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First Generation Biofuels in Military Transport

Lithuanian case

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Abstract

Investment in renewable energy sources for military purposes is to dramatically increase in the coming years due to tactical, geopolitical, economic and environmental reasons. Major military powers have started to explore various opportunities for alternative liquid fuels while small countries are facing multiple barriers. The Military of Lithuania has been chosen as a research object to reveal what drivers and barriers are affecting it in adopting sustainable innovations, in this case, first generation biofuels.

Keywords: biofuels, military, innovations.

Executive Summary

Energy dependency is a national threat to the countries that import a major share of their energy fuels. At the same time, military's transport and overall capabilities are very strongly dependent on the fossil fuels. It is expected that spending on renewable energy technologies in the military worldwide is going to rise over the next couple of decades significantly. The majority of this spending will be applied to revolutionize mobility function including land, air and sea vehicles by focusing on biofuels and synthetic fuels application. There are four major areas where this application could benefit the military: tactical, geopolitical, economic and environmental.

In Lithuania diesel fuel and gasoline, refined from imported petroleum, is used for everyday military needs. In case of a conflict this fuel would need to be convoyed into the country. Lessons learned in military conflicts show that convoys are often an attractive target. It is likely that same would apply in Lithuania if there was a conflict. One way to decrease such casualties is by decreasing the amount of convoying. This is possible to do by using locally produced biofuels and tactically distributed production plants. Such fuel production and distribution system would decrease energy dependency from oil exporters and would decrease the cost of logistics since the price of fuel that are delivered to foreign countries increases several times. Last, but not least the pollution by land vehicles should be discussed. A considerable reduction in emissions could be achieved due to the biofuels use and if applied in more countries the reduction could become significantly larger.

Although Military Strategy of Lithuania is yet to be updated with energy security goals based on the new Lithuanian National Energy Strategy, it is expected to follow its foreign ally experiences and seek to build a military that uses less energy, has more energy sources, and has the energy sources it needs to fulfill its missions. This research raises the following requirements for alternative fuels. It must be a first-generation biofuel produced locally in sufficient quantities; it must be compatible with nondeployable land forces transport equipment or require only minor adjustments that can be easily installed; it must be suitable for all seasons use in Lithuania; its greenhouse gas emissions must be less than or equal to those of fossil fuels.

One way to research this study is through the systematic approach of Technological Innovation System (TIS) and its three elements (actors, networks, institutions) as well as seven functions that these elements must fulfill for a particular innovation to be applicable in a market or an organization (entrepreneurial activities, knowledge development, knowledge diffusion, guidance of the search, market formation, resource mobilization, support from advocacy coalitions). A new application of older knowledge as well as a fresh revolutionary discovery in science may be considered an innovation. Many years might be required for new ideas to diffuse to other organizations or applications and yet after it is received it is still considered to be a "new" by the public that receives its benefits. For that reason the technology innovation system analysis has been chosen as a tool to discuss drivers and constrains of the biofuels' future in the armed forces

Actors in Technological Innovation System for biofuels-in-military include idea-generators, producers, consumers (prime movers). Military of Lithuania has a very limited Research and Development division with even more limited budget. Nevertheless, academic resources seem to be sufficient in the country to further develop biofuels use in transport. Resources in production are more than ample for military use in Lithuania, although distribution network is very limited. Potential stocks for biofuels are increasing meaning that production should not fall short anytime soon. Technological application of biofuels (E85) seems to have issues in

finding their niche in the market, yet there are still some companies presently installing flex-fuel systems.

Military consumes only a tiny share of the biofuels market, therefore only a tiny GHG emission saving may be achieved even if all fuels would be replaced to alternatives. More than that, a relatively small consumer has less power to shift the market trends. Nonetheless, as a biofuel user it would contribute towards decreasing the gap between capacity and actual production of biofuels in local production plants. Today, military is lacking practical application of biofuels therefore it is unable to provide a feedback to manufacturers, but most importantly it lacks an ability to procure the technology, thus, it cannot be considered to be a prime mover as well. Despite all this MND provides political support and if considered as a part of government in a wide sense, then it does provide economic help through subsidies. To conclude, without a prime mover TIS is lacking initiative and experience that could be followed and adapted by others.

Presently there is no actively noticeable network that would be dealing with biofuel applicability in the military, although separate actors and even groups can be noticed. The National biofuels technology platform where researchers, academia and entrepreneurs were all working towards developing biofuel production has been established a few years ago and is no longer functioning. The benefit of this platform has been controversial. MND has had mutually successful cooperation with Kaunas University of Technology it is likely that similar collaboration with idea generators from academia would further benefit the MND as well as academia.

Local institutions, instead of providing help, although sometimes unintentionally, provide many bureaucratic barriers. On the other hand, international institutions, mostly EU, have given a lot of momentum to biofuel market. Lithuania is forced to follow EU directives and it has been one of the major drivers in promoting biofuel production in this country. Institutional element is significant in this case, since political will, despite low financial capabilities, might bring about some change in this particular technological innovation system. At times a priority which is officially noted might get accomplished without significant financial expenses.

Out of seven TIS functions only four have been satisfied in this particular system. Lithuanian armed forces do not show any signs of entrepreneurship, however, there are other civilian actors who although are lacking political power and financial capabilities are introducing biofuel technology to the wider market, therefore it fulfills the function requirement. Knowledge is being developed in applying learning-by-searching principle among Academia and the researchers in think tanks. Learning-by-doing process is applied by the producers of biofuels and other local entrepreneurs such as flex-fuel installers. Knowledge diffusion, on the other hand, is flawed since actors are not exchanging the expertise with each other. Technological lock-in applies to the guidance of the search function due to the Single Fuel Policy (SFP). Nevertheless, biofuel market is formed in Lithuania although some signs of the struggle are also visible. Today the military does not have resources mobilized for the biofuel adoption therefore it does not fulfill the function requirement. However, political will and therefore support from advocacy coalition is clearly existent.

The requirement to all NATO allies to comply with SFP brings about a discussion. As an example, member countries, such as Lithuania before acquiring vehicles must check that it would comply with this policy and this represents technological lock-in that applies physically as in this case and psychologically i.e. the mindset, even when looking for renewables, is set to look only for alternative fuel that could be used in SFP vehicles. Number of studies discussed in this research included this requirement, this one is no exception. However, how good of an alternative can one find when one is trying to match it with something that is not even close to perfect? Yet a rhetoric question could be raised: "wouldn't it be better if vehicles would comply with MFP (Multiple Fuel Policy) – the more types of fuel it can use the better?"

In conclusion, only three biofuels: bioethanol, biodiesel and biogas fulfill the requirements that enable it to replace mineral fuels. That includes sustainability, volume production and local commercial availability. Biogas although not an alternative as a transport fuel today, would not be a feasible option in a future military use either due to its characteristics. Bioethanol is unsuitable for military purposes. Its volatility, tendency to attract water are among limitations, however, the biggest issue is that it is not suitable in tactical transport vehicles since the fleet is adapted to F-34 and petroleum diesel only.

The total present capacity of biodiesel production allows producing 440 tons of biodiesel a day. This, in theory, is enough for all Army tactical vehicles to cover a distance of around 700 km/day! It is still widely discussed whether biodiesel harms the engine or not and whether pure biodiesel can be successfully used in a transport vehicles. At the moment a fair conclusion is a blend of 30-35% biodiesel in a conventional diesel. This seem to be the best solution since it is more widely accepted as harmless to the engine and fuel supply system. However, according to the TIS and its functions, the application of biofuels in the military can not be implemented just yet due to aforementioned barriers.

Recommendations to promote biofuels-in-military and other technological innovation systems in the military:

- National policy supporting the development.
- Avoid bureaucracy, increase inter-ministerial cooperation.
- Forming the guidelines to initiate think tanks.
- Avoid technology lock-in.
- Avoid made-up platforms rather support bottom-up approach.
- MND should increase networking with think tanks.
- R&D division, mobilizing resources.
- MND as a prime mover.
- MND should apply learning-by-doing educational system.
- Continuous support from advocacy coalitions.

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Abbreviations

Btu	British thermal unit
CO_2	carbon dioxide
EU	the European Union
EUR	Euro, the official currency of the Euro zone in the European Union
FAME	Fatty Acid Methyl Ester
FMV	Swedish Defence Materiel Administration
F-34 (JP-8)	Jet fuel based on Kerosene, used in applying Single fuel concept.
GHG	green house gas(es)
GDP	gross domestic product
HMMWV	High Mobility Multipurpose Wheeled Vehicle
ILUC	The indirect land use change
kpt.	Captain
Lt. Col.	Lieutenant colonel
MND	the Ministry of National Defense Republic of Lithuania
NATO	the North Atlantic Treaty Organization
NO_x	mono-nitrogen oxides (nitric oxide – NO and nitrogen dioxide – NO_2)
RME	Rapeseed Methyl Ester
SFP(C)	Single Fuel Policy or (Concept)
TIS	Technological Innovation System
USDoD (DoD)	the United States Department of Defense
VAT	Value Added Tax

1 Introduction

1.1 Background

Energy dependency is a national threat to the countries that import a major share of their energy fuels. Economies are still reliant on the availability of oil and natural gas. Any disruption of supply usually brings vast economic losses. On the other hand, energy-exporting countries are seeking to maintain diplomatic leverage by preserving "security of demand" (Yergin, 2006). Military is directly and indirectly involved in security of supply and therefore in energy security issues. Military owns responsibility to defend strategic energy infrastructure. More than that, continuous supply of fossil fuels for the nation and its own needs must be assured since military's transport and overall capabilities are very strongly dependent on the fossil fuels.

Energy dependence on petroleum and natural gas imports by the oil and gas exporters is not only causing the technological shift in military transport, but also in civil societies. The transport sector presently has a few major problems. Apart from economic issues related to increasing gasoline prices it also has a serious impact on the environment because of greenhouse gas emissions (GHG). Today, biofuels are distinguished as a single direct substitute for oil in vehicles available on a considerable scale. High blends require only cheap modifications while low blends can be used in unmodified existing vehicle engines (Turcksin, et al., 2011). Tendencies towards technological innovation in this field in civil societies and especially in militaries are being noticed.

According to Pike Research, spending on renewable energy technologies in the military worldwide is going to rise over the next couple of decades. It is likely to grow from $1.8 billion (EUR 1.3 billion) per year in 2010 to $26.8 billion (EUR 18.8 billion) by 2030. The majority of this spending will be applied to revolutionize mobility function including land, air and sea vehicles by focusing on biofuels and synthetic fuels application that can serve as replacements for traditional petro-fuels. (Energy Security Center, 2011; PikeResearch, 2011) This trend is also likely to be spread and applied in civil sector later.

1.2 Problem definition

After Winston Churchill took a decision to convert Royal Navy from coal to oil in 1912, he stated that "safety and certainty in oil lie in variety and variety alone" (Shea, 2010). Today, most of the European militaries as well as its allies in North America are directly dependent on fossil fuel supply from the third nations i.e. countries that do not belong to Euro-Atlantic block of nations. At the same time major oil exporters happen to be located in regions of instability. Middle East has been a region of ongoing conflicts while Venezuela and Russia have been countries of unpredictable political leadership. A current armed fight in Libya also proves that the region is unstable (von Hippel, et al., 2009). Throughout history, energy has been the limiting factor in all military operations (The Role of Biofuels, 2009). It is self explanatory that without liquid fuel military is unable to perform its functions.

Shortage of fuel might be critical to any military operation. Probably the best example to illustrate it - the end of the Second World War when due to the limited oil reserves and well planned bombings from Allies, Germany possessed only 5% of the oil it had at the beginning of the war (Shea, 2010). Historically that has been proven to be true many more times. Needless to say that the worst case scenario for an energy importing country would be an armed conflict that would involve major oil exporting countries on the other side of the front. Grubliauskas (2011) argues, that a way to protect countries and their critical infrastructure lies only in diversification of energy routes, suppliers, and sources (Grubliauskas, 2011). On the other hand, there is no evident reason to believe that similar conflict would be taking place anywhere or any time soon.

Yet, that does not eliminate the core issue – militaries use a lot of fossil fuels. Thus, apart from the strategic factor, there are also environmental and economic aspects that need to be considered. Military together with the society could work hand in hand to move toward renewable fuels. By doing so it would help to reduce greenhouse gas (GHG) emissions and would stimulate local production of biofuels. However, at the present very few militaries have provided vast effort to step towards that direction while countries with significantly lower military budgets such as Lithuania are lacking behind. Therefore, in order to promote the search for alternative fuels there is a need to study available renewable resources as well as barriers and drivers to its applicability in countries with very limited military budgets.

It might seem to be a paradoxical situation since sustainability and military are understood as nearly antonyms by many. However, geopolitical situation in the world does not seem to be making a dramatic shift in the way countries have been functioning for many years. At least, not any time soon, meaning that militaries will stay and will keep on using a vast amount of liquid energy. For that reason, actions to reduce a negative environmental impact of these institutions have been prioritized by some states for a few years now, while others at the first glance seem to have noticed this matter only recently or admittedly have not done anything in this area yet.

1.3 Research objective and questions

In order to address the problem mentioned above, this research intends to examine the present system of alternative fuels that could at least partially fulfill military needs for liquid fuels in the near future in Lithuania. The most important research goal is to analyze environmental, economic, geopolitical and strategic aspects of locally produced biofuels applicability to the military needs. The research objective is to provide recommendations to governing institutions that would help the military to adapt innovations in the future.

The main research question is as follows:

What are the underlying drivers and barriers to a wider use of biofuels in the military?

The following sub-question is also to be answered:

What (if any) locally produced biofuel could possibly replace fossil fuels in the military of Lithuania in the near future without compromising military capabilities?

1.4 Research methods

The data for this analysis was collected through the combination of two research methods – literature review and personal interviews.

1.4.1 Data collection and sources

Literature review was initiated through the various databases (LibHub, EBSCOhost, ScienceDirect), related web sites such as European Union law web site, Ministry of National Defense or Ministry of Agriculture of the Republic of Lithuania etc., as well as Google search engine. A "snow-ball" method was later applied after some relevant literature for a certain part of a topic was found - Suurs (2009), Nuffield Council on Bioethics (2010) as well as Janulis & Makarevičienė (2004) i.e. their reference list was used for further research. A large amount of the literature sources are academic peer-reviewed papers and articles written by the experts in the field. The author is also grateful for some up to date data that was obtained from the interviewees. The purpose of the literature review was to find an applicable theoretical and conceptual framework as well as to research up to date information on the issue.

The interviews have been selected during a research on institutions and organizations dealing with biofuel production, distribution, military logistics, government and then finding specialists as well as authorities that work in the relevant field at those institutions. The whole range of actors involved have been interviewed including farmers, producers, retailers, consumers as well as governing institutions. Interviews were conducted in person, by phone and by email. It often consisted of a short questionnaire connected to a specific part of the topic and linked to the position held by an interviewee i.e. interviews with local biofuel producers and farmers stayed within the issues related to growing feedstock and biofuels production, while an interview with a Minister of National Defense was limited only to political factors affecting the topic under discussion.

1.4.2 Data analysis

Since the research area is closely related to energy security topic, literature review has been chosen to be applied on 4 A's (availability, acceptability, accessibility, affordability) conceptual framework that is commonly used in energy security literature. It appeared to be a well suited construction to overview the market of locally produced biofuels and reveal issues it faces since it incorporates almost all important aspects into these four dimensions and it is an easy structure to follow to.

Technological Innovation System (TIS) concept has been chosen to analyze drivers and constraints of biofuels applicability in the military. It appeared that the seven function "checklist" provides a good insight on what is necessary for a successful application of a certain innovation and what essential part(s) might be missing in the system.

1.5 Scope and limitations

The geographical scope of this research is applied and focused to Lithuania. The country is situated in the Eastern Europe and is a member of North Atlantic Treaty Organization (NATO) and the European Union (CIA , 2011), organizations that directly affect issues related to the national defense and economy. Despite the geographical scope the data applicable to this research has been also collected from various countries worldwide. This was needed to provide exceptional examples of various initiatives in foreign countries that are currently available and practiced; while in the meantime Lithuanian Military, governmental institutions or other bodies are lacking behind in those cases. These examples are not always directly related to the Armed forces of Lithuania; however, it is always relevant to the biofuels transport sector.

The technology application in this research is focused on land-based military transport vehicles, while air and sea transport have been either mentioned partially as an example in a certain case or excluded from the list. The reasoning behind it is that land vehicles represent the largest liquid fuel consumption share. It also represents the most important military capacity in Lithuania based on the number of personnel and equipment (Lithuanian Armed Forces, 2011). Lastly, the aim of this research is to discuss biofuel applicability in a broad sense taking into account economic, environmental, geopolitical, tactical aspects and not to analyze details of technological applicability alone.

This research limits itself to the first generation biofuels only. Biofuels discussed are locally produced biogas, bioethanol and biodiesel only. Liquid fossil fuels are referred to petrol (gasoline), diesel and liquefied natural gas used for road vehicles. In the research it is assumed that fossil fuels have a greater environmental impact compared to the first generation biofuels. Despite that, the controversy of this widely discussed topic is recognized and to a limited extent has been summarized in environmental acceptability chapter.

It is also recognized that this research is not an all-embracing study that could potentially discover a single easy solution to this subject, but rather stimulate a discussion. It is due to the various conditions and multiple complex factors that affect the biofuels applicability in the military. All of it cannot be physically discussed in a time given. Some factors would require a separate in depth research therefore aspects such as technical engine modifications, a change in the military tactics in case of biofuels use, crude oil price affect on biofuel price etc. have not been covered. The analysis of this research is focused on the barriers and drivers affecting the possible transition from liquid fossil fuels to locally produced renewable energy in the armed forces of Lithuania in economic, environmental and policy aspects.

A common data collection challenges were experienced during the research of the topic. The major challenge was an availability of interviews. It was mostly limited to the busy schedule of interviewees therefore many times in person interviews were replaced by phone or e-mail interviews instead. Also a few interviewees refused to be interviewed while some have not responded, likely due to the summer holiday season. Another significant challenge was a lack of related studies on biofuels applicability in the armed forces of Lithuania. Nevertheless, it was partially covered by the information from foreign experiences.

The target audience for the thesis is a public involved in the biofuels market, also those dealing with innovations in military logistics as well as authorities interested in energy and national security. This does not limit the audience to Lithuania only, but rather could be of interest to anyone, especially those of other central or eastern European countries with similar geopolitical situation and comparable biofuels production infrastructure.

1.6 Thesis outline

The structure of the thesis is presented in the table below.

