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Evaluating CO_2 Emissions from Public and Private Sector at Local Level in Albania

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Abstract: The paper aims to provide insight on the level of energy consumption and carbon emission per each sector. The municipality of Roskovec is located in the south part of Albania and has a total population of 32,990 inhabitants. The total area of the municipality is 118 km^2. The research contributes in identifying the main source of emissions and categorizes them according their weight. The methodology used in the reseach is based on the IPCC (Intergovernmental Panel on Climate Change) methodology by considering the activity and the emission factors. In line with the methodology, the study has considered the main sectors building, transport, waste and agriculture. The municipality of Roskovec has in total 42 municipal objects including kindergardens, municipality buildings, cultural buildings etc. The main results show that the transport sector accounts the highest part of the energy consumption and GHG (greenhouse gas) emissions with the a total 51 GW energy consumption or 13,212 ton-CO^2. The second sector after the transport is the building sector with 45.5 GW followed by waste and waste water. Based on the existing data, the municipality shall work in the replacement of the existing caris with electrical ones and secondly invest in building renovation of the private and public sector.

Key words: Climate change mitigation, carbon emissions, carbon accounting, public services.

1. Introduction

In recent decades, environmental concerns have dominated global discussions due to degradation, global warming and climate change, mainly caused by GHG (greenhouse gas) emissions from human activity, along with some natural factors [1]. Global warming, mainly driven by CO_2, is a major threat [2]. While CO_2 is essential in electricity and heating, fossil fuel consumption has alarming health impacts [3]. Since energy use is the main source of CO_2, carbon intensity can be reduced by restructuring energy systems, improving efficiency and applying advanced technologies [4]. Growing global energy demand continues to increase CO_2 levels [5].

Industrialization and urbanization in emerging economies have accelerated this trend [6]. Emissions are shaped by energy and carbon intensity [7]. Over 70% of global greenhouse gas emissions arise from the energy sector [8]. The combustion of fossil fuels for power, transport, heating and industry remains dominant [9], with coal producing the highest emissions, followed by oil and natural gas, while renewable sources generate minimal CO_2 [4]. However, even renewable sources such as biomass can add to emissions depending on usage patterns [10, 11]. For this reason, emission-reducing and energy-conserving strategies have become a worldwide consensus to respond to and mitigate global climate change. One of the most important steps is the accurate calculation of carbon emissions in various regions to clarify drivers and to allocate emission reduction responsibility to countries and economies. The scientific and rational carbon emission accounting approach is a suitable basis for the determination and implementation of carbon emission

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reduction targets and policy formulations [12]. Furthermore, Albania as a candidate country to European Union has to reach some significant targets on carbon emission reduction. According to the National Energy and Climate Action Plan, the country has to reduce approximately 3,170 kt CO_2 by 2030 considering all the sectors. The main source of carbon emissions is produced from transport, building, agriculture and forestry. The local government in the country plays a significant role in the emission reduction through regular monitoring and policy implementation. The Roskovec Municipality is located in the South of Albania where agriculture is the main source of the economy. The city has a population of 32,508 (2022) and the total area is 118 km^2. This research paper aims to contribute in the carbon emission reduction through quantifying the emissions and propose measures.

2. Methodology

Methodology of the LECAP (Local Energy and Climate Action Plan) for Roskovec, Albania: The methodology applied for the development of the Local Energy and Climate Action Plan (LECAP) is based on the guidelines of the CoM (Covenant of Mayors) and the IPCC (Intergovernmental Panel on Climate Change) (AR5) methodology for GHG (greenhouse gas) accounting. It provides a standardized approach for all signatory municipalities while combining local data analysis with internationally recognized practices.

The methodology for calculating greenhouse gas emissions for the baseline emissions inventory is developed according to the GES Protocol (Greenhouse Gas Protocol) developed by the WRI (World Resources Institute) and the WBCSD (World Business Council for Sustainable Development). In the GES Protocol, emission categories are classified as follows:

Emissions from urban and suburban public transportation, private vehicles, fuel-based heating, electricity generation, wastewater treatment are calculated with specific formula. All formulas are detailed in Pashaei and An's [13] article. For Roskovec, a risk assessment was conducted for 11 sectors: buildings, transport, energy, water, waste, agriculture/forestry, land planning, environment, health, emergencies and economy.

