Assessing climate change impacts of Greek energy mix based on LCA

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Climate change represents a critical research issue due to a series of impacts that both the physical and man-made environment experience during the last years. Extremes weather events, changes in biodiversity, desertification of the most vulnerable regions and relevant socio-economic effects are among the main consequences of such a phenomenon. Greenhouse Gas (GHG) emissions are among the basic factors causing and intensifying climate change and thus currently implemented practices and future policies place emphasis on their reduction.

The energy sector has a strong relation with climate as it affects climatic conditions and atmosphere quality, mainly through the emissions produced during energy generation processes and energy consumption. According to the International Energy Agency, in 2018 the global energy-related CO_2 emissions increased by 1.7% and reached a historic high of 33.1 Gt CO_2 (https://www.iea.org/geco/emissions/). Energy production is still dependent on fossil fuels in many countries despite the fact that the use of Renewable Energy Sources (RES) is constantly increased. The transportation sector has also an important share in the total GHG emissions released to the atmosphere while other sectors contributing to emissions are agriculture, industry, households, etc. The European Union has already published the new legislative framework setting the new energy target goals for the year 2030. The goals refer to (European Commission – Energy): a) the reduction of GHG emissions by 40% compared to 2005 levels, b) at least 27% share of renewable energy consumption, c) the improvement of energy efficiency at EU level with an indicative target of at least 27% (compared to projections) and d) the completion of the internal energy market by achieving the existing electricity interconnection target of 10% by 2020, with a view to reaching 15% by 2030. It should be also mentioned the close interconnection of energy sector with water resources, land uses and food production. When talking about hydropower plants, water is needed for energy production; land uses such as agriculture exploit energy, something that entails the consumption of energy for agri-food production (cultivation of edible crops). The sectors of energy, water, land, climate and food can be considered as a ‘nexus’ where each sector interacts with the rest. In this context, feedbacks and unanticipated consequences are created while impacts on one sector entail impacts of varying degrees to the others (Papadopoulou et al., 2017; Sušnik et al., 2018).

Life Cycle Assessment (LCA) is a popular environmental impacts assessment methodology having been applied among others in renewable energy technologies (Pehnt, 2006), renewable energy for electricity generation (Varun et al., 2009), energy analysis for the building sector (Cabeza et al., 2014), etc. This paper focuses on the assessment of climate change impacts derived from the energy sector in Greece. Towards this end, a LCA was conducted with the support of the SimaPro software. The SimaPro software allows for the LCA of a product or service, from its production to the assessment of its environmental impacts. LCA was adopted in order to assess environmental impacts associated to all stages of the energy sector life cycle. Both fossil and renewable energy sources were explored; processes for generating electricity were analysed; sectors consuming electricity were delineated, and; GHG emissions derived from such sectors were investigated.

The energy sources used for electricity generation in Greece were firstly defined including fossil fuels (coal, oil, natural gas) and RES (biomass, solar, wind, hydropower). Then the several sectors, demanding electricity generated from the aforementioned energy sources, were determined with the support of the E3ME econometric model (Pollitt et al., 2007) and relevant data provided from the Ministry of Environment and Energy for the year 2016. Fifteen sectors were totally determined such as power own use and transformation, paper and pulp, agriculture forestry, iron and steel, non-ferrous metals, non-metallic items, chemicals, other constructions, other industry, food-drink-tobacco, households, rail transportation, road transportation, air transportation, other transportation services. It should be mentioned that for each sector the corresponding values per energy source used for the production of electricity needed were estimated. The next step concerned the distribution of emissions per sector, per energy source and per GHG. According to the available data, seven types of GHGs (carbon dioxide, methane, nitrous oxide, nitrogen oxide, carbon monoxide, non-methane volatile organic compounds and sulphur dioxide) were matched to each of the fifteen sectors along with the respective energy source. At a second level the fifteen sectors, consuming electricity produced from the respective energy sources, were inserted into LCA analysis. Energy sources covering the electricity needs of each sector were also determined as well as the energy demands and the respective GHGs released in the atmosphere. After the definition of input data, the ‘ReCipe 2016 Endpoint (I)’ method for the assessment of environmental impacts was applied. This method takes into consideration three main impact categories: human health, ecosystem quality and changes in the resources. According to the preliminary results, the sectors exerting the higher environmental impacts due to their emissions are: the road transportation, agriculture forestry, chemicals and food-drink-tobacco (Figure 1). Such emissions affect: human health (65%), terrestrial ecosystems (25%) and terrestrial acidification (10%).

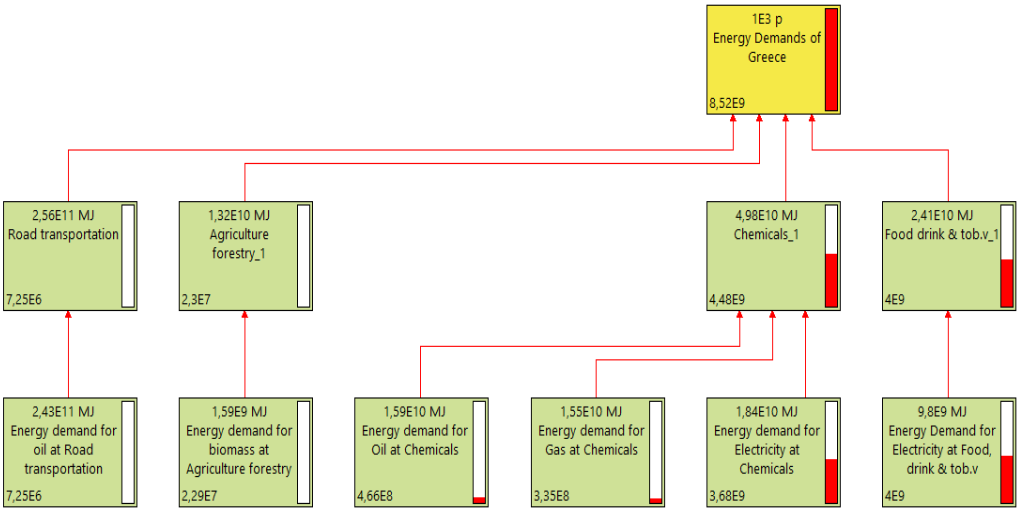

Figure 1: Energy sectors with the higher environmental impacts

Conclusively, the LCA for the energy sector allowed for a detailed analysis of the Greek energy mix and GHG emissions through: the decomposition of the energy system into sub-models; the exploration of the energy needs in Greece and their translation into quantitative terms; the quantitative analysis of the respective GHG emissions per sector and energy source; the assessment of the current environmental impacts on human health and ecosystems; the analysis of future trends, and; the investigation of possible future energy demands.

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