THE POSSIBILITIES AND CHALLENGES FOR APPLICATION OF LIFE CYCLE ASSESSMENT FOR SUPPORT SUSTAINABLE TRANSPORT

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Abstract

Sustainable transport system refers to desirable combinations of government policies, infrastructure and technologies which minimise environmental impacts and refers to economic and social issues. The aim of this paper was to study the possibilities and challenges for application environmental life cycle assessment (LCA) methods for support sustainable transport. LCA is the most holistic approach of assessing environmental impact and selecting eco-innovation in transport sector. The role of LCA in the development of green transport taking into account challenges related to transport policy, the European Commission's 2050 strategy as well as the circular economy was presented. In European Union countries government actions are aimed at increasing the use of alternative fuels and supporting the development of electromobility. Transport sector needs new and appropriate tools like LCA that will support decision making regarding the development of mobility with alternative and future fuels, technologies and materials etc. in whole vehicle's life cycle.

Keyword: Sustainability, life cycle assessment, transport, environmental impacts

1. INTRODUCTION

Sustainable transport refers to combination of environmental, economic and social issue in all aspects relating to the automotive industry. Life cycle assessment (LCA) is appropriate tool for development of green transport taking into account life cycle approach, transport policy challenges, the European Commission's 2050 strategy and the circular economy guidelines [1-5]. In European Union countries government actions are aimed at increasing the use of alternative fuels and supporting the development of electromobility [6-8]. LCA support decision making regarding whole vehicle's life cycle. LCA is the most holistic approach of assessing environmental impact and selecting eco-innovation in transport sector. Up till now LCA was used primarily for the assessment of greenhouse gases and cumulative energy consumption, especially for alternative fuels [8]. Developing methods taking into account the life cycle approach are becoming increasingly important in the new circular economy.

The aim of this paper was to study the possibilities and challenges for application environmental life cycle assessment (LCA) method for support sustainable transport.

2. ENVIRONMENTAL ASSESSMENT METHODS FOR TRANSPORT SYSTEM - A REVIEW

Life cycle approach of transport system includes holistic and very complex analytic system. Life cycle approach consists of many activity and stages for example: vehicle life cycle, fuel life cycle, maintenance of road, end-of life etc. The most famous environmental assessment methods with life cycle approach in transport are Well-to-Wheel (WTW) and Life-cycle-assessment (LCA). WTW focuses on energy consumptions in transport fuels cycle and greenhouse gas emissions (GHG) from transport fuels. An WTW study on automotive fuels has been developed by collaboration between European Council for Automotive Research and Development (EUCAR), Environmental Science for European Refining (CONCAWE) and Joint Research Centre of the European Commission (JRC). According to WTW environmental assessment takes into account the phases connected with extraction of raw materials, refining and distribution of fuels and fuel exploitation (**Figure 1**)

[7,8]. Fuel life cycle covers two phases: Well to Tank (WTT) and Tank to Wheel (TTW). The WTW method can be understood as a simplified LCA.

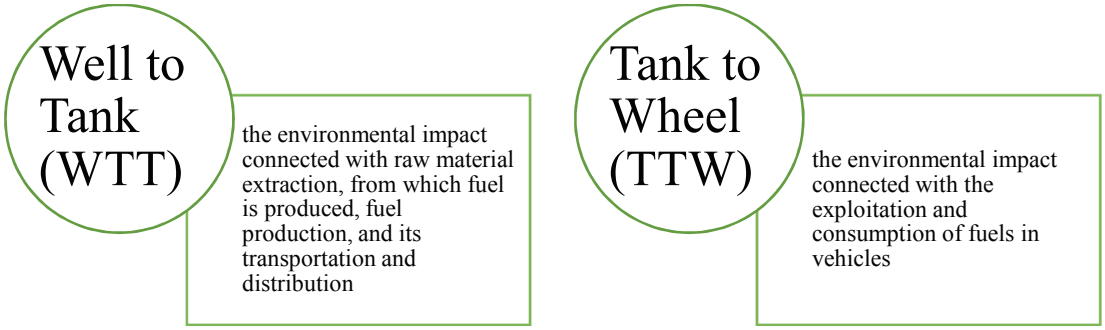

Figure 1 Phases of Well to Wheel

Life cycle assessment (LCA) is a tool, which is used for environmental aspects assessment of product and service or process by identifying relating flows and quantifying potential impact on the environment in the whole life cycle, i.e. from the acquisition of raw materials through the period of exploitation and finally the disposal. LCA is the subject of international standards ISO 14040:2006 and ISO 14044:2006 [5]. According to the International Organization for Standardization (ISO) standards LCA consists of four phases, which are shown in **Figure 2**.

