(internal and external stakeholders) about achieved their satisfaction (from the offered services, cooperation with individual organizational units, communication, access to information, etc.).

Katarzyna Wąsowska[194], **Radosław Korneć**[195]

6. Oil Saving in Air Transport

6.1. Introduction

The first serious oil crisis, which had a big influence on the functioning of air transport, took place over forty years ago. Since then one has been observing a significant technological development, and a rise in the potential of decreasing the energy cost, but the system of transport has remained unchanged. Even though transport in general, has become more energy-saving, 96% of the energy needs in the European Union still depends on crude oil and mineral oil products. In 2010 the European Union imported oil for about 210 bln EUR. The lack of a solution concerning the dependence of air transport on oil can affect the citizens' opportunity to travel and the safety of the economy. Bearing this in mind it is worth asking some questions. Are there any ways to decrease the consumption of oil in air transport? To what degree can alternative solutions influence crude oil saving in air transport?

6.2. Some Motives of Searching for Oil Savings in Air Transport

Flying does not belong to the economic means of transport. However, the factors such as time, distance, safety etc. marginalize the economic indicators (the quantity of oil used) and put this kind of transport in the first place, or even make it irreplaceable. So, to what extent does air transport contribute to the usage of crude oil and what is the scale of the dependence of aviation on jet fuel production?

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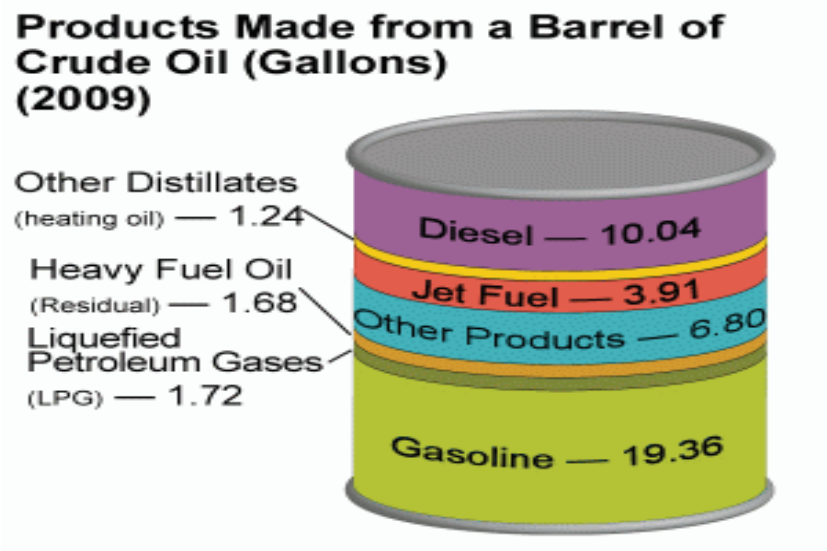
Jet fuel and other products originate from the processing of crude oil. From one barrel we can obtain 8% to 9% of jet fuel, depending on technology. Quantitative proportions of products which are obtained from one barrel of crude oil are shown in Figure 6.1. As can be seen, only one tenth of the crude oil extracted in the world can be consumed by air transport. This is a serious limitation which is felt in every attempt of interfering in the market by the countries controlling oil drilling and supply. In this way a thesis that air transport, as first, will suffer from the results of a potential oil crisis is confirmed, and that is also due to the proportions and limited possibilities of obtaining products made from crude oil, including jet fuel. This situation will last as long as the technology of the air drive is based on naphtha.

