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The Contributions of Logistics to Enhance Energy Efficiency in Freight Transport

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1. General conditions

In early environmental management frameworks, operating line managers were only involved vaguely. Separate units within organizations were held responsible for ensuring environmental excellence in divisions such as product development, process design, operations, logistics, marketing, regulatory compliance or waste management. Nowadays the situation has changed. The quality revolution of the 1980s as well as the supply chain revolution of the 1990s made clear that the best practices call for the integration of environmental management with day-to-day operations. [1]

Logistics in particular is the process of planning, implementing and controlling the efficient, cost effective flow and storage of raw materials, in-process inventory, finished goods and related information from point of origin to point of consumption for the purpose of meeting customer requirements. [2] As mentioned above the field of responsibility in companies was expanded to environmental aspects since the discussion of topics such as climate change, greenhouse effect or the emission of carbon dioxide inevitably pertains to freight traffic which is intrinsically tied to logistics. Therefore responsible persons in logistics have to seek to minimize pollutant emissions while maximizing energy efficiency. In general organizations face three different kinds of motivation to go for a sustainable environmental management in logistics: an economic, a managerial as well as a social motivation: [3]

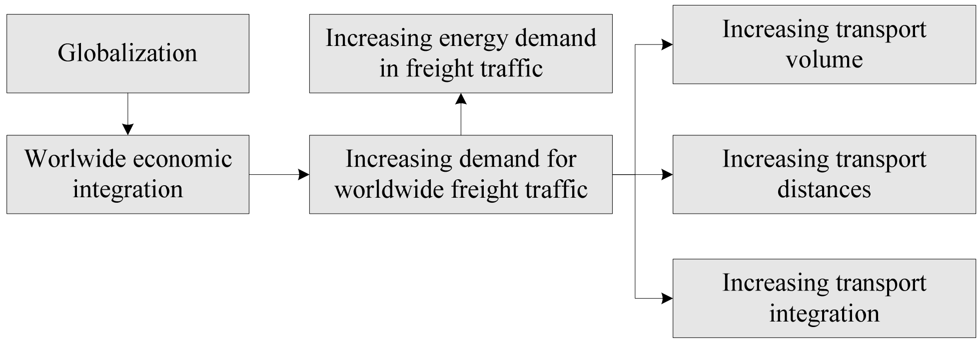

Figure 1: Economic motivation for sustainable environmental management

Due to the shortage of resources accompanied by price increases, alternative energy resources will become more attractive and cost-effective, which is the principal of the managerial motivation:

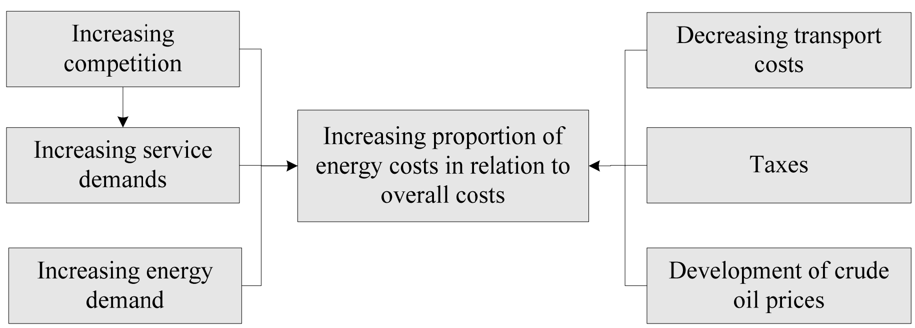

Figure 2: Managerial motivation for sustainable environmental management

The third reason for sustainable environmental management is the so called social motivation:

