, and, ii) contribution to reducing greenhouse gas emissions in the context of national, EU and the UNFCCC policies.

The main result of the project was a national strategy "Assessment of technology needs for climate change mitigation and adaptation for Montenegro" with a related action plan. The project is complementary to ongoing projects and initiatives in this area and is expected to contribute to the development of national policy on climate change, integration of these issues into sectoral policies and awareness raising about climate change.

TNA Results and Main Findings

Priority Sub-Sectors for the Reduction of Emissions and Adaptation

Important sub-sectors for climate change mitigation and adaptation were identified on the basis of data from the Environmental Protection Agency Emissions Inventory for 2009, and the data from the First National Communication on Climate Change. The participants of the TNA process selected the priority sub-sectors. Preference, during selection process, was given to those sectors for which it was presumed that if technological interventions were to be implemented, they would bring the greatest benefits in terms of achieving development priorities (environmental, economic and social), a reduction in greenhouse gas emissions and a reduction in vulnerability to climate change. An overview of priority sub-sectors is shown in Table 7.1.

Table 7.1 Overview of priority TNA sub-sectors

Priority sub-sectors for emissions reduction	Priority sub-sectors for adaptation
• Energy generation (41% of total GHG emissions) • Energy consumption in housing and services sectors (9% emissions) • Aluminium production (synthetics gasses – 30% emissions) • Road transport (12% emissions)	• Water resources • Public health • Agricultural land • Agricultural production • Coastal area • Forests

Technology Prioritization

In the priority sub-sectors appropriate technologies have been identified and classified into appropriate categories (from short-term technologies in small-scale applications to medium and long-term large scale technologies[29]). Technology prioritisation, within different categories, was done on the basis of the assessment of social, economic, climatic and environmental issues that would benefit from their application. The TNAssess program was used as a technical support tool for the prioritization of certain technologies. This software tool allows for the analysis of decisions based on several criteria during participatory meetings, and technological options can be evaluated by at least four criteria - development benefits for the environment, economy and the society, as well as reduction of greenhouse gas emissions and reduced sensitivity. In some cases, additional criteria were introduced, such as market potential, for example.

Preferred Scope of Application and the Dissemination of Priority Technologies in Montenegro's TNA Strategy

In the final phase of the TNA process, specific objectives for priority technologies were set, and barriers identified; these are now slowing down or impeding the application and dissemination of technology in certain areas. To counteract the barriers, solutions have been suggested and measures defined with the aim of creating a more favorable environment and to accelerate the application and dissemination of technologies, thus completing the National TNA Strategy. Integral parts of Montenegro's TNA Strategy are:

- Priority technologies portfolios for the reduction of emissions and adaptation, with costs and benefits;
- Specific objectives, i.e. preferred scope of application regarding certain technologies (set out on the basis of official documents and consultations); and
- Set of measures for accelerating the transfer, application, and dissemination of technologies, all of which are an integral part of the action plan for the implementation of the strategy (definition based on consultations with process participants).

Raising Public Awareness on the Global Climate Change Issues

One of the identified needs was raising public awareness, both in general terms and in specific fields:

- Raising public awareness on global climate change issues (information campaigns);
- Promoting new technologies with low GHG emissions;
- Intensifying educational and promotional activities for all key sectors in terms of reducing GHG emissions;
- Training agricultural producers and disseminating information on appropriate adaptation measures.

29 Categories of technologies and / or measures that are used in the TNA process are: technology of small (i. e. those applied at a household level) or large scale, and short-term (currently available on the market) or medium to long-term technology (currently in the pre-commercial or research phases, which will become available in the medium or long term).

So far, the most successful activities related to awareness raising on climate change have been organised within the framework of projects relating to public health and climate change (cooperation between GIZ, the Public Health Institute of Montenegro and the Red Cross). Activities have been carried out relating to heat waves and there have been demonstrations of first aid provisions during heat waves. These demonstrations were organized on beaches and in health centers in direct contact with the general public and produced significant effects. In the field of energy efficiency, significant media campaigns have been realized and centers of energy efficiency established, but with limited results.

Regional IPA Project 'Forum of South East Europe on Adaptation to Climate Change' was implemented in four countries of the Western Balkans, with the assistance of the Austrian Red Cross as the lead applicant along with the following partners: the Red Cross of Montenegro, the Red Cross of Macedonia, the Croatian Red Cross, and the Center for Environmental Improvement (CUZS). The Project was launched in November 2010, and lasted two years.

The Montenegrin Red Cross was responsible for the project in Montenegro. During its two-year duration the project strengthened the role of civil society organizations; it was an important factor in socio-economic dialogue with government institutions, it increased the knowledge of civil service organisations, their organisational capacities, their advocacy capacities, and also improved the quality of services provided by these organisations to end users. The network 'Climate Response' was also established in Montenegro. This comprises 14 full-fledged members and five associates, as well as a number of representatives from organisations dealing with the protection of the environment, socio-economic issues, human rights, and representatives of the private sector, who were actively involved in the implementation of the project. All of the network members have undergone training in relation to national and EU policies related to climate change, advocacy, and communication.

Furthermore, in Montenegro, as well as in the other three countries, a National Study on the Vulnerability to Climate Change was developed, with active participation by all members of the network and in consultation with the civil service, along with relevant governmental and non-governmental institutions. In addition, a Regional Study on Vulnerability to Climate Change was developed; this represents a synthesis of 4 reports that were drafted in respective countries. In line with the recommendations from the Vulnerability Study, an Advocacy Strategy was developed, which provides recommendations for active participation in four areas (water resources, energy sector, agriculture and public health) that were identified by the Vulnerability Study.

Through the establishment of the Southeast Europe Forum, the project has created a platform for regional cooperation among civil service organisations and public officials.

Alongside the mentioned activities, the project focused increasingly on raising awareness regarding climate change with the general public; thus a number of activities were implemented in this respect, such as the campaign 'Climate has Changed... How About You?' which was focused on heat waves and unusually cold weather situations. Within the campaign, TV spots were broadcasted, flyers distributed, etc.

Financial Resources

Financial resources are essential in order to adequately address climate change issues. The national funds that are available for activities linked to climate change are limited, so there is a need for fundraising, the involvement of the private sector, and the raising of awareness of policy makers. The budget of relevant ministry does not allocate funds for climate change issues, so projects are mainly financed by international institutions (UNDP, GEF). Even in the future, funding from international financial institutions such as the World Bank, the UNFCCC Adaptation Fund, and the Green Climate Fund along with bilateral assistance obtained through initiatives related to climate change will remain the main sources of funding. Through active participation in EU research programs such as the 'Framework Program' and 'Horizon 2020', additional funding for activities linked to climate change can be secured.

In order to adequately implement the UNFCCC Convention, it is necessary to secure significant financial resources in the following areas:

- strengthening institutional and human resources for addressing climate change;
- scientific research in area of climate change;
- setting up of an efficient system for monitoring GHG emissions and and for periodical reporting;
- implementation of mitigation measures per sector in Montenegro;
- implementation of adaptation measures per sector in Montenegro;
- stimulating initiatives in the areas of energy efficiency and renewables;
- creating incentives for the development of forms of transport which represent the best solutions in terms of GHG emissions, and the improvement of energy efficiency in transport;
- incentive measures (such as, for example, tax relief) for the import of cars and technologies which have low GHG emissions.

The Secretariat of the UN Framework Convention on Climate Change (UNFCCC), based in Bonn, provides organizational and technical support for the implementation of its convention, as well as for related agreements and institutions. In the framework of the UNFCCC, in 2010, a Technology Mechanism was established; its aim was to encourage a transfer of technology through public-private partnerships, to promote innovation, to promote the use of a technology roadmap along with action plans, and to work with developing countries on the issues of technology transfer, joint research and development activities. The Technology Mechanism comprises the Technology Executive Committee (TEC) and the Climate Technology Centre and Network (CTCN). The TEC adopts policy and oversees the UNFCCC framework for technology transfer, while the CTCN, located within UNEP, is responsible for implementing the Technology Mechanism, responding to the demands of developing countries (parties to the UNFCCC), and for relating to the development and transfer of technology. Finally, the institution in charge of providing information on technology (TT: CLEAR) provides information on the activities concerning technology transfer within the UNFCCC and improves the flow of information regarding the development and transfer of environment friendly technologies.

At the end of 2013, the Secretariat of the UNFCCC launched a major global inventory of all international initiatives that support climate change mitigation and adaptation to climate change. This inventory mostly includes energy technologies, but also some wich are outside the energy sector. The so-called International Cooperation Initiatives Database (ICID) contains 60 such initiatives presented in the following manner: the name of the initiative, description and year of establishment, type of initiative, thematic focus, regional presence and participation. The inventory includes more than twenty initiatives, all of which are directly related to low-carbon energy technologies. Among them are a considerable number which target local cities and regions as well as the private sector. Most initiatives are global, while some focus on specific regions.

The Green Climate Fund (GCF) is the operating entity of the financial mechanism of UNFCCC, in accordance with Article 11 of the Convention. Given the urgency and seriousness of climate change, the purpose of the fund is to provide a significant and ambitious contribution towards global efforts to achieve the goals set by the international community in the fight against climate change. GCF contributes to achieving the ultimate goal of the UNFCCC. In the context of sustainable development, GCF encourages the achievement of low-emissions by supporting developing countries to limit or reduce GHG emissions, and to adapt to the impact of climate changes whilst taking into account the needs of developing countries which are particularly vulnerable to the adverse effects of climate change. GCF plays a key role as a catalyst in terms of providing finances related to climate change, both in public and private areas and at both international and national levels.