Figure 6.1
Products made from one barrel of crude oil



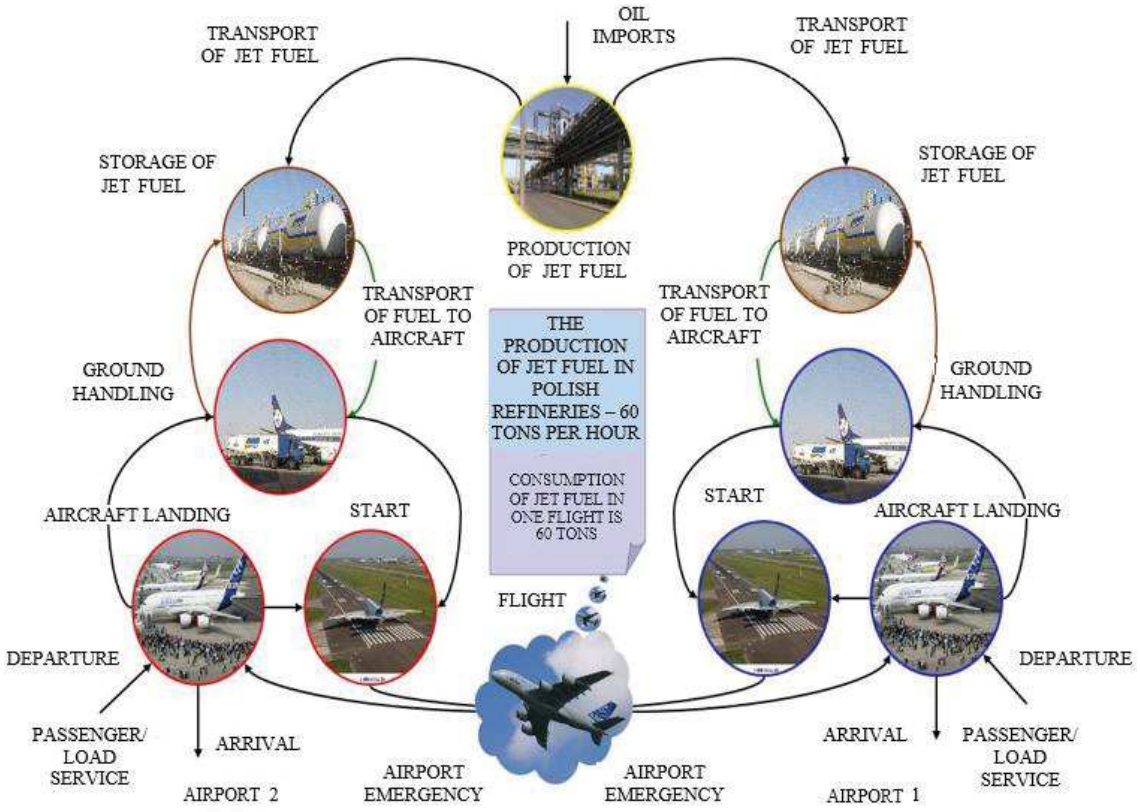
Source: www.weglowodory.pl (access: 23.05.2016).

Completing a freight cycle by one plane is connected with the preparation of a minimum four airports, each with a stock of fuel for the full coverage of a journey by a given plane. These are: the airport for taking off and the take - off alternate; the destination aerodrome and the destination alternate. If it is a flight from Warsaw to New York with a Boeing 767 the consumption of fuel will be about 40 tons while flying one way, which means that it is necessary to have 4x40=160 tons of fuel in all those aforementioned airports. Taking into consideration the efficiency of Polish refineries producing jet fuel, a company would have to work about five hours (productivity of 80 tons in two and a half hours) to secure such a flight[196]. The full cycle of

[196] www.interia.pl (access: 15.04.2015).

production and usage of jet fuel from the import of crude oil to the production and storage of the ready product, to delivering it for complementing the tank in a plane, is presented in the figure below.

Figure 6.2
The system of dependence of air transport on the oil extraction (import) and fuel production



Source: own elaboration.

Modern planes use a lot of fuel. This consumption can differ, depending on a load with cargo/ passengers, as the data in Table 6.1 show. Transport planes described in Table 6.1 can be divided according to: coverage (small, medium and large), jet fuel consumption, novelty of construction (year of production), and one can compare various types accordingly. However, in our analysis it is most important to indicate the role of technological development in oil saving. It is possible to notice minor differences in fuel consumption per hour in old and new planes, but the real proof of progress is a visibly big differentiation in the plane coverage with a similar fuel usage per hour. This development has been made by better efficiency of engines (more powerful engine thrust) with the same consumption of fuel per hour, and also by improving the aerodynamics of plane constructions.

