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The evolution of transport systems and related energy use in Europe, India and the world: new needs, migration towards "ITS" through telematics and a technological overview of ITS

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THE EVOLUTION OF TRANSPORT SYSTEMS AND RELATED ENERGY USE IN EUROPE, INDIA AND THE WORLD:

new needs, migration towards "ITS" through telematics and a technological overview of ITS

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EBTC Transport Flagship Mission to India, Delhi, 14 September 2010

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QUESTIONS FOR THIS PRESENTATION

- ? How much do the transport systems impact the use of energy?
- ? How has energy consumption evolved in transport systems?
- ? How much does the use of energy impact within each transport mode?
- ? What is the involvement of the governments in the use of oil for traction?
- ? What solutions can be prospected in a changing economy?
- ? ITS in general

WHERE AND HOW MUCH
we may influence ENERGY EFFICIENCY in transport systems and role of ITS

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- *The purpose of this presentation is a general framing on the role and impact of the transport systems in the general energy consumption and on what is the impact of consumption on the operational cost of the different transport modes.*

- *These elements are essential for a clearer understanding of where and how much energy efficiency can impact the different transport modes and provide the ground for some general considerations on the energy demand in the transport systems and the reasons for "ITS".*

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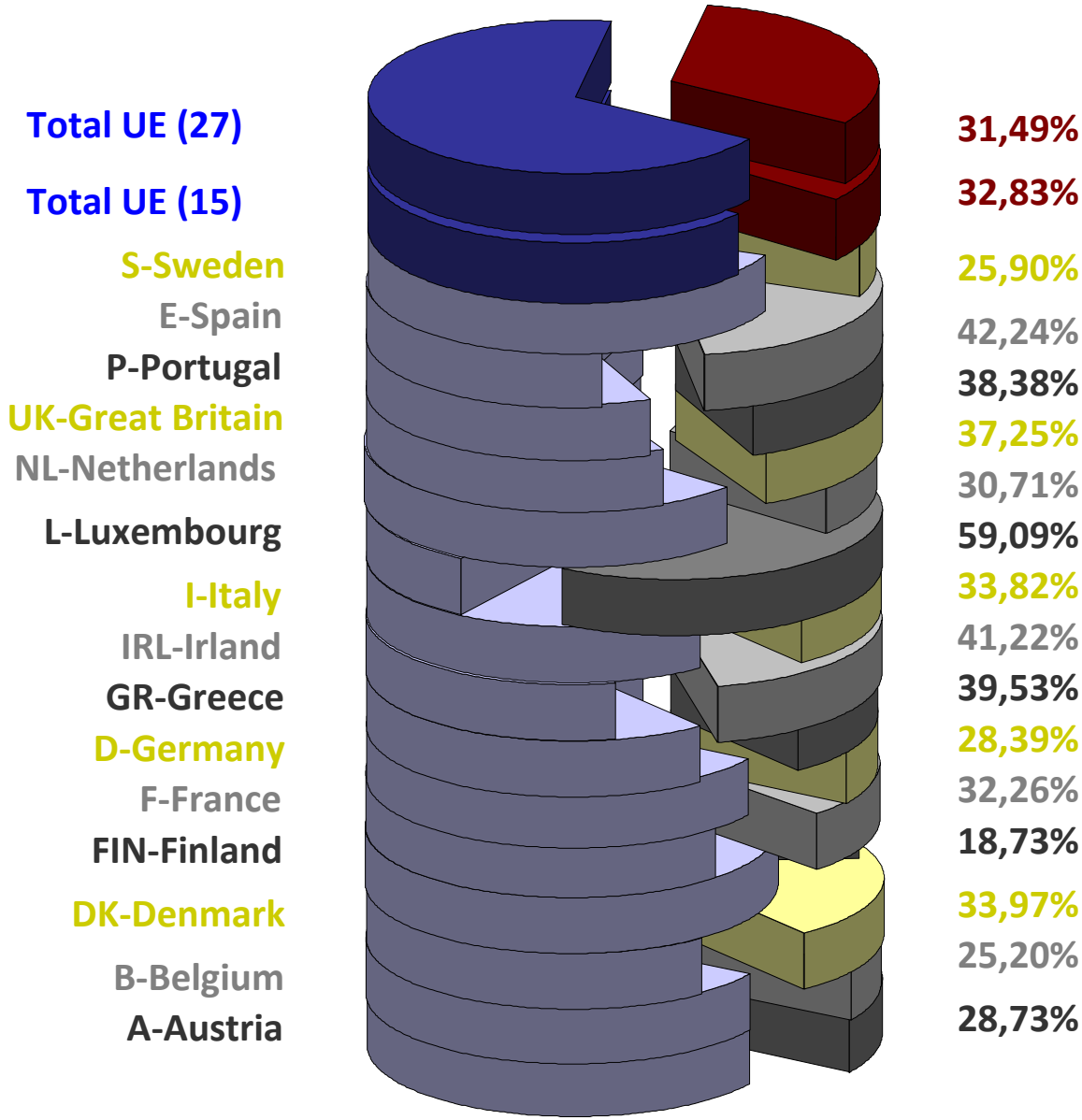
1. How much the transport systems impact the use of energy?

- The impact in **Europe** (EU-25) of the transport systems in the overall use of the energy consumed in the EU-25 (30.7%; according to Eurostat 2004; 31- 32% in the following years) is > by nearly 10% versus the world average (20.42% in 2003), on the grounds of the greater motorized average mobility versus other continents.
- Many short-range displacements are carried out by individual, not motorized, mobility through a natural, quickly renewable energy.

[Source: EIA – Energy Information Administration, International Energy Outlook, June 2006]



Impact of the energy consumption of transport on the final domestic consumption in EU and in the relevant nations (2006)

Sources: Eurostat and Databook, "Energia e Petrolio in Italia" 2009 by "Unione Petrolifera" - I

The transport field is mainly characterized by the use of vehicles with **distributed energy use**, with the exception – in general terms – of the transport systems operating on **fixed installations (rail, rope, metros, APM)**




Almost all these transport systems are based upon **oil derived fuel**, and the alternatives are featured by significant limits; the transport systems operating on fixed installations do not strictly depend on it (electrical lines supplied by power stations) and, according to a belief widespread in the literature, allow better use of energy.

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- The transport field, whose role in the modern, post-industrial economies has nowadays become essential, is the only sector to be almost exclusively based upon **a sole primary source**, i.e. **oil**: indicatively, **98%** in Europe and **96%** in North America

- The other sectors, on the other hand, are based upon a mixed heterogeneity of energies, which is not consistent in the different areas of the world, because of the variability of resources available within the territory, of the level of economic development and other social, political and economic factors.

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2. How energy consumption has evolved in transport systems?

- Incidence of single transport modes
- Circulating road vehicles
- Fuel consumption

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EU-25				
Transport modes	1990	2004	1990-2004 Variation (%)	Share on the overall energy consumptions, 2004 (%)
Road	227’957	290’013	27%	**82.5%**
Railway	9’125	9’250	1%	**2.6%**
Air	28’378	47’420	67%	**13.5%**
Inland navigation	6’578	5’047	-23%	**1.4%**

Consumption by transport modality in 1990 and 2004, in 1000 *toe*, *tonne(s) of oil equivalent*
[Source : Campbell, 2007]

