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THE ROLE OF INLAND WATERWAY NAVIGATION IN A SUSTAINABLE TRANSPORT SYSTEM

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Abstract. Sustainable development has become a guiding principle of human activities nowadays. Sustainable transport can take a great part in future development. Today this is not the case, and road transport contributes to this above all. For sustainable transport development the necessity of modal shift is inevitable and the inland waterway navigation should get the higher share of the total transport where there is an alternative. This presentation shows the reasons why the inland waterway navigation can increase the level of sustainability.

Keywords: sustainable development, sustainable transport, indicators, assessment, inland waterway navigation, STPI (Sustainable Transport Performance Indicators).

1. Introduction

"Sustainable development" has been defined in various ways. The simplest statement of the best-known definition is: …meeting the needs of the present without compromising the ability of future generations to meet their own needs, balancing and integrating a prosperous economy, a quality environment, and social equity… the "3 E's" of sustainability [1]. So, for the first approach sustainability is determined by the societal, economical and environmental aspects (Fig 1).

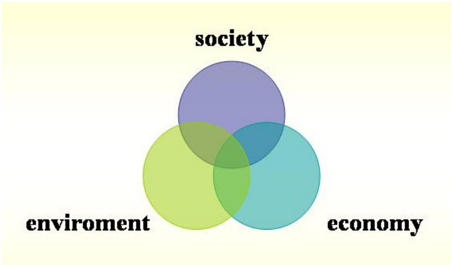

Fig 1. Conventional approach to sustainability

Often, the sustainable development is focused on the sustainable transport, because of its considerable and well-known effects on environment and society [2].

The definition of sustainable transport adopted by the Ministers of Transport of the 15 European Union countries is as follows:

A sustainable transport system is defined as one that:

- allows the basic access and development needs of individuals, companies and societies to be met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations;
- is affordable, operates fairly and efficiently, offers choice of transport modes, and supports a competitive economy, as well as balanced regional development;
- limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and, uses nonrenewable resources at or below the rates of development of renewable substitutes while minimising the impact on the use of land and the generation of noise [3].

This definition should be favored because it is concrete, comprehensive, and "has been reviewed by political mechanisms and received general political acceptance" [4].

This definition is already more complex, showing the dependence of sustainability on some other aspects as well. With accordance to our study [5], we can recommend a general approach to sustainability as shown in Fig 2.

From this it can be stated that our future depends not only on the needs of economy and society and impact of our activity on the environment, but also on the use of natural resources of our planet. The economic

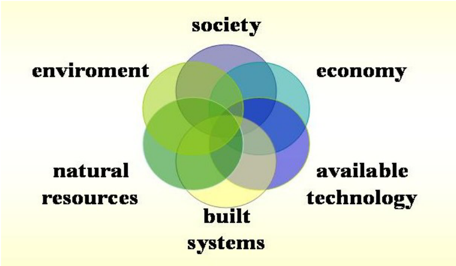

Fig 2. Modern approach to sustainability

use of natural resources depends greatly on the built systems and on the applied technology [5].

But if one has a look around Europe or the world he or she can find that considering the above aspects we are far, sometimes very far from sustainability. It can be stated that the economic aspects are well over the two (or five) other. Lower costs, greater profit is the determining factor at the moment. A good sign is that on the governmental level we are aware of this and actions have been taken to change the intolerable situation.

So, for sustainable development and transport it is essential to have clear laws, stability in financial support, developed taxation system (pricing), well-defined priorities, etc. [6, 7], but – as we think – it must be based on technology development including the total innovation process from education through research, development, engineering and production to operation (services provided) and recycling. Only the usage of such a philosophy can result that the continuously increasing needs of the economy and society can be covered beside using not more, even less natural resources and generating less impact on the environment, as it is demonstrated by Fig 3 [5].

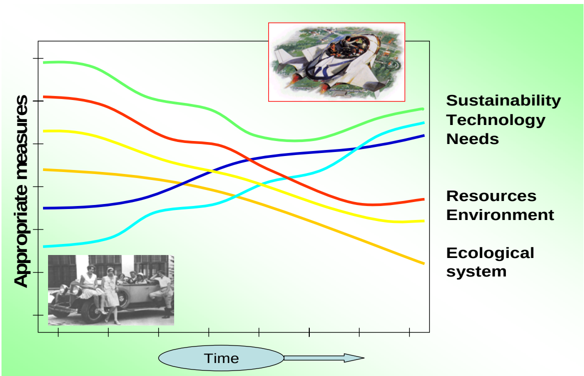

Fig 3. Effect of technology on the sustainable development

2. Indicators of sustainability

To help the decision-makers to achieve progress towards sustainable transportation a general method has been elaborated. Numerous references, like [8–11] are dealing with the description of the method in detail. The main thing in this is to find appropriate indicators of different types and numbers that show good or bad progress from the sustainable transportation point of view [12].

