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Personal Mobility in the Context of Sustainable Development

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ABSTRACT: Personal mobility can be shaped by many possible means, from strategic international agreements on joint standards, through national legislation on health and safety, sustainable municipality planning and development, up to education and promotion of environmentally friendly life style. This paper follows some of the main trends in the historical development of the travel demand, and shows the evolution of the personal mobility into an environmentally sensitive area.

KEY WORDS: personal mobility, sustainable development, vehicles, biofuel, environment

As mankind evolves, it conquers every space it can reach. The expansion of the habitual “presence range” of an average modern human being is influenced by his increased ability to travel, and to do it fast - between his living area, schools, shops, working places, administrative centers and the scenes of his social and recreational activity. The need for mobility can be therefore divided into daily mobility and tourist or leisure mobility, and in both cases this ability to move for the modern human means to use machines.

“I will build a motor car for the great multitude. It will be large enough for the family but small enough for the individual to run and care for. It will be constructed of the best materials, by the best men to be hired, after the simplest designs that modern engineering can devise. But it will be so low in price that no man making a good salary will be unable to own one - and enjoy with his family the blessing

of hours of pleasure in God’s great open spaces.” (Ford, 1922)

Contrary to general belief Henry Ford was not the first mass producer of automobiles. E.g. “Ransom Eli Olds started mass producing internal combustion vehicles in 1901” (Shields, 2007) But Ford really succeeded in his plan for great volumes and made history by selling more than 15 million units of his first “mass production” model T between 1908 and 1929. Many other car makers followed suit and here we are now - only in 2012 the world production of cars and commercial vehicles was 84,141,209 units (International Organization of Motor Vehicle Manufacturers). The total number of vehicles in 2010 was 1.015 billion, including cars, light-, medium- and heavy-duty trucks and buses registered worldwide, but excluding off-road and heavy-duty vehicles. (WardsAuto) According to The International Organization of Motor Vehicle

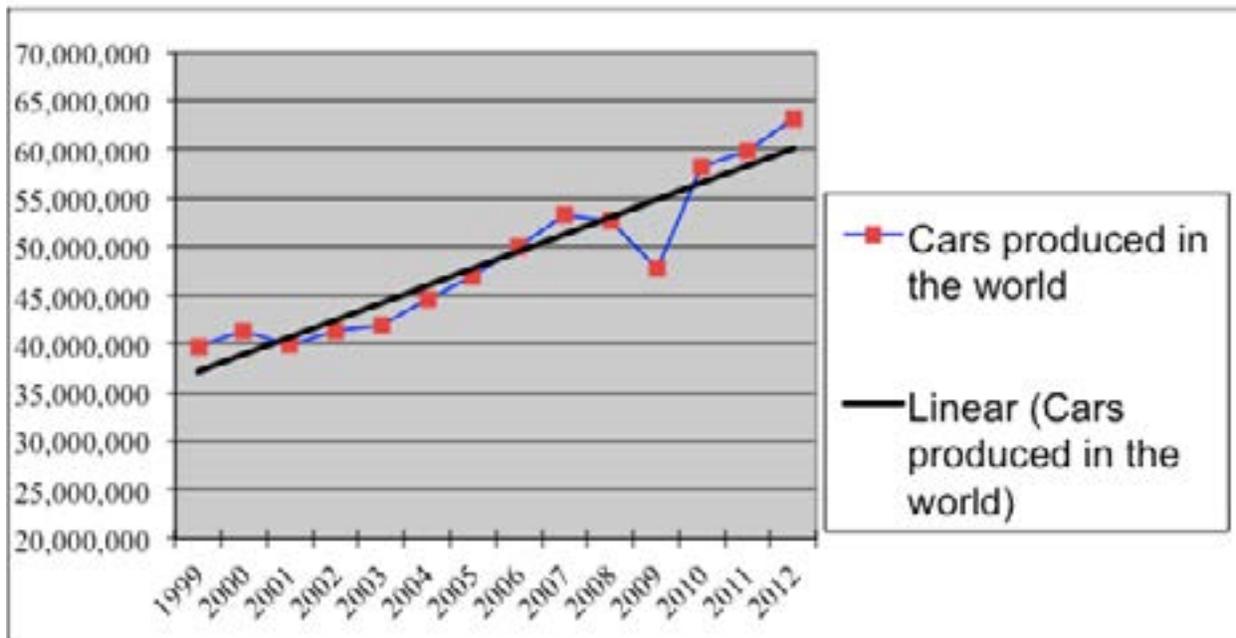


Figure 1 Cars produced in the world (www.worldometers.info/cars/)

