7th International Scientific Conference
"Business and Management 2012"
May 10-11, 2012, Vilnius, LITHUANIA

ISSN 2029-4441 print / ISSN 2029-929X online
ISBN 978-609-457-116-9 CD
doi:10.3846/bm.2012.129
http://www.bm.vgtu.lt

LOGISTICS AND ITS ENVIRONMENTAL IMPACTS

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Abstract. Nowadays logistics plays a significant factor in competitive strategies based on leadership within costs, differentiation (also within logistics service), shortening time cycles and the use of the company's capacities. The management-oriented integration of all logistics functions and processes becomes more important, because it is conditioning not only effective enterprise modernisation, but also opening new possibilities of solving problems and using potential effects in the operating and strategic activities. The number of motor vehicles on our roads is huge and still growing. The advantages of increased mobility need to be weighed against the environmental, social and economic costs that transport systems pose.

Keywords: logistics, environment, innovation, green logistics, reverse logistics.

Jel classification: Q57

1. Introduction

Logistics globally and especially transport of goods affects air pollution. This is why it is more and more important that greenhouse emissions are kept under control.

The aim of this paper is to highlight the direct and indirect impacts of logistics on the environment. In this paper are used and processed information of the organizations that deal with sustainable logistics, logistics research impacts on the environment, innovation in transport, such as European Environment Agency (EEA), Eurostat, Innovative Manufacturing Research Centre (IMRC), European Commission (EC), Organisation for Economic Cooperation and Development (OECD), Logistic Cluster.

During the World War II logistics evolved greatly. Logistics as a term appeared in 18th century military language. In the last century logistics had transformed itself from military sphere to the civil sphere.

Currently logistics is perceived as a practical business tool, enabling companies to achieve strategic, tactical and operational objectives in an integrated and rational and cost of goods and services addressing the quality of material resources, transportation, transformation and maintenance tasks according to user needs (Braškienė 2009).

Logistics has always played and it still does play a significant part in competitive strategies, because management-oriented integration of the logistics processes and logistics functions becomes more and more important considering its influence of effective organisation and enterprise modernisation and of opening new possibilities of solving problems and using potential effects in the operating and strategic activity (Witkowski 2010).

The aim of rationally managed companies is not only to achieve a smooth flow of goods at any cost, but also maintenance of balance of the sustainable logistics system.

Traditionally, sustainable logistics is concepttually considered in terms of three main pillars (Witkowski 2009) environmental sustainability, economic sustainability, social sustainability (Fig. 1).

Environmental sustainability is defined as the ability of the environment to continue to function properly indefinitely. The goal of environmental sustainability is to minimize environmental degradation and to stop and reverse the process that leads to environmental degradation (Witkowski 2009).

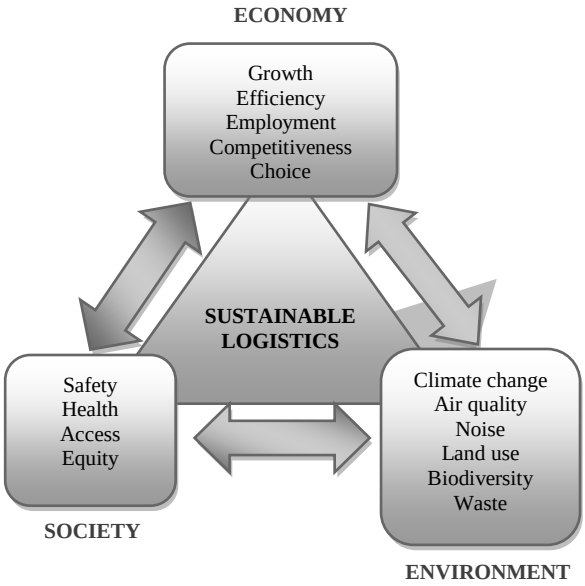

Fig.1. Balance of economical, social and environmental objectives and their interface with logistics (IMRC 2010)

Economic sustainability is defined as the way to achieve economic growth whilst respecting environmental limits, finding ways to minimise damage to the nature and making use of the earth's resources in a sustainable way. *The social pillar* of sustainable development is defined as a compilation of actions and efforts to promote development that does not deplete the stock of social and human resources but rather contributes to the enhancement of their potential. The social pillar also refers to the concept of "building sustainable and harmonious communities" (Witkowski 2009).