Table 1-1 Thesis outline

Chapter	Content
1	Background of the research together with the underlying problem is presented in this chapter. Research objective and questions are raised. Methods of the research are then discussed. Lastly, the scope and limitations are set.
2	Chapter No. 2 explains how the military and sustainability are related and how biofuels may contribute to military's performance.
3	Technological Innovation System (TIS) concept is reviewed in Chapter No. 3. Three elements of this theoretical framework are discussed and seven system functions are explained.
4	Literature review based on 4 A's structure is presented in this chapter.
5	Data analysis based on TIS is presented in Chapter No. 5.
6	Technological lock-in and its affect on the search for alternative military fuel is discussed in this chapter.
7	Concluding remarks of the study are provided in Chapter No. 7.
8	Recommendations to policy makers are introduced in this chapter.

2 Rationale behind the biofuel use in the military

Some may argue that military and sustainability do not go hand in hand. In a wide sense they are considered antonyms to each other as if evil vs. good. This in many cases is true – having in mind the very nature of the military which is to destroy the enemy. Additionally, present technology that is big and robust using a lot of liquid fuel does not seem to reflect the term sustainability: "meeting their present needs without compromising the ability of the future generations to meet their needs" (United Nations General Assembly, 1987). For this purpose, the reasoning why military could consider sustainable biofuel application is discussed next.

2.1 Tactical aspect

The use of fossil fuels in the military is a challenge in many perspectives. Many European countries, including Lithuania import absolute majority of its liquid energy sources used in the military transport and other applications. It makes a country dependant on the third party state(s), oil exporter(s). In some cases that may not be an obstacle, however, a recent history shows that conflicts tend to take place in regions where oil exporting countries are located. It then affects the world's oil supply and thus directly influences the cost and availability of fossil fuels in the military. Yet military oil consumption is growing.

In a World War II soldiers used an average of 1.5 gallons (5.7 liters) of fuel a day while during the Iraq War (2004) the number skyrocketed to 27 gallons (102.2 liters) (energyNow, 2011). In some scenarios, it may be envisioned that oil supply could be drastically reduced or cut off to one or few countries, meaning that the country would be left with its national oil reserves only. That would also mean that an opposing country especially if that is a major oil exporter would get an advantage since without oil supply and/or natural gas supply a country and its military could function only for a limited period of time. Alternative liquid fuels that can be locally produced in tactical quantities are therefore of a high interest to national defense organizations.

Over the period of 2003 – 2007 in Iraq and Afghanistan more than 3,000 soldiers and contractors were wounded or killed from attacks on fuel and water convoys (U.S. Department of Energy, 2010). Today convoys are still often attacked in these missions. U.S. Transportation Command reports 1,100 attacks on ground convoys in 2010. It accounts for 60% of all U.S. military deaths in Iraq and Afghanistan, and though air delivery is presently safer it is ten times as expensive as ground delivery (U.S. Department of Defense, 2011). One way to decrease casualties is by decreasing the amount of convoying. This is possible to do by using locally produced biofuels and tactically distributed production plants. It is suggested that biofuel plants located next to the military bases in Afghanistan would provide multiple advantages. It would not only save the lives and the money for military transportation, but also would encourage poppies' growers to turn to biofuel stock cultivation which would provide less money to narco-terrorism. (Irvine, 2010)

However, situation in Afghanistan is a different story that requires a separate research. The absence of war is the main difference between present situation in Lithuania and Afghanistan. Secondly, when it comes to the fuel use in Afghanistan a so called "Single fuel policy (concept)" applies to ally countries meaning that only a NATO fuel F-34 (JP-8) based on kerosene is used there that fits all tactical transport and weapon systems used in this operation (Bernatavičius, 2011). In Lithuania yet diesel fuel and gasoline is used for everyday military needs. Finally, narco business from poppies does not require immediate attention in Lithuania. However, one relevance remains - tactical approach. In case of a conflict in Lithuania, fuels would need to be supplied to the military while intentional disruptions are likely to occur. Convoying by sea or by land would take time and as seen from aforementioned examples –

dangerous. Therefore, the best solution to this issue could be a locally produced and distributed liquid energy.

2.2 Energy security

Energy security aspects are often being distinguished between strategic and operational security. Security of supply that is the most of the interest in this case can be split into technical security of energy supply and geopolitical/economic security of energy supply (Nuffield Council on Bioethics, 2011). Technical security would encompass availability of resources at the peak of demand while geopolitical/economic security refers to price volatility and relationship with the outside supply. In both cases alternative fuels provide at least a partial solution. In terms of technical security biofuels may to some extent replace conventional fuels reducing their need in the peak time, while in geopolitical/economic aspect it creates competition to imported fuels. It is unlikely that biofuels would entirely replace mineral fuels in a short term. Nevertheless, even a small fraction in an overall consumption pattern may be important not only in the case of convoying or when the supply of fossil fuels is cut off in the country, but also in peace time to take initial steps in reducing energy dependency.

2.3 Economic aspect

Apart, from energy security aspect economic and environmental factors must be discussed. Militaries today are among the major users of liquid fuel that are used by thousands of ground vehicles. Yet it means that not only the fuel must be purchased from a third country, but in many cases it must be then transported to the conflict zone which increases the fuel price significantly. Karbuz (2008) argues that indirect costs for transporting fuel to battlefields and distributing it to the end-user that obviously also involve liquid fuel use increase the price significantly. After the cost of logistics is summed up the price of delivered fuel in the U.S. Army reach as much as $13-$19 per gallon (EUR 2.4-3.5 per liter) compared to the present price of $3.5-4.5/gallon (EUR 0.6-0.8/liter) in the gas stations (USDE, 2011). In other branches like the Air Force, these costs can be much higher and reach up to $42 a gallon (EUR 7.7 a liter) (energyNow, 2011). Although situation in Iraq or Afghanistan may seem irrelevant to that of Lithuania due to the fact that troops are located abroad it might be deceptive. Unless fuel are produced locally in small tactical quantities, meaning that production is distributed throughout the region or a country it will still be required to deliver it to the location of forces despite where it may be – Asia, Europe, North America, Middle East or middle of Lithuania.

2.4 Environmental aspect

The alternative fuel should also be considered for another reason – climate change. Military transport technology have never been distinguished as economic or environmentally sound. Military equipment has usually been built to be effective and withstand various challenges yet its energy efficiency has often been left behind. Meaning that everyday hundreds of thousands vehicles worldwide emit greenhouse gases in a very inefficient way. A well known, High Mobility Multipurpose Wheeled Vehicle (HMMWV or Humvee), normally uses as much as 20 liters/100km of diesel fuel, although often this number might be as high as 30 liters/100km on the highway and 60 liters/100km in the urban area (Richard, 2008). This light armored vehicle is among the smallest vehicles used in the battlefield by NATO and its allies. Other armored transporters and tanks consume significantly more. It does not, however, mean that the major fuel consumption is necessary taking place in the hot spots of the world. Rather contrary, a majority of militaries are located in home countries and they exploit thousands of tons of fuel for everyday practices. Therefore, even a relatively small reduction in emissions due to the biofuels use would bring a considerable reduction in pollution and if applied in more countries the reduction could become significantly larger.

2.5 The goal in energy security for military

In a following weeks Committee on National Security and Defense is to discuss an updated National Security Strategy of Lithuania that encompasses energy security aspect of a whole country. Following that, a Military Strategy of Lithuania is to be updated. Today, as an example to be followed is mentioned the *Energy for the Warfighter: Operational Energy Strategy* by U.S. Department of Defense (USDoD). (Lapinskas, 2011) It emphasizes the fact that until U.S. forces rely on liquid fossil fuels the vulnerability of supplies is going to raise risks of soldiers' lives and increase operational costs. There is a strong interest in a long term national energy security in USDoD. Therefore steps should be taken together with other Federal agencies as well as private sector in order to diversify and secure fuel supplies. The goal is to build a military that uses less energy, has more energy sources, and has the energy sources it needs to fulfill its missions. Military – able to contribute to national goals through reducing reliance on fossil fuels, cutting greenhouse gas emissions, and stimulating innovation in the civilian sector. (U.S. Department of Defense, 2011) Based on this strategy, it is possible to predict that the Armed forces of Lithuania strategy is to include similar goals to those mentioned in this document.

2.6 Alternative fuel requirements

This study sets itself the following requirements that the biofuel should meet in order to be applied for military use in Lithuania:

- It must be first-generation biofuel, produced nationally and in sufficient quantities.
- It must be compatible with nondeployable land forces transport equipment or require only minor adjustments that can be easily installed.
- It must be suitable for all seasons use in Lithuania.
- Its greenhouse gas emissions must be less than or equal to those of fossil fuels.

2.7 Army transport fleet

For obvious reasons information on military technical capacity is not easily accessible, however, publicly available sources have been used to get a grasp on the transport park of the Army of Lithuania. As of 2008, over 200 administrative cars, 30 buses and around 400 four-wheel-drives have been in use in the military of Lithuania of various producers and brands (Ambrazevičius, 2008). Additionally, major tactical transport equipment includes diesel fueled 50 SISU E13TP- 8x8 multifunctional combat support armored trucks (Lithuanian Armed Forces, 2011). Around 1500 four wheel drive medium trucks, out of which the most popular are Mercedes-Benz Unimog with a turbo diesel engine consuming 22-28 liters/100km. Around 200 High Mobility Multipurpose Wheeled Vehicles (HMMWV) with 6.5 l. diesel engines, are exploited. In UN register of conventional arms 221 M113 armored personnel carriers are registered as in use (UN register of conventional arms, 2011). An unknown number of Swedish Bv 206 tracked articulated all-terrain carriers with either industrial Ford V6 gasoline or Mercedes-Benz turbo diesel engines are also used by the Army (Arctic tracks, 2011).

3 Analytical framework

The 4 A's (availability, accessibility, acceptability, affordability) of energy security has been chosen as a conceptual framework for a literature review. It provided a structure to discuss background information on liquid biofuel situation in Lithuania. Analytical framework of Technological Innovation System (TIS) has been applied to illustrate and analyze research problem. It then led an analysis part of the study towards the conclusions and the answers to research questions that have been raised in the beginning.

3.1 Technological Innovation System concept

A systematic view on technological innovation must be taken in order to realize how diverse agents interact with each other and what outcome they bring (Carlsson & Stankiewicz, 1991). One way to approach this system is through the three elements of TIS (actors, networks, institutions) and seven functions that these elements must fulfill (entrepreneurial activities, knowledge development, knowledge diffusion, guidance of the search, market formation, resource mobilization, support from advocacy coalitions) for a particular innovation to be applicable in a market or an organization. (Suurs, 2009)

Technological innovations are complex processes, involving multiple social and technological factors. It can be assumed to be a set of interlinked technologies and institutions that are being (re)shaped through the activities of actors. Most of TIS studies seek to examine a particular technological innovation in order to evaluate processes that are supporting or impeding it. (Suurs, 2009) There are many technological systems in a country and some actors participate in multiple of them. However, each TIS is unique and thus they develop and diffuse differently (Jacobsson & Johnson, 2000).

Carlsson and Stankiewizc (1991), Jacobsson and Johnson (2000), Jacobsson and Bergek (2004) distinguishes three elements within TIS definition: actors, networks and institutions. Suurs (2009) deviates from an earlier literature and suggests that networks, although of key importance, should be replaced by the element of technologies. He argues that a network is rather a combination of related factors, but not a factor in itself (Suurs, 2009). Nevertheless, this thesis chooses three basic elements that are discussed in the classical TIS literature. Each of the categories is described below.

3.1.1 Actors

The category of actors includes any organization contributing directly or indirectly to the innovative technology with its knowledge, competences, generation, diffusion or utilization of the technology. The success of evolution of TIS very much depends on the skills, abilities and interrelations of actors involved. The range of actors in TIS might be vast to include technology developers, adopters, private as well as public performers (Suurs, 2009). A particularly important actor is a so called prime mover. This system builder is usually equipped with technical, financial as well as political powers and is able to affect the development of technology extremely sturdily. Prime movers are responsible for promoting an emerging technology by raising awareness, undertaking investments, providing legitimacy and diffusing the innovation. (Jacobsson & Johnson, 2000; Jacobsson & Bergek, 2004)

3.1.2 Networks

Networks make up important links between the actors to transfer tacit and explicit knowledge. It may be concentrated for certain market and/or product development, yet it may be non-market related and be only used for a more general diffusion of information. Individual actors increase their resource base through the knowledge and information they access. Therefore, they gain relative advantage to those actors that are not a part of a network. (Jacobsson &

Bergek, 2004) On the other hand, the network may constrain an actor and set a limit to its technological choice (Jacobsson & Johnson, 2000).

3.1.3 Institutions

Institutional structures i.e. the rules of the game are at the core of the innovation system. There are two types of institutions. Formal institutions are the rules that are being enforced by some authority such as laws, policy decisions, company directives, contracts or educational system. Informal institutions are shaped by the shared interaction and culture. (Jacobsson & Johnson, 2000) Informal institutional structures can be divided into normative and cognitive. The normative rules are of moral significance such as the responsibility felt by a firm to reduce pollution. Cognitive rules incorporate collective mind frames or social paradigms. Dominant vision among actors within TIS could be an example. (Suurs, 2009) It is essential that cognitive rules would form a guideline especially at the beginning of the TIS since most of the time anything but vision is the main driver supporting an emerging technology.

3.2 Seven system functions

The system functions are processes necessary for TIS build-up. It can be regarded as a checklist of major activities that need to be fulfilled in order for TIS to develop properly. It must be noted that there are number of ways to fulfill these activities. It is also possible that activities contribute to a system function negatively; in that case, it would imply a total or a partial breakdown of TIS (Suurs, 2009).

3.2.1 Entrepreneurial activities

Entrepreneurs make a foundation for the whole TIS. In a common sense entrepreneur would translate knowledge into innovations and business opportunities. The process involves experiments and demonstrations to prove the practical value of the emerging technology in a commercial environment. The process is essential in overcoming the unforeseeable consequences and other uncertainties associated with innovative technologies. Entrepreneurs might be private or public actors as long as their experiments with an emerging technology are market-oriented. (Carlsson & Stankiewicz, 1991; Suurs, 2009)

3.2.2 Knowledge development

Learning-by-searching and learning-by-doing are the two types of learning activities that are widely used on the emerging technology as well as on markets, producers, users etc. Knowledge development also has the tendency to generate variety and increase uncertainty within the system. Other system functions such as Entrepreneurial Activities or Guidance of the Search keeps this variety in check. Typical knowledge development centers are not limited within academia or other research institutes, but may also include other actors especially those promoting learning-by-doing activities. (Sagar & van der Zwaan, 2006; Suurs, 2009)

3.2.3 Knowledge diffusion

Knowledge diffusion very much influences networking or cooperation in TIS. Network is a form of versatile inter-organizational relationship through which new information is generated. The more complex the task, the more one may be forced to rely on the expertise of others. (Carlsson & Stankiewicz, 1991) A broad variety of actors and even networks might be involved in knowledge diffusion process. Expansion and success of the TIS depends on the communication activities among heterogeneous actors i.e. policy makers, technology developers, scientists and the inclusion of new actors within networks (Suurs, 2009).

3.2.4 Guidance of the search

While knowledge development is a source of technological variety, the guidance of the search corresponds to the selection process. Selection is necessary in order to properly allocate resources and narrow down the broad visions to feasible desirability based on the emerging technology. The right direction is essential otherwise the first three functions: entrepreneurial activities, knowledge development and diffusion will lead nowhere. The guidance of the search should be an interactive process performed by all interested actors. However, only a positive guidance of the search stimulates the emerging technology while a negative one might lead to digression or even a rejection of development. (Suurs, 2009)

3.2.5 Market formation

For the emerging technology to be successful it must have a demand in the market. The market formation includes activities contributing towards it – financial support, taxation of competing technologies. Markets are considered to be the vital selection environment of an innovation. The difference between the guidance of the search and market formation lies in users' inclusion to generate a demand. Marketing campaign by a private company might be one way to form a market. However, in case of sustainable innovations this system function is usually performed by governmental bodies, through the set-up of formal institutions. (Suurs, 2009) The key aspect in market formation is to explore niche markets where an emerging innovation is in some aspects superior to the prevalent technology (Jacobsson & Bergek, 2004).

3.2.6 Resource mobilization

Market formation, guidance of the search, creation of knowledge and the formation of prime movers require appropriate financial incentives and/or economic risk absorption (Jacobsson & Bergek, 2004). The allocation of financial, material and human capital through investments, subsidies, educational systems or mobilization of natural resources are necessary for TIS developments. An innovative technology would not thrive without financial or natural means, or without actors with the right expertise and aptitude. Although resource mobilization may be initiated by various actors, it is anticipated that a mature TIS will attract more private contributors. (Carlsson & Stankiewicz, 1991; Suurs, 2009)

3.2.7 Support from advocacy coalitions

A resistance to an emerging technology might be felt from actors interested in that energy system. Therefore, it must be counteracted by lobbyist from advocacy coalitions. Sabatier (1998) argues that significant change within a system is achieved through the competition of interest groups representing different value and ideological attitudes. The major weakness and the only tool that advocacy coalitions employ is the power of persuasion. In this system function actors try to persuade other actors to take certain actions that they are not capable of conducting themselves. This is the major difference between the support from advocacy coalitions and guidance of the search. NGOs and industries would normally fulfill this system function. (Sabatier, 1998; Suurs, 2009)

4 The 4 A's literature review

The topic of liquid biofuel use in the military is closely related to energy security issue. The 4 A's of energy security structure has been chosen to depict the literature review in a concise and well comprehended manner. It also has worked as a screening tool when selecting relevant data. The background information on biofuels market in Lithuania is presented in four major areas in this chapter. Typically the 4 A's approach (Availability, Acceptability, Accessibility, Affordability) is used to define energy security condition in a state or a region. A number of indicators are often used to define the situation in each of the four elements that are so vital in ensuring energy independence. Indices will not be used in this research since the overall objective is not to discuss energy security situation in Lithuania, however, the four elements remain: a) energy resource availability; b) barriers to accessibility; c) environmental and ethical acceptability; d) investment cost affordability (APERC, 2007). This type of structure provides a coherent layout for multi dimensional aspects of the topic.

4.1 Availability

Today a demand for liquid fuel is growing rapidly while reserves are being steadily depleted. U.S. Energy Information Administration informs that world liquid fuels consumption in 2010 grew to a record high 86.8 million barrels per day (bbl/d). It is expected that consumption is still to grow by 1.4 million bbl/d this year and by 1.6 million bbl/d in 2012. (EIA, 2011) Every country as well as every organization using fossil fuels is interested in securing the constant supply. In the meantime biofuels importance is growing partly due to the shifting energy supply trends in the world. On the other hand, renewable energy including biofuels have supply capacity constraints which is a major limitation to adopt it as a substitute for conventional fuels (APERC, 2007). Due to the need to review present and future production trends the Availability element of 4 A's is used. In energy resources availability element, liquid biofuel production capabilities as well as agricultural trends in Lithuania are discussed.