Manufacturers (www.worldometers.info/cars/) 43,546,991 cars and commercial vehicles were produced in the first 6 months of 2013. Figure 1 shows the production figures - and the respective trend - of passenger cars, defined as motor vehicles with at least four wheels, used for the transport of passengers, and comprising no more than eight seats in addition to the driver's seat.

Car production has never stopped increasing in the examined period with the exception of the economically burdened 2001 and 2009.

At the beginning of the XXth century the mass production of the automobiles brought forward a new type of human mobility. The growth in welfare and the affordability of the means of transportation naturally created an increase in the demand for travel, both in terms of distance covered and of time spent on the road. In Western societies, "the spread of high-speed travel due to increased car availability

among the households resulted in a widening of the activity space of individuals" (Vilhelmson, 1999). Certainly, if the individuals can afford cars, they can volunteer for work farther away from home, they can choose a larger shopping center at a more distant location, or they can buy a bigger home away from the cramped big city.

Nowadays according to (Metz, Saturation of Demand for Daily Travel, 2010), the average distance travelled by an individual, as well as the number of trips made is strongly related to his income. Similar conclusion is drawn by (Orfeuil & Soleyret, 2002): "Household income has a major impact on travel practices for all the markets." While it may be easy to accept the presumption that higher income produces more travel, the approach is not perfect, because individuals who cannot afford to live closer to their place of work also travel more, but apparently not because they have higher income.

