Modelling and Assessing Environmental Impact in Transport to Meet the Sector's Climate Goals in 2050

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Abstract: - The transport sector has had and continues to have an extraordinary impact on the annual final consumption report based on fossil resources limited by technology and as a result has brought and continues to present very serious problems for the impact on the environment. The transport sector, particularly in developing countries, has a critical role in final energy consumption and greenhouse gas emissions reduction strategies. Albanian transport sector ranks first in terms of total energy consumption and consequently in emissions that may increase particularly rapidly, and the costs of future retroactive mitigation activities may be prohibitive if no energy efficiency measures (EEM) are undertaken. The total energy consumption by the end of 2050 is calculated using multiple variable regression methods driven by the GDP growth rate, and population projections, while the combination of energy fluxes by fuel type is based on National Energy and Climate Plan (NECP) requirements. In this study two scenarios are developed using an advanced energy system analysis computer model, EnergyPLAN, enabling a smart, sustainable, flexible, diversified, and environmentally friendly Albanian transport sector based on renewable energy sources (RES) and electricity. In this paper the integration of different alternative energy sources and future expected energy sources driven by two basic criteria: the security of supply, with a minimal environmental impact toward 2050 goals by using EnergyPLAN are proposed.

Key–Words: - EnergyPLAN, Transport Sector, GHG, Optimization, Smart Energy System, Multivariable Regression and Statistics.

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1 Introduction

The global energy crisis, volatile fuel prices, and the emerging climate change agenda and geopolitical issues have provided additional challenges for countries to carry out their strategies to help better manage their energy sectors. For most developing countries, transport is usually the major energy consumer, followed by buildings and industry. As the largest and fastest growing energy-using sector, transport was responsible for 23 percent of world energy-related GHG emissions in 2004, and about 75 percent comes from road vehicles. The transport sector in Albania totally depends on fossil resources, which accounted for 100% of its annual energy demand in 2020. Consequently, the transport sector ranks first in terms of pollution in the country, [1]. Special support should be given to candidate countries in establishing clear policies and programs for a sustainable transport sector based on green technologies. People are driving on an insufficient number of poorly maintained roads and unguaranteed fuel quality, the lack of alternative urban transportation specifically rail transportation, and generally lack the money and institutional determination to fix the problems. The idea of a carbon-free, sustainable, flexible, and environmentally friendly transport system based on RES, and ramping up electrification and biofuels undoubtedly will play a major role in fully decarbonize road transport toward the 2050 roadmap. Thereafter, electrification will be the prominent lever, with electricity as an energy carrier representing three-quarters of energy consumption in road transport by the end of 2050, [2].

Hence, encouraging energy systems with broad integration of renewable energy sources will be the dominant energy carrier in the global energy system and will play a major role in the process of deep decarbonization of power systems, including the transport sector [3] preventing the negative effects of the current transport sector on human health and using less energy per activity level. In this paper transport energy demand scenarios that include biofuel, hydrogen, and EVs are designed based on demographic, economic, and many other assumptions and projections. The hypotheses raised in this paper consider the increase in demand for energy in the future, and economic growth as well as the problems of security of energy supply influenced by global crises and geopolitics, [4].

Therefore, the purpose of this study is to design policies, integrate and define efficient energy scenarios in the transport sectors in Albania fully in line with the requirements of the Energy Strategy for Albania 2018-2030, as the core strategic document for the country's energy sector, is fully coherent with other national policies and strategies and the European Green Deal's objectives with the main aim in supplying clean, affordable and secure energy; building and renovating, promoting a cleaner construction sector; accelerating the shift to sustainable and smart mobility; eliminating pollution through measures to cut pollution rapidly and efficiently and in line with National Energy and Climate Plan (NCEP) in 2030 and 2050. The NECP is developed under three main reports such as the second National Strategy for Development and Integration (NSDI II) based on the United Nations' Sustainable Development Goals; the obligations arising from the signature of the United Nations Framework Convention on Climate Change (UNFCCC) and the Energy and Climate Acquis of the Energy Community. Referring to Sustainable Development Goals, SDG 7- Affordable and Clean Energy, calls for ensuring universal access to modern energy services, improving energy efficiency, and increasing the share of renewable energy, specifically in the transportation sector. The progression of climate change leads to changes in the availability of renewable energy.

With Albania producing almost 100% of its electric energy from hydroelectric sources [5], related changes in the water cycle are of crucial impact, output from reservoir hydroelectric power plants and Run-of-river is expected to decrease by 15% and 20% by 2050, while photovoltaics output is expected to increase by 5%. In a nutshell, import dependence and high distribution losses in the electricity grid and reduction of fossil fuel in the total final energy consumption (TFEC) are challenges to be dealt with as more than 65 % of TFEC is based on fossil fuel sources as given in Figure 1 (Appendix). Albania depends almost exclusively on hydropower for its electricity generation (98% produced from hydropower), making it increasingly vulnerable to unfavorable hydrological conditions in the summer, especially in view of the predicted effects of climate change in the Western Balkans region. Apart from the fact that there is no constant production, electricity from hydropower is not sufficient to meet the annual demand.

2 Some Data and Statistics on the Transport Sector

The most effective scenario is that it integrates new technologies and provides the best and the cheapest cost solution. The central problem is that cities in developing countries are growing and motorizing at a very fast rate, even faster than the urbanization rate. The gross inland consumption in the country is estimated to be around 2177 ktoe in 2022, while the final energy consumption results in 1972 ktoe. The transport sector shares around 38% up to 40 % of the total final energy consumption (712 ktoe) in the country. The transport sector is dominated by road transport sharing 90% of the total energy consumption within the sector, while the rest belongs to rail transport with nearly 0% (2.1ktoe), aviation 5 % (36.88 ktoe) and inland navigation 5% (34.30 ktoe). The total number of active vehicles until December 2023 is 867,765 [6] representing 43 types of vehicles and 2016 different brands of which 699,337 belong to personal passenger vehicles (81%).

The vehicle fleet in our country continues to rise faster. The total number of active vehicles until December 2023 is 867,765 [6] representing 43 types of vehicles and 2016 different brands of which 699,337 belong to personal passenger vehicles (81%). The sector continues to be dominated by relatively old vehicles compared to other European countries, with a fleet of vehicles older than fifteen years.