3. Results and Disccusion

In 2022 the total greenhouse gas emissions from all sources within the administrative boundaries were estimated at 20,458 tons of CO_2. The categorization of these emissions is detailed in the table below:

This analysis includes fuel consumption in buildings, transport, waste and water supply as the largest sources of carbon emissions. Public buildings account for about 0.3% of energy consumption or carbon emissions compared to other sectors. Residential buildings account for about 43.2% of total energy consumption within the municipality. Commercial buildings account for 2.3% of consumption, followed by street lighting at 0.4%. Transport accounts for the highest share with approximately 52% of energy consumption. This is followed by waste at 0.2%, water supply and sanitation at 1.1% and finally the irrigation sector (agriculture) at 0.3%.

Table 1 Categories of GES emissions (GES Protocol).

	At the municipal level	At the urban area level
Category I	Direct emissions (e.g., from the municipal vehicle feet, fossil fuel consumption for heating in buildings)	Direct emissions (e.g., from vehicles in city)
Category II	Indirect emissions (e.g., eletricity consumed in municipal buildings)	Indirect emission (e.g., from eletricity consumed in city)
Category III	Consumption-based emissions (e.g., emissions arising from the acquisition and use of goods and services, including their production and transportation)	Consumption-based emissions (e.g., products and services consumed in the city, due to their production and transportation in another place or region)

Table 2 Data on energy consumption levels and carbon emissions.

2022			
	GWh	CO_2 (tons)	Contribution
Buildings	45.5	6,063	46%
Municipal buildings	0.3	108	0.30%
Residential buildings	42	4,935	43.20%
Commercial buildings	2	872	2.30%
Street lighting	0	149	0.40%
Transport	51	13,825	52.10%
Municipality-owned vehicles	0.6	166	0.60%
Public transport	3	752	2.80%
Private transport	48	12,906	48.70%
Other sectors	2	570	1.60%
Waste	0.2	49	0.20%
Water supply & sewerage	1	409	1.10%
Agriculture (irrigation)	0.3	112	0.30%
Total	98	20,458	100%