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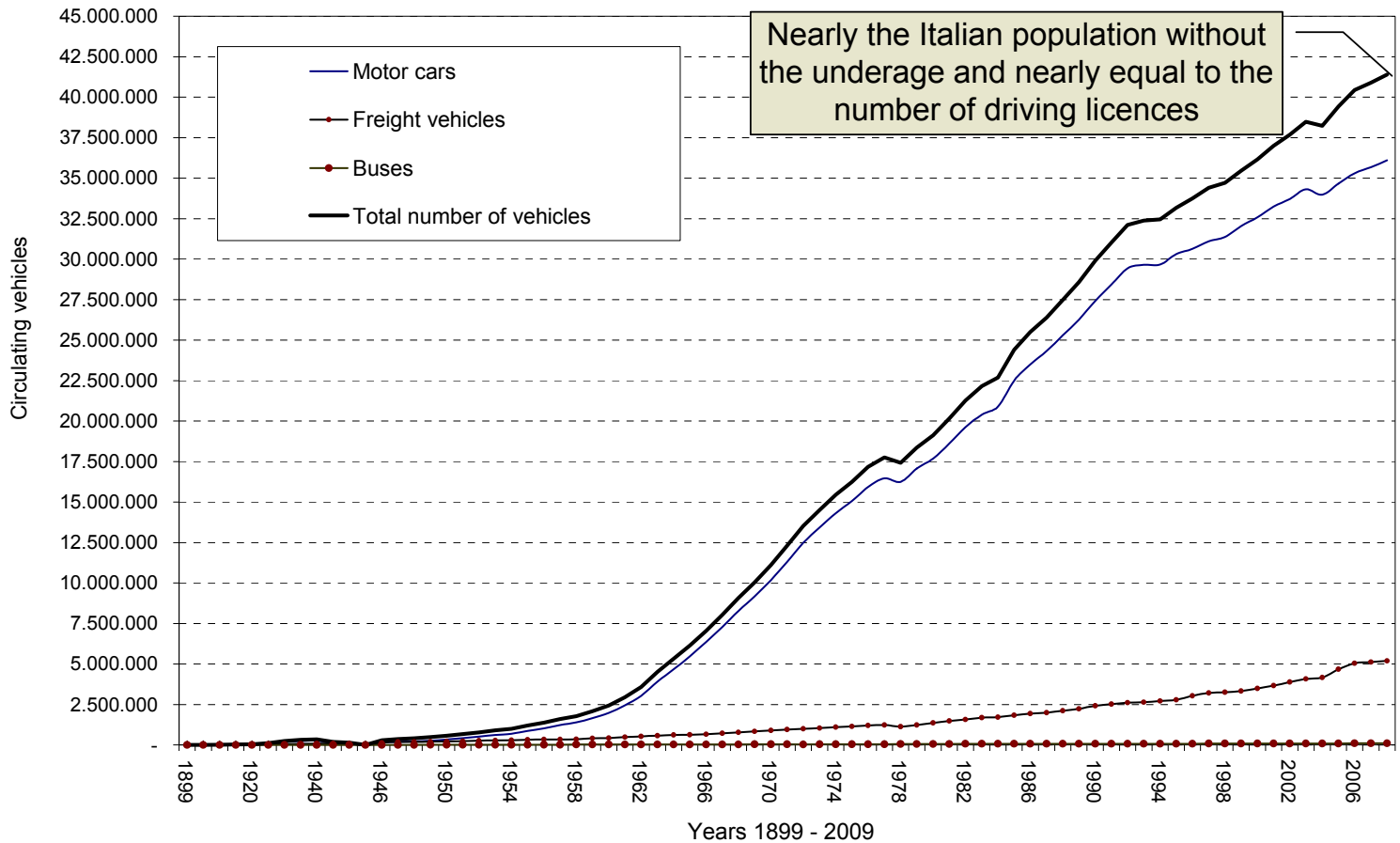
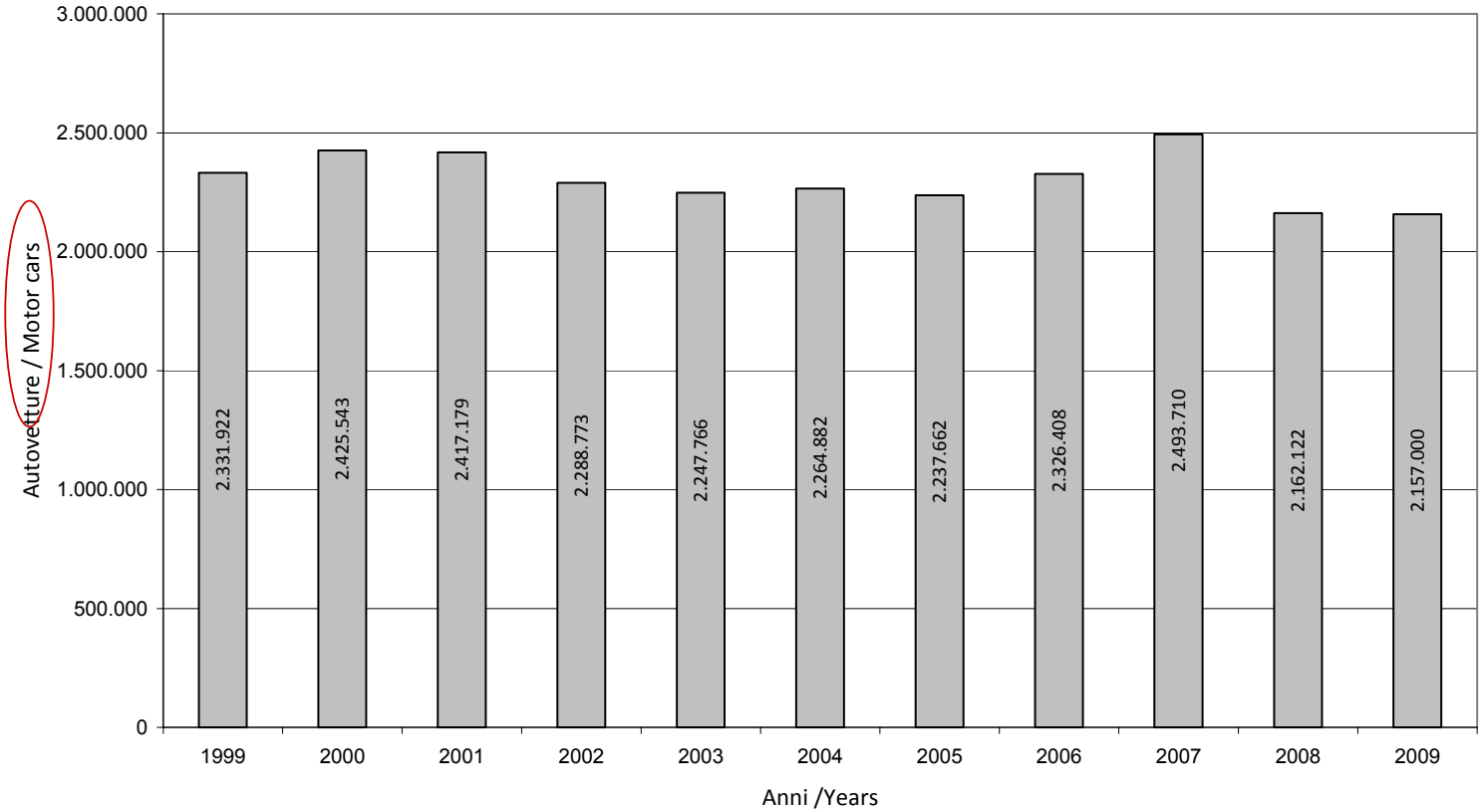
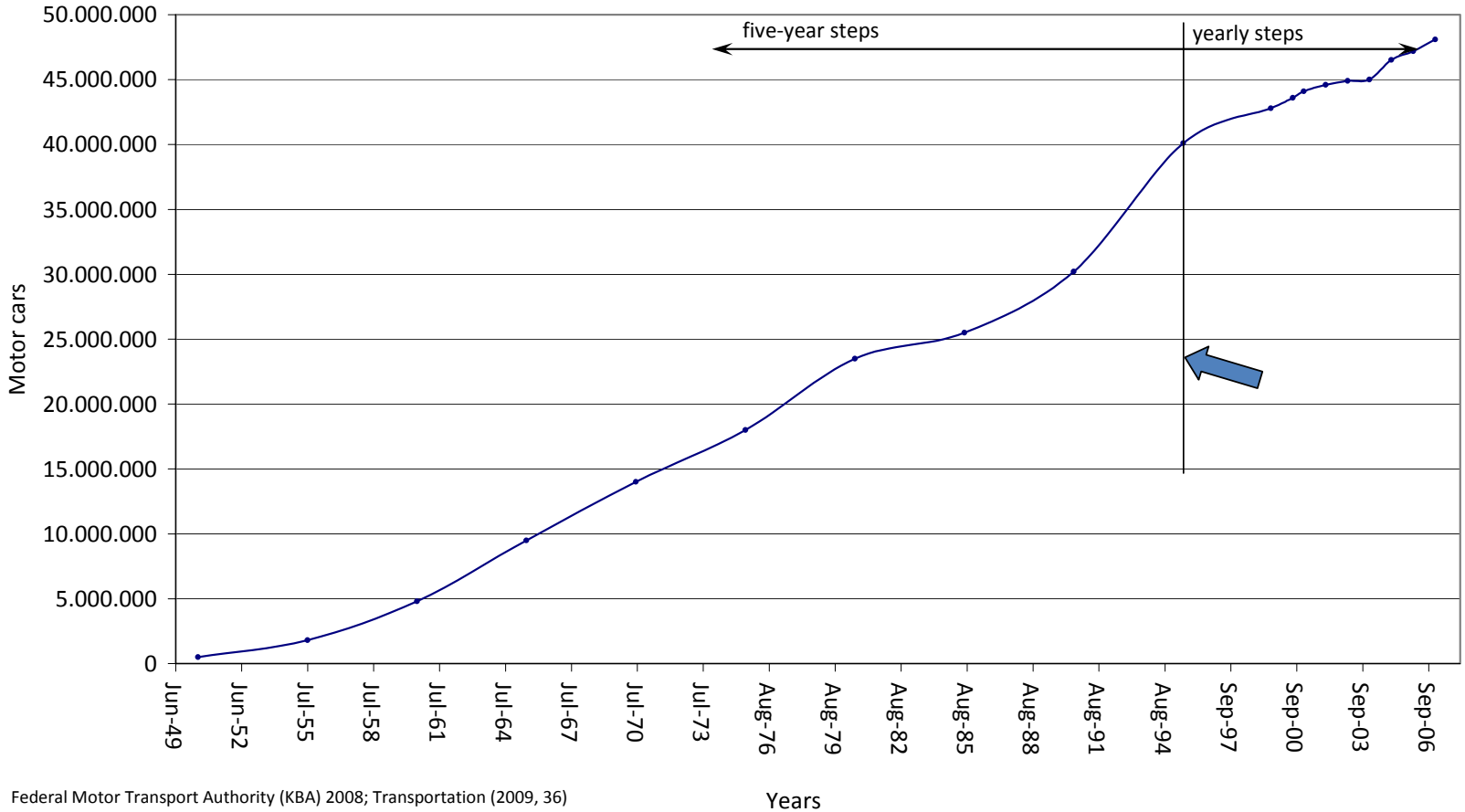
Evolution of the light and heavy-duty vehicles in Italy



The number of light and heavy-duty vehicle registrations in Italy (our example) has remained ~consistent with the one of the last 6 to 7 years, i.e. approx 3 million units/year.