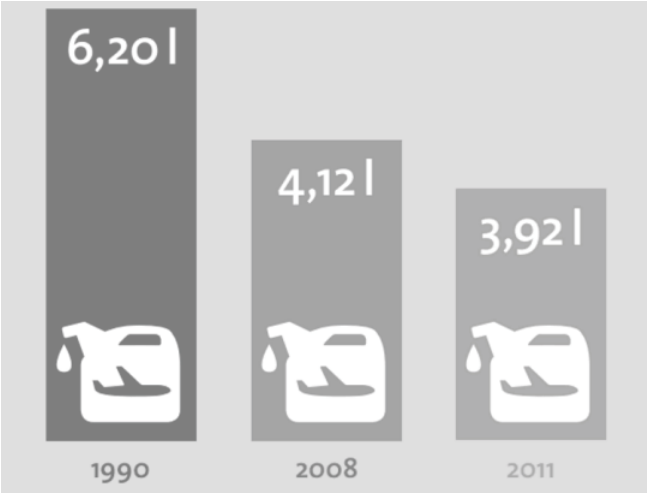
Table 6.1
Parameters of chosen types of transport planes

Types of plane	Tanks capacity [kg]	Fuel consumption [kg/h]	Max. coverage [km]	Coverage with a load [km]
Boeing 737-300	16140	2499	5300	3900
Boeing 737-400	17325	2600	5300	3900
Boeing 737-600	22137	2500	7300	5300
Boeing 737-700	20536	2500	6036	5100
Boeing 737-800	20780	2600	5370	4680
Boeing 767-200 ER	73100	2200/4300	12400	9800
Boeing 777-200	143200	3000 1sil.	13500	11100
Boeing 757	36966	-	7222	6287
Boeing 747-400	184314	-	13450	-
A300-600	52700	-	6670	-
A300-600R	52700	-	7505	-
A300-600 F	57927	-	-	4850

Source: own elaboration based on commercial brochures.

In 2013 the German Aviation Association BDL (Bundesverband der Deutschen Luftverkehrswirtschaft) published the results of research from 2011, performed on the planes belonging to the members of the association (among others Lufthansa, Air Berlin, Tui), which showed that for transporting one passenger for a distance of 100 km, less than four liters of jet fuel is needed (on the average). It is important to underline that the average usage of fuel per passenger is constantly decreasing, and since 1990 it has decreased by 37%[197] (Figure 6.3).

Figure 6.3
The parameters of jet oil usage for transporting one passenger for 100 km



Source: www.samolotypasażerskie.pl (access 25.05.2016).

[197] www.samolotypasazerskie.pl (access 25.05.2016).

6.3. The Share of Jet Fuel in Costs

The accessibility to oil (quantitative, qualitative and price wise) on the world markets, has a significant influence on the financial results of the air transport companies and the state of the economy. The introduction of jet engines in the 1970s created more demand for fuel and contributed both, to the growth of prices and the improvement of the service standards. The share of fuel cost in the costs of services was 30% to 40%. At the same time researches were taken to improve the indicators of the economic transport in the areas of plane constructions and service organization.

In practice, there is a big difference in the costs of services in the performance of civil aviation in various countries. In the European Union some efforts have been taken to unify the elements of air transport costs, in which the fuel stands for about 39%. The value of jet oil is shaped by the demand and supply on the world markets, so the EU regulations cannot be fully obeyed because the prices, to a large extent, depend on the economic conditions.