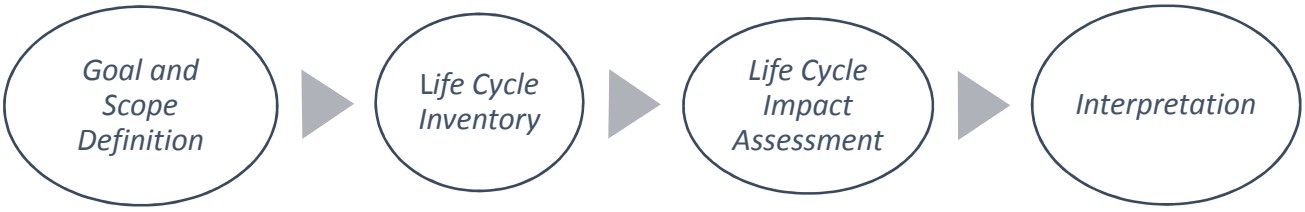

Figure 2 The phases of LCA

LCA provides a broader approach to environmental analysis than WTW. LCA takes into account environmental impact in the whole vehicle life cycle, from the production stage, vehicle manufacturing process, the stage of exploitation to the end of life cycle of vehicle with waste management. LCA enables assessment of greenhouse gas emissions and other environmental impacts like depletion of abiotic resources, fossil fuels demand, minerals and metals demand, ecotoxicity, eutrophication, cumulative energy demand, human health ecosystem quality etc. The scope of LCA analyses during the vehicle life cycle is shown in **Figure 3**.

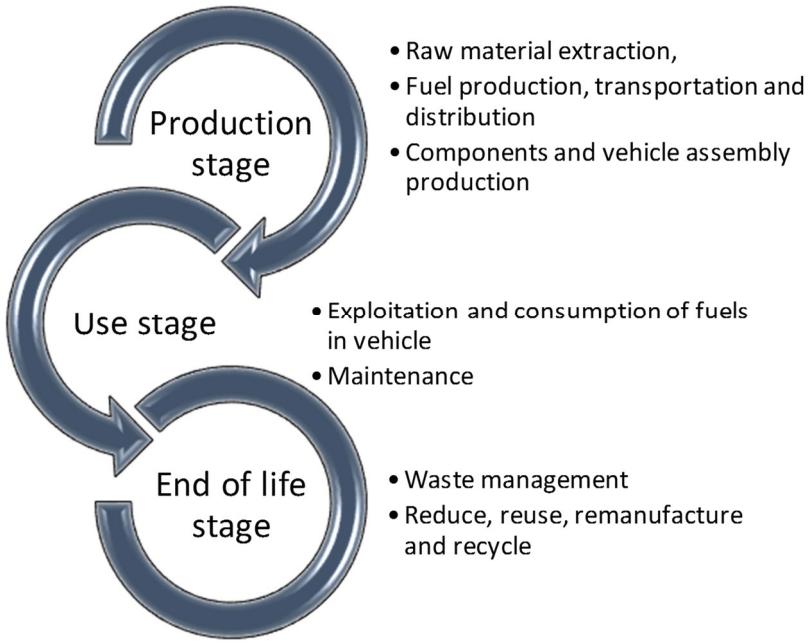

Figure 3 Life cycle stages of vehicle

3. APPLICATION OF LCA FOR SUPPORT SUSTAINABLE TRANSPORT

The European Union (EU) has implemented mandatory sustainability criteria for biofuels for transport in the Renewable Energy Directive (RED). These focus on greenhouse gas (GHG) emissions and biodiversity related demands [9, 10]. In the paper [11] sustainability criteria for renewable energy used in transportation were shown. It was concluded that hydrogen and synthetic fuels can play an important role in the decarbonisation of the transport sector, but their production is highly energy intensive and involves significant energy losses. Therefore, the direct use of electricity is always preferable. Most importantly, a significant reduction of CO_2 emissions compared to the use of fossil fuels is only achieved if the fuel production is based exclusively on additional renewable sources [11]. Electromobility shall be considered to contribute to sustainable transport mobility. Electric vehicles (EVs) are the future of road transport and offer potential for reducing pollution. EVs have become an important element in the development strategies of the automotive industry. LCA is appropriate tool for comparative analysis of EVs considering the life cycle from cradle to grave with the current and future energy systems used to charge EV batteries [7].