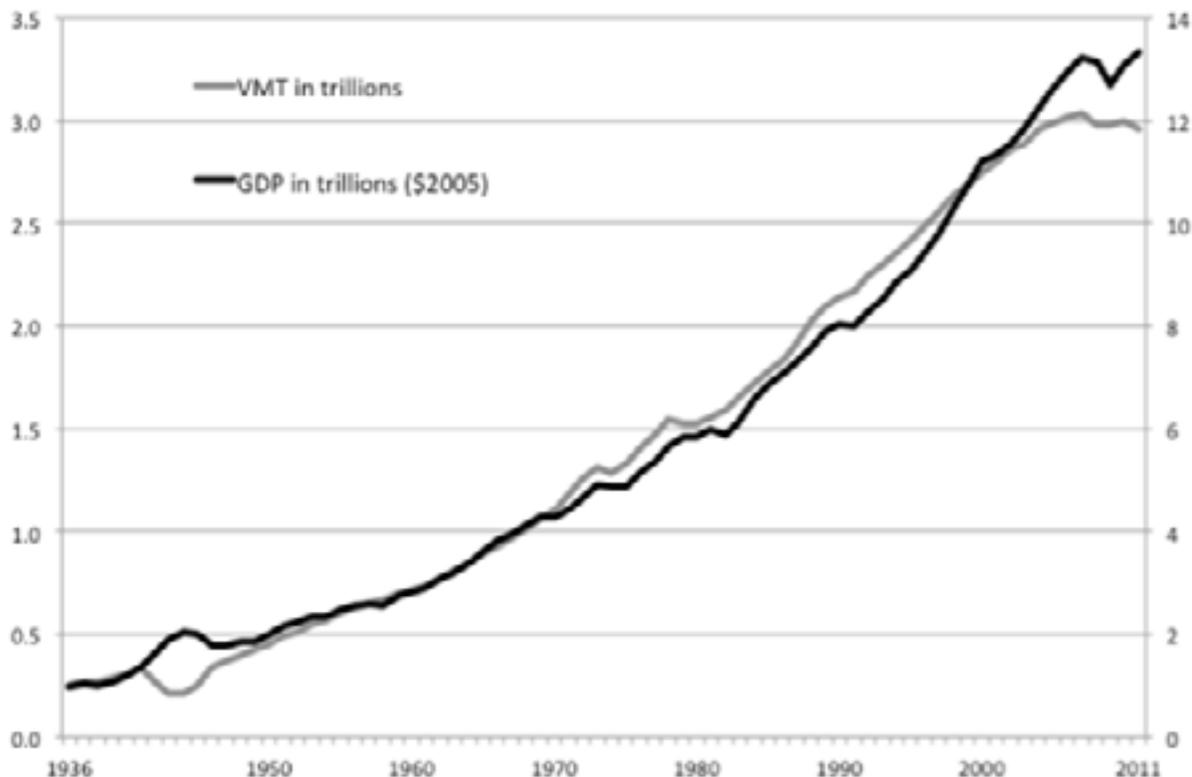


Figure 2 Total Auto and Truck VMT (trillions) and GDP (trillions of \$2005), 1936 - 2011, VMT (vehicle miles traveled) axis on left; GDP on right. (Ecola & Wachs, 2012)

It is reasonable to expect, that the increase in personal travel demand must also stop at some point. If not for other reasons, then certainly due to the individual's time restraint. Unsurprisingly, this has already been independently confirmed for the developed markets.

Figure 2 shows the relation between GDP and vehicle miles traveled (VMT) in the USA for the period between 1936 and 2011.

Except for the war period, GDP and VMT have grown together until 2003. Presumably, the growth in VMT in the USA by that time might have reached a point of saturation and could not cope with the growth of wealth.

In the UK Metz, based on the 'The National Travel Survey of Great Britain', states that "the average trip rate has held steady at about a thousand journeys per person per year over the nearly four decades of the Survey, while the average travel time has been about an hour per person per day throughout. The average distance travelled increased from 4500 miles per year to reach 7000 miles in 1995, since when there has been little further change" (Metz, Demographic determinants of daily travel demand, 2012).

Using the National Travel Survey statistics of the UK (Transport, 2013) we can even see a clear decline in the distance travelled (Figure 3) as well as in total trips made (Figure 4).

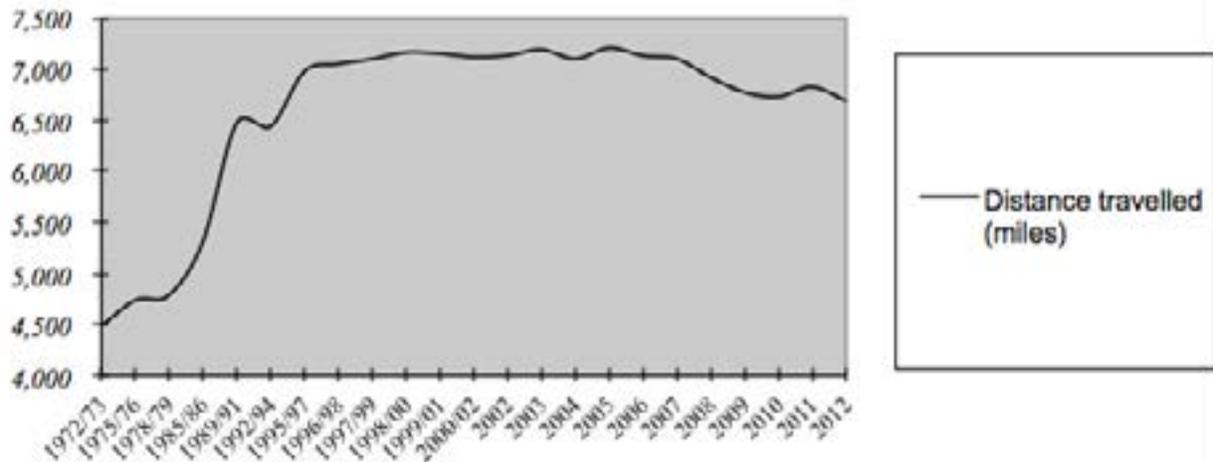


Figure 3 Distance travelled in the UK (miles) - National Travel Survey statistics of the UK