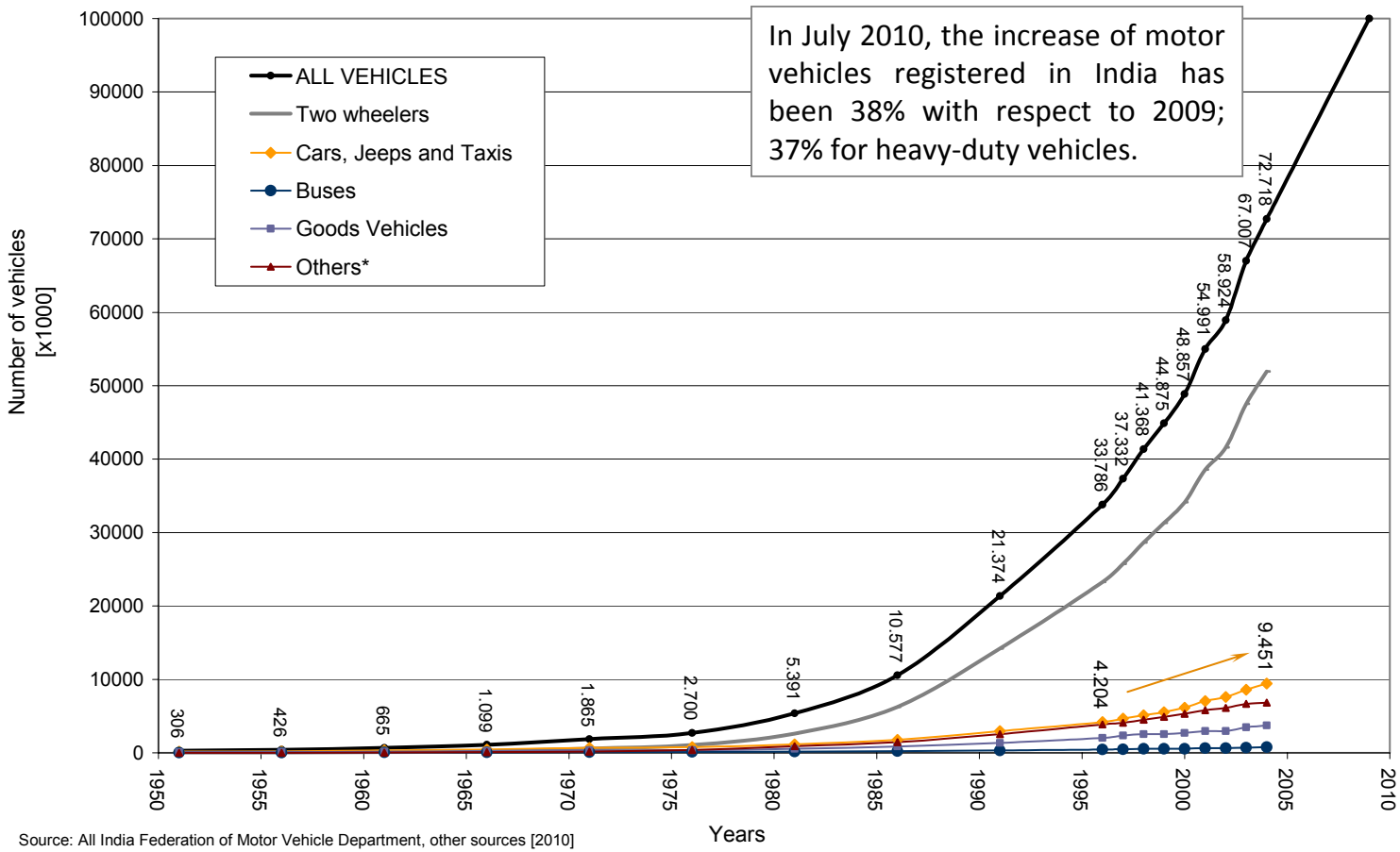


Evolution of motor cars in Germany since 1950 until 2007



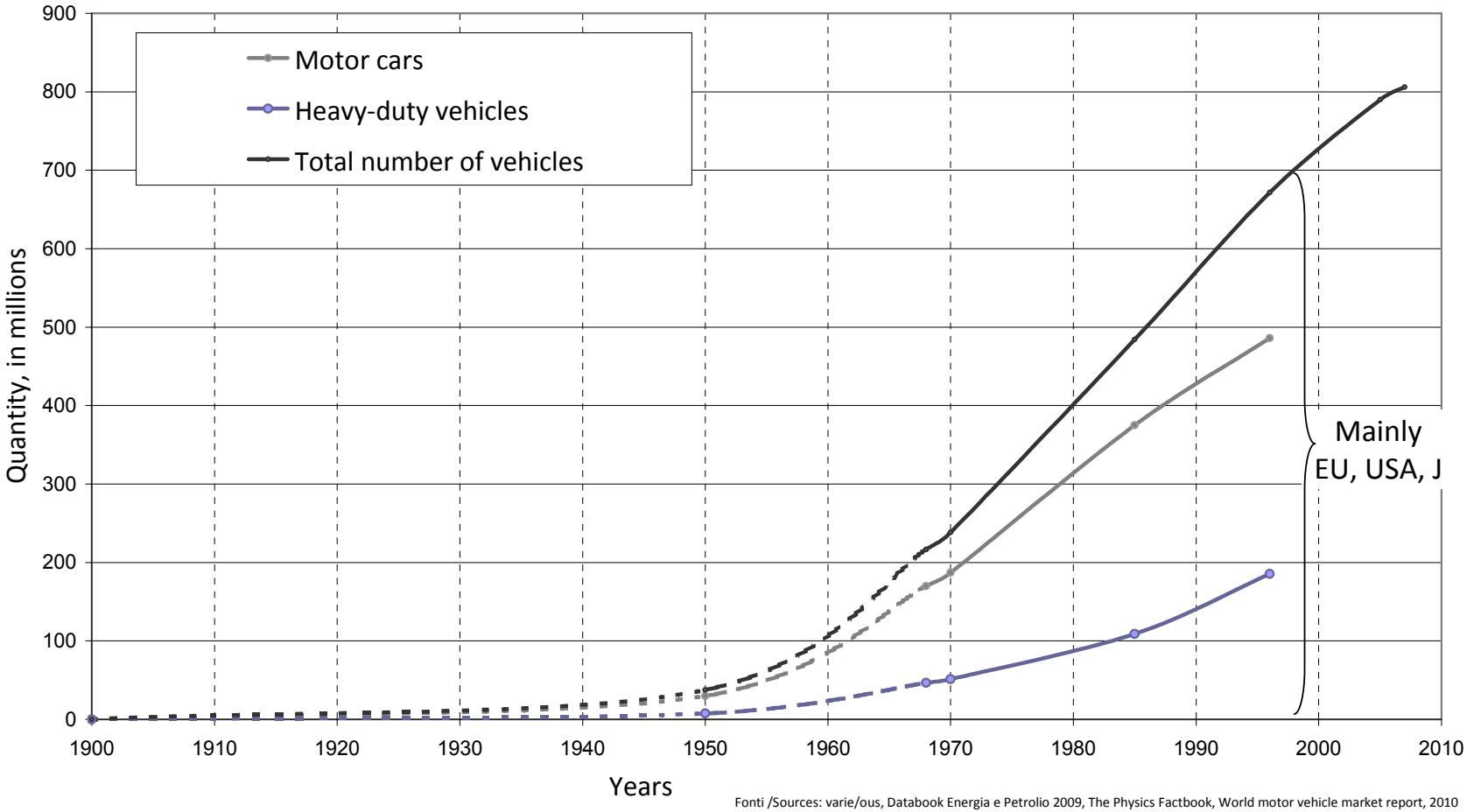
Federal Motor Transport Authority (KBA) 2008; Transportation (2009, 36)

Total number of registered motor vehicles in India, 1951-2010 [x1000]



Source: All India Federation of Motor Vehicle Department, other sources [2010]

Vehicles circulating in the WORLD: approximate trend on the basis of few known data and estimates from different sources



Fonti /Sources: varie/ous, Databook Energia e Petrolio 2009, The Physics Factbook, World motor vehicle market report, 2010

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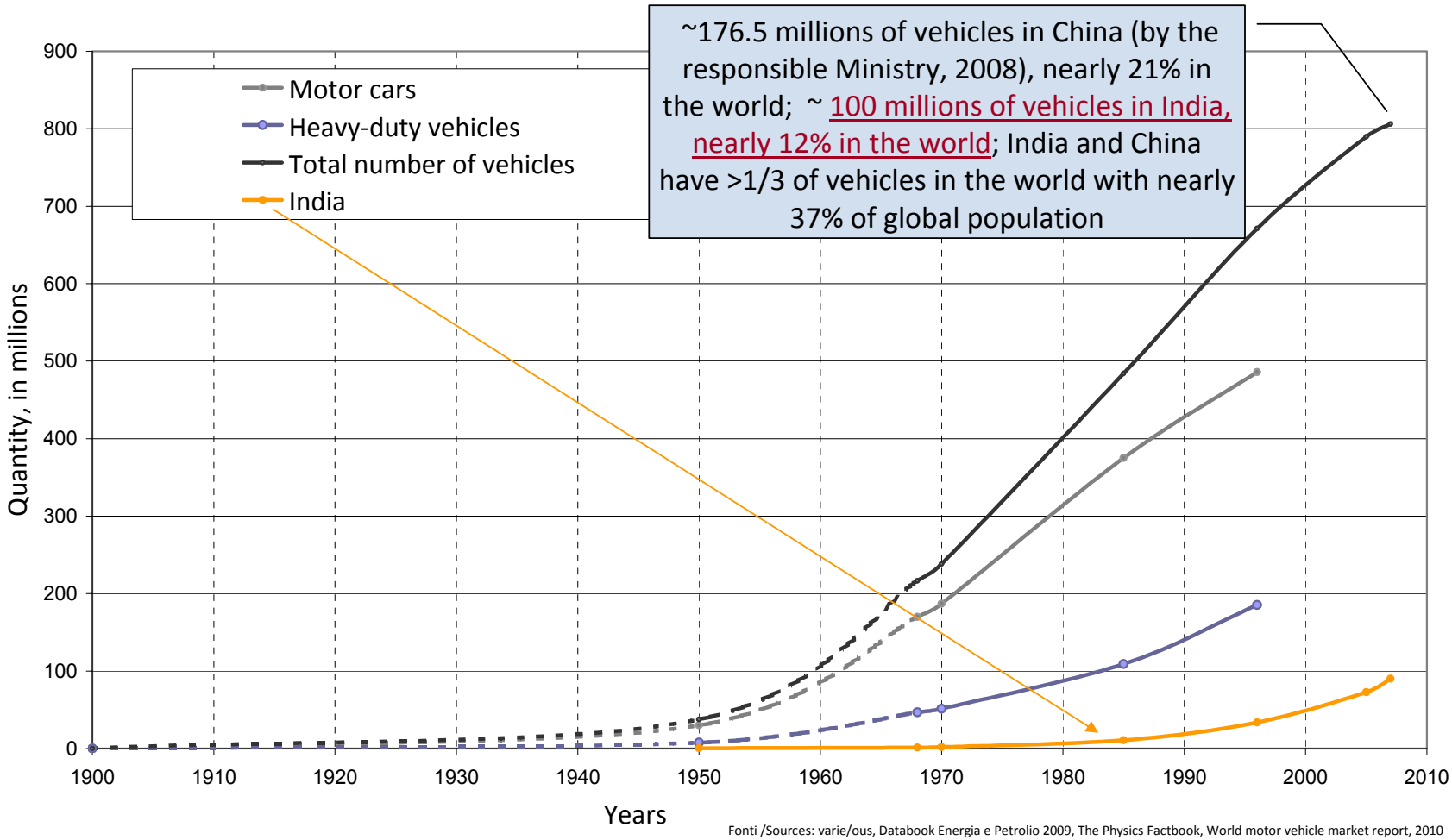

Fonti /Sources: varie/ous, Databook Energia e Petrolio 2009, The Physics Factbook, World motor vehicle market report, 2010

