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Joanna SĘK[1]

INNOVATIVE TECHNOLOGIES IN LOW-EMISSION TRANSPORT

Summary. This paper discusses the legal framework of electromobility in the European Union, including Directive 2014/94/EU. The main issues implementing this directive into Polish legislation were discussed (for example, Dz. U. z 2018 r., poz. 317). The Additional European Parliament recommendations included in the resolution of 25 October 2018 were also presented. The second part of the article contains information on electromobility in road transport, for example, the number of new vehicles registered in 2018 according to types of fuel. In addition, the main goals of the AFI directive for maritime and inland transport were presented, together with examples of innovative solutions that meet the major objectives of electromobility and sustainable development.

Keywords: European transport policy, low-emissions vehicles, alternative fuels, innovations

1. INTRODUCTION

In 2001, the European Commission issued the first document (White Paper) [22] addressing the issues of the EU transport policy. It pointed out the need to change the share of individual transport modes through, including support of maritime and inland waterway transport.

[1] Faculty of Maritime Technology and Transport, West Pomeranian University of Technology, Szczecin, Piastów Avenue 41, 71-065 Szczecin, Poland. Email: joanna.sek@zut.edu.pl

Five years later, the White Paper underwent a mid-term review, which added tasks related to countering traffic congestion [3, 12].

New strategic goals were included in the next edition of the White Paper issued by the European Commission in 2011, according to which by 2030, 30% of road freight transport over distances greater than 300 km should be transferred to other means of transport, for example, rail or water transport, and by 2050 it should be over 50% of this type of transport [23]. Moreover, a 40% reduction in gas emissions from international maritime transport (by 2050) was also recommended; it is similarly proposed that by 2050, 40% of fuels used in air transport should be low-emission. In addition, a 50% reduction in the number of conventional cars by 2030 was agreed upon for urban transport, and by 2050 for decommissioning.

In 2016, the European Commission published a communication [4] proposing means to accelerate decarbonisation in transport and achieve zero emissions in the EU, which is in line with the provisions of the Paris Climate Conference in 2015.

2. LEGISLATIVE SOLUTIONS REGARDING ALTERNATIVE FUELS IN THE EU

2.1. Directive 2014/94/UE

One of the most important activities at the European level aimed at intensifying the work on the implementation of alternative fuels in transport was the establishment of the Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure (directive AFI) [5]. The main goal of the directive was to define a uniform framework enabling the development of alternative fuels infrastructure networks, thereby making it possible to reduce the use of crude oil in transport, and thus reduce the negative impact of transport on the environment. The AFI Directive also defines alternative fuel definitions (Fig. 1), minimum requirements for the expansion of, for example, charging points for electric vehicles or refuelling points for natural gas LNG and CNG, that is, requirements for alternative fuels infrastructure and technical specifications for these points.

Importantly, the AIF Directive is not only limited to road transport but presupposes the future possibility of uninterrupted movement of seagoing and inland vessels or alternative fuel vehicles throughout the EU.

Due to the fact that the scope of work envisaged in the directive is very wide, it forces undertakings for various types of fuels. In the case of building the new infrastructure, it was assumed that the development would first concern urban agglomeration areas and basic areas belonging to the Trans-European Transport Network (TEN-T). The TEN-T guidelines also require that inland and seaports, airports and core network roads that are part of the TEN-T core network allow access to alternative fuels.

The AFI Directive assumed the obligation to transpose provisions into the law of the Member States by 18th November 2016, however, transposition into Polish provisions was established by the Act of 11th January 2018 on electromobility and alternative fuels (hereinafter referred to as the Act on electromobility) [1].

