Modelling the Business-As-Usual Energy Scenario for the Albanian Household Sector

Altin Maraj

Abstract—This paper shows the results obtained from the development of the Business-As-Usual Scenario for the household sector in Albania. Actually, this sector is the biggest consumer of electricity with 48% of the total provided in the last year. The modelling of the energy system is achieved through the utilization of the Low Emissions Analysis Platform. The performed analysis refers to a long-term period and is extended till 2050. Firstly, the tool is employed to forecast annual data for the population, economy, precipitation and average temperature. Secondly, the tool provided results related to the energy demand, GHG emissions and the fuel share referring to the household sector. The obtained results obtained from the simulation offer a clear view regarding the household sector in Albania in the future. For the year 2050, the household energy use is forecasted to rise till 1.449 MTOE/year and the electricity will provide 45.42% of it. Also, the GHG emissions in the same year will be 3.348 Mt CO$_2$eq/year. It is noticed that biomass contribution in GHG emissions will be 76.9%.

Index Terms—Energy Scenario, Business-As-Usual, Household Branch, Required Energy, Greenhouse Gas Emissions, Fuel Share.

I. INTRODUCTION

In developing countries, the household branch represents a high share of their required energy. Variations in the total energy consumption are strongly related to demographic developments, changes of energy demand per capita, end-use structure, and used appliances. The fuel choice is heterogeneous and depends from each country available energy sources and cultural habits. In general, the energy consumption in the household sector refers to electricity and non-electricity branches. The first one is related to electric appliances as air-conditioning units, water heaters, refrigerators, lighting, etc. The second one is related mainly to cooking devices such as wood stoves, LPG stoves, charcoal stoves, etc. Also, the energy consumption shows its impact on greenhouse gas (GHG) emissions.

Energy consumption regarding air-conditioning and space heating in the household branch is considered from Isaac and van Vuuren. They focused their study in the worldwide context of climate change. They estimated a steep increase of the required energy related to air-conditioning during the time period from 2000 to 2100. The income rise will be its main effect on this variation. By considering the 2000 as a reference year, related emissions will rise from 0.8 Gt CO$_2$/year till 2.2 Gt CO$_2$/year for the end year of 2100 [1].

Van Ruijven et al. presented and applied for India a bottom-up model leaning on Image Energy Regional model or TIMER. It referred to the energy usage in the residential sector and the related CO$_2$ emissions. For this sector, they founded that the energy usage in 2050 will increase 65-75 % compared to 2005. While the CO$_2$ emissions could grow up to 9-10 times compared to the reference year [2].

Haas and Schipper looked over the impact of effectiveness to foresee the required energy from the household branch. The authors emphasized the idea that improvements in efficiency will be very helpful to forecast the required energy in the household branch [3].

An interesting “hybrid” model is suggested by Xu and Ang. It decomposes the household sector into several subsectors having different energy consumption drivers. Also, they applied it for the case of Singapore. At the end, they analyzed the relationship between the conventional model and the hybrid one [4].

Jiang et al. through the utilization of monthly household expenses defined the carbon emissions from the household branch for about fifty one cities in Japan. To analyze the relationship between GHG emissions and several other factors (demographics, capita income, climate, etc.) a regression analysis is performed [5].

Tanatvanit et al. employed an end-use approach to foresee the energy demand increase for the household branch in Thailand. Also, they included energy efficiency improvement programs in the household branch. To achieve their research objectives, they made use of the LEAP model by building the Business-as-usual (BAU) scenario and other ones. To provide information for their impact on the surrounding environment, even the CO$_2$ emissions were defined [6].

Pukšec et al. used the Household Energy Demand (HED) model to obtain projections regarding the required energy for long term periods in the household branch in Croatia. HED is a bottom-up model. The BAU scenario in this case is developed through the utilization of this model [7].

Astudillo et al. studied the energy efficiency potential for the province Quebec. They build even the Business-as-usual scenario for the household sector by making use of the TIMES model. Also, they defined measures to reduce the peak demand in this sector [8].

Nieves et al. developed a positive and a negative scenario for Colombia through the utilization of the LEAP model. For the household branch, future predictions regarding the required energy were provided. Referring to the scenario named as “negative” and to the year 2005, the growth rate is 70.7% (2030), whereas for the 2050 it was 168.7%. Referring...
to the “positive” scenario and to the same year, the growth rate is 12.8% (2030), whereas for the 2050 it was 50.4%. Also, they defined GHG emissions for each sector [9].

Liya and Jianfeng performed the scenario analysis regarding the reduction of CO₂ emissions based on LEAP model. They developed a Business-as-usual scenario, also [10].