2. Logistics and the environment

The interface between logistics and the environment is embedded in the value adding functions a firm performs. As resources are used to create desired utilities, pollutants are implicitly produced as by-products during each step of the integrated supply chain process. Proper management and awareness of the environmental implications of logistics activities can significantly reduce the negative impact. Integrative environmental management means that every element in the corporate value chain is involved in minimization of the firm's total environmental impact from start to finish of the supply chain and also from beginning to end of the product life cycle. Managers must reassess their logistics decisions in such a way that they can respond to impacts coming from other functions such as marketing and manufacturing and from external sources such as the government and the consumer. Logistics managers play a critical role in the company's environmental management programme because their decisions, though affected by other functional decisions in the supply chain, have a direct impact on the environment (Wu, Dunn 1994).

Logistics has direct impact on the environment by:

- choosing the right kind of transport,
- preferring suppliers with shorter shipping routes,
- using trucks producing lower amount of emissions,
- using returnable containers,
- using of recyclable packs or that ones with ability of biodegradation.

Indirect logistics impacts are associated with:

- evaluation of ecological contractors' approaches,
- use of wasteless technology,
- use of low toxic materials and high recycling goods and segments (for example BWM vehicles consist of 95 % of adjusted components).

Innovations are judged as the growth engines of society. Increasing customer needs and new business models in trade and industry offer many chances to develop new markets by means of innovative logistics services. Technology improvements also enable logistics processes to be created more efficiently. Green innovations can have a major impact in reducing the environmental burden of this industry particularly in terms of pollution and greenhouse gas emissions.

3. Green and reverse logistics

Green logistics (or sustainable logistics) is concerned with reducing environmental and other negative impacts associated with the movement of supplies. Green supply chains seek to reduce negative impact by redesigning sourcing, distribution systems and managing reverse logistics so as to eliminate any inefficiency, unnecessary freight movements and dumping of packaging (Logistics Cluster 2010).

Reverse logistics emphasizes source reduction and substitution over reuse and recycling. Source reduction refers to doing the same things with less resource.

The practice reduces total waste in the system. Substitution means using more environmentally friendly materials instead of regular ones that end up as pollutants. Reuse is employing the same item multiple times in its original form so that little is discarded. Recycling gives discarded materials a new life after some chemical or physical processes (Fig. 2) (Wu, Dunn 1994).

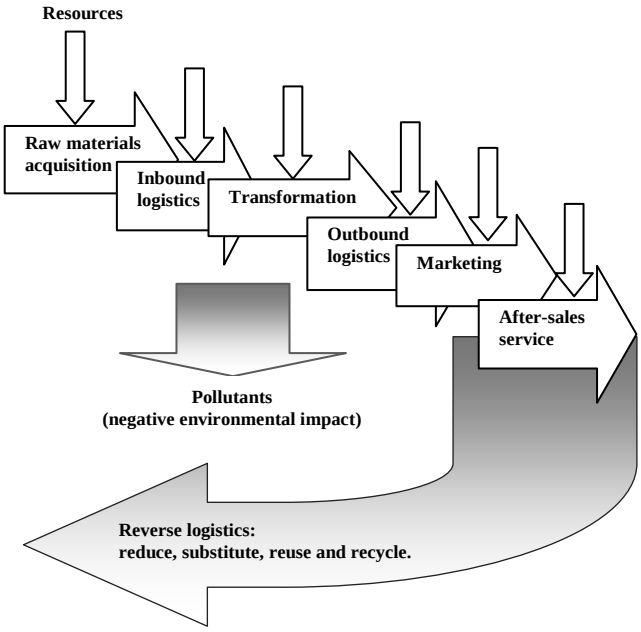

Fig.2. Reverse logistics in the logistics system (Hawks 2006)

Figure 3 and 4 shows the difference between a traditional supply chain model and model influenced by green/reverse logistics.

