Review of Major Greenhouse gas emissions in Skopje

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Abstract: Climate change is a serious threat to the environment and people's health, wellbeing and quality of life, reducing access to natural resources and harming the economy and infrastructure. Greenhouse gases, as the most significant driver of observed climate change are attributable primarily to human activities. Worldwide, net emissions of greenhouse gases increased by 35% in the last three decades. The comparison between emissions of different gases based on a global warming potential concept is made with climate change indicators that characterize emissions of the gases, their concentrations in the atmosphere and the change over time.
Like most urban centers, the majority of greenhouse gas emissions in Skopje result from electricity generation, transportation and other forms of energy production. The main problems originate mainly from the sector of stationary energy accounted for about 75% of the total gas emissions ranging from 4948 kt CO_2-eq in 2008 to 5343kt CO_2-eq in 2012. As the most dominant greenhouse gas carbon dioxide, CO_2 accounted for 93% of the total emissions. Significant measures to reduce its emissions in the sectors of energy supply, buildings and transportation are proposed. They are expected to achieve 22%, or more ambitious 32% reduction in emissions by 2020.

Keywords: climate change, greenhouse gases, CO_2 emissions.

1. Introduction

Life on the Earth is possible due to the natural greenhouse effect. This phenomenon maintains the warmth of our planet, thus ensuring the normal functioning of the physiological functions of all living organisms [1]. The climate system is a shared resource whose stability can be affected by industrial and other emissions of carbon dioxide (CO_2) and other greenhouse gases (GHGs): CH_4, N_2O, HFCs, PFCs, SF_6, NO_x, CO, NMVOCs, SO_2 [2]. In the last three decades, net emissions of GHGs increased by 35%, worldwide [3]. This is the most significant driver of observed climate change which is a serious threat to the environment and people's health, wellbeing and quality of life, reducing natural resources and harming the economy and infrastructure. Over this period, the emissions of CO_2, which makes up the vast majority of greenhouse gas (GHG) emissions (about three quarters of total emissions), increased by 42%. This increase is attributable primarily to human activities [3].

The comparison between emissions of different gases, based on a so-called Global Warming Potential (GWP) concept is made with climate change Indicators, in order to convert amounts of other gases into carbon dioxide equivalents. These Indicators characterize emissions of the gases, their concentrations in the atmosphere and the change over time. Properly selected indicators, based on appropriately selected time series, enable appropriate action in the process of environmental protection and are especially relevant for the creation of an environmental policy [3]. GWP became established as a method for comparing the climate effects of emissions of different greenhouse gases, 20 years ago. Its wider utility and in particular, its use to compare the climate impact of emissions of CO_2 with non-CO_2 greenhouse gases, soon followed (e.g. Lashof and Ahuja 1990; IPCC 1990), [4].

2. Global Greenhouse Gas emissions

Concentrations of CO_2 and other GHGs in the atmosphere have increased since the beginning of the industrial era [2]. The majority of the world's emissions result from industry, electricity generation, transportation, and other forms of energy production and use [3].

GHG emissions from industry (direct and indirect emissions, that account for about 21% of 2010 global emissions), (Fig.1), primarily involve fossil fuels burned for energy, as well as chemical, metallurgical and mineral transformation processes not associated with energy consumption and emissions from waste management activities, [5].

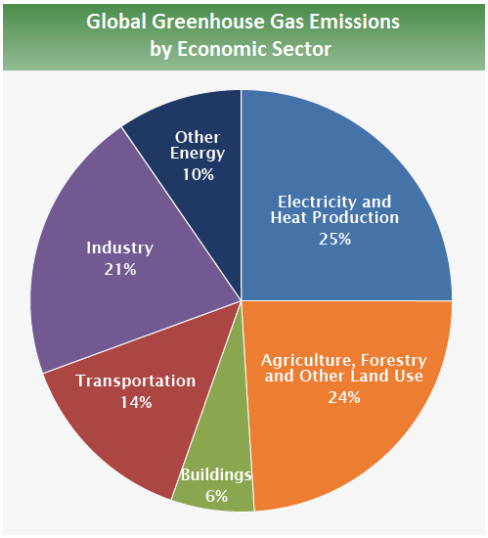

Fig. 1. Global GHG emissions by economic sector; Source: IPCC (2014); based on global emissions from 2010

Emissions from electricity generation and heat production as largest single source of global greenhouse gas emissions (about 25% of 2010 global emissions), (Fig.1), include burning of coal, natural gas and oil for electricity and heat production [5].

