INVESTMENTS IN EDUCATION DEVELOPMENT

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Transport and Environment -
Selected Chapters

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CONTENTS

KEY WORDS: sustainable transport; sustainable transportation; transport and environment; environmental aspects of transport; environmental impacts of transport; transport planning; transport ecology; transportation ecology.

FOREWORD: PURPOSE OF THE PUBLICATION

This textbook deals with selected environmental topics related to transport. The text is primarily intended for Czech students that want to enhance their environmental knowledge and communicate in English. It may also be helpful for foreign and academic-exchange students. The publication should be useful not only for academics, but also for interested non-academics in public administration, non-profit organisations, transport companies, tourism agencies, and elsewhere. Readers with little preliminary knowledge of environmental issues should be able to read this text.

The text is not a comprehensive treatment of the subject; only some topics are covered. Moreover, the text does not focus on *technological* measures through which people attempt to protect the environment in the area of transport. Although technological development cannot be omitted, this publication mainly deals with organisational approaches through which human society strives to improve the current situation. This book addresses the transport subject from the perspective of social disciplines, such as public policy, economics and urban and regional development.

Almost certainly, we will face increased economic and cultural globalisation during their our lives, for better or worse. English is currently the first foreign language for most of foreign language speakers. Environmental issues will stay with us for years to come. Therefore, it is important to develop international language skills, and understand environmental problems whose solution will need international cooperation. This textbook hopes to facilitate this endeavour by bringing attention to transport, an area with a profound influence on our life style and life quality.

ÚVOD: ÚČEL PUBLIKACE (CZ)

Tento text se zabývá s vybranými tématy životního prostředí v souvislosti s dopravou. Je určen především pro české studenty, kteří si chtějí rozvinout své environmentální znalosti a komunikovat v anglickém jazyce. Může být také užitečný pro zahraniční studenty a studenty přicházejícími do České republiky v rámci akademické výměny. Publikace by měla přijít vhod nejenom na vysoké škole, ale i pro neakademiky ve veřejné správě, v dopravních firmách, v neziskových organizacích, v turistických kancelářích a jinde. Čtenáři s malou předchozí znalostí environmentálních témat by měli být schopni rozumět tomuto textu.

Text není kompletním pojednáním předmětu doprava a životní prostředí. Jsou pokryta pouze některá témata. Dále, text se nezaměřuje na technologická opatření, kterými lidé usilují chránit životní prostředí v oblasti dopravy. Ačkoliv technologický vývoj nemůže být pominut, tato publikace se věnuje především organizačním přístupům, kterými se lidská společnost snaží zlepšit současnou situaci. Tato kniha se věnuje dopravním tématům z pohledu společenských disciplín, jako jsou veřejná politika, ekonomika a rozvoj města a regionu.

Téměř jistě se budeme setkávat se vzrůstající ekonomickou a kulturní globalizací během našich životů, ať k lepšímu či k horšímu. Angličtina je v současnosti prvním cizím jazykem pro většinu lidí se znalostí cizí řeči. Environmentální problémy s námi zůstanou i v příštích letech. Proto je důležité si rozvinout schopnosti komunikace v mezinárodním jazyce a rozumět záležitostem životního prostředí, které budou vyžadovat mezinárodní spolupráci. Tento text se snaží podpořit toto úsilí tím, že obrací pozornost na dopravu, oblast se zásadním vlivem na náš životní styl a kvalitu života.

HOW TO STUDY THIS BOOK?
(SUGGESTION)

The *main body of text* is complemented by information in *boxes*, *underline notes*, *review questions* and *glossary*. Go through the main body of the text. Make sure you understand the key points and are able to answer or to discuss the *review questions*. The text in the *boxes* provides either *definitions* or *supplementary text* to the main text body. You may find useful to learn the *definitions*. The *supplementary text*, containing detailed information, is not crucial for comprehension of the main points of the chapter. However, it may further clarify some topics or provide some real life examples. The *underline notes* serve for clarification and extension of the study material, and may be skipped in a fast reading mode. The *glossary* annex serves for a quick reference of some terms, in case of need.

London Traffic Photo: J. Kordas

Chapter 1 INTRODUCTION

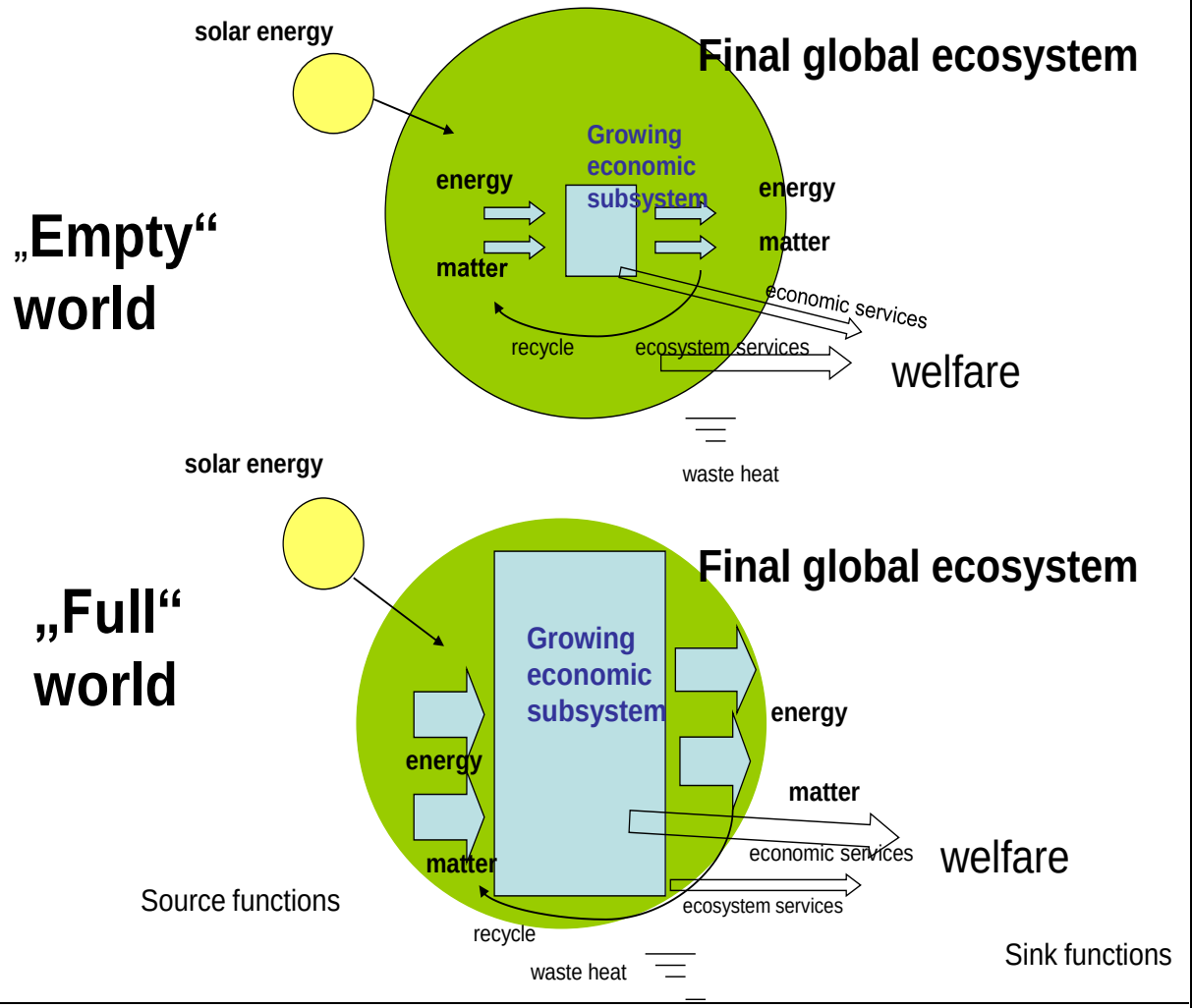
Transport can have a positive impact on the life of individual humans and the whole society. Historically, it has positively contributed to the cultural and trade exchange. Transport supported the overall increase in the standard of living, and helped to raise knowledge and education of nations. However, in the last decades, in many places of the world, serious environmental problems have been encountered with the growing transport volumes. [1 2 3]. The environment is closely connected with quality of living and with human health that is threatened by transport pollution. [4] Consequently, medical practitioners, citizens groups, governments and public administrations, various scientific institutions and technology entrepreneurs started to focus their attention on the environmental aspects of transport. The growing intensity of some environmental problems on a worldwide scale [5] forces us to look for effective solutions in the area of public policy, economy and technology.

Study of environmental issues of transport is a part of environmental science. Knowledge of environmental issues is part of basic education in modern societies. Environmental education is a prerequisite for qualified political decision-making in public administration. In the private sector, production, marketing, transport and finance managers are increasingly facing changes related to environmental limitations and opportunities. Environmental knowledge has begun to influence human lifestyles, consumer choices, and technology usage and development.

There are more than seven billion people on the Earth, and their consumption is increasing. The era of the "empty" world is over. According to some economists, free **public goods**, such as pure air, clean water, and abundant biodiversity, have gradually become **scarce commodities**. Also free physical space in cities and countryside of many countries is becoming rare. The life supporting ecosystems of the physically finite Earth are progressively being strained from the growing human economy. Current economic and political systems are criticised as being inadequate for new environmental conditions. Some concerned scientists have warned that human economic activities have already reached or exceeded some global source and sink limits (see Figure 1).

Rapid technological and social developments in the second half of the 20th century, and the associated environmental problems, gave rise to the discipline of **environmental science**. Environmental science integrates knowledge from various natural and social sciences. Among these knowledge sources are biology, chemistry, medicine, economics and politics. Environmental science helps us understand how the Earth functions, how humans interact with the Earth, and how to develop solutions to environmental problems.[6] The study of **environmental issues of transport**, which is a part of environmental science, also requires an interdisciplinary approach by combining information and ideas from both natural and social sciences.