From the study performed by [7] group that leads to high levels of pollution in our country is the group of vehicles manufactured from 1980 to 2002. There is a slight improvement compared to the 2015 level, anyway vehicles aged over 15 years still dominate the vehicle fleet in our country, sharing 70.5 % of the total numbers as given in the graph in Figure 2 (Appendix). Considering the above factors as well as the quality of the fuel, which remains another unresolved issue for the government further complicates the position of the transport sector in Albania. According to our forecast, the vehicle fleet in our country will continue to rise based on annual average historical growth and the income growth rate. The final energy consumption by the end of 2050 will be calculated using a multivariable regression model based on population projections and GDP growth rate.

As depicted in the graph in Figure 3 (Appendix) the group of vehicles with an average age of 9 up to 15 shares 22.7 % of the total passenger fleet in the country, while the group of new cars shares only 2.7 %, [6].

From the data in the chart, as depicted in Figure 4 (Appendix), the number of vehicles registered in our country until 2023 that use oil as fuel is 513,760 (73.5%) and 114,050 (16.3%) with gasoline, 2,891 electric vehicles (EV) and 64,601 of gasoline-gas powered engines. The number of electric cars and other alternative fuels shares a negligible portion in terms of annual energy balance within the transport sector with 0.4 %.

So, unless developing countries, including Albania, make investments today that would curb their long-term transport sector emissions growth, it is unlikely that they would follow an emissions direction and fight GHG much differently than those exhibited by prosperous countries.

While the other categories of road transport sector are almost 100% diesel and 100% petrol for motorcycles. Based on the latest data the distribution of vehicles of all categories (%) registered for the first time in the period January-December 2023 by fuel type is depicted in the graph in Figure 5 (Appendix) showing that diesel and petrol cars dominate, while electric vehicles share only 2.3% from the total of 78 157 new registered vehicles where 82.4% belongs to passenger cars.

The fuel type of other vehicle categories is 100 % fossil fuel. The passenger cars distribution by fuel type for the newly registered vehicles in the period January up to December 2023 is given in Figure 5 (Appendix).

As can be seen from the graph in Figure 4 and Figure 5 (Appendix) an optimistic strategy that would consider the promotion of locally produced biofuels, such as: biodiesel, bioethanol, and bio-methane is considered part of our solution. The integration of biofuels should consider sustainability criteria for long-term projections, an option that will reduce dependence on oil imports and increase national energy security. The integration of biofuels will contribute to the improvement of air quality in urban centers and the most important thing is that it will help diversify the fuel fluxes within the transport sector in Albania. The share of electric vehicles (EV) is at low-rate values bunching only 0.4% within the sector. The introduction of a series of measures for smart and sustainable transport, including a revision of the actual National Energy and Clime Plan (NECP) [8] and National Energy Strategy 2018-2030 [9] and Law No. 24/2023 on “Promoting the Use of Energy from Renewable Sources” as given in [10] is necessary.

3 Materials and Methods

EnergyPLAN is an advanced energy system modelling tool, which has been under development since 1999. The structure of the model is given in Figure 6 (Appendix) including the whole system in one control volume. Such structure enables to exploit the synergies between different sectors as encapsulated in the smart energy system concept enabling the experts to easily take a holistic approach focusing on the analysis of cross-sectoral interaction. Traditionally diverse demand sectors, such as buildings, industry, and transport, are linked with supply technologies through electricity, gas, district heating, and cooling grids based on a high share of renewable energy sources. The key objective is to model a variety of options so that they can be compared with one another, rather than model one 'optimum' solution based on defined pre-conditions. Using this methodology, it is possible to illustrate a palette of options for the energy system, rather than one core solution. This could classify EnergyPLAN as a simulation tool rather than an optimization tool [11], even though there is some optimization within the model. In this way, EnergyPLAN enables the analysis of the conversion of renewable electricity into other energy carriers, such as heat, hydrogen, green gases, and electrofuels, as well as the implementation of energy efficiency improvements and energy conservation.

The latest model has improved strongly enough and includes features such as a better algorithm to make use of electrolyzers to balance electricity and a better algorithm to use thermal storage. An option to enter max and min prices on the external market in the case of bottlenecks. An option to include HTL and Pyrolysis in the biomass conversion. An option to calculate H_2 grids and convert them to a 100% H_2 solution. An option to include Biochar from Pyrolysis. A choice to incorporate other emissions than CO_2 facilitating to compute various emissions such as N_2O, NOx, PM2.5 CH_4, and SO_2. When applying the CO_2 emission (kg/GJ) of each of the four fuel types as an input, the model calculates the CO_2 emission simply by multiplying the fuel consumption by the emission data. The need to integrate other alternative fuels with zero emission, based on the internal energy potential and global trends are the main pillars of the methodology. Reduced dependence on energy imports will not only contribute to improving the security of the energy supply but also to the macroeconomic and political stability of the country by decreasing the domestic budget deficit.

4 Scenario Conceptualization

Energy scenarios provide a framework for exploring future energy perspectives, including various combinations of technology options and their implications in the whole system driven by independent variables such as the economic growth rate, population, fuel prices, and other limitations including reduction of GHG and energy importation level. The energy demand in the transport sector is increasing constantly, a situation that has increased the sector's dependence on carbon-intensive fossil fuels, resulting in high energy-related emissions-and so is unsustainable and unecological. Our approach strives for to invigorate and prop up locally produced biofuels such as biodiesel, bioethanol, and bio-methane and inject electric vehicles (EV) to reduce critical excess electricity production (CEEP) in the cases of high share of renewables into the future power systems. In this perspective, different fuels and energy carriers should be combined to assess and control targets required in our National Energy Strategy 2018-2030, in the National Sectoral Strategy for Transport 2016-2020, as well as in the National Energy and Clime Plan (NECP) as given in Table 1 (Appendix), respectively.

The increase in energy demand in the transport sector is calculated by applying a forecasting methodology driven by the historical data of the last 12 years of energy consumption within the transport sector, economic growth, and other policy factors given in the current strategic energy documents. Forecasting, and making predictions about future energy consumption, especially in the transportation sector plays a key role in the decision-making process and measures to maintain or achieve the desired energy and climate goals. The strategic priority is to accelerate the integration of Albania's transport system and create an integrated market that includes the entire transport infrastructure. Despite the significant investments and efforts made by governments in the last decade, to improve the road infrastructure, the transport sector still does not show optimistic indicators for economic development in Albania. In the transport sector, the projected emission increase results from a continuously increasing gasoline and LPG use from 2018 to 2050, which is a function of the projected economic growth and increased demand for transport services. Electrification is expected to pick up towards 2030 but is projected to have the smallest share among all fuels.