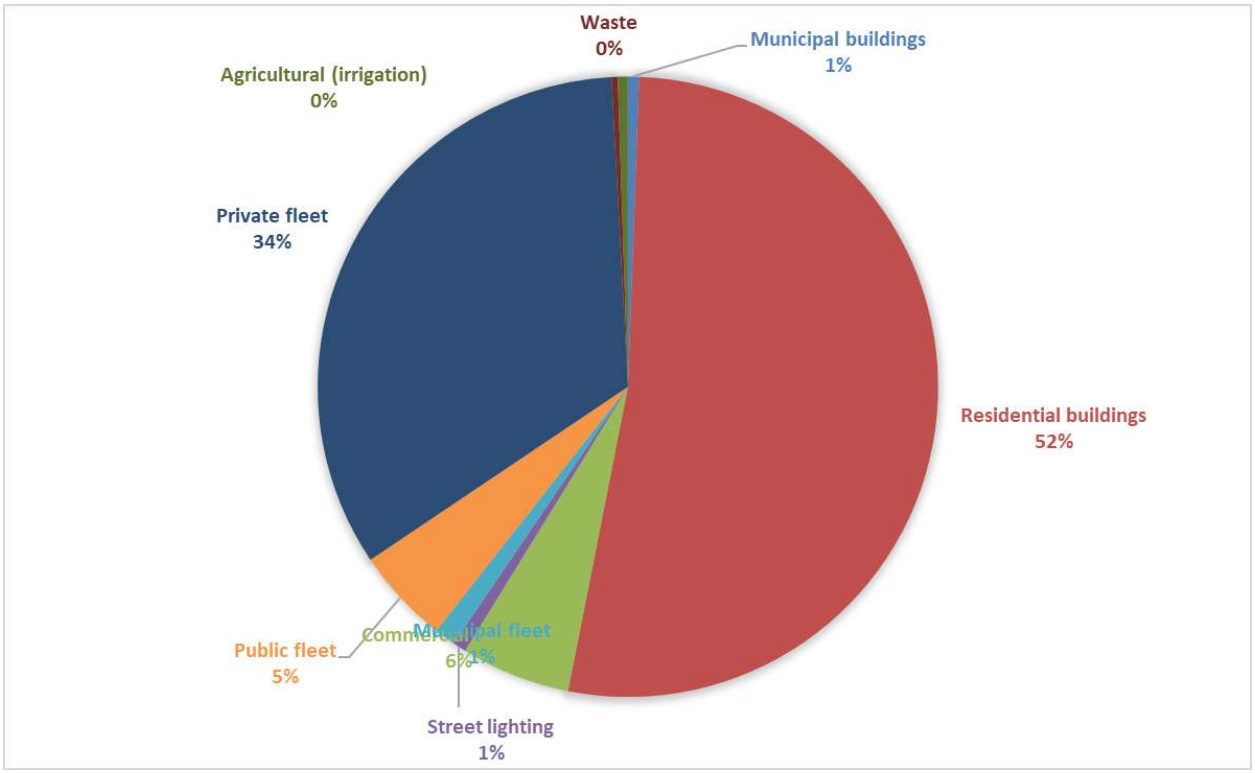


Fig. 1 The share of the emissions per sector.

The total energy consumption from the building sector is estimated to be 45.5 GWh during 2022 which categorized the building the second sector in regards to the energy consumption comparing with the other sectors. Moreover, the research has contributed in the development of projections to evaluate the trends of emissions and the energy demand in the next 10-15 years. According the national strategies, the country has to reduce the emission by 11.5 % until 2030 per each sector. At national level there are already 2 (two) main scenarios: (1) with measures and (2) without measures. In the first scenario there are already proposed a number of measures and in the second measures.

1. The assessment shows that in the no-measures scenario, energy demand will increase by around 21% by 2040 compared to the base year 2022, reaching 0.39 GWh and leading to higher CO_2 emissions. In contrast, under the with-measures scenario, energy consumption is projected to fall to 0.21 GWh (a reduction of 35-40%). The analysis considers both electricity and fuel (wood) consumption.

2. For commercial buildings, in the no-measures scenario, energy demand is projected to increase by about 21% by 2040 compared to the baseline year (2022), when consumption was 3.19 GWh. In contrast, under the measure's scenario, consumption falls to 2.1 GWh, a reduction of 35%-40%. The assessment only considers electricity use, as data on fossil fuels (oil, wood, natural gas) were not available, although electricity remains the dominant source of energy for businesses. This study contributes to the growing literature on the connection between energy consumption and greenhouse gas emissions by providing an analysis of the local context in the Municipality of Roskovec. The results show that global awareness of the impact of energy consumption on climate change is high, but at the local level clarity on sectoral sources of emissions and concrete reduction measures is often lacking. This gap reflects the well-known "knowledge–action gap", where knowledge on climate issues does not automatically translate into practical intervention plans [1, 2]. One of the most notable findings is related to the large weight of the transport and building sectors in total emissions. For 2022, transport contributed 13,825 tons of CO_2, while buildings contributed 6,063 tons of CO_2, following the same logic observed in the international literature, where these sectors constitute the main sources of urban emissions [8, 9]. This is consistent with the studies of Liu et al. [4] and Mi et al. [12] which emphasize the central role of energy consumption and energy structure in shaping the carbon footprint. An approach based on accurate emissions measurements and the identification of concrete measures is essential for designing local policies and adapting to climate change [6, 14].

4. Results and Disccusion

The main source of the energy comes from the transport which accounts around 51% of the total energy consumption and GHG emissions comparing with another sector. The total number of private cars in the city is estimated to be 24,690, the number of municipal fleets is 15 and public cars are estimated to be 33. The old age of the cars and the low quality of the fuel have an influence on the production of emissions. The second sector after the transport is the building sector. The current municipal buildings are heated mainly from electricity and wood/gas. The current building conditions are low in terms of energy performance for heating and cooling. This condition makes the sector more vulnerable and contributes the second in the production of emissions after the transport. The third sectors are waste, waste-water and agricultural with the lowest emissions comparing with the other sectors. Overall, the municipality, shall regularly monitoring the carbon emissions through a well-established monitoring and verification system which will lead in the implementation of measures. Moreover, a number of specific measures for the building, transport shall be further developed and analyzed.

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