CONCEPTUAL FUNDUMENTALS OF ALTERNATIVE MOTOR FUELS IMPLEMENTATION: MODERN CHALLENGES, PROBLEMS AND PERSPECTIVES

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Introduction

One of the features of the modern world is the increased attention of the international community to the problems of rationality and efficient use of energy resources, the introduction of energy saving technologies and searching of renewable energy.

The main environmental damage associated with global climate change of the Earth – greenhouse effect, caused mainly from mining, processing and burning of fossil fuels – coal, oil and gas. The greenhouse effect is up to 75% share of the anthropogenic environmental damage. In this regard, the satisfaction of growing needs of the world's population in fuel, electricity and heat simultaneously with the environmental safety necessitates the development of renewable energy, because oil – not single raw material for getting of high–efficient organic fuels for engine.

Transportation and environment

At the modern stage of development the use of energy accounts for a major fraction of all anthropogenic emissions of greenhouse gases (GHGs), and in most industrialized countries transportation fuel use produces a major fraction of all energy-related emissions.

Globally, transportation contributes approximately 14 % of GHG emissions (fig. 1). GHG emissions from this sector primarily involve fossil fuels burned for road, rail, air, and marine transportation. Almost all (95 %) of the world's transportation energy comes from petroleum-based fuels, largely gasoline and diesel.

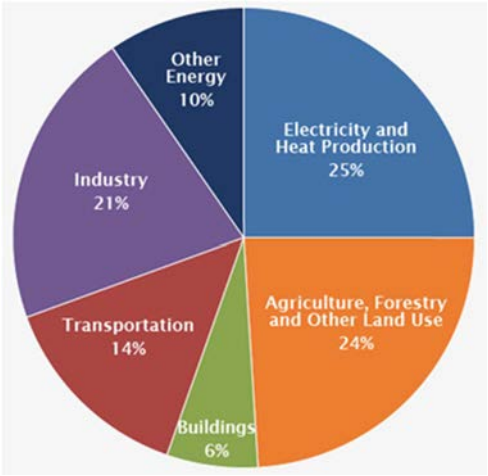

Fig. 1. Global GHG emissions by economic sector

Transport emissions are expected to increase rapidly over the next few decades. The *IEA* projects that energy use and CO_2 emissions in developed countries will rise by approximately 50 % between 2000 and 2030. Emissions in developing countries are expected to rise even faster, in some cases more than doubling between 2000 and 2020.

The largest sources of GHGs emissions in transportation sector include passenger cars and light-duty trucks, including sport utility vehicles, pickup trucks, and minivans. The remainder of GHGs emissions comes from other modes of transportation, including freight trucks, aircrafts, ships, boats, and trains, as well as pipelines. The particular share of aviation emissions is about 2 %. The activities of the transportation release several million tons of pollutants each year into the atmosphere: Pb, CO, CO_2, CH_4, NO_x, N_2O, CFCs, PFCs, SF_6, C_6H_6 and other VOC's, Zn, Cr, Co, Cd, PM (ash, dust).

Production and use of motor fuels

The vast majority of modern transport vehicles is powered by conventional motor fuels, which are predominantly derived from crude oil. Globally, the transport sector is responsible for around 28 % of energy consumption, and demand is still growing (fig. 2).

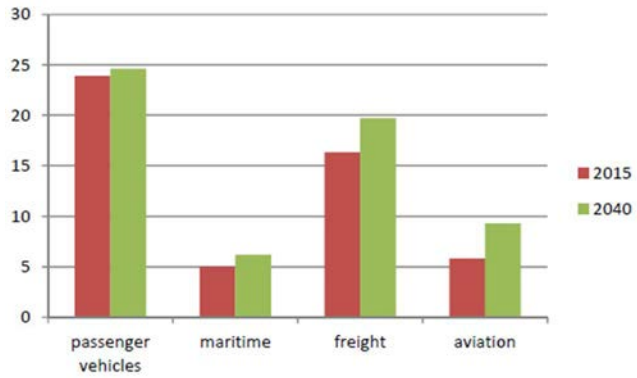

Fig. 2. The World Oil Demand for the Transport Sector (Source: IEA World Energy Outlook 2016), mb\day

The transport sector constitutes about 56% of global oil consumption, and it is heavily dependent on oil products (92%) (fig. 3). Alternatives to oil products are natural gas, biofuels, and electricity (Key World Energy Statistics 2016).