4.1.1 Biofuel production capabilities in Lithuania

The bio-energy sector is one of the priorities for the Ministry of Agriculture that not only reduces dependency on the imported fossil fuels, but is also another source of income for the local farmers. Today Lithuania produces two types of first generation biofuels that are being used in transport: biodiesel and bioethanol while biogas is only used for cogeneration of heat and electricity. Biofuel production especially that of bioethanol was mostly inspired by human and technical resources that were present at a time. The excess production capability in the limited alcohol market was another driver to shift towards bioethanol production. Biofuel makes up a significant part of the bio-energy sector.

There are six biofuel plants of a total production capacity of 220 thousand tons: 160k tons of biodiesel and 60k tons of bioethanol. The present capacity is enough to follow European Commission requirement (one tenth of all fuels used) by the year 2020. Conversely, over the last couple of years the capacity has not been reached due to the EU regulations that had an upper limit for biofuel additives. Last year 89k tons of biodiesel and 39k tons of bioethanol has been produced while it is expected that this year the production is to increase to 110k tons and 40k tons respectively. (Ministry of Agriculture of the Republic of Lithuania, 2011).

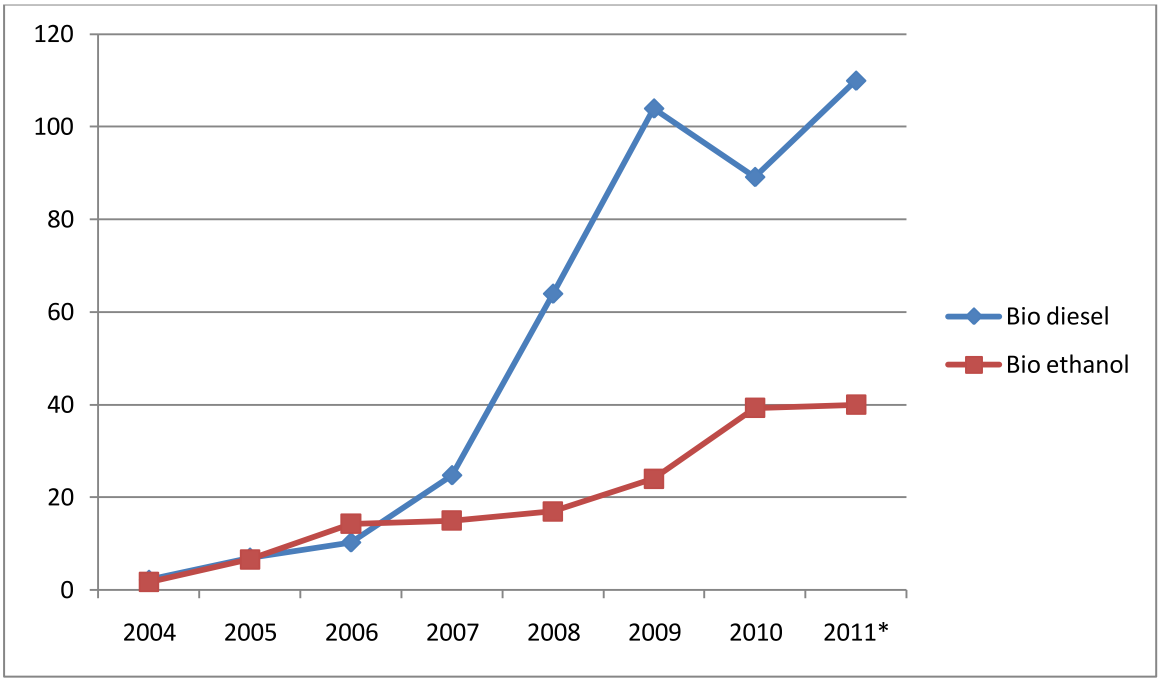

Figure 4-1 Bio fuel production in Lithuania 2004-2011, (thousand tons)
*Source: (Ministry of Agriculture of the Republic of Lithuania, 2011), * Planned*

Biogas production, on the other hand, faces different issues. There are seven operating biogas plants in Lithuania, yet all of the energy is used in the cogeneration process to simultaneously produce electricity and useful heat (Jakubauskienė, 2010). The major problem related to biogas adoption in the transport sector lies within the absence of related legal regulations. Biogas producers can only sell electricity since. Rules and quality standards to supply biogas to the pipes as well as to gas stations might not be prepared until the end of 2014 (Mano Ūkis, 2010). Biogas infrastructure building permits are also hard to receive due to bureaucratic procedures (Ministry of Agriculture of the Republic of Lithuania, 2011).

Yet, bureaucratic obstacles are not unaccompanied. Today there are many advising to use arable land to grow corn for biogas in Lithuania. However, Rimas Lipskas, director of the crop production department at the Chamber of agriculture, argues that the use of corn as a stock to produce biogas would most likely increase the cost of the biogas. As a result, it would reduce its competitiveness. The best stock from economic and environmental point of view is the organic waste materials such as pig farm sewage or water treatment plants' sludge. In the existing conditions biogas production is likely to be profitable only when electricity and heat is being sold. Otherwise the technology is expensive and gives profit if its power is over 500 kW, while in Lithuania the government supports only plants up to 250 kW. (Lipskas, 2011)

The production of biogas is more costly than fossil fuel, thus a governmental support is needed, yet after 2010 fewer biogas power plants qualify for this support (Žukas, 2011). Biogas is also available only on local scale, while natural gas comes in large quantities. Finally, natural gas, although a fossil fuel is considered to be a reasonably clean fuel. Therefore, it is difficult for governments to promote and support another clean fuel, but for a much higher price (Plombin, 2003). Nonetheless, the natural gas will eventually come to an end while biogas will always be available. It is also evident that these obstacles will have to be dealt with if this type of renewable energy is not to be wasted.

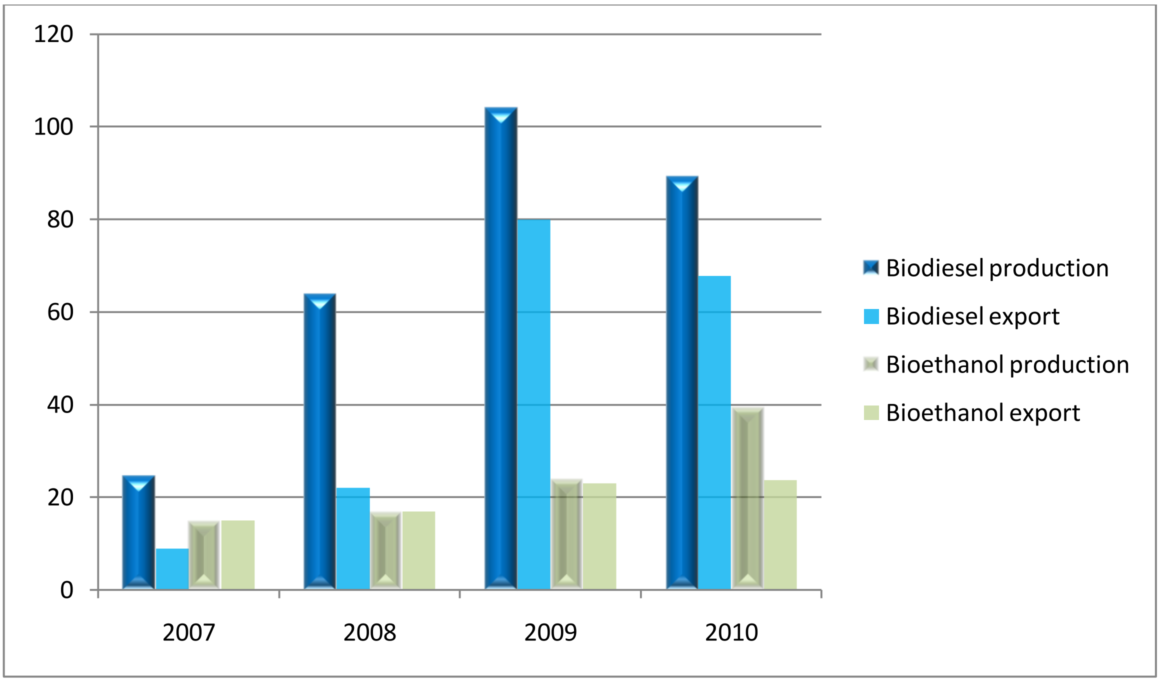

Figure 4-2 Bio fuel production and export share 2007-2010, (thousand tons)
Source: (Ministry of Agriculture of the Republic of Lithuania, 2011)

Overall, the future of biofuel production in Lithuania seems to be optimistic – it should not be hard to produce enough biodiesel and bioethanol to meet the EU requirements for additives in diesel and petroleum. As seen in the Figure 4-1 earlier, the capacity has not been fully used yet. Additionally, local consumption makes up just a small share compared to export of locally produced biofuels, thus, the export part may be reduced if necessary (see Figure 4-2). Together with a growing production, ethics of biofuel, however, must remain on the agenda since potential food stocks and agricultural land are used to produce fuels instead of food. This aspect is important since as many as three tones of grain are required to produce one tone of ethanol and a similar ratio is that of the rapeseed methyl ester (Lipskas, 2011).

4.1.2 Agricultural trends

In 2010 (May 3 – September 30) Lithuania conducted its first farm-level Agricultural Census since its accession to the European Union. The census involved over 450,000 farmers and family farms, agricultural companies, and agricultural-related enterprises. The final data is not to be published until 2012; however, preliminary data revealed that farm consolidation initiated by the EU accession process resulted with 27% fewer farms. Yet, the land area in agriculture expanded nine percent and the average farm size increased by 48%. (Kingsbury, 2011)

According to the Census, utilized agricultural land made over 2.7 million Ha. Out of that number, over 2.1 million Ha were used as an arable land while more than 21,000 Ha were present as unutilized agricultural land. Major changes in crops sown have been noticed. Sown area decreased for potatoes by 60% and for sugar beats by 40%. Yet, sown area for cereal crops increased by nearly 17% while for rapeseed – 385% to 256,000 Ha in 2010 (Kingsbury, 2011). The numbers show that farmers prefer to grow cultures that not only can be used for alimentary products, but also as a potential raw material for biofuels. It is, however, a speculation of data while a true reasoning motivating most of the farmers is still unidentified. Nevertheless, it is obvious that the potential stocks for biofuels production have been increasing over the last few years.

4.2 Accessibility

Barriers to accessibility have been chosen as the second element. This element mostly encompasses legal and geopolitical aspects that are affecting the production of biofuels in Lithuania. According to Asia Pacific Energy Research Centre (2007), originators of 4 A's model, the lack of financial subsidization, lack of commitment to promote the use of renewable energy as well as limited access to advanced technology are the possible constrains limiting accessibility to renewable energy. A commitment to promote biofuels can be well illustrated based on the legal system, therefore, relevant legal background of EU and Lithuania is discussed below. Access to advanced technologies in any sector is being limited by the large financial investment burden that is required to start the production. Biofuels are no exception. A large amount of capital is required to build or convert existing plants i.e. ethanol to other biofuels and/or adjust present military transport technology to biofuels. Therefore, existing support from national government to install advanced biofuel technology as well as technological barriers are also presented in this chapter.

4.2.1 EU Biofuels Directive

EU Directive 2003/30/EC, on the promotion of the use of biofuels or other renewable fuels for transport, set a required use percentage for all European Union members to be reached by the end of 2005 and 2010. As of this year, a volume of 5.75 %, calculated on the basis of energy content, of all petrol and diesel for transport purposes placed on countries' markets, should have been used by each state. According to the European Parliament and the Council Directive 2003/30/EC, at least the following fuels shall be considered as the biofuels:

- Bioethanol – ethanol produced from biomass and/or the biodegradable fraction of waste;
- Biodiesel – a methyl-ester produced from vegetable or animal oil, of diesel quality;
- Biogas – a fuel gas produced from biomass and/or from the biodegradable fraction of waste, that can be purified to natural gas quality;
- Biomethanol – methanol produced from biomass;
- Biodimethylether – produced from biomass;
- Bio-ETBE (ethyl-tertio-butyl-ether) – produced on the basis of bioethanol (the required percentage by volume to be consider as biofuel is 47 %);
- Bio-MTBE (methyl-tertio-butyl-ether) – produced on the basis of biomethanol. (the required percentage by volume to be consider as biofuel is 36 %);;
- Synthetic biofuels – synthetic hydrocarbons, produced from biomass;
- Biohydrogen – hydrogen produced from biomass, and/or from the biodegradable fraction of waste;
- Pure vegetable oil – produced from oil plants through pressing, extraction or similar procedures. (EU Parliament and The Council, 2003)

4.2.2 EU Renewables Directive

The European Parliament and the Council Directive 2009/28/EC, on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, states that a 20 % target for the overall share of energy from renewable sources and a ten percent target for energy from renewable sources in transport would be appropriate and achievable objectives. Thus, it endorses the following compulsory objectives. One fifth of the overall Community energy consumption by 2020 shall consist of energy from renewable sources and a minimum target of 10% shall be achieved for the share of biofuels in transport petrol and diesel consumption. Inter alia, it shall be introduced in a cost-effective way. (EU Parliament and The Council, 2009)

The Directive argues that despite the incentives for biofuels use provided in it and the growing demand worldwide it should not have the effect of encouraging the destruction of bio diverse lands since finite resources that are recognized in various international instruments are of value to all mankind and should be preserved. It also provides some requirements that the biofuels must meet. The greenhouse gas emission saving from the use of biofuels must be at least 35 %. Starting 1 January 2017, the greenhouse gas emission saving shall be at least 50 % and at least 60% from 1 January 2018 for biofuels and bio-liquids produced in installations in which production started on or after 1 January 2017. (EU Parliament and The Council, 2009) National legal acts related to the biofuel use in the Republic of Lithuania are discussed next.

4.2.3 Renewable sources energy law of the Republic of Lithuania

Renewable sources energy law (2011) is to assure sustainable development of energy produced from renewable sources in the future; to further stimulate advancement in innovative energy technology and its application; to assure sustainable use of renewable resources. The main goal of the law is to achieve that by 2020 not less than 23% of total energy consumed would come from renewable energy and that by 10% of renewable fuels would be used in the transport sector. This law also meets the requirements set by EU Directive 2009/28/EC. (Seimas of the Republic of Lithuania, XI-1375, 2011)

4.2.4 Energy law

Energy law of the Republic of Lithuania (2002) determines main national energy goals. The law also states what executive governing bodies are to oversee the energy sector and assigns their responsibilities for this matter. According to the document the Government of Lithuania creates and executes national energy policy. In the meantime, Ministry of Energy together with Ministry of Transport and Communications, as well as, Ministry of Environment are the core governing bodies responsible for national energy policy implementation. (Seimas of the Republic of Lithuania, IX-884, 2002)

4.2.5 Lithuanian national energy strategy

National energy strategy (2002) has set up a line of action in the energy sector for the twenty years period. In order to promote local production and ensure environmental protection the priority has been put on the renewable energy sources. The strategy commits to continual improvement of conditions and legal base for biofuel production and use in Lithuania. Also, according to the document, oil reserves were to be established by the year 2010 to be enough to supply needs for a ninety days period in case of any supply disruptions. (Seimas of the Republic of Lithuania, IX-1130, 2002)

4.2.6 Biofuels and bio-oils law

The goal of the law is to promote production and use of renewable energy sources (solid and liquid biofuel, and bio-oil) that would correspond to the EU legislation. The law requires conformity with the EU directives to meet the minimum volume of blends in gasoline and diesel fuel. It also requires that European standards for the biofuels would be met. Biofuels and bio-oils law of the Republic of Lithuania (2000) aims to reduce energy dependency from fossil fuel imports; promote local production and reduce environmental impact. It assigns Ministry of Agriculture to support biofuel production through the promotion of biomass cultivation. Ministry of Agriculture, together with the Ministries of Environment, Energy, Education, Transport and Agriculture are to coordinate actions to publicly endorse the use of biofuels. (Seimas of the Republic of Lithuania, VIII-1875, 2000)

4.2.7 Biofuel production development funding rules

Minister of Agriculture order No. 3D-132, *biofuel production development funding rules*, describe the subsidy system for locally harvested rapeseeds and grains that are being used for local biodiesel and bioethanol production. The target group of this subsidy system is the local biofuel producers who may suffer from the increasing stock price (Minister of Agriculture order No. 3D-132, 2004). The government is covering a part of the raw stock cost. A limit of subsidized raw stock is revised yearly. Currently, a subsidy of 160 lt. (EUR 46) is being paid for one ton of rapeseed and 114 lt. (EUR 33) for a ton of grain. The support is adjusted according to the production capacity of a certain plant and its profitability which must not exceed 5% per year. (Ministry of Agriculture of the Republic of Lithuania, 2011; BioenergyBaltic, 2011) Other fiscal tools encouraging the use of renewable energy sources in Lithuania include value-added tax, excise duty for fuels, income tax, natural resource tax, oil and natural gas resource tax and pollution tax. Fiscal tools concerning renewable fuels in Lithuania are designed by two laws: *excise duty law* and *environment pollution tax*. (Janulis & Makarevičienė, 2004)

4.2.8 Excise duty law

Excise duty law of the Republic of Lithuania foresees a reduction on excise duty for energy sources produced from biomass (as it is defined in Biofuels and bio-oils law of the Republic of Lithuania) including bioethanol and fatty acid methyl esters. A reduced excise duty is also applied to blends with fossil fuels. A reduction on duty corresponds to the percentage that a renewable energy fuels make up in the blend i.e. a diesel fuel with 10% of biodiesel in it would receive a 10% lower excise duty. (Seimas of the Republic of Lithuania, IX-1987, 2004)

4.2.9 Environment pollution tax

Environment pollution tax of the Republic of Lithuania also foresees fiscal support for biofuel users. Private or corporate person is exempted from the tax if pollution is being caused from a mobile transport vehicle that uses biofuels. However, some requirements must be met first. Biofuels must fit the standard and the owner must provide a document proving the use of biofuels (Seimas of the Republic of Lithuania, IX-720, 2002).

4.2.10 Subsidies for biogas

Biogas production is subsidized for small plants (2007-2013) by three programs: “Agricultural land modernization”, “Transition to agriculture” and “Support to business development”. Last two programs require selling at least 50% of produced electricity to the national network. A support to one project is up to 1.7 million lt. (EUR 490,000), however, due to the excess demand, application process has been stopped. Larger projects of a value exceeding 18 million lt. (EUR 5.2 million) have also been subsidized by the Ministry of Agriculture; however the funding has reached the limit as well. (Mano Ūkis, 2010)

4.2.11 Sustainability control

According to Directive 2009/28/EC, biofuel producers and exporters should consider installing voluntary sustainability schemes. National biofuel sustainability control method is being installed where the National Paying Agency and the Environment Protection Agency should be supervisors. The Ministry of Agriculture does not consider installing additional control so that an administrative burden for farmers is not increased. The present control scheme for good agricultural and environmental requirements is being utilized. It has been in use since 2004. (Ministry of Agriculture of the Republic of Lithuania, 2011)

4.2.12 Technological barriers

Today NATO members and its allies use Single Fuel Concept (SFC) that has been started in the U.S. in late eighties and early nineties. The logic behind this policy has been very clear – to simplify fuel operations for deployed forces i.e. tactical vehicles, aircrafts, electricity generators to use the same fuel. After gasoline turbine powered equipment started experiencing troubles especially in low temperatures related to paraffin hydrocarbon content in the diesel that forms wax-like particles, experimenting with a 50/50 blend of diesel fuel and aviation kerosene fuel (JP-8) began. It was later decided to use only JP-8, again, to simplify fuel operations – one instead of a blend of two. Experiments have shown no major differences when compared to diesel fuel. (Le Pera, 2005) NATO later applied F-34 title to this fuel which despite the overall success revealed some flaws in operations.