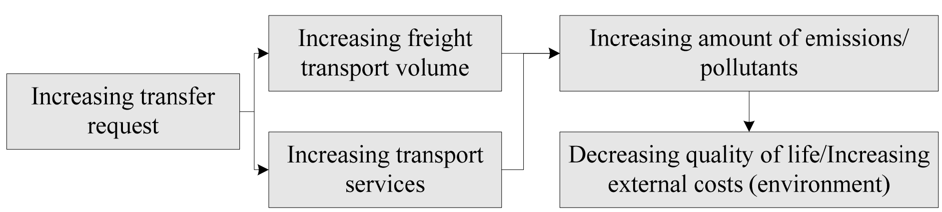

Figure 3: Social motivation for sustainable environmental management

According to the Intergovernmental Panel on Climate Change (IPCC) traffic accounts for 13,1% of the worldwide emissions of carbon dioxide. [27] In spite of various efforts (see chapter 3.2), logistics and in particular traffic are even responsible for a quarter of the total emission in Austria. The stake of traffic carriers in Austria additionally initiates the negative development of emissions caused by road freight traffic:

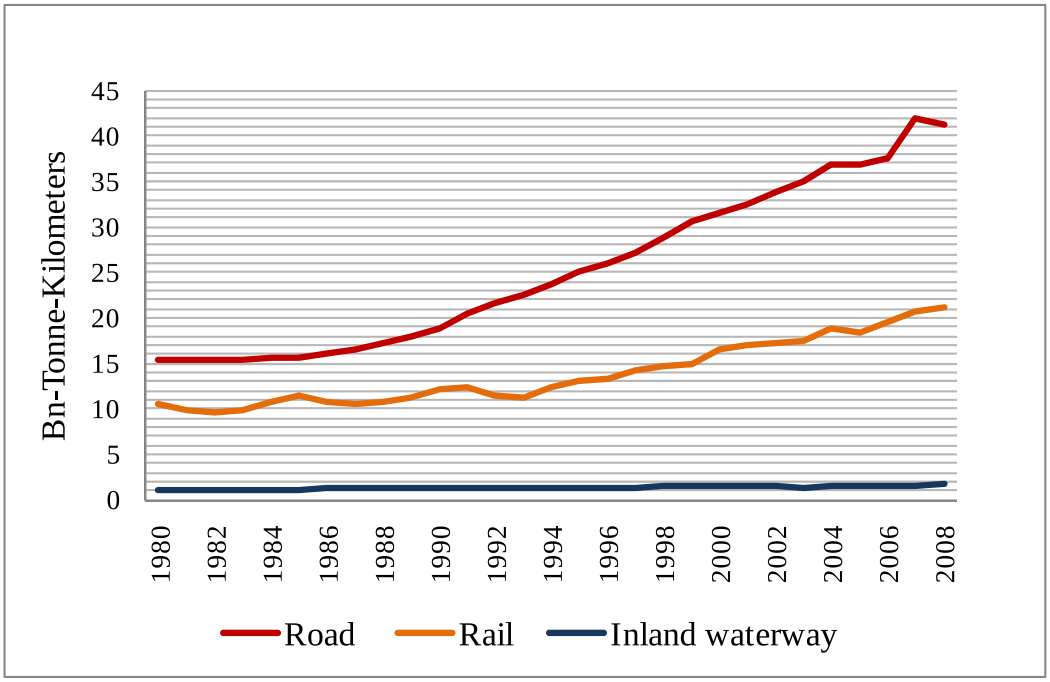

Figure 4: Traffic carriers in Austria [4]

In In a macro-economic view the efficiency of transport systems as well as the efficiency of a national economic depict a reciprocal relation. Both transportation and shipping are fundamental prerequisites for the adequate satisfaction of goods demand, a higher division of labor and more competition. This is valid for the domestic market as well as for foreign trade. Economic prosperity increases the demand for freight traffic inversely. [5]

Modern logistics management is able to increase transport efficiency by means of innovative concepts. Nevertheless short periodic and low-inventory economic processes are responsible for a fast growth in freight traffic and are the reason for the affinity towards road haulage, which is responsible for the dependency on fossil fuels. As long as the supply with these fuels seems to be secured, transport and logistics will be kept organized in the same way, ignoring this alarming dependencey. In addition the people in charge of the transport policy operate as if fossil fuel were at unrestricted disposal and available at moderate prizes. CThe construction of traffic infrastructure and the elimination of traffic bottlenecks seem to be the only agenda. [6] A paradigm shift is inevitable, especially in the face of the aspired reduction in carbon dioxide emissions by 2020. [7]

2. Transport, Traffic and Logistics

Logistics and Supply Chain Management focus on the adequate configuration of the process chain (goods, information and data) while at the same time tracking an increase in efficiency as well as effectiveness. Hence overcoming distances (transport, handling) and times (storage) are the core elements of logistics, which necessitate accordant energy consumption. In addition to time and cost aspects, questions concerning energy efficiency come into force.