LEAP model is utilized to evaluate the efficiency of different measures undertaken in Korea to protect the environment till 2050. Five policies were implemented and the obtained results were referred to the results of the BAU scenario. These policies will further reduce the final energy demand by 25.5 % referred to the BAU scenario. Also, a reduction till 21.6 % for GHG emissions is forecasted [11].

Yophy et al. modelled the Taiwan’s energy system to foresee the required energy for a long-term period. BAU scenario is developed through the utilization of the LEAP model. Through the model, the GHG emission potential from different sectors is provided [12].

Subramanyam et al. utilized LEAP model to define possible improvements related to energy efficiency for two branches in Alberta. Different scenarios were developed and analyzed for the long-term period. The GHG mitigation for these fast and slow penetration scenarios were 28 Mt and 55 Mt, respectively [13].

A new model to evaluate the environmental impact in thirteen cities of China is proposed from Mi et al. It is based on input and output approach. Also, they presented their values “per capita”. For the cities of Shanghai, Beijing and Tianjin is defined that annual emissions are 14 t CO₂/capita, 12 t CO₂/capita, and 10 t CO₂/capita, respectively [14].

Zhou and Gu investigated the required energy from the household branch in thirty provinces of China. The related CO₂ emissions were considered, also. They defined that in 2012, this branch represented 30 % of the total required energy. Whereas, the carbon dioxide emission represented around 66.3 % of the overall value. For the considered branch, an increase of 218.3 % of the required energy was notified [15].

Aminnekooei et al. developed even the Business-as-usual scenario regarding the energy consumption for Iran. They utilized LEAP model. Also, they evaluated even the GHG emissions in their work [16].

Winkler et al. considered the case of South Africa by developing the long-term BAU scenario. Forecasts of GHG emissions were obtained for the household branch, as well for the others. For this branch is defined that CO₂ emissions will rise from 9.6 t CO₂/capita (2003) to 32 t CO₂/capita (2050) [17].

In this work, the development of BAU scenario for the Albanian household branch is performed. For this aim, a bottom-up modelling process is utilized. Low Emissions Energy Platform (LEAP) is employed to forecast for long-term time periods the required energy in this branch. Also, the forecast for related greenhouse gas emissions is carried out.

II. METHOD

The utilized methodology for the household sector only is described. The household sector is very important for each country. The required energy and related GHG emissions generated in the branch represent a key point for being considered in the energy and environmental strategies.

A. Geographical Location

Albania has a land area of 28,748 m² and is located at southeast region of Europe, on western part of Balkan peninsula. The land border has a length of 657 km, whereas the sea one is 316 km. Also, the lake border and the river one have lengths of 72 km and 48 km, respectively. The Ionian and Adriatic Seas form the coastline in southwest and west part, respectively [18]. Fig. 1 shows the location and terrain of country [19]. Generally, the summer is dry and hot, whereas the winter is humid and mild. Average temperatures vary between (7 – 17.6) °C. The average value of precipitation is 1,430 mm/year [18].

![Fig. 1. Geographical location](image)

The high scale of urbanization and the related activities is accompanied by worsening further the air quality. Each sector (household, transport, industry, etc.) represents its effect on the air pollution.

B. Key Assumptions

1) Population

It is foreseen a slight decrease of the Albanian population in the long-term. Table I shows yearly values of the rates regarding the population change. These values are utilized for modelling the Business-As-Usual scenario [20].
2) Economy

Gross Domestic Product is considered highly proportional to the required energy for each country. During the time period from 2008 till 2035 is foreseen an increase of around 3.2%/year. Generally, developing countries fall in the maximum value of economic expansion [21].

Table II shows the forecast for Gross Domestic Product changes in Albania. The increase of employed values in this work is very conservative. Anyway, projections for higher rates of growth are available in different reports, like 4%/year during 2015 [22], [23].

| TABLE I: FORECAST REGARDING ALBANIA | Annually rates, % |
|-------------------------------------|-------------------|
| 2015-2020                           | 0.22              |
| 2020-2025                           | 0.07              |
| 2025-2030                           | -0.26             |
| 2030-2035                           | -0.26             |
| 2040-2045                           | -0.56             |
| 2045-2050                           | -0.56             |

The country showed a continue increase of its Gross Domestic Product. This was due to the foreign investments and exports (chrome, electricity, etc.). Also, the additional power capacities installed through hydro power plants and photovoltaic systems represented their positive effects in economy [24].