Smoke that was produced by JP-8 did not fit some of the exhaust system smoke generators. Hot starting issues and loss of power have been noticed on certain families of engines. A 6.5-liter with the commercially manufactured Stanadyne fuel-injection pump has been one of them. This engine has been powering HMMWVs that experienced multiple issues in Iraq. Other failures included, sustained operation during high temperatures, corrosion, increased wear and leakage of some engine parts as well as lack of enhancing additives such as corrosion inhibitor and lubricator. All in one, diesel vehicles with rotary-distribution and fuel-injection pumps seemed to have significant issues. None of this has been noticed during the test period. Partly due to lower temperatures and different qualities of fuel that has been supplied. (Le Pera, 2005) Other later tests also proved JP-8 to have same or better qualities than diesel fuel (Fernandes, Fuschetto, & Filipi, 2007). SFC has been strongly supported by the authorities and presently it applies to all deployed forces, including Lithuanian (Bernatavičius, 2011).

In the report published by RAND Corporation (2011), a nonprofit organization that has been originally formed to offer research to U.S. Armed forces, it is claimed that biodiesel and bioethanol are not suitable for military purposes and next generation synthetic fuels are proposed as an alternative. Since this study limits itself to first generation biofuels RAND Corporation proposal will not be discussed, however, the remarks on bioethanol and biodiesel are to be mentioned. According to them, bioethanol production is increasing in the U.S., yet, this fuel is unsuitable to military since nearly all power systems are designed for jet (F-34 or JP-8) and diesel fuels, additionally its volatility, low energy density and a tendency to attract water is mentioned. Biodiesel is incompatible since it contains fatty acid methyl ester (FAME) that are banned by USDoD due to possible water entrainment, microbial contamination, low thermal stability and a high freeze point. All in one, although widely accepted in civilian markets in U.S. and Europe, these biofuels are unsuitable since they pose safety risk, generate maintenance problems, and complicate fuel delivery and storage. (Bartis & Van Bibber, 2011)

A similar research has been carried in Sweden by the Swedish Defence Materiel Administration in 2007 and 2008. Specifications that it had to meet included a minimum change to diesel engines, least investments, biofuel availability in other countries for example Afghanistan. The conclusion was similar to that of RAND; synthetic diesel based on bio components was named to be superior to biodiesel with FAME. However, their main reasoning was related to local biofuel incompatibility with biofuels produced abroad and the long vehicle storage time that sometimes might be up to four years with the fuel in the tank - during the long period of time the biofuels may lose its quality and negatively affect the vehicle's fuel system. (Holmberg, 2011)

On the other side of the coin, there are reports claiming biodiesel, especially that of a high quality, to be a proper replacement for diesel fuel. Although lower biodiesel energy content reduces engine power up to five percent it provides less engine wear and less air pollution.

Major technical barriers include deposits and clogging as well as low cold weather performance. Nevertheless, these issues might be overcome when high quality biodiesel (fully transformed from oil to biodiesel) and some additives are used. Pure biodiesel proved to operate well to about 5°C while winter blends were effective at -20°C and below. All in one, high quality biodiesel can be used in exactly the same manner as petroleum diesel fuel. (Ciolkosz, 2009)

4.3 Acceptability

Most of the scholar articles related to energy security discuss acceptability in environmental dimension providing advantages and disadvantages to the environment of various mineral fuels. Biofuels are no exceptions since the environmental impact they cause are widely discussed. Diverse unintended negative environmental impacts during production are mentioned as a major drawback of renewable fuels that are overall admittedly seen as a viable and attractive fuel especially in transport sector (APERC, 2007).

Savickas (2006) argues that results of various researches and studies on biofuel usage in transport are often insufficient and controversial due to the lack of scientific and application experiments such as those on the impact of biofuels to the parts and operation of engines. These factors are slowing the process of biofuel adaptation in Lithuanian market. Additionally, together with expanding biofuel production mostly positive environmental aspects are mentioned which at times misguides public opinion in the country. (Savickas, 2006) Admittedly one truth applies here – "a combusted liter of biofuel will never perform better for the environment than a non-combusted liter of fossil fuel" (Bessou, Ferchaud, Gabrielle, & Mary, 2011).

However, a negative environmental impact especially in the production phase is not the only negativity particularly when first generation biofuels are discussed. Ethical issues related to fuel production out of food stocks also arise and must be dealt with. Acceptability element shortly discusses environmental impacts and ethical issues linked to the production of first generation renewable liquid fuels. This literature review is by no means all inclusive, but it provides an insight on diversity of opinions related to environmental benefit of biofuels.

4.3.1 Biogas characteristics and impact on environment

Biogas are produced by the anaerobic digestion of a variety of organic wastes such as sewage sludge, wet manure slurries from agriculture, dry manures from animal beddings, waste from food processing etc. Anaerobic digestion process is made of the three main parts: pre-digestion treatments, digestion and post digestion treatment, see Figure 4-3.(NSCA, 2006)

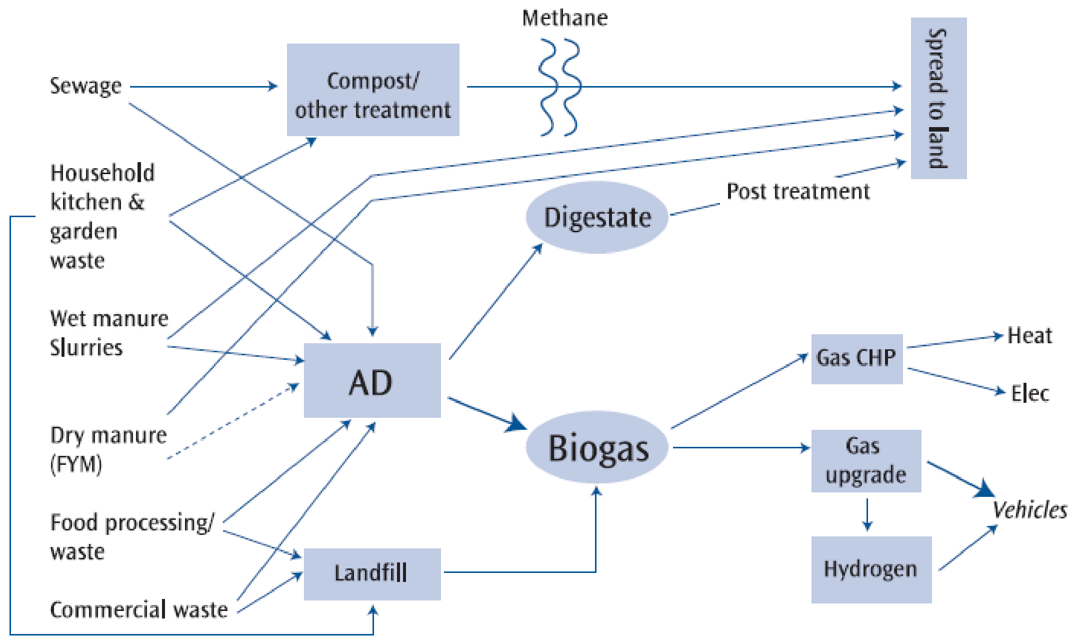

Figure 4-3 Biogas route map
*Source: National Society for Clean Air and Environmental Protection (NSCA, 2006), *AD – Anaerobic digester, CHP – Combined heat and power*

Similar to other biofuels biogas can be produced in a decentralized manner, yet it has a relatively higher efficiency. Compared to ethanol it yields two times the energy per hectare of energy crops and could take an average car twice around the world on a hectare's worth of biogas. It can also be obtained from a variety of biomass resources such as organic waste, manure, dedicated energy crops etc. More than that, the fuel can be used in two efficient ways. Firstly, as a gas for compressed natural gas (CNG) vehicles; and, secondly, as a fuel to produce power and heat in cogeneration process. (TheBioenergySite, 2008) Additionally, biogas can be considered as a possible way to gradually move to hydrogen as energy carrier. Biogas and hydrogen, if produced from sustainable sources, are renewable fuels. In addition hydrogen and biogas can both be distributed on the natural gas grid and used in natural gas vehicles. (Jönsson & Persson, 2003) Therefore, an emerging interest in the gaseous biofuel is not surprising.

When biogas is used as the transport fuel its purity specifications are the strictest compared to those used for heating or production of electricity. Biogas has to be upgraded to natural gas quality before it can be used in vehicles designed to use natural gas. Biogas as a fuel must contain a minimum of 96% of methane compared to 20% and 40% respectively. The amount of vapor must be lower than 15 mg/Nm^3, the H_2S content lower than 100mg/Nm^3 and the particles should not exceed 40 microns in size. Upgrading cost depends very much on the plant size. A small plant that produces less than 100 m^3/h may have a two to three times higher upgrading costs compared to a plant with a production capacity of 200-300 m^3/h. The electricity demand for upgrading relates to 3-6% of the energy content in the upgraded gas. (Plombin, 2003; Jönsson & Persson, 2003)

Biogas and compressed natural gas both consist of methane therefore the two can be used in parallel (Scania group, 2008). Compressed natural gas (CNG) used in vehicles are usually in gaseous form which is clear, odorless, and non-corrosive. When released, compressed natural gas will mix with air and become flammable. Yet it is flammable only when the gas mixture in the air is 5% - 15%. When the mixture has less than 5% or more than 15% of natural gas, it does not burn i.e. there is either not enough gas or the oxygen in the mixture. Natural gas is lighter than air, thus it dissipates promptly when released from tanks. (Consumer energy center, 2011) As a result, the CNG fleet consisting of over 8,000 CNG vehicles was involved only in 7 fire accidents and only one was directly related to failure of natural gas fuel system. Also no fatalities have been experienced in that particular research (Clean vehicle education foundation, 2010).

Today there are quite a few bi-fuel powered cars run by compressed natural gas or biogas with gasoline as a back-up. The engine uses separate fuel systems. It automatically switches to the back-up petrol system once the natural gas or biogas tank gets empty. A spark ignition engine which is used for CNG vehicles is 15-25% less efficient than diesel engine. It is yet cheaper and emits fewer pollutants. According to Volvo's calculations almost 100% of greenhouse gas emissions are reduced by their S80 bi-fuel model when it drives on biogas while CNG reduction approximates to 25% compared to gasoline. More than that, due to the difference in fuel price the operating costs of this bi-fuel car might be up to 60% less than gasoline cars and up to 40% less than diesel vehicles. (NSCA, 2006)

Overall CO_2 emissions from biogas fuelled vehicles may be reduced between 75% - 100% compared to fossil fuels. Additional emission savings may be achieved when liquid manure is used as a stock. In such a case up to 200% of emissions may be avoided due to the fact that liquid manure when untreated generates methane emissions that are 21 times more powerful as a greenhouse gas compared to carbon dioxide. Therefore, there is a double benefit from replacing fossil fuels in the engine ignition system and reducing methane emissions from waste manure. Finally, biogas improves local air quality by discharging lower exhaust emissions than conventional fuels when it is used in transport vehicles. (NSCA, 2006) Another advantage, apart from reduced carbon dioxide and particulates emission, is manure that can be used as a fertilizer (about 80% of it), while the process itself reduces nitrous oxide emissions. (Stenkjaer, 2008)

In civilian application biogas is recommended for urban transport mostly. It shows very good emission characteristics and can also fuel heavy vehicles, yet it can be applied only for short operation ranges. Gaseous fuel take a larger volume due its lower density compared to liquids, therefore the fuel tanks only allow to cover shorter distances. More than that, gaseous fuels require a costlier infrastructure. According to retailers, biogas is rather a future alternative to natural gas, since, today the infrastructure and production of biogas is very costly and cannot compete on the market (Statoil, 2011). However, from the technical perspective of retailers, there is no difference whether to sell natural gas or biogas. The use of local sewage or waste for biogas production has proved to be the most cost-efficient and sustainable method in supplying local city fleets with a clean fuel. (Scania group, 2008)

The safety of CNG vehicles in a civilian use is not disputed much. Natural gas pressure tanks that can also be used for biogas storage in a car are much thicker and stronger than gasoline or diesel tanks. In smaller fueling locations and on vehicles CNG may be stored in thick-walled steel, aluminum, or composite tanks that are made to last over 20 years. These cylinders are designed not to rupture when fully fueled over six times a day all year around which is far beyond what they will experience in real life. Industry standards test them even further. Cylinders must even withstand a bonfire test. More than that, a penetration by a 30 caliber (7.62 mm) bullet that is a standard for most NATO automatic rifles must be resisted without any rupture. Additionally, a research of a CNG fleet that traveled 178.3 million miles (286.9 million kilometers) shows that CNG vehicle injury rate has been up to 37% lower while collision rate was 31% lower compared to the gasoline fleet. (Clean vehicle education foundation, 2010; Arthurs, 2011)

Gas fuelled heavy transport that could best represent military needs, are quite expensive regarding fuel infrastructure installations on the vehicles as well as extra repair and maintenance. It, thus, cannot compete on pure economic ground with other fossil or bio fuels. Environmental performance regarding CO_2, particles, NO_x has been observed to be about equal of ethanol and biogas. It also depends on fuel source and feedstock that is being used to make it. Therefore qualities of bioethanol and biogas may vary. In Sweden, where heavy transport production is well developed, the ED95 (ethanol) originates from Brazilian sugar cane and the gas is normally pure biogas therefore emission reduction values of 70% or better are achieved. (Wästljung, 2011)

4.3.2 Bioethanol characteristics and impact on environment

Bioethanol is the most widely used biofuel in transport worldwide recommended for city and regional transport with a short to medium operation range. Its major advantage is commercial volumes that can be produced from a multiple feedstock such as sugar cane, beets, grain etc. Figure 4-4 illustrates bioethanol production process. Large sustainable volumes are also expected to be supplied in the future. It can be used as a pure fuel and in low blends. Bioethanol has not only been applied to cars, but also to heavy transport. Although, such examples are absent in Lithuania, some experiences can be shared from other European countries. According to Scania group (2008), one of the successful manufacturers of heavy transport, the same energy efficiency parameters as that of a standard diesel engine are met for their produced bioethanol fueled engines. A barrier to a wider application in their case is a lack of a local fuel supply infrastructure, thus Scania contributes towards its development (Scania group, 2008).

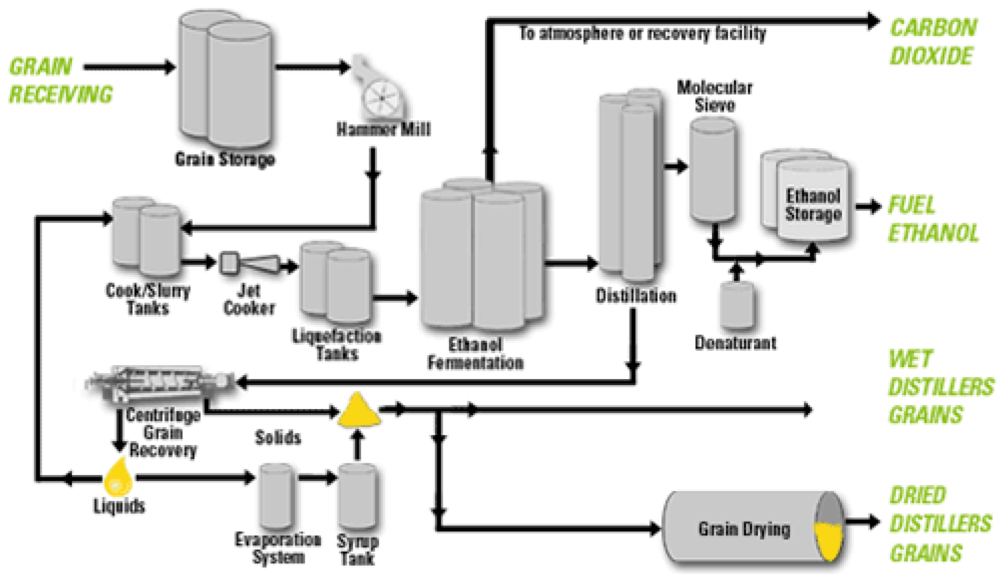

Figure 4-4 Bioethanol production process
Source: (LiquidMaize, 2006)

Some argue that the greenhouse gas exhaust emissions during the working phase of a vehicle and during its production process puts bioethanol in a disadvantaged position. On a tank-to-wheel basis biogas car enjoys a minor benefit over diesel and biodiesel, and a more significant benefit over petrol and ethanol cars. On a well-to-wheel basis bioethanol reduces the greenhouse gas by 30% compared to diesel while biodiesel reduces it by 50% and biogas more than 75%. (NSCA, 2006) However, ethanol is considered by them to be the most cost-effective renewable fuel in the market concerning availability, infrastructure and reliability of tested technology. It accounts for absolute majority (around 90%) of all available renewable vehicle fuels today. (Scania group, 2011)

Others claim opposite. According to them, fuel with bioethanol supplements is very efficient environmentally, yet economically it is not that efficient due to the lower energy stored in biofuels and that is a reason why its production requires government support in subsidies. CO_2 emissions when E85, which is also a common biofuel in Lithuania consisting of 85% of bioethanol, is produced using corn ethanol are reduced by 20%, taking into account a whole life-cycle of process, including production and distribution. Moreover, when E85 is made from cellulose materials i.e. corn, wheat stalks or forestry bio-waste the number can get as high as 75%. E85 also reduces the emissions of benzene and 1,3-butadiene while acetaldehyde emissions are increased (U.S. Department of Energy, 2010).

Bioethanol together with other conventional fuels must fully meet quality requirements that protect from detonation and minimizes harmful chemicals concentration in it. Therefore, various oxygenates are used in order to increase ignition properties and anti-detonation, yet according to EU regulations oxygen cannot exceed 2.7% in the fuel. Recently the most popular chemical used to oxygenate fossil fuels in Lithuania have been methanol. However, methanol has a higher toxicity compared to ethanol, it is poisonous for humans and is a potential contaminator of groundwater since it dissolves in water easily (Ziv, 2011). For these reasons, the priority has been given to the ethanol despite the fact that both alkanes are rather instable in the fuel mix. In Lithuania, dehydrated bioethanol used as an additive in the fossil fuels must meet the quality standards and get certified to prove it, see Table 0-2.