Transport constructs a subset of traffic which again constructs a subset of logistics:

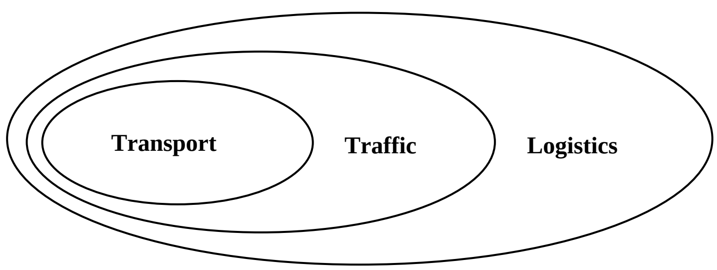

Figure 5: Logistical connection context [8]

(Freight) Traffic will -– besides energy supply, feeding and farming as well as “building and living” – be one of the most fundamental scopes of action, which have to put the principle of sustainability into practice. [9] There are two considerable domains of different actors, which can contribute to achieving environmental improvements: one is the macro domain (actions taken by governments and legislative authorities) and one is the micro domain (actions taken by enterprises). In the macro domain it has been recognized that transport is among the main sources of environmental pollution. Measures taken in the past are numerous but unsatisfactory due to their inability to keep pace with the growing transport volumes. Improving the sustainability of the transport sector requires a comprehensive and integrated transport and environment policy approach which combines legislative and economic instruments in a comprehensible way across all traffic carriers. At this point only a few examples for potential contributions to a more sustainable transport sector shall be mentioned:

- Elaboration of a long-term and coherent strategy for fuel
- Acceleration of EE-vehicles (EE: enhanced environmentally friendly)
- Promotion and prioritization of warehouses (for example) in regard to energy saving aspects
- Internalization of external costs etc.

In general, logistics can follow three approaches within transport policy in order to minimize the negative impact on the environment:

- Realization of a modal shift
- Reducing the demand for transport
- Reducing the impact of transport

In the micro domain it is about a shift within enterprises, which means that they will have to restructure their processes. [10] The formation of transports and transport services provided to logistical services are characterized by a different point of view. Logistical services are determined by transport, storage and handling processes. The two latter process categories (storage and handling) are in particular part of so called intra-logistics, which involves the organization, control, execution and optimization of the in-house movement of goods in industry, retail market and public institutions. [11]

In this paper, examples for the three categories transport, handling and storage on a micro level thus enterprises will be given:

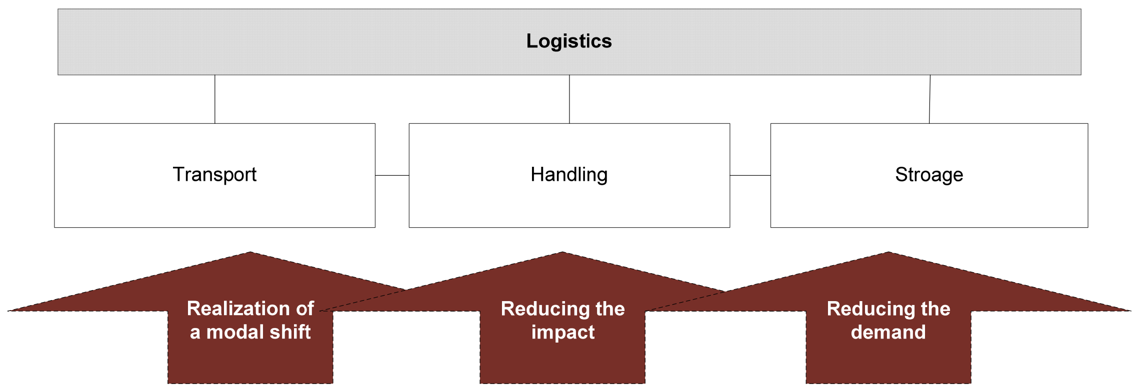

Figure 6: Areas of consideration

3. Basic strategies to enhance energy efficiency

When only considering input-output-relations within companies (as as system), a so called black-box consideration takes place. This means, that elements within companies and their relations among themselves respectively are not subject matter. An example is the black-box consideration of energy efficiency in a company in an economic way:

$$\text{Energy Efficiency}\left[\frac{\$}{\text{kW h}}\right]=\frac{\text{Net Production Value [\$]}}{\text{Prime EnergyInput [kW h]}}$$

Equation 1: Energy Efficiency [12]

Logistical processes offer numerous strategies to enhance energy efficiency. The three underlying strategies mentioned before can be applied in all parts and categories. At the beginning, an example for enhancing energy efficiency on the micro domain, more precisely for handling activities, will be given.

3.1.Increase energy efficiency in handling activities

Warehouses, cross-docking centers and commercial buildings generally hold huge potentials for energy savings. The final energy is applied for various applications, such as space heating, information and communication technology, lightening and so forth. Alongside mechanical energy used in freight traffic, space heating predominantly uses final energy. As already mentioned, improving warehouses concerning their energy consumption is one of the most important aspects to be considered.

A survey among Austrian companies in the year 2008 revealed that energy savings potentials average out at 6% in the field of electricity and at 23% in the field of heating. [13] In spite of this proven saving potentials it is obvious that energy efficiency comes second when planning and implementing intra-logistical processes. When planning material flow systems, energy costs are in the majority of cases estimated all in. A percentaged orientation is geared to overall investment costs and amounts for the most part at 3% of the total energy costs per year. Focusing on investment costs curbs the distribution of energy efficient systems. Due to the variety of electric motors implemented in materials handling equipment, energy savings up to 30% could be realized.

In-house materials handling contributes considerably to the energy consumption in companies. In cooperation with the Johannes Kepler University in Linz (Department for Production and Logistics Management), the University of Applied Sciences has developed a “prototype for a dynamic sequencing of in-house materials handling”. Within this project an (online and/or offline) optimization of MHE/forklift movements was realized. In order to minimize the number of drives at the same time as optimizing capacity utilization, an adequate regulation of the in-house materials handling has to be implemented previously. Sequencing as well as determining drives must not happen stochastically but rather has to follow defined priority rules and meet specified efficiency criteria. Following this mathematical sequencing employees receive necessary (online) information about the next working step. This system is called forklift guidance system. The implementation of a forklift guidance system can follow different optimization strategies: First cost savings due to a reduction of drives can be realized. This reduction is generated because of so-called “cycle runs” which contribute to the avoidance of empty drives. This strategy is primarily reasonable if long drives in more than one warehouse have to be made. Secondly, an improvement concerning the availability of forklifts can be aspired, which is realized by a harmonization of forklift usage. Provided one forklift has to serve multiple areas, exact information about the requirements situation of the single demand carrier facilitates optimal sequencing of transport orders. Thirdly, handling of goods as well as stacking ground can be optimized.

The project showed that dynamic sequencing by implementing an algorithm contributes to reducing the overall capacity necessary for order processing. Empty drives can be minimized as well as the efficiency of the fork lift can be maximized. Consequently the number of drives can be reduced which results in an overall minimization of energy consumption. [14]

3.2.Increase energy efficiency in transport

Relevant environmental impact caused by traffic and transport can be classified as follows:

- Energy consumption (does not display an environmental impact but represents consumption of resources)
- Atmospheric load
- Noise pollution
- Land consumption

Energy consumption and/or efficiency in (road) transport are dependent on various factors. The following figure demonstrates these correlations:

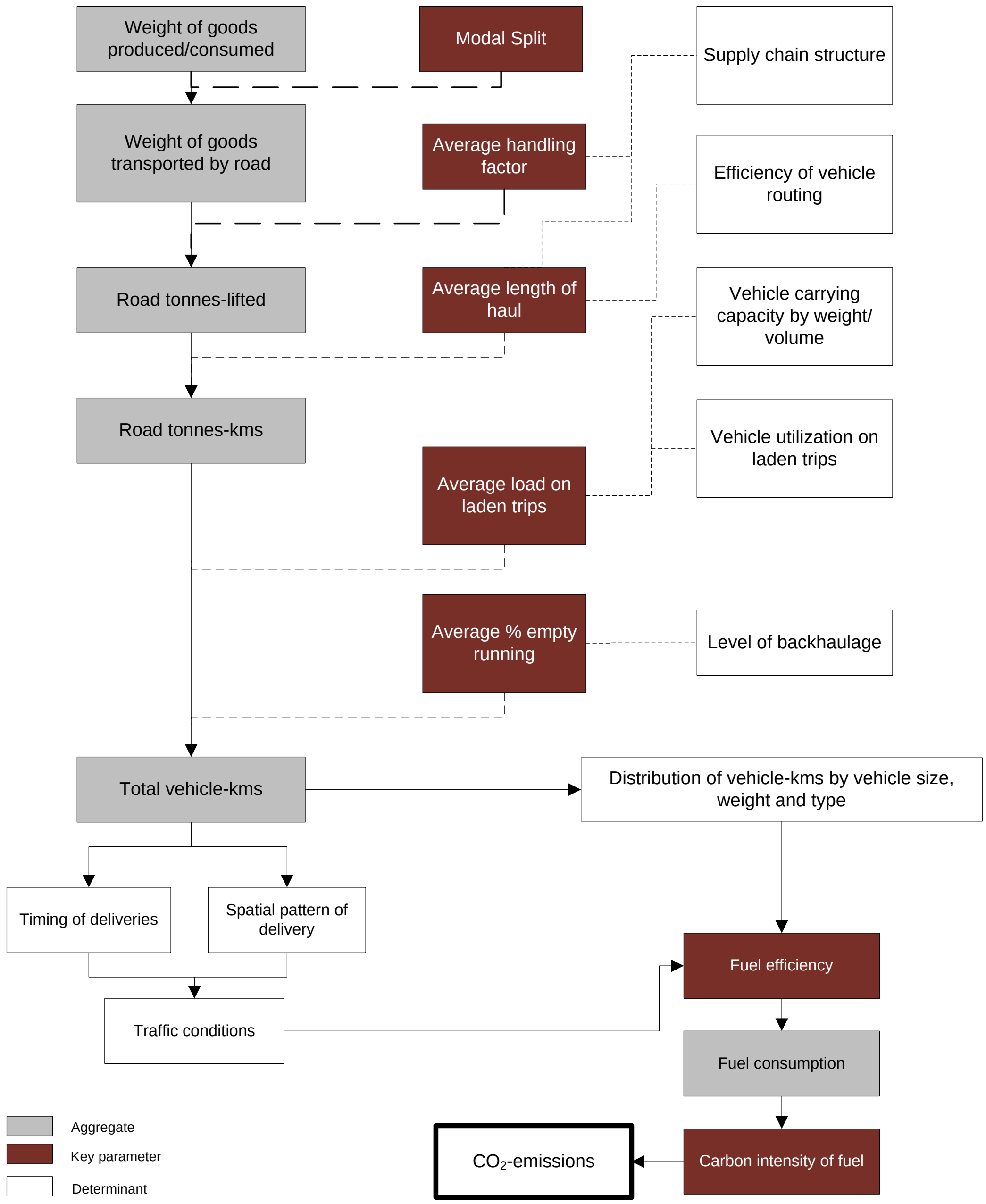

Figure 7: Energy efficiency in transport [15]