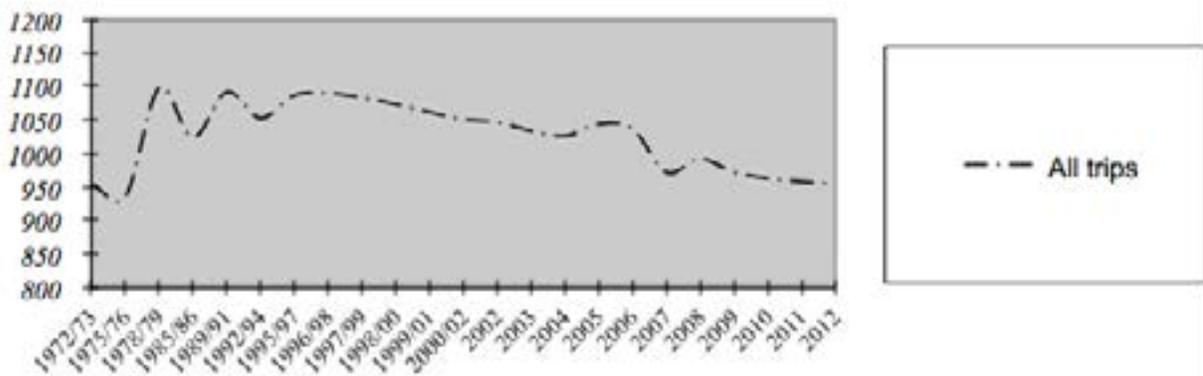


Figure 4 All trips made in the UK - National Travel Survey statistics of the UK

The saturation of the demand for daily travel as described by Metz is similar to “the saturation of ownership and use” as described by Lee Schipper based on the stagnating vehicle use not only in the UK, but in Australia, Germany, France, Italy and Japan (Schipper, 2009). A similar phenomenon - stagnating and decreasing “vehicle miles traveled per capita” in the US - even leads Puentes and Tomer to the bold suggestion that “there may be a ceiling on the amount of driving that Americans are capable of” (Puentes & Tomer, 2008).

In Sweden “time saved by using faster modes of transport is now being spent on stationary activities to a greater extent than during the 1970s and 1980s” (Vilhelmson, 1999). Without mentioning it explicitly, Vilhelmson involuntarily confirms that in terms of travelling the increased travelling speed seems to have always had a rebound effect in Sweden - reducing travel time through higher speed gave the opportunity to cover longer distances within the same time, and it is only recently that spending this additional time on stationary activities has become more popular.

Concerning motoring, the rebound effect is more often related to cost saving, rather than time saving. Ironically, only one person (Schipper, 2009) among the above cited authors mentions this type of rebound effect by name, stating that, “there is no evidence of any important rebound of driving because of greater fuel economy in Europe, although as Schipper and Fulton (2009) and Schipper (2009) point out, diesel cars in Europe are driven significantly more (50–100%) than gasoline cars.”

It is quite difficult to agree with the first half of his citation regarding the non-existence of important rebound of driving. We must give this author credit, though, because the second half of the same sentence finely confirms that same denied rebound, mainly by brilliantly citing two of his own papers not published yet at the time of printing the editorial.¹

The reality is that general rebound effect is a fact, although in the U.S. Kenneth Small and Kurt Van Dender reveal “evidence that the rebound effect diminishes with income, and possibly increases with the fuel cost of driving. Since incomes have risen and real fuel costs have fallen, the rebound effect has declined considerably over time.” (Small & Van Dender, 2007)

I strongly disagree with this conclusion. If we presume that the rebound effect shall cause people to drive more due to cost saving, that shall definitely involve a clear perception by the consumer of what his fuel costs are. Obviously, this may not be appropriate to expect in this case, because another paper examining “the reality of how US consumers are thinking and behaving with respect to automotive fuel economy” plainly says, “We found no household that analyzed their fuel costs in a systematic way in their automobile or gasoline purchases. Almost none of these households track gasoline costs over time or consider them explicitly in household budgets. These households may know the cost of their last tank of gasoline and the unit price of gasoline on that day, but this accurate information is rapidly forgotten and replaced by typical information.” (Turrentine & Kurani, 2007)

¹Schipper, L., 2009. Automobile Fuel Economy and CO2 Emissions in Industrialized countries: Troubling Trends through 2006. Transportation Research Review, in press.

Schipper, L., Fulton, L., 2009. Disappointed by Diesel? The Impact of the Shift to Diesels in Europe through 2006. Washington, DC. Transportation Research Record, submitted for review.