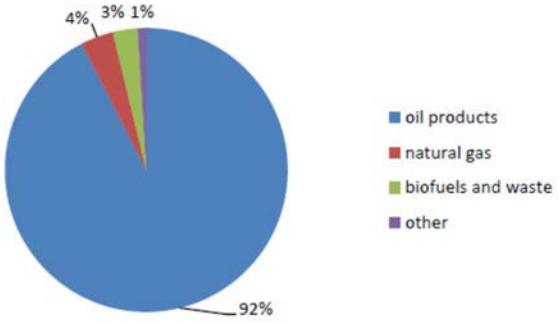

Fig. 3. Total Final Fuel Consumption in the Transport Sector (Source: IEA Key World Energy Statistics 2016)

Natural gas use in transport constitutes only 6.9% of total natural gas consumption. According to the IEA's *World Energy Outlook 2016*, natural gas use in transport is slowly growing. Two-thirds of the projected growth is occurring in road transport; most of the remainder is liquefied natural gas (LNG) for the shipping sector.

Production and use of biofuels in transport sector

Biofuels currently contribute around 3 % of energy used in transport globally. Biofuels production has more than tripled since 2005 and has reached 74 megatonnes of oil equivalent (Mtoe) in 2014 (fig. 4). An estimated three-fourths of this production is fuel ethanol, and most of the remainder is biodiesel produced by the esterification of fatty acids; hydrotreated fats and oils also contribute a minor but increasing share. Advanced biofuels production from lignocellulosic biomass is still under development, and volumes produced are estimated to constitute less than 1 % of total biofuel volumes. Most of the biofuels produced are consumed in low-level blends in conventional vehicles; alternative fuel vehicles, which need to use highlevel blends of biofuels or other sources of energy, have been adopted quite slowly.

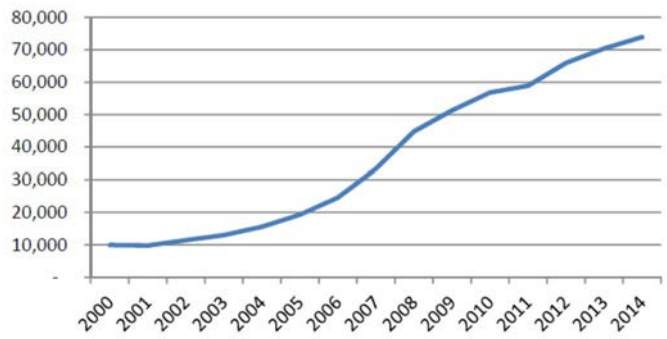

Fig. 4. World Biofuels Production in 2014 (ktoe) (Source: IEA Headline Energy Data

Production and use of aviation fuels

Modern civil aviation is developing constantly. The world volume of aircraft transportation increases on 4–5 % annually. As a result during last decade consumption of fuels for air-jet engines has increased on 21 %. As it is stated in about 5.5 thousand barrels of jet fuel is produced and consumed in the world daily. Today, according to the data presented by the World Airfleet, there are 2 thousand airlines around the world. The world amount of passenger air travels increases on 4 – 5% annually. Basing on IATA forecasts the world civil air fleet will reach 35 thousand units till 2025.

Increasing of air fleet and number of flights lead to growing of jet fuel use. Some scientists state that we use about 290 thousand ton of jet fuel daily. Thus, production of jet fuels is still one the leading branches in world oil processing.

Such situation promoted strengthening of ecological requirements to quality of jet fuels. Number of influential organizations took measures on prevention of aviation negative impact on environment.

The resolution of European Parliament about minimization of the consequences of aviation activity for climate change (INI/2005/2249) clearly states that: “European Parliament strongly demand the cooperation in implementation of jet biofuels, in such a way promoting minimization the consequences for climate changes”.

International Air Transport Organization has announced the task to reduce CO_2 emissions on 50 % by 2050. At the same time European Commission has adopted policy on the reduction of CO_2 emissions on 60 % by 2050. the share of low-carbon aviation fuels should reach 40 % by 2050.