The emissions from transportation sector which account about 14% of global gas emissions for 2010, (Fig.1), primarily involve fossil fuels burned for road, rail, air and marine transportation. Almost all (95%) of the world's transportation energy comes from petroleum-based fuels, largely gasoline and diesel [5].

2.1. Carbon dioxide

Carbon dioxide is naturally present in the atmosphere as part of the Earth's carbon cycle - the natural circulation among the atmosphere, oceans, soil, plants and animals. It is the primary greenhouse gas emitted through human activities that alter the carbon cycle in two ways; by adding more CO_2 to the atmosphere and by influencing the ability of natural sinks, like forests, to remove CO_2 from the atmosphere. While CO_2 emissions come from a variety of natural sources, human-related emissions are exclusively responsible for the increase that has occurred in the atmosphere since the industrial revolution. Fossil fuel use is the primary source of CO_2 [5]. About three-quarters of these emissions are due to fossil fuel burning, [6]. It can also be emitted from direct human-induced impacts on forestry and other land use, such as through deforestation, land clearing for agriculture and degradation of soils [5].

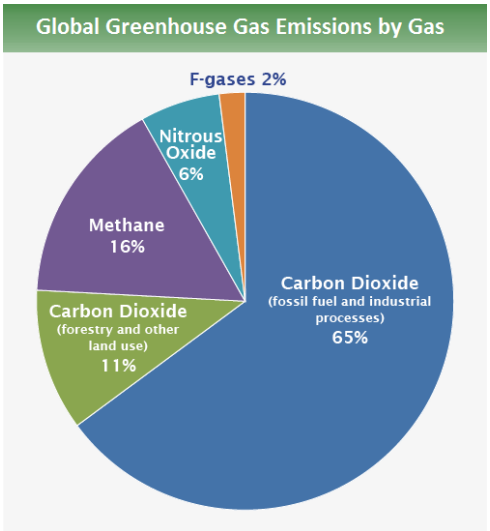

Fig. 2. Global GHG emissions by gas; Source: IPCC (2014); based on global emissions from 2010

2.2. Kyoto protocol

The basis for international action to address climate change is provided by the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol, as an international agreement that sets binding targets for 37 industrialized countries and the European Community for reducing greenhouse gas emissions for six gases: CO_2, CH_4, N_2O, HFCs, PFCs и SF_6 [2]. The Kyoto Protocol is a very important step in limiting GHG emissions since legal obligations have been specified for the first time, [1]. The Convention on Climate Change sets an overall framework for intergovernmental efforts to tackle the challenge posed by climate change. In the direction of developing and publishing the national emission inventories of GHGs, as a key element for assessing progress towards meeting commitments and targets, developed countries have specific commitments to reduce total emissions by at least 5% in the first period (2008-2012), compared to emissions from 1990. The United States has committed to reduce emissions by 7%, the European Union (EU) as a whole by 8% and Japan and Canada by 6%. Recently, the US has withdrawn its commitment within the framework of the Kyoto Protocol, causing worldwide harassment**.** Republic of Macedonia has ratified the Kyoto Protocol to the UNFCCC on 18.10.2004, [1].

3. Situation regarding emissions in the Republic of Macedonia

In the direction of tackling climate change, individual countries need to estimate how much emissions they emit and how much they are likely to emit in the future, [2]. The Republic of Macedonia has conducted a National Inventory of anthropogenic emissions to identify the major sources and removals/sinks of GHGs, [7]. This is in accordance with an emission inventory reporting obligation towards the Convention on transboundary air pollution and its eight protocols as well as the European Environmental Agency (EEA), [8]. The Inventory preparation was coordinated by the Ministry of Environment and Physical Planning of the Government of the Republic of Macedonia. Climate change issues are incorporated into the Law on Environment, including details on the preparation of GHG emissions Inventory as well as an Action plan on measures to reduce the increase of GHG emissions and to mitigate the adverse impacts of climate change [7]. At the National level, the quantities of emitted and removed GHGs in the atmosphere are presented according to the type of greenhouse gases through indicators that provide information on emissions from sectors: energy, industrial processes and product use, agriculture, forestry and others land use (AFOLU) and waste, [9].

In the period 1990 – 2012, energy sector is the biggest contributor to the National GHG emissions with an average share of 77% of the emissions. The second contributor with an average share of 9% is the waste sector. Agriculture, forestry and land use (AFLOU) follows with 8%. The industrial processes sector share averages 6% of the National GHG emissions over this period, [7].