For evaluation, modeling and simulation of the sustainable development, sustainable transportation indicators and indexes can be applied. The key definitions for these words are given by Gudmunsson in [11, 13, 14].

Before future investigations, we must introduce some definitions: an *indicator* is a variable selected and defined to measure progress toward an objective, *indicator data* are values used in indicators, the *indicator set* is a group of indicators selected to measure comprehensive progress toward goals, and an *index* is a group of indicators aggregated into a single value.

According to [9], interest in indicators is strong, and even appears to be growing.

A long list of references could be inserted here in that proposal and selection of indicators of sustainable transport discussed in detail. They are a bit different, but full standardization of indicator sets may never come – and may not even be desirable – as goals, and objectives, and the particular project vary from place to place.

After deep examination of the references [4, 10, 15] and a study of the important characteristics of the inland waterway navigation, namely water transportation system, some of the most important indicators defined by us, are shown in Table.

3. Assessment of sustainability

Nowadays the assessment or evaluation is mainly carried out in general or as we call it: on macro level. As a result of this general approach, new transport policies are worked out and new priorities are drawn up by the state-, regional- and local governments. However, modification of laws, pricing policies, taxation, etc. are still expected.

On the other hand, decisions are made not only on the macro-, but also on company (in our terminology: micro) level. In this field the question arises so that – considering, for example, a freight transportation task of a forwarding company – which alternatives are more sustainable, if there is a possibility to choose from different solutions. Within the European Commission supported CREATING project [12], our department (together with other parties) is working on the assessment of specific single- and multimodal transportation tasks, taking into consideration the previously discussed aspects of sustainable transport.

The above-mentioned indicators are determined for the macro level assessment, however lots of indicators can be used on micro level as well, projected to the specific transport task.

In the following chapters we show how the inland navigation performs on macro level, compared to the other modalities. In this paper we focus only on freight transport and only on those indicators of sustainability where data is available [12, 15]. Although great efforts have been done in this way, good and comprehensive data for a great number of indicators are not available at this moment. It is the task of the future, that statistical offices shall collect data on sustainability in a well-defined and controlled way.

Sustainable transport indicators

ECONOMIC INDICATORS	
TRANSPORT OPERATION COSTS	Transport prices
PRODUCTIVITY / EFFICIENCY	Utilisation rates, Energy consumption efficiency of transport sector, Energy efficiency
COSTS TO ECONOMY	Infrastructure costs, External transport costs, Final energy consumption
BENEFITS TO ECONOMY	Gross value added, Benefits of transport
ENVIRONMENTAL INDICATORS	
RESOURCE USE	Consumption of solid raw materials, Land take
EMISSIONS TO AIR	Transport emissions of greenhouse gases, Greenhouse gas emissions from manufacture and maintenance, Transport emissions of air pollutants, Air pollutant emissions from manufacture and maintenance
EMISSION TO SOIL AND WATER	Polluting transport accidents, Runoff pollution from transport infrastructure, Wastewater from manufacture and maintenance of transport infrastructure, Discharges of oil, Discharges of wastewater and waste
NOISE	Exposure to transport noise
WASTE	Generation of non-recycled waste
SOCIAL INDICATORS	
SAFETY AND SECURITY (users, drivers, the affected)	Accident related fatalities and serious injuries, Security of cargo

3.1. Economic aspects

Transport prices:

All international transport modes have managed to reduce their transport prices over the past 20 years. Road, rail and water transport have done a 36 %, 45 % and 52 % reduction respectively. As it can be seen from Fig 4, water transport was and is the cheapest, followed by rail and road. In the meantime road transport gained a significantly higher market share.