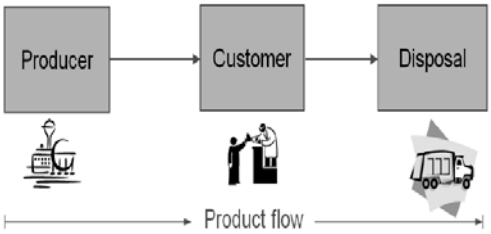

Fig.3. Traditional Supply Chain Model (Barker 2008)

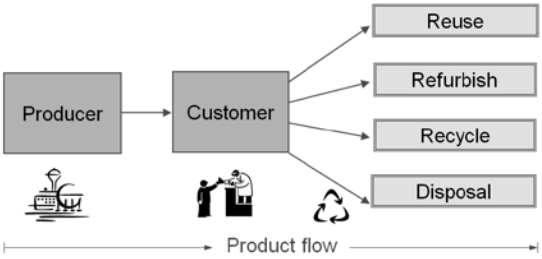

Fig.4. Product Recovery Supply Chain Model (Barker 2008)

Mission of the reverse logistics is the collection, sorting, dismantling and processing of used products, parts, by-products, surplus stock and packaging materials to ensure the new use or a material recovery in a manner that is environmentally friendly and economically interesting (Škapa 2005).

Engineers from Massachusetts Institute of Technology in Cambridge (USA) observed the behaviour of the trucks on the highway and found out that the bumpers capturing vibrations do not use the energy produced by this process. Therefore they developed a new type of bumper that converts kinetic energy into electricity usable for air conditioning, vehicle electronics or batteries. Vehicles electronic devices of today (in some cases) need up to one litre of petrol per 100 km. But by the highway driving is the energy efficiency of this equipment minimal. Israeli and British engineers plan to apply on the surface of the highways so-called piezoelectric coating, which is sensitive to pressure. With this coating will be possible to obtain electricity from impact force of going cars (GEO 2010).

4. Sustainable logistics and transport, greenhouse gas emissions

In the *Green Trends Survey*, respondents identified climate change as one of the most serious problems currently facing the world; the results show that environmental concerns are shared by people in Europe, Asia and the Americas, alike. Already today, citizens around the world are not only concerned about climate change, but are taking action in favor of more environmentally responsible behavior. Sustainability is becoming a key buying criterion. Consequently, there is growing demand for sustainable logistics products, e. g., offering carbon offsetting (DP AG 2010).

According to the study, logistics plays a key role in comprehensive carbon reduction efforts because of its expertise and positioning along the supply chain. The study also points out a number of interesting facts, including (DP AG 2010):

- 63% of business customers believe that logistics will become a strategic lever for CO_2 abatement.
- Out of 1.62 billion tons of truck emissions in Europe, roughly one quarter are caused by trucks running empty – often due to legal requirements.
- Aerodynamic drag is responsible for 40% of the fuel consumption of heavy trucks at highway speeds.
- 84% of consumers in China, India, Malaysia and Singapore say they would accept a higher price for green products. By comparison, only 50% of consumers in Western countries are willing to pay more.

Much of the early research on the environmentla impact of logistics was motivated by the growth of lorry traffic at a time when lorries were much noisier and more polluting than today. Numerous studies were conducted in the 1970s to assess the nature and scale of these effects, many of them in the UK. Their focus was on the local environmental impact of lorries (McKinnon et al. 2010).

Sustainable transport systems make a positive contribution to the environmental, social and economic sustainability of the communities they serve. Transport systems exist to provide social and economic connections, and people quickly take up the opportunities offered by increased mobility (Schafer 1998). The advantages of increased mobility need to be weighed against the environmental, social and economic costs that transport systems pose.