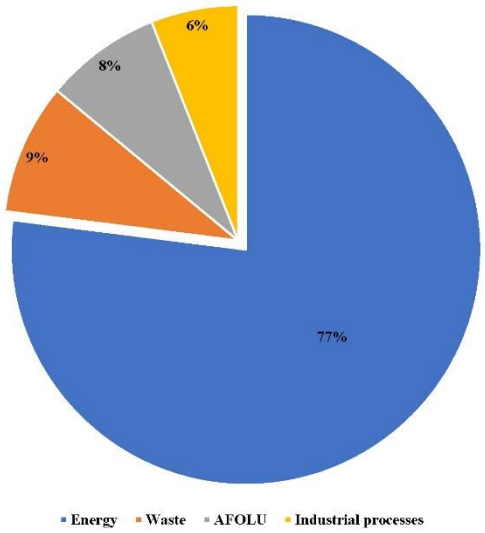

Fig. 3. Contributions by sector to national GHG emissions; Source First Biennial Update Report on Climate Change, [7]

According to the GHG emissions database of the Ministry of Environment and Physical Planning for the period 1990 – 2014 [10], the national CO_2 emissions for the energy sector, show an increase of over 10000 kt CO_2-eq in 1996 and 1998. These emissions decrease to 7702 kt CO_2-eq in 2014 (Table 1).

Table 1. Total national emissions by sectors for the period 1990-2014 [kt CO_2 –eq]

Year	National CO_2 emissions (kt CO_2-eq)	Year	National CO_2 emissions (kt CO_2-eq)	Year	National CO_2 emissions (kt CO_2-eq)
1990	9201.23	1999	9543.88	2008	8729.22
1991	8994.82	2000	9681.92	2009	8355.01
1992	8885.31	2001	9639.35	2010	8282.53
1993	9129.21	2002	8806.00	2011	9243.82
1994	8873.27	2003	8602.13	2012	9162.82
1995	8834.07	2004	8522.08	2013	8162.67
1996	10010.67	2005	9082.78	2014	7702.36
1997	8920.25	2006	8189.63		
1998	10201.10	2007	8666.23		

4. Green House Gas Emissions in the city of Skopje

Like most urban centers, the majority of GHG emissions in Skopje result from electricity generation, transportation and other forms of energy production. In order to undertake concrete measures and projects for the City of Skopje, a Reference GHG Inventory and an Action Plan for Sustainable Energy Development have been prepared. The Reference CO_2 emission Inventory was prepared for 2008 as a reference year [11], in accordance with the Intergovernmental Panel on Climate Change (IPCC) Protocol as the executive body of the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO) in the implementation of the United Nations Framework Convention on Climate Change (UNFCCC), [11].

The Inventory covers the sector of buildings, public lighting and transport in the selected 2008 and 2012. The main goal is to give consistent calculations in order to observe the moving direction of the city's GHG emissions. This database will be used as a basis for the preparation of the Climate Change Strategy of Skopje in the future, [12].

4.1. Buildings sector

Total CO_2 emissions from the buildings sector include emissions from electricity consumption (87.06%) and thermal energy (8.28%), as emissions from combustion of fuels. The rest of the emissions account for heating oil (3.04%), coal (1.53%) and heavy fuel oil (0.09%), (Fig.4.).

In this sector, household buildings contribute with 81.59%, commercial buildings with 16.48%, while buildings owned by the City with 1.93%. The total CO_2 emissions from the buildings sector are 1675 kt CO_2-eq (Fig.4.), [11].