Stability is a key characteristic for automobile fuels. Savickas (2006) carried out an experiment of bioethanol stability in a blend with petrol in order to identify chemical lamination process. The test took 30 days, and the fuel mixes have been constantly moved from warm temperature (17-18 °C) to cold (0.5 – 1.2 °C). Ethanol share in a blend varied from 10% (E10) to 85% (E85). The experiment showed no signs of lamination, meaning that fuel blend remained as a single liquid, however, the results changed instantly once some water were added to the mix. In less then a minute all blends experienced lamination where ethanol and water sank to the bottom of the laboratory flask. This experiment also revealed that various blends with bioethanol decreased hydrocarbon emissions from a test vehicle, yet CO_2 emission in E10 increased compared to gasoline. (Savickas, 2006)

When production is evaluated according to fossil energy use ethanol has a positive energy balance i.e. the ratio of energy in the fuel to energy required to produce it. A goal is that fuel's ratio is less than one, or else, more fossil energy is being spent during the production phase than what is later received of a final product. However, another important aspect is not only how much of the total energy is being used, but also what type of energy it is. Today, due to the environmental causes and the depletion of fossil resources it is prioritized that the minimum amount of petroleum, coal and/or natural gas would be used in fuel production. The energy required to produce gasoline and ethanol is compared in Figure 4-5.

A total of 1.75 British thermal units (Btu) (1.8 kJ) of energy is required to produce 1 Btu (1,055 joules) worth of energy in ethanol. However, only 0.74 – 0.82 Btu (0.78-0.86 kJ) of fossil energy is required while the rest of the energy comes from sunlight throughout the photosynthesis process to grow the stock, which is corn, in this example. As a result, ethanol wastes a lot less fossil energy compared to gasoline (Andress, 2002; U.S. Department of Energy, 2010).

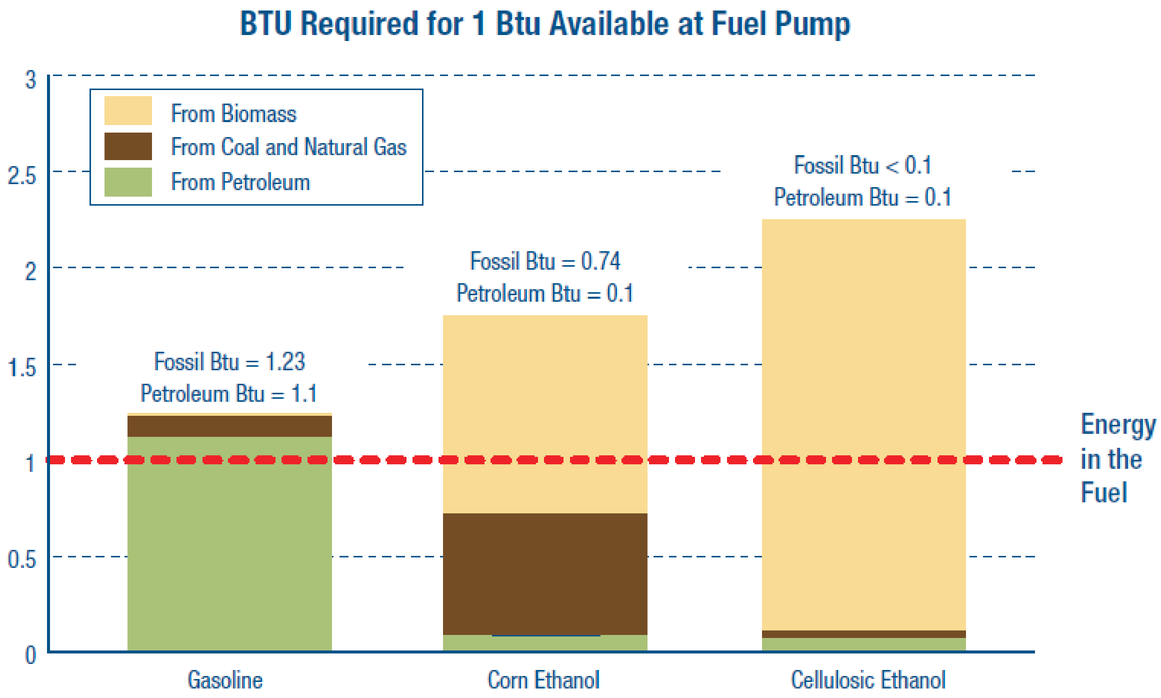

Figure 4-5 Comparison of energy required to produce bioethanol and gasoline. Source: (U.S. Department of Energy, 2010)

Since E85 is in a liquid form it requires only slight modifications to be adapted to fuel dispensing stations, including storage tanks, pumps, hoses and dispensers. Although, presently ethanol is being distributed via roads and rails some countries consider dedicating separate pipelines for this purpose especially when larger quantities of ethanol are used. Existing petroleum pipelines may not be used due to ethanol's affinity to water.

Considerable modifications are required to conventional cars to provide flexible fuel ability – to be fueled by E85 in parallel to gasoline (U.S. Department of Energy, 2010). The price to install flexible fuel system on gasoline fueled car presently starts from EUR 400 (UAB Altas). Other limitations include reduced fuel economy since E85 has a lower energy content compared to gasoline. This means that an automobile will drive about 25% shorter distance with a full tank of E85 than when it is fueled with petrol. The lack of infrastructure is another obstacle that reduces E85 attraction to customers.

Bioethanol may act as an octane enhancer and improver of combustion (Turcksin, et al., 2011). A blend of 10% ethanol usually upgrades an octane number of gasoline by one to the following number i.e. from 92 to 95 etc (Šimėnas, 2003). Nevertheless, producers recommend that blend with 10% of bioethanol should be used in unmodified vehicles; higher blends require technical changes in the car (Drąsutavičius, 2011). Ethanol does not harm nor clog fuel injection system in the engine due to the use of anticorrosive and other additives that are also used in petrol. Ethanol also increased antifreeze characteristics. A usual antifreeze additive in the petroleum is alcohol; therefore the more ethanol is in the fuel the more resistant it is to the cold weather. Ethanol releases sediments that form in the fuel system over the long run therefore it might clog the fuel filter. However, once the fuel system is clean again the engine efficiency increases. Ethanol does not blend well with a diesel fuel although experiments in Chicago city public transportation have showed significant reduction in air pollution when such blends were used. (Šimėnas, 2003)

4.3.3 Biodiesel characteristics and impact on environment

Biodiesel is a liquid fuel produced from esterified plant oil that can be applied for all types of operation and ranges. This biofuel is the most suitable for long distance coverage and heavy applications such as haulage. It is easy to handle and can be easily blended with regular diesel. Biodiesel or FAME (fatty acid methyl ester) is being made from various feedstocks with different quality features, see Figure 4-6 for production technology. Most common sources in Europe include rapeseed, jatropha and waste cooking oil. Production of biodiesel with outstanding combustion properties is also available in a synthetic way from biomass, waste and natural gas, but commercial volumes are not available yet. Nevertheless, it has a great potential as an alternative fuel in the future. (Scania group, 2008)

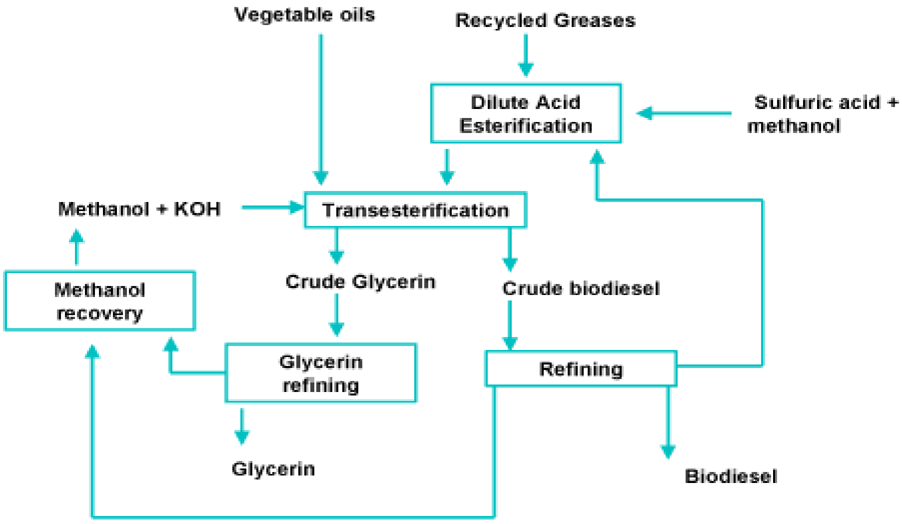

Figure 4-6 Biodiesel production technology
Source: (USDE, 2011)

The biodiesel may to some extent affect rubber parts in the car; however, researches have proved that a diesel blend with 30% of RME reduces these negative effects significantly. Lower blends of biodiesel can also enhance lubricity properties (Turcksin, et al., 2011). Additionally, biodiesel dissolves the deposits that build up in the fuel tanks, filters and pipelines over a period of time when a usual diesel is used. This rapid contamination may clog the filters and disorder entire fuel supply system. However, there is an easy solution to this problem. Before using the biodiesel it is recommended to clean the supply system and to change the fuel filters. Once this is done the system is likely to function more efficiently due to decreased contamination with sediments (Lukoil Baltija , 2010).

The optimum blend of biodiesel fuel is diverse and is claimed to be 30%, 35% or even 50% of RME. Biodiesel improves the lubrication of the engine. Smokiness is reduced by 60% compared to fossil fuels. RME also contains a larger amount of oxygen (10.8%) than diesel fuel, therefore it burns better in the engine. The temperature of the burst is over 1200°C for RME compared to that of 550°C for diesel. This is significant factor to the military since it secures a better fire prevention and thus are more suitable for the engines of the vehicles that carry people, explosives or flammable materials. It also suits better for stationary engines that work indoors. (Lukoil Baltija , 2010) A stationary power generation plant in the military is another way to put it for a good use.

The cetene number of diesel fuel is usually equal or higher than 51 while the minimum requirement during the winter season is 48. A cetene number of RME is also 51 meaning that these fuels are very similar according to this parameter. The cetene number is important since it shows how quickly the fuel is inflamed. The higher the number, the easier it is to start the engine especially during the winter season. The parameter that RME is not meeting is the ash-content. It not only increases a slag, but also accelerates the abrasion of cylinders of the engine. The recommended ash-content should not exceed 0.01%, yet RME contains up to 0.02%. Nevertheless, the ashes of RME are not differentiated by the same abrasive features as those of fossil fuels. (Lukoil Baltija , 2010)

A Swedish experience shows that for heavy transport operation economy is best for biodiesel with ethanol not being far behind. At a diesel price above ca 12 SEK/liter (EUR 1.3) those biofuels are competitive, but due to the operational life of a bus which is 10 years or more, it may experience fluctuation in price and therefore diesel may become cheaper. Biodiesel has been observed to have equal to or slightly higher emission of NO_x than fossil diesel and varying emissions of CO_2. In a life cycle perspective, the combustion emission of CO_2 is considered to be "renewable". Default values from EU say that biodiesel reduces CO_2 with ca 38% compared to diesel, but most Swedish RME is likely to show significantly better figures (60-65%) in a Life cycle analysis LCA. (Wästljung, 2011)

4.3.4 Ethical issues

Probably the biggest opposition to first generation biofuel production comes from those who blame it for aggravation related to food security in the world. Some recent reports have accused large-scale biofuels production of driving up food prices and increasing global food scarcity. More than that, some reviews argue that the poor are harmed the most by the rising food prices that are driven by increasing demand for biofuels. One of the example, is a so called "tortilla riots" that took place in Mexico late 2006 – early 2007. This widely publicized incident occurred when yellow corn increased in price significantly. Yellow corn has been imported from the US as an animal feed. White corn that is traditionally used to make tortillas was then started to use instead. This caused the price of white corn and therefore of tortilla, which is a staple food for poor, to skyrocket. It then made thousands of people to go out to streets protesting against it. In the end, Government had to subsidize the sale of white corn. Nevertheless, while there is a common consensus that biofuels production does contribute to increasing food prices, there is a lack of general agreement as to the extent of its impact (Nuffield Council on Bioethics, 2011). However, this is only one side of a coin.

The other side argues that biofuel production is a way to put on the market food stocks that otherwise would go to waste. More than that, it is even referred to as a type of economic support to local farmers since bioethanol producers, for example, in times of high grain yield are considered as a last option to sell the surplus of the harvest (Lukoil Baltija , 2010). Also, a rise in food prices usually incorporates multiple other significant factors such as high energy prices and currency fluctuations. Therefore, blaming biofuels alone for spikes in food prices does not seem to be a correct view on the matter.

Many studies can be found that argue the benefits of biofuels and GHG savings that are captured due to the period of the feedstock growth. However, most of it has failed to take into account indirect land use change (ILUC). This topic has become more relevant over the last couple of years. Searchinger et al. (2008) argues that carbon emissions occurring as farmers convert forest and grassland to new cropland in order to replace the grain diverted to biofuels drastically increases GHG emissions. Researches estimated that corn-based ethanol, instead of producing savings, would double emissions over the 30 year term and further increase GHG for the next 167 years (Searchinger, et al., 2008). Although, the results of the study have been highly contested, it brought up a discussion on the table that must be taken into account.

Other controversies include water usage, deforestation and contamination by chemicals. Both, corn and sugarcane, require four times as much water than the amount of ethanol is being produced in the final product i.e. 4 liters of water is used to produce 1 liter of ethanol, when gasoline requires only 1.5 liters of water. Additionally, agrochemicals used as fertilizers contaminate the underground waters. Finally, in some countries biofuel production threatens lands of high biodiversity as more land is being turned to grow feedstock for fuels (Nuffield Council on Bioethics, 2011). All of this must be considered when the wider use and application of biofuels is discussed.

4.4 Affordability

A major challenge for renewable energy is cost competitiveness. Alternative energy cost more than conventional energy due to its nature, specific construction and generation costs. Still, it is argued that if external costs are taken into account, renewable energy development will prove beneficial. A way to effectively reduce the cost of alternative energy development is through technology advancement (APERC, 2007). In this section investment affordability and users affordability is discussed.

4.4.1 Investment affordability

Randelli (2008) argues that production costs of biofuels vary depending on geographical location as well as on the prices of raw stocks. The extent of refining undertaken and the supplementary utilization of by-products and waste is important as well as the method of production that is chosen. Biodiesel and bioethanol contain less energy per liter than diesel fuel or gasoline; therefore the total cost should be compared based on the same energy equivalent.

Economic efficiency is directly related to the energy stored in a fuel which can then be calculated and compared. For example, calorific value of gasoline (Hg) is 43.950kJ/kg while ethanol (H_e) is 27.396kJ/kg (Savickas, 2006). The difference in heat properties of fuels is essential since they all have a different energy content therefore its cost cannot be compared based on its volume alone. It can be easily calculated that 10% of ethanol mixed with 90% of gasoline reduces the heat properties of a fuel by 3.7%. It means that E85 fuel would provide 32% less heat value i.e. an engine power decreases and more fuel are needed due to the lower energy intensity. This fact reduces biofuels attractiveness in the market. However, the heat loss might be partly compensated by the better ignition qualities of ethanol.

The following figure provides a cost of biodiesel and bioethanol in EUR per tones oil equivalent (toe) in 2006.

Fuel type	Feedstock	Source of cultivation	Costs (€/1,000 l)			
			Production	Distribution	Total	Total energy equivalent (€/tonnes of oil equivalent)
Biodiesel	Oil seeds	USA	514	49	563	647
		EU	605	47	652	750
Bioethanol	Corn	USA	241	46	287	428
	Sugar beet	EU	527	43	570	850
	Sugarcane	Brazil	195	46	241	359

Figure 4-7 Costs of biodiesel and bioethanol (EUR/toe)
Source: (Randelli, 2008)

However, it is essential to notice another significant factor that limits the expansion of local biofuel markets in Europe. As shown in Figure 4-7**Error! Reference source not found.**, despite the fact that the data is few years old, it is obvious that Europe faces a strong competition from US and Brazil. Yet, local biofuel competiveness is increased by the high taxes on conventional fuels that at times might be as high as 57% for petrol as it were in UK in 2008.

4.4.2 Users affordability

In the same 2008, the fuel tax made UK drivers to pay the most in the entire European Union. Spain had a tax of 31%, Italy – 45%, France – 48%, Germany – 52% (Winnett, 2008). Today UK fuel tax rate is 66 euro cents (50%) while Germany has an average tax of both diesel and gasoline equal to 55 cents (46%) (European Federation for Transport and Environment, 2011). In order to be competitive, biofuels cost should not exceed the prices of fossil fuels. As of August 21st, EU average price for a liter of gasoline excluding value added tax (VAT) was EUR 1.184 and EUR 1.106 for a liter of diesel fuel (Europe's energy portal, 2011). Having in mind, high crude oil price it is reasonable to expect that biofuels technology will evolve and its competiveness will increase.

5 Analysis

Interestingly enough, technology that is very common and broadly used in some organizations or countries may still be innovative in other industries or nations. Biofuels as a liquid fuel for transport has been known since the days of Rudolf Diesel and his engine that ran on peanut oil (Biofuel.org.uk, 2010). However, it has never been widely accepted and used in many sectors and organizations including the military. A new application of older knowledge may be considered an innovation as well as a fresh revolutionary discovery in science. More than that, many years might be required for new ideas to diffuse to other organizations or applications and yet after it is received it is still considered to be a "new" by the public that receives its benefits (Tornatzky & Lemer, 1992). For that reason the technology innovation system analysis has been chosen as a tool to discuss drivers and constrains of the biofuels' future in the armed forces.

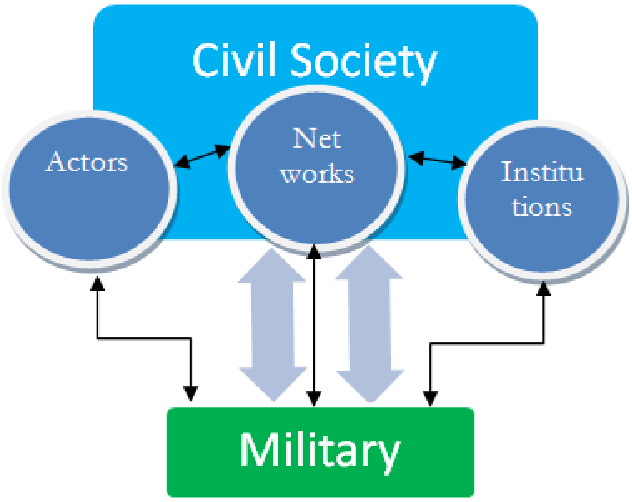

Figure 5-1 Biofuel-in-military TIS connection to civil society

Technological innovation is a driver and a result of a complex social, economic and political interaction. Decision makers in government and private companies face a challenge in predicting the course of technological change due to its complexity (Coates, et al., 2001). A technological system can be defined as a network of actors interacting in a certain economic area under a certain institutional infrastructure(s) and engaged in the generation (in terms of knowledge flows rather than goods or services) of technology. In the presence of an entrepreneur and an adequate critical mass, networks may be transformed into development blocks (Carlsson & Stankiewicz, 1991). What has been established within the three elements of TIS (actors, networks and institutions) related to biofuels development are discussed next.