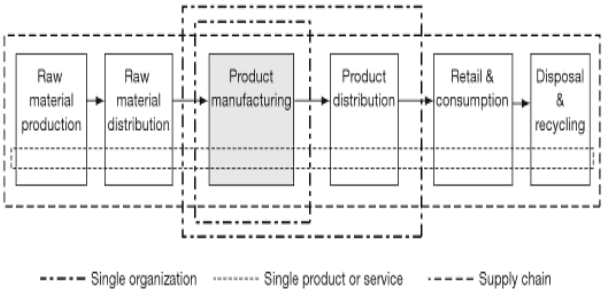

Fig. 5. Different Types of Carbon Footprint based on Carbon Trust, 2006 (McKinnon et al. 2010)

The term sustainable transport came into use as a logical follow-on from sustainable development, and is used to describe modes of transport, and systems of transport planning, which are consistent with wider concerns of sustainability. (Litman 2009).

European Commission defines sustainable transport as *"a key challenge of the EU Sustainable Develepment Strategy (EU SDS). The strategy's objective is to ensure that our transport systems meet society's economic, social and environmental needs whilst minimising their undesirable impacts on the economy, society and the environment."* (EC 2011).

There is one good example for solving the problem of sustainable transport. An initiative of the TfL (Transport for London) which provides us with new technologies implemented in public transport. They start to buy new fleet of buses – hybrid buses. Combining a conventional engine with an electric motor, hybrid buses are quieter, cleaner and more fuel efficient than standard diesel buses. These vehicles reduce emissions of local pollutants and carbon dioxide by at least 30 per cent compared to conventional diesel buses. Compared with conventional diesel buses, hybrids deliver considerable environmental benefits, including (Transport for London 2011):

- 89 % reduction in oxides of nitrogen,
- 83 % reduction in carbon monoxide,
- 40 % reduction in fuel use,
- 38 % reduction in carbon dioxide,
- 30 % reduction in perceived sound levels (noise reduced from 78 to 74 decibels).

By the end of March 2012 the total number of hybrid buses in the fleet will be 269.

The transport sector accounts for about 25 % of total commercial energy consumed worldwide, and consume approximately one-half of total oil produced. Its emissions include greenhouse gases, most notably CO_2, as well as particulate matter, lead, nitrogen oxides, sulphur oxides and volatile organic compounds all of which have negative impacts at local and often at regional levels. In addition, it is associated with adverse noise and land use impacts (Gorham 2002).

In the midst of growing sustainability concerns, transport systems pose a range of environmental problems. This is especially so for road transport, which has been increasing its share of transport relative to other modes. These problems include noise and air pollution caused by traffic congestion and the increase in CO_2 and other vehicle emissions. In particular, heavy vehicles used in freight transport are considered to be the main source of these problems. Concerns for the environment and safety are the major drivers behind regulation and legislation affecting freight transport (OECD 2002).

Automobiles are by no means the biggest CO_2 contributors, but they are a significant factor. As more and more people in emerging countries demand more and better mobility, the number of vehicles in the world is set to rise, offsetting progress already made in reducing fuel consumption of new vehicles. The International Energy Agency forecasts the increase in CO_2 emissions from traffic worldwide keeping pace with average increases from other sectors, so although the overall problem is set to get bigger, the road transport share should stay about the same (OICA 2007).

Globally, road transport is responsible for about 16 % of man-made CO_2 emissions (Fig. 6). It is a common misconception that global warming is mainly caused by cars and trucks. It is important to understand that there are other, larger, contributors and all sources of CO_2 emission must be addressed if the problem is to be solved (OICA 2007).