In the Polish Warsaw-Okęcie airport fuel is delivered by PKN Orlen, which provides services of fueling plane tanks in thirteen Polish airports. It is necessary to know the price of fuel to assess the cost of fueling a tank of 14 tons capacity. Right now the price of one liter of jet fuel is 2.23 PLN[198] . There are about 1170 liters in one ton of fuel, so:

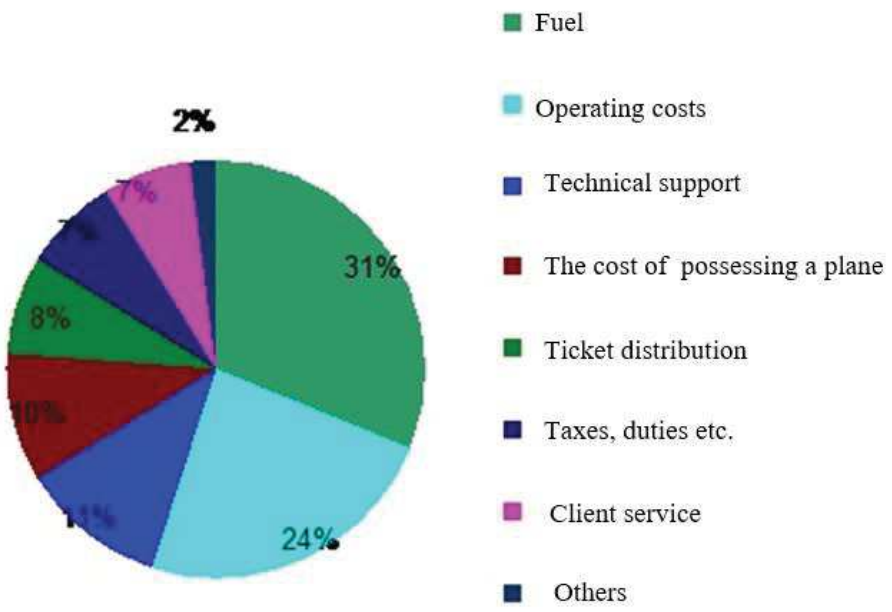
$$14(1170 \cdot 2{,}23) = 36\,527 \text{ PLN}$$

In the above analysis there are still absent prices for: ground handling, catering, hangar and the duty which an air carrier has to pay. They are not taken into consideration because, very often, they are not announced to the public. Everything depends on the agreement signed by the air carrier and the suppliers of fuel or catering. It can be different for the air carrier “X”, which can pay price “x”, and another air carrier “Y” which can pay price “y” even buying jet oil from the same supplier. The same concerns ground handling and other services which are offered by various companies operating in a given airport.

As can be seen, there are many different elements in air transport, however, the cost of fuel is dominating, and every rise in price on the world markets influences the price of air transport services. To complete the investigation let us look at the average costs of airlines in 2015 (Figure 6.4)

[198] Price on 03.06.2016 - www.dlapilota.pl

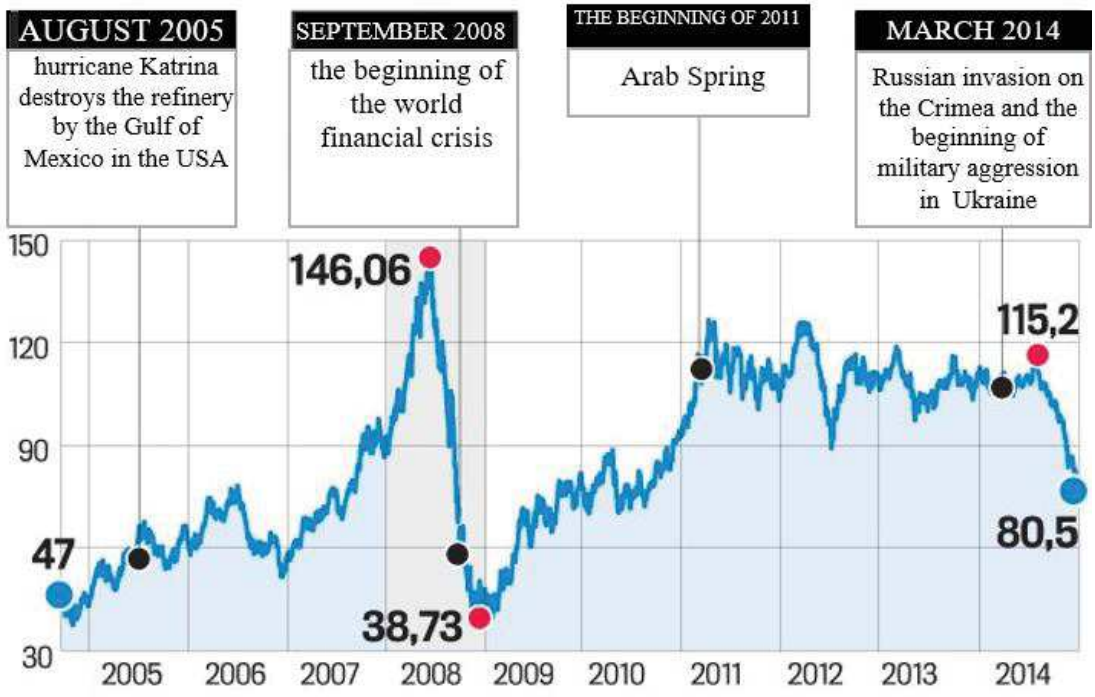
Figure 6.4
Average costs of airlines in 2015