An overview of initiatives per institutional category:

1. International forums with a mandate to finance all low-emission technologies
    - Global Green Growth Forum (3GF)
    - Group of Twenty (G20)
    - Global Green Growth Institute (GGGI)

- The Major Economies Forum on Energy and Climate (MEF)
- United Nations Development Program (UNDP)
- United Nations Environment Program (UNEP)

2. International forums with a mandate to finance energy low-emission technologies
   - Clean Energy Ministerial (CEM)
   - Carbon Sequestration Leadership Forum (CSLF)
   - International Partnership for Energy Efficiency Cooperation (IPEEC)
   - Global Bio-energy Partnerships (GBEP)
   - Sustainable Energy for All (SE4ALL)
   - UN-Energy

3. International organisations with a mandate to finance all low-emission technologies
   - United Nations Industrial Development Organisation (UNIDO)

4. International organisations with a mandate to finance energy low-emission technologies
   - International Energy Agency (IEA)
   - International Renewable Energy Agency (IRENA)

5. Regional forums with a mandate to finance all low-emission technologies
   - Union for the Mediterranean (UfM)
   - UN Regional Economic and Social Commissions

6. Regional organisations with a mandate to finance all low-emission technologies
   - Association of Southeast Asian Nations (ASEAN)
   - African Union (AU)
   - European Union (EU)
   - League of Arab States (LAS)
   - Organization of American States (OAS)

7. Regional organisations with a mandate to finance energy low-emission technologies
   - Regional Center for Renewable Energy and Energy Efficiency (RCREEE)

8. Non-governmental forums / networks
   - Renewable Energy and Energy Efficiency Partnership (REEEP)
   - Renewable Energy Policy Network for the 21st Century (REN 21)

9. NAMA financing
   The number of funding sources available to support NAMA during their different stages of development include: UK/Germany NAMA Facility, Global Environment Facility (GEF), Germany (ICI), UK (ICF), Denmark (Global Frame, GCPF), European Union and European Commission (GEEREF, LAIF, AIF), Australia, France (AFD, FFEM), NEFCO (NCF, NPI), multilateral developmental institutions (ADB, IDB, WB Group) and the Green Climate Fund.

10. European Platform for Climate Change Adaptation (Climate-ADAPT)
    Climate-ADAPT aims to support current and future EU member states in adaptating to climate change. This is a European Commission initiative that helps users to access and share information on:
    - Expected climate changes in Europe
    - Current and future vulnerable regions and sectors
    - National and transnational adaptation strategies
    - Adaptation case studies and the potential for possible adaptations
    - Tools supporting adaptation planning.

7.4 Ongoing Projects Addressing Climate Change in Montenegro

NAME OF PROJECT	PROJECT OUTCOME	DURATION	BUDGET AND DONOR(S)	IMPLEMENTING ORGANISATION AND PARTNERS
Adaptation to climate change in the Western Balkans	Improved adaptation to climate change in the Western Balkans (Albania, Montenegro, Macedonia, Serbia), particularly in flood and drought risk management.	2012-2018	3,500,000 € (for entire region) German International Cooperation (GIZ)	Ministry of Sustainable Development and Tourism (MSDT) Ministry of Agriculture and Rural Development (MARD), Institute of Hydrometeorology and Seismology of Montenegro (IHSM), Ministry of Internal Affairs (MIA) – Directorate for Emergency Situations, Municipal protection and rescue services, Institute of Public Health (IPH), World Health Organisation (WHO), Red Cross of Montenegro (RCM), Capital of Podgorica
Building resistance to natural disasters in the Western Balkans and Turkey	Strengthening resistance of IPA beneficiary countries (Albania, Bosnia and Herzegovina, Croatia, Macedonica, Serbia, Kosovo, Turkey and Montenegro) to natural disasters in line with the priorities set by Hyogo Framework for Action (2005-2015).	2012–2014.	2.200.000 EUR European Commission (IPA)	World Meteorological Organisation (WMO) and United Nationas International Strategy for Disaster Reduction (UNISDR, Institute of Hydrometeorology and Seismology of Montenegro (IHSM) and MIA– Directorate for Emergency Situations
Cross-border flood protection and rescue	Building flood resistance of cross-border zone and target municipalities by developing technical and human capacity, through cross-border cooperation and awareness raising of prevention and combat against this natural disaster.	2012–2014.	230.000 EUR IPA, II component, cross-border cooperation Montenegro-Serbia	MIA – Directorate for Emergency Situations FORS Montenegro (Foundation for Development of the North)
Optimum use of energy and natural resources and mitigation of natural disaster effects	Improving sustainable use of natural resources at national and local level and strengthening disaster response system.	2013–2015.	2.750.000 EUR EU contribution (IPA) 445,000 € National contribution	MIA – Directorate for Emergency Situations, Ministry of Economy and Ministry of Health
Holistic model of integrated forest fire protection	Prevention and mitigation of damage caused by natural disasters focusing on fire and earthquake risk, in order to improve, promote and strengthen institutional capacity in implementing activities to mitigate disaster impact faced by the Adriatic region.	2013–2016.	Budget total: 9,363,801 € Budget for Montenegro: 564,158 € IPA ADRIATIC	Project leader: Split-Dalmatian region Partners: 19 partners from Albania, Bosnia and Herzegovina, Montenegro, Greece, Croatia, Italy, Slovenia and Serbia Project leader in Montenegro is the Montenegrin Academy of Arts and Sciences (MASA). Partner: Ministry of Internal Affairs – Directorate for Emergency Situations

NAME OF PROJECT	PROJECT OUTCOME	DURATION	BUDGET AND DONOR(S)	IMPLEMENTING ORGANISATION AND PARTNERS
Civil protection for candidate countries and potential candidate countries	Project objective is two-fold and should: (1) Contribute to further development of civil protection capacity of partner countries and (2) Support gradual inclusion and cooperation of partner countries in EU civil protection instruments, particularly the EU civil protection mechanism. Participating countries: Albania, Bosnia and Herzegovina, Former Yugoslav Republic of Macedonia, Montenegro, Serbia, Kosovo and Turkey.	2013–2015.	2.000.000 EUR Multi-beneficiary IPA programme, Stage II (2013-2015)	Activities in Montenegro are lead by the Ministry of Internal Affairs – Directorate for Emergency Situations Project is implemed under the auspices of the Directorate General for Humanitarian Aid and Civil Protection of the European Commission (DG ECHO)
CAMP "Integrated management of coastal zone of Montenegro", and development of National Strategy of Coastal Area Integrated Management for the Mediterranean		2011–2016.	147.000 EUR Government of Montenegro 204.000 EUR i 81.000 USD – UNEP/MAP	MSDT IHMS
Programme of EE in public buildings	Improving EE and conditions in target buildings under the authority of the Ministry of Education and Sprot (primary, secondary and special schools, kindergartens and student dormitories).		13.000.000 EUR German Development Bank (KfW)	Ministry of Economy
MONTESOL	Setting up a financial tool to ensure favourable loans to households for the installation of solar water heating collectors.		1.000.000 USD	Ministry of Economy United Nations Environment Protection Programme (UNEP) and Italian Ministry of Environment Protection, Land and Sea (IMELS)
Solar Summer Pasture Settlements	Creating better conditions for life and work by providing solutions to electricity supply - installation of photovoltaic systems in summer pasture settlements.			Ministry of Economy, MPRR, Local government units
Regionaln energy efficiency programmes in the Western Balkans	Developing a legal framework for the establishment of ESCO concept in Montenegro.		European Bank for Reconstruction and Development (EBRD)	Ministry of Economy

NAME OF PROJECT	PROJECT OUTCOME	DURATION	BUDGET AND DONOR(S)	IMPLEMENTING ORGANISATION AND PARTNERS
MVP project (Platform for integrated monitoring and verification of action plan implementation)	Setting up a platform for integrated monitoring and verification of implementation of national energy efficiency action plans		Regional fund opoened for EE in South-East Europe by the German International Cooperation (GIZ ORF EE)	Ministry of Economy
Open regional fund for South-East Europe - Energy efficiency	-Support to capitals of SE Europe in implementing sustainable energy action plans -Starting a public dialogue on sustainable use of energy in SE Europe -Monitoring and evaluation of implemented measures from national energy efficiency action plans in SE Europe	2012–2015.	2.500.000 EUR For the entire region German International Cooperation (GIZ)	Capital of Podgorica NGO Civic Alliance (School of Democratic Governance) Ministry of Economy (Directorate for Energy Efficiency)
Energy Wood within the framework of FODEMO projects (Development of Forestry in Montenegro - II stage)	Setting up an attractive and sustainable financial mechanism for providing interest-free credits for housholds to install heating systems using modern forms of biomass (pellet, briquettes).	2013–	130,000 € Government of Grand Dutchy of Luxembourg	Ministry of Economy MPRR Lux-Development – Luxembourg Agency for Development Cooperation
Solar energy in the tourism sector of Montenegro	Developing ainformation base for investing in solar thermal systems for tourism sector of Montenegro in order to support greater use of solar thermal systems for heating and/or cooling.		German International Cooperation – GIZ	Montenegro Centre for Energy Efficiency (CCEE) Ministry of Economy
Beautiful Cetinje	Economic revival of the Montenegrin royal capital by reviving its cultural heritage using energy efficient solutions, expert training, support to small entrepreneurs and by encouraging ideas and innovations in green design and overall urban development.	2011–2015.	5.162.750 USD Royal Capital Cetinje and UNDP	UNDP Royal Capital of Cetinje, Ministry of Culture, Ministry of Economy
Cadastar of small watercourses	Developing a Cadastre of small watercourses with a potential for small hydro-power plants up to 1MW in the territory of 13 municipalities across Montenegro: Kolasin, Mojkovac , Andrijevica, Berane, Bijelo Polje, Plav, Rozaje, Pljevlja, Zabljak, Savnik, Pluzine, Niksic and Danilovgrad. Cadastre includes over 70 watercourses.		European Bank for Reconstruction and Development (EBRD)	Ministry of Economy
Sustainable energy development in Kolasin municipality	Preparation of plans for the design of technical studies necessary for planning energy development of Kolasin municipality as well as creating possibilities for the implementation of projects of small hydro-power plants.	2012–2014.		Ministry of Economy Company Gaudal from Norway