In Table 2 (Appendix) two main scenarios designed for the transport sector in Albania in the way toward 2050 goals are introduced. The main goal of this research paper is to calculate the required energy carriers to meet demand and reduce emissions as per NECP requirements. The integration of alternative fuels, e.g., electricity, H_2, renewable fuels such as synthetic fuels, but also biofuels has been considered an efficient approach to reduce conventional fuel use in a well-designed plan. Electricity can be used in the direct form in all forms of transport: in the road, rail, and marine transport sector and to a lesser extent aviation. Electric-based direct transport is one of the most promising technologies with high reliability, safety, and efficiency for transport. The main driver of the transport sector is the demand for mobility, forecasting a rising annual demand for per person-km growth rate, while transport of freight is projected to undergo growth with a GDP evaluated 3.4% in 2050.

5 Regression Analyses and Energy Forcasting

The major problem related to energy demand in the future and the consequent scientific challenge is that its production greatly depends on available resources, overall economic and population growth rate, urbanization rate, efficient and new resources or technologies that may replace existing energy systems. The greater the number of independent variables the more accurately the demand of energy in a future growing demand would result. Regression analysis is a statistical technique to set the relationship among different independent variables influencing a phenomenon and the mean value of the corresponding function. Univariate regression is analyzing the relationship between a dependent variable $X_1, X_2 \dots\dots\dots\dots X_n$ and one independent variable Y.

5.1 Multiple Linear Regression Model (MLR)

In this study, the historical transport energy data consumption from 2010 up to 2022, known as dependent parameter (Y) given in kilo tonne oil equivalent (ktoe), is a function of many independent variables and quantities such as activity level (AL) or simply vehicle numbers, GDP (Billion €), population projection, and income growth rate (%), are used as an input to create a multiple regression model with interaction effects. The interaction effect occurs when the effect of the independent variables on the future energy demand in the transport sector changes subject of the other variables (independent variables). The regression model with interaction effects is an extension of the general regression presented as follows in Eq.1:

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots . \beta_n x_n + \varepsilon \quad (1)$$

where β_0 is the intercept and x represent each independent variable. The other β parameters present the slope coefficient of the variable. All β parameters are defined in the model creation process to minimize the error ε. The interaction effects are added to the general form of the multiple regression model as follows in Eq.2:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_1 x_2 + \cdots . \beta_n x_n + \beta_1 x_m x_n + \varepsilon \quad (2)$$

where $x_1 x_2$ is the interaction between two variables Population (Thousand) and GDP (billion €).

In Table 3 (Appendix) historical energy consumption, Population and GDP are given for the period from 2010 up to 2022. The energy data for the transport sector are provided from the National Energy Balance report. The transport sector shares approximately 38 up to 40 % of the total energy consumption in the country level, while GDP values after 2022 are calculated using Forecast. Linear function based on World Bank national accounts data, and OECD National Accounts data files. The results of "Forecasted" values on transport energy consumption (ktoe) and GDP (Billion €) starting from 2023 up to 2050 using an elasticity coefficient of 1.05 and 1.2 respectively are given in Table 3 (Appendix). By the end of 2050 the total energy consumption is expected to rise to a total value of 1773.40 ktoe.

In Table 4 (Appendix) the simulation results of multi-variable regression for the chosen independent variable are given. Multiple R value results 0.872, while R Square is 0.760 and adjusted R Square is 0.733 for a set of observation numbers of 21 as shown in the ANOVA test table and results portrayed by Table 4 (Appendix). The intercept value results in -370.80, Population coefficient of 0.299, and GDP coefficient of 27.850 with a p-value less than 0.05 (0.0113).

From the multi linear regression analyses (MLR) simulation, the energy consumption (ktoe) in accordance with GDP (billion €) is given in the graph Figure 7 (Appendix). The correlation between GDP (billion €) and energy consumption (ktoe) is given by the mathematical expression in Eq.3:

$$y = 2.1396 \cdot x^2 - 38.852 \cdot \mathrm{x} + 943.26 \qquad (3)$$

The coefficient of determination (R^2) of this function is approximately 0.92, which represents a good correlation, while the consumption based on population variability is given from mathematical expression as given in Eq.4:

$$y = -0.7656x + 2989.4 \qquad (4)$$

The coefficient of determination (R^2) value of the correlation is $R^2 = 0.8609$.

Energy demand is a function of income growth rate, and population. The more the household income the higher the energy consumption is expected. This is a universal approach in energy modelling science, in which the growth in one variable is rated as a function of the growth in another (independent) variable.

As can be seen from the plot, energy demand is strongly dependent on economic development and population income rate. In the future GDP is expected to reach a value of 32.69 billion euro by the end of 2050.

6 Simulation and Results

In this section the simulation results are given per each scenario considering energy demand from 2020 up to 2050 and the total emission impact for both scenarios is given. The fuel distribution for the chosen period between 2020 and 2050 for both cases, the baseline scenario and mitigation scenario are depicted in the graph in Figure 8 and Figure 9 in Appendix.

In the case of the baseline scenario, the total energy demand in 2050 the corrected fuel consumption 20.63 TWh splited down as follows: 12.60 of TWh diesel, 4.44 TWh of petrol, 2.8 TWh of LPG and 0.79 TWh of EV, as it can be seen in the graph in Figure 8 (Appendix). In this scenario hydrogen and biofuel, are introduced supported by high EV penetration. The total energy demand in 2050 results around 19.02 TWh. The baseline scenario does not consider any change in the technology branch, using the same distribution and growth rates from historical data. In this scenario, the emission impact is expected to deteriorate the situation of the sector. In the graph in Figure 9 (Appendix) the simulation results for the case of Mitigation scenario are sketched out. In the case if Mitigation scenario would be applied then EV and hydrogen penetration by the end of 2050 must be 2.3 TWh and 0.87 TWh, respectively.