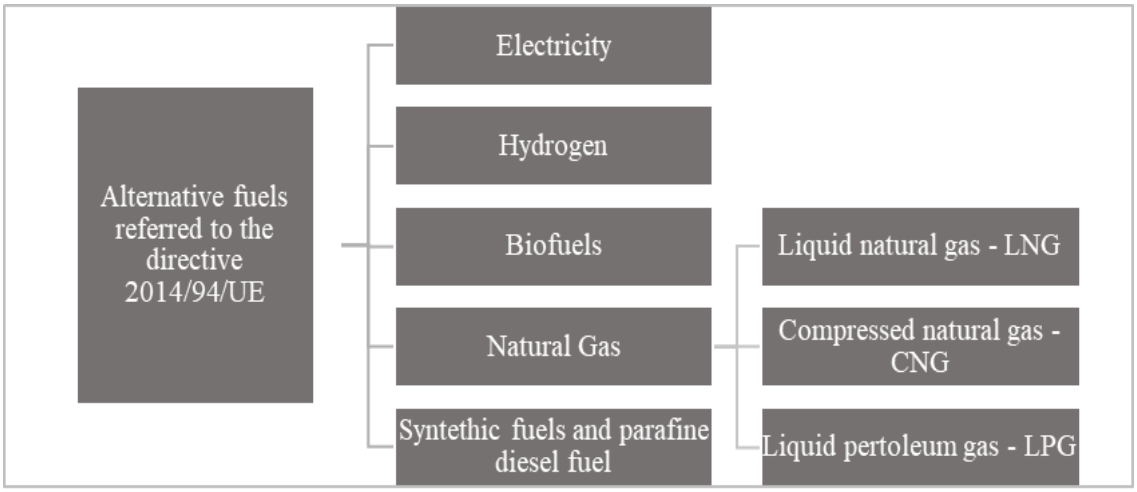

Fig. 1. Alternative fuels referred to directive 2014/94/UE [5]

2.2. Act of 11th January 2018 on electromobility and alternative fuels

The Act on electromobility specifies:

1) rules for the development and operation of infrastructure for the use of alternative fuels in transport, including technical requirements for the infrastructure;
2) obligations of public entities regarding the development of alternative fuels infrastructure;
3) information obligations in the field of alternative fuels;
4) conditions for the operation of clean transport zones;
5) national policy framework for the development of alternative fuels infrastructure and the manner of their implementation.

In accordance with art. 16, the Act on electromobility imposes on the President of Office of Technical Inspection (UDT) new obligations, including:

- issuing opinions on the compliance of technical documentation of the designed charging station with the requirements;
- conducting technical tests of charging stations and charging points, which are part of the charging infrastructure of public road transport in the field of safe operation, repair and modernisation. The tests are carried out [1]:
  - before putting the charging station into service or the charging infrastructure of public road transport;
  - each time in the event of repair or modernisation of such a station or infrastructure, including consisting in increasing the number of charging points, or changing the place of installing a charging point in this station or infrastructure;
- issuing decisions to suspend the operation of a charging point if it does not meet the technical requirements as a result of technical tests;
- UDT also maintains the Alternative Fuels Infrastructure Register (eipa.udt.gov.pl), which is a public register providing information on electric and natural gas vehicles to users, including the location of the natural gas station or charging station (Fig. 2).

Fig. 2. CNG/LNG loading and refuelling bases in Poland [21]

2.3. New initiatives for the directive 2014/94/EU

In November 2017, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – Towards the broadest use of alternative fuels - an Action Plan on Alternative Fuels Infrastructure under Article 10(6) of Directive 2014/94/EU, including the assessment of national policy frameworks under Article 10(2) of Directive 2014/94/EU was issued. In this communication, Parliament called for a more ambitious approach to energy from renewable sources in transport and for additional incentives to introduce sustainable alternative fuels for those modes of transport that currently have no alternative to conventional fuel.