NAME OF PROJECT	PROJECT OUTCOME	DURATION	BUDGET AND DONOR(S)	IMPLEMENTING ORGANISATION AND PARTNERS
Coastal windmills: research and development POWERED	Analysis of the current situation in regulations and procedures for the construction of windmills and implementation of research to design a map of winds in the zone of the Adriatic Sea and identify potential locations where windmills at sea could be constructed.	2011–2014.		Ministry of Economy
Distribution of energy generation and smart energy management in isolated regions of Montenegro	Analysis of the current situation in Montenegro and identifying the areas with low quality and safety of energy supply, analysis of the potential for renewable energy sources in those regions, impact of their potential use on the environment and technical possibilities to improve the supply.	2012–2014.		Ministarstvo ekonomije Italijanska kompanija „D'Appolonia"
Optimum use of resources in order to reduce the negative impact of natural disaster on climate change	Point to possibilities for multisectoral cooperation in resolving shared problems.	Project implementation has started	IPA	Ministry of Economy
Sustainable energy development (transport)	Development of a relevant regulatory framework in order to increase sustainable energy use, particularly in transport sector	Project implementation has started	IPA	Ministry of Economy
Towards developing tourism with low CO_2 emissions	Reducing GHG emissions in Montenegro tourism secotr by promoting the adoption of CO_2 reduction policies and regulations; establishing sustainable funding mechanisms; and support to design and implementation of major investment in tourism infrastructure with low CO_2 emissions.	2014–2019.	3.507.306 USD Globalni fond za zaštitu životne sredine (GEF)	UNDP Ministry of Sustainable Development and Tourism
ECRAN (Environment and Climate Regional Accession Network)	Project of the Environment and Climate Regional Accession Network (ECRAN. Administrative capacity in the area of climate change should be strengthened to respond to a need for enhanced climate action in a sustainable way. The purpose of the project is developing administrative capaicty in the area of environment protection and climate change.	2013–2017.	5.000.000 EUR	Partner states: Albania, Bosnia and Herzegovina, Croatia, Kosovo, Macedonia, Montenegro, Serbia, Turkey and Iceland Project leader in Montenegro: Ministry of Sustainable Development and Tourism

NAME OF PROJECT	PROJECT OUTCOME	DURATION	BUDGET AND DONOR(S)	IMPLEMENTING ORGANISATION AND PARTNERS
LocSEE (Low Carbon South East Europe)	Project intends to develop capacity of public and other climate change institutions and strengthen participation of key stakeholders in policy design for the entire region of South-Eastern Europe. The project is co-funded by South-East Europe interstate cooperation programme, which intends to improve territorial, economic and social integration in South-East Europe. The project is lead by the Bolzano European Academy (EURAC).	2012–2014.		Project involves 17 partners from South-East region (11 active partners and 6 observes) and includes key actors addressing climate change, including national ministries, government services, universities and research organisationa and international organisation. 11 active partners include institutions from old EU member states (Austria, Italy, Greece, new EU member states (Slovenia, Hungary, Croatia), candidate countries (Macedonia, Montenegro, Serbia) and potential candidates (Albania). Project leader in Montenegro: Ministry of Sustainable Development and Tourism
Harmonisation of seismic hazard maps for the Western Balkans	Development of new seismic hazard of the region, promotion of the national seismology network among all participating countries, training of young researchers in seismic hazard assessment	2007–2011.	Budget for Montenegro 105,000.00 EUR	Project leader: Institute of Hydrometeorology and Seismology of Montenegro (IHSM); Partner states: Albania, Bosnia and Herzegovina, Croatia, Macedonia, Serbia and Turkey.
Improvement of harmonised seismic hazard maps for the Western Balkans	Improvement of seismic hazard maps of the region and development of a harmonised regional data base of accelero-metric data.	2012–2015.	Budget for Montenegro: 52,000.00 EUR	Project leader: Institute of Hydrometeorology and Seismology of Montenegro (IHSM); Partner countries: Albania, Bosnia and Herzegovina, Croatia, Macedonia, Serbia and Turkey.
GEPSUS	Design and development of software system for computer simulation and monitoring of natural disasters as well as of disasters caused by the human factor, with a focus on air pollutants	2011–2014.	Budget for Montenegro, 148,200 EUR	Project leader in Montenegro: Faculty of Electrical Engineering (University of Montenegro) Partner countries: Italy, Israel and Slovenia
Developing capacity for the cleansing of unexploded lethal devices in Montenegro	Promoting Montenegrin capacity for detection, transport and destruction of unexploded devices	2013–2016.	Budget for Montenegro: 260,000 EUR	Project leader for Montenegro: Directorate for Emergency Situations of the Ministry of Internal Affairs Partner country: the Netherlands

7.5 Future Projects – Project Ideas Relating to Climate Change in Montenegro

PROJECT OUTCOMES	PROJECT ACTIVITIES
Improving GHG inventory	Continued education in area of human resources Procurement of IT equipment
Adaptation to climate change in the area of water resources management	Detailed analysis of present climate change impact and of prospects of future climate change impact, with one of the key activities being the creation of a climate-hydrological model
Monitoring of surface and ground waters	Continued implementation of Hydrological Stations Master Plan in Montenegro, Development of projects based on the Montenegro Ground Water Monitoring Study Procurement of modern measurement equipment for field work
Ensuring efficient hydrology data management	Upgrade of a modern hydrology database, in line with WMO standards Education of staff to work on database Necessary IT support
Putting conditions in place for implementation of modern hydrology models in water resources management	Defining model software for typical hydrological conditions in basins Recruiting and educating staff to work on hydrological models
Continued work on delienation and characterisation of water bodies in line with the Framework Water Directive ((2000/60/EC)	Delienation and characterisation of water bodies in the Adriatic Sea Basin Delienation and characterisation of water bodies in the Danube Basin (Black Sea Basin)
Improving the conditions for the management of catchment areas used for public water supply	Detailed information in the cadastre regarding wells for public water supply Conditions for the protection of water quality at wells Protection of future potential wells
Improving the protection of surface and ground water field monitoring system	Consistency in the implementation of legislation – hydrotechnical facilty of water body Defining a framework to enable cooperation between hydrometeorological services and the relevant authorities at a local goverment level
National Drought Management Policy	National policy design based on drought risk management
Strengthening the meteorological monitoring network	Restoration of meteorological precipitation stations
Development of Climate Change Adaptation Strategy in the health sector together with the action plan and of the Action Plan for Heat Waves	Expert and scientific research implemented in order to assess the vulnerability of the health sector to the impact of climate change
Harmonisation and implementation of EU energy and climate legislation	EU package for energy and climate; Privatisation of the electricity market.
Ensuring stability in energy supplies by investing in the development of new large hydro-power plants	HE Moraca HE Komarnica
Increasing the share of renewable energy sources in the energy sector	mHE VE FE biomass power plants
Improving energy efficiency in industry	Cogeneration Solar thermal energy Energy management
Improving energy efficiency in transport	Fuel replacement Hybrid and electric vehicles More extensive use of public transport Improving rail cargo transport
Improving energy efficiency in households and in the service sector	Better thermal insulation Implementation of regulatory framework for energy efficiency of buildings Implementation of regular energy check-ups for heating and air-conditionig systems Certification of energy saving characteristics Labelling of household appliances regarding energy saving Financial support given for investment in renewable energy sources in consumption areas

ANNEX I

CATEGORIES OF GHG SOURCES AND SINKS FOR 2011	Emmissions CO_2 (Gg)	Absorbtion CO_2 (Gg)	CH_4 (Gg)	N_2O (Gg)	CO (Gg)	NO_x (Gg)	NMVOC (Gg)	Sox (Gg)	HFC (Mg)	CF_4 (Gg)	C_2F_6 (Gg)	SF_6 (Mg)
Total national emissions and elimination	2.685,7	2.166,9	17,7	0,7	33,2	10,15	8,29	39,73	0,008	0,076	0,01	0,108
1. Energy	2.526,9		4,20	0,12	21,60	10,04	4,56	39,12				0,108
A. Fuel combustion (sectoral approach)	2.526,9		2,5	0,12	21,6	10,04	4,02	39,12				
1. Generation and transformation of electricity	1.741,8		0,023	0,04	0,55	5,80	0,04	38,35				
2. Industry and building construction	96,6		0,0	0,002	0,045	0,13	0,01	0,10				
3. Transport	520,3		0,11	0,06	6,36	3,48	1,04	0,09				
4. Households and services	139,7		2,35	0,02	14,55	0,40	2,90	0,55				
5. Agriculture	24,2				0,07	0,23	0,02	0,03				
6. Other	4,3											
A. Fugitive fuel emissions			1,65				0,54					
1. Solid fuels			1,65				0,46					
2. Oil and natural gas							0,08					
2. Industrial processes	158,8		0,0007	0	11,31	0,1	0,64	0,61				
A. Production of lime	2,7											
B. Chemical industry												
C. Production of iron and steel	4,9		0,0007	0,00	0,104	0,008	0,003	0,004				
D. Aluminum production	151,2		00,00	0,00		0,093		0,559		0,076	0,01	
E. Other production												
F. Production of halocarbons and sulphur hexafluorides												
G. Use of halocarbons and hexafluorides									0,008			

3. Use of solvents and other similar products							3,06					
4. Agriculture			9,27	0,6	0,28	0,01	0,002	0,00				
A. Enteric fermentation			7,6	0,00								
B. Manure management			1.66	0.12								
C. Cultivation of rice												
D. Arable land			0,00	0,48								
E. Burning of savanas												
F. Burning plan remnants in the fields			0,01	0,00	0,28	0,01	0,002	0,00				
G. Other												
5. Changes in the use of land and forestry		2.166,9										
A. Changes in stock of forest biomass		2.166,9										
B. Changes in forest land and grass areas												
C. Deserted managed land												
D. Emissions and elimination of CO_2 from soil												
E. Other												
6. Waste			4,00	0,00			0,033					
A. Solid waste removal			2,5	0,00			0,033					
B. Waste water treatment			1,5	0,00								
C. Burning of waste												
D. Other												
7. Other												
Memo												
International bunkers	133,22		0,00	0,00	0,134	0,207	0,261	0,024				
Air transport	79,04		0,00	0,00	0,134	0,207	0,261	0,024				
Maritime transport	54,18		0,00	0,00								
CO_2 biomass emissions	216,52											

ANNEX II

NAMA and Cost Benefit Analysis for Montenegro During the Period 2014-2020

So date there is no unique NAMA structure. However, according to NAMAs submitted to the UNFCCC Secretariat, the following major elements can be identified:

- developing countries voluntarily implement a set of measures for the reduction of anthropogenic GHG emissions;
- measures need to be adapted to individual countries and their national circumstances, in accordance with the specific needs of the country as well as in terms of the principles of the convention regarding common but also differentiated accountability;
- measures need to be carried out in relation to sustainable development, which means that they need to be incorporated into broader sustainable development strategies of individual countries;
- measures must be measurable, reportable and verifiable (MRV principle);
- measures should be supported by developed countries in an equally measurable, reportable and verifiable manner.

Many countries have started to develop NAMA ideas and have provided detailed proposals for the purpose of obtaining international support and recognition. However, only some of NAMA's proposals have commenced their implementation phase. Therefore, considerations regarding the implementation of NAMA are still largely theoretical.