Source: www. aviasg.com (access: 25.05.2016).

Constant oil price fluctuation on the world market do not bode well for the weaker air carriers (Figure 6.5). Specialists analyzing the market of air carriers describe the limits of keeping air transport for $85 to $115 per barrel.

Figure 6.5
Oil price fluctuation on the world market



Source: www.wyborcza.biz (access: 23.03.2015).

6.4. The Influence of Innovation for Oil Saving in Air Transport

Taking into consideration the fact that a black scenario of exhausting oil resources may come true, the world of science should – and actually is doing that – work intensively to introduce technological changes enabling the elimination of oil from its key usage in industry and transport, especially in aviation. Replacing oil with some substitutes is one of the way of making the economy immune to oil crises. Science does not have much time for its mile stones in this area, because it takes from 15 to 30 years of research and tests for an invention to implement it, and our present oil resources can be sufficient for 40-50 years. The directions of technological innovation in air transport will be shown in this part of the chapter.

Thinking about huge oil consumption and the new economic and financial crises, as well as a still growing dependence of the national economies on the natural and power generating raw materials, one can state, with complete responsibility, that nowadays, this situation is a driving force making people search for some alternative sources of energy. The best example is the United States seeking alternative sources of energy for their armed forces.

One of the innovative ideas, which was tested by American scientists, concerned a method of obtaining fuel from algae. At first it seemed unbelievable, however, after analysis by the US Department of Defense it sounds quite realistic, as we can read: "Every day the army uses over 350 thousand barrels of crude oil, which stands for 1.5 per cent of the national consumption, and in the case of federal institutions – over 95 per cent. This is more than the yearly usage in most countries in the world"[199]. When we look even further at the costs of armed forces paid by the USA, it becomes obvious that searching for alternative sources of energy is necessary because "(…) only in 2006 the fuel for the army cost almost $12 bln. The rising tendency is clear: two years previously the expenditure was 7.8 bln, and four years earlier – 5bln"[200]. Analyzing a labour - intensive process of fuel supply, one can discover that it accounts for 70% of all supplies. In the peak phase of actions in Iraq, the US military contingent used 40 thousand barrels of petroleum every day. The estimated cost of supplying one litre of petroleum can be even several hundreds of dollars.

No wonder that the US Department of Defense was looking for any possible ways to replace conventional fuel with some easier accessible, cheaper and transport wise unlimited resources. May 2008 was a breaking point in that search, as the B-1 bomber broke the sound barrier using, for the

[199] Chulda R., Wojsko idzie w zielone, Polska Zbrojna Nr 36 z dnia 6 września 2009, p. 40.
[200] Ibidem.

first time, a mixture of an ordinary JP8 fuel and a synthetic fuel, tested in a laboratory in 2006.

The research aimed at least at a partial independence from fuel originating from crude oil is still being performed. "Land forces are testing the vehicles with a hybrid drive and batteries supporting the individual ordnance of soldiers, and the air forces are examining the possibility of using lighter materials for constructing all elements of planes, which can limit fuel consumption"[201].