Following this communication, in October 2018, the European Parliament adopted a resolution calling on the Commission to amend Directive 2014/94/EU on the development of alternative fuels infrastructure and to focus on its proper implementation [6]. The communication states that transport is the only major economic sector in the European Union in which greenhouse gas emissions have increased since 1990; whereas this sector is responsible for 23% of CO_2 emissions, and this percentage is still growing. Road transport is responsible for almost 75% of all energy used in transport and is the source of almost 73% of greenhouse gas emissions in this sector. There is also a steady increase in traffic related to the increase in movement and volume of goods transported in the EU, as well as increased mobility of people, which, as projected for 2030, will have an impact on climate change, air quality and energy consumption as well as infrastructure. Reducing the emissions of road transport using sustainable alternative fuels requires a flexible approach, which means that different alternative fuels may be needed in different segments of the car market [6].

In addition, shipping is related to 80% of global trade volume and advocates for 3% of global greenhouse gas emissions, contributing to air pollution near coastal areas and ports. Faced with the significant contribution of shipping to the global transport market, the gradual acceptance of alternative fuels in shipping will have a significant positive environmental impact.

In point 8 of the resolution, the importance of sustainable urban planning, shifting from private use to shared and public use of transport and calling on the Commission and the Member States to particularly turn their attention to the deployment of alternative fuels infrastructure for collective and public transport services, such as buses, trams, trains, shared cars, taxis and minivans, as well as for bicycles, scooters and motorcycles was underlined [8, 10, 17, 18]. Furthermore, the deployment of alternative fuels infrastructure in urban and suburban areas, (with priority to those where air quality is poor) was also encouraged [16].

3. ELECTROMOBILITY IN DIFFERENT MODES OF TRANSPORT

3.1. Electromobility in road transport

In road transport, according to the Directive 2014/94/EU or Polish Act of electromobility, it is important to specify the different types of vehicles, especially electric and hybrid vehicles:

- electric vehicle means a motor vehicle equipped with a powertrain containing at least one non-peripheral electric machine as an energy converter with an electric rechargeable energy storage system, which can be recharged externally [5];
- hybrid vehicle - a motor vehicle within the meaning of art. 2 point 33 of the Act of 20 June 1997 - Road Traffic Law, with a diesel-electric drive, in which electricity is accumulated by connecting to an external power source [1].

It is worth noting that hybrid vehicles, even though they use electricity to drive, does not belong to the group of electric vehicles.

In 2019, the European Automobile Manufacturers' Association (ACEA) published a report which contains a variety range of information/statistics about alternative fuel vehicles, for example, car market by fuel type (Tab. 1 and Fig. 3), the average CO_2 emissions of new cars and infrastructure availability.

Tab. 1

Registrations of new cars in the EU28, by fuel type in 2014-2018 [in units] [20]

	2014	2015	2016	2017	2018
Petrol	5,358,452	6,036,564	6,800,116	7,563,104	8,532,104
Diesel	6,599,462	7,039,611	7,175,630	6,617,051	5,406,574
Electrically-chargeable	69,958	148,027	155,634	218,083	301,581
- Battery electric	37,517	59,165	63,479	97,667	149,737
- Plug-in hybrids	32,441	88,862	92,155	120,416	151,844
Hybrid electric	176,525	218,755	278,729	426,769	578,620
Fuel cell	38	176	123	253	266
Natural gas (CNG)	97,214	78,511	57,609	49,553	65,092
Other (LPG + E85)	141,452	140,321	118,430	156,710	164,310

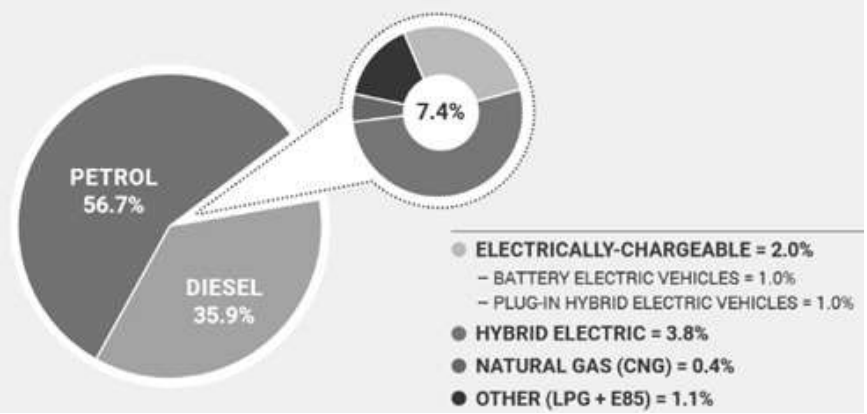

Fig. 3. Market share of new cars in the EU, by fuel type in 2018 [20]