Based on the above projection and fuel types and distributions, the total emission per scenario using EnergyPLAN is calculated and given in the graph in Figure 10 (Appendix). Such simulation is performed assuming different energy sources with various specific emission loadings. In Table 5 (Appendix) specific emissions deriving from burning fossil fuels such as SO_2, PM2.5, NOx, CH_4, and N_2O are given.EnergyPLAN arranges the fuel demand for each technology and multiplies with the selected defined emission factor that enables to calculation the total emission per each scenario as given in equation 5-9.

$$SO_{2\,Transport} = F_{SO_{2\,Transport}} \cdot PES_{Transport} \qquad (5)$$
$$NO_{x\,Transport} = F_{NO_{x\,Transport}} \cdot PES_{Transport} \qquad (6)$$
$$CH_{4\,Transport} = F_{CH_{4\,Transport}} \cdot PES_{Transport} \qquad (7)$$
$$N_2O_{Transport} = F_{N_2O_{Transport}} \cdot PES_{Transport} \qquad (8)$$
$$PM2.5_{Transport} = F_{PM2.5_{Transport}} \cdot PES_{Transport} \qquad (9)$$

The simulation results of the total yearly emissions and each pollution component are given in the graph in Figure 10 (Appendix). The model calculations show that changes in emissions by scenario are evident as fuel shares and technologies change, too. In the case of the Mitigation scenario with the integration of sustainable fuels such as biofuel, hydrogen, and EV share a significant reduction of energy due to improved efficiencies and pollution are evidenced. In the case of the Mitigation scenario, as it is depicted in the graph given in Figure 10 (Appendix) the reduction level per each component is substantial. The proposed scenario reduces the emission level by 71.1% in terms of CO_2, 83% less CH_4, PM2.5, SO_2, and 82.2% less N_2O. To identify the least cost solutions for the integration of fluctuating renewable energy sources into current or future 100% renewable energy supplies one must take a Smart Energy Systems approach [14], which is the focus of the next step work.

7 Conclusion

In this research work the total energy demand for the whole transport sector is calculated based on a multivariable regression method that includes two independent variables, X_1=GDP growth rate, and X_2=population projections. A strong correlation between GDP and energy consumption is evidenced, the strength of the relationship between energy demand with population is weaker. Based on historical energy demand and economic data within the time horizon from 2010 up to 2022 the population is reduced due to the emigration rate, while on the other hand GDP is increased. Multiple R-value of the proposed system that that impact energy demand results in 0.872. Mixing oil with biodiesel at a level of 35 % is mandatory to meet climate goals in 2050.

The optimal introduction of EV and H_2 should be designed for the overall Albanian energy system, while Hydrogen as a transportation fuel is forecasted to cover all freight sub-branch and passengers' vehicles at a level of 0.87 TWh.

The proposed scenario reduces the emission level by 71.1% in terms of CO_2, 83% less CH_4, while producing 82.2 % less PM2.5, SO_2, and N_2O. A combination of energy efficiency measures (EEM) and low-carbon approaches would reduce transport energy consumption from 20.64 (TWh) in the case of baseline scenario 2050 to close to 18 TWh by 2050 if proposed scenario would be applied.

7.1 Future Work

The design and configuration of a 100 % RES transport sector must be carefully investigated. Also, it should be noted that energy savings are extremely important and can be coupled with fluctuating resources (wind and solar) and biodiesel.

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Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

- Lorenc Malka, has developed the mathematical model and has carried out the simulations in EnergyPLAN computer energy model. He has collaborated with the formulation, writing and revision of the manuscript and supervised the numerical study, made the figures and editing.
- Raimonda Dervishi was responsible for the entire Statistics and has implemented the regression analyses and participated to analyze and synthesize study data.
- Partizan Malkaj was responsible on formulation, supervising, evolution of overarching research goals and aims.
- Ilirian Konomi has collaborated with the formulation, writing and revision of the manuscript.
- Rrapo Ormeni has collaborated with the writing and revision of the manuscript.
- Erjola Cenaj has participated to analyze and synthesize study data.

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Conflict of Interest

The authors have no conflicts of interest to declare.

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Rrapo Ormeni, Erjola Cenaj

APPENDIX

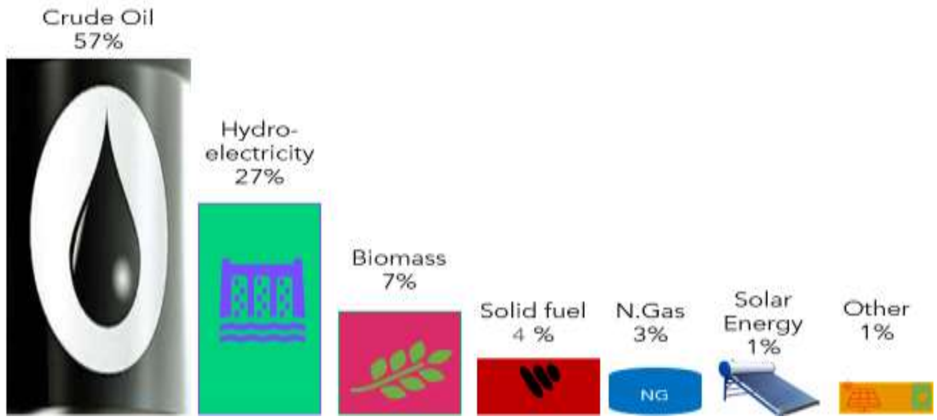

Fig. 1: Total energy consumption by fuel type (%)