Contrary to the ground transport sector, which can use electric energy, aviation has no near-term alternative to liquid hydrocarbon fuels (electric commercial aircraft are unlikely before 2040). Therefore, alternative aviation fuels are considered to be the main and leading energy solution to mitigate the emissions growth of the industry in the medium term

The special attention to the question of civil aviation “greening” is traditionally paid by ICAO (International Civil Aviation Organization). During the 38-th session of ICAO Assembly that was held in November 2013 there was a proposal on “… collecting information about development of alternative aviation fuels … and estimating the progress in reaching global tasks of the modern civil aviation”. In a result the AFTF (Alternative Fuel Task Force) Group was created. Its main task is review and analysis of alternative kinds of fuels, available feedstock, technologies and volumes of its production.

However during the 39-th session of ICAO Assembly that was held in 2016, the development, deployment and use of alternative motor fuels become officially recognized as a key measure for reducing climate changes resulting from air transport activity. States and governments were recommended to provide complete approval and support for activities intended for alternative fuels development and implementation.

The main principles of European Policy in sphere of alternative aviation fuels use are stated in the following documents:

- Directive 2009/28/EC of the European Parliament and Commission on 23.04.2009 about stimulation of energy from renewable sources use;
- Agreement of the European Commision on 08.02.2006 “ European Union Biofuel Strategy” that determines 7 strategic directions for development and production of biofuels by the member and associated states;
- Directive 2009/30/EC of the European Parliament and Commission on 23.04.2009 about technical requirements to gasoline, diesel and gas fuels and implementation of the mechanism for monitoring and reduction of greenhouse gases (Directive on Fuel Quality).

Today there is a great variety of technologies for alternative jet fuels production. The most well-developed among them are:

- Fuels derived from conventional oil;
- Fuels derived from unconventional oil feedstock (oil sands and oil-shales);
- Fuels derived synthetically from natural gas, coal, or biomass via the FT process;
- Fuels derived from renewable plant oils and animal fats (ethers of fatty acids and hydroprocessed renewable oils);
- Fuels derived from alcohols (ethanol and butanol);
- Fuels derived from micro- and macro-algae;
- Fuels derived from household waste and halophytes via pyrolisis.

Before the 2012 there was no practical experience in application of aviation biofuels in Ukraine. National aviation university was first who started researches intended for development of alternative jet fuels. Generalizing the world's experience in alternative jet fuels development we have concluded that the most optimal kind of aviation biofuels is biokerosene, which is derived from renewable oils. Feedstock for biocomponents production is oils, obtained from seeds of various agricultural oily plants: rape, sunflower, camellina, jatropha, canola, palm oil, etc. The main factor for feedstock selection is surely geographical and climatic conditions typical for country-producer and optimal for certain oily plant cultivation.

In general Ukraine among other countries have considerable resource potential for alternative jet fuels production from plant oils. Being one of the leading countries in Europe by volumes of rape and sunflower production Ukraine is still one of the top rapeseed exporters to EU. At the same time Ukrainian oil producers promote growing of new biofuel cultures, such as camellina, soy and some others. Today, Ukraine has all possibilities for alternative jet fuels manufacturing for satisfaction of its own needs and for export also.

Implementation of biofuels derived from plant feedstock surely has potential and perspective for its future development. Application of biofuels should be totally is the scope of sustainable development principles and doesn't do harm to food industry. In future application of alternative jet fuels will have the following positive results: availability of feedstock that is important for countries, which don't possess it own deposits of fossil fuels; saving of exhaustible energy resources; decreasing volumes and toxicity of aircraft exhaust gases, thus protecting air quality in lower atmosphere layers; comparative simplicity and low cost of biofuel production process; low price for biofuel comparing to traditional kerosene; stimulation of agricultural complex development in countries-producers of biofuels.

References

[1] Advanced Motor Fuels Annual Report, 2016, IEA, 150.

[2] Alternative aviation fuels: overview of challenges, opportunities, and next steps, 2017, 81.

[3] Fact Sheet, Alternative Fuels, 2017, IATA, www.iata.org/pressroom/facts_figures

[4] Overview of Alternative Jet Fuels in 2014, 2015, 7, www.icao.int/

[5] Alternative Jet Fuel Environmental Sustainability Overview, CAAFI Environmental Sustainability Overview, 2014, 27 p. http://www.caafi.org

[6] Iakovlieva A. and Boichenko S., 2012, Systems and means of motor transport, 3, 239.

[7] Kondili E. and Kaldellis J., 2007, Renewable and Sustainable Energy Reviews, 11, 2137.

[8] A. Yakovlieva, S.Boichenko, O. Vovk, K. Lejda, O. Gryshchenko, Advances in Sustainable Aviation. Springer International Publishing, 2018. 4.