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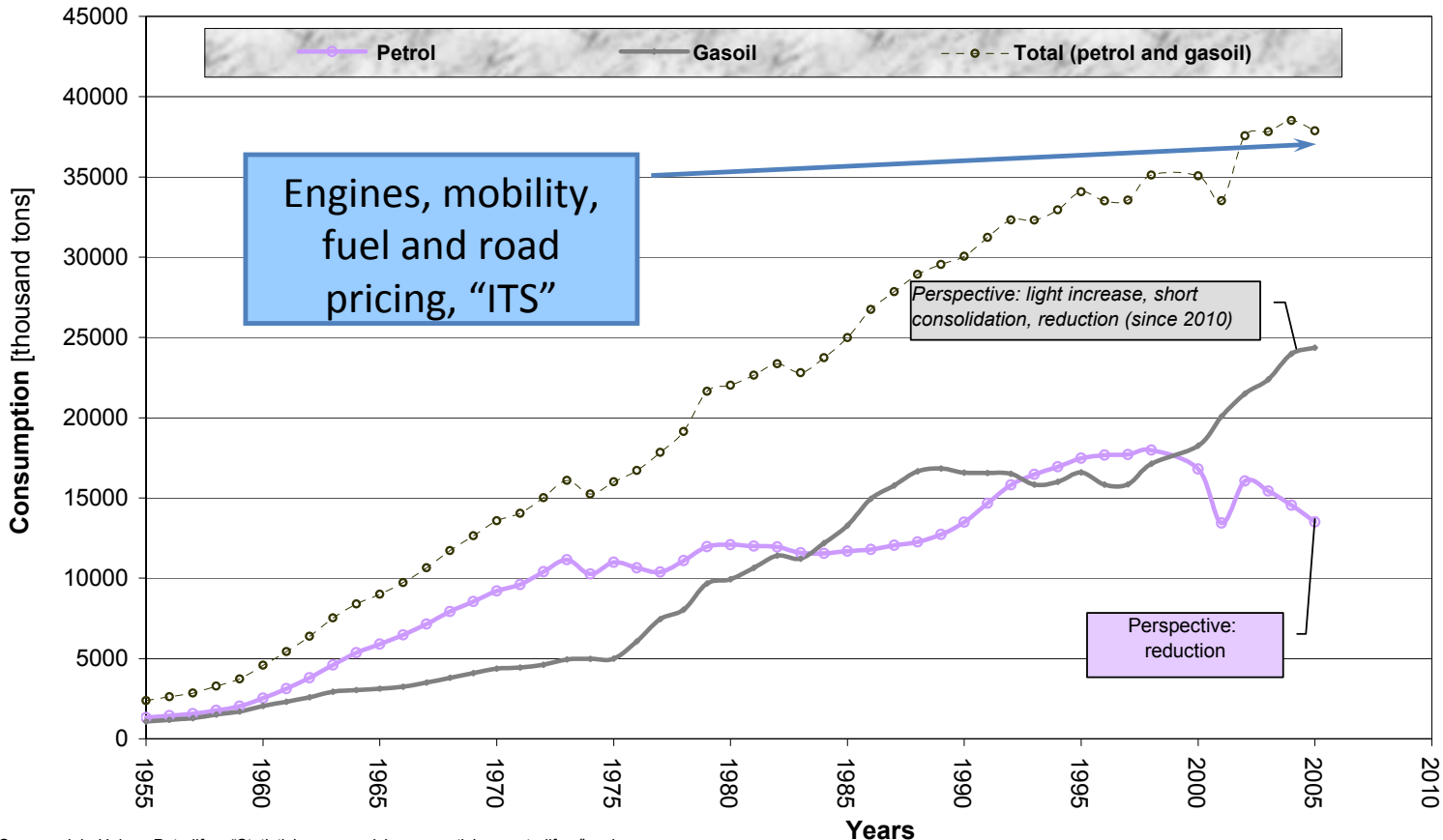
An example: evolution in the consumption of petrol and gas oil for automotive traction, Italy, since 1955 until 2008, in thousand tons



Source: elab. Unione Petrolifera "Statistiche economiche energetiche e petrolifere" various years.

The consumption of petrol and gas-oil in Italy (2005):

≈ 18 billion e 766 million litres of **petrol (fuel)**

≈ 29 billion e 85 million of litres of **gas oil (diesel)**

Total: approximately 47 billion 851 million litres

Sources : Ministry for the Economical development; data by "Unione Petrolifera, Energia e Petrolio in Italia" – I, 2009

The consumption of gas oil is remarkably higher than the one of petrol, in spite of the fact that the number of petrol vehicles in Italy is in the order of the double; two main reasons:

- the average yearly distance covered by the gas-oil vehicles versus the petrol ones is definitely higher;
- approximately 91% of the freight vehicles are fuelled by gas oil; as well known, they cover long distances throughout the year, and their consumption is higher than the one of cars.

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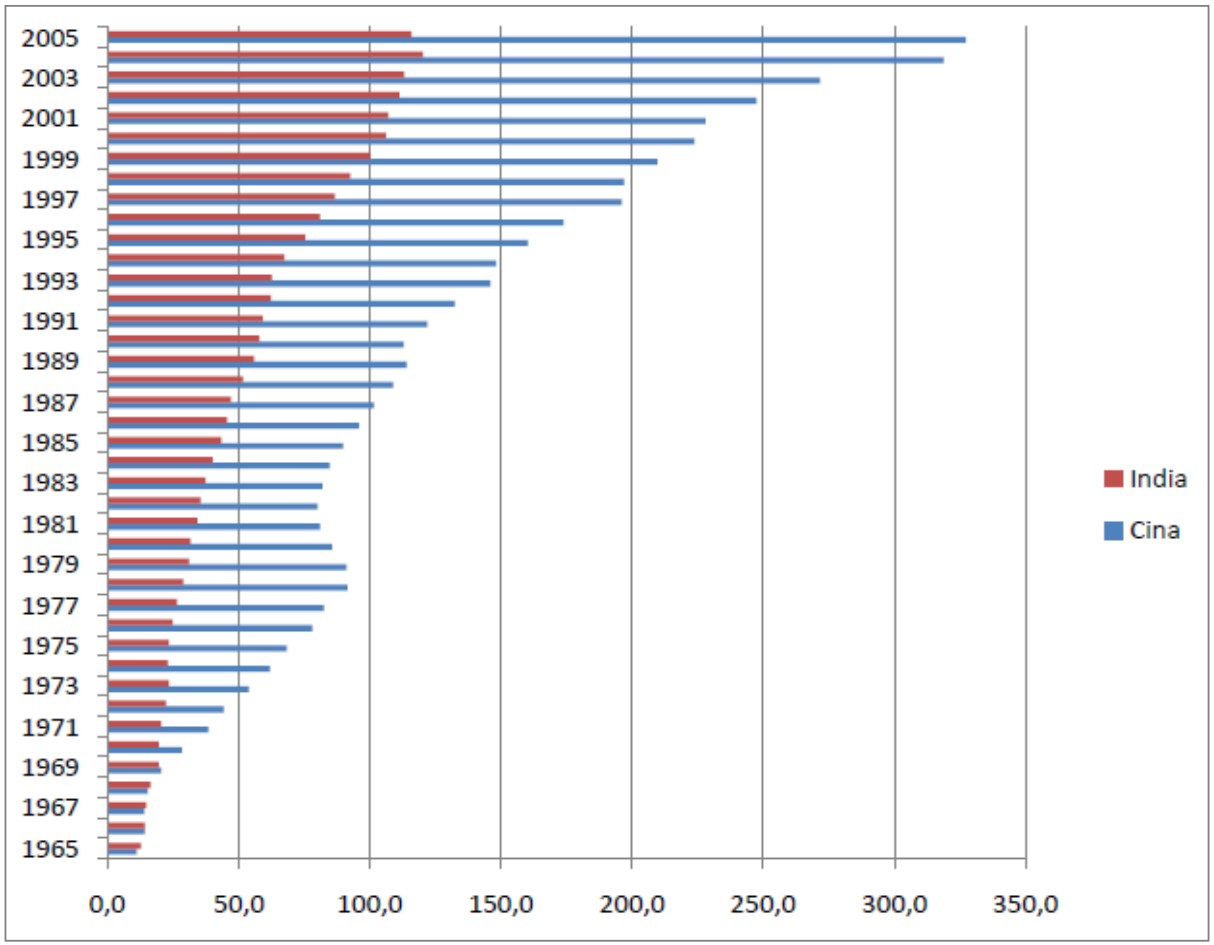

Historical series in the consumption of oil in India and China [million tons/year]

If we consider China in particular, we can observe a spreading of oil consumption: in 40 years, consumption moved from ~11 million tons/year (1965) to up to ~327 million/year (2005): a 2,900% increment in consumption for an average increase of ~72.5 % every year.

The same considerations concern India, which has recorded an increase of ~900% within the same timeframe.

The alert concern the future: the two States record an overall population of ~2.5 billion people, a datum which certainly raises grounds for reflections if compared to the one of Europe: the European population is of approximately 500 million inhabitants, i.e. 1/5 of the overall population of China and India

→ yearly consumption per capita of oil → situation probably quite worrying.