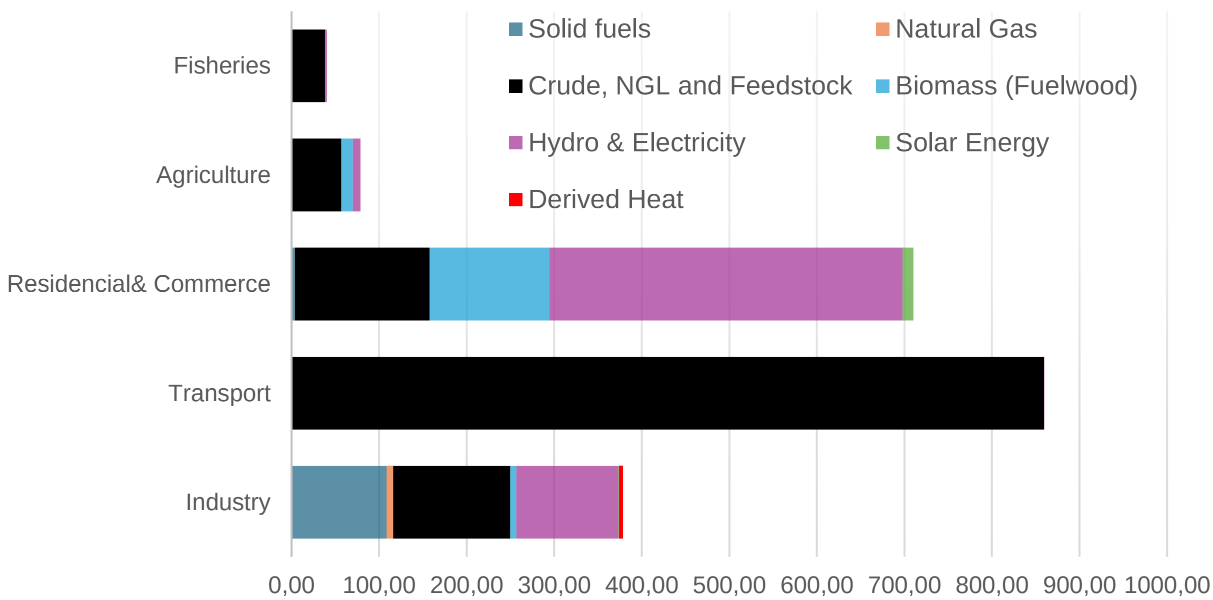

Fig. 2: Distribution of energy consumption by fuel and sector in Albania

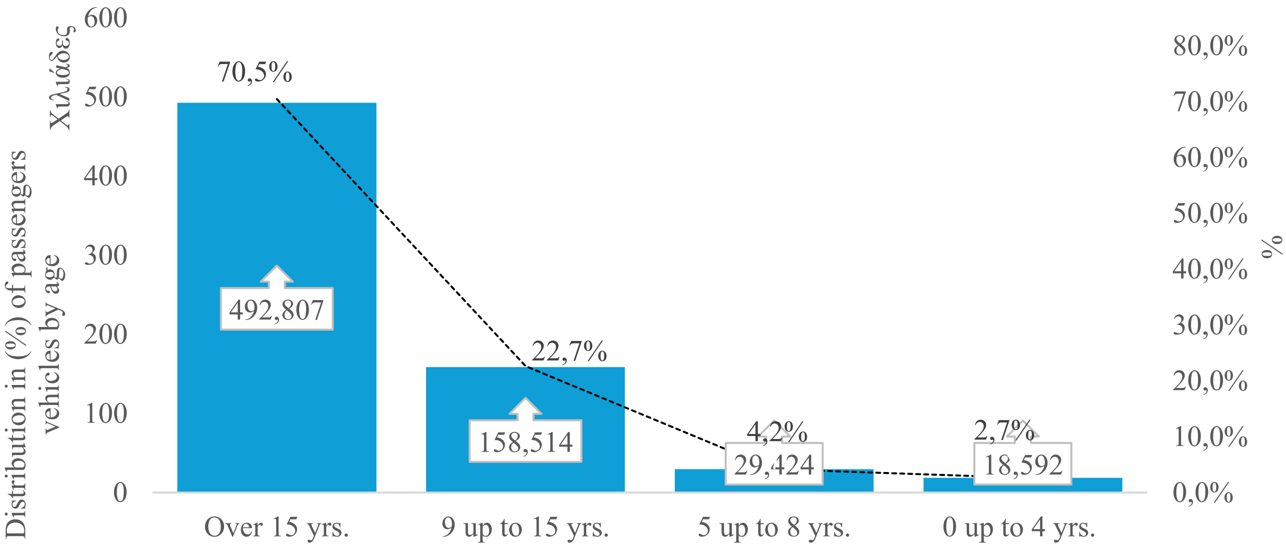

Fig. 3: Distribution in (%) of passenger vehicles by manufacture production year

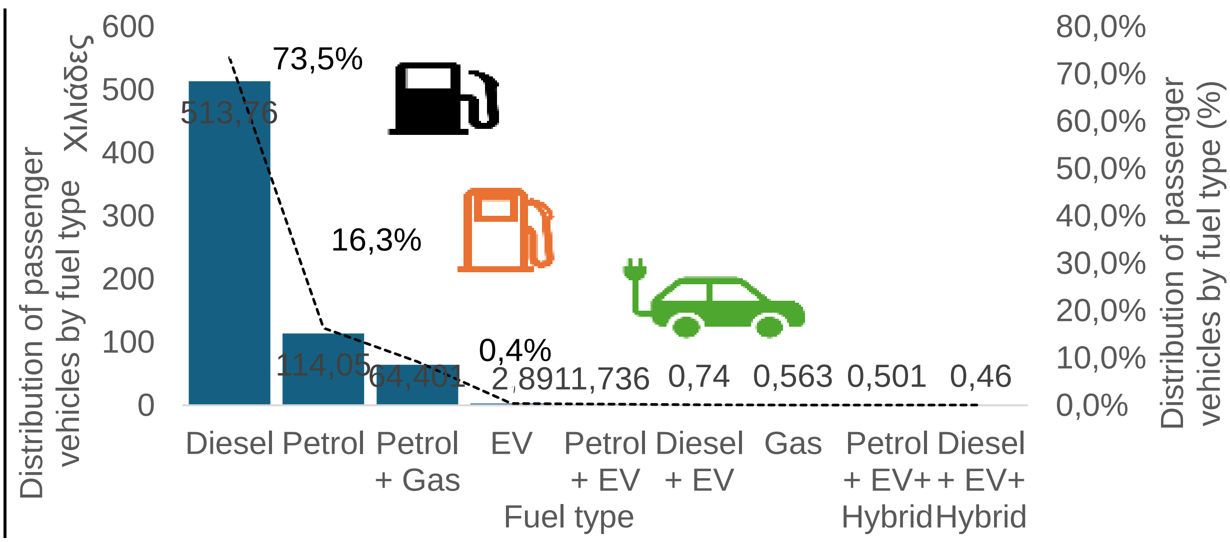

Fig. 4: Distribution of passenger vehicles (Thousand and %) by fuel type