It may be much more probable, that the explanation for the “considerable decline” of the rebound effect lies in my earlier suggestion - namely, an individual shall sooner or later run out of additional time he may spend on motoring, and that this breakthrough has been naturally achieved by the North American nation.

At global level, however, according to the International Energy Agency, the “demand for transport appears unlikely to decrease in the foreseeable future” - the World Energy Outlook 2012 projects that transport fuel demand will grow by nearly 40% by 2035. (International Energy Agency, 2012)

The explanation for the seemingly contradictive reports on saturation and growth at the same time is twofold. The personal travel demand in many less developed countries is still far from its saturation level; and population in some of these countries is growing with steady rates. In regard to those nations, which still have plenty of time to spend on travel, their progress shall be monitored with special care: “Energy use in the transport sector grows faster than in any other sector of the global economy. Of that growth, an increasing proportion originates in emerging countries. This is a reflection of the low levels of car ownership in these countries and the near saturation levels achieved in nations like the United States. It is therefore important to understand better how increases in wealth affect car ownership and use, and how these in turn will affect energy consumption and (until hydrogen becomes commonplace fuel) emissions and greenhouse gases.” (Ortúzar & Willumsen, 2011)

Back in 1986 the Hungarian professor Pál Michelberger described the main trends in the technical development of the automotive industry of that period as follows:

- Safety enhancement (including both active and passive safety)
- Environmental improvement (mainly reducing exhaust and noise through electronic management of the burning process, use of catalysts and unleaded gasoline)
- Energy efficiency (reducing fuel consumption through advanced engine efficiency, improvements in the whole powertrain and its management, decreasing energy loss due to weight, drag and not utilized heat, as well as better traffic management)
- Comfort enhancement (suspension, air-conditioning, ventilation, automatization, soundproofing)
- Reliability enhancement (maneuverability, braking ability, mechanic reliability in terms of failure rate - safe life, fail safe - and diagnostics)
- Flexibility of production and design (to meet the demand at an acceptable cost) (Michelberger, 1986) (pp. 41-82)

28 years later these trends are still valid! While safety and comfort still sell well everywhere, it was a strategy effectively focused on reliability, affordability and environmental friendliness that helped Toyota to become the world’s leading automaker. At the same time the very close connection of the ‘environment’ and the ‘energy efficiency’ categories in the above grouping may nowadays become a basis for discussion and/or even argument, whether their separate listing is justified.

In this paper I will handle these two topics as one category aimed at improving environmental efficiency of vehicles by all possible means, including reduced exhaust and noise through perfection of engines, fuels, the whole of the drivetrain, the whole

vehicle architecture, and much more, including the perfection of the drivers themselves.

To start with, from technical point of view another important trend has reemerged in the last decades: in search of improvement manufacturers have been investigating the use of different fuels and have been building hybrid vehicles. Beside the most common fuels - gasoline and diesel - alternative fuels like CNG, LNG, bio-ethanol, biodiesel, hydrogen and electricity are gaining their share, although most of them are rather revitalized, than invented. For example, CNG has been used in Italy since 1930s; the first commercially available Flex-Fuel Vehicle (FFV), capable of using gasoline and bio-ethanol was Ford's Model T in 1908; the first Hybrid Electric Vehicle (HEV) was built in 1900 by Ferdinand Porsche; electric cars used to dominate the vehicle market at the end of the XIXth century; and the very first operational Internal Combustion Engine (ICE) in history was running on hydrogen more than two centuries ago. (Tkatchenko, 2009)

All solutions can have different advantages under different circumstances. For example, here is the conclusion of a study aimed to identify options of fuels and propulsion technologies, applicable to bus transit in the state of Rio de Janeiro and which present a potential reduction in CO₂ emissions in the short term: "The use of CNG dedicated buses and diesel-gas systems best suits in regions where natural gas is available at a competitive price with diesel. The same thing occurs for the use of ethanol in buses. The use of hybrid-drive buses best suits at congested large city urban transit. The other fuel options (biodiesel and diesel from sugarcane) can be used across the country without problems if the alternative fuel's price cope diesel price." (D'Agosto, Ribeiro, & de Souza, 2013)

A bold approach to the solution - a portfolio of fuels! Beside the appealing tailor-made attitude this way of thinking shall give decision makers a chance to avoid erroneous trends on a large scale and to resist the pressure of the lobbies (see later).