Road transport is responsible for 17.5 % of overall greenhouse gas emissions in Europe and its emissions increased by 23 % between 1990 and 2009. To reduce the CO_2 emissions of the road transport sector, European legislation has introduced mandatory CO_2 emissions limits for new passenger cars. The average emission level of a new car registered in the European Union in 2010 was 140.3 gCO_2/km. Overall, car manu-

facturers must achieve a CO_2 emission target of 130 g CO_2/km by 2015 as an average value for the fleet of new cars registered in the EU. This target will be gradually phased in from 2012. Almost all manufacturers must reduce emissions to meet 2015 targets under European legislation for new passenger cars, based on average CO_2 emissions for each manufacturer (EEA 2011).

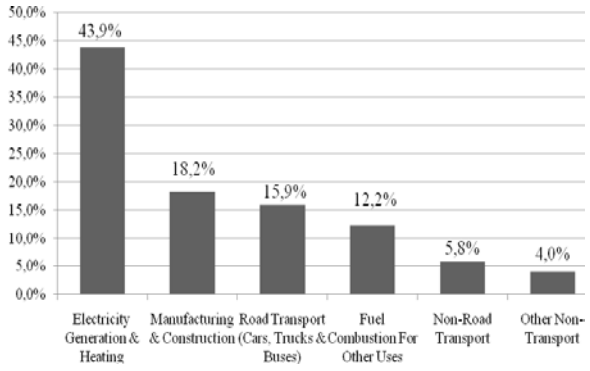

Fig.6. Man-made CO_2 emissions (OICA 2007)

Fig. 7 shows limit value curve of average CO_2 emissions. The size of the bubble is proportional to the number of vehicles registered in Europe.

Specific emission targets (expressed as an amount of CO_2 emissions per vehicle kilometre) are assigned to each car manufacturer (or pools of manufacturers) depending on the average mass of the fleet. We point out some of key findings of European Environment Agency (EEA 2011):

1. If car manufacturers make no further improvements in carbon efficiency of new cars between 2010 and 2012, non-compliant manufacturers could face fines which in total would add up to € 10 billion.
2. *Toyota Motor Europe* is already compliant with its 2012 target, and also less than 1g CO_2/km from the more stringent 2015 target. *Automobiles Peugeot* and *Automobiles Citroën* are also both close to reaching their 2015 target already. These manufacturers need to cut their emissions by less than 5g CO_2/km to meet the target, a value correspondding to the average reduction of emissions from new passenger cars between 2009 and 2010 in Europe.
3. Among the larger manufacturers, *Daimler AG*, *Honda Motor Co*, *Nissan International SA*, *General Motors Company*, *Mazda Motor Corporation* and *Dacia* will have to reduce the average emissions of their fleets by more than 14 g CO_2/km over the next five years.
4. There are three manufacturers which produce only electric vehicles – so their emissions are listed as zero. Of the manufacturers producing some conventional-fuelled cars, *Maruti Suzuki India Ltd* had the lowest CO_2 emission level overall (104 g CO_2/km). The average mass of its fleet is the lowest among all the car manufacturers registering vehicles in Europe. Among the larger manufacturers, *Fiat Group Automobiles Spa* had the lowest average CO_2 emissions in 2010 (125 g CO_2/km).

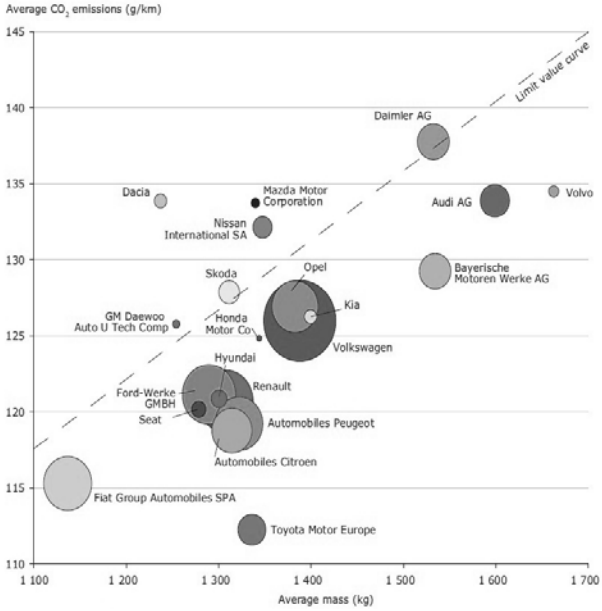

Fig.7. Distance to 2012 target by individual manufacturers in 2010 (only manufacturers registering > 100 000 vehicles in Europe) (EEA 2011)