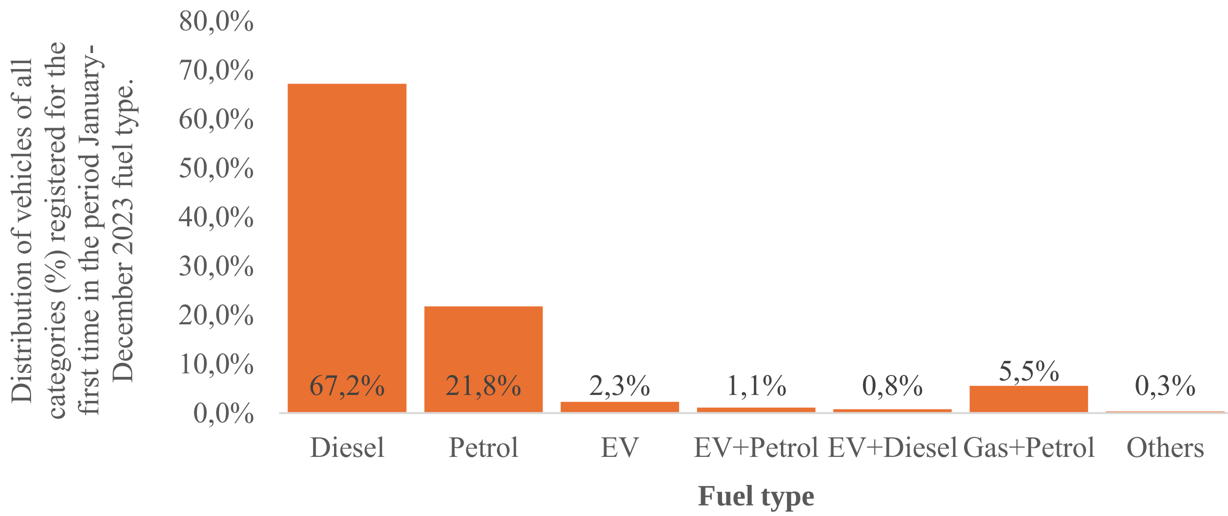

Fig. 5: Distribution of passenger vehicles (Thousand and %) by fuel type

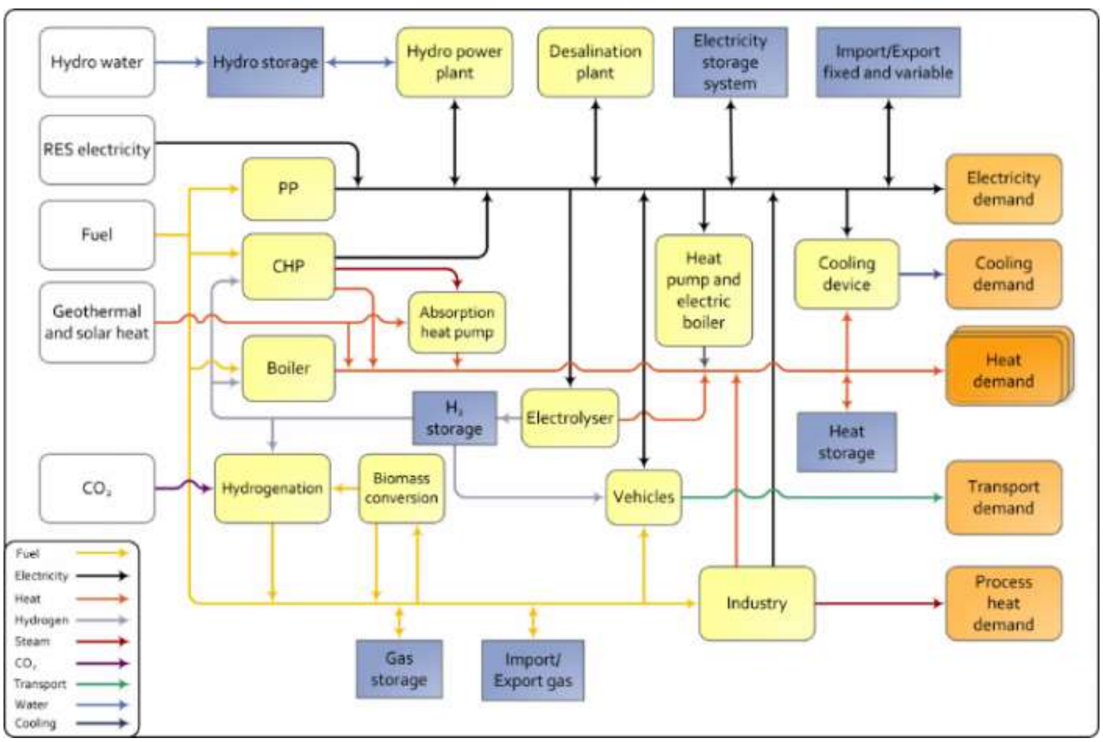

Fig. 6: EnergyPLAN model structure, [11]

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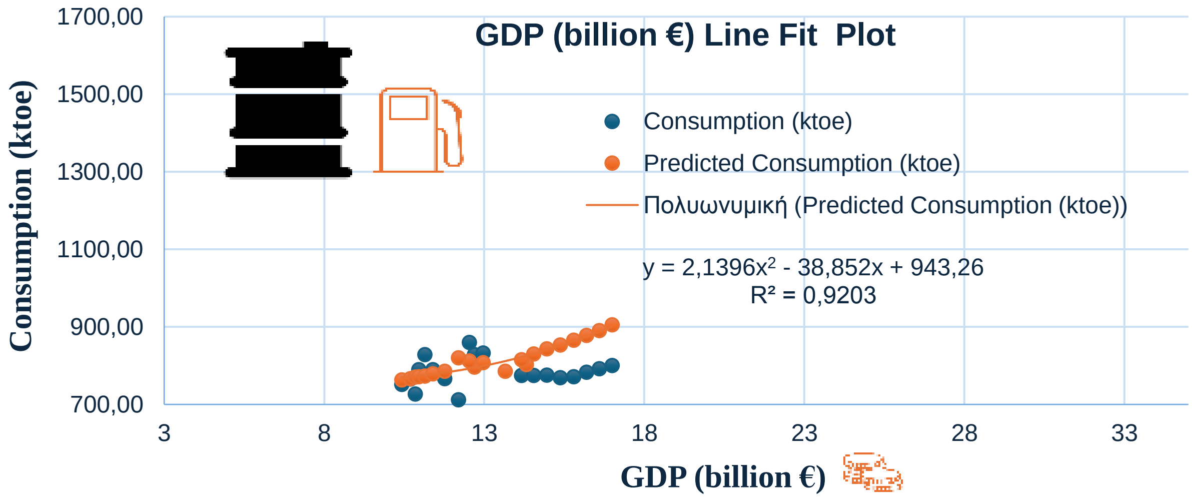

Fig. 7: Energy consumption (ktoe) fitted to GDP (billion €)