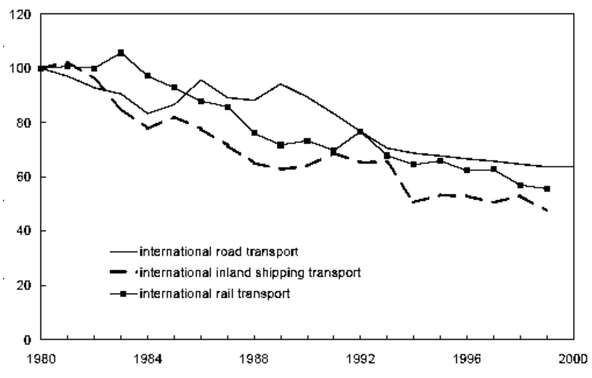

Fig 4. Real price indices in the Netherlands, per tonne-km (1980=100)

The reason for the greater price reduction of rail and water transport can be explained by increased competition with road transportation, when rail and IWW had to reduce the prices to keep the market share as high as possible. Rail transport, once dominated by unit transport, is now only considered competitive when executed with full train loads (shuttles). Rail and water transport had to concentrate on high-volume markets over long distances, and road, stimulated by motorway construction and rapidly improving truck technology, could take over the rest [16].

IWW transport is the cheapest mode, however, it is not enough to attract more customers and achieve a greater share from the modal split.

Infrastructure costs:

The infrastructure costs cover the construction and maintenance of the network and transhipment terminals.

Since most of the waterways are natural, it seems that the infrastructure cost of inland navigation is rather small. On the other hand, for fair comparison it should be noted that for effectively navigable rivers dams and locks and maintenance work (dredging) are needed.

So the question is interesting, but because of very different material and labour prices and taxation systems the comparable data were hard to find at the time of writing. However it can be stated that this indicator may have a great influence on the results of the sustainability assessment.

External costs:

The external costs of transport are detailed very well in [17]. Generally it can be stated that external costs of transport are large and uncertain (estimated at about 8 % of EU GDP). The most important categories of external costs are accidents, air pollution and climate change. Congestion is the largest component in many urban areas.

Considering only goods transport in the year 2000, the total external cost of transport in EU 15 + Switzerland and Norway (EU 17) was 236 billion EUR/year. The share of the different modalities are shown in Fig 5.

However, the picture is different, if we compare the absolute cost per year to the yearly transported volume (relevant data are also from [17]). In such a way a spe-

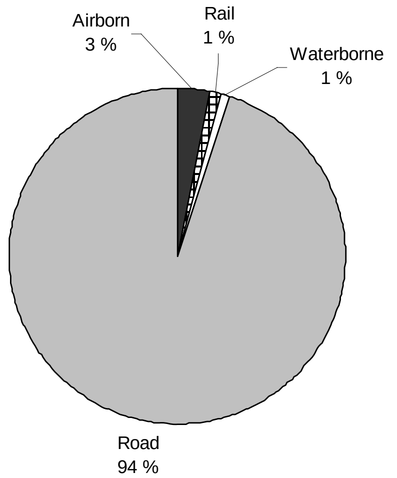

Fig 5. Share of transport modes from the total external costs of freight transport (EU-17)

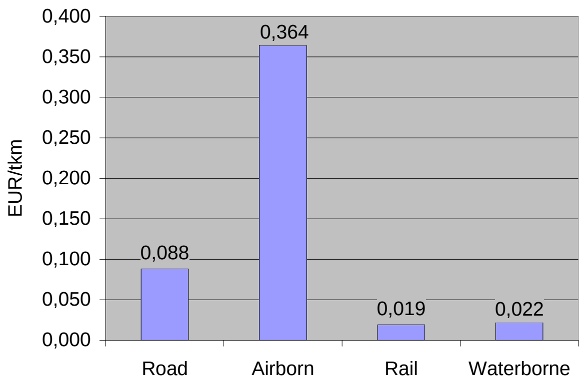

Fig 6. Specific external costs of transport modes in 2000, in EU-15 plus Norway and Switzerland

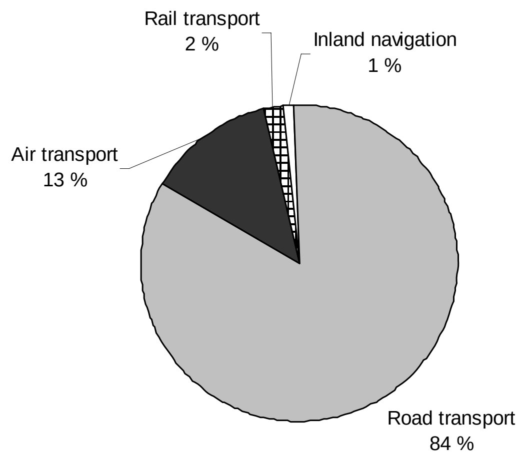

Fig 7. Modal split in energy consumption of freight transport, in EU-25 (in 1000 tonnes of oil equivalent) [18]