Today, one's hopes are pinned to synthetic fuels which can be produced from natural gas, coal and biomass, and can provide an alternative for crude oil. Many of the aforementioned technologies originate from the twenties of the previous century. During World War II the Germans produced synthetic fuel from coal and wood on a large scale[202]. Nowadays, the methods of production of synthetic fuel used in commercial flights have been elaborated in the Republic of South Africa.

The production of a special fuel for armed forces is not simple because:

- it is different than civil fuel,
- it has to be adapted to the sound breaking flights,
- there is no universal fuel which can be used in all kinds of armed forces to power various engines and army equipment, including aviation,
- it has to be more resistant to temperature fluctuation (from minus 20 degrees Celsius to plus 140 degrees Celsius),
- harmful gas emission.

In the federal institutions of the United States it is forbidden to buy fuel causing higher air contamination than that coming from crude oil, but in spite of that the American air forces are planning to buy 400 mln gallons of synthetic fuel a year (starting in 2016).

In the Defense Advanced Research Project Agency – DARPA, intensive research is taken to create a modern fuel which could be used in planes, land vehicles and warships. Scientists hope that during the next few years they can create fuel which will be able to fulfill the high expectations of the armed forces. Using renewable resources results in cost reduction, as well as diminishing the natural environment pollution.

Right now DARPA is doing research on alga, seeds and corn, because they are used to produce oil, which can later be transformed into fuel. Scientists pin their hopes on efficient algae because some of their species are characterized by a huge growth of mass (some of them are able to increase their mass and size many times during several hours). Intensive research also

[201] Ibidem.

[202] P. Cichy, *Alternatywne źródła energii*, [in:] *Energia w czasach kryzysu,* ed. K.Kuciński, Difin, Warszawa 2006, p. 156-160.

focuses on choosing the right type, because the fastest growing species give little oil. Maybe some time in the near future we are going to witness a genetic modification aimed at creating the ideal alga variety.

Searching for alternative sources of energy is connected with some difficulties both, technological – the sensitivity of biofuel to temperature fluctuation - and financial – too expensive production: today the prices are from several dozen to several hundreds of dollars per gallon. Scientists from the National Renewable Energy Laboratory is Colorado state: "This price is obviously too high. We have to lower it". However, one still does not know whether it is realistic, especially that many institutions have withdrawn from further research, believing that it is impossible, and stopped looking for those ways of obtaining fuel.

There is still fear that the work on biofuel, ongoing for the last twenty years, will fail because of too high a price of the new products. So far the research has been discontinued as it turned out to be impossible to decrease the cost below the price of crude oil or natural gas. However, the army still hopes to solve the problem, especially having some information that a firm called Algaeventures Systems from Maryville managed in March to lower the cost of production by 99%.

Recently, an important topic, resulting in lots of controversy among politicians, scientists and the general public is the possibility of using hydrogen as an alternative source of energy. During several years of research it has been proven that hydrogen is cleaner and can be a more common source of fuel than crude oil. However, the availability of hydrogen technology and the dissemination of this sort of fuel will not destroy the products of our civilization based on crude oil. The basic question is: How can hydrogen be obtained? Today the simplest way to extract it for chemical purposes is using crude oil. There is also a new approach to acquire hydrogen from salt water, which we have plenty of on Earth. If one has a sufficient amount of electric power, hydrogen can be obtained in a quite simple way. It can also be used in various equipment in many different ways, which does not need any "extraordinary" technology. For the first time hydrogen was used in car transport in Rome several years ago. The secret that some taxis used hydrogen did not last long and when it was revealed many people objected, believing that the gas is very dangerous. In fact a hydrogen tank is no more dangerous than the tank of petroleum, and a decision was taken that drivers can use it. The only change is that instead of, creating fear, products of combustion of mineral matter (carbon dioxide, nitrogen compounds) there will be water, and the negative aspect of the whole situation is fear of new phenomena[203].