Transport was responsible for 24 % of all EU greenhouse gas emissions in 2009. The Roadmap states that EU Member States are required to reduce greenhouse gas emissions from transport by 60 % by 2050, compared to 1990 levels. Since emissions actually increased by 27 % between 1990 and 2009, the EU must make an overall 68 % reduction between 2009 and 2050 (EEA 2011).

Transport is a segment which has negative impact on environment. Share of European Union (EU) on environment pollution caused by production of greenhouse gases from transport (specifically CO_2) is about 932 135 tonnes per year (year 2009). Thereof the largest contributor is Germany (153 307 tonnes), France (130 570 tonnes), United Kingdom (119 189 tonnes), Italy (119 258 tonnes) and Spain with 94 467 tonnes (Eurostat 2011).

Indicator *"Greenhouse Gas Emissions from Transport"* shows trends in the emissions from transport (road, rail, inland navigation and domestic aviation) of the greenhouse gases regulated by the Kyoto Protocol. Only three gases are relevant in the context of transport (carbon dioxide,

methane, and nitrous oxide) and these have been aggregated according to their relative global warming potentials (Eurostat 2011).

Table 1. Greenhouse Gas Emissions from Transport (Eurostat 2011)

Country	Greenhouse Gas Emissions from Transport (1000 tonnes of CO_2 equivalent)
Slovakia	6 207
Poland	44 439
Czech Republic	18 512
Hungary	12 676
Estonia	2 156
Latvia	2 777
Lithuania	4 451
United Kingdom	119 189
Austria	21 650

The European Commission (EC 2011) adopted in 2011 a roadmap of 40 concrete initiatives for the next decade to build a competitive transport system that will increase mobility, remove major barriers in key areas and fuel growth and employment. At the same time, the proposals will dramatically reduce Europe's dependence on imported oil and cut carbon emissions in transport by 60% by 2050.

By 2050, key goals will include:

1. No more conventionally-fuelled cars in cities.
2. 40% use of sustainable low carbon fuels in aviation; at least 40% cut in shipping emissions.
3. A 50% shift of medium distance intercity passenger and freight journeys from road to rail and waterborne transport.
4. All of which will contribute to a 60% cut in transport emissions by the middle of the century.

5. Biofuels

Huge resources are expended annually developing diverse CO_2-efficient vehicles that run on alternative fuels like bio-diesel, ethanol, hydrogen and natural gas or that use electric or hybrid vehicle technology. Bio-fuels represent an attractive new resource that can reduce CO_2 emissions as well as improving energy security by reducing reliance on imports from the traditional oil-producing regions. (OICA 2007) Biofuels are expected to reduce dependence on imported petroleum, reduce greenhouse gas emissions and other pollutants as well as increase demand for agricultural products.

Biofuels have been in existence since the 1970s. Prior to 2010, every global commercial biofuel plant was either for first-generation ethanol or biodiesel (Greentechmedia 2010).

Biofuels are derived from biomass that is renewable and biodegradable. For this reason, it will accordingly cause lasting effects on generations to come. However, one major concern of wide scale biofuel production is the increased need of growing crops to meet the demand. This leads to some arguments, since it might require extensive land that may involve forests, wild habitats and agricultural lands (Biofuelguide 2007). The European Union (EU) established a 20 % target for renewable energy use by 2020 and a 10 % target for renewables in the transport sector by 2020. Bioenergy, including solid biomass and waste, is expected to represent 60 % of the EU's renewable energy use and biofuels is expected to cover most of the 10 % renewable energy use in transport. Widely perceived as carbon neutral, new studies reveal that these policies could be increasing emissions compared to fossil fuels (Transport and Environment 2010).