The methodology for sustainability performance assessing of production and use of transportation fuels with Life Cycle Sustainability Assessment (LCSA) was presented by [10]. LSCA constitutes of the integration of results from social life cycle assessment (SLCA), environmental life cycle assessment (LCA) and life cycle costing (LCC). To integrate the results from the three different assessments into an LCSA was applied Multi Criteria Decision Analysis (MCDA) methodology. Life Cycle Sustainability Assessment (LCSA) is a methodology which can be used to assess broad sustainability impacts, including environmental, social and economic aspects. According to paper [12] LCSA can be a combination of the three life cycle approaches for environmental, social and costing perspectives. Recent overviews of the LCSA methodology concept was presented in the papers [13-16].

It was reviewed organizations that perform LCA analyses. The examples of LCA application for support sustainable transport by international organizations are shown in **Table 1**.

Table 1 LCA application for support sustainable transport by international organizations

Type of analysis	Organisations	References
Well-to-wheels study	European Council for Automotive Research and Development (EUCAR) Environmental Science for European Refining (CONCAWE) Joint Research Centre of the European Commission (JRC) EUCAR/JRC/CONCAWE collaboration	https://iet.jrc.ec.europa.eu
Life cycle assessment of electric vehicles	The European Association for Electromobility	https://www.avere.org
Environmental impact of automobiles	WorldAutoSteel	https://www.worldautosteel.org
Greenhouse gas emission of automotive materials	World Steel Association	https://www.worldsteel.org
LCA of advanced materials in automotive design	The Automotive Applications Council (AAC)	https://www.autosteel.org
Tyre LCA	The European Tyre and Rubber Manufacturers' Association ("ETRMA")	http://www.etrma.org
LCA of batteries for vehicles	Association of European Automotive and Industrial Battery Manufacturers (EUROBAT) European Automobile Manufacturers Association (ACEA) Japan Automobile Manufacturers Association (JAMA) Korea Automobile Manufacturers Association (KAMA) International Lead Association (ILA)	https://www.acea.be

Possibilities and challenges for LCA application for support sustainable transport are shown in **Figure 4** and **Figure 5**, respectively. Depending on the making decisions, LCA allows to evaluate the direct and indirect impacts of transport system. LCA is efficient tool for decision making for support sustainable transport.