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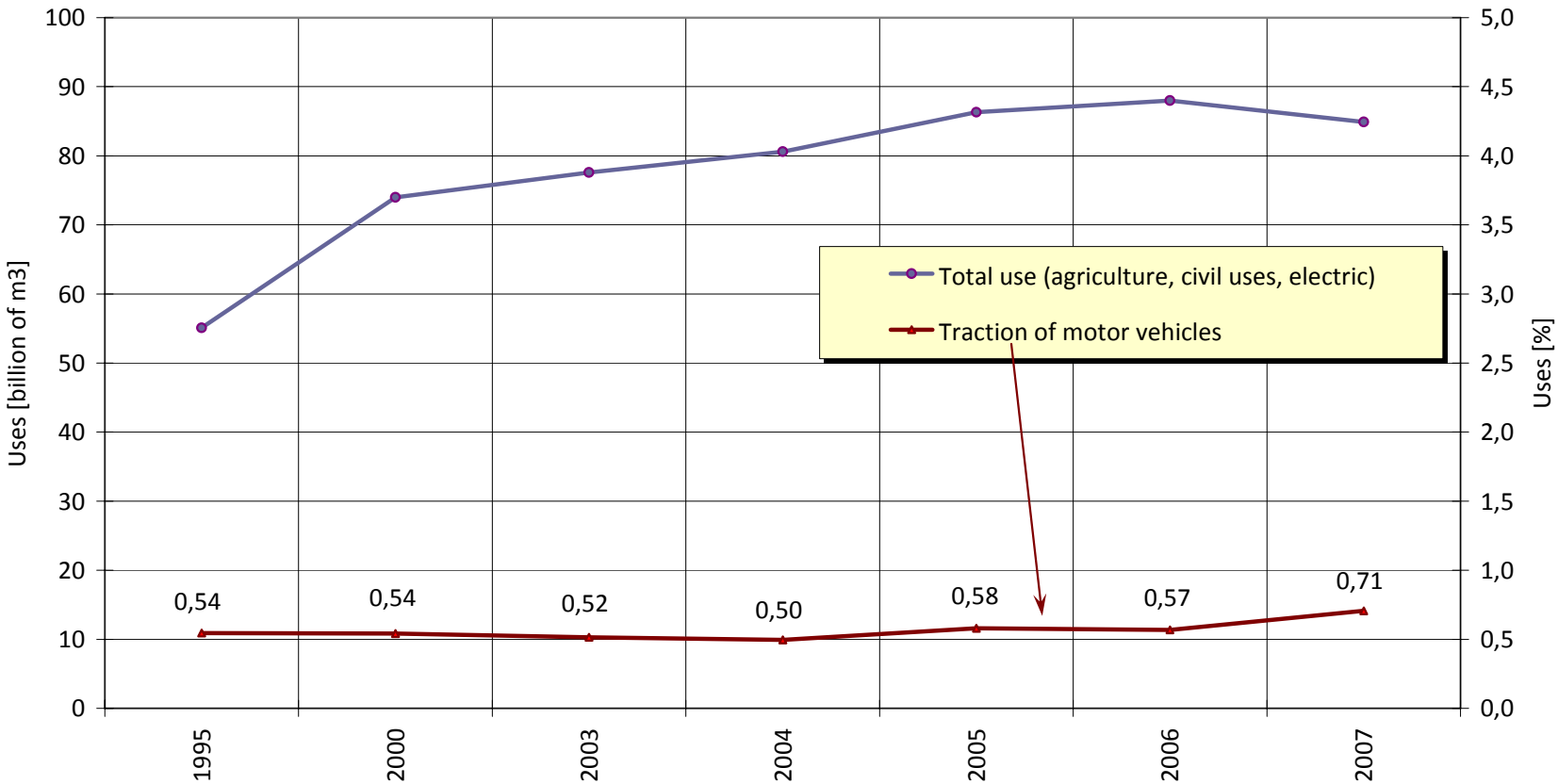
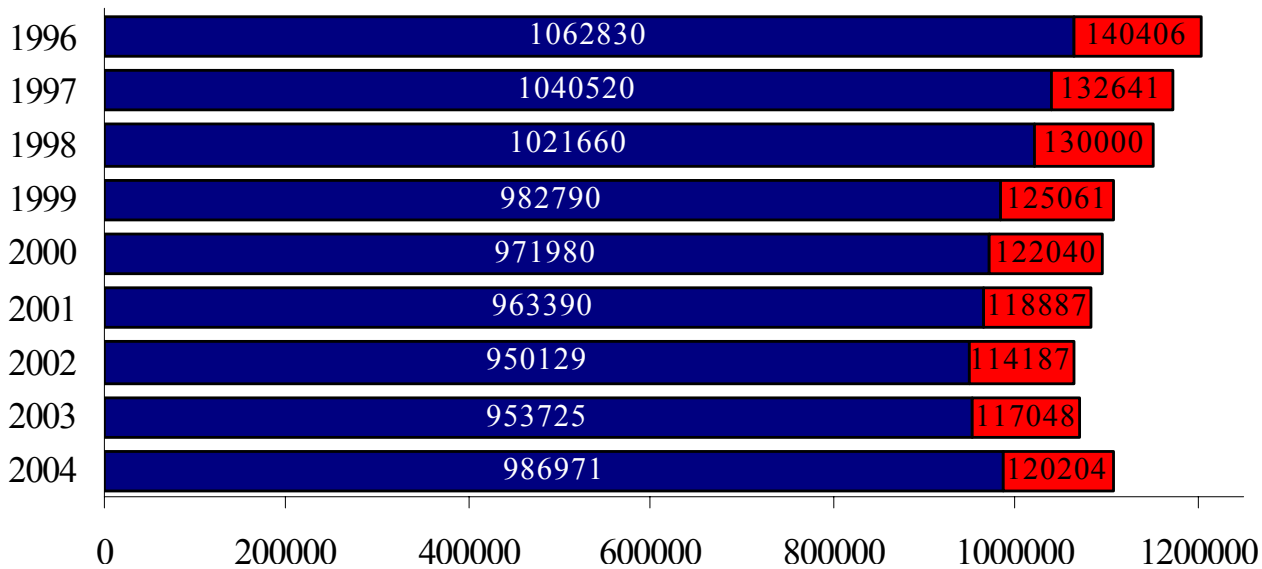
Use of natural gas for motor traction



Sources: Ministery for the Economic development , Snam Rete Gas; Databook "Energia e Petrolio", Italy, 2009

Rail transport, Italy



Energy use for traction [toe] in the years 1996-2004: in blue, electric energy, in red gas oil

Energy use in the last years [source : Trenitalia (2005); "*Rapporto Ambientale" 2005* - I]

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3. How much the use of energy impacts the different transport modes?

- Road transport
- Rail transport and other transport installations
- Air transport
- Maritime transport

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Impact on the running cost of energy consumption in railways, subways and tramways

- ~ **4-5%,** indicatively, for the Italian railways, on the overall running cost, according to some recent data [current unofficial data]
- ~ 11% for ATM in Milan, taken as an example, as energy cost on the 2009 budget, approximately 50% (**5.3%**) for rail systems and subway in the specific case [official data, 2009];
- **~6%** as energy impact on the budget in case of the traction for the VAL automated metro in Turin, plus an equivalent value for other electric power supply means [indicative data, 2009].

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The **RAILWAY** transport system:

- has set itself objectives and has undertaken some responsibilities, also on a formal point of view;
- examples:
  - energy recovery in braking, to be utilized immediately (acceleration-braking of trains); use of double-layer capacitors in heavy-duty traction; installation of photo-voltaic systems on buildings and railway sheltered stops; geothermal probes, photo-voltaic barriers; optimisation of the speed to be followed; air conditioning of the environment tuned to the number of passengers who are actually transported at a given moment; reduction of masses wherever viable; aerodynamics; performances (power supply and recovery); materials in wheels.

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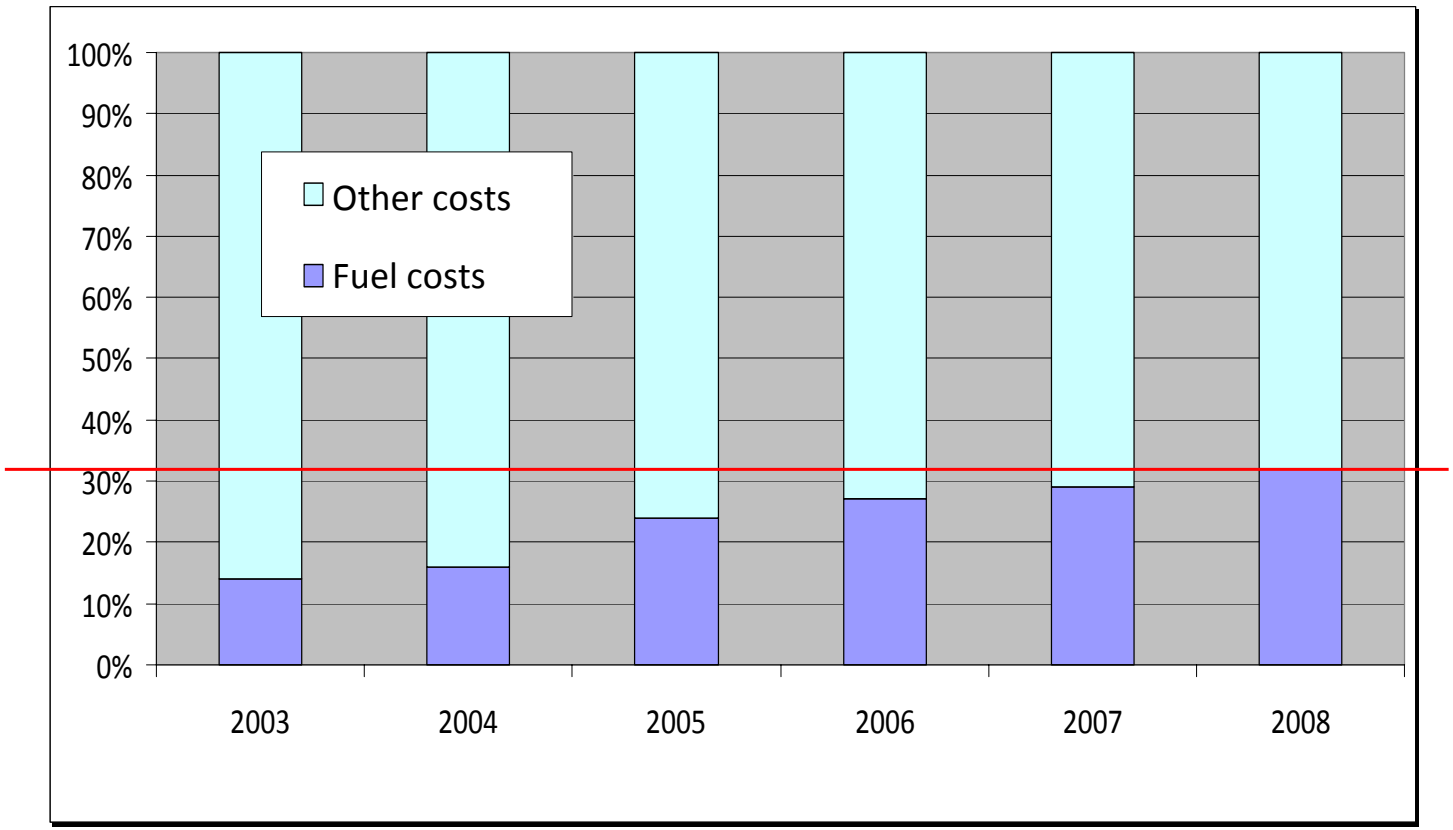
Impact of energy consumption in air transport

IATA (*International Air Transport Association*) has measured the impact of the cost of fuel on the airline activities, identifying that:

- in 2003 it represented 14% of the overall cost
- in 2007 the impact grew up to 29%
- in 2008 (increment of the cost of oil/barrel) a new increment up to 32%

ATA (*Air Transport Association*), which represents the main airlines of the United States, has declared that the cost of fuel influences the air fare by ~40% (2008).