3) Climate

Different models are available to forecast the climate characteristics globally, or for specific world regions [25]. Lindner et al. forecasted the climate change impact in the Mediterranean area till the year 2100. For this region an average growth of 3 to 4 °C for the yearly average temperature is foreseen. Whereas, the annual rainfall will drop by 20% [26].

Giannakopoulos et al. foresee that till the year 2060, an increase of 2°C will occur in the Mediterranean area. The Albanian territory is forecasted to have 10% less yearly precipitation. This will be accompanied with an extended dry season, which is foreseen to be 30-days more. For that reason, space cooling will require more energy to be achieved [27].

Because of the country topography and location, substantial variation of its climate is foreseen. It is interesting to highlight that the synergy of decreased precipitation and increased temperature will be accompanied with drier and hotter summers [28].

Albania is characterized by an extensive variation of the annual rainfall. The minimum value of 910 mm/year is noticed in the eastern part, whereas the maximum one in the northern part with 2260 mm/year. The mean annual rainfall referring to the country area is around 1634 mm/year. Around 66% of the overall rainfall is identified in the period between October till March. In the last years, it is identified a very slight decline of the annual rainfall in Albania [28]. Till 2080 is foreseen that the annual rainfall will be reduced by 25%, 21%, 24% and 20%, respectively in the regions of northern, central, southern and western part of the country [29].

4) The Required Energy

Each branch of a country economy represents its demand for energy. The share for each branch depends mainly from the structure of the economy and its degree of development. It exists also a very strong relation between the required energy and the economy expansion. According to the National Energy Efficiency Action Plan, the final energy consumption was 1841 KTOE. The share for the household branch was 23%, which is considered the second energy consumer after the transportation one [30].

In 21st century, a stable balance between the supplied and the required energy is noticed. The energy use in the Household branch depends mainly on several applications related to space cooling and heating, food preparation, heated water preparation and storage, lighting and other home equipment which use electricity. For this reason, it is crucial to have a clear panorama regarding the existing patterns of the consumption of energy sources in these applications. This will serve as the initial step to define the appropriate measures with the primary objective to save energy in the household branch.

It is noticed that around 83.7 % of biomass is consumed to cover the required energy in this branch. Whereas, the oil covers only 3.8 % [30]. Regarding the electricity consumption, the Household branch is leading by 48 % of the total in 2019 [31].

Revenues represent their strong impact on the required energy in the household branch. Leaning on a performed analysis it was concluded that 11.6 % of the total energy demand in the household branch is consumed for heating purposes. This amount corresponds to around 10.4 % of the household revenues [32].

Business-As-Usual scenario does not include any policies or measures related to energy reduction in the considered branch. Taking into consideration this scenario structure, an annual growth of 3 % for the required energy is forecasted. This growth will follow the GDP tendency and is strongly related to its variation.

C. Software Model

LEAP software is utilized to perform the modelling phase for this case. It is employed to forecast the required energy and the GHG emissions from the Albanian household branch in the future. Referring to the energy demand side, the tool is considered a bottom-up model. It has the ability to perform long term forecast, which are necessary to build different scenarios [33].

The LEAP model is a tool that allows energy analysts to develop and compare different long-term energy and environmental scenarios. This comparison will be very important for policymakers to identify policies accompanied with the best results regarding the improvement of the energy efficiency and the reduction of GHG emission from different sectors or the whole energy system.

The structure utilized in this work is shown at Fig. 2. It is applied to evolve the BAU scenario in the household branch.

| TABLE II: PROJECTIONS FOR THE GDP | 2011 | 2013 | 2017 | 2018 |
|----------------------------------|------|------|------|------|
| GDP, %/year                      | 2.0  | 1.7  | 3.821| 4.062|

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III. RESULTS AND DISCUSSIONS

The primary objective of this work is the prediction of required energy from the household branch in a developing country. Its secondary objective consists in estimating the potential emissions of GHG in the household branch, by referring to different fuels used within it. To obtain these objectives several phases are designed and implemented. In the first phase, a database is created. Data from reports and policies are inserted in the database. In the second one, the tree within the Low Emissions Analysis Platform is created. In this case, the bottom-up modelling is considered. The necessary data are inserted in the branches of the tree. This is performed in accordance with the data availability and the necessary requirements. This phase is very important and depends on available data. Also, it depends strongly on the targeted analysis. In the third one, the main results related to the Albanian household sector are shown. The simulation refers to the time period from 2000 to 2050.