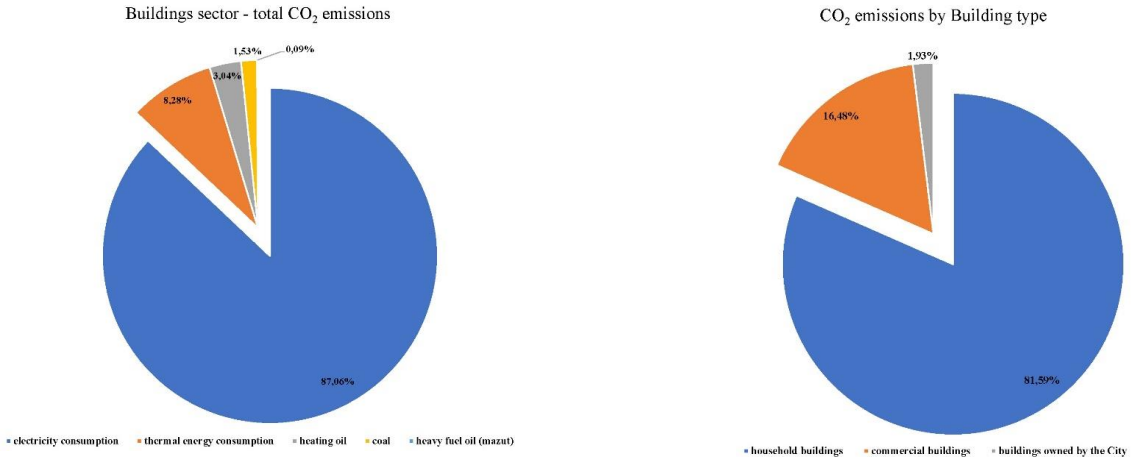

Fig. 4. CO_2 emissions in Buildings sector

4.2. Transport sector

The most important factor in air pollution in urban areas, which greatly contributes to the generation of greenhouse gases - CO_2, CH_4 and N_2O is the transport sector, and especially road transport. Type of fuel, design performance of the engine and vehicle, driving mode, external meteorological conditions, engine maintenance and age are the main factors that influence the CO_2 emission from motor vehicles. CO_2 emissions [kt CO_2-eq] from various subsectors from the transport sector in the City of Skopje are posed in the Table 2:

Table 2. CO_2 emissions from the transport sector in the City of Skopje

Sector	CO_2 kt-eq emissions
Vehicles owned by the City	4.46
Public transport	27.06
Private and commercial vehicles	229.53
Total:	261.05

The transport sector includes: vehicles owned by the City, public transport and private and commercial vehicles that emit more than 87.9% of the total CO_2 emissions (Fig.5.), [11].

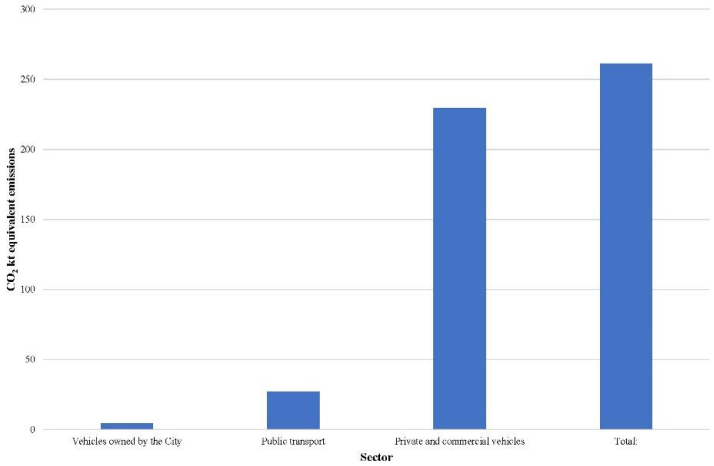

Fig. 5. CO_2 emissions in Transport sector

4.3. Public lighting

The Public lighting sector of the City of Skopje considers CO_2 emissions arising from the public lighting electricity grid, i.e. the indirect emissions of CO_2 from the electricity consumption, [11]. The total CO_2 emissions from the public lighting sector are 48.67 kt CO_2-eq. The total emission of the CO_2 emissions Inventory of the City of Skopje is 1984.72 kt CO_2-eq (Table 3).

Table 3. CO_2 emissions in the City of Skopje by sector

Sector	Buildings	Transport	Public lighting	Total
kt CO_2-eq	1675.00	261.05	48.67	1984.72

The largest source of emissions, as well as energy consumption, is the buildings sector with emissions share of 84%, followed by the transport sector with share of 13.5% and public lighting with 2.5% of emissions share (Fig. 6), [11].

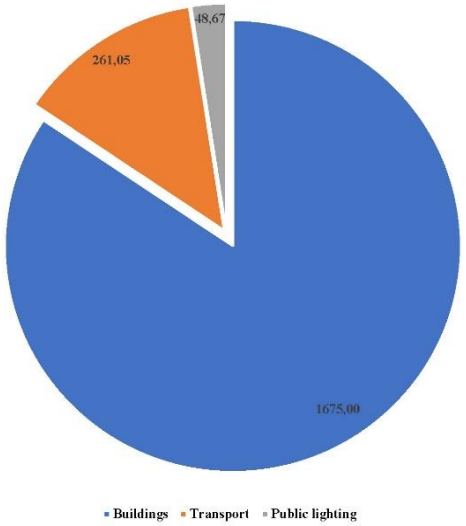

Fig. 6. Total CO_2 emissions in the City of Skopje by sectors (in kt CO_2 – eq)

As the most dominant greenhouse gas carbon dioxide, CO_2 accounted for 93% of the total emissions. The emissions of CH_4 and N_2O amount to about 6 % and 1 %, in 2008 and 2012, respectively. The main problems originate mainly from the sector of stationary energy accounting for about 75% of the total gas emissions (Fig.7), ranging from 4948 kt CO_2-eq in 2008 to 5343kt CO_2-eq in 2012, [12].