➡ sole transport mode for which there are, at present, very few alternatives to oil derived fuels on board.



Influence of the cost of fuel on the total of the air transport activities: fuel costs and other costs (IATA, 2008)

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Maritime transport: gigantism of ships and containment of energy costs (economies of scale)

The development of the freight traffic in containers has involved the development of progressively larger and more capacious ships, namely:

- panamax with a typical load capacity between 2,500 and 3,500 20-foot containers (TEUs);
- post-panamax of I-II-II generation, whose maximum capacities evolved from 3,500 to ~8,000 TEUs.

- An 8,089 TEUs ship berthed for the first time in the Mediterranean Sea (Gioia Tauro) in 2006;
- the first 11,000s TEU ship was completed at the end of 2006;
- the first 14,000 TEUs container ship docked in the Mediterranean Sea (Gioia Tauro) in 2009.

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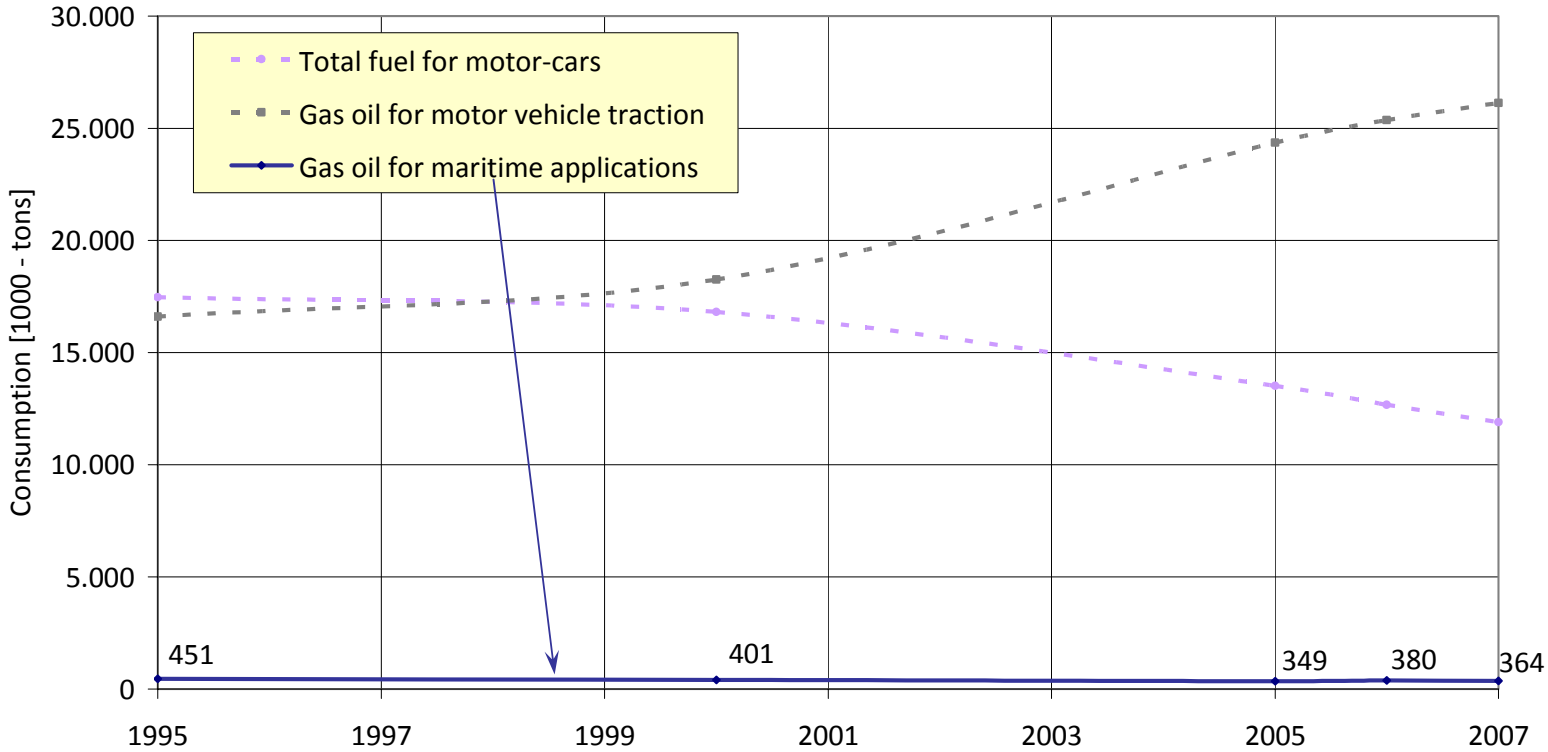
Composition of oil consumption: petrol (fuel) and gas oil for motor-vehicle traction; gas oil for maritime use; example for Italy



Sources: Ministry of the Economical development, Databook "Energia e Petrolio", 2009 - Italy

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4. What is the involvement of the governments in the use of oil for traction?

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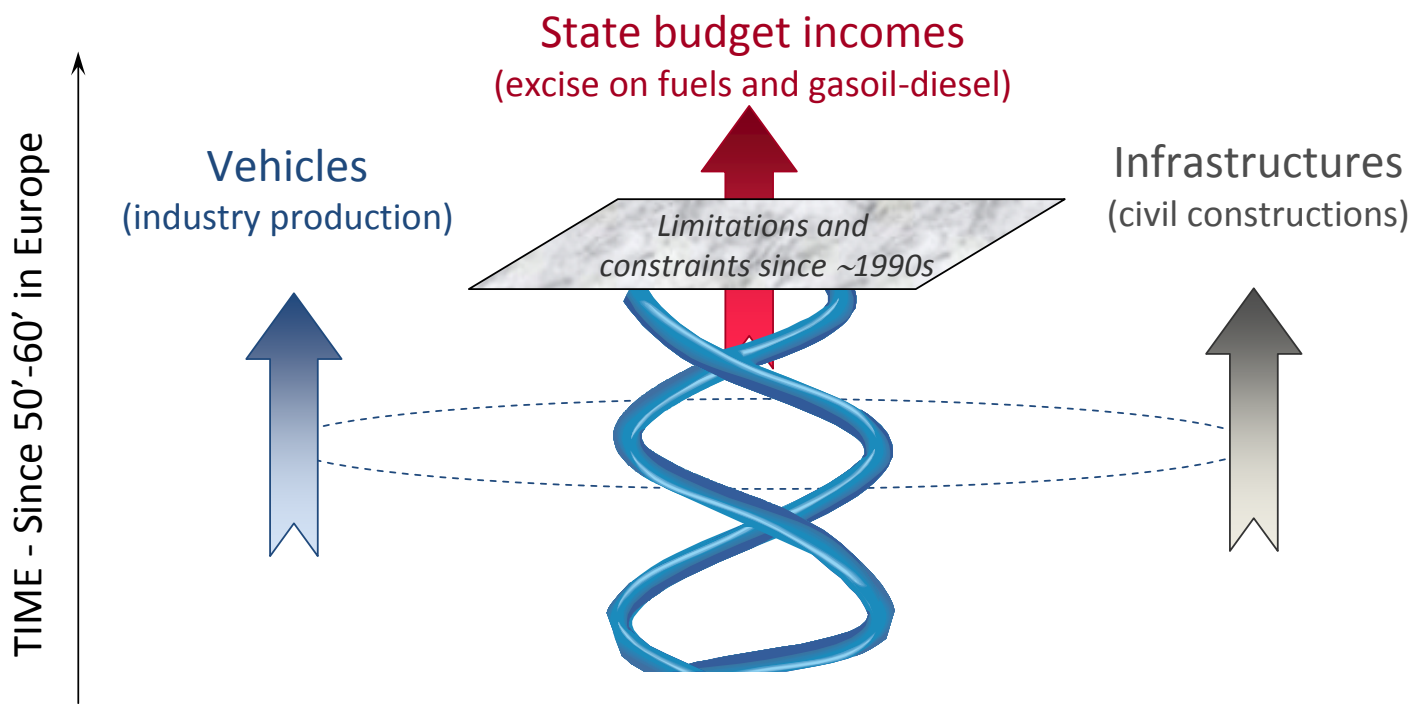

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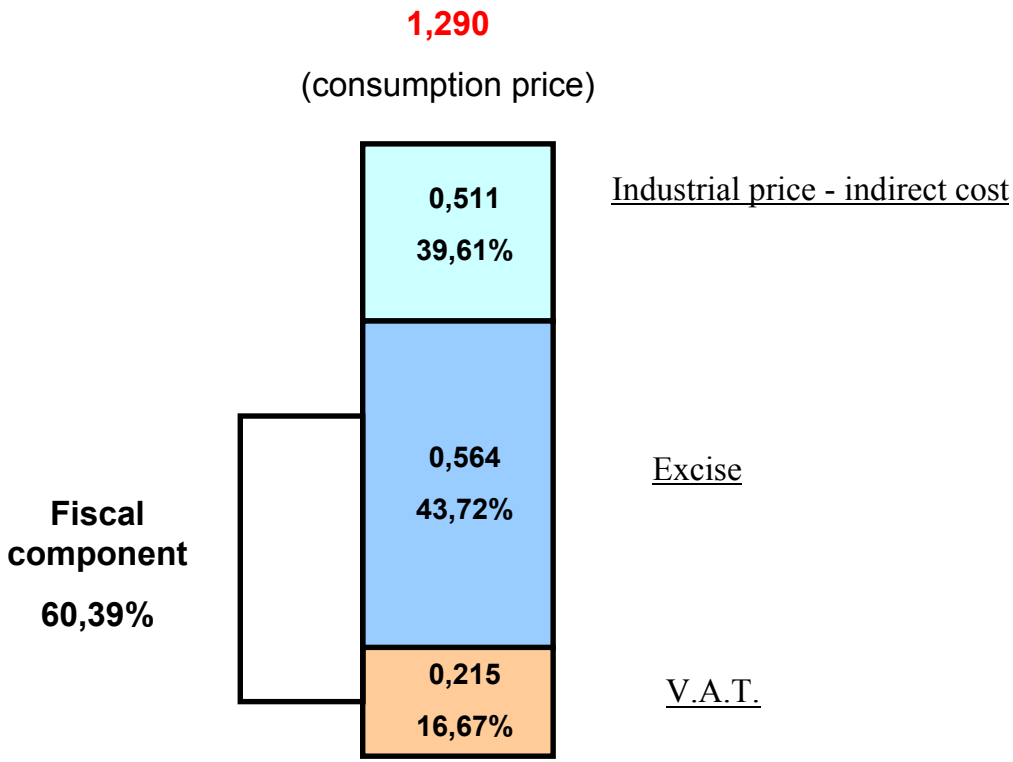

Fiscal composition referred to one litre of fuel in a given moment
(data of 2005, Italy)

Income for petrol excise duty in 2005 = 0,5631 €/litre · 18,765,833,333 litres = 10,567,040,750 €;

Income for gas oil excise duty in 2005 = 0,4114 €/litre · 29,084,720,238 litres = 11,965,453,906 €;

Total revenue for excise duties in 2005 = 10,567,040,750 + 11,965,453,906 = **22,532,494,656 €**

Abstract of the State budget (Italy): 2005 excise duty.