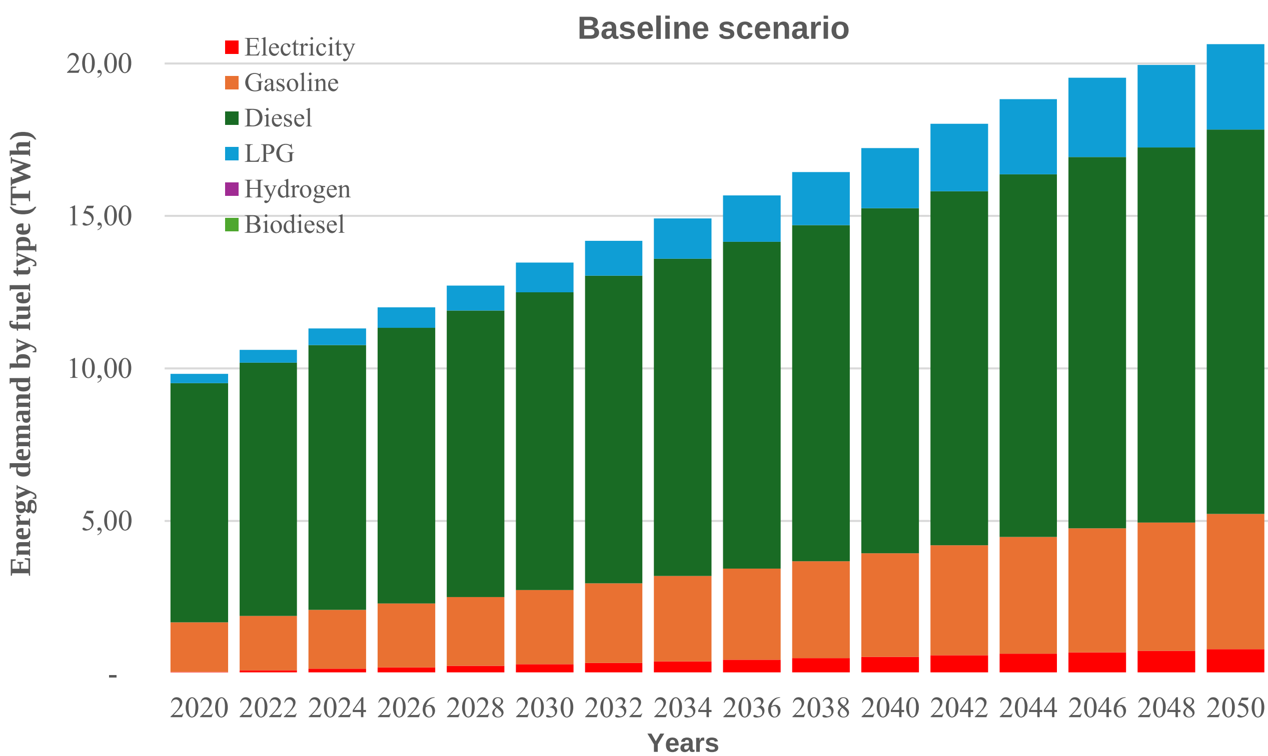

Fig. 8: Projected energy demand for Baseline scenario by fuel type (TWh)

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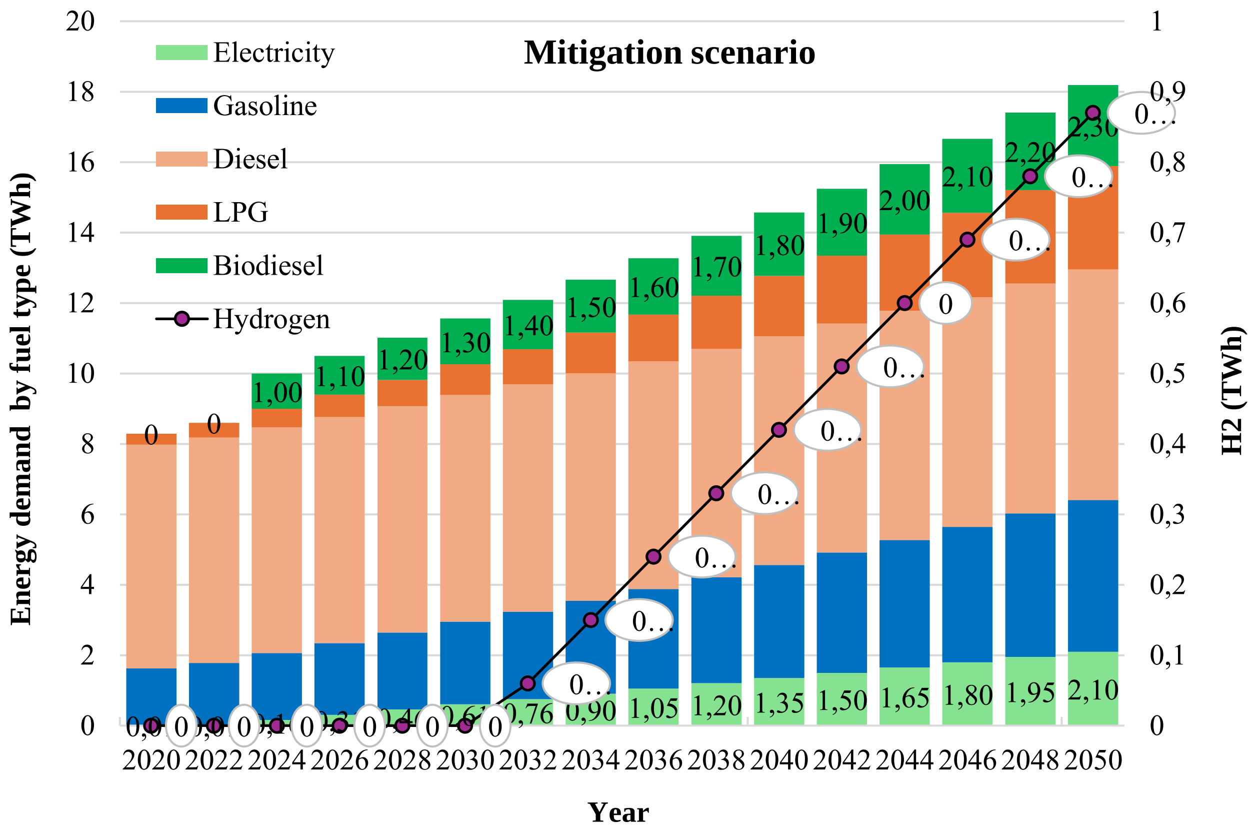

Fig. 9: Projected energy demand for Mitigation scenario by fuel type (TWh)