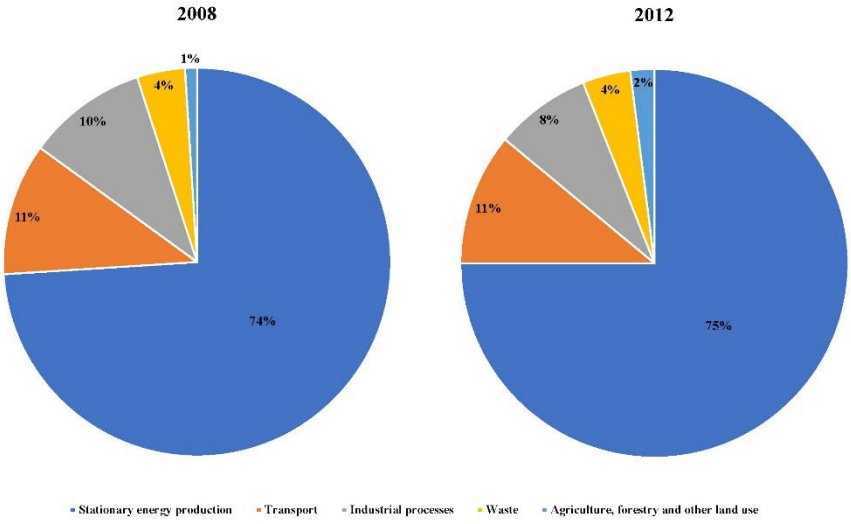

Fig. 7. Total CO_2 emissions in the City of Skopje in 2008 and in 2012

The 8% increase in emissions since 2008 is mainly due to the increased production and consumption of energy in 2012, as well as the forest fires that damaged some of the land in the course of that year. The sector of stationary energy (i.e. emissions from residential, commercial and institutional buildings and facilities,

manufacturing industries and construction, energy industries and public lighting) accounted for about 74% of total GHG emissions in 2008 and 75% of the total in 2012, [12].

Conclusion

The energy needs of the City of Skopje are mainly covered with the use of fossil fuels, that are combusted for direct accumulation of heat or transportation. The electricity, which is produced mainly by thermal power stations using lignite, also has a significant share. For those reasons, CO_2 is the dominant GHG, accounting for more than 90% of the total emissions of the city. The sectors of energy supply, buildings and transportation that participate with more than 80% share in the total GHGs have significant potential for reducing CO_2 emissions. Unless measures are taken in the future, in these three sectors, together with the waste sector, an increase in total greenhouse gas emissions is projected to reach 6175 kt CO_2-eq by 2020, i.e. 7220 kt CO_2-eq by 2025. That means an increase of about 46% for 2025 compared to 2012, or an annual growth rate of 2.9%.

The Law on Environment includes an action plan on measures and activities to abate the increase of GHG emissions and to mitigate the adverse impacts of climate change. In this direction, significant measures to reduce these emissions in the critical sectors are proposed. A total of 13 measures with a potential to reduce 1384 kt CO_2-eq or 22% compared to the reference scenario by 2025 (scenario without measures) are proposed to mitigate climate change. This implies adoption of policies to reduce or prevent GHG emissions.

The indicated measures cover: installing solar thermal systems and solar power plants, renovation of existing and construction of new energy efficient residential buildings, stimulating energy efficiency measures and enhancing the heating insulation, greater penetration of heat pumps, penetration of devices with higher class of efficiency, modernization of the lighting, renewal of fleet vehicles, procurement of vehicles for the city of Skopje in accordance with Green public procurement criteria, 5% share of bio-fuels in transportation in 2020. They are expected to achieve 22%, or more ambitious 32% reduction in emissions by 2020. The more ambitious mitigation scenario contains the same measures, but instead of 5%, bio fuels in transport would participate with 10% in 2020.

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