Another promising alternative fuel, though less known to the general public, is Dimethyl ether (DME), which can be produced from coal, natural gas or other organic resources. "The use of DME as a diesel fuel has been expanded as the most promising alternative for gas oil, because it gives little particulate material under any operation conditions." (Adachi, Komoto, Watanabe, Ohno, & Fujimoto, 2000)

"The life-cycle CO₂ emissions from production and use of fuels made by indirect coal liquefaction (ICL) would be lower than with production and use of petroleum-derived transportation fuels." (Larson & Tingjin, 2003). Which means, when liquid fossil fuels become scarce and/or too expensive, coal will come into fashion again. As it is now in China, whose dependency on oil and whose abundant coal supplies make the CTL (coal-to-liquids) technology increasingly popular.

Similarly to the other alternative fuels, the idea to produce liquid fuel from coal is not new. Richard Vietor (Vietor, Richard H. K., 1980) based on (Krammer, 1978) and (Hughes, 1969) points out that due to its encouraging governmental policy "by 1942 Germany was synthesizing about half of its gasoline, diesel oil, and aviation fuel from coal". In his highly educational work: "The synthetic liquid fuels program: energy politics in the Truman era" Vietor shows, how a similar option was seriously discussed in the US in the 1950s', but the oil lobby forced the idea out in order to protect its own interests. As Representative Carl Perkins (D-Kentucky) put it before the closing of the debates: "We have a process

that has been proved successful and has reached the point of being commercially competitive with crude oil. Yet, because of that fact, we want to destroy that process in favor of the oil lobby.” (Vietor, Richard H. K., 1980)

It seems that the oil business has always been very successful as a powerful lobby, and as a great survivor too. With the emerging of electric lightbulbs as a replacement for kerosene lamps the oil industry desperately needed a new customer base: “Rockefeller’s company, Standard Oil, transformed its eventual loss of the kerosene market in the illumination business into an even more lucrative commerce, initially with locomotive engines and then with the automobile. In the United States of America (USA), internal combustion engines powered only 22% of the cars sold in 1900: 38% were electric and 40% were powered by steam engines. The situation changed rapidly: by 1905 gasoline-powered automobiles had defeated their competitors. The number of car registrations in the USA grew from 8,000 in 1900 to 902,000 in 1912. Considering that gasoline engines powered the vast majority of these cars, by any standard it represented a remarkable success for ICE technology.” (Sovacool & Hirsh, Beyond batteries: An examination of the benefits and barriers to plug-in hybrid electric vehicles (PHEVs) and a vehicle-to-grid (V2G) transition, 2009)

And, of course, for the oil industry. The mutual dependency of ICE and oil strengthened over the decades. “The discovery of lead for the automotive fuels in the 1920’s, by Thomas Midgley (from GM) and by Harry Ricardo (sponsored by the Asiatic Petroleum Company) occurred independently of each other... The tetra-ethyl lead was a knock-suppressant, which reinforced even further the optimization of fuel quality and the functioning of the internal combustion engine. This knocking of

the engine should be avoided since it meant loss of power, overheating and damage to the pistons and it’s associated parts. This discovery illustrates that the two communities (automobile and oil) converged through the finding of a similar solution – the discovery of lead – by two completely different approaches.” (Taminiau, 2006)

But with the resolution of the “knocking” problem almost instantaneously a “health” problem appeared.

According to Jerome Nriagu the first gallon of leaded gasoline was sold on 2 February 1923 to a motorist in Dayton, Ohio, and the extreme surge in the popularity of this type of fuel very soon brought an outbreak of severe lead poisoning, prompting the United States Public Health Service to halt the production in May 1925 and initiate an investigation.

“An intensive industrial lobby was mounted which effectively forestalled any government regulation on lead in gasoline... Thus, the threat of gasoline lead to public health remained essentially neglected and unappreciated for well over 30 years... As to be expected, the fight to censure a highly profitable product with multinational oil and automobile industries as key players was particularly acrimonious, but ultimately the concern for the risk to public health has outweighed any economic benefits.” (Nriagu, 1990)

We shall take into consideration that in addition to endangering humans lead is damaging the catalyst converters as well. “