The financing of NAMA is a central issue when it comes to climate negotiations. The manner in which NAMAs are being financed determines whether they are recognized as unilateral or whether they require financial support. A transparent assessment of the overall costs and possible additional costs for mitigation actions is a necessary starting point for the initiation of NAMA financing. The implementation of unilateral NAMAs will be funded by domestic financial resources, usually through the redirection of existing financial resources within a country. Assisted or supported NAMAs use domestic sources in order to obtain international financial resources, ideally from institutions that are already active in a country. Therefore, both one-sided/unilateral and assisted/supported NAMAs start with the identification and provision of domestic funds. Public funds can also be used as a foundation for private sector investments. In such cases, creating a stimulating environment for private/corporate financing must be taken into account from the beginning of NAMAs.

The quantification of NAMA benefits, both in terms of their reduction of GHG emissions and their added value for sustainable development, are of great advantage and thus they have a wide number of users including: state administration bodies, international donors and financiers, non-governmental organizations (NGOs), supervisory bodies (such as the ones at UNFCCC), scientific workers, academics and the private sector. This advantage determines whether NAMAs are successful or not. The quantification process begins with the measurement of the status quo- or basic scenario. A base of zero is used for the measurement of benefits and costs of NAMAs. After the basic scenario has been determined, a MRV system (Measurement, Reporting and Verification) is applied and used to measure the performance of the NAMA, both in terms of the reduction of GHG emissions and also regarding the sustainable development of goals.

NAMA projects are the result of measures obtained for achieving a reduction in GHG emissions. The National inventory of GHG shows that the energy sector is the main source of GHG emissions (mainly CO_2), i.e the generation of electricity and the consumption of energy in industry, transport, households and services. The second important source of GHG emissions (synthetic gases) is produced by the sector of industrial processes. NAMA projects must focus on these two sectors. Another interesting area, however, that also should be focused on (also through NAMA projects) is sinks in forestry areas in terms of changes in both the use of soil and forests. The number of sinks could be increased through improvements in forests (through sustainable forest management) and by encouraging afforestation, the filling and care of coppice forests, fire protection, and by the sustainable and efficient use of trees in the processing industry.

Sectoral Measures for NAMA in the World

Energy- Generation of Electricity

Globally, there are many different examples within the energy sector, and the following are proposed as examples that may be relevant within the context of Montenegro:

- Feed-in tariff for renewable energy sources;
- Programmes for achieving energy efficiency;
- Goals for renewable energy sources;
- Support for certain renewable energy technologies (e.g. biomass).

Transport

Examples from around the world that are relevant to the transport sector include:

- Planning forms of mass transportation;
- Improving the quality of public transport;
- Improving the road infrastructure for non-motorised traffic;
- Change in prices for road use in order to reduce pollution;
- Improved parking management;
- Careful design of economic development along railway corridors;
- Careful consideration of reduction in subsidies through the introduction of fuel tax;
- Improvement of used fuel standards to achieve lower CO_2 emissions;
- Improvement of regulations concerning trucks and lorries in order to reduce emission levels;
- Promotion of eco-driving through campaigns;
- Construction of cycle tracks.

Industry and Services

Examples in the world in the areas of industry and services include:

- Programs of efficiency improvement (energy and any other efficiency);
- Encouraging technological improvements through various sectors in order to introduce new
- technologies with lower emissions;
- Resolving issues regarding employees with completed years of service and inefficient facilities and technologies;
- Gradual elimination of HFC gas use for cooling, air conditioning and foam (cooling and insulation), as well as the introduction of climate-friendly alternatives for HFC gases.

Construction Industry

Examples in the world which are still applied in the construction industry include:

- Construction standards (regularly increasing energy efficiency);
- Credit lines for the use of sustainable, energy efficient technologies;
- Programmes encouraging the replacement of conventional boilers with solar water heaters;
- Programmes for labeling and the introduction of minimum standards for energy efficiency in house-

hold appliances;
- Certificates awarded to programmes achieving low-energy construction levels and to low-energy buildings;
- Additional requests for energy efficiency from existing credits/mortgage housing programs (e.g. Mexico).

Agriculture

Examples in the world within the agriculture sector include:
- Reduction of emissions at farms;
- Improving the management of arable land;
- Improved management in husbandry;
- Improved management of manure;
- Stronger action towards the removal of carbon dioxide;
- Increase in the content of organic substances;
- Increase in the quantity of organically grown plants;
- Rehabilitation of peatland and swamps used for agricultural purposes;
- Increase in the efficiency of agricultural equipment and management;
- Reduction in fuel consumption;
- Use of alternative sources of energy;
- Use of biomass for energy in agricultural processing and for the generation of electrical power.

Forestry

Examples in the world within the area of forestry (where there is the greatest potential for reducing emissions through sinks) include:
- Reduction of emissions through deforestation and forest degradation;
- Afforestation;
- Managing degraded land/land restoration;
- Improved/sustainable forest management;
- Preservation and conservation of forests.

Waste

In order to improve the situation in the area of waste management in Montenegro, it is necessary to:
- Coordinate legislative framework with EU regulations, to the greatest extent possible.
- Implement legislation.
- Improve the awareness of households, small and medium enterprises, industries;
- Increase the level of recycling and composting;
- Increase the use of methane and energy recovery from waste;
- Reduce illegal waste disposal.

Regional/Local Measures for NAMA

On a local level, the most significant measures are certainly related to the municipality of Podgorica and the coastal area. These are the areas with the greatest risk of pollution (Podgorica, as the capital city with a high level of commercial activity; the coast during the tourist season with a higher number of residents present during two summer months). In addition, Podgorica has the ability to act autonomously and conduct policy measures in the areas of environmental protection. That is why SmartCities European initiative is welcome in order to improve the sustainability of Podgorica and other major towns, particularly along the coast.

Overview of NAMA Project Proposals Presented in Tabular Form

A comprehensive overview of the NAMA measures was given in the previous section. These measures arise from initiatives for the reduction of GHG emissions and have been applied in neighbouring countries and around the world. The afore-mentioned measures are more than sufficient for achieving the goals of the UN Framework Conference for Montenegro.

Energy

Energy is the most important factor in GHG emissions and consequently the greatest attention is paid to this sector. The following measures arise from all of the afore-mentioned sources. The most important measures for the reduction of GHG emissions in this sector include:

- Efficient lighting in households and services;
- Efficient appliances in households and services;
- Natural gas for cooking in households and services;
- Natural gas for heating in households and services;
- Hydro power plants;
- Small hydro power plants;
- Wind power plants;
- Solar photovoltaic panels (PV);
- Cogeneration plants.

These measures include encouraging feed-in tariffs for OIE, programs for the achievement of energy efficiency, as well as programs for encouraging the transfer of household usage to other available efficient technologies which have greater levels of energy efficiency or use renewable sources of energy.

Transport

Transport could enable an annual reduction in emissions of about 100kt ktCO_{2eq}. In the transport sector, the following projects are included:

- Transport management- intelligent transport systems;
- Increasing the efficiency of diesel engines;
- Liquified gas;
- Biofuels;
- Hybrid vehicles;
- Cycle tracks.

These measures include the planning of different forms of mass transportation, increasing the quality of public transport, improved parking management (enabled in cooperation with local governments), taxes which would encourage the use of more efficient vehicles (with reduced emissions), as well as campaigns for efficient transport and eco-driving.

Industry and Services

Industry and services are the second largest in terms of GHG emissions and have the potential to annually reduce their level of emissions by about 270 ktCO_{2eq}, ; this could mainly be achieved by improving processes at the aluminum plant and at the ironworks. Specific measures include:

- Increase in the energy efficiency of electrolysis at the aluminum plant;
- Use of internal anodes at the aluminum plant;
- Automatization;

- Restructuring of the aluminum plant;
- Restructuring of the ironworks.

Construction Industry

The construction industry has the potential to annually reduce its emissions by about 300 ktCO_{2eq}. NAMA measures in this area are as follows:

- Solar thermal systems to provide hot water in households and services;
- Thermal systems to be used for heating and cooling and for water heating in households and services;
- External insulation of building;
- Efficient air-conditioning systems to be used in households and services.

These measures include the gradual introduction of construction standards and energy certification, particularly in new buildings.

Agriculture

GHG emissions in agriculture could be reduced, and the level of emissions from sinks could be increased. NAMA measures are as follows:

- Soil binding (with the construction of terraces);
- Regular spatial and timed crop sequences;
- Regular use of fertilizers.

These measures include increasing the level of organic compounds in the soil and the introduction of organic agriculture.

Forestry

Forestry could enable the creation of the largest sinks to reduce GHG emissions. Therefore the sector could be improved and strengthened through the following measures:

- Afforestation;
- Forest management.
- These measures also include the goals of the National Forest Strategy:
- Improvement of forests and sustainable management with an increase in timber stocks in commercial forests ranging from 104 to 115 million cubic meters of gross felled timber.
- GDP increase, from 2% to 4% of the total GDP in the sectors of forestry, the wood industry and other industries depending on the type of forest.

Waste

The waste management sector is in its initial development stages so it will be necessary to introduce a series of adjustment measures during the process of EU accession. Measures/projects are as follows:

- Waste segregation;
- Recycling;
- Generation of electric power and thermal energy resulting from methane from landfills.

Goals in this sector include increases in the shares of waste separation and the reduction of biodegradable waste below 50% up to 2020, as well as the flaring of landfill gas in sanitary landfill sites.