Entrate derivanti dall'attivita' ordinaria di gestione			
ACCISA E IMPOSTA ERARIALE DI CONSUMO SUGLI OLI MINERALI, LORO DERIVATI E PRODOTTI ANALOGHI			
IMPOSTA RISCOSSA IN VIA ORDINARIA	INIZ.	1.955.484.768,34	22.209.270.000,00
	VARIAZ.		322.091.133,00
	DEFIN.	1.955.484.768,34	22.531.361.133,00

[internal analysis by Politecnico di Torino, on published data, carried out in 2008 on data of 2005]

Subsequently, in 2005 the consumption of fuels involved, as excise duty and V.A.T., State revenue of approximately **31,712,424,567 €.**

This value can be added to the V.A.T. for the purchase of vehicles and the road tax.

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Having available the data of the vehicle fleet, the average distance covered per year and the average emissions of the vehicles, the total emissions can be estimated per means of transport (e.g. for Italy).

	Number	Km/year	g/km	Emissions (g)
Morot cars	35.209.404	12.326	157	68.136.604.851.528.00
Two-wheels	4.938.359	6.300	104	3.235.612.816.800.00
Commercial vehicles + Others + Special vehicles	345.156	10.000	210	724.827.600.000.00
Buses	94.437	45.000	420	1.784.859.300.000.00
Industrial vehicles + Trailers + Others	3.785.913	40.000	320	48.459.686.400.000.00
Rails (3%)	-	-	-	4.050.000.000.000.00
Airpl. (6%)	-	-	-	8.100.000.000.000.00
Total emissions				134.491.590.968.328.00

g
- 134.491.590.968.328 (gr.)

Mg
- 134.491.590,97 (million of gr)

Mt
- 134,49 (million of tons)

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ASSUMPTION: payment for the use of the natural resources?

- Oxygen beside CO_2, might be analysed
- ROAD SOIL ➲ actual use of the infrastructure (*road pricing* with the help of "ITS" - *Intelligent Transport Systems*)

We operate on transport DEMAND and make the market more correct

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5. What solutions can be prospected in a changing economy?

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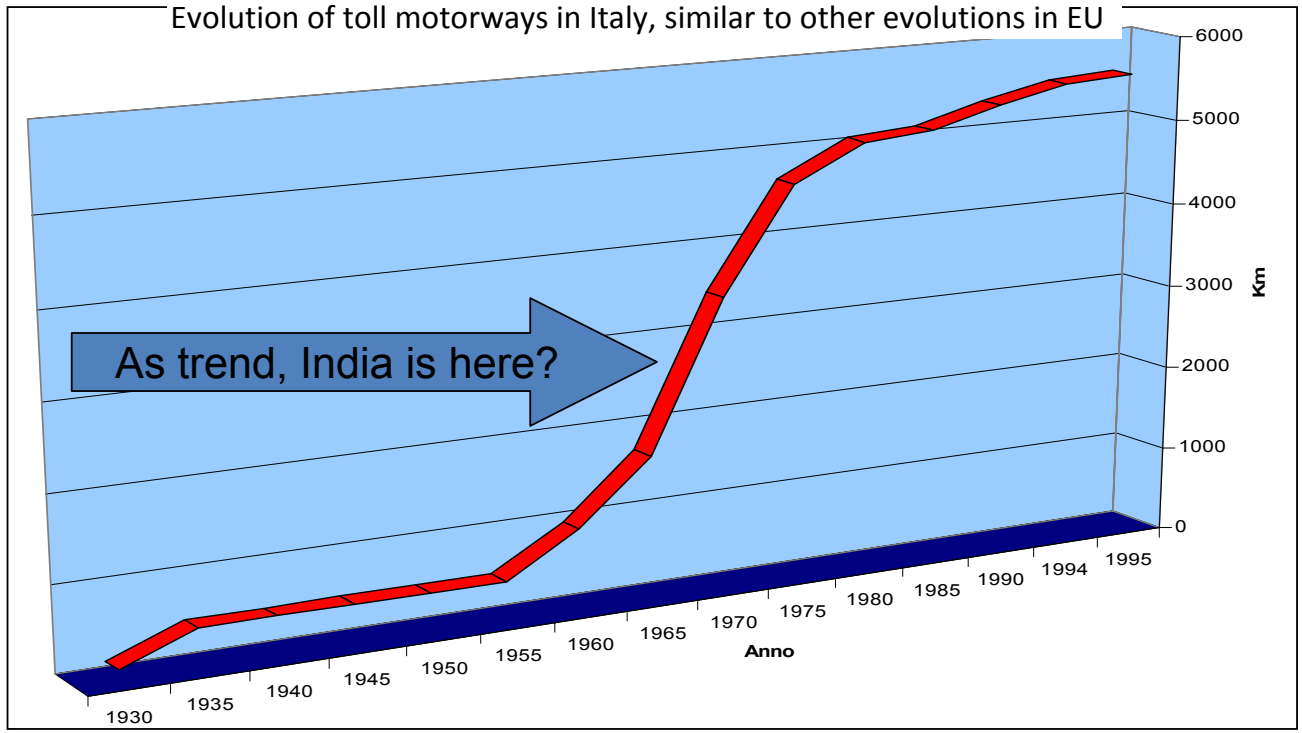
Evolution of transport needs



EU economic system is therefore moving from a context which was primarily based upon industrial and civil *production* - the latter, in this specific case, as creation of transport infrastructures - to greater focus on *efficiency*, *quality*, *safety* *and* *security*.

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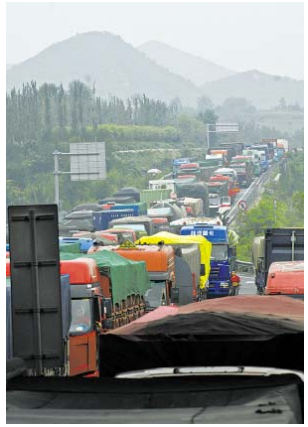
Limits to the growth of mobility in Europe

The development of the circulating fleet, infrastructures and mobility, which have significantly marked the 2nd half of the last century in Europe, show today some conditioning:

1. The saturation of the land, as infrastructures on the territory and vehicles on the infrastructures;
2. The possible limitedness of the energy resource - of oil in particular, at least at widely accessible prices – on which transport depends for at least 98% (EU);
3. The release within the environment of gases and combustible materials;
4. The maintenance and technological upgrading of the existing infrastructures;
5. Safety, a conditioning objective dictated by the EU on roads and in many countries;
6. The increment linked to the relationships between people, a possibly ethic objective.

☞ We should not necessarily expect a relevant increase in the mobility-transport and related consumption in EU, while we have to pursue their safety, security, quality and efficiency, mainly from the energy viewpoint; in *future* we might have also "teleworking" e "telepresence".



- ~100 km queuing in China in August 2010
- traffic in Delhi
- development of highways and rail network in India

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Fixed guideway

Solutions: possible limitations, innovative VEHICLES (engines, fuels…), LOW ENERGY and SHARED transport systems (railways, rope installations, metros, APMs), rational and optimised MOBILITY, fuel and road pricing, "ITS"

- ITS (*Intelligent Transport Systems*) and Infomobility are expected to facilitate this process of migration towards systems with *less queuing and optimized routes* through a *better use of both the road network and energy* to prevent the primary accidents as well as the propagation of collisions by informing the users, foster the remote access to reservations and payments, avert injuries to people and damage to both the vehicles and the environment in the broad meaning of the word.

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«ITS integrate telecommunications, electronics and information technologies - in short, 'telematics' - with transport engineering in order to plan, design, operate, maintain and manage transport systems.
This integration aims to improve safety, security, quality and efficiency of the transport systems for passengers and freight, optimising the use of natural resources and respecting the environment.
To achieve such aims, ITS require procedures, systems and devices to allow the collection, communication, analysis and distribution of information and data among moving subjects, the transport infrastructure and information technology applications».

This definition was created by the ITS EDUNET, 2009; used by IET ITS technical-scientific review

Telecommunication systems
Automatic identification systems (AIS)
Radio frequency identification (RFid);
Bar-codes and two-dimensional codes;
Magnetic-strip cards;
Smart cards;
Identification by video technology;
Biometric systems.
Automatic location systems (AVLS)
Traffic data collection and automatic classification systems
Electronic data interchange (EDI)
Cartographic databases and *geographic information systems* (GIS).

APPLICATIONS

- monitoring traffic and road conditions;
- control and management of traffic-lights (centralised, with priority and acoustical ones);
- control and management of parking, on-street and within parking areas;
- control and management of transits with vehicle stop;
- control and management of transits and routes without vehicle stop;
- traffic infraction detection devices and enforcement systems;
- traffic and traveller information systems:
- on-board information;
- ground systems for user information and data exchange;
- control and management of passenger transport services;
- control and management of freight fleets and intermodal transport units;
- on-board route guidance and navigation;
- integration of the various applications listed above.