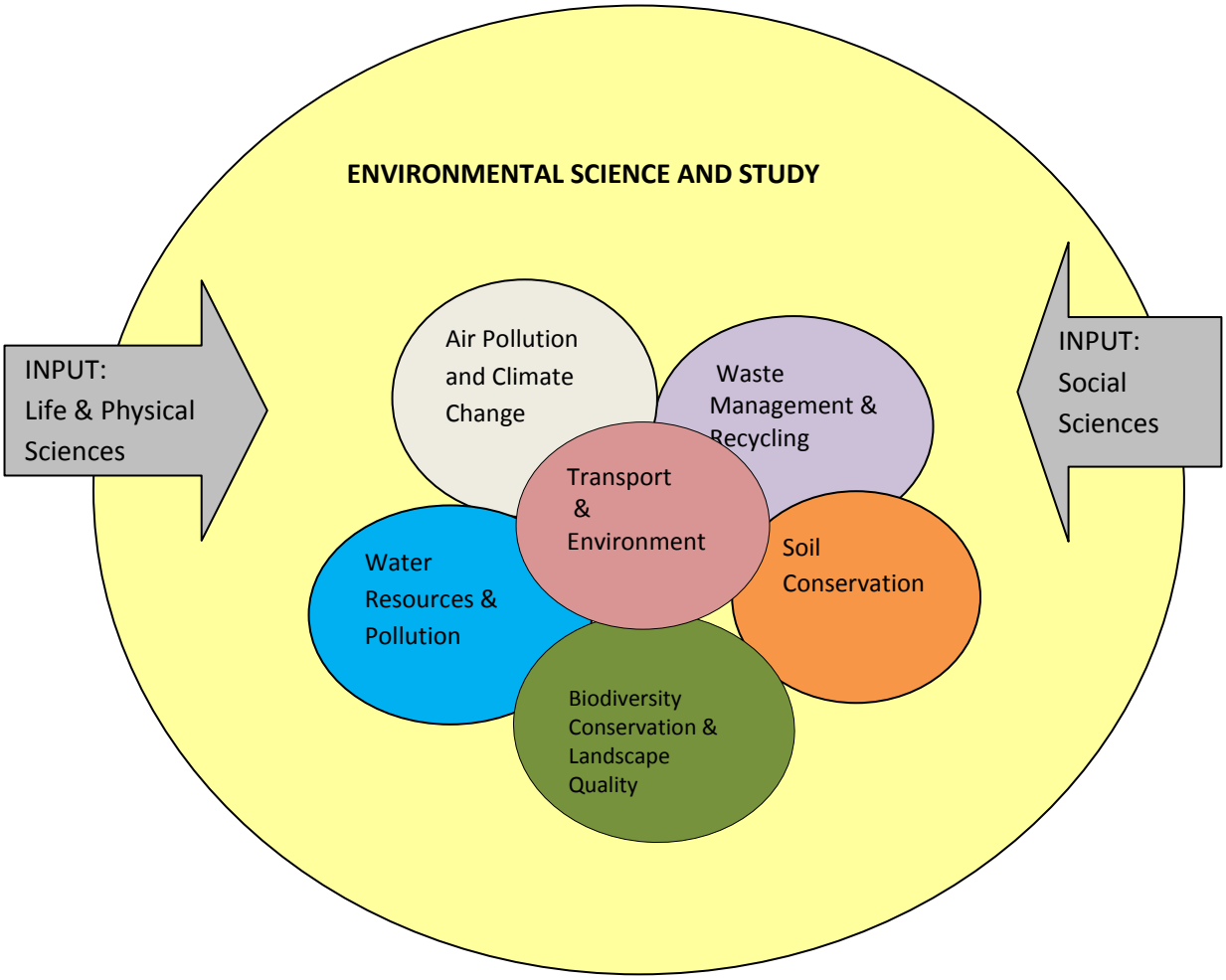
Illustration No. 1 : DEVELOPMENT FROM AN EMPTY WORLD TO A FULL WORLD



Source: Adapted from Daly H., Farley (2003): *Ecological Economics. Principles and Applications.* Washington, DC: Islands Press, p. 17-18.[7] and from Costanza et al. (1997*): An Introduction to Ecological Economics*. Boca Raton, Fl: CRC Press, p. 6.[8]

Environmental science or environmental studies are divided into several broad areas. After an introductory course/module on environmental science, the protection of specific components of the environment (air, water, soil, and biodiversity) may be studied in separate courses/modules. Other areas of study include waste management and recycling, radiation protection, environmental health, environmental politics, environmental economics, international environmental relations, environmental technologies, alternative energy sources, etc. All these areas are relevant when we deal with transport, because various modes of transport touch every one of them. The environmental issues of transport have increasingly grown prominent and have become a subject of interest and research of various practitioners and scientists.[9 10 11 12 13] However, comprehensive texts on the subject are still relatively scarce, considering the profound influence of transport in our lives and in our landscapes.

Illustration No. 2: ENVIRONMENTAL SCIENCE/STUDY



QUESTIONS FOR REFLECTION AND DISCUSSION

1) In the presented "empty world – full world" model, what goes in and what goes out of the economic subsystem? Where does transport belong in the model?

2) What are the sources and what are the sinks in the model? What outside sources are in the model? What source functions are important for transport?

3) What sink functions can you observe in your home city/town or village? Can the sink functions be related to transport?

4) What is the main point of the presented "empty world – full world" model?

5) Have you observed any relation of transport and biodiversity?

Chapter 2 ROLE OF TRANSPORT AND TRANSPORT PLANNING

2-1 Why transport?

What is transport? From the point of view of the human society, transport is a means of meeting the needs that cannot be satisfied locally. In order to meet these needs, people, animals and things move physically between localities, using energy, vehicles and infrastructure. These needs may be:

- employment (commuting to the place of work)
- education and childcare (children getting to schools and kindergartens)
- family and social life (visiting family and friends)
- recreation and entertainment (tourism to natural places and cultural monuments, sports, going to cinemas, theatres, concerts)
- medical care and contact with public administration (seeking medical treatment, dealing with tax administration and social security)
- goods and materials delivery
- shopping and other

Definition: Transport

Means of meeting the needs that cannot be satisfied locally.

Transport may assist in meeting of these requirements, and contribute thus to human well-being. If the need can be satisfied locally, no transport is used, other than a walk or a wheelchair. Transport is usually not a need in itself, it is a means towards fulfilling a need. Transport is an instrument, not a goal.[1] This is an important point for public policy and public spending.

Modern urban and community planning considers how to meet the needs locally, before devising costly and environmentally problematic transport infrastructures to meet the needs in distant locations. The volume of traffic gets reduced, if there are schools, services, employment opportunities, green spaces, clean air, entertainment and sports facilities close to home. Decision makers in public administration (elected officials, public service employees) bear the responsibility for transport management, since much of this is not a matter of individual choice.

Transport is a derived need, in most cases, since it arises from other needs that provide the ultimate utility. Transport has a service/mediator function, while the actual utility is in a non-

[1] Note: There are some individuals for whom transport (such as driving a motorcycle or a racing car) may be a goal, or a "need" / want in itself. However, most of motorized traffic is a means to meet another ultimate need.

transport area. Public administration should consider various ways of reaching the ultimate utility ("real needs"), and prevent excessive and non-desirable transport flows. This should be reflected in land use planning by public authorities.[2]

2-2 Access or mobility?

Accessibility and *mobility* are terms widely used in journalistic and political languages. Though these terms may sometimes overlap, they are not equivalent. More mobility does not necessarily mean more accessibility. Access, not mobility, is what most people desire.

Mobility in transport reflects the physical movement of people and goods. It can be measured by number of journeys, travel time spent, distance travelled, tons transported, etc. Some outdated concepts of economic development imply that all increase in mobility is beneficial and contributes to social progress [3]. An increase in overall mobility was therefore an aim of public policy in the past, and public finances were spent (and sometimes wasted) accordingly. Besides transport, the term *mobility* is a also used in sociology describing movement of individuals between various social strata.

Accessibility in transport reflects the ability to reach opportunities. These opportunities lead to satisfaction of needs in non-transport areas. The ultimate goal of most transportation is "access," people's ability to reach other people, institutions, goods, services and activities. [14] [15]

In remote countryside areas, access to services, goods and people will often require a lot of mobility. In well-designed urban settings, accessibility of services, goods and people may involve short trips and require little mobility. Accessibility is influenced by the costs of transport. High costs may prevent access for an individual or a social group, whether because of financial weakness or distant home location. Public administration sometimes decide to support public transportation to address the problem of distant locations or financial costs.

Accessibility may also relate to personal physical dispositions. Disabled people, children and elderly have often less access compared to young healthy adults, even though the same distance is involved. Accessibility with a wheelchair is still a problem in many public and private buildings. Such social aspects of transport were frequently overlooked by designers and public administrators in the past, however there was some improvement in the last years.

As noted earlier, movement or transport in cities and rural countryside is not an end in itself. People move in order to reach people, services, things and institutions. In car-oriented cities and

[2] Note: In some countries, the terms *space planning* or *zoning* are used instead of *land use planning.*

[3] Note: Progress: an (abstract) move towards a higher quality (for ex., higher quality of living). From the social point of view, progress needs not to be connected with a more complex technology, or physical aspects such as speed and volume.

suburbs, a concept/design that was supported by public policies of the 20th century, human activities tend to spread out. This compels inhabitants to travel further and further to access same goals [16]. They have the same accessibility with increased mobility. Some people call it a *forced increase in mobility*. On the other hand, progressive public policies may result into an increase of local access to services (for example, by building schools), or to recreation (for example, by establishing quiet zones, city parks), while reducing mobility and traffic.

A single-minded disintegrated effort to smooth the traffic flows is not sufficient for effective public policy. Innovative public policies increase the choice for the inhabitants; to reach accessible destinations cheaper, in less time, more comfortably, with less damage to public health and the environment. In some cases, this may involve the support of close destinations with an aim to meet more needs with less traffic.

While stressing the accessibility perspective, mobility and traffic still remain important tools of social organisation. However, they are viewed as 'tools' not as 'ends in themselves', and the public decision-making is adjusted accordingly. The purpose of public funding is not to increase traffic volume or kilometers travelled. Compact city designs, planning for proximity, support of local business and improved communication systems may increase accessibility, instead of forcing mobility. Improved access instead of increased mobility is promoted in advanced urban and transport planning.

2-3 Transport Planning

An improvement in environmental aspects of transport starts with proper urban, community and transport planning. Technological solutions. such as cleaner engines and fuels, can help. However, they have not solved the problems of traffic congestion and total environmental damages, since the human population and overall motor vehicle use have increased.

The traditional goals of urban transport planners were the following:

- to solve the problems of increased traffic intensity (traffic congestion, road wear and damages)
- to create conditions for the future growth of traffic volume

Today, the transport planners have additional tasks:

- to solve environmental and social problems of transportation
- to change traditional goals and approaches, in order to meet new demands and challenges

2-4 Traffic Induction

Traffic congestion became a wide-spread phenomenon in developed and newly industrialized countries, especially in urban areas. Traffic congestion has its substantial economic costs, in terms of lost time, more fuel consumed, and other factors. Adding more road capacity to the existing one seemed to be an obvious solution. However, quite often, expected smooth traffic flows did not result, and some problems, such as noise and air pollution, even increased.

Transport planning and project appraisals in the past often ignored the factor of *traffic induction*. Paradoxically, adding roads and increasing roads capacity may result into more traffic and recurring urban traffic jams in the medium and long terms. This was learned through practical experience and also scientists shed some light on this complex phenomenon.[17] [18] [19]

Traffic induction is a situation when the supply of a new capacity of infrastructure raises demand. A new motorway, system of bicycle paths, railway line or a pedestrian zone results into a higher demand for the particular way of transport. The traffic that fills up the new or enlarged transport line consists of redirected traffic that formerly used other lines, modes of transport, or day time. In addition to that, the new or enlarged transport line may fill up also with traffic that earlier did not exist. This induced traffic originated in consequence of better conditions for this type of transportation.

The traffic induction may relate to all modes of transportation. However, the most typical undesirable case is the situation when a new road capacity added to an urban area, instead of promised smooth traffic flows, delivers chronic traffic congestions within few years or even months.[20]

This is not to say that in all infrastructure building for motor vehicles the disadvantages of induced traffic outweigh the benefits. However, the phenomenon of traffic induction is quite prominent and needs to be taken into account in advance during transport project appraisal. Simply adding more roads capacity is not a solution for a crowded urbanized landscape with an already dense road system. As popularly put, we cannot build our way out of traffic congestion and environmental problems associated with intense traffic.