Table 1. Overview of potential NAMA measures and projects

NAMA impact on environment, economy and society	Impact on sustainable development															
	Environment					Society					Economy					
Measure/Project	GHG emission reduction	Air quality	Biodiversity Conservation	Water	Waste	Health	Rural development	Energy access	Life quality	Fight against poverty	Employment	Industry competitiveness	Cost saving	Reducing dependence on import	Potential market development	Fiscal and/or financial effects
1. ENERGY																
1.1. Efficient lighting in households and services	+										+	+	+	+	+	
1.2. Efficient appliances in households and services	+												+	+		
1.3. Natural gas for cooking in households and services	+	+	+					+	+				+	+		
1.4. Natural gas for heating in households and services	+	+	+				+	+	+	+		+	+	+		
1.5. Hydro power plants	+		−	−			+	+				+		+		
1.6. Small hydro power plants	+	+				+	+	+			+			+	+	+
1.7. Wind power plants	+		−				+	+						+	+	
1.8. Solar PVs	+				−	+	+	+		+	+			+	+	
1.9. Cogeneration plants	+						+	+			+	+	+			
2. TRANSPORT																
2.1. Transport management- intelligent transport systems	+	+				+	+	+	+	+	+	+	+			−
2.2. Increase the efficiency of diesel engines	+	+											+	+		
2.3. Liquified gas	+	+		+	+	+		+			+					−

NAMA impact on environment, economy and society	Impact on sustainable development															
	Environment					Society					Economy					
Measure/Project	GHG emission reduction	Air quality	Biodiversity Conservation	Water	Waste	Health	Rural development	Energy access	Life quality	Fight against poverty	Employment	Industry competitiveness	Cost saving	Reducing dependence on import	Potential market development	Fiscal and/ or financial effects
2.4. Biofuels	+	+				+		+			+			+	+	
2.5. Hybrid vehicles	+	+						+			+		+	+	+	
2.6. Cycle tracks	+	+	+	+		+	+		+	+	+		+	+		−
3. INDUSTRY AND SERVICES																
3.1. Increase in energy efficiency of electrolysis at the aluminum plant	+	+	+			+						+	+			−
3.2. Inert anodes at the aluminum plant	+	+	+			+										
3.3. Automatization of the heating process and its improvement	+	+	+	+	+	+						+	+	+		−
3.4. Restructuring of the aluminum plant	+	+	+			+					−	+	+	+		+
3.5. Restructuring of the ironworks	+	+	+			+					−	+	+	+		+
4. CONSTRUCTION INDUSTRY																
4.1. Solar thermal systems for hot water in households and services	+							+	+	+	+		+	+	+	
4.2. Thermal systems for heating, cooling and water heating in households and services	+	+									+		+	+	+	
4.3. External insulation of buildings	+					+					+	+	+	+	+	
4.4. Efficient air-conditioning systems in households and services	+					+	+					+	+	+	+	

NAMA impact on environment, economy and society	Impact on sustainable development															
	Environment					Society					Economy					
Measure/Project	GHG emission reduction	Air quality	Biodiversity Conservation	Water	Waste	Health	Rural development	Energy access	Life quality	Fight against poverty	Employment	Industry competitiveness	Cost saving	Reducing dependence on import	Potential market development	Fiscal and/or financial effects
5. AGRICULTURE																
5.1. Soil binding	+		+	+							+					
5.2. Crop rotation	+			+							+					
5.3. Fertilization management and cultivation of arable land	+		+	+												
6. FORESTRY																
6.1. Afforestation	+	+	+	+		+	+	+	+	+	+	+		+	+	
6.2. Forest management	+	+	+	+			+	+	+		+	+		+		+
7. WASTE																
7.1. Waste segregation	+	+		+	−	+	+		+		+	+		+		+
7.2. Recycling	+	+		+	−		+		+		+	+		+		+
7.3. Generation of electric power energy and thermal energy from methane from landfills	+	+		+	+		+	+	+			+		+		+

Cost- Benefit Analysis and MACC Diagram

CBA or cost-benefit analysis is the assessment of investment projects where project income is compared with investment costs. During the upcoming years, costs and income will be reviewed at their current value in order to compare them at one single point in time, as economic theory states that the value of money changes with time. In other words, the value of money decreases with time; therefore interest is charged on borrowed money in order to return the 'same value' of the borrowed money plus interest to the lender. During this process various rates are used as discount factors or discount rates depending on the type of project, but lately discount rates (discount factors) of 7% have become the constant for commercial projects and other categories. It can be concluded that 7% is the acceptable annual depreciation value for money. On the other hand, in terms of complex compounding, projects in which the value of money is X, along with an annual discount factor of 7%, the duration is expected to be about 14 years on average. Regarding all other issues, analyses have been based on EU directives and rules when analyzing costs and benefits.

When it comes to ecological projects and the use of cost-benefit analyses, discussions can help to develop the use of a lower discount rate (discount factor) due to the fact that the afore-mentioned factors represent the assumed duration of assets. Experts for sustainable development and ecologists shift discount rates (discount factors) towards a zero value since the benefits (e.g. of clean air) do not reduce over time. In the same manner and seen through a current perspective, costs associated with the reduction of emissions will not cost less nor will they be worth less. Lately, CB analyses in the areas of environmental protection and sustainable development have used discount rates (discount factors) between 0.1% and 3% (Pearce, Atkinson and Murato, 2006). Discount rates (discount factors) should be lower for ecological and sustainable development projects, but a selection of positive rate means that it is necessary to achieve implicit calculations which indicate individual benefits or costs. This is hardly justifiable when considering small open economies which struggle with methodology and the collection and reliability of data. Therefore, cost-benefit analyses have been completed by comparing cumulative benefits with cumulative costs without factoring in discounts, and without using a discount factor of zero; it has, however, been assumed implicitly that the costs and benefits of these projects are of an indefinite nature.

Cost Estimates

The study 'Assessment of Technological Needs for the Mitigation of Climate Change and Adaption in Montenegro: National Strategy and Action Plan"(2012), adopted by the Government of Montenegro, contains cost estimates for certain projects and technologies based on basic purchase costs and the cost of the installation of technologies. Therefore, the afore-mentioned cost estimates regarding certain projects and measures have been used for the cost estimates in CBA. In cases where this has not been possible, assessments of similar projects along with assessments of project proposals in Montenegro and in the region have been used to calculate cost estimates for Montenegro. The following table indicates the results of the cost estimates and identifies the opportunities for a reduction in the level of emissions.

Table 2. Cost estimates and opportunities for reducing emissions during the period 2014-2020

Measure/Project	TNA 2012. Cost over 25 years, based on the level of technical potential, mill. of €	TNA 2012 GHG reduction potential Mt cumulat. reductions	Other sources Cost over 25 years, on a level of technical potential, mill. of €	Other sources GHG reduction potential Mt cumulat. reductions
1. ENERGY				
1.1. Efficient lighting in households and services			18,00	10,48
1.2. Efficient appliances in households and services			162,00	10,01
1.3. Natural gas for cooking in households and services			150,00	50,00
1.4. Natural gas for heating in households and services			150,00	50,00
1.5. Hydro power plants	1.413,30	64,70		
1.6. Small hydro power plants	199,10	11,05		
1.7. Wind power plants			100,00	25,00
1.8. Solar PVs	191,50	2,00		
1.9. Cogeneration plants			150,00	34,00
2. TRANSPORT				
2.1. Transport management-intelligent transport systems			5,00	5,00
2.2. Increase the efficiency of diesel engines			5,00	5,00
2.3. Liquified gas	49,50	0,03		
2.4. Biofuels			3,00	9,00
2.5. Hybrid vehicles	180,00	0,01		
2.6. Cycle tracks			2,00	1,00
3. INDUSTRY AND SERVICES				
3.1. Increase in energy efficiency of electrolysis at the aluminum plant	2,20	1.175,00		
3.2. Inert anodes at the aluminum plant	20,07	1.175,00		
3.3. Automatization of the heating process and its improvement	5,57	1.175,00		
3.4. Restructuring of the aluminum plant			30,00	8,00

Measure/Project	TNA 2012. Cost over 25 years, based on the level of technical potential, mill. of €	TNA 2012 GHG reduction potential Mt cumulat. reductions	Other sources Cost over 25 years, on a level of technical potential, mill. of €	Other sources GHG reduction potential Mt cumulat. reductions
3.5. Restructuring of the ironworks			15,00	8,00
4. CONSTRUCTION INDUSTRY				
4.1. Solar thermal systems for hot water in households and services	636,25	0,18		
4.2. Thermal systems for heating, cooling and water heating in households and services			160,30	3,00
4.3. External insulation of buildings	1.840,81	0,03		
4.4. Efficient air-conditioning systems in households and services	466,93	0,02		
5. AGRICULTURE				
5.1. Soil binding			2,00	2,00
5.2. Crop rotation			2,00	3,00
5.3. Fertilization management and cultivation of arable land			2,00	3,00
6. FORESTRY				
6.1. Afforestation			1,00	20,00
6.2. Forest management			1,00	20,00
7. WASTE				
7.1. Waste segregation			1,55	7,00
7.2. Recycling			1,55	7,00
7.3. Generation of electric power energy and thermal energy from methane from landfills			1,00	7,00

Source: Ministry of Sustainable Development and Tourism, "Technology Needs Assesment for Climate Change Mitigation and Adaption for Montenegro: National Strategy and Action Plan", (2012), Podgorica.

Measure/Project 1.1. indicated that similar average projects for smaller towns of 60,000 inhabitants in neighbouring countries (e.g. Karlovac in Croatia and others) were worth 3 million €; this means that for a town with 360,000 inhabitants in Montenegro, such a project would be worth 18 million €.

Measure/Project 1.2. included research concerning the average price of standard appliances used in Montenegrin households (according to the results of the MONSTAT census), measured in terms of the cost of replacement to provide new and more efficient appliances. The total value was 900€ (estimated replacement cost of major household appliances, adjusted to reflect prices in Montenegro); this figure was multiplied by 178,149 households to obtaining a total replacement cost of 162 million €.

Measure/Project 1.3 and 1.4 took into account the most recent gas connections to households in various parts of Croatia and compared these projects with Montenegro; this lead to an estimate for the same project in Montenegro being worth a total of 300 million €; this was uniformly distributed between items 1.3 and 1.4. Although the installation of gas is a huge project, there are a large number of households that would benefit from this; thus lower costs per installation are then multiplied by the number of households to receive the estimate of total costs.

Besides a couple of projects in Montenegro within the 1.7 measure/project (wind power plants), there are also a considerable number of projects in neighbouring countries. Depending on market trends, the installation of MW capacity costs 1 million € on average, and the total cost for such a project would therefore be worth 100 million € for 100 MW.

Cogeneration plants as in 1.9. are also present in neigbouring countries and as a result of checking prices it can be concluded that the average price of equipment and projects would amount to 1.5 million € for 1 MW (combined electric and heat power) of energy. This would result in the total project being worth 150 million € for 100 MW.

Romania has a significant level of manufacturing and also has a high number of biodiesel projects 2.3. According to this data, the production of 5,000 tons of biodiesel and additional services worth around 3 million € is planned.

Projects for cycle tracks, as in 2.6, such as the ones financed by IPA close to Dubrovnik, cost 1million € for 100 km of track. Therefore, a project of 200 km (half of such tracks would be in larger cities, and half of on the coast) would cost around 2 million €.

According to proposals from banks and trustees, the cost of restructuring the aluminum plant, as in 3.3., would amount to 5 million € in terms of redundancy along with an additional 25 million € to repay bank debts and to cover working capital; a total of 30 million €.