5.1 Actors

Actors are clearly a significant element of TIS. Some actors generate ideas, others turn it into production and some are obviously using or consuming the product. Without actors TIS would not function and no innovation would get applied in the society. On the other hand, actors may not be aware that they belong to a certain TIS. This in fact is not so uncommon. Actors who surely know they take a leading part in innovation system are the prime movers. These actors are the first to apply the technology either for the benefit of their organization or to make profit from a perspective business model.

5.1.1 Idea generators

Idea generators in Lithuania are mostly located among Academia and researchers while the military's capabilities in this aspect are rather limited. A so called, research and development division (R&D) consist of only one person and an annual budget of only 250 thousand lt (EUR 72 thousand) (Juknevičienė, 2011). Major academic institutions dealing with biofuels and/or its applicability to transport include:

- Vilnius Gediminas Technical University: Faculty of Transport Engineering: Department of Automobile Transport; Department of Transport Technological Equipment; Department of Transport Management. Faculty of Environmental Engineering.
- Kaunas University of Technology: Faculty of Chemical Technology: Department of Environmental Engineering. Faculty of Mechanical Engineering and Mechatronics: Department of Transport Engineering. Institute of Energy Technology. Institute of Environmental Engineering.
- Aleksandras Stulginskis University (former Lithuanian University of Agriculture): Faculty of Agronomy. Faculty of Agricultural Engineering. Faculty of Forestry and Ecology.
- Lithuanian Energy Institute: Laboratory of Renewable Energy.
- Lithuanian Academy of Applied Sciences, Institute for Alternative Energy.

5.1.2 Producers

Local producers of biodiesel and bioethanol are the key actors allowing a discussion on the wider application of biofuels in the military. Local volume production is necessary to satisfy potential military needs and the capacity is here. There are four biodiesel and two bioethanol producers with a total production capacity of 220 thousand tons.

Table 5-1 Biodiesel and Bioethanol production capacity

No.	Biodiesel producers	Production capacity (thousand tons/year)
1	UAB „Mestilla“	110
2	UAB „Rapsoila“	30
3	UAB „Arvi cukrus“	12
4	KB „SV Obeliai“	8
	Total of biodiesel:	160
	Bioethanol producers	
5	UAB „Biofuture“	40
6	UAB „ Kurana“	20
	Total:	220

Source: (Ministry of Agriculture of the Republic of Lithuania, 2011)

There are also seven biogas plants operating in Lithuania that use various waste materials to produce gas. Eleven more are planned to be build in the near future. It is considered that as many as 200 biogas plants could operate in Lithuania. Today, ca 400,000 ha of agricultural land in Lithuania is lied waste. Therefore, if all the land that presently is not exploited be used for that purpose as much as 80 thousand cubic meters of gas could be produced, that would be equal to 40% of the annual natural gas usage in Lithuania (Jokūbaitis, 2011; Ministry of Agriculture of the Republic of Lithuania, 2011). Yet, until the standard for biogas use in vehicles is approved and other bureaucratic barriers are removed all locally produced biogas will be continued to use in a cogeneration process to produce electricity and heat.

Other actors contributing towards the production and market formation in Lithuania the most are the retailers. As shown in Biofuel network for transport, Figure 5-2, currently there are over 30 fuel stations that sell E85 fuel in Lithuania. This network is not sufficient for a comfortable use of a flexible fuel vehicle. The expansion of E85 sales, on the other hand, depends on the market demand. Today retailers argue that there are very few vehicles that run on E85, thus there is no reason to expand sales (Statoil, 2011). The network has been growing over the last couple of years though and is expected to grow in the future. Biodiesel, on the other hand, can be found in every single fuel station. However, it is used as a blend and is not being sold as a fuel by itself. The major retailers such as Statoil, Lukoil, Orlen and others claim that the EU required biodiesel blend is being bought from local producers first and then it is imported from other countries (Statoil, 2011). Yet the overall ratio is unknown. Nevertheless, these local retailers make up a significant market share for biodiesel producers in Lithuania.

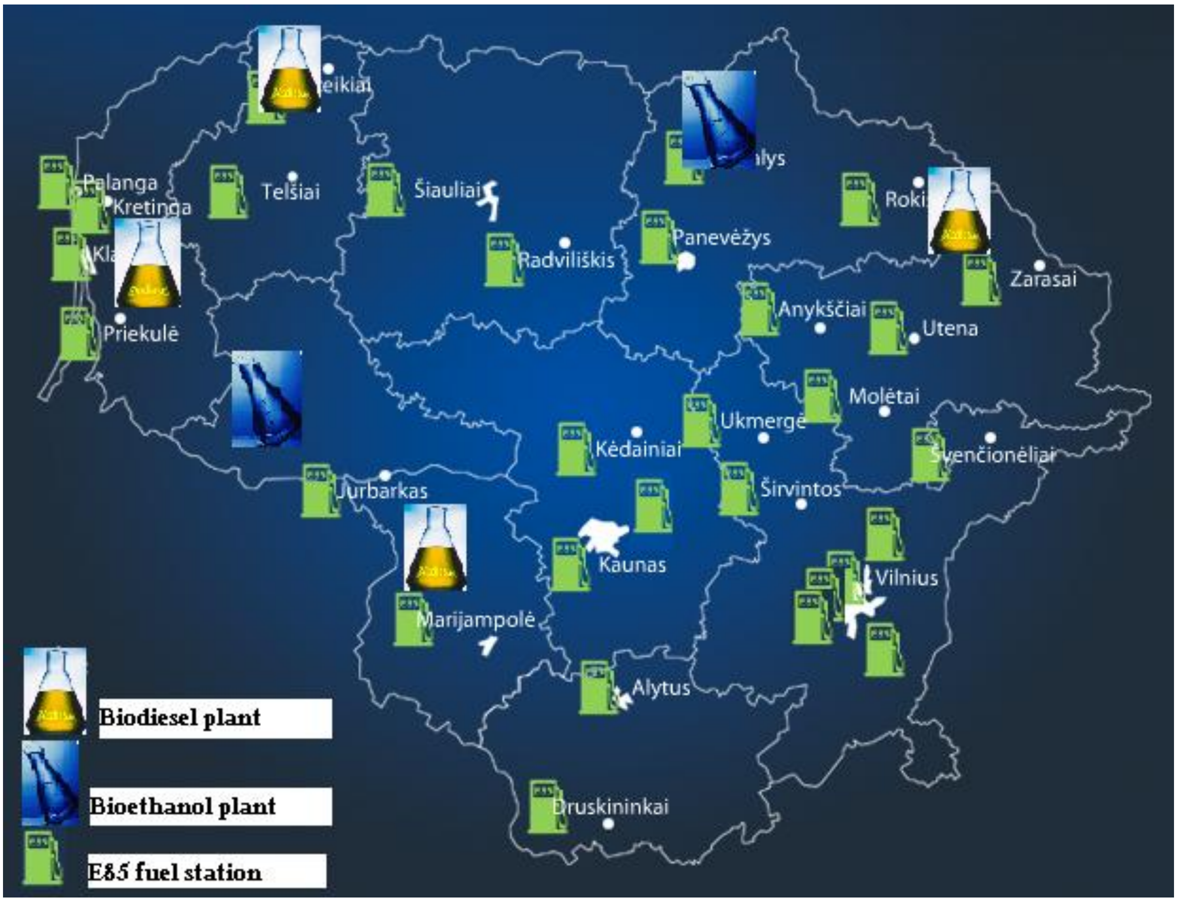

Figure 5-2 Transport biofuel network in Lithuania
Source: Adapted from E85 fuel stations (UAB Kurana, 2010)

Last but not least, companies installing equipment that enables to fuel cars with renewable fuels must be mentioned. Since Lithuania does not have any car manufacturers in its territory these companies together with renewable fuel retailers perform the initial steps of market formation by advertising the technology and its benefits, and by attracting first consumers. The success of such businesses is essential for the further thriving development of TIS. Although some companies such as UAB Altas experienced a failure to find a niche in the E85 market some companies continue their activities. It is even possible to come across web sites offering to purchase a flexible fuel system online and install it by yourself. The price is almost twice as low compared to those of a companies installing it, for a four cylinder engine – 755lt (EUR 219) and 1100lt (EUR 319) for 5-8 cylinders (E85EU adapters, 2010).

CNG market, on the other hand, is nonexistent in Lithuania. Main reason being the high popularity of liquefied petroleum gas that has had its customers for some years now, and due to the high difference in fuel economy between LPG and gasoline it is not likely that its popularity is to decrease any time soon. Conversely, LPG is seen nearly as the only economically feasible fuel for Lithuanians especially if taxes on diesel are further increased. Although, LPG is considered to have lower CO_2 emissions than gasoline, much of the advantage is lost when the LPG system is adapted to gasoline engines that are not engineered to take advantage of the low emission potential of LPG. In such a case the system is not optimally calibrated that often reflects on the vehicle performance, fuel economy, and emissions (Nett Technologies Inc.). Nevertheless, the choice of LPG among the people has very little to do with environmental aspect. Additionally, its characteristics make it not a viable option for the military purpose.

5.1.3 Consumers

It may seem that the only actor consumer in the TIS for biofuels adaptation in the military is and should be considered the armed forces of Lithuania. Nonetheless, it is important to follow all renewable liquid fuel consumers in the local market since they may affect the overall consumption pattern and trend, thus, affecting Lithuanian military that seem to be a follower rather than a front runner in this matter. Presently, fuels are bought on the open auction. The only requirement that the fuels would meets the criteria that is required at that particular season of the year. The major supplier over the years has been Mažeikiai oil refinery plant, presently owned by PKN Orlen, a polish oil refiner and petrol retailer in Lithuania (Kazlauskaitė, 2011).

Mažeikiai oil refinery, together with other biggest fuel retailers is among the major consumers of locally produced biofuel, having in mind that the absolute majority of it is still being exported. Lithuanian military, on the other hand, consumed 314 tons of gasoline and total of 2,458 tons of diesel in 2010, out of which 1,985 tons were used for Army needs and the rest to fuel Navy vessels (Kazlauskaitė, 2011). It seems that the consumption in 2012 is to increase. According to Central portal of public procurement (2011) Military of Lithuania has put up a public auction on purchasing 3,000 tons of diesel fuel named as for ships and vehicles, and additional 40 tons of diesel fuel for generators (CVPP, 2011).

5.1.4 Exemplary foreign prime movers vs. Military of Lithuania

Prime movers are the system builders that are usually equipped with technical, financial as well as political powers and are able to affect the development of technology extremely sturdily. An exemplary prime mover in the military world is USDoD. It holds all of the aforementioned powers. Needless to say, high fossil fuel prices are negatively affecting military capabilities at the same time reducing the overall probability of success in operations that it is involved in. USDoD has decided that energy innovations must be first accepted in order to significantly reduce fossil fuel use i.e. a movement from lab to market is necessary. To achieve that, USDoD applies three principles: a) economic and political support of energy innovations research; b) practical application testing and feedback to producers on its effectiveness; c) procurement of technology (Molis, 2011). Although, Department of Defense has little to do with the TIS that is being discussed, it is still a reference to see what is missing in Lithuanian military to become a prime mover.

A prime mover may be any actor in the system. There are multiple examples of civilian organizations or companies worldwide that initiated first moves towards renewable energy use that later were transferred to militaries. Swedish Biofuels AB is the one. This company could also hardly been called a prime mover in a wide sense since it was lacking political and financial capabilities, but it had technology; other necessary powers came later when political interest together with other organizations joined forces.

In summer 2008, the U.S. Ambassador in Sweden, Michael Woods contacted the Swedish Defense Minister with a proposal to establish bilateral collaboration in order to perform a demonstration on bio-based jet fuel in a JAS 39 Gripen aircraft. The Ambassador had been searching for innovative military solutions that would also be of interest to American risk capital when he came across the Swedish Biofuels AB that used a unique process for the production of a fully bio-based and carbon dioxide-free jet fuel. Swedish defense materiel administration (FMV) was then appointed to examine potential of such project. Later on, the project was started with cooperation between the US and Swedish Air Forces as well as Swedish Biofuels and the aircraft industry (Saab, Volvo Aero, General Electric). The biggest challenge of similar demonstrations thus far has been to get the fuel certified for combat aircraft due to the safety aspects. Therefore, the present demonstration concentrates on the properties of biofuel and its possible effects on engines and aircraft systems. The success of the project would also forward the development of biofuels applicability in the civil aviation. (FMV, 2009)

Sweden has also some notable prime mover initiatives in civilian transport sector when it comes to biofuel use. Scania, Swedish bus and heavy truck manufacturer, has received another large order by Keolis Sverige, public transport company at the beginning of the year. Over 120 new urban and suburban buses are soon to join Stockholm fleet. Stockholm is a cradle of Scania, committed to replacing half of its public transportation fleet with vehicles powered by renewable fuels by 2012, Another 35 will drive passengers on intercity routes. Scania manufactures ethanol, biogas and rapeseed methyl ester (RME) fueled buses. Scania has developed ethanol-powered trucks and buses since the late 1980s. Since then more than 800 ethanol-powered buses have been built for urban use in multiple European cities and Sao Paulo soon to receive its first 50 units. Keolis, at the same time, is seeking to strengthen its position in sustainable urban transport. Today, 45% of their vehicles run on either ethanol, biogas or biodiesel. The percentage should increase to as much as 60% after the new acquisition will start to operate by the end of the year. The company states that carbon-dioxide emissions are reduced by 70% using ethanol and by 64% using RME compared to conventional diesel engine. (Ethanol summit , 2011; Scania group, 2011; Keolis, 2011) Scania seem to have all the powers necessary to be a prime mover.

It is a relatively large company capable of producing large quantities of vehicles. It also has a tried-and-tested technology that has been used worldwide. Finally, political opinion and will in Sweden related to renewable energy also helps it to achieve its goals. The Scania success story with buses strongly depends on cooperation with some proactive Swedish public transport operators (Wästljung, 2011). Apart from being a prime mover, Scania also has a capability of building networks as such with Keolis (Keolis at the same time cooperating with Municipalities), which is essential for a further technology development.

Lithuanian ministry of defense does not come even close when compared to afore mentioned frontrunners. Although, there is a political will to support the military and its membership in NATO, the required 2% of the National gross domestic product (NGDP) have never been achieved since Lithuania has been accepted to this alliance in 2004. The budget of ministry of defense for 2011 is 871 million litas (EUR 252.2 million) or 0.85% of GDP, 3.3% of national budget for this year (Ministry of National Defense, 2011). Lack of financial capabilities naturally limits the adoption of innovative technologies and it is one of the reasons why Lithuanian Military can hardly be considered as a prime mover. It is neither able to procure innovative technology nor to support innovators financially. On the other hand, the present political leadership shows strong support to the military and sees the need to consistently increase its budget in the future (Juknevičienė, 2011).

5.1.5 Actors' analysis

Lithuanian military has a very limited R&D division with even more limited budget. R&Ds are usually idea generators in militaries that develop and apply innovations. Apart from that it cooperates with other institutions generating applicable ideas in civilian world. Ministry of National Defense of the Republic of Lithuania (MND) will have to invest more human and financial resources if it hopes for a wider application of biofuel and other innovations. Nevertheless, academic resources seem to be sufficient in the country to further develop biofuels for transport.

Resources in production are more than ample for military use in Lithuania. Despite the fact that production has been growing over the last few years, only a little more than a half of total biofuel capacity has been put to use last year. It is easy to calculate that the total present capacity of biodiesel alone allows producing 440 tons a day. This, in theory, is enough for all Army tactical vehicles (except administrative cars and BV-206, since the amount of these vehicles and its fuel consumption is unknown) to cover around 700 km/day! That is enough to drive across the Lithuania twice. While this year's spare capacity would let the whole fleet to drive more than 200 km/day. It proves that there is plenty of spare capacity. On the other hand, this capacity cannot be quickly taken advantage off since the distribution network is very limited in Lithuania. Therefore, it would be left up to the Military to distribute it however it sees fit the best. This is a barrier to TIS adoption in a peace time. In case of a conflict on local grounds location of biodiesel and bioethanol plants seem to be suitable for proper distribution of fuel in the whole country.

It is also worth to notice the agricultural trends. The farms have grown and lands sown with grain and especially with rapeseed have skyrocketed since Lithuania's integration to EU. This fact also satisfies TIS for biofuels in the military, since the potential stocks for biofuels are increasing. The same cannot be concluded about the producers of technical capacity. There are still some companies presently installing flex fuel systems, however, some has lost an interest in this business; although, the technology is available and may be even bought from the local stores online. Do it yourself principle seem to fit military, since it has the human capacity who should be able to accomplish it.

A relatively low consumption of fossil fuels by the MND has both advantages and disadvantages. Low consumption mean that only a tiny share of GHG emissions may be saved even if all fuels would be replaced to alternatives. More than that, a relatively small consumer has less power to shift the market trends than, for example, USDoD. On the other hand, Lithuanian armed forces liquid fuel consumption is just a little fraction of the overall renewable fuel production in Lithuania. Therefore, it seems that there should not be any obstacles to satisfy all its needs for biofuels. It would also contribute towards decreasing the gap between the capacity and the actual production of biofuels in local production plants.

Lithuanian military cannot be considered to be a prime mover in this field. Compared to foreign prime movers it is lacking practical application of biofuels therefore it is unable to provide a feedback to manufacturers, but most importantly it lacks an ability to procure the technology. Despite all this it provides political support and if considered as a part of government, in a wide sense, then it does provide economic help through subsidies. Nevertheless, without a prime mover TIS is lacking initiative, experience that could be followed and adapted by others. Without a prime mover the equilibrium remains unchanged in the system i.e. nobody is trying to update the system with innovative decisions, in this case it means that fossil fuels are not challenged by anyone or anybody. However, it is nearly impossible to predict when/if an actor becomes a prime mover and the situation changes.

5.2 Networks

Networking is closely related to the concept of “development blocks”. Development blocks are synergies among economic agents that go far beyond inputs and outputs exchanged in markets. The potential of the development block must be discovered by the entrepreneur. The role of the entrepreneur is to provide the vision that can turn a network into a development block. At times it might require large influence and financial resources therefore some noticeable “champions” are such as the U.S. Department of Defense, Japan’s Ministry of International Trade and Industry at the height of its influence (presently Ministry of Economy, Trade and Industry) or major business corporations. Another prerequisite is a favorable environment i.e. a “critical mass” of the resources for the development block. Resources include people, ideas, physical resources and infrastructure. (Carlsson & Stankiewicz, 1991)

National biofuels technology platform was created as a part of European initiative of technology platforms in order to incorporate Lithuanian biofuel market into European Union innovation sphere. The goals of this particular platform were to augment cooperation between the academic community and businesses; increase its competitiveness in European Union by attracting monetary, technologic and academic investments; adapt and prioritize strategic planning according to EU strategy; identify challenges and barriers in academic world in order to prepare competent specialist; lastly to get involved into dialogue with as many market participants as possible in order to identify their expectations.