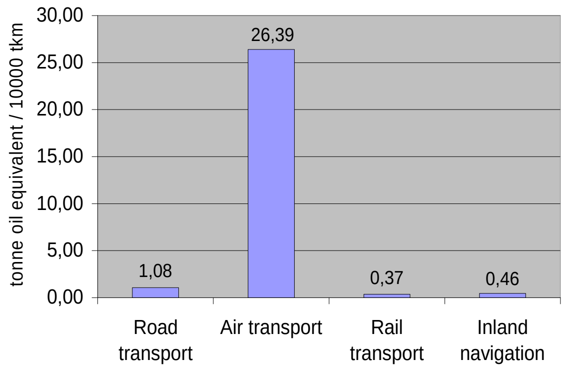

Fig 8. Specific energy consumption of transport modes, in EU-25, in 2000

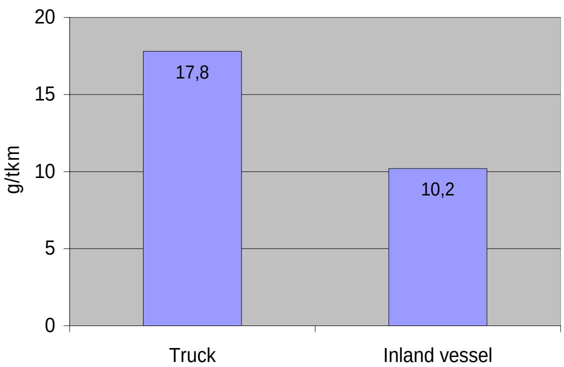

Fig 9. Average specific fuel consumption

cific value with a dimension of EUR/tkm is created, and now this shows a more realistic picture (Fig 6).

From this it is obvious that IWW transport is still in a good position considering sustainability.

Final energy consumption:

Transport energy consumption increased by 22 % between 1990 and 2000. It is the largest energy-consuming sector, being responsible for about 35 % of the total energy consumption in 2000. Aviation is the sector's fastest growing energy consumer and road transport is the biggest. From this absolute point of view inland navigation performs best (Fig 7).

Energy efficiency:

From the energetic point of view the different transportation systems can be classified according to use of the energetic coefficient, namely energy used for transporting 1 tkm commercial load (energetic coefficients, e = kWh/tkm) [19].

Although trucks consume 2–3 times more energy per tonne-km than rail or ship transport, inland navigation is not as advantageous as before (Fig 8).

Another way to compare energy efficiency of the various modes is the measurement of the fuel consumption per tonne-kilometre. In [20] the data as shown in Fig 9 can be found, but it neglects variations in performance due to different degrees of utilization of loading capacity.

3.2. Environmental aspects

Emissions to air:

Generally speaking, the emission depends on the primary source of energy, hydro and aerodynamics of the vehicles and type of applied power and propulsion systems.

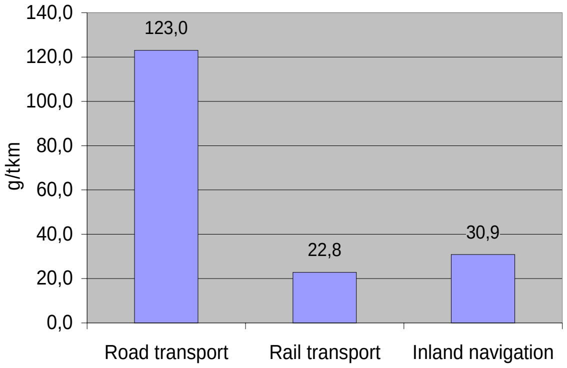

Fig 10. Specific CO_2 emissions by mode, in EU-15, in 2000, data from [21]

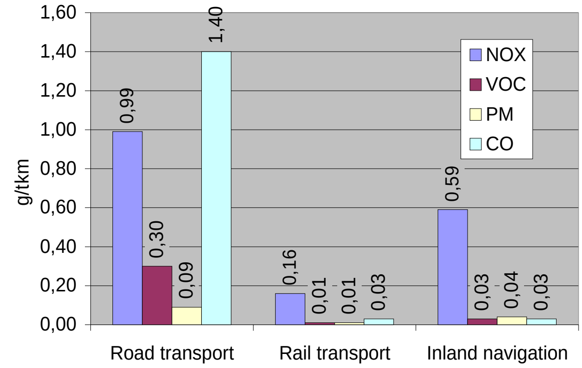

Fig 11. Specific emissions of air pollutants by mode, in EU-15, in 2000, data from [22]

Emissions of GHGs from transport increased by 21 % between 1990 and 2001, contributing to a fifth of the total GHG emissions in 2001 in the EU. The main contributor to transport GHG emissions is CO_2 (97 %) and road transport is, in turn, the largest contributor to these emissions (92 % in 2001). Actual data from [21] are presented in Fig 10.