The ironworks, as in 3.4., is on a somewhat smaller scale, and therefore estimates are that 5 million € would be required for redundancy along with 10 million € for the repayment of bank debts and to cover working capital; a total of 15 million € according to documents provided by trustees and banks.

Thermal systems for heating and cooling and for water heating in households, as in 4.2., have been estimated by comparing the cost of introduction of such appliances (estimated at 900 €) into 178,149 residential units in Montenegro. Therefore, this project amounts to 160.3 million €.

According to similar agricultural projects in the coastal areas of neighbouring countries, as in item 5, a project involving the binding of soil and the construction of terraces would amount to around 2 million €, while the introduction of crop rotation (including public campaigns and the education of farmers) is also estimated at approximately 2 million € according to similar projects.

Afforestation projects for areas damaged by fire have been compared with other forestry sectors, and according to NAMA measures, it has been calculated that a project of this type would cost around 1 million € for areas identified for afforestation. Forestry management project costs are estimated at 1 million € according to similar projects (education, corporate management and restructuring) conducted by government institutions and companies responsible for such resources.

Regarding the waste sector, waste segregation and recycling projects have been carried out in a few cities in Slovenia and Serbia. It can be concluded that such projects could be implemented in Montenegro for 3.1 million €, this amount to be evenly distributed between items 7.1 and 7.2. Project studies in their initial phases in neighbouring countries amount to 1 million € for around 1 million tons of waste.

Assessment of Benefits

Benefits have been distributed into the following categories: general benefits in environmental protection areas and social, or economic benefits (comprising the impact on employment and market development potential, competitiveness of industry and cost savings, reduction in dependence on imported fuels, GDP). Since there is no systemic or functional model for economy-energy-ecology that is capable of producing cumulative indicators in the second round, direct benefits only were listed. The general benefits in the areas of environment and social benefits are shown for the purpose of illustrating the benefits of reducing emissions through specific means and measures. This should (ceteris paribus) result in sufficiently reduced levels of emissions which should, in turn, prevent the most negative scenarios both globally and in Montenegro; such measures should also prevent an annual reduction of 1% of GDP according to Stern's report.

The economic benefit of employment and market development potential has been assessed in terms of potential number of newly-employees and their net salaries. The economic benefits of competitiveness in industry along with cost savings have been assessed in terms of percentage reductions in costs and prices brought through such measures. The economic benefit of reducing dependence on imported fuels has been assessed on the basis of replacing existing sources with new ones and on the basis of savings (mostly equivalent to the cost savings). The economic benefit for GDP has been assessed in terms of the impact of an increase in the level of employment, of competitiveness and of a reduction in the dependence on importation - mostly due to an increase in the level of employment according to GDP and based on LEAP and MMCG2009 coefficients.

Table 3. Benefits by individual projects and measures (in millions of €)

Measure/Project	Effects on sustainable development						
		Economic					
	Environment and social overall	Employment and potential for market development	Competitive industries and cost savings	Reducing dependence on imported fuels	GDP	OVERALL	TOTAL
1. ENERGY							
1.1. Efficient lighting in households and services	0,06	10,87	124,75	124,75	63,90	324,26	324,32
1.2. Efficient appliances in households and services	0,04		89,11	89,11		178,21	178,25
1.3. Natural gas for cooking in households and services	2,05		142,57	142,57		285,14	287,18
1.4. Natural gas for heating in households and services	2,05		106,93	106,93		213,85	215,90
1.5. Hydro power plants	2,65	3,05	840,00	840,00	63,84	1.746,90	1.749,54
1.6. Small hydro power plants	0,45	1,53	100,80	100,80	63,83	266,96	267,41
1.7. Wind power plants	1,02		100,80	100,80		201,60	202,62
1.8. Solar PVs	0,08	3,05	67,20	67,20	63,84	201,30	201,38
1.9. Cogeneration plants	1,39	3,05	67,20	67,20	63,84	201,30	202,69
2. TRANSPORT							
2.1. Transport management- intelligent transport systems	0,20	1,53			63,83	65,36	65,57
2.2. Increase the efficiency of diesel engines	0,20		70,00	70,00		140,00	140,20
2.3. Liquified gas	0,00	3,05	140,00	140,00	63,84	346,90	346,90
2.4. Biofuels	0,37	3,05			63,84	66,90	67,27
2.5. Hybrid vehicles	0,00	3,05	63,00	63,00	63,84	192,90	192,90
2.6. Cycle tracks	0,04	1,53			63,83	65,36	65,40
3. INDUSTRY AND SERVICES							
3.1. Increase in energy efficiency of electrolysis at the aluminum plant	48,08		84,00	84,00		168,00	216,08
3.2. Inert anodes at the aluminum plant	48,08		84,00	84,00		168,00	216,08
3.3. Automatization of the heating process and its improvement	48,08		84,00	84,00		168,00	216,08
3.4. Restructuring of the aluminum plant	0,33	-30,53	84,00	84,00	63,62	201,09	201,42
3.5. Restructuring of the ironworks	0,33	-30,53	84,00	84,00	63,62	201,09	201,42
4. CONSTRUCTION INDUSTRY							
4.1. Solar thermal systems for hot water in households and services	0,01	3,05	285,14	285,14	63,84	637,17	637,18

Measure/Project	Effects on sustainable development						
		Economic					
	Environment and social overall	Employment and potential for market development	Competitive industries and cost savings	Reducing dependence on imported fuels	GDP	OVERALL	TOTAL
4.2. Thermal systems for heating, cooling and water heating in households and services	0,12	3,05	111,38	111,38	63,84	289,66	289,78
4.3. External insulation of buildings	0,00	10,87	891,05	891,05	63,90	1.856,87	1.856,87
4.4. Efficient air-conditioning systems in households and services	0,00	3,05	222,76	222,76	63,84	512,42	512,42
5. AGRICULTURE							
5.1. Soil binding	0,08	6,11			63,86	69,97	70,05
5.2. Crop rotation	0,12		67,20	67,20		134,40	134,52
5.3. Fertilization management and cultivation of arable land	0,12		67,20	67,20		134,40	134,52
6. FORESTRY							
6.1. Afforestation	0,82	3,05			63,84	66,90	67,72
6.2. Forest management	0,82	3,05			63,84	66,90	67,72
7. WASTE							
7.1. Waste segregation	0,29	6,11			63,86	69,97	70,26
7.2. Recycling	0,29	6,11			63,86	69,97	70,26
7.3. Generation of electric power energy and thermal energy from methane from landfills	0,29		67,20	67,20		134,40	134,69

Source: Author's calculations

Environmental benefits as well as social benefits represent 1% of GDP in real terms and according to assessments (according to prices in 2005) during a seven year period (2014-2020), this amounts to 162 million € distributed between all of the measures, according to the estimated potential reduction in GHG emissions as shown in Table 2.

Economic benefits through employment have been assessed on the basis of a monthly net salary of 770 € during the period 2014-2020, multiplied by the number of employees, as prescribed by an individual measure. In the case of the restructuring of the aluminum plant and ironworks, a negative number of redundancies has been envisaged.

Measure/Project 1.1. calculations include (according to saving estimates) 14€ per lightbulb, 10 lightbulbs per household, 127,293 of urbanized households; the same amount for services, multiplied by 7 seven years.

Measure/Project 1.2. calculations include an increase in efficiency of 25% or 100 € per household, multiplied by 127,293 urbanized households, multiplied also by 7 years.

Measure/Project 1.3. calculations include an increase in efficiency of 40 %, or 160 € per household, multiplied by 127,293 urbanized households, multiplied also by 7 years.

Measure/Project 1.4. calculations include an increase in efficiency of 30% or 120 € per household, multiplied by 127,293 urbanized households, multiplied also by 7 years.

Measure/Project 1.5. calculations include meeting 20 % of energy needs, multiplied by the share of energy in GDP, multiplied also by 7 years.

Measure/Project 1.6. calculations include meeting 2% of energy needs, multiplied by the share of energy in GDP, multiplied also by 7 years.

Measure/Project 1.7. calculations include meeting 2% of energy needs, multiplied by the share of energy in GDP, multiplied also by 7 years.

Measure/Project 1.8. calculations include meeting 1% of energy needs, multiplied by the share of energy in GDP, multiplied also by 7 years.

Measure/Project 1.9. calculations include meeting 1% of energy needs, multiplied by the share of energy in GDP, multiplied also by 7 years.

Measure/Project 2.2. calculations include savings of 10 € per vehicle on a monthly basis, multiplied by the number of vehicles covered (250,000), multiplied also by 7 years.

Measure/Project 2.3. calculations include savings of 20 € per vehicle on a monthly basis, multiplied by the number of vehicles covered (one-third of 250,000), multiplied also by 7 years.

Measure/Project 2.5. calculations include savings of 30€ per vehicle on a monthly basis, multiplied by the number of vehicles (5,000), multiplied also by 7 years.

Measure 3., meeting 10 % of energy needs was assessed regarding energy savings. This was multiplied by the share of energy in GDP, multiplied also by 7 years, equally distributed between all 5 measures.

In the construction industry (measure 4) and according to assessments provided by energy efficiency experts, annual savings per residential unit should amount to 320€ for solar devices for hot water, to 125€ for thermal systems for heating/cooling/hot water, to 1,000 € for external insulation, to 250€ for more efficient air-conditioning systems, multiplied by number of urbanized residential units (127,293), and then multiplied also by 7 years.

In agriculture, crop rotation and fertilization management could save up to 1% of energy needs, multiplied by the share of energy in GDP, multiplied also by 7 years.

In waste sector, the production of electricity from methane could save around 1% of energy needs, multiplied by the share of energy in GDP, multiplied also by 7 years.