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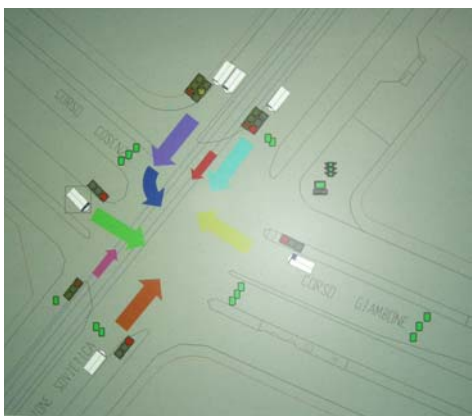
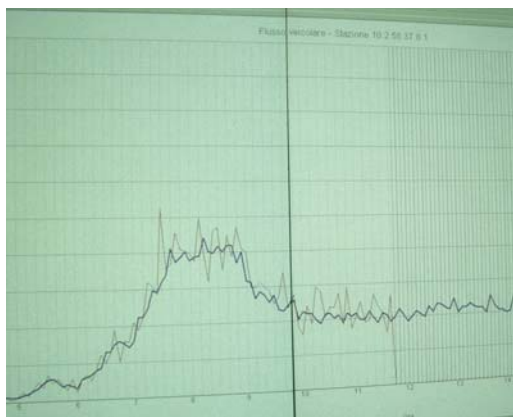
Examples of instruments for data collection and remote monitoring; in sequence: traffic data collection on the pavement, aside the road, on-board a vehicle for a public transport


Examples concerning the analysis of collected data:

urban context, with traffic light cycle control on the basis of traffic and priority to public transport, automatically localised; comparison of vehicular flows observed and forecasted; control room

e.g. taken from “5T” system operating in Torino (Italy, 1991-2010), but many other have been spreading in Europe





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Examples concerning the freight transport and logistics

Example for systems for revealing the access in a restricted area within a urban centre

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Examples of instruments for informing users (in sequence: along a motorways through variable message signals - VMS; on-board, both with direct communication among vehicles and through broadcasting via video-diffusion, also for navigation and optimisation in the use of the network)

Variable message signs or panels

Examples of inter-vehicle and infrastructure-to-vehicle communication systems (sources: CRF-Centro Ricerche Fiat and Audi)

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Information systems at public transport stops
(Torino - I,
Zurich - CH,
Munich - D)

- As regards the e-learning platform, a cutting-edge **multimedia platform** designed specifically to meet e-learning requirements has been developed and at present subject to enhancement.
- The web site: **www.its-elearning.net**

who can move autonomously (i.e. people); whilst terms such as transport and handling better suit freight; logistics – on the other hand - should be employed when referring to the related organizational activities. The applications that can be employed may be databases – e.g. to collect information concerning a place, the status of a delivery, etc. – and applications for transactions, maps for localisation, tracing, tracking, etc.
The transmission of information may both be active - i.e. conveying information or a request of information from the moving subject - and passive, i.e. by the automated reception of any information, reading of a label when passing close to a gateway, etc.

Advanced technology and, in particular, telematics applied to transport can mitigate several issues and inefficiencies which affect the system, with particular reference to mobility. Sound results have already been achieved, even though the users are not always acquainted on the actual and spread use of many of such applications. A momentous transformation is thus in progress as related to the way of conceiving mobility and whatever is related to it, including the tele-presence.
Infomobility may involve road, rail, maritime, aerial, inland navigation and intermodal transport.

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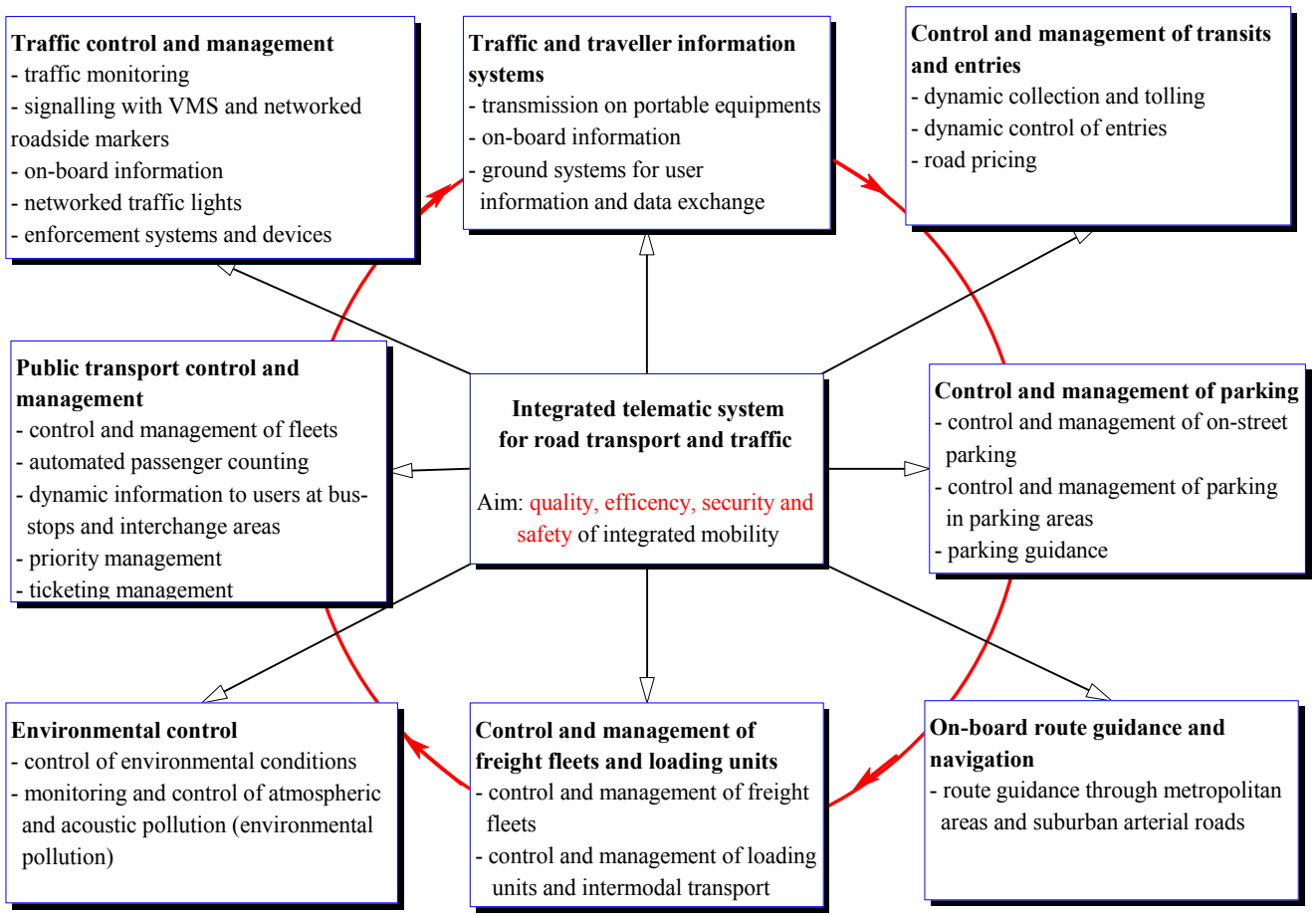

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Conclusions

- **Pursue a better use of transport systems and related infrastructures in terms of quality, safety, security and efficiency – of engines and the whole transport system – also (not only) with the use of telematics and "ITS"**

Energy efficiency, independence from petroleum

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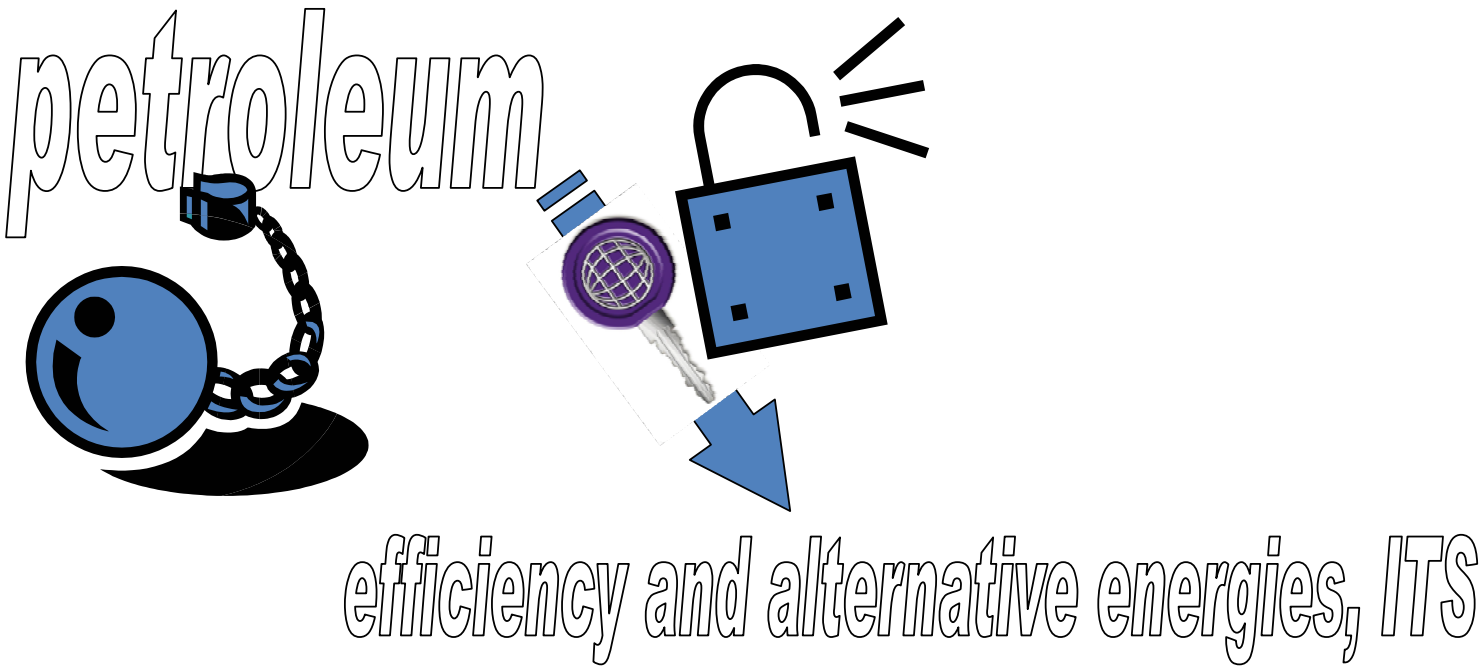

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