The induction principle applies also to the building of ring roads and bypasses around cities and towns. A ring road (beltline, loop) is a circumferential route around a city that is built with an aim to relieve the inner-city transport situation. While it has the potential to improve the congestion and environment in the inner city, the promise will often not materialize. After opening the ring road, other measures need to be taken to push the traffic out of the city centre. These accompanying measures may be the reduction of space for cars, opening of new pedestrian zones, paid car entry, increase of parking fees, etc. Otherwise the centre will get filled with intense traffic again, after a short time relieve. Public administration will have to take measures that are

unpopular with certain interest groups, in order to provide a general improvement of transport situation. Understanding and considering the concept of *traffic induction* is crucial for planning of various modes of transport. The opposite of the term of *traffic induction* is the term *traffic evaporation.*[4]

QUESTIONS FOR REFLECTION AND DISCUSSION:

1) What are the benefits of transport? Are there any attached problems that should be solved?

2) How do you define transport in a non-physical way?

3) What is the difference between mobility and accessibility? Can we have more accessibility with the same or decreased mobility?

4) What are the current goals of transport planners in public administration?

5) What is traffic induction and what significance may it have for public expenditures?

Urban transport in Istanbul, Turkey.

Left: A lane reserved exclusively for public bus *(Metrobus)* helps to make public transportation more reliable and more attractive.

Photo: JM

[4] Note: *Traffic evaporation* is a situation when the reduction of capacity of infrastructure decreases demand.

Chapter 3 TRANSPORT AND BASIC TERMS OF ENVIRONMENTAL SCIENCE

In the area of transport, we deal with a range of environmental issues, including several *components of the environment*. In addressing these issues, we get inputs from the science of *ecology* and from the concept of *sustainable development*. Let us clarify some of these basic terms and relate them to transport.

Definition: Environment

All external conditions and factors (both living and non-living) that affect an organism during its lifetime, and are essential for its future development.

By organisms, we mean both humans and non-humans. We do not consider the environment for man/woman *(Homo sapiens)* only, but also for other living beings (animals, plants). Some early textbooks regard the environment as the environment for humans only, while new texts are less anthropocentric.[5] The environment is substantially influenced by transport, in some cases negatively (factors such as gas emissions, noise, etc.). The share of transport in some environmental problems may be increasing (air pollution in urban areas, greenhouse effect, landscape fragmentation). The organism (human, animal, plant) is affected during its lifetime. Moreover, environmental effects upon the parental organism may also influence its future offspring (children, juveniles, subsequent generations), for example, through birth defects, genetic degradation, low fitness, etc. Improvement of environmental conditions may work in the opposite direction (stronger and healthier individuals, genetic improvement, etc.).

Definition: Environmental Science

A physical and social science that integrates knowledge from various natural and social sciences (for example, from biology, chemistry, environmental economics, and environmental politics) to explain how the Earth functions, to study how humans interact with the Earth, and to develop solutions to environmental problems.

[5] Note: The term *anthropocentric: denotes* a worldview or an attitude that regards and interprets the world in terms of human values and experiences only. An alternative view may be called *biocentric* or *ecocentric*, including the idea that species and ecosystems may have their own internal value that is not dependent on utility for humans.

The environmental science is the most general discipline dealing with the environment and environmental issues. It should not be equated with ecology, a biological discipline. Environmental science or environmental studies encompass a broad area. The protection of specific components of the environment (water, air, soil, and biodiversity) may be studied as separated sub-disciplines. The impact of transportation on components of the environment is a matter of scientific interest and of public policy measures. Environmental science also covers waste management (including recycling of vehicles), and environmental health (including relation between human health and transport pollution).

Definition: Components of the Environment
Parts of the environment, including air, water, soil and rocks, organisms and ecosystems (biodiversity), and energy flows.

The division into components is frequently applied by public administration, such as government ministries and regional authorities. Public administration institutions often include separate departments for air, water, and biodiversity protection. Some of this division is also used by large private firms, such as car manufacturing companies. Different employees may be in charge of air protection, water protection, and waste handling.

In the area of transport we have to deal with protection of the following components of the environment and related environmental issues (examples of environmental problems):

- Air (exhaust fumes by cars, ocean ships, airplanes)
- Water (road runoff pollution from rain and melting snow, boating pollutants)
- Soil (road runoff pollution, road base leaching, acidification of soil through acid rain)
- Biodiversity (barrrier effect of motorways, space occupation by transport infrastructure, direct killing on roads)

Definition: Ecology
A natural science, a part of biology, that studies relationships between living organisms and organisms' relationships with abiotic factors in the environment.

The term *ecology* is different and more narrow than the term *environmental science*. In the original and correct sense, ecology is a biological discipline. An ecologist is a scientist that observes and analyses relationships between living organisms and organisms' relationships with abiotic factors in the environment. Ecology, as a neutral discipline, needs not to be involved with environmental protection or nature conservation, and the same is true for scientists – ecologists. Ecologists, as pure biologists, need not to deal with nature protection, since nature protection necessarily touches social disciplines (law, environmental education, environmental politics). However, ecology and ecologists may provide information for environmental and nature protection, just like geologists, chemists, climatologists, etc.[6] For example, ecology may provide

[6] Note: Furthermore, there exists a discipline of *applied ecology*.

information on the effect of land fragmentation by motorways on mammals, on the effect of air traffic on birds, or on the effect of locks[7] on river biota.

In common speech and in journalistic texts, the term *ecological* and *ecology* is often used in the sense of *environmental* and *environment.* In addition to that, in some countries and languages, there may be a substantial overlap of these terms. [8]

Definition: Sustainable Development
A type of development that allows the present generation (of humans) to meet its basic needs without undermining the ability of future generations to meet their needs, preserves the vital functions of ecosystems and does not decrease biodiversity.[9]

In the older form of definition, the *sustainable development* was defined in a short way as „*a type of development that allows the present generation (of humans) to meet its basic needs without undermining the ability of future generations to meet their needs.*" [21] Later the terms *ecosystems* and *biodiversity* were added, making it less anthropocentric. The term *basic needs* aims to express the difference between "*real / essential" needs* and *wants*, since some human *wants* are potentially endless.

"The earth provides enough to satisfy every person's need but not every person's greed…When we take more than we need we are simply taking from each other, borrowing from the future, or destroying the environment and other species."
Mahatma Gandhi, *Principle of Enoughness*

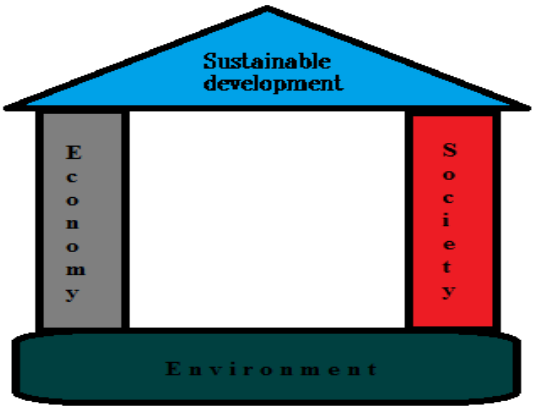
Photo: zitate.net,http://zitate.net/mahatma%20gandhi.html access 11-11-14

[7] Note: A *lock* is a facility built on a river in order to raise and lower boats between stretches of water of different levels. Locks were built to make rivers more easily navigable, however they present a barrier to water biota. Modern locks are therefore equipped with fish passes, structures around the barrier that enable fishes´ natural migration.
[8] Note: For example in Germany, we find scientific and academic institutions such as: Leibnitz Institute for Ecological Urban and Regional Development (*D:* Leibniz-Institut für ökologische Raumentwicklung), or Chair of Transport Ecology (D: Lehrstuhl für Verskehrsökologie). These institutions use the term „ecological, ecology" in a broader sense, beyond biological science.
[9] Note: Sourced from the Czech Law On the Environment, No. 17/1992 Coll., §6.

There were more definitions of sustainable development worked out.[10] Sustainable development is often illustrated as a structure with various elements, pillars, or factors. In our text, a most simple illustration is presented.

Illustration 1:

Model of Sustainable development



Aspects of Sustainable Transport Development

Sustainable transport development is a part of the overall sustainable development. Connecting to the three-pillar model of sustainable development, we deal in our textbook with the following selected aspects of sustainable transport development, with an emphasis on the environmental pillar:

- Social aspects of transport
- Economic aspects of transport
- Environmental aspects of transport

[10] Note: Some scientists doubt whether sustainable development can be achieved with continually growing world economy and human population. They claim that unlimited material growth of world economy and consumption is not possible, since the Earth has its physical and biological limits. A more equal distribution of material wealth, and a focus on non-material aspects of the quality of living, rather than growing material production and consumption, are emphasized. There is a related discussion on the meaning, sense and message of the GDP (Gross Domestic Product) economic indicator (not all growth in GDP is positive).

REVIEW QUESTIONS:

1) What are the difference between ecology and environmental science?

2) What are the components of the environment, and how they can be affected by transport?

3) How can you define sustainable development?

Photo: J. Kordas

Chapter 4 SUSTAINABLE TRANSPORT SYSTEM AND PUBLIC POLICY

How can be transport improved? Practical measures to address transport problems are carried out as a part of public policy. Public policy is designed and carried out by elected politicians and appointed public officers. Public policy may include environmental policy, transport policy, urban and rural development policy. The goal of sustainable transport system is pursued by policies on local, regional, nationwide and international levels. That means, your town mayor, regional deputies a bureaucrats, members of parliament, the European Commission; all these policy makers can influence your transport, for better or worse. And, certainly, many appointed officers in public administration/government of all levels. However, what is a sustainable transport system? And, what do we know about policies relevant for transport?

Various international and national institutions have declared their concepts of sustainable transport. Among the international ones, the United Nations[22] and the Organisation of Economic Co-operation and Development presented their definitions of sustainable transport. The supra-national European Union, also, worked out its concept, and the same did several national governments, ministries and other institutions in their areas of activity.

4-1 Sustainable Transport System – OECD Concept

According to the OECD [11] [23], a sustainable transport system is one that:

- *Does not endanger public health or ecosystems.*
- *Meets needs for access while*
  (a) the use of renewable resources is below their rates of regeneration, and
  (b) the use of non-renewable resources is below the rates of development of renewable substitutes.

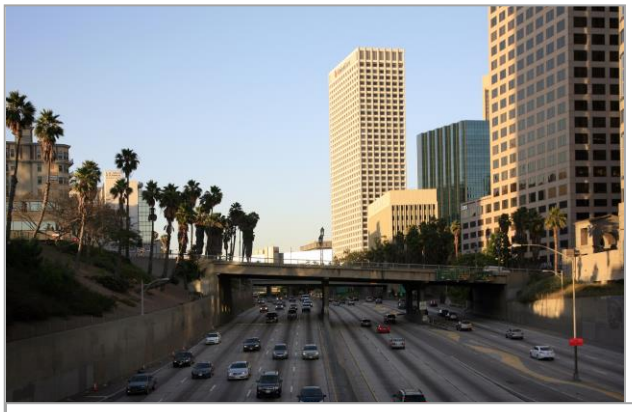


Photo: Individual car transport in Los Angeles, U.S.A.