Table 4. CBA by projects and measures (in millions of €)- Source: Calculations by author

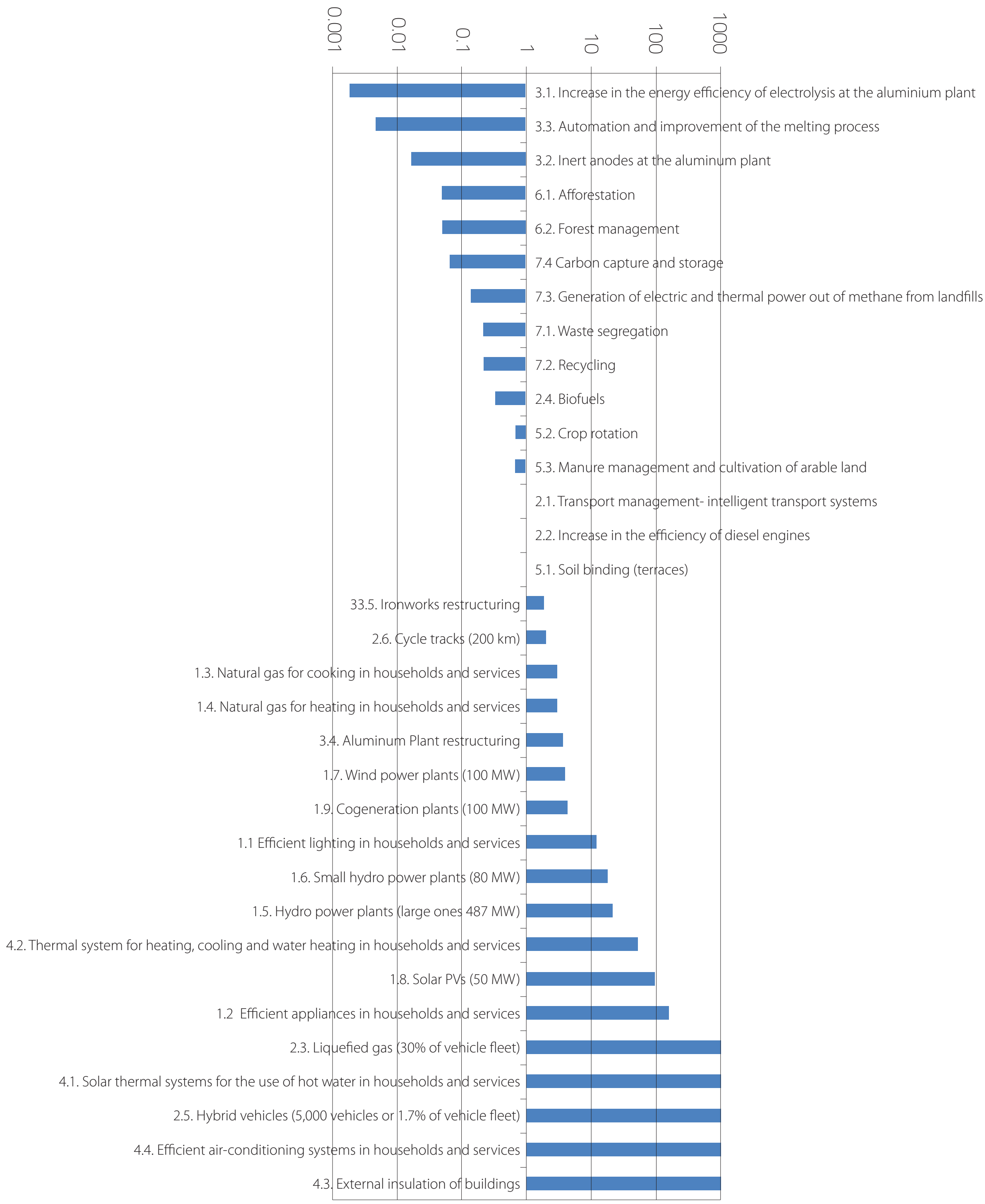
Measure/Project	OVERALL cost during 25 years on a level of technical potential, in mill. €	TOTAL benefit mil. €	TOTAL benefit minus costs mil. €
1. ENERGY			
1.1. Efficient lighting in households and services	18,00	324,32	306,32
1.2. Efficient appliances in households and services	162,00	178,25	16,25
1.3. Natural gas for cooking in households and services	150,00	287,18	137,19
1.4. Natural gas for heating in households and services	150,00	215,90	65,91
1.5. Hydro power plants	1.413,30	1.749,55	336,25
1.6. Small hydro power plants	199,10	267,41	68,31
1.7. Wind power plants	100,00	202,62	102,63
1.8. Solar PVs	191,50	201,38	9,88
1.9. Cogeneration plants	150,00	202,69	52,69
2. TRANSPORT			
2.1. Transport management- intelligent transport systems	5,00	65,57	60,57
2.2. Increase the efficiency of diesel engines	5,00	140,21	135,21
2.3. Liquified gas	49,50	346,90	297,40
2.4. Biofuels	3,00	67,27	64,27
2.5. Hybrid vehicles	180,00	192,90	12,90
2.6. Cycle tracks	2,00	65,40	63,40
3. INDUSTRY AND SERVICES			
3.1. Increase in energy efficiency of electrolysis at the aluminum plant	2,20	216,26	214,06
3.2. Inert anodes at the aluminum plant	20,07	216,26	196,19
3.3. Automatization of the heating process and its improvement	5,57	216,26	210,69
3.4. Restructuring of the aluminum plant	30,00	201,42	171,42
3.5. Restructuring of the ironworks	15,00	201,42	186,42
4. CONSTRUCTION INDUSTRY			
4.1. Solar thermal systems for hot water in households and services	636,25	637,18	0,93
4.2. Thermal systems for heating, cooling and water heating in households and services	160,30	289,78	129,48
4.3. External insulation of buildings	1.840,81	1.856,87	16,06
4.4. Efficient air-conditioning systems in households and services	466,93	512,42	45,49
5. AGRICULTURE			
5.1. Soil binding	2,00	70,05	68,05
5.2. Crop rotation	2,00	134,52	132,52
5.3. Fertilization management and cultivation of arable land	2,00	134,52	132,52
6. FORESTRY			
6.1. Afforestation	1,00	67,72	66,72

6.2. Forest management	1,00	67,72	66,72
7. WASTE			
7.1. Waste segregation	1,55	70,26	68,71
7.2. Recycling	1,55	70,26	68,71
7.3. Generation of electric power energy and thermal energy from methane from landfills	1,00	134,69	133,69
TOTAL	5.967,63	9.605,16	3.637,56

The total cost is close to 6 billion €. The total benefits are 9.6 billion €. Net benefits are 3.6 billion €. The highest net benefit is seen in the industry sector; this is due to increases in efficiency at the aluminum plant and at the ironworks. The lowest net benefits are evident in the area of construction industry due to the fact that all the projects in this field are demanding and cost a lot of money.

Based on the calculated costs and estimated levels of reduction in emissions, a tool for the prioritization of emission reduction projects has been attached; the estimated MACC curve for Montenegro is shown.

Graph 1. MACC curve for Montenegro: ratio of project costs to potential reductions in the level of emissions



Graph 1. shows a model of the MACC curve which showns projects on the X axis, and project costs and the estimated reduction in the level of emissions (in logarithmic scale in order to fit in the same graph) on the Y axis - both were estimated and defined during the CBA analysis in tables 6.1.- 6.3.[30] Measures are organized in order, from the lowest to the highest cost along with reductions in the level of emissions. In brief, according to the amounts invested in projects, measures on the left reduce the level of emissions to the greatest extent. Thus, the implementation of these projects would most effectively reduce emissions to achieve target levels. The right hand side shows the measures which could significantly reduce the emissions, but the costs of these projects are so high that their introduction is less attractive in terms of the ratio between project costs and the reduction of emissions[31]. The most significant are the favourable measures outlined for the aluminum plant; such a plan is based on reducing capacity to an optimum level and where all technology is not replaced rather than on a bankruptcy plan. It is often considered that the renovation of building facades can contribute to the reduction of emissions, but the cost of this would be very high as estimates have been made using TNA (2012) where it is assumed that such work would apply to all residential units.

When projects in Montenegro are categorised according to annual costs and according to their GHG reduction potential, the following list of priorities is obtained, from the most efficient to the least efficient (as shown in the MACC graph):

3.1. Increase in the energy efficiency of electrolysis at the aluminium plant
3.3. Automation and improvement of the melting process
3.2. Inert anodes at the aluminum plant
6.1. Afforestation
6.2. Forest management
7.4 Carbon capture and storage
7.3. Generation of electric and thermal power out of methane from landfills
7.1. Waste segregation
7.2. Recycling
2.4. Biofuels
5.2. Crop rotation
5.3. Manure management and cultivation of arable land
2.1. Transport management- intelligent transport systems
2.2. Increase in the efficiency of diesel engines
5.1. Soil binding (terraces)
3.5. Ironworks restructuring
2.6. Cycle tracks (200 km)
1.3. Natural gas for cooking in households and services
1.4. Natural gas for heating in households and services
3.4. Aluminum Plant restructuring
1.7. Wind power plants (100 MW)
1.9. Cogeneration plants (100 MW)
1.1 Efficient lighting in households and services
1.6. Small hydro power plants (80 MW)

30 On the original MACC curve (McKinsey 2007, published in Mckinsey & Company, „Pathways to a Low- Carbon Economy: Version 2 of the Global Greenhouse Gas Abatement Cost Curve"(2009), costs for (marginal costs curve) are calculated as annual additional operational costs minus potential cost savings, divided by the amount of emissions reduction. The potential for CO2 reduction is technical potential.

31 Compared with Cowlin, Shannon; Jaquelin Cochran; Sadie Cox; Carolyn Davidson; and Wytze van der Gaast, „Broadening the Appeal of Marginal Abatement Cost Curves: Capturing Both Carbon Mitigation and Development Benefits of Clean Energy Technologies", (2012), Paper presented at the 2012 World Renewable Energy Forum Denver, Colorado, May 13-17, 2012.

1.5. Hydro power plants (large ones 487 MW)
4.2. Thermal system for heating, cooling and water heating in households and services
1.8. Solar PVs (50 MW)
1.2 Efficient appliances in households and services
2.3. Liquefied gas (30% of vehicle fleet)
4.1. Solar thermal systems for the use of hot water in households and services
2.5. Hybrid vehicles (5,000 vehicles or 1.7% of vehicle fleet)
4.4. Efficient air-conditioning systems in households and services
4.3. External insulation of buildings

Based on the above, it can be concluded that this list of priorities could be used when choosing measures to be developed as NAMAs. Such measures will assist Montenegro in achieving its goals for the reduction of GHG emissions.

Specific NAMA Projects

Based on meetings held (in October/November 2013) with representatives from ministries and agencies in Montenegro and bearing in mind the priorities mentioned within this chapter, a list of concrete projects for NAMA has been prepared and is presented below.

Following an analysis of the reductions in GHG emissions and the priorities identified by ministries and agencies, these include projects in the areas of energy, forestry and waste.