In Fig. 3 the trend for the Albanian population is shown. For the BAU scenario a decrease of population after 2020 is foreseen. This is related to the immigration of population towards the other countries. The tendency shows quite a good congruence with United Nations predictions, also. In 2050, the population is foreseen to be 2.83 Million inhabitants. This variable is expected to show its effect in the energy demand during the coming years.

Fig. 4 also shows the tendency of averaged values of household income for each year during the considered time period of developed Business-As-Usual scenario. The tool uses existing data of this parameter and extrapolates new values for the coming years. Taking into consideration the characteristics of the scenario, it is accepted that household income and GDP per capita have a similar change rate. In this scenario, a steep increase is notified. According to the Business-as-usual scenario it is foreseen that the average annual household income for the year 2050 will be 9668 €/year.

At Fig. 5 is displayed the tendency of yearly mean temperature obtained from Business-As-Usual scenario. It is noticed that this variable undergoes a slight and continuous rise each year. According to the scenario, the annual mean temperature increases slightly till 2025. The increase is 0.95°C greater than 2010. After the year 2025, the increase is slightly higher achieving an increase of 2°C at 2050. The annual mean temperature in the year 2030, 2040, and 2050 is foreseen to be 17.36 °C, 17.78 °C, and 18.2 °C, respectively.

The long term forecast of required energy for Albanian household branch is shown at Fig. 6. In the case of Business-As-Usual scenario, a steady rise is forecasted beyond the year 2010.
Fig. 6. Forecast for the required energy in the household branch

From the graph, it is observed that required energy increases with the same tendency as that of GDP per capita. This is related to the assumption that the required energy keeps a similar change rate as the GDP per capita. In 2010, the total energy demand in the household sector was 0.489 MTOE/year. From the model results that this quantity will be 0.601 MTOE/year (2020), 0.790 MTOE/year (2030), 1.069 MTOE/year (2040), and 1.449 MTOE/year (2050).

Fig. 6 shows also the fuel share for the household branch. The fuel share is very important to determine the GHG emissions from this sector. It provides a clear view for the forthcoming years and an important tool to build inherited scenarios related to household branch. It is observed that the biggest share of required energy for this branch will be covered from electricity, followed by biomass, oil, solar thermal, heat, and coal. In the year 2050, the electricity will provide 45.42% of the energy demand. Whereas, the biomass and the oil nearly 36.73% and 17.25% of it, respectively. The remains will be covered by the other sources.

In Fig. 7, it is shown a long term forecast related to GHG emissions originated from the household sector for the Business-As-Usual scenario. It is observed that emissions of GHG follow a continuous rise. This occurrence is highly dependent on the change of GDP and income. From its graph, it is noticed that GHG emissions in 2020 are 1.389 Mt CO$_2$ eq/year. Other values for this variable referring to a decade time period are forecasted to be respectively 1.826 Mt CO$_2$ eq/year in 2030, 2.473 Mt CO$_2$ eq/year in 2040, and 3.348 Mt CO$_2$ eq/year in 2050.

Fig. 7. Forecast for GHG emissions from the household branch

Quantities of GHG emissions released from the utilization of each fuel source in the household branch are shown at Fig. 7, also. In 2050, the GHG emissions from biomass will constitute around 76.9% of the total. The rest is originated from oil products by 22.77%, and from coal by 0.33%.

The graph clearly identifies the contribution of biomass in the emission of GHG from the household branch. Till 2050, its share will keep higher values compared to oil products and coal.

IV. CONCLUSIONS

In this paper, the Business-as-usual scenario for the household sector of Albania is developed. With the aim to develop it, a vast quantity of necessary data is utilized. The data start from the year 2000. The ability of the LEAP model to perform long-term analysis made it possible to have annual forecasted results along a time period of 50-years.

Leaning on the obtained results, it was noticed that:

a) The GDP will be a key parameter in defining the required energy from the household branch. The forecast for 2050 indicates that it will be 21.52 Billion €/year. Whereas, the average annual household income will be 9668 €/year.

b) The prediction related to the required energy from Albanian household branch shows an upward trend. Considering the 2010 as a reference year, it results that this variable in 2050 is foreseen to be 2.96-times higher.

c) The fuel share in the household sector will be dominated from electricity. In the year 2050, the energy demand in this sector will be provided from electricity 45.42%, from biomass 36.73%, and from oil products 17.25%.

d) The GHG emissions generated from the household sector will increase each year. This is strongly related to the variation of the total energy demand from this sector. GHG emissions in the 2050 is foreseen to be around 3.348 Mt CO$_2$ eq/year.

e) The fuel contribution in GHG emissions for the household sector will be highly dominated from biomass by 76.89% of the total (2050).

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