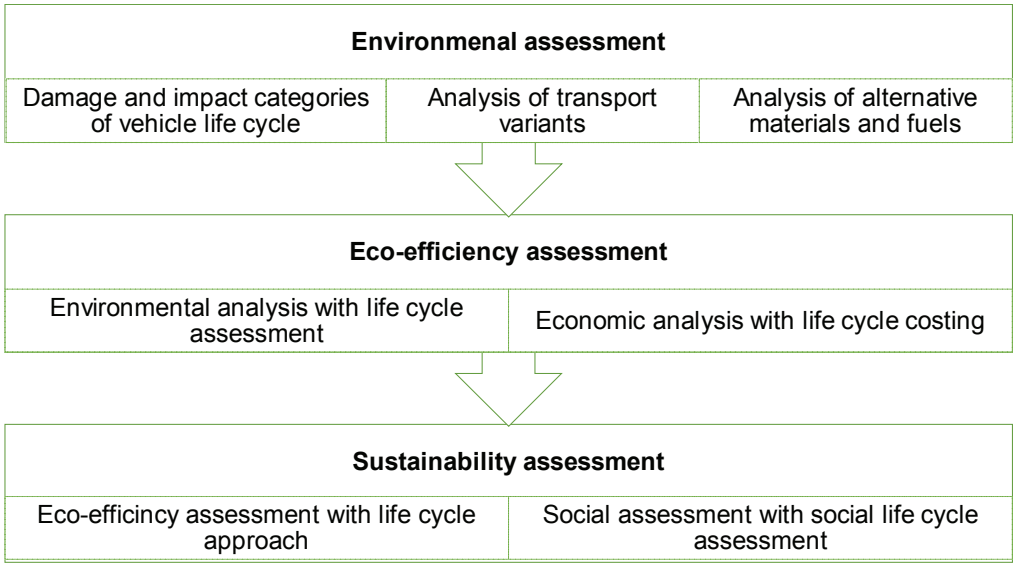

Figure 4 Possibilities for LCA application for support sustainable transport

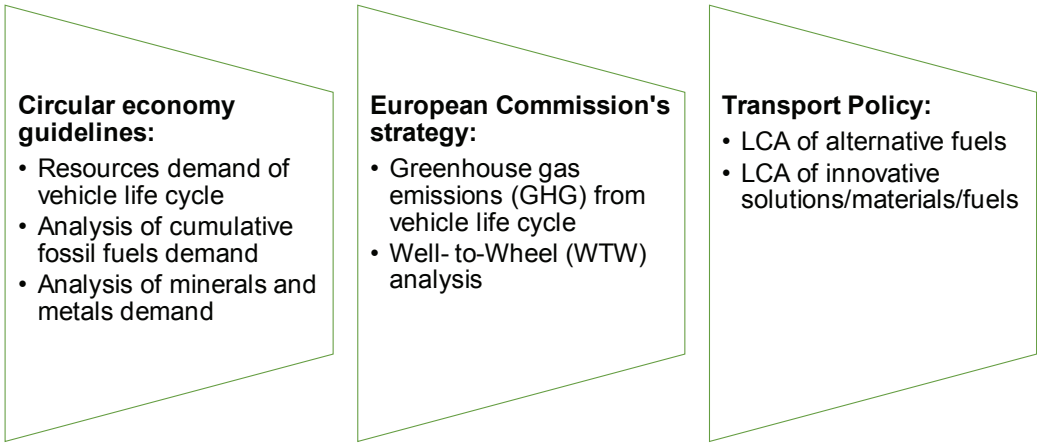

Figure 5 Challenges for LCA application for support sustainable transport

The challenges for the LCA application are primarily related to European Union strategy, including European Strategy for low-emission mobility, relevant directives, circular economy guidelines as well as national regulations. Due to the fact that transport represents almost a quarter of greenhouse gas (GHG) emissions in Europe and is the main cause of air pollution in cities, The European Union has set main targets for reducing its GHG emissions progressively up to 2050. In Poland the new Act on Electromobility and Alternative Fuels is introduced. On the 5th of February 2018, the President of the Republic of Poland signed the Act on Electromobility and Alternative Fuels. The Act on Electromobility and Alternative Fuels is the first set of rules in Poland that pertain to the issue of electromobility and is intended to promote electromobility and alternative fuel vehicles. The Act transposes Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure. The introduction of the Act forces the analysis including LCA for alternative fuels, especially for electric vehicles, taking into account national conditions.

Implementation of the Circular Economy Action Plan is associated with a reduction in the use of fossil fuel resources, minerals and metals. Therefore, comparative assessments of the use of alternative raw materials, fuels, waste or new technologies should be made to select the most ecological ones. The use of LCA allows such evaluation of environmental aspects with life cycle approach.

4. CONCLUSIONS

Life cycle assessment (LCA) and Well to Wheel (WTW) can be used to support decision-making on environmental aspects of transport, particularly with regard to vehicle life cycle management. LCA method focuses on many impact and damage categories during the stages related to the life cycle of vehicles and takes into account guidelines regarding circular economy. The WTW analysis is a simplified LCA analysis.

It was concluded that the methods for sustainability assessment taking into account the life cycle approach (LCA, LCC, SLCA and LCSA) are suitable tools and should be developed in the transport sector. These methods are used to support decision-making on the three aspects of sustainable transport.

Based on analysis performed was the statement that the proposed methods are appropriate and useful tools that could be used for decision support for sustainability assessment of transport with life cycle approach. However, further research is needed to develop these methods.

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