Throughout the last decades numerous programs were implemented in order to diminish the impact of traffic on the environment. The following table gives a brief overview about measures taken:

Program / Contract	Quintessence	Classification	Starting-point for traffic control
Vancouver (1996) OECD-TST	Principals for sustainable mobility	Guidelines	• Principle No. 3: Responsibility for the environment • Principle No. 6: Integrated Planning • Principle No. 8: Decrease of emissions • Principle No. 9: Social services (polluter principle)
Kyoto Protocol (1997)	Reduction of greenhouse gases	Guideline, environmental and quality targets	• Reduction of greenhouses gases (Art. 2, vii) • Downsizing and abolishment of market distortion due to the application of market instruments (emission trading) (Art. 2, v) • National contribution to the attenuation of climate changes (Art. 10)
EST-OECD (1994)	Reduction of emission (base year 1990)	Guideline, environmental and quality targets	• Reduction of emissions • Identification of polluters (local, regional, global)

EC directive 96/92/EG to 2001/81/EG	Air quality and critical values	Environmental and quality targets	Maximum amount of emissions (Directive 2001/81/EG)

Table 1: International environmental commitments [16]

Furthermore in 2007 the EUU Heads of State and Government set a series of demanding climate and energy targets to be met by 2020. These are

- A reduction in EU greenhouse gas emissions of at least 20% below 1990 levels
- 20% of EU energy consumption to come from renewable resource
- A 20% reduction in primary energy use compared with projected levels, to be achieved by improving energy efficiency.

Collectively they are known as the 20-20-20 targets. [17]

But for all that in the latest EEA Report (No 9/2009) it is cited, that transport is the sector in Europe in which negative emission drivers (transport demand and increasing share of road transport) most outgrew the positive emission drivers (fuel efficiency and fuel shift). Between 1990 and 2007, CO_2 emissions from transport rose by 29% in the EC-27. These increases were mainly induced by growing transport demand, characterized by large increases of traffic performance (in tonne-kilometers). An increased share of road freight transport as opposed to other transport modes supplemented the increased transport demand for goods. Modal shift is therefore taking place in the wrong direction. [18]

This examination result again clarifies the necessity to increase energy efficiency in the transport sector. Possible strategies were outlined at the beginning of this paper. In this chapter some concrete starting points and practical examples will be given.

General activities

Changes in the transport sector result in perceivable reductions of emissions or enhancements concerning energy efficiency. The entailed shift to more environmentally friendly modes of transport is pushed by the following approaches:

- Development and implementation of handling methods and equipment for the intermodal freight transport
- Simplification and facilitation of the access to railroad transportation
- Development of energy-efficient first and last mile concepts in road transportation
- Internalization of external costs

The publicized reduction of the impact by traffic and transport can be supported by the following dues:

- Intelligent deployment of telematics/ITS (intelligent traffic systems)
- Application of local source strategies
- Modification of packaging for improved utilization of freight hold
- Synergetic increase of freight hold utilization and avoidance of empty drives by means of horizontal cooperation

Reducing the demand

A survey conducted at the Upper Austrian University of Applied Sciences dealt with own-account transport operations of Austrian companies. The question was how many companies operated own-account transports and the reasons therefore. Anyway 49% of the companies surveyed operated own-account transports and the essential reasons given were supposed cost savings as well as quality aspects. The following figure illustrates the capacity utilization of the truck fleet of the particular companies:

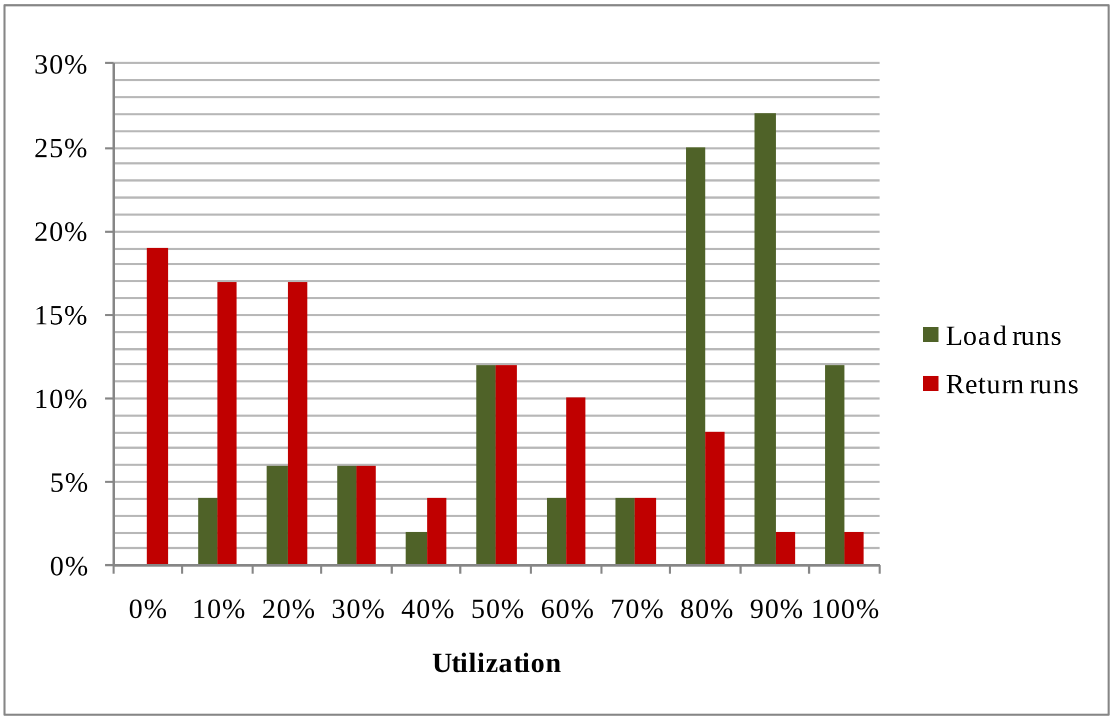

Figure 8: Utilization of truck fleets [19]

This result clarifies the huge potential, especially in the return runs, for horizontal (or vertical) cooperation. The above mentioned synergetic increase of freight hold utilization and the avoidance of empty drives respectively contribute exceedingly to a reduction of carbon dioxide emissions. In this context so called logistic pooling systems have to be mentioned. Within these systems truck use (sometimes even warehousing) is planned and optimized company-wide. The physical transport of goods with trucks of the manufacturer or carrier is accomplished in the course of a collectively planned optimization of transport capacities. This can be realized by the minimization of empty drives or rather by the shared utilization of one truck by several manufacturers when supplying a retailer. [20] Well-known companies aim for transport cooperation by now. The logistics cooperation of Mars and Ferrero in wide parts of the German state Nordrhein-Westfalen shows, for example, that between 10% and 15% of transport activities can be cut down. Half of the total number of 8000 deliveries could have been concentrated. [21]

Nestlé UK serves – together with a competitor – more than 20 delivery routes with one logistics service provider. This is part of an initiative in Great Britain, in which companies consolidate freight in order to reduce empty drives. Logistics service providers or freight forwarders operating on behalf of one company carry freight of other companies on their return runs. The consumer goods industry intends to save 200 million truck kilometers by this logistics pooling concept. [22]

Reducing the impact of freight transport

Another project worth mentioning focuses on the cooperative scheduling of the regional freight traffic. This project is accomplished at the Upper Austrian University of Applied Sciences. In the project “time4trucks” traffic forecasting data of infrastructure operators are combined with data of shippers in order to unload neuralgic street road sections. Hence traffic congestions, time losses, costs and planning uncertainty as well as additional carbon dioxide emissions can be avoided. The consolidation of data allows for influencing traffic conditions, what leads to improved fuel efficiency and fuel consumption respectively. [23]

Realization of a modal shift

On the grounds of technical and organizational conditions each carrier possesses definable advantages. Road haulage scores with its flexibility, almost infinite interconnectedness and organizational simplicity. Advantages of rail transport comprise economic and environmentally friendly transport of large and specifically heavy bulk over long distances. Transports by plane are characterized by speediness over long distances. One reason for the advancement of intermodal transport is the intelligent combination of specific carriers according to specific vantages along the transport chain. Therefore the transport chain can be designed more efficiently. At least in Europe mental barriers concerning a comprehensive utilization of intermodal transports is evident.