The platform included major biodiesel and bioethanol producers as well as members from Vilnius Gediminas Technical University, Kaunas University of Technology, Aleksandras Stulginskis University, Lithuanian Energy Institute and Lithuanian Academy of Applied Sciences (NTPC, 2006). The opinions on the usefulness of this network are controversial. Liudvikas Rimkus, professor at the Vilnius Gediminas Technical University and a member of the board of the platform, said that National biofuels technology platform does not seem to be efficient and that it has not been operational for a while. According to him, out of 26 platforms that have been created only two are truly functioning (Rimkus, 2011). However, the other member of the board of the National biofuels technology platform, Asta Lapinskienė, argued that the platform was created to work on the laws related to biofuels and as an advisory body to the government. Therefore, after it has completed this task it stoped functioning (Lapinskienė, 2011).

The most expressed military and academia networking has been between the MND and Kaunas University of Technology, Institute of Defense Technology. The partnership has been lasting since 2000 when this Institute was founded. It also provided mutual benefits. The Institute of Defense Technology has contributed towards adoption of number of innovative technologies, although not related to biofuels, yet respectively MND helped to build its way to wider cooperation in international, NATO level.

5.2.1 Networks’ analysis

Presently there is no actively noticeable network that would be dealing with biofuel applicability in the military, although separate actors and even groups can be noticed. The most related network that has been officially created was the National biofuels technology platform where researchers, academia and entrepreneurs were all working towards developing biofuel production. However, the outcome of this platform is controversial, some argue for its benefits while others claim it was inefficient and unproductive. This raises the question whether such official platforms that have been purposely constructed are of any use. It is likely that such platforms would be more beneficial if they are created by the principle bottom-up i.e. with the initiate of producers, academia and not the government.

It is also likely that in some cases idea generators from academia would benefit from cooperation with the MND as have well been represented by the collaboration among Kaunas University of Technology and the Ministry of National Defense. MND might not be able to finance various researches or procure innovative technologies, but it sure could help in connecting research institutions (actors) dealing with biofuels to other military organizations with higher financial capacity. All in one, although not presently functioning, the network for biofuel TIS is existent; if not as a whole then as a sum of actors that are not aware that they are a part of TIS.

5.3 Institutions

TIS of biofuels are mainly driven by the local and European formal institutions. Viktorija Sankauskaitė, head of the renewable energy sources division at the Ministry of Energy, argues that bureaucratic tendencies limiting the actions of biofuel producers in Lithuania are no unusual for European practice. Despite that, bio-methane standards are likely not to be ready until the end of 2014. However, according to her, there are no certain obstacles it is rather the whole process that naturally takes a long time (Sankauskaitė, 2011).

Today, responsibility of biofuels production lies within a few ministries. Some argue that only one or two ministries should be responsible and are unhappy that some institutions like Ministry of agriculture must share responsibility of biofuels (Žukas, 2011). Others, however, claim that all related ministries should be involved and work together in order to achieve noticeable advancement (Savickas, 2011). Even large foreign companies like Scania emphasis that tax exemptions from CO_2 and energy tax for biofuels are vital for the renewable fuels technology to compete (Wästljung, 2011).

According to Lispkas (2011) a resistance is also felt from the Ministry of Energy: “they are not interested in small scale production since there are a lot of uncertainties with the supply. They want steady supply in big quantities, while the cost of energy is not that important to them” (Lipskas, 2011). There are no strict standards for biodiesel in Europe that is the reason why palm oil is being imported and used as additive in diesel fuel in many European countries; although if quality of various biodiesel is compared then rapeseed oil appears to be on top, soy oil being the second and palm oil with the worst quality. However, when it comes to the environmental aspect palm oil has the least negative affect (if not to consider ILUC), and rapeseed is on the bottom of the list. (Lipskas, 2011)

Nonetheless, the most important institution in the TIS for biofuels in the military is obviously the Ministry of National Defense. The political support from this institution to innovations is firmly expressed by the highest leadership. The Minister of Defense says that Lithuanian military has unquestionable political support yet financial difficulties that country is presently experiencing do not allow it to develop many innovations since budget holes must be fixed first. The Minister is yet confident in human capacity and Military’s ability to adopt technological innovations, however, ambitions must be well measured first and situation in the market must be considered. As one of the positive actions towards innovations the Minister mentioned the establishment of Energy Security Center this year. (Juknevičienė, 2011)

5.3.1 Institutions’ analysis

Although some Ministries claim that no barriers are purposely built and that it is a normal European practice to take a few years to adopt a fuel standard, it could be argued by many, that this process has a title – bureaucracy, and that it is an obstacle by itself. There seem not to be a reason to wait two and a half years for a standard that is already existent in some European countries for example - Sweden. Also there seem to be unwillingness to work towards promoting and developing innovative energy solutions simply due to the extra work that is required. Therefore, instead of providing help, although sometimes unintentionally, some institutions provide barriers.

On the other hand, institutions have given a lot of momentum to biofuel market. Lithuania is forced to follow EU directives and it has been one of the major drivers in promoting biofuel production in this country. The fact that farmers grow more rapeseed and grain has obviously a lot to do with the EU legal requirements for certain biofuel blends to be used in the transport fuel. Despite the foreign competition when some of the required biofuels are imported, such legal acts also motivate local entrepreneurs to start the production. However, the most important factor is innovation in the military support from the civilian leadership. Even with low financial capabilities political will might bring about some change in this particular technological innovation system.

Figure 5-3 A checklist of seven TIS functions

5.4 Entrepreneurial activities – check mark

Turning innovations into business opportunities is the first of the seven functions that must be check listed and satisfied in a case of successful TIS. Innovative technologies often face various uncertainties and entrepreneurs may help to detect and eliminate it by experimenting with an emerging technology and later directing it to the market. Entrepreneurs that are experimenting with alternative fuels in Lithuania are public transport companies. However, they apply the technology to the market to receive indirect benefit i.e. not by selling it, but by eco-branding the public transport as well as by saving expenses on conventional fuels. Buses in Vilnius city use diesel and petroleum with the same amount of biodiesel and bioethanol add in it as required by EU legislation. Experiments with the older buses and 100% biodiesel did not bring any success. Higher concentration of biodiesel requires engine adjustments or even replacement. Recently 100 new buses were bought that use compressed natural gas and may be later fueled by biogas (Rosocha, 2011).

The only true entrepreneurs in biofuel for transport sector are biofuel producers and companies installing equipment to adapt cars to renewable fuels. These companies test and experiment with equipment/production and try to direct it to the market as a business opportunity. It is challenging at the beginning to find a niche at the new market. However, at the same there lies a motivation behind it. AB "Biofuture" turned away from the alcohol production since bioethanol production market was a new one without other producers in it. It installed advanced zeolit ceramic membranes necessary for bioethanol dehydration and started the production. Presently half of the production is sold in Lithuania, half being exported. Their production is mostly used for fuel as ETBE or a blend in petrol as well as for chemical industry (Drąsutavičius, 2011).

UAB Altas, a company that specializes in automobile upgrading with various security, comfort and economy systems started to install Flex-fuel technology a couple of years ago. However, the experiment did not last long and less than a year after the start, they were made to discontinue it. The reason behind it was unreliability of a system. Car engine would not function properly and it needed to be recalibrated over and over again. Their first impression was that they were installing the equipment improperly, however, after the foreign experts' visit they were offered to check E85 quality. PKN Orlen confirmed, the fuel did not meet European standards. Lukoil, Russia's oil company operating in Lithuania and a major E85 retailer installed Flex-fuel systems into multiple of its cars. Yet, at least once a week every vehicle was forced to visit Altas to get fixed. Jurkša, Altas director of Kaunas division, says, that he personally would not mind to use the system despite its flaws, however, he would not dare to offer it as a reliable product to anybody else. When environmental aspect is the key priority and the car engine function is in the second place then this system might be beneficial. E85 drastically reduces emissions therefore is sometimes used to cheat during the maintenance inspection that is required every two years in Lithuania (Jurkša, 2011). These entrepreneurial activities are taking place in the civil market, however Military of Lithuania is not active yet.

The Minister of the National Defense of the Republic of Lithuania, Rasa Juknevičienė, believes that the military is capable of further developing new technologies yet some limitations are presently limiting this process (Juknevičienė, 2011). Lt. Col. Ona Tatolytė, Director of the Procurement department, at the Ministry of National Defense agrees that Lithuanian armed forces have major limitations at the moment including insufficient funding to support innovations. The present situation, according to her could be compared to the private life – one would like to buy a new hybrid car, but it is too expensive. On the other hand, military needs what is simple, tested and reliable. Bottom line: "there should be a national policy supporting such development otherwise it finds its place at the end of the list". (Tatolytė, 2011)

Similar policies are applied in other countries. The U.S. National Defense Authorization Act of 2007 commanded the Pentagon to produce or acquire 25 percent of its facility electrical consumption from renewable sources. As a result, the air force today is the major renewable power purchaser in the United States. (Karbuz, 2008) The U.S. Navy is being powered with a 3.8 megawatt wind/diesel hybrid plant, the largest of this type in the world. The Naval Air Weapons Station at China Lake, California, uses a geothermal energy plant. The Defense Department is also one of the largest customers of the U.S. biofuels industry representing nearly one tenth of the ethanol market and 0.6 percent of the biodiesel market. However, considering solely from the environmental perspective there are some drawbacks with these initiatives. Most of the Pentagon's efforts are concentrated on generating electricity, which accounts only for about 12% of military energy consumption compared to 75% of oil. (Karbuz, 2008; energyNow, 2011) Nevertheless, such actions show willingness to test large scale application of renewable energy that could possibly be later applied in the civil market.

Other attempts to save liquid fossil fuels include Navy ships and Army land vehicles in Germany, Sweden and U.S. (The Bundeswehr Transformation Centre, 2010) Some presently exploited hybrid propulsions drive amphibious assault ships not only uses energy-saving propulsion system, but also includes anti-fouling coatings to reduce drag and solid state lighting to increase energy efficiency. It is expected to save millions of Euros in annual fuel costs over the course of its lifespan (Energy and Environmental Readiness Division). Solar powered blankets' use should take off the significant battery weight of ammunition, which today amounts to an average 45 kg for each soldier. It is three times as much compared to the World War II (energyNow, 2011). Alternative liquid fuels are seen as a prudent insurance policy against high oil prices and future oil supply disruptions. Aircrafts, naval vessels, land vehicles as well as support equipment that use alternative liquid fuels have been started to certify by NATO countries. In the long term, alternative fuels are likely to be a significant part of the energy sector therefore there is a strong support to this development by investments in Research, Development, Testing, and Evaluation of alternative fuels. (U.S. Department of Defense, 2011).

5.4.1 The reasoning

It may be concluded that innovations, experimenting and the military does not necessarily go hand-in-hand today due to limitations mostly related to financial situation in the country. Lithuanian armed forces do not show any signs of entrepreneurship although there are reverse examples in the world. The aforementioned technologies, after it is tested and applied are very likely to be later adapted in the society and provide financial benefit to the country. Historically military has been an inventor and an entrepreneur. Radar, jet engine, internet, night vision are a few of innovations later successfully applied in the civil society. Obviously, not many militaries in the world can use similar resources that the U.S. military has, but political determination is also important.

It has been noticed, that at times a priority which is officially noted might get accomplished without additional financial expenses, this is proved by what some interviewees mentioned "it has to be on the priority list - otherwise it won't get done". Despite the fact that Lithuanian Military is not an entrepreneur – there are other civilian actors who although are lacking political power and financial capabilities are introducing biofuel technology to the wider market. For this reason it can be concluded that entrepreneurial activities in this TIS is existent in Lithuania and thus can be marked so on the checklist.

5.5 Knowledge development – check mark

Biofuel options must be well weighted before any big political initiatives are being started to implement. When options are properly weighted environmental benefit may be achieved, however, the possible negativities must be also considered. Economic benefit is also achievable, yet again, if everything is carefully taken into account: policies, subsidies, market, fertility of certain crops in local lands e. g. in U.S. due to its climate rapeseed are significantly more fertile yet investments are the same in U.S. and here in Lithuania etc. (Savickas, 2011)

Learning-by-searching principle is widely used in the Academia and among the researchers in think tanks. The number of academic institutions researching and developing ideas in this sphere is more than sufficient and results they provide bring up controversial discussion, which obviously benefit the technology. However, the missing link in this function is the guidelines that could be followed by the researcher's i.e. the government does not do enough to attract researchers for example by providing future plans for its organizations and what technologies it would like to acquire. Guidelines for Armed forces of Lithuania in energy security are also unclear, but hopefully a new National Military Strategy is to encompass that and researches will work to develop possible solutions.

The importance of developing the knowledge first before applying to any organization is hard to argue. Learning-by-doing process seems to be mostly applied by the producers of biofuels and other local entrepreneurs such as Flex-fuel installers in this TIS in Lithuania. They have the technology; they are participating in the local and international (producers) market, and most importantly they follow the trends and develop the knowledge on how biofuels must be produced or how the technology must be applied in the transport. For this reason the knowledge development function is present in TIS and can be check marked.

5.6 Knowledge diffusion – cross mark

After the new technology has been released it must enter the practice to become effective innovation only then it can be diffused to other possible users. However, complex technologies require considerable adaptation and accommodation by the users, therefore, their perspective is a significant factor. As a rule, adaptation is even more complicated when an adopter is not an individual, but rather a group or an organization (Tornatzky & Lemer, 1992). Success is achieved when many heterogeneous actors share their ideas and rely on the expertise of others.

Today there are multiple diverse opinions on what the drivers of a wider application of biofuels in civil society and the military are. According to some: “all three drivers (energy security, economic and environmental are equally important) for transition to biofuels” (Sankauskaitė, 2011). Others claim that economic benefit is the main and the single motivator (Lipskas, 2011). While the third party sees energy security and environmental aspects as the main drivers for the alternative fuels, while economic aspect is not that significant (Statoil, 2011).

It is obvious that different stakeholders see the situation differently, from their own perspective. However, it is also noticeable that they all are lacking the knowledge that the other actor(s) has. It must be reminded that knowledge diffusion very much affects their cooperation and the more complex the task, the more one is forced to rely on others. Therefore when actors are not exchanging the expertise they have with others it leaves big knowledge gaps in between the actors and the networks. The difference in the knowledge obtained by the various stakeholders concludes that the information is not properly diffused in the system; therefore the first cross is being marked.

5.7 Guidance of the search – cross mark

Guidance of the search is a selection process which is necessary in order to properly allocate resources and express the priorities in the country or an organization. The process that is noticeable in the biofuels-to-military TIS is a so called technological lock-in. It refers to: “macro level forces that create systematic barriers to the diffusion and adoption of efficient and sustainable technologies” (Carrillo-Hermosilla, 2008). To put it in simple terms, it requires a lot of human and economic resources to transfer to a sustainable technology when the whole system has been built around a certain inferior technology. In this case it is a Single Fuel Concept that the militaries are built upon. Although it proved to be working, it had a significant amount of technical barriers to be overcome. Now, when it is in use, all tactical weapons system must be adopted to use it, not vice verse.

This study limits itself to examine Lithuanian military’s ability to adopt alternative fuels and though on local grounds it use conventional fuels (diesel and gasoline) in the operations abroad it must use F-34. This fact limits its physical and psychological ability to search for better solutions that could be locally available. Tactical vehicles must be adapted to F-34 period. Instead of creating fuels that would match military’s requirements, its tactical needs based on local environment it is building military around a fuel. From tactical perspective, it is not preferable, again, due to energy dependency. A progress in this issue might be achieved when clear energy security guidelines to military are drawn. Today, there is no guidance of what alternative fuel we are searching for – cross mark.

5.8 Market formation – check mark

The core indicator showing whether a market is formed for the technology is demand in the market. Market structure is a significant factor for technology innovations. Markets may vary in scope, complexity, levels of competitiveness, in the potential for development, in its preferences etc. The role of the market is in essence to create competitive pressure rather than to test different alternatives (Carlsson & Stankiewicz, 1991). Successful new technology usually has a tendency to be broad up by the market demand that is initiated by the practical needs of individuals or social policy rather than a technology development. In other words, “market pull” is a stronger force for innovation compared to “technology push” (Tornatzky & Lemer, 1992). Various economic risks cannot be effectively absorbed by the entrepreneurs alone therefore the amount of innovative activities may be lower than socially desirable. Mechanisms which absorb some risks are necessary. Proper legislation, capital markets, fiscal policies, public procurement, subsidies and insurance schemes might encourage entrepreneurial activity (Carlsson & Stankiewicz, 1991).

Market demand is a key driver to many entrepreneurs and technologies. Scania claims it to be an essential factor, which depends on economy and to some extent to political opinion and the will (Wästljung, 2011). Lithuanian biofuel market reduced its attraction when the high prices of grain increased the E85 price, although during the earlier years when the price was significantly lower a lot of it was consumed. In a last half a year a price of E85 increased from 2.99lt per liter (EUR 0.86) to 3.65lt (EUR 1.06) while a liter of A95 cost around 4.50lt (EUR 1.30) (Degalukainos.lt , 2011). Today, the major issue is the E85 fuel that does not meet the standard, if the situation changes, Jurkša believes that it might find the niche among the drivers (Jurkša, 2011). Other local biofuel market issues include international competition. The major oil production company in Mažeikiai refuse to buy all of their bioethanol therefore it is safer for producers to export the bioethanol (Drąsutavičius, 2011). Market also reflects to ethical issues. The indirect land use change (ILUC) that is caused due to the expansion of croplands for ethanol and biodiesel production worry customers and it reflects the demand of biofuel related technology (Wästljung, 2011).

All this show many barriers that the biofuel market is facing today. The great expression of the struggling market demand is comparison between the true production and overall capacity that has not been reached. However, the trends are showing increasing demand. Additional user (military) would even further increase the demand which would use more of the present biofuel capacity in Lithuania. Other barriers include international competition and increasing biofuel stock price that is also affecting the price of bioethanol. This in turn reduces public interest in the technology. Nevertheless, the major market driver is EU. Its directives require biofuel blend to be used in conventional fuels and the amounts of these blends are to increase. This increases overall market demand for the product and technology. All in one, biofuel market is formed in Lithuania – check mark.