Transport is also a small, but rapidly growing source of N_2O emissions. Since transport is not a large source of N_2O, this will not have a major impact on the overall trend of the total EU GHG emissions.

The specific emissions of air pollutants (acidifying substances, ozone precursors and particulates) from freight transport (Fig 11) decreased in most modes of transport. The highest reduction of specific emissions can be found in the road sector, following the increasingly stricter emission standards. Rail has only slightly improved its performance over the past decade. Inland waterway freight transport stabilised its emissions per tonne-kilometre, while maritime passenger and freight transport have increased their specific emissions over the past decade.

Rail and water transport are still relatively clean forms of transport – compared with road and air transport – but without any regulations on their emissions, these modes might lose this leading position.

The reason of this great performance of rail transport might be the wider use of electric traction. However, it is a question what kind of power-plant has produced the electricity used by trains, and how much pollution was emitted during the production of that amount of power needed for one tonne-kilometer in rail transport.

Noise:

Noise pollution is a more "standing" discipline within the conjoint research devoted to environmental impacts of transport. As a consequence, for the quantification of transport mode-related noise production and intermodal comparisons between them, several studies could be consulted. However, noise levels for the different modes of transport appear to be rather difficult to operationalize on a consensuated basis as they depend highly on the specific area, amount of vehicles, frequency, duration, people living in the vicinity etc. Most important, they appear to depend on the observer himself. Therefore noise nuisance is usually indicated as a percentage of people exposed to and annoyed by high noise levels >45 dB(A).

The maximum allowed inland shipping noise, allowed by the regulations of the Central Commission for Navigation on the Rhine (CCR), is 75 Db(A) at 25 mtr. perpendicular to the hull of a passing vessel. Many studies indicate that noise produced by ships, as compared to other transport modalities (trucks, planes, trains) is not considered as relevant. Consequently only noise impacts of these other modalities have been described in literature [20].

3.3. Social aspects

Safety:

According to different references based on the statistical data, the number of fatalities and severe injuries in IWW are not relevant to the other transport modes. Hence, it can be stated that inland waterway navigation is still the safest transportation mode.

4. Assessment on micro level

As it was already mentioned we are working on the method of assessment also on micro (company) level. After giving an overview about sustainable transport [5] for the project partners, our next step was to examine the possibilities of calculation and quantification of the STPI [23].

For micro level assessment the working groups in the CREATING project defined a fourth field of assessment, namely logistics. It may not be obvious but logistics has a great importance in specific transport tasks also from the sustainability point of view.

It was our task to work out a method for evaluation of the logistics aspects of a transport scenario. In our proposal [24] we defined the following logistics indicators: logistics character of freight, geographical conditions of the transport route, border crossings, transported cargo volume, number of transshipment and flexibility. In the time of writing we assessed the first scenarios with promising results.

Further information will be given in the following creating project reports.

5. Conclusions

From the above it is obvious that inlandly waterway navigation is still a very environment-friendly, safe, and effective transportation mode as it was known for a long time. Because of this, if it can achieve a larger share from the modal split, it could greatly contribute to a more sustainable transport system. Therefore action should be taken to increase its share in the total transport market. To encourage the modal shift the abandonment of difficulties in the multimodal transportation should be promoted.

However, it is wise to consider the following:

- road transport is developing very rapidly, and the actual differences in the indicators may appear in the future without developing inland waterway transport as well;
- rail transport in some aspects is ahead and so can be a substitute of inland navigation in multimodal transport chain;
- inland navigation can never work alone, pre- and post haulage is needed, but due to the logistics problems of internal loading/unloading and the administrative work related to this, it is not cost-effective enough for forwarders;
- it is slow in this rapid world.

It comes from all of the above that action is also needed to strengthen the above-mentioned favourable position of inland navigation.

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