[203] T. Kaczmarek, R. Jarosz, Czy ropa rządzi światem?, Oficyna Wydawnicza Branta, Bydgoszcz 2006, p. 169.

Alternative sources of energy were one of the topics of a conference concerning energetic crisis in the Canary Islands and the diversification of energy sources, which took place in June 2006 in Santa Cruz, Tenerife. Manuel Cendagorta-Galarza Lopez, the director of the Technological Institute of Renewable Energy INTER answered the question about the usage of the alternative sources of energy in transport in a following way: " Transport? You are asking about the most difficult thing. All the alternatives we were talking about for the last two hours – photovoltaic cells, current windmills etc. - are the ways of obtaining electricity. We cannot confuse the energy problem with the problem of electricity"[204].

He also gave an opinion concerning hydrogen: "Hydrogen is not a source of energy. This is a problematic solution, because hydrogen used as a battery in the energetic chain loses a lot of energy – this is its nature. I work with hydrogen, and believe me, it will never work"[205].

Other participants at the conference such as Gonzago Piernavieja – the head of the Renewable Energy and Water Department ITC, physicists Ricardo Guerrera and the head of the Canary Islands before the Energy Crisis Association - Juan Jesus Bermudezalso participated in the debate. "We need to develop energy crops" said Gurrera, but Piemavieja interrupted: "but to do that we need huge space which we don't have!"; and Cendagorta agreed: "In the island where even potatoes are imported let's forget biofuels".

Today the resources of crude oil are mostly in the countries which are politically unstable. Oil, whose reserves are still big but are depleting over the years, is used as a base of political power[206].

All those doubts seemed to be justified, and more important are the ways enabling the economic use of fuel in air transport such as:

- optimization of the flight plan, appropriate choice of planes depending on the distance and load, the reduction of non-commercial flights (technical and test flights, positioning flights);
- constant monitoring of the fuel prices, invoicing and the analysis of fuel quality;
- plane balancing and the optimization of load distribution before every take-off;
- implementing the procedure of regular fuselage and engine cleaning;
- optimization of refueling and fuel reserves on all routes, the optimization of the take-off and initial climb procedures, the choice of proper speed during flight;

[204] http://www.peakoil.pl (access: 25.10.2008).
[205] Ibidem.
[206] W. Potocki, Ropa naftowa a wzrost gospodarczy. Teoria i praktyka, Wydawnictwo Poltext, Warszawa 2014, p. 106.

- optimization of the systems influencing fuel consumption (electric equipment, undercarriage, reverse thrust, flaps etc.) taking into consideration the conditions of the infrastructure in a chosen airport and the flight management system;
- careful choice of time windows to minimize fuel consumption during taxiing, starting the engine and electric equipment as late as possible, using the appropriate power to take off (depending on the airport and weather conditions), using one engine during taxiing"[207].

"There are some encouraging conditions to introduce innovative solutions in modern transport such as:

- the development of various scientific disciplines as well as methods and research tools;
- world scientific potential working on problems of transport;
- mature technological and industrial spheres which supply transport;
- abundance of new materials and nanotechnologies useful for transport;
- the appearance of new breakthrough technology (new generation accumulators of large capacity, new hydrogen for fuel cells);
- successful informatics and information applications in transport.

There are also factors discouraging innovation such as:

- hostility of the oil lobby towards innovation concerning thrust;
- technological conservatism and skepticism of many communities and politicians involved in transport;
- a big risk and capital intensiveness of implementing innovation in transport;
- the accumulation of traditional means of transport which are still in a good technical state;
- the belief in discovering new oil resources"[208].

New innovative ideas, which also appeared in civil aviation, are as follows:

- the concepts of new generation planes,
- new generation navigation equipment,
- air traffic control systems based on informatics and satellite technologies,
- new generation airports and landing strips,
- changes in the organization of ground movement (taxiing, engine testing); it is estimated that one third of fuel is consumed by the plane ground movement.