There have been studies that prove many benefits of substituting fossil fuels (petroleum, etc.) with biofuels such as biodiesel and ethanol. In its simplest sense, such biofuels are biodegradable which means they are derived from organic materials. They are naturally renewable. Consequently, reliance on foreign sources of fossil fuels will be significantly reduced. Moreover, these biofuels emit nontoxic and cleaner emissions in comparison to traditional fuels. These alternative fuels also do not promote global warming, since the carbon they emit is taken back to the environment (Biofuelguide 2007).

The share of alternative fuelled cars on the road has grown steadily, comprising more than 5 % of the fleet in 2009. Most of these were using liquefied petroleum gas (LPG), while electric vehicles made up 0.02 % of the total fleet (EEA 2011).

Biofuels can be made using a wide range of crop and forestry products. Since 2000, worldwide biofuel production has grown at an annual rate of 10 %, reaching 90.187 billion litres in 2009. Of this total, 82 % corresponds to bioethanol and 18% to biodiesel. Brazil is the world's second largest producer of bioethanol, with some 33.2 % of the market share, behind the United States with 54.7 %. Argentina is the world's second largest producer of biodiesel, with 13.1% of the market share, also behind the United States with its market share of 14.3% (Diesel Truck News 2011).

Biofuels have been in existence since the 1970s. Prior to 2010, every global commercial biofuel plant was either for first-generation ethanol or biodiesel. Biofuels are an inherently local proposition. Europe is the most important biodiesel producer in the market, with European rapeseed

accounting for 58 percent of the global biodiesel produced in the world (Greentechmedia 2010).

Since biofuels are attempting to replace petroleum, any discussion about the future of biofuels must be grounded within the context of the economics of petroleum.

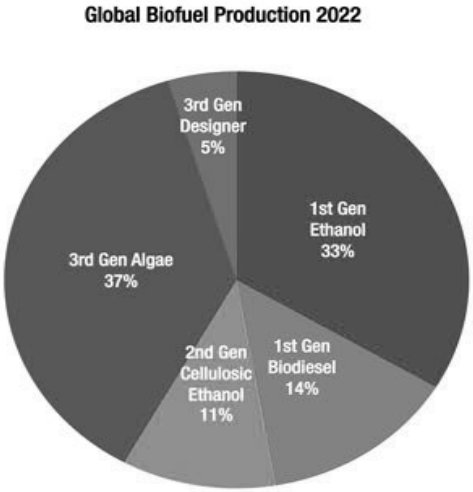

Fig.8. Global Biofuel Production in 2022 (Biofuels 2010)

By 2015, cellulosic ethanol will be the largest "advanced" biofuel, comprising 2.4 billion gallons of the estimated 50 billion gallons of global biofuel produced. By 2022 (Fig. 8), algae biofuels are the largest biofuel category overall, accounting for 40 billion of the estimated 109 billion gallons of biofuels produced (Greentechmedia 2010).

6. Conclusions

Logistics has got direct and also indirect impact on environment. Transportation of goods and materials is responsible for greenhouse gases emissions. Automobile manufacturers are annually developing diverse CO_2-efficient vehicles that run on alternative fuels (bio-diesel, ethanol, hydrogen and natural gas) or that use electric or hybrid vehicle technology. Biofuels are expected to reduce dependence on imported petroleum, reduce greenhouse gas emissions.

Nowadays, interest in the environment increases and companies must take into account the external costs of logistics associated mainly with climate change, air pollution, noise or vibration. Reducing of environmental impact of logistics can help to demonstrate corporate social responsibility.

Reuse of resources as well as monitoring of business processes impacts on the environment is very important theme to talk about. Natural resources are limited. In case we want to save healthy environment for the next generations, we have to understand the relationship between environment and industry.

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