The ACEA report, Tab. 1 and Fig. 3 present that [20]:

- 2.0% of all cars sold in 2018 were electrically-chargeable (+1.4 % since 2014);
- 3.8% of new passenger cars in the EU last year were hybrid electric (+2.4 % over the last five years);
- 0.4% of all cars sold in 2018 were natural gas-powered (-0.4 % since 2014);
- fuel cell vehicles currently account for a negligible share of total EU car sales.

The presented statistics show that the use of alternative fuel cars is still not acceptable. The availability of alternative fuel vehicles is quite limited in comparison to conventional fuel vehicles, for example, in 2017 only 19 battery models of electric cars and 25 models of plug-in hybrid vehicles were available for sale in Europe in contrast to more than 417 models of vehicles with combustion engines [20].

European Parliament and the Council show their recommendations about charging electric vehicles. When charging electric vehicles at charging points, it should be proper (if it is rational from a technical and financial point of view) to use intelligent measuring systems to contribute to the stability of power systems in such a way that the batteries be charged from the network during hours with low overall demand for electricity, and to enable secure and flexible data transfer. The use of intelligent metering systems optimises charging for the benefit of the power system and consumers.

The Polish law in the field of public transport services demands the share of zero-emission buses to be at least 30% of their fleet in the local government unit (excluding communes and countries) whose population does not exceed 50,000.

3.2. Electromobility in maritime and inland waterway transport

In inland waterway transport, the main role in the field of alternative fuel play (based on the AFI directive), the Central Commission for Navigation on the Rhine and the Danube Commission as experts. The AFI directive recommends cooperation between both Commissions and the European Commission for the development of alternative fuels infrastructure.

An additional deadline has been set by the directive AFI for maritime and inland ports for the construction of a coherent network of LNG refuelling points in the Member States, the cut-off date is 31 December 2025 (for maritime ports) and 31 December 2030 (for inland ports).

LNG refuelling points include LNG terminals, tanks, mobile containers, bunkers and inland barges. All decisions on the locations of the LNG refuelling points at ports would be based on a cost-benefit analysis including an examination of the environmental benefits.

LNG, CNG or electricity are not the whole types of alternative fuels. Another one is biofuel [15], which was connected with inland waterway vessels for the first time in March 2019. The first inland vessel that runs fully on 100% sustainable biofuel is called For-Ever. It is an inland barge dedicated to transporting Heineken export beer from a brewery in Zoeterwoude to the deep-sea terminals in the Port of Rotterdam [19].

A consortium of companies; GoodFuels, Reinplus Fiwado Bunker (biofuel supplier) and Combined Cargo Terminals (CCT) informed that it was possible to reduce the carbon dioxide (CO_2) emissions from engines up to 90% in inland waterway vessel. The local emission of CO_2, nitrogen oxides (NOx) and particulate matter (PM) will be measured along the way.

4. INNOVATIONS IN ELECTROMOBILITY

4.1. Modern technology in the production and storage of electricity for transport

Presently, according to new more restrictive requirements relating to gaseous and particulate pollutant emission limits in all kinds of transport, all users are looking for new techniques and technologies to apply on their vessels, vehicles, etc., to fulfil the technical requirements as quickly and cheaply as possible [9].

In maritime inland waterway transport, there are few possible technologies, which can be implemented on vessels to reduce emissions and reduce the negative effects on the environment. One of the solutions is to use the full electric power supply for vessels. According to this concept, all parts and equipment of the ship are powered by electricity from batteries, which after being depleted can be charged by the on vessel/on land generator or be replaced. It is possible to charge batteries from the wharf during, for example, the unloading of the ship. Such equipped unit would not cause the emission of harmful substances into the atmosphere (NOx, SOx, CO, etc.).