J. Kordas 2012

Under the renewable resources in this OECD definition, we may include bio-fuels or solar energy. Non-renewable resources are crude oil or natural gas. Currently, we use the non-renewable resources not below, but above the rates of development of renewable substitutes. The non-renewable crude oilis still a dominant source of energy in transportation. The share of transport in the world consumption of crude oil has been increasing. At present, most of world

[11] OECD: Organisation for Economic Co-operation and Development. This international economic organisation includes most developed countries and some other countries. It aims to support economic progress and world trade, and also the exchange of experience and best practices among member countries.

crude oil is processed for transport fuels (gasoline, diesel, jet/kerosine). The renewable (bio-fuels and other forms of energy) still form a minor part of energy consumption. This is not expected to change in the next decade, since transport growth is expected particularly from developing and newly-industrialised countries. [24] (Even though the U.S.A. and Europe may go against the trend). [25] [26] By the OECD definition, the current transport system is not sustainable. Certainly, also the production and use of renewable crop-based bio-fuels is related to some environmental problems [27] [28] that countries needs to solve.

4-2 Sustainable Transport System – European Union Concept

Unlike the OECD and some other international organisations, the European Union (EU) has more power to implement its concepts. Let us take a look what sustainable transport means at the level of the EU. According to the EU Council of Ministers of Transportation (2001), a sustainable system of transport meets the following principles [29]:

- *Basic access needs are met safely and in a manner compatible with human and ecosystem health, and with equity within and between generations.*
- *The transport system allows a choice of transport mode. It is financially affordable, operates efficiently and supports economy.*
- *Emissions and waste remain within the planet's absorption capacity.*
- *The consumption of non-renewable resources gets minimized. The use of renewable resources respects the sustainable yield level. Components are reused and recycled.*
- *Use of land and the production of noise are minimized.*

The above mentioned principles emphasise *safety*, since traffic accidents present transport costs, both in material damage and human live loss. *Ecosystem health* creates conditions for a good quality of human life, and for a prosperous economy in the long term. Historically, transport developed with little concern about ecosystem health. At present, there are some efforts, at least in developed countries, to limit the negative effect of transport infrastructure on ecosystems (fauna migration objects[12], water protection measures, etc.). The *choice of transport mode* may be a problem in some countries or locally. The choice of transport mode is strongly related to priorities of public spending and taxing (roads or railways, public transport development, tax breaks for airlines, etc.).

[12] Fauna migration object: For example, a bridge or a tunnel that allow a safe crossing of a road or a railway for animals.

Our planet Earth has some *absorption capacity* (soil, water, air) that can neutralise some pollutants and decompose some wastes in the long term. However, this absorption capacity is not limitless, and serious damages may occur if the limits are crossed. *Reuse and recycling* are more sustainable alternatives to landfill sites and incinerators. *Use of land*, associated with impermeable soil sealing and barriers for movement of biota, is an increasing ecological problem around the world. The land use problems can be reduced by proper land use planning carried out by public authorities, and by voluntary private efforts of informed ethical businesses and educated citizens.

4-3 National Environmental and Transport Policies

Sustainable development is a concept or a paradigm officially acknowledged by most governments of the world and by many institutions. The acknowledgement of this concept is declared in various national and international documents, treaties and pieces of legislation. Governments and supranational institutions (such as the European Union) devise policies in various areas of human activity that should be in line with sustainable development. Public policies should be roadways towards reaching sustainable development.

Definition: Public policy
A set of ideas or a plan of what to do in particular situations that has been agreed by the government. [13]

Public policy is :

- a commitment and a principled guide for public officials
- implemented by policy instruments (laws, taxes/subsidies, etc.)

Public policy is a long-term strategic concept how some area of human activities should be governed or administered by public officials. This strategy has often a written form. A particular public policy may have a form of legal act (such as a governmental decree signed by the prime minister). Countries have their national transport policy, environmental policy, energy policy, industrial policy, and other policies. Public policies are a result of a political process, or of *politics.* We should distinguish between *politics* and *policy*. Although these terms are related, they are not the same.

Definition: Politics
A process by which groups of people make collective decisions.

[13] Source: Cambridge Dictionary, 1995.

An alternative definition would be: "*Politics is a process through which individuals and groups try to influence or control the policies and actions of governments at the local, state, national, or international levels.*" (Miller, 2002).[30] In the area of transport management, the ultimate decision-making will be political. Scientists can provide input, however, it is up to the politicians and public administrators to decide what level of air pollution is acceptable, or what modes of transport will be supported by public finances. In a participative democracy, various concerned citizens groups and non-governmental organisations (NGOs) may influence the decision making of public administration. Furthermore, vehicle manufacturers and their suppliers, freight companies, road builders, oil companies and car clubs are prominent transport lobby groups. These lobby groups influence public policy decisions on transport infrastructure building and environmental regulation. [31] [32]

All these activities belong to the process called *politics* and may be reflected in transport *polic*y of a particular country, or in a *policy* of a supranational body, such as the European Union. Transport policy is a strategy aiming to reach some goals in the area of transport, while the environment policy is a strategy aiming to reach some goals in the area of the environment. These two strategic policies have common points and overlaps, and should be compatible. Transport and its particular aspects (modes of transportation, public and private financing, regulation of pollution, etc.) is influenced by politics and policies. National policy gets implemented through the work of government departments, and regional and local authorities that may have their own strategic documents, respecting the national policy framework.

The **national transport policy** declares what goals a state/government has in particular areas of transport, such as safety, economics, equal access, sustainable development and public health, etc.. It also includes obligations from international agreements and financial aspects.

For example, a national transport policy may identify a problem:
(The Czech Republic examples taken from the last two national ransport policy documents)

- *Transport is a large source of noise and emissions of health-damaging substances.*[33]
- *There are no sufficient measures taken for a removal of environmental burden by transport infrastructure*.
- *Public transportation is often of lower quality, which leads to preferences for individual car transportation*.
- *There are no sufficient measures taken for traffic calming*[14] [34] *of city centres, as well as measures supporting bicycle and pedestrian traffic*.
- *There is a problem with landscape fragmentation and barrier effect*.[35]

Furthermore, national transport policy may demand problem removal or reduction:

[14] Note: *Traffic calming* consists of physical design and other measures, including speed humps, narrowed roads and closures, put in place on roads in order to slow down or reduce motor-vehicle traffic and to enhance safety for non-motorists.

(The Czech Republic examples taken from the last two transport policy documents)

- *It is necessary to create conditions for a decrease of transport noise and emission in compliance with the EU legislation*.
- *Every measure proposed in the transport policy will be realised while taking into account the protection of the Natura 2000 localities.*
- *It is necessary to ensure the passability of road network for animals at suitable localities*.

A properly designed national transport policy, as a strategy, should include broad goals and specific objectives whose achievement can be verified.[15] Specific objectives should be measurable and quantifiable. Indicators of public transport development[16], traffic calming[17], landscape fragmentation and other can be used to find out whether objectives were achieved. A well-designed policy should also include expected sources for reaching the objectives, and should establish priorities for public spending. When verifiable objectives and related indicators are missing, it is not possible to evaluate the work of governments and public officials, and declared policy may be just an empty proclamation.

Besides *a national transport policy*, that includes some environmental standpoints, there is a *national environmental policy*, that may have a part on transport. These policies should complement and be compatible with each other. In order to ensure that, each national policy may be published in a form of governmental decree (not just ministerial decree or order) after a lengthy approval process. In this process, various ministries, experts, special interest business groups and environmental NGOs take part. In non-democratic countries, public participation in policy design may be limited.

4-4 The European Union Transport Strategy

The European Union (EU), as a supranational entity, gradually develops its transport strategy. The EU transport policy is still small and weak compared to the common agriculture policy, with its regulation and financing. Strategic policy documents of the EU often come out in the form of a *white papers*.

[15] For example: (Broad) goal: *Reduce the air pollution by truck transport in urban areas*. (Specific) objective: *Pollutant fine particles (PM 2.5) should not exceed the limit value of 25 µg/m3, 1 year averaging period, by January 1, 2015.* (Specific) objective: T*he fleet average to be achieved by all new cars is 130 grams of CO_2 per kilometre (g/km) by the year 2015.* (Note: This EU standard is not for an individual car, but for a whole fleet of a particular large manufacturer - fleet of Fiat, Renault, Daimler, etc.).

[16] For example: Indicator illustrating the share of people using public transport in the total personal transport. Current status and development over time. Indicators of public transport quality and accessibility.

[17] For example: Number of traffic calming measures per km of road length.

European Union Strategic Document for Transport: White Paper 2011 [36]

This strategic EU document should provide a roadmap to a *Single European Transport Area*. It seeks to promote a competitive and resource efficient transport system for the members states.
The European Commission plans 40 specific initiatives for the following decade that are supposed to support economic stability, make transport more sustainable, and reduce the European Union´s dependence on imported petroleum. The key goals are related to the reduction of conventional fuels, the decrease of CO_2 and other emissions, and the support of railways. Special attention is given to the urban pollution problem.

The key goals to be reached by 2030:

- *Achieve essentially CO_2-free city logistics in major urban centres.*
- *Triple the length of the existing high-speed rail network and maintain a dense railway network in all member states.*

The key goals to be reached by 2050:

- *Elimination of conventionally-fuelled cars in cities.*
- *A 40% use of sustainable low carbon fuels in aviation.*
- *A 50% shift of medium distance intercity passenger and freight journeys from road to rail and waterborne transport.*

European Commission Building, Brussels

Photo: JM

As can be seen, these are quite ambitious targets, in view of the current situation and in view of increasing volume and distance of transport.[37] However, the European Union has legislative and financial tools to achieve these goals if the consensus of the member states can be maintained.

4-5 Goal/Objective[18] Setting and Policy Evaluations

Has there been a real improvement in transport? Objectives and indicators are required for an evaluation of a policy or a plan. They are also necessary for performance evaluations of public employees, whether elected (politicians) or assigned (public administration officials). An important rule is that the achievement of objectives must be verifiable. How do we verify the achievement of objectives? The objectives must be set in a way so that it is possible to measure their achievement or to provide some other method of verification.

An objective should have the following qualities:

- Relevant, clear and specific
- Measurable/verifiable
- Time limited
- Quantifiable (whenever possible)
- Realistic

Some policy makers avoid defining quantifiable objectives. However, quantification is possible in most cases, and should be used to measure the effectiveness transport management by public administrators and elected politicians.

Examples (fictional) of policy objectives that can lead to verifiable policy results:
YES !

- decrease of traffic noise levels, in dB (A),[19] by 4 % on selected streets, measured against initial base level, by the year 2020
- a 30% decrease of NOx concentrations, a 30% decrease of PM_{10} particles[20], by 2020
- total elimination of specified high-polluting vehicles from the designated city centre by 2018
- increase of pedestrian zones by 3000 m^2, increase of safe bicycle lanes by 40 km in the town area by 2020
- increase of the share of barrier-free vehicles in the city public transport to 90 % by 2018

[18] Note: Goals can be understood as broad general aims, while objectives as more specific aims whose achievement can be easily verified.

[19] Note: Noise is measured in *decibels* (dB). *Decibels A-weighted, (dB(A))* units are adjusted for the sensitivities of human hearing. Decibels are an instantaneous measurement, therefore various indexes are used to quantify noise over a time period. *Leq* expresses the equivalent continuous sound level in dB(A) for a specific time period. Leq (8 hours) is used in many traffic noise standards by WHO (World Health Organisation) and OECD.