On all accounts it is necessary to shift the main leg to the carrier rail and to keep the track as long as possible. The simple principle is, the longer the main leg and the distance travelled, the more environmentally friendly the transport. Moreover it is essential to implement intelligent first and last mile concepts as mentioned at the beginning of this chapter, since empty runs can be discovered numerously in feeder services.

4. Summary

Potential contributions of logistics to enhance energy efficiency in freight traffic are numerous. The paper described starting points as well as concrete projects implemented in little.

In general it can be stated, that ecological strategies contribute to the requirements of customers concerning environmentally friendly and sustainable products. Logistics holds a prominent position in this context, since companies can contribute significantly to the reduction of environmental pollution when applying adequate strategies.

It is necessary to not only identify the different strategic, tactical and operational decisions influencing the environment but also to relate them to each other in order to be able to foresee the consequences on the environment. [24] Abrahamsson and Aronsson [25] point out that there are three main steps to consider when designing new logistics structures:

- Calculation of the total costs and delivery service of the existing structure
- Calculations for alternative structures
- Calculations on dimensions and size of facilities

Decisions made on different levels create opportunities as well as determine limitations concerning decisions made on other levels. The following figure demonstrates these conditions:

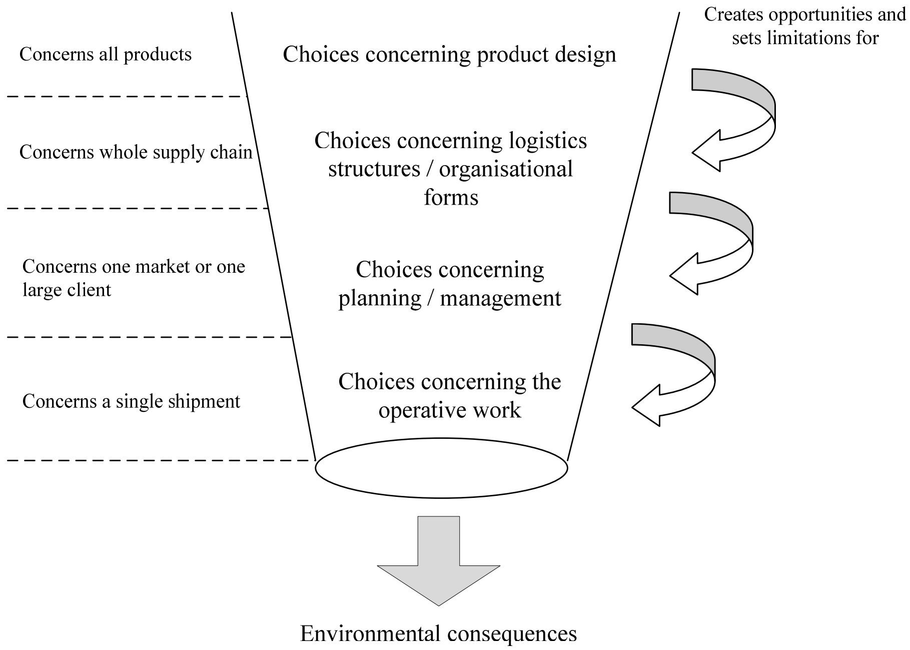

Figure 9: Logistics decision levels and their interdependencies [26]

In succession of improved planning and organization of logistics processes an increase of the ecological as well as logistical efficiency can be realized. The significance of environmental aspects within logistics will step up continuously in the future. A number of reasons, such as rising commodity and energy prizes, increasing integration accompanied by further negative environmental impacts, contribute to this relevance. In addition to that it can be expected, that so called external environmental costs will be assigned to the particular polluter and will no longer be borne by the general public.

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Table of figures