This solution was implemented in 2018 on two 111-metres ferries, the Tycho Brahe and Aurora (Fig. 4), which were converted to operate by battery power. The conversion to electrical power has resulted in a huge drop in carbon dioxide (CO_2) emissions. According to the shipowner, this complex project took less than four years to complete with a financial scope of around SEK 300 million (USD 33.1 million) [24], and no other environmental investment or technical improvements would have achieved comparable emissions reductions [7].

Fig. 4. Aurora ferry [24]

Another innovation, which can easily be implemented on inland and sea-going vessels is the modern energy storage called Skoonbox. It is a mobile battery for different purposes, for example, to the industry, different kinds of events or as a battery for electric fueled vessels; it can offer zero-emission propulsion. The Skoonbox exchangeable battery is the size of a 20-foot container (Fig. 5). The certificate for marine applications had been issued to the battery box.

Fig. 5. Skoonbox [19]

Skoonbox can similarly be used on land, for example, as a shore power supply for vessels; it can reduce both the emissions and the harmful noise caused by inland/maritime ships [7] especially in ports. Another advantage after full mobility (the customer can order the box wherever he/she wants) is the possibility to design the Skoonbox directly with the customer order.

Currently, the use of electric power supply by the freight fleet of inland waterway vessels is not possible in long-distance relations [11], however, the use of replaceable batteries on the ship as a fuel may, in the long run, reduce the emission of harmful substances into the atmosphere, for example, on waterways located in cities.

Another example of the implementation of a modern solution in the field of electricity production is the possibility of generating electricity using sea waves. The main product is called the OE Buoy (Fig. 6) [14]. It is a wave energy converter, which absorbs energy from ocean waves to generate green, sustainable electricity.

Fig. 6. OE 35 buoy [13]

The prototype of the buoy, OE 35 buoy, was constructed in US shipyard Vigor in Portland (Oregon) in spring 2019. The $12 million project was funded by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, along with the Sustainable Energy Authority of Ireland. The wave device – dimensions: 125 feet long (38 m), 68 feet tall (21 m), and 59 feet wide (18 m) [14]. The buoy is shaped like an "L" with a long open chamber that sits below the waterline and a turbine above the water. As water enters the open chamber it forces air upward, which turns the turbine to generate electricity.

The buoy is set to be released off the coast of Oregon where it will make a 25-day journey to the U.S. Navy Wave Energy Test Site in Kaneohe Bay Hawaii for 12 months for full-scale sea trials. The 826-ton OE Buoy has a potential rated capacity of up to 1.25 MW in electrical power production giving it the ability to support a range of exciting uses, for example, offshore fish farming, off-grid applications for remote island communities as well as utility-quality electricity supply. It can be used to power supply for cities, harbours, etc. According to data presented by Ocean Energy, each deployed commercial device could reduce CO_2 emissions by over 3,6005 tons per year [14].

5. CONCLUSIONS

The information contained in the article regarding the applied requirements for the implementation of alternative fuels infrastructure in the EU and their transposition into Polish law has allowed the issue of electromobility to be presented in a new light.

The examples of innovations featured in this article were aimed at presenting modern solutions used on a large scale, for example, in the short- and long-range transport, industry, etc.

The provisions of the EU and Polish law relating to electromobility, the AFI directive applies to almost every branch of transport. However, it should be noted that they require a number of investments related to, for example, the development, implementation and commissioning of a number of infrastructure elements such as charging points, etc.

Therefore, a constant expansion of the infrastructure for alternative fuels should be expected while taking into account the priority modes of transport, for example, road transport in the medium- and short-term, where the share of vehicles fueled with alternative fuels is constantly increasing, for example, inland waterway transport in the long-term.

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