5.9 Resource mobilization – cross mark

Resource mobilization necessary for successful TIS should include financial, material and human capital through investments, subsidies, educational systems as well as mobilization of natural resources. Most of these resources must be within the organization where the technology is to be applied; clearly some of the possessions can be shared with other actors e.g. natural resources. Feedstock is an important resource to biofuel market. Savickas (2011) argues that careful calculations should be done first and experiments should be carried to test whether certain cultures are economically and environmentally feasible e. g. willows and wickers, although had been widely promoted, appeared to be a mistake in local lands. These measurements, however, are to be properly managed only when all related ministries will coordinate their actions together and decide on one goal. Business is to be involved, however, it should not create laws. (Savickas, 2011) Maskvytis (2011), the local farmer, who presses his own rapeseed oil argues that biodiesel producers affect the price yet not significantly. The major determinant of the price is the overall market, thus he also exports his production to other countries such as Estonia (Maskvytis, 2011). At the moment there is a shortage of grain therefore it limits the production. Banks refuse to provide loans due to the increased grain price. The major use of bioethanol in the future is in transportation although in Lithuania it only makes 2-3% of the production. Government subsidizes production – which is necessary to survive (Drąsutavičius, 2011).

Today it is claimed by many that mineral fuels are not to become any less admired in a near future. A trend, especially that in the transport sector, is leaning toward increasing their efficiency rather than drastically shifting to alternatives. Therefore, whether biofuels will ever have enough resource mobilized to their wider application is still a question. From what is seen in the civilian market it can be concluded that financial support from the government is effective, material and human capital is present and natural resources are sufficient. However, this is in the civilian market and for the military to adopt biofuels these resources must be available in the organization. Opposite, from the market formation where military might be simply one of the actors in the market. Today the military does not have resources mobilized for the biofuel adoption therefore it must be cross marked.

5.10 Support from advocacy coalitions – check mark

For a TIS to be successfully implemented in an organization it is not enough to have a knowledge, market and resources. A vital aspect is advocacy coalitions' support that can affect TIS directly or indirectly. Today when facing certain difficulties biofuel producers require more help from various institutions. The low price of the production is mostly affected by the "Rotterdam" i.e. imports from the strongly subsidized U.S. and Brazil, which is the largest economic barrier for competitiveness (Drąsutavičius, 2011). Higher taxes on biofuels than on fossil fuels in many EU countries construct a strong barrier to technology producers (Wästljung, 2011). These are examples where EU economic help would affect TIS indirectly – subsidies would increase the biofuel and transport technology production therefore it would be easier for a military to apply it.

Other indirect advocacy coalitions support for this TIS could be foreign militaries. They could either share expertise and knowledge (U.S., Sweden, Germany), show support to technological innovation or could lead by example e.g. British forces at Lashkar Gar base in Afghanistan are metering all energy consumption to meet base fuel consumption reduction in half by 2013 (energyNow, 2011). It would be an additional motivator to apply innovative technology, however, not strong enough to be a driver by itself – it is unlikely that Military of Lithuania would adopt biofuels or any other innovation just due to the support or knowledge from other militaries.

Advocacy coalitions capable of directly affecting TIS are also capable of taking the decision that certain innovations would be applied. In this case it is NATO and the Government of Lithuania. Although at times NATO is considered to be a "Gentlemen's club" without strict requirements to its allies, it is obvious that SFC is applied and used by all. Therefore if it decides to impact biofuel use it probably could. However, the most significant advocacy coalition is the Government of Lithuania. Military is just a tool that is used by political will, therefore if the policy is to adopt biofuels – it will be done. More then that the Government may influence that cooperation with other frontrunners would be achieved. Based on the information collected it can be concluded that political will and therefore support from advocacy coalition is existent. An indirect support is also visible from allies that are researching alternative fuels, as well as, from EU whose policies support biofuel development. Therefore, support from advocacy coalitions is check marked.

6 Discussion

The technological innovation system of potential biofuel applicability in the military has been analyzed through the three elements of TIS (actors, networks, institutions). Seven functions that these elements must fulfill: entrepreneurial activities, knowledge development, knowledge diffusion, guidance of the search, market formation, resource mobilization, support from advocacy coalitions, have been questioned and discussed. The complete checklist of this particular TIS is depicted in Figure 6-1.

Figure 6-1 A complete checklist of TIS

Three out of seven functions are unsatisfactory in this TIS. It shows that the application of biofuels in the military can not be implemented at this time due to the barriers in knowledge diffusion, guidance of the search and resource mobilization functions. Most of the underlying reasons have been mentioned in analysis part and appear due to the lack of resources or bureaucracy in local government. Despite that, one issue needs to be still elaborated on. It is a technological lock-in.

First of all it must be noticed that SFC was originally established to simplify fueling operations especially those in foreign lands. It seems it makes sense - one fuel is a great idea, it is easier to ship and use. Yet nobody is asking a question why it needs to be shipped in the first place since shipping or convoying is dangerous, time-consuming, expensive etc. Therefore it follows – there is no local liquid fuel source or the resources are insufficient. In such a case, these barriers are the core issues that in all logic should be targeted and addressed. It would be tough to argue that local fuel supply would benefit (tactically, economically) the military less than liquid fuel that are being shipped in. Wouldn't it be smarter to explore local resources in those foreign lands? Is a single fuel an advantage overall?

The SFC fuel has not been perfect since the beginning, and considerable technological difficulties occurred while first applying it. Nevertheless, the policy pushed it further and eventually technological issues have been fixed meaning that engines have been adapted to the fuel. As a result today, the requirement to all NATO allies is that their tactical transport vehicles would comply with SFC. Would have it been possible to adapt these vehicles to any other fuel instead?

Member countries, such as Lithuania before acquiring vehicles check that it would comply with this policy. This is an absolute technological lock-in that applies physically as in the case just mentioned and psychologically i.e. the mindset is directed to look only for alternative fuel that could be used in SFC vehicles. All researches discussed earlier in this study included this requirement – this study, funny enough, as well. However, how good of an alternative can you find when you are constantly trying to match it with something that is not even close to perfect? Yet one could ask a rhetoric question: "wouldn't it be better if vehicles would comply with MFC (Multiple Fuel Concept) – the more types of fuel it can use the better?"

7 Concluding remarks

Only three biofuels – bioethanol, biodiesel and biogas fulfill the requirements that enable it to replace mineral fuels. That includes sustainability, volume production and local commercial availability. Other possible alternatives, such as next generation biofuels, hydrogen, proposed by other researches are not commercially available in the world and will not be in the near future. All these aspects suggest that the only achievable short term solution is the first generation biofuels adaptation while at the same time researching other conceivable long term options.

Biofuels could be a great option as a strategic reserve fuel for military purpose. It would be locally produced and could be used to fuel transport and also as a fuel for electricity generation. Today the most viable option for alternative fuel in the military transport is biodiesel. Biogas although not an alternative as a transport fuel today, would not be feasible in a future as well, due to its characteristics i.e. gaseous form. On the other hand, bullet proof fuel tanks available in civilian market today could potentially fit MND gasoline cars that are not necessary used as tactical transport. This would reduce emissions and thus promote the Military as a frontrunner in the environmental field. Additionally, it would provide potential economic savings, given that biogas are cheaper than petrol.

There are a couple of reasons why bioethanol is unsuitable for military purposes. Its volatility, tendency to attract water are among them, however, the biggest issue is that it cannot be used in tactical transport vehicles since the transport is adapted to F-34 and diesel only. Even in non tactical gasoline vehicles ethanol (E85) use would require adapters. This investment although might look feasible appeared to be unreliable in the civilian market. It must be reminded though, that many of the issues related to E85 were related to its questionable quality, therefore if high quality bioethanol is used it is likely that the investment could be successful.

The last of the three locally produced biofuels that fits environmental and volume requirement is the biodiesel. The total present capacity of biodiesel production allows producing 440 tons of biodiesel a day. This, in theory, is enough for all Army tactical vehicles (except cars and BV-206, since the amount of these vehicles and its fuel consumption is unknown) to cover around 700 km/day! While this year's spare capacity would let the whole fleet to drive more than 200 km/day. However, technical issues apply to biodiesel. It is still widely discussed whether biodiesel harms the engine or not and whether pure biodiesel can be successfully used in a transport vehicles. Some argue that due to FAME characteristics biodiesel is unsatisfactory in cold season and negatively affects fuel supply system in the vehicle. Others claim that these barriers may be easily overcome if high quality of biodiesel is used and some additives are mixed in it; more than that, it cleans the fuel system and thus after the fuel filters are changed the vehicle runs more efficiently.

All in one, there seem to be a controversy whether a pure biodiesel is suitable as a transport fuel in the military and nothing, but on site testing could prove who is right. At the moment a fair conclusion would be that a blend of 30-35% biodiesel in a conventional diesel could be a best solution since it is more widely accepted as harmless to the engine and fuel supply system. It would provide environmental benefit and would 30% reduce the need of conventional fuels while promoting local biofuel production. From a tactical perspective, blending is a barrier in military operations, although in case supply of fossil fuels on local grounds is drastically affected then biodiesel could be put in for a good use.

8 Recommendations

In order to overcome cross-marked functions/barriers the following recommendations, mostly directed to the policy side, are advised that could not only benefit biofuels-in-military TIS, but potentially in applying other innovations in the military as well:

- Endorse National policy supporting the innovation development – it has been observed that at times economic constrains can be overcome, when human resources are available. In other words, if there is a national policy that clearly states priorities it is likely it will get accomplished despite the lack of resources that the country or organization might be facing – if energy security is on the top of priority list it will get accomplished eventually.
- Avoid bureaucracy, increase inter-ministerial cooperation – bureaucracy is a huge issue in many countries and thus far it has been lacking effective drugs to fight it, however, knowledge and expertise share could and should be implemented in inter-ministerial level.
- Form the guidelines to initiate think tanks – it is essential to clearly state what it is an organization want to achieve, only then think tanks can be put in use and help in developing the technology. It is likely that Academia would show initiative by itself to solve one or the other issue.
- Avoid technology lock-in – it is easy to get into the lock-in, but very complicated to get out, therefore the best way out is not to get into such problem in the first place. MND should promote discussions and the development of alternative fuels and not lock itself within SFC.
- Avoid made-up platforms rather support bottom-up approach – networking is essential in innovation technologies. It should be promoted, at the same time; it cannot be purposely invented since after the initial failure it reduces the possibility of further success.
- MND should increase networking with think tanks – the research capacity is large in Lithuania and financial aspect is not always of key importance to Academia. MND has connections that might be a tradeoff to researchers.
- Develop R&D division, mobilize resources – MND, given that its budget increases in the coming years, should invest more in R&D. R&D in the future could be envisioned as a link between civilian Academia and the military.
- MND as a prime mover – MND should follow innovative trends in ally countries and show more initiatives in adapting them locally. MND as a prime mover should be a vision. ESC that has been created this year together with the Ministry of Energy is a great example of prime mover activity.
- MND should apply learning-by-doing educational system – military has a human capacity, it does not cost much to use a vehicle on certain biofuel blends. This could be done together with representatives of Academia who possess the required technology to observe engine work etc.
- Continuous support from advocacy coalitions – it is essential that the MND would continuously support innovation in the military either directly or indirectly - by stimulating other allies to work together in this sphere.

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Appendixes

Table 0-1 List of interviewees

Date	Name of interviewee	Organization	Position	Interview type
2011 06 23	 Juozas Žukas	Ministry of Agriculture of the Republic of Lithuania	Deputy director of the resource and quality department	By phone
2011 06 27	Andrejus Rosocha	UAB "Vilniaus autobusai" (Vilnius city auto-buses)	Specialist of the technical department	By phone
2011 06 27	 Viktorija Sankauskaitė	Ministry of Energy of the Republic of Lithuania	Head of the renewable energy sources division	By phone
2011 06 28	 Lt. Col. Ona Tatolytė	Ministry of National Defense Republic of Lithuania	Director of the Procurement department	By phone
2011 06 28	 Ramutė Kazlauskaitė	Ministry of National Defense Republic of Lithuania	Senior specialist of the Material resources department	By phone
2011 06 28	 Rimas Lipskas	Chamber of Agriculture Republic of Lithuania	Director of the Crop production department	In person
2011 06 30	N/A	Lietuva Statoil	Sales manager	E-mail
2011 07 25	Vladimiras Drąsutavičius	AB "Biofuture"	Director of the bioethanol production department	In person
2011 08 16	 Raimondas Maskvytis		Farmer, Rapeseed oil producer	By phone

2011 08 16	 Ingela Bolin Holmberg	Swedish Defence Materiel Administration (FMV)	Product Manager Environment, Fuel and Lubricants	By email
2011 08 17	 Juozas Savickas	Lithuanian Energy Institute	Senior research associate	In person
2011 08 18	 Klaudijus Jurkša	UAB "Altas"	Director of Kaunas division	By phone
2011 08 18	 Mantas Lapinskas	Seimas of the Republic of Lithuania	Advisor to the Committee on National Security and Defense	By email
2011 08 19	 Liudvikas Rimkus	Vilnius Gediminas Technical University	Assoc. Prof. Dr., Department of structural mechanics, Faculty of Civil Engineering	By phone
2011 08 19	 Asta Lapinskienė	Lithuanian Academy of Applied Sciences, Institute for Alternative Energy	Alternative Energy specialist	By phone
2011 08 19	 Urban Wästljung	Scania group	Manager, Sustainable transport	By email
2011 08 22	kpt. Valdas Bernatavičius	Ministry of National Defense Republic of Lithuania	Armament and control systems department, Tactical transport systems officer	By email
2011 08 25	 Rasa Juknevičienė	Ministry of National Defense Republic of Lithuania	Minister	In person

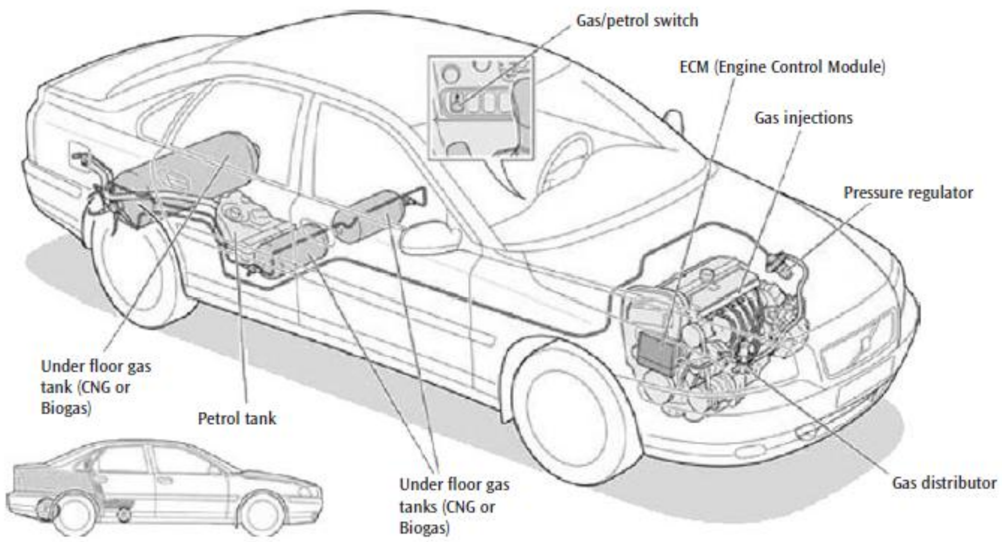


Figure 0-1 The Volvo S80 Bi-fuel

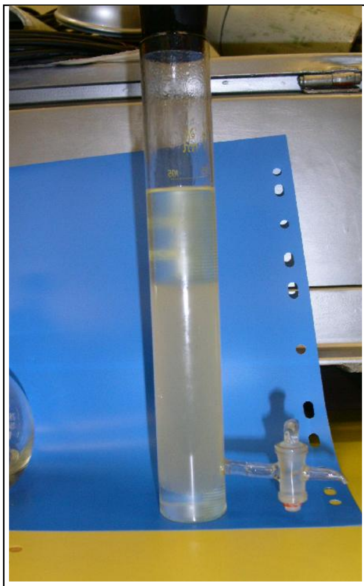
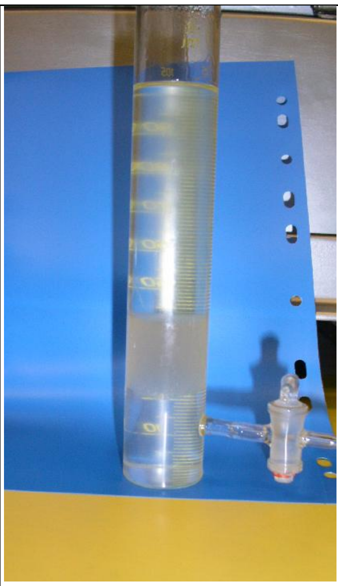
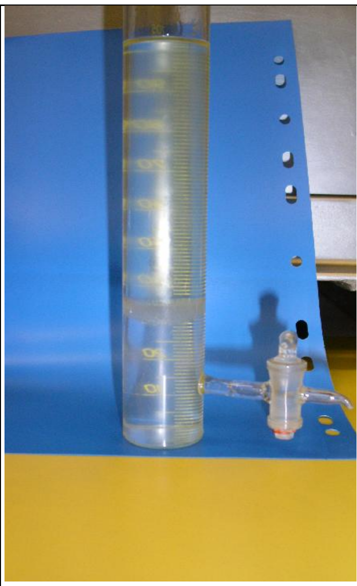
Source: (NSCA, 2006)

Table 0-2 AB "Biofuture" dehydrated ethyl alcohol quality requirements

Quality parameters	Standard
Etilo alkoholis, ne mažiau kaip, tūrio % (*Ethyl alcohol*)	99,5
Denatūrantas, mg/l (*Denaturant*)	0
Vandens kiekis, ne daugiau kaip, tūrio % (*Water*)	0,5
Tankis, esant 20^0C, kg/m³ (*density*)	780 - 795
Išvaizda ir spalva (*color*)	Švarus ir skaidrus (*clear and transparent*)
Aldehidai, perskaičiuoti į acetaldehidą, mg/l a.a (*Aldehydes*)	≤300
Metilo alkoholis, mg/l a.a. (*methyl alcohol*)	<1300
Aukštesnieji alkoholiai (fuzeliai), perskaičiuoti į izopentilo ir izobutilo alkoholių mišinį (3:1), mg/l a.a . (*Other alcohols*)	≤5000
Esteriai, perskaičiuoti į etilacetatą, mg/l a.a. (*Esters*)	≤500
Rūgštingumas (perskaičiavus į acto rūgštį), tūrio % (*Acidity*)	≤0,02
Na, mg/l	≤2
Fe, mg/l	≤5
Cu,mg/l	≤0,07
Sausųjų liekanų ne daugiau kaip, mg/l a.a. (*Particles*)	Max 20
Cl, mg/l	0
S, mg/l	≤3,0
P, mg/l	≤1,0
Dervų kiekis,mg/l (*Resins*)	≤10,0

Source: (Savickas, 2006)

Table 0-3 Examples of lamination by bioethanol blends after 10ml of water have been added

Source: (Savickas, 2006)