[207] www.lotniczapolska.pl (access: 30.03.2015).
[208] http://www.pomorze2030.pl (access: 10.01.2011).

The most innovative and important solutions are:

- the concepts and prototypes of vertical takeoff and landing aircrafts with variable geometry of wings (*Rotorcraft, Tiltrotor*), produced by Textron, Erica and others,
- new generation cargo airships (*Airship, Dirigeable*),
- eco friendly planes with low emission of noise and CO_2,
- new generation "flying wing" aircraft (without traditional fuselage),
- large passengers planes (the type of Airbus 380, a prototype of a 1000-seat Boeing 797 *Blended Wing,* experimental Boeing planes and NASA X-48B) for minimizing the number of take-offs and landings and limiting congestion,
- new generation airports (including *Smart Automated Airports*, *Highway in the Sky*, *Off- Shore Air Stations*),
- the connection of big airports with cities and transforming them into logistic centres (*Aéropolis*),
- safe, automated air traffic control ATS"[209].

Taking the aforementioned into consideration, the future looks optimistic. However, one should remember that our problems today result from yesterday's choice, and our generation can take decisions which will allow the future society to live in a safe and affluent world.

6.2. Conclusion

The exhaustion of crude oil is a fact and our civilization can disappear if we do not find some alternative ways of obtaining fuel. Transport, including aviation, may not exist or function soon, because of it high cost. It is possible to prevent political or economic crises, but resource crisis can be only mitigated by new technologies which will not be based on crude oil. The other ways may include: savings, the accumulation of stocks, signing agreements for oil supply, and international control over the exploitation of crude oil resources. It is possible to enlarge the stock of oil adapting closed salt mines, which could be treated as a deposit of Arab countries and NATO. Besides, the member states of the EU have been obliged by EU regulations to keep oil stocks covering the needs for 90 to 120 days[210].

Scientific research has shown that, because of the approaching crisis of limited, or complete exhaustion of natural resources, including crude oil, it is

[209] Ibidem.

[210] Komunikat Komisji do Parlamentu Europejskiego i Rady - Europejska strategia bezpieczeństwa energetycznego COM(2014) 330 z dnia 28.05.2014.

necessary to continue the search for alternative sources of energy (substitutes), no matter how expensive it is, and in spite of the lack of expected results .

Hitherto, the attempts of replacing traditional products originating from crude oil by hydrogen or biofuel have failed for economic and technical reasons. Those substitutes turned out to be impractical, especially in air transport. The current research and the analysis of literature do not show the negative effects of alternative energy sources because of lack of data in this field.

To prevent the undesirable results of possible crises, airlines all over the world combine with each other in alliances (fusions), which help survive the time of crisis. The effects of such behaviour can be, and often is, the decrease of fuel costs and other payments (airport charge, using air space), which lowers the costs of their performance.

The conclusion of the above investigation is that the negative effects connected with the exhaustion of crude oil resources can be mitigated to some extend by: the modernization of aviation equipment (buying planes which consume less oil) and the elimination of some unnecessary costs – e.g. setting up cheap airlines, or creating marketing activities aimed at maximizing the rate of occupying seats in passengers planes.

Jerzy Kolarzowski[211]

7. The Crossroads of Praxeology in the Second Half of the 20th Century T. Kotarbiński – P. Bourdieu*

It is intended by the author to analyze the praxeology of Tadeusz Kotarbiński, a prominent Polish reist, awarded the French Legion of Honour, as well as to present the famous French sociologist P. Bourdieu. The contributions by Kotarbiński were inhibited by Real Socialism whereas Bourdieu wrote during the disintegration of the French colonial empire and the anti-leftist backlash in the French intellectual elites – the processes of the last quarter of the 20th century. The common denominator for Kotarbiński's normative praxeology and the *dominium potestas* of the socio-praxeological concepts by Bourdieu include the recognition of the pressure of time and openness to various aspects of the social context. Indeed, Bourdieu posits

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* Presented at a conference celebrating 25 years of the Praxeological Society [Towarzystwo Naukowe Prakseologii] on 14 May, 2015.