Table 5. Specific NAMA projects- Example of a specific NAMA project

No	Project Title	Description	Potential for reduction of emission ($GgCO_2$/ ann.)	Investment costs (EUR)	Implementation Plan	Implementation body	Domestic/ internationally financed project
1	Wind power plants	.Energy Development Strategy prescribes the construction of wind power plants. Measure regarding construction of wind power plants with a total installed capacity of 100 MW is prescribed after consultations within CBA.	500	100.000.000 EUR	2015–2020.	Montenegrin Electric Enterprise/Ministry of Economy	International financing
2	Energy efficiency in buildings	Energy Development Strategy prescribes the restoration of facades and efficiency measures in heating for all public and residential buildings	1.000	2.000.000.000 EUR	2015–2020.	Montenegrin Electric Enterprise/Ministry of Economy	International financing
3	Solar power plants	Energy Development Strategy prescribes the construction of wind power plants. Measure regarding the construction of solar power plants with a total installed capacity of 50 MW is prescribed after consultations within CBA.	300	191.500.000 EUR	2015–2020.	Montenegrin Electric Enterprise/Ministry of Economy	International financing
4	Programme of bare land afforestation	In Montenegro, there is significant area in Montenegro, classified as bare land, or forest land suitable for afforestation. Afforestation of this area (around 40,000 ha) during longer period of time would result in the positive use of land for all forest functions.		550.000 /per year	2014–2024.	MPRR	50/50

No	Project Title	Description	Potential for reduction of emission ($GgCO_2$/ ann.)	Investment costs (EUR)	Implementation Plan	Implementation body	Domestic/ internationally financed project
5	Development of electrical power generation programme based on use of wood biomass	In Montenegro, there is significant potential of wood biomass for development of energy generation, which is confirmed through development of related studies. Previously, two Feasibiility studies were developed regarding heating supply for municipalities Kolasin and Pljevlja, as well as around 10 business plans for launching facilities for production of briquettes and pellets.These types of programmes have contributed to the development of a green economy in Montenegro.		1.000.000/ per year	2014–	MPRR, local government	40/60
6	Construction of facilities for the collection and flaring of landfill gas and its further exploitation	Landfill gas, which is produced by the anaerobic decomposition of waste due to the presence of methane (45-60%) and carbon-dioxide (40-60%), should be collected and flared using an automatically closed torch for flaring with characteristics 650 Nm^3/h and thermal power 600-3,000 kW, thereby protecting the environment from adverse effects, particularly methane and carbon-dioxide.		150.000,00 €	Construction begins in 2014, and facilitities will start working after minimum acquired conditions for flaring	Možura d.o.o	50/50

Development of Specific NAMA Projects

Of all the NAMA project proposals identified by ministries and agencies, two different sectors have been selected and analysed in greater detail.

In the forestry sector, the afforestation of bare land has been chosen since it requires a minimum level of investment, the shortest time for implementation and the shortest time to achieve the first results. In the waste sector, the project that has been selected is the the construction of facilities for the flaring of landfill gas.

NAMA in energy sector: Wind power plants

General information

Description

Programme for the construction of wind power plants with a total installed capacity of 100 MW

Technology and description of measures

According to recently developed studies, there is huge potential for wind energy use in Montenegro. Assuming that only high and medium productiveness of this potentials has been taken into account, the gross capacity of wind power plants which could be installed amounts to around 400 MW. Of this amount, 100 MW is in areas of high productivity (or with approximate capacity factor of 30%) and 300 MW is in areas of medium productivity (or with approximate capacity factor of 25%). Technically, total wind potential is assessed at around 900 GWh/ann.

Location
Coastal areas, hills around Niksic.

Implementing bodies
Electric Company of Montenegro and the Ministry of Economy

Implementation Plan
In phases 2015-2020

Financial information

Financing and costs
According to assessments by the Ministry of Economy and the Electric Company as well as by expert consultations carried out for CBS, 100 million Euros is required to complete the entire project, which would be conducted over the following seven years.

Description of necessary support
The Ministry of Economy and the Electric Company of Montenegro could ensure resources for the development of locations and projects, with subsidies of delivered kilowatt hours (kWh), while the remaining financial resources could be sought from international institutions and private investors.

Expected emissions reduction and MRV

Expected mitigation potential
Potential of around 5,000 $GgCO_{2eq}$ is expected.

Measurement, Reporting, Verification (MRV)

Following parameters would be measured:

- Number of installed MW
- Number of supplied MW in Electric Power network

Other information

Contribution to sustainable development

According to economic criterion, the project encourages sustainable development in the following areas:

1. Economic development of energy- construction of wind power plants would enable the development of areas where they would be located.
2. Sector priorities- increasing renewable sources of energy by increasing installed wind power plants would be important for Montenegro's overall contribution to climate change; this project also represents meeting priorities in the energy sector and getting closer to the EU climate goal 20-20-20.

In social terms, the project encourages sustainable development in the following areas:

- Improvement of living standards- the implementation of the project would result in a growth in employment levels as well as increases in income, and a reduction in electric power costs at both local and regional levels.

According to criteria affecting the environment and natural resources, this project would encourage sustainable development in the following areas:

1. Climate- enables a reduction in emissions in other sectors
2. Natural potential- enables the use of wind energy which is under-utilised.

Consultations

The Ministry of Economy will conduct public consultations relating to NAMA. These consultations will present the final outcomes and goals that are expected to impact on the local environment and on employment opportunities; comments will be collated and unified. The Ministry of Economy will undertake necessary measures in order to respond to comments submitted during public consultations and will announce the results. Public consultations will be organised via web pages and via meetings near the project locations.

<u>NAMA in the forestry sector: Afforestation of bare land</u>

General information:

Description
Program of bare land afforestation

Technology and description of measures
In Montenegro there is significant area classified as bare land- forest land suitable for afforestation. Over a significant period of time, the afforestation of this area (around 40,000 ha) would result in the positive use of this land and would achieve all the benefits present from forest land.

Location
Various locations, 40,000 ha

Implementation bodies
The Ministry of Agriculture and Rural Development of Montenegro (MPRR).

Implementation plan
Afforestation in phases 2014-2024

Financing and Costs
According to assessments made by MARD, 5.5 million is required for the completion of the entire project during the next ten years; this is equivalent to 550,000 € per year.

Description of necessary support
MARD would provide half of the resources (2.75 million €), while the rest of the resources would be sought from foreign sources.

Expected Reduction in Emissions and MRV

Expected mitigation potential
The expected potential is 40,000 ha after afforestation. So far, calculations state that forests in Montenegro cover 638,000 ha (Monstat 2012) and comprise sinks totalling around 7,000 Gg CO_{2eq}. The afforestation of bare land equalling 40,000 ha would increase total forest area by 6.27%, and sinks by 6.27%, i.e. 439 $GgCO_{2eq}$.

Measurement, Reporting, Verification (MRV)
The following parameters would be measured:

- Hectares of forested bare land (ha)- measurement by operational body for forests within MPRR- data would be collected and delivered on a monthly basis
- Assessment of forest sinks would be performed according to climate change reports
- Verification would be conducted by sending annual results for external verification outside the country.

Contribution to Sustainable Development:

According to criteria affecting the environment and natural resources, the project would encourage sustainable development in the following areas:

- climate- afforestation would lead to an increase in sinks that would compensate for emissions in other sectors.
- water- afforestation would improve circulation and water collection, particularly in forested areas.
- soil- afforestation would stabilise the ground in forested areas and prevent erosion and the leaching of soil.
- biological diversity- afforestation would enable the development of living species in forested areas.
- natural resources- afforestation would increase the area of forests and the quantity of wood.

NAMA in the Waste Sector: Facility for the Flaring of Landfill Gas

General Information:
The construction of facilities for the collection and flaring of landfill gas along with its further exploitation.

Description:
Landfill gas, which is produced by the anaerobic decomposition of waste due to the presence of methane (45-60%) and carbon-dioxide (40-60%), should be collected and flared using an automatically closed torch for flaring with characteristics 650 Nm^3/h and thermal power 600-3,000 kW, thereby protecting the environment

due to adverse effects, particularly methane and carbon-dioxide. Landfill gas should be flared at a closed torch at a minimum temperature of 1,000 °C, with a gas retention of 0,3 s.

Technology and Description of Measures:
The production of landfill gas from waste disposal sites lasts for decades and available quantities of gas for the cost-effective generation of energy last for twenty years. Systems for gas collection from disposal sites could collect approximately 60% of produced methane. Energy generation from landfill gas is cost-effective for huge waste disposal sites with relatively high gas production levels. At smaller waste disposal sites, landfill gas could be collected and flared using torches. Greenhouse gas emissions would be reduced by energy generated from landfill gas in the following two ways:

- by the flaring of landfill gas, methane is replaced carbon-dioxide that is twenty times weaker,
- by reducing the consumption of fossil fuels.

Location:
Inter-municipal landfill Mozura near the town of Bar.

Implementation body:
Mozura d.o.o.

Implementation plan:
Construction would begin in 2014 and facilities would become operational as soon as minimum requirements had been for the flaring of landfill gas.

Financing and Costs:
Project costs, including procurement costs and the installment of one closed-type torch, are defined according to data including torch prices (27,000- 150,000 €), depending on the temperature of flaring and gas flow. The latest and most energy efficient technology is around 150,000 €.

Description of necessary support:
Ministry of Sustainable Development and Tourism and Mozura d.o.o. would provide part of the funds, while the rest of the money (150,000 €) would be sought from foreign sources.

Expected Reduction in Emissions and MRV:

Expected mitigation potential:
The expected potential of the reduction in emissions has been calculated according to the size of the disposal site and according to assessments performed for other disposal sites (Croatia).
Annual reduction in emissions: 700,000 tCO_{2eq}
Total reduction (2014- 2020): 4,900,000 tCO_{2eq}

Measurement, Reporting, Verification (MRV)
The following parameters would be measured:

- Energy generated during one year (kJ)- calorific heat value created by flaring of methane- data would be collected and delivered on a monthly basis
- Methane consumption (m^3)- data source represents the measurement of methane volume at a landfill - data would be collected and delivered on a monthly basis
- Verification would be conducted by sending annual results for external verification, outside the country.

Contribution to Sustainable Development:

According to criteria affecting the environment and natural resources, the project would encourage sustainable development in the following areas:

- Energy resources - landfill torch would introduce new energy resources by exploiting unused methane at landfills
- Climate – methane, use of fuel and CO_2 levels would all be reduced
- Soil - stabilisation of landfill sites, expansion and improvement as well as the flaring of methane would reduce soil pollution.

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