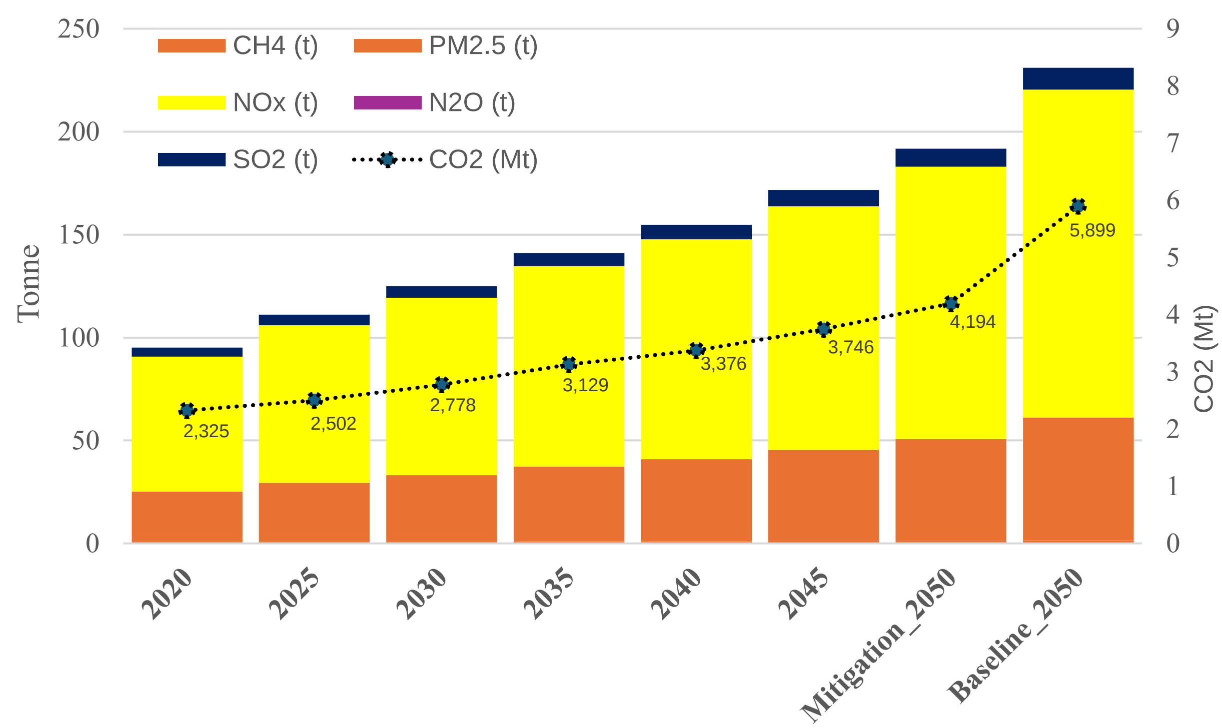

Fig. 10: Emission impact for each of scenarios. Baseline scenario versus Mitigation scenario

Table 1. National Energy and Clime Plan (NECP) targets

NECP goals	Value	Year
RES SHARE	54.4%	2030
Reduction of CO_2	18.7 %	2030
Energy demand reduction	8.4 %	2030

Table 2. Scenarios developed and main parameters drivers affecting energy demand.

	Description	Parameters
Baseline scenario	No changes in the technology branch	Demand calculated using the latest 12 years of fuel and technology trends
Mitigation scenario	Integration of EV, Biofuel, and Hydrogen	Demand calculated based on new technologies introduced considering improved efficiencies
	GDP	34.63 (billion euro) in 2050

Table 3. Transport energy demand forecasting (ktoe) using multiple variable regression analyses.

Year	*Consumption (ktoe)*	*Population (Thousand)*	*GDP (billion €)*
2010	751.60	2,913.00	10.42
2011	765.20	2,905.20	10.69
2012	726.80	2,900.40	10.84
2013	789.20	2,895.10	10.95
2014	828.00	2,889.10	11.14
2015	789.20	2,880.70	11.39
2016	766.80	2,876.10	11.76
2017	828.00	2,873.50	12.7
2018	832.80	2,866.40	12.97
2019	860.00	2,862.40	12.54
2020	627.00	2,856.70	13.66
2021	691.00	2,850.50	14.32
2022	712.00	2,843.50	12.2
2023	**=FORECAST.LINEAR (x, known y_s, known x_s) *1.05 = 774.91**	2,780.00	=FORECAST.LINEAR (x, known y_s, known x_s) *1.02 **14.16**
2024	**774.49**	2,791.85	**14.55**
2025	**775.74**	2,789.43	**14.96**
2026	**769.27**	2,785.45	**15.38**
2027	**771.33**	2,780.60	**15.79**
2028	**782.70**	2,775.18	**16.20**
2029	**792.19**	2,769.35	**16.59**
2030	**800.49**	2,763.20	**17.00**
2031	**822.80**	2,756.81	**17.53**
2032	**854.40**	2,750.21	**18.11**
2033	**902.11**	2,743.44	**18.61**
2034	**918.40**	2,736.52	**19.26**
2035	**941.78**	2,729.47	**20.06**
2036	**967.76**	2,722.31	**20.49**
2037	**1005.56**	2,715.04	**21.14**
2038	**1047.70**	2,707.69	**21.82**
2039	**1094.37**	2,700.26	**22.54**
2040	**1143.84**	2,692.76	**23.29**
2041	**1196.57**	2,685.19	**24.08**

Year	*Consumption (ktoe)*	*Population (Thousand)*	*GDP (billion €)*
2042	**1253.60**	2,677.56	**24.91**
2043	**1314.24**	2,669.87	**25.76**
2044	**1377.53**	2,662.13	**26.63**
2045	**1445.02**	2,654.34	**27.54**
2046	**1518.28**	2,646.51	**28.49**
2047	**1601.00**	2,638.63	**29.46**
2048	**1688.86**	2,630.72	**30.48**
2049	**1782.25**	2,622.76	**31.58**
2050	**1773.40**	2,614.78	**32.69**

Table 4. Multivariable regression simulation results.

Regression Statistics	
Multiple R	0.872083979
R Square	0.760530466
Adjusted R Square	0.73392274
Standard Error	25.4597082
Observations	21

ANOVA

	df	SS	MS	F	Significance F
Regression	2	37054.9043	18527.45215	28.5831	2.58972E-06
Residual	18	11667.54135	648.1967415		
Total	20	48722.44565			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-370.8050769	1231.200559	-0.30117358	0.76673	-2957.461467	2215.851313	-2957.461467	2215.851313
Population (million)	0.299405685	0.393095203	0.761662016	0.45613	-0.526456691	1.125268061	-0.526456691	1.125268061
GDP (billion €)	27.85062522	9.87574319	2.820104238	0.01134	7.102458692	48.59879176	7.102458692	48.59879176

Table 5. Emission factor used to evaluate emissions from the transport sector in Albania, [12], [13].

	g/GJ input fuel				
Component	**SO_2**	**PM2.5**	**NOx**	**CH_4**	**N_2O**
Value	141	798	2132	20	0.6