[20] Note: Particulate matter (PM) air pollution is measured in $\mu g/m^{3.}$

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- increase of satisfaction of public transport users (measured by points in questionnaire results), by 2020

Examples (fictional) of policy goals with a high risk of becoming empty declarations:
NO ! 

- we will decrease traffic noise in the city
- we plan to reduce air pollution by transport in the town
- we will address the problem of high-polluting vehicles
- we will support pedestrian zones and bicycle traffic
- we bear in mind the interests of our handicapped citizens
- we will increase the quality of public transport

Evaluations of Public Policies

Meeting of the declared policy aims, both at the EU and at the national level, has to be checked by independent evaluations. Independent evaluations are carried out by people and institutions that are not employed by and not dependent on the evaluated public administration institutions. Academic institutions, independent research bodies and NGOs may be suitable in some cases. If the expected results (objectives) are not met, it is to be determined whether there was a bad implementation[21] of the policy, or the (initial) design of the policy has some flaws. Public employees should be held to their responsibility. Proper evaluations also make use of *indicators* for verification and measurement of results. These *indicators* can use *objectives* set by policy makers, however, should not be limited to these. *Indicators of transport sustainability* are not dealt with in this chapter.

QUESTIONS FOR REFLECTION AND DISCUSSION

1) What can be the aspects of a sustainable transport system (as reflected in the OECD concept and in the EU concept). Name at least three aspects.

2) What is the difference between public policy and politics?

[21] Note: Implementation of the policy: How the adopted policy was carried out (realized) by responsible people and institutions, how the measures and actions taken during a particular period supported the policy goals. The process of moving an idea from concept to reality

3) Do you know of any official public policy document related to transport in your country (city, town)?

4) Set two specific objectives related to urban transport pollution. How can you quantify the objectives, so that their achievement is verifiable?

Photo: J. Kordas

Chapter 5 SOCIAL AND ECONOMIC ASPECTS OF TRANSPORT

5-1 Social Aspects of Transport

Social aspects of transport may be looked upon from various angles. The **opportunity for equal access** can be one of them. The opportunity for equal access may be reduced because of various reasons, for example, in consequence of physical disability or disadvantage. Public transport in the past was quite illustrative in terms of unequal access. Public transport is an environmentally beneficial mode of transport, especially in urban areas. However, historically, and at many places still today, there were whole social groups that are disadvantaged, or even excluded from regular public transport. These groups were largely overlooked in construction of vehicles and of access routes, as well as in transport process management by public authorities and private companies. **Social exclusion** may be result of unequal access in transportation.

Among the groups of people that are routinely disadvantaged in using public transport belong:

- Physically disabled people
- Seniors
- Pregnant women
- People with small children
- Children

Photo source: blogs.vancouver.com, retr. 18-7-2014.

A term *transportation disadvantaged* is used for these people.[38]

In addition to that we may add to these disadvantaged groups:

- Persons with large baggage

It is estimated that these people together form almost half of the human population, and are majority clients for public transport. [39] These people, by using public transport, contribute to the sustainability of transport in general.

Photo: Wheelchair user

Source: allied.mobility.com, retr. 18-7-2014.

Design, technology and organisational measures that can help the transport disadvantaged groups:

- Barrier-free stations
- Short access station and stop design
- Low floored buses
- Wheelchair boarders
- Space reserved for the exclusive use of transport disadvantaged

- Tactile guide ways, tactile warning surfaces
- Guardrails
- Special traffic signals
- Security and Alarm System
- Well-trained transport company employees

and other.

Municipal programs that aim to improve the situation of the transport disadvantaged groups have been designed in various cities around the world, especially in Europe. Still, a large part of transport remains discouraging, or even inaccessible, for transport disadvantaged social groups.

5-1 Economic Aspects of Transport

Economic aspects of transport are a very wide topic. In our text, we will take a brief look at two issues that are related to the environment – the existence of *externalities* and *public policy economic instruments* in transport.

5-1-1 Externalities

Negative externalities are costs that a producer or consumer shifts to other parties, and does not provide compensation for them. Externalities are an unintended by-product of activities of the producer. Externalities create a divergence between the private and social costs of production or consumption. Social cost includes all the costs of production or consumption Third party (external) costs arise, for example, from pollution of the air or water.

- SOCIAL COST = PRIVATE COST + EXTERNALITY
- SOCIAL COST = COST OF CAR, MAINTENANCE AND FUEL + COST OF CAR POLLUTION AND TRAFFIC CONGESTION (house facades' cleaning, increased medical bills and work disability, lost working and leisure hours, etc.)

Clean-up costs and health costs are typical costs that a polluter shifts to other parties, and this is also the case in transport.

Since free market is not able to solve externalities (actually market externalities are cited as one of market failures), government regulation attempts to compensate for them. Most of these measures are unpopular with vested interests, and often also with much of the public used to the status quo.

Some of the **ways of externalities reduction:**

- Setting of obligatory standards (for ex., maximum limits of emissions, maximum contents of harmful ingredients)
- Mandating end-of-pipe technologies (particle filters, catalytic convertors)
- Environmental tax introduction (taxing polluters and spending the money for environmental clean-up)
- Various public policy incentive instruments/economic instruments (for example, fees imposed on the purchase of highly-polluting or high-energy consuming vehicles)

Traffic Congestion as Externality

Traffic congestion means costs in terms of lost working and leisure hours. Traffic congestion will not be solved even by the cleanest technologies. Individual car drivers create traffic congestion in urban areas at the expense of other transport mode users. The photographs bellow illustrate the point by comparing the public space required by individual cars, a bus, and bicycles to transport the same number of people (40 passengers).

Amount of space required to transport the same number of passengers by car, bus, or bicycle.
Event info at www.facebook.com/Urban.Ambassadors - Photos by www.tobinbennett.com
(Des Moines, Iowa - August 2010)

5-1-2 Public Policy Incentive Instruments (Economic Instruments)

Public administration may decide that it is in public interest to financially discourage or encourage certain behaviour related to environmental impacts. Besides the already mentioned environmental taxes and fees, **payments for the use of public road infrastructure** (motorways and other roads) can be used to cover the public expenses (construction, maintenance) associated with it. Current technologies allow relatively easy tracing of vehicle use of roads. The idea that riders should pay for the use of all roads, according to their impact on the roads

and on the environment, gets gradually more attention. The physical impact on the road, and associated maintenance and repair costs, is highly related to the weight of the vehicle. **Payments of entrance to city centres** are another measure through which municipalities attempt to reduce air pollution and traffic congestion in large cities. All these measures are unpopular with many groups of people, however, the central idea is that these economic costs should be shifted to the user and polluter and not covered by public money.

On the other hand, public administration may decide that it is in public interest to financially support environmentally-desirable behaviour. **State subsidies** to municipalities for the purchase of public transport vehicles is one example. **Tax breaks** for low-polluting vehicle operators are another one.

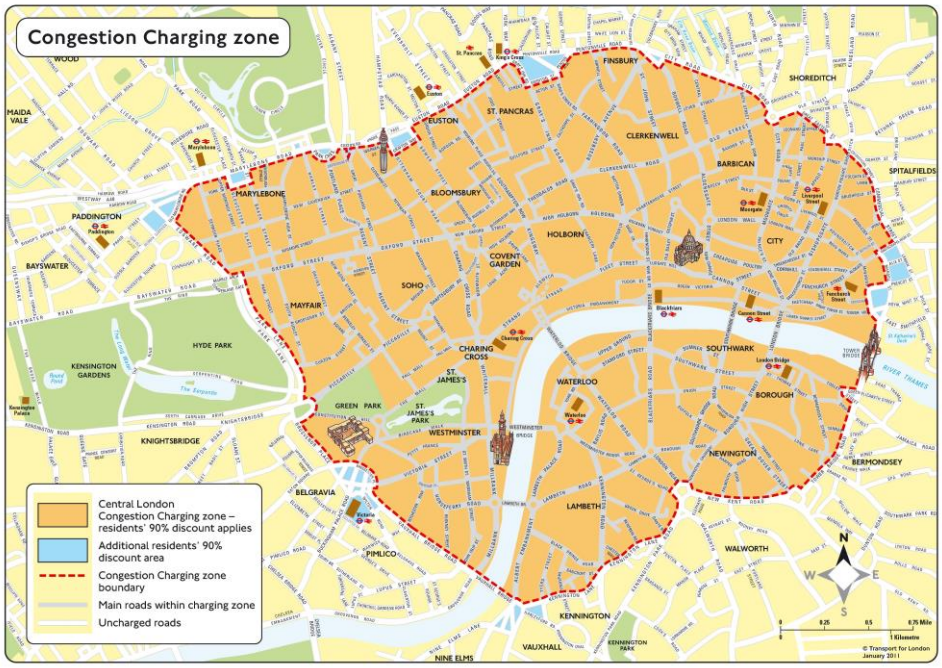


Photo: London Gongestion Charging Zone
Source: www.tfl.gov.uk, retr. 25-8-2014

Chapter 6 ENVIRONMENTAL ASPECTS OF TRANSPORT - AIR

While we appreciate all the positive contributions of transport (see Introduction), transport is also connected with serious environmental problems, some of which are on increase. Environmental impact of transport receives increased attention from public administrations, scientists, and citizen groups.

The European Environmental Agency reported that transport consumes about a third of all final energy, and accounts for about a fifth of greenhouse in the European Economic Area countries. [40] Transport is a key factor of urban air pollution and of noise nuisance. Furthermore, transport has a substantial impact on biota and landscape because it fragments natural areas into small patches with negative consequences for animals and plants.

What is to be solved, by governments, companies, and individual citizens, in order to make transport environmentally sustainable? The following are the **negative impacts of transport on the environment**:

- air pollution
- water pollution
- soil contamination and erosion
- damage to biodiversity and landscape character
- waste generation and transport accidents

7-1 Transport and Air Pollution

This is a the effect with the highest awareness of the general public, relative to other environmental issues. The traditional black smog was replaced by the yellow smog in many large cities of the world. While the black smog was mostly generated by industry and apartment heating, the yellow smog is mainly a result of intensive motorized traffic. However, the *operation* of transport vehicles is not the only source of air pollution related to transport. We have to take into consideration the whole product and service life cycle.

According to the product/service life cycle assessment (LCA) in transport, the sources of air pollution can be divided:

- production (for ex., air pollution during manufacturing of vehicles, infrastructure construction)

- operation (for ex. exhaust fumes of cars, ships and diesel locomotives, airplane emissions)
- disposal (for ex., incinerators)

7-1-1 Transport and air polution – production phase

Air pollution related to the production phase of transport originates, for example, through painting and coating of vehicles, energy consumption in vehicle manufacturing, exhaust fumes in asphalt manufacturing and application, and during tyres and fuel production.

Vehicle manufacturing and air pollution

Painting and coating accounts for a substantial share of environmental impacts on air during vehicle manufacturing. Managers responsible for environmental protection in automobile factories have to pay a special attention to the coating and painting factory units. New techniques such as "in-mold painting" could reduce discharges of hazardous materials (nickel, copper, and hexavalent chromium) into the atmosphere. [41]

Car manufacturing - illustrative photo
Source: http://www.greenmfgnews.com/news/1971/Honda%27s-Ohio-and-Alabama-Auto-Plants-Earn-EPA-Energy-Star-Rating, retr. 15-9-2014

Production of vehicles uses lot of energy.[42] [43] A large car manufacturer may have its own power plant. The supplying power plants, just like other power plants, are a source of air pollution. Coal-powered power plants release mercury, other heavy metals, acid gases, and particles that harm people's health. [44] [45] [46] Heat cogeneration and solar energy has been used by some car manufacturers. [47] [48] . Government regulation promoting lower-energy technologies and cleaner energy production may be used to reduce the negative environmental effects. [49] [50]

Transport infrastructure manufacturing and air pollution

Construction of roads and other infrastructure is connected with environmental effects in the area of air pollution. For example, asphalt fumes and vapours, and energy consumption. Asphalt fumes and vapours during manufacturing of asphalt and during application of asphalt pavement present human health risks when inhaled, especially for workers. [51] [52] Cleaner production and lower-energy technologies, on-site protection, and enforcement of occupational safety rules are ways to counter associated health risks.

Transport fuel production and air pollution

Transport and crude oil are closely related in the current world economy. Transport sector consumes more than half of world´s crude oil (petroleum) at present, and its share on the crude oil consumption is predicted to increase. [53] Crude oil is at present the dominant source for transport energy, and most of world´s crude oil supply is consumed by transport. Petroleum refining has significant environmental impacts. [54] Air pollution through toxic vapours is one of them. [55]

Petroleum refinery

Photo: Walter Siegmund, Wikipediahttp://en.wikipedia.org/wiki/File:Anacortes_Refinery_31911.JPG, retr. 11-8-2014

Producers may use some technical means to reduce the impact during production, transfer and storage of petroleum, such as deployment of *vapour recovery systems* to collect VOCs[22], installing *floating roof tanks* and *pressure vented caps* to reduce evaporation. Other measures can include *painted* (not dark) *tanks*, installed in shade (not sun) to reduce vapours, etc. [56] Standard end-of-pipe technologies used to reduce environmental impacts are *flares* (the conspicuous burning of waste gases that looks like momentaneous fire in the air above the refinery), *scrubbers* (removal of SO_2 and organics) and *electrostatic precipitators* (removal of small particles) . [57]

Phases, preceding manufacturing, during which significant environmental impacts arise, are crude oil exploration,[58] extraction[59] and long-distance transport of crude oil [60]. These are not dealt with in this text.

7-1-2 Transport and air polution – operation phase

Gases emitted by various vehicles – cars, airplanes, ships, and other means of transport, pollute air [61] [62] [63] [64] [65] and contribute to greenhouse effect. [66] [67] [68] [69] [70]. Automobile traffic is

[22] Note: VOCs = Volatile Organic Compounds. Some man-made volatile organic compounds present a threat to human health, and are precursors to smog. Environmentally harmful VOCs originate, for example, in transport operation (gasoline and diesel engines), and in production and application of coatings and solvents. Countries differ in their definition of regulated VOCs. Many VOCs are hydrocarbons (HC). However, not all hydrocarbons are VOCs, and not all VOCs are hydrocarbons.

currently the largest source of transport air pollution, though the proportion of air transport (aviation) is rising rapidly. [71] [72]

Source: Auto Extract Systems., UK, http://www.autoextract.co.uk/p/Company, retr. 17-7-2014

Exhaust gases from conventional engines (gasoline, diesel) are complex mixes composed of dozens of chemical substances [73] [74], including substances that are dangerous for human[75] and ecosystem [76] [77] health and components that contribute to the "greenhouse effect". [78] [79]

Some air pollutants caused by traffic are regulated by law (emission limits), other air pollutants are not regulated. The absence of regulation of some air pollutants is due to costly and insufficient measurement technology, and due to absence of information. Some of the non-regulated air pollutants may be more harmful to the environment and human health than the regulated ones. [80]

Following is a partial list of pollutants present in vehicle exhaust gases:

- Carbon monoxide (CO)
- Particulate matter (PM)
- Nitrogen oxides (NOx)
- Benzen (C_6H_6)
- Polycyclic Aromatic Hydrocarbons (PAH)

Carbon monoxide (CO) *(Cz: oxid uhelnatý)*

The poisonous gas carbon *monoxide* (CO) should not be confused with carbon *dioxide* (CO_2) . Carbon monoxide is odourless and colourless, which increases the potential risk. It is formed during the combustion of fossil fuels such as petrol, diesel, and coal. In transport, carbon monoxide is emitted primarily from passenger cars, and lorries.

There are other anthropogenic sources of carbon monoxide than automobile traffic, such as industrial facilities, domestic heating, lawn movers, etc. However, in the cities, emissions from internal combustion engines (gasoline, diesel) form up to 95 % of CO emissions. [81] According to the estimates, road transport generates almost 90% of all carbon monoxide emissions in the United Kingdom. [82]

Emissions of carbon monoxide are the highest from idling engines *(Cz: volnoběh)* and particularly in winter season. CO originates during incomplete combustion of fuels, including

'cold' or badly tuned automobile engines. Passenger car, lorry and bus exhausts from attached garages, nearby roads, or parking areas can be areas of increased health risk.
At low levels of exposure, carbon monoxide causes mild effects that may be mistaken for the flu. Headaches, dizziness, nausea and fatigue belong to the symptoms. [83] Exposure to high levels of carbon monoxide in closed garages (even in attached garages), or other non-vented inner spaces, can be deadly for humans. The effect on humans depend on their health status, age, length of exposure, and other aspects. Carbon monoxide, when inhaled, blocks oxygen from the brain, heart, and other vital organs. Newborn children, fetuses and people with chronic illnesses are particularly vulnerable. [84]

Carbon monoxide is short-lived in the atmosphere. It may contribute to tropospheric (ground level) ozone creation and photochemical pollution.

There are engine and after treatment technologies that can reduce CO emissions. Since they require some additional costs for manufacturers and consequently on consumers, at least initially, legislation is usually needed to bring them to application. *Diesel oxidation catalysts* [85] belong to the standard after treatment technology that reduces CO emissions by individual vehicles.[23] Increase in overall traffic can however result into an overall increase of local pollution (many "cleaner" vehicles may pollute more than few "dirty" vehicles).

Particulate matter (PM), or particulates *(Cz: suspendované částice, polétavé částice)*

Particulates are a microscopic solid or liquid matter suspended in the air. Since they can penetrate deep into lungs, or even to the blood stream, they pose a serious threat to human health. Particle pollution consists of a mix of components, including acids (nitrates and sulfates), organic chemicals, metals, and soil particles. [86]

PM is can be both primary pollution and secondary pollution. A part of man-made particle pollution, known as *primary particles*, is emitted directly from a source, such as construction

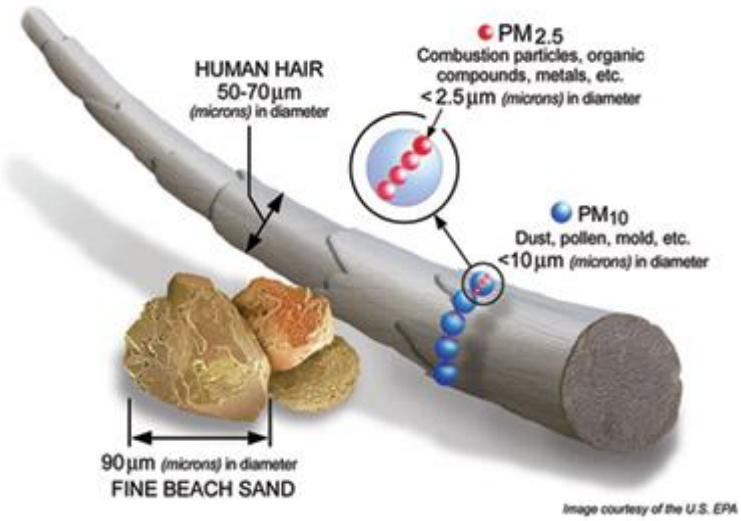


Illustration 7-1 : Particulate Matter
Source: U.S. EPA (online: http://www.epa.gov/airquality/particlepollution/basic.html), retr. 11-7-2014.

[23] Note: It is typical for all types of transport pollution, that though individual vehicles are becoming ceaner, the overall level of pollution is on increase in some countries, since there are more vehicles on the roads and in the air.

sites, unpaved roads, and smokestacks. Another part, known as ***secondary particles***, is formed through chemical reactions in the air, from chemicals such as nitrogen oxides and sulphur dioxide that are emitted from vehicles, factories and power plants. S*econdary particles* make up most of the fine particle pollution in the United States.[87] Diesel exhaust is a major contributor to PM pollution, [88], however also gasoline-powered cars generate particles.

There are serious health effects of transport-generated PM, whether from coarse (PM_{10}), fine ($PM_{2.5}$), or ultrafine particles ($PM_{0.1}$). Road transport particulates bind various materials with carcinogenic effects. Medical studies have shown that PM pollution is a source of serious respiratory diseases and asthma. Various scientific studies illustrate the share of premature deaths due to PM pollution. [89] [90] [91] PM pollution receives increased attention in the last years, due to its medical effects and due to its increase in the cities. The coarse particles (PM_{10}) are measured by public authorities in Europe the last years. The fine particles ($PM_{2.5}$), and ultrafine particles ($PM_{0.1}$), that can penetrate dangerously deep into the human organism, are not monitored in many cities yet, due to absent measuring equipment (only as subsets of coarse particles).

There are engine and after treatment technologies that can reduce particulates. Since they require some additional costs for manufacturers and consequently for consumers, at least initially, regulation is usually needed to bring them to use. *Particulate filters* [92] belong to the standard after treatment technology that reduces PM pollution by individual vehicles. Regular technical inspection, especially of older vehicles, is necessary to ensure their proper functioning and presence.

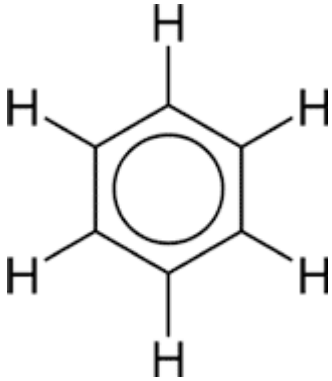
Nitrogen oxides (NOx) *(Cz: Oxidy dusíku)*

Transport is a major producer of nitrogen oxides. In the last decades, NOx emissions decreased in most European countries due to legislation and structural change. NOx pollution sources gradually shifted from energy and industrial sources to transport. In Europe, transport has currently the highest NOx share among sectors; over 40 %. of Europe´s NOx pollution is generated by the transport sector. [93]

Nitrogen oxides cause lung irritation and weaken the organism's immunity against respiratory infections such influenza and pneumonia. [94] Furthermore, NOx emissions assist the formation of ground level ozone and particulate matter. [95] Through their contribution to acid rain, NOx emission damage ecosystems (forest, water). NOx reduction is aimed through Euro standards, and equivalent exhaust standards abroad that have been mandated in the European Union, United States, Australia and elsewhere (see European Emission Standards section).

Benzene (C_6H_6) *(Cz: Benzen)*

Benzene belongs to the group of monocyclic aromatic hydrocarbons. It is a volatile organic compound (VOC). Its aromatic sweet smell is typical for fuel service stations. It is, same as other aromatic hydrocarbons, a part of fuel composition. Benzene is a part of crude oil, and of automobile gasoline (petrol). It has toxic, mutagenic[96] and carcinogenic[97] [98]effects.



The main source of benzene emissions are exhaust fumes of gasoline engines, fuel evaporation during distribution, storage and dispensing. Crude oil refineries also are sources of benzene pollution. [99] Benzene reduction in gasoline fuel, in order to decrease the environmental risk, has been mandated in Europe, U.S.A., Canada, Australia and Japan. [100]

Polycyclic Aromatic Hydrocarbons (PAHs) *(Cz: Polycyklické Aromatické Uhlovodíky (PAU))*

Polycyclic Aromatic Hydrocarbons are chemicals that are often found together in groups of PAHs The PAHs are found naturally in the environment but some are man-made. The PAHs originate when materials like oil, gas, coal, and garbage are burned, and the burning process is not complete. PAHs are persistent in the environment and they do not burn easily. Vehicle exhaust fumes and air pollution from petroleum refining are sources of PAHs, together with other sources.

Although the health effects of various PAHs are not alike, 17 PAHs have been identified as of most concern for human health. [101] For example, the benzo(ghi)perylen (BghiP), $C_{22}H_{12}$, a potentially carcinogenic substance,[102] is present directly in combustion engine vehicle exhausts. The benzo(a)pyren (BAP) $C_{20}H_{12}$, another potentially carcinogenic substance,[103] originates from infrastructure, vehicles and fuels. The BAP can relatively easily be proven in the environment, therefore is is used as a reference pollutant for PAHs in an environmental analysis.[104]

The PAHs can enter the body is through breathing polluted air, ingestion of contaminated food, or even through skin contact. Once in the body, PAHs target fat tissues, and particularly kidneys and liver. Breathing of harmful PAHs and skin contact appears to be associated with cancer in human population and caused birth defects in laboratory animals. [105]

In the area of transport, PAHs can be reduced at three levels: infrastructure, fuel and vehicle. In the area of infrastructure, for example, companies and public administration have a choice of materials used for road pavements. In the area of fuel, for example, PAHs can be reduced by an adjustment of the combustion process (contents of PAHs and oxygen). At the level of a vehicle, PAHs can be limited, for example, through end-of-pipe technologies, and by the style of driving.

Besides technical measures, proper traffic management by public authorities (incl. reduction of unnecessary traffic flows) can contribute to pollution reduction.

Ground-level (Tropospheric) Ozone (0_3) *(Cz: přízemní troposférický ozón)*

Human-created tropospheric ozone is an important secondary pollutant. It is formed when emissions from transport and industrial sources (such as nitrogen oxides and volatile organic compounds) react in the presence of sunlight. The ground level ozone should not be confused with stratospheric ozone, 11-50 km above Earth´s surface, that provides a crucially important filter for harmful ultraviolet rays. (Please distinguish the "bad" ozone from the "good" ozone!).

Ozone is toxic for humans, animals and plants. High levels of ozone, that have been repeatedly reached in industrial countries, cause tiredness, breathing problems, inflammation of airways, coughing and throat irritation. They contribute to asthma and are associated with an increased human mortality. [106] A part of human population is especially susceptible to relatively low levels to tropospheric ozone. Particularly vulnerable are small children, sports performing and outdoor exercising people and elderly. [107]

The reduction of ground-level ozone pollution can be achieved through reduction of emissions of ozone precursors (NOx, VOC). Personal protective measures can be taken (avoiding demanding physical outdoor activities, such as jogging, during periods of high ozone level. Air pollution tends to be highest in the afternoon or early evening hours for most places, but this may vary according to the locality. [108] Weather forecasts predict ground-level ozone concentrations in some areas.

Regulated Automobile Emission Values – European Emission Standards (Euro Standards)

European emission standards define the limits for exhaust emissions of new vehicles sold and operated in the European Union. They regulate some types of pollution caused by automobile vehicles, and are legislated by the European Union directives.[109] These are environmental norms best-known to general public, or to car owners. The Euro standards 1-6 (or I-VI) are defined according to the production date of a vehicle. That means old cars can legally pollute more than new cars. A mandated technical check-ups have to certify that car´s technical properties adhere to its Euro standard (as declared in the car´s technical documentation).

Some cars, manufactured before introduction of Euro 1 in 1993, reach no Euro standard (Euro 0), and still can operate in some European countries. However, governments may provide disincentives for operating old polluting vehicles. Among these disincentives is the prohibition of import of Euro 0 vehicles, special sales tax on low Euro categories, no-entry to some cities or city centres for low categories, etc.).

Passenger cars fuelled by petrol have 5 regulated emission limits within the Euro 6 norm (that came into power in September 2014). These limits are imposed on the following pollutants:

- CO (carbon monoxide)
- NOx (nitrogen oxides)
- PM (particulate matter
- THC (total hydrocarbons)
- MMHC (non-methane hydrocarbons)

Passenger cars fuelled by diesel have 4 regulated emission limits within the Euro 6 norm. These limits are imposed on the following pollutants:

- CO (carbon monoxide)
- NOx (nitrogen oxides)
- PM (particulate matter)
- HC + NOx. (hydrocarbons together with nitrogen oxides)

Regulated Emission Limits for Automobiles in the European Union – passenger cars

Emission Factors g/km						
EURO 6 Sept 2014	**CO**	**THC**	**NMHC**	**NOx**	**HC+NOx**	**PM**
diesel personal car	0,5	--	--	0,080	0,170	0,005
petrol personal car	1,0	0,10	0,068	0,060	--	0,005 (only direct injection engines)

Comment: Hydrocarbons are measured in a different way for diesel passenger cars than for petrol (gasoline) personal cars.

Heavy duty vehicles (lorries, buses) fuelled by diesel have 4 regulated emission limits within the Euro VI norm:

- CO (carbon monoxide)
- NOx (nitrogen oxides)
- PM (particulate matter
- HC (hydrocarbons)

While for passenger cars the norms are set by vehicle driving distance, g/km, for lorries (trucks) they are set by engine energy output g/kWH. That means, we cannot directly compare the standards for passenger cars and lorries or buses.

Regulated Emission Limits for Automobiles in the European Union – Heavy Duty Diesel Engines (lorries + buses)

Emission Factors g/kWh						
EURO VI Dec 31, 2014	**CO**	**HC**		**NOx**		**PM**
diesel lorry/ bus	1,5	0,13	--	0,4		0,01

Comment: Hydrocarbons are measured in a different way for diesel trucks and buses than for diesel passenger cars.

Other Vehicles´ Emission Standards and Non-European Emission Standards

There are Euro standards also for light commercial vehicles, non-road vehicles and rail vehicles. In the United States, the U.S. Environmental Protection Agency (EPA) sets standards for automobile emissions since 1970´s.[110] Australia bases its standards mostly on the European Union standards, and uses also selected U.S.A. and Japanese standards. [111]

Other Air Pollutants by Road Traffic

As noted earlier, Euro standards for vehicles do not regulate all types of pollution caused by automobiles, not even air pollution during operation of a vehicle. For example, **abrasion** of road surface and tires, as well as mechanical abrasion of various car construction parts (brakes, clutches) are not addressed by the Euro standards, though they contribute significantly to air pollution through particulates. Some dangerous materials (such as asbestos) are gradually phased out of car manufacturing. **Asbestos dust**, however, still presents a hazard in older vehicles and

spare parts (asbestos brake linings, clutch parts, etc.).[112] The **SO_2 pollution** has been addressed in the past not by Euro Emission Standards, but by standards on fuel. Consequently, SO_2 pollution by car operation has been largely reduced in Europe. **Emissions of CO_2** (carbon dioxide), which is not a standard pollutant, however contributes to greenhouse effect, are addressed by European Union average standards imposed on manufacturers´ fleets. European manufacturers are obliged to reduce CO_2 emissions to 130 grams per km by their "average" car. by 2015. [113]

7-1-3 Transport and air pollution – disposal phase

The end of vehicle´s useful "life" does not coincide with the end of its environmental impact. Toxic battery acids, plastics, rubber, glass and metal pieces may stay in the environment. Fortunately, a large part of the car materials can be recycled (up to 80% of its weight), especially its metal parts. The remaining 20 % that cannot be recycled is called *auto shredder residue.* [114] Old automobile tyres can be burned as a fuel or incinerated in cement kilns. Air pollution is generated in consequence of old tyres and waste incineration, and has been addressed by the EU legislation. [115]

Chapter 7 ENVIRONMENTAL APECTS OF TRANSPORT – WATER AND BIODIVERSITY

7-1 Water Pollution Classification

Water pollution during road transport can be divided into:

- Pollution by regular traffic
- Pollution by traffic accidents

- Pollution of surface waters
- Pollution of ground waters

7-2 Water pollution from regular traffic

Water runoff from motorways and streets causes damage to surface streams, public water supplies, ponds, lakes and vegetation. [116] The runoff from these roads contains particulates from exhausts, abrasion from tyres and auto parts, oil leakages, remnants of toxic de-icing materials, and salt. Not only the vehicles, but also the road itself can be a source of water pollution. The body of the road can leak its construction materials into the ground waters.

7-3 Measures that can be taken to reduce water pollution:

- water clean-up facilities alongside the motorways (currently seems very costly and is applied only on a very small scale in some countries)
- reduction of road material leakage through proper construction materials´ selection and proper maintenance of road to prevent erosion and leakage

7-4 Transportation of Dangerous Goods

Transport of hazardous materials may result into spillage and contamination of water during a road transport accident. The ADR Agreement, *European Agreement concerning the International Carriage of Dangerous Goods by Road,* that set rules for hazardous materials transport, has been signed by most European countries.

7-5 Impacts on Biodiversity

Fragmentation of habitats and the barrier effects through motorways and other high-capacity roads has a serious negative effect on biodiversity.[117] [118] Some animals need relative large territories for feeding, or migrate regularly. Besides bisecting of habitats, direct destruction of habitats results through building of transport infrastructure. In Europe, particularly vulnerable are large and medium-size carnivores such as brown bear *(Ursus arctos)*, wolf *(Canis lupus*), and the Euroasian lynx *(Lynx lynx).* All these carnivores are rare species in Europe, and strictly protected in most of European countries. Furthermore, long-migrating large herbivores, such as the Euroasian moose *(Alces alces)*, that is rare in many parts of Europe, are vulnerable to landscape fragmentation. Additionally, also relatively common game species such as the Red Deer (Cervus elaphus) and the European Hare (*Lepus europaeus)* may be substantially influenced by transport through isolation and direct killing. Locally populations of amphibians *(Amphibia)* can be largely wiped out by intense traffic at the time of their seasonal migration.

Fragmentation is a process and result of dividing up contiguous ecosystems, or landscape units, into smaller separated patch-like areas. It is a result of human activities, such as transport infrastructure building, urban development and agriculture intensification.

The effect on flora may be relatively smaller than on fauna, however, even here one can follow negative effects. Zoochory, is a way of seed dispersal when seeds are transported on the outside of animals, often mammals.

The following is a partial list of **negative effects of high-capacity roads on fauna**:

- direct killing
- interruption of migration routes for food and partners
- genetic degradation
- water, soil and noise pollution harmful for biota
- spread of non-native invasive species

7- 6 Biodiversity Conservation Measures and Approaches

The following are some possible **measures** that people can undertake **to reduce the negative effects of roads on animals**:

- Avoidance of particularly valuable natural areas in infrastructure building
- Construction of migration objects for animals (green bridges, eco-tunnels)
- Preference of railway against road transport, and preference of public transport against individual car transport (in order to reduce the likelihood of killing and due to the usually lower separation effect of rail)
- Occasional and seasonal transfer of animals by humans (for example, amphibians)

- Hazing technologies and fencing at proper places (However migration may be needed for genetic diversity and food sourcing, so fencing may not be appropriate at many places.)
- Reduction of speed limits in natural areas and road closure at particular time of the year.
- Technical warning signals for drivers.

Migration Object for Amphibians, Saxony, Germany
Photo: J. Moravec

GLOSSARY

Alternative Fuels.
Fuels that are used to propel motor vehicles instead of common-use fuels, such as diesel or gasoline. Among these belong ethanol, methanol, propane or compressed natural gas, liquid natural gas, electricity and others. Some of these fuels are from renewable sources (plants). Alternative fuels are supposed to be have a less negative effect on the environment, and/or to provide safety against future depletion of crude oil. The effect on the environment needs to be verified for the whole life cycle.

Access (in Transport)

In a general sense: people's ability to reach other people, institutions, goods, services and activities. The ultimate goal of most transport. In a narrow technical sense: the opportunity to enter and exit a transport mode.

Accessibility (in Transport)

The degree of access. The capacity, structure and physical design of transport are key factors of accessibility.

Biodiversity

The variety of Earth's species (species diversity), the variety of the genes they contain (genetic diversity), and the variety of ecosystems in which they live. Species diversity includes plants, animals and other living organisms. Biodiversity is used as a measure of the ecosystem health.

Commuter Rail

Local or regional passenger train between a city, with employment opportunities, and its suburbs, with residential housing. It usually offers multi-trip tickets, season tickets (travel passes for a specific period of time), or specific station-to-station fares. It stops in the central business district, or another place of concentrated regular work opportunities. Another name: suburban rail.

Diesel Fuel (Petroleum Diesel, Petrodiesel)

A world-wide used fuel in transport and industry. A transparent liquid manufactured from petroleum in refineries. Chemically a mix of mostly organic compounds, hydrocarbons, with additives to produce a fuel suitable for use in compression-ignition engines (diesel engines).
Petroleum diesel (fossil diesel) is the most common diesel fuel. Synthetic diesel is produced from vegetable oil (biodiesel), natural gas, coal, etc.

Environmental impact assessment (EIA)

A process for carrying out an advance evaluation of all potential environmental effects of a development project. In the EU, public authorities have an obligation to carry out an EIA in case of large projects or projects of specific type (such as a motorway construction). In the United States, an environmental assessment (EA) is obligatory for some projects. The outcome of the evaluation should assist public authorities in approval, rejection, or modification of a private or public project.

Environmental management system (EMS)

A set of procedures and techniques used by businesses and other institutions that is supposed to reduce environmental impacts. A well-designed EMS can increase operating efficiency through saving of energy and materials. Businesses and other institutions (schools, public administration) can be have their EMS certified by accredited companies or public agencies.
Transport businesses (such as bus services) may have their formal EMS. Non-transport institutions may have transport aspects evaluated (commuting of employees or students) alongside other aspects in their EMS.

Exhaust fumes

Combination of gases ejected from an engine as waste.

Ethanol.

An alternative fuel in transport. A liquid alcohol fuel produced from agricultural products such as sugar beet, maize, potatoes, grain and sugar cane.

Fragmentation

The process of dividing up contiguous ecosystems, or landscape units, into smaller separated patch-like areas. It is a result of human activities, such as deforestation, urban development and transport infrastructure building and operation.

Intermodal Terminal.

A terminal which can accommodate more than one mode of transportation (rail and bus, rail and boat, rail and truck, airplane and underground) of freight or passengers). Intermodal terminal may specialize at handling specific types of freight (for ex. bulk commodities).

Intermodal Transport

The transport of passengers or freight that uses more than one mode of transport. The change may take place at a terminal specificallydesigned for such a purpose.

Green Logistics

Supply chain management strategies and practices and that reduce the environmental impact of distribution. They focus on material handling, energy choice and consumption, waste management, packaging and transport.

Infrastructure

1) In a transport system (narrow sense): all fixed components, such as roads, railroads, airports, sea and river ports, signal equipment, terminals, parking lots, tram and bus stops, loading, reloading and maintenance facilities, etc.

2) In transport planning (wide sense): all elements of transport systems, including fixed components, vehicles, organisational units with personnel and supporting equipment.

Just-in-Time Management

The way of production and inventory management in which materials or goods arrive when needed (just-in-time) for production or consumption. Warehousing tends to be minimal or non-existent, which leads to cost reduction. Just-in-time management is sometimes criticized for

shifting warehousing space to transport vehicles on motorways (less standard warehousing may result into more frequent rides with associated environmental problems).

Mercury

Heavy metal. A chemical element with symbol Hg. Used in measuring devices and fluorescent lamps. Environmental pollutant emitted by fossil fuel power plants. Mercury is also present in car exhausts [119]. Causes neurological damage, including lower IQ, in unborn children and little children exposed during the first few years of life.[120]
Mercury poisoning can be caused by water-soluble mercury compounds, or by inhalation of mercury vapour, or by consumption of contaminated fish meat. [121]

Mobility (in transport)

The physical movement of people and goods. Mobility can be measured by the number of journeys, travel time spent, distance travelled, tons transported, etc.

Modal Split (share).

The proportion of passenger or freight traffic that uses various modes of transportation.

Negative externality (external cost).

Costs that the producers or users shift on individual third parties, or on the public, and do not provide compensation for them. Externalities are typically not taken into account by the decision-makers in the market.

Nitrogen Oxides

A product of combustion of fossil fuels. A group of air pollutants produced by conventional engines of transport vehicles. Excessive concentrations have negative health effects.

Park and Ride.

A way of transit in which people drive cars or ride bicycles to a transit station, and park their vehicles in the area provided for the purpose. They then ride the transit system or take a car-or vanpool to their destinations.

Particulate Matter (PM)

A widespread air pollutant, consisting of variety of solid and liquid particles suspended in the air. Commonly used indicators distinguish between particles with a diameter of less than 10 μm (PM_{10}, "coarse particles") and of particles with a diameter of less than 2.5 μm ($PM_{2.5}$, "fine particles"). In transport, a major source of particles are diesel engines. This PM presents a serious risk for human health and is subject of emissions´ regulation in car manufacturing (exhaust fumes), and of immissions´ monitoring in urban areas (concentrations of PM at particular sites/streets). Other sources of PM in transport are abrasion and wear-and-tear of tires, road surfaces and mechanical parts of vehicles.

Petrol (Gasoline)

A worldwide used fuel in transport and industry. A transparent liquid manufactured from petroleum in refineries. Chemically a mix of mostly organic compounds, hydrocarbons, with additives to produce a fuel suitable for use in spark-ignition engines (petrol engines). Poisonous for humans and other organisms. Currently one of the dominant sources of energy for road transport. Petrol is a term preferred in the United Kingdom, while the term gasoline in the United States.

Petroleum (Crude Oil)

A naturally occurring, oily, flammable liquid composed principally of hydrocarbons. Typically is drilled from wells beneath the earth's surface. Rarely occurs in springs and pools on earth surface. Considered the most important natural resource for the economies of industrial nations. Currently, most of crude oil is used by transport sector, other uses are in manufacturing.

Product Life Cycle Assessment (LCA)

An evaluation of environmental impacts of a product in all stages of its "product life" It starts with raw material extraction, continues through manufacturing, distribution, use, and ends with disposal or recycling. Both energy and material inputs are considered. LCA should help to avoid

a narrow view of environmental impacts. The LCA can be carried out not only for products, also for services.

Propane.

An alternative fuel. Propane is a liquid petroleum gas (LPG) that is stored under pressure. It originates as a by-product of oil and natural gas production.

Public policy

A concept, a plan, a set of ideas of what to do in particular situations that has been agreed and is implemented by the government. A commitment and a principled guide for public officials. Public policy is implemented (realized) by policy instruments (laws, taxes/subsidies, etc.)

Public Transport.

Passenger transport services available to any person who pays a required fare. It typically operates on regular time schedules, along planned routes, and makes specific stops. It is designed to serve a relatively large number of people at one time.

Heavy Rail

An electric railway in public urban transport with the capacity for a "heavy volume" of traffic. It is characterized by exclusive routes, multi-car trains, high speed, and high platform loading. Also known as "metropolitan railway (metro)", subway or underground some countries. It may move both underground and above the surface.

High Speed Rail

A rail transportation system with a speed of at least 200 km/h on upgraded existing tracks, or 250 km/h on newly built dedicated high-speed tracks (a EU definition) at one section. Usually built in densely populated regions. Outcompetes air transport for distances of several hundred kilometers.

Light Rail

An electric railway with a "light volume" passenger capacity compared to heavy rail.
It may use both shared or exclusive routes, high or low platform loading and multi-car trains or single cars. Also called tramway, "streetcar," or trolley car.

Rapid Transit

Rail or bus transit service that operates on an exclusive fixed route, separate from other modes of transport. Shared public transport service, usually local, that uses dedicated right-of-ways and avoids traffic congestion created by individual transport vehicles.

Rate

The price of transport service paid by the customer. Transport rates are regulated or negotiated (free market), depending on the type of transport (public passenger, freight, etc.), and depending on the public policy. From the buyers point of view, it is the monetary cost of moving a passenger or a unit of freight between two places.

Ridesharing

A form of transport, other than public transport or taxi, in which at least two people share the use of a vehicle, such as a car or a van, with other persons to make a journey. Ridesharing may be practiced in regular commute or for an occasional trip. Also called "carpooling" or "vanpooling". Rideshare programs include matching services (which help to find travel partners), and support measures that give rideshare vehicles priority in traffic and parking.

Smog

Mixture of gases and particles that appears as a haze or a fog in the air. The two prime pollutants in smog usually are ground-level ozone (O3) and particulate matter (PM), but there are also other pollutants present. The modern photochemical smog in the cities is largely due to transport emissions. The winter smog may differ from the summer smog, since its is more a result of PM contribution, rather than of ground-level ozone.

Sustainable Development

A type of development that allows the present generation (of humans) to meet its basic needs without undermining the ability of future generations to meet their needs, preserves the vital functions of ecosystems and does not decrease biodiversity

Tanker (tank ship)

An oceangoing vessel specially designed to carry liquid or gas in bulk. Main types include (crude) oil tanker, gas tanker and chemical tanker.

Traffic calming

Physical design and other measures, including speed humps, narrowed roads and closures, put in place on roads in order to slow down or reduce motor-vehicle traffic as well as to enhance safety for non-motorists.

Transaction costs.

Costs required for gathering information, negotiating, and enforcing legal obligations. High transaction costs of control/monitoring and enforcement may provide limits to some ways of environmental protection in transport.

Transport

Means of meeting the needs that cannot be satisfied locally.

Transport Mode

The physical way a transport movement is performed. Usual modes of transport are aviation, rail, road, ship, cable and pipeline transport.

ACRONYMS AND ABBREVIATIONS

EC – European Commission

EIA – environmental impact assessment

EMS – environmental management system

EPA – U.S. Environmental Protection Agency

EU - European Union

LCA – life cycle assessment

HC - hydrocarbons

PM – particulate matter

VOC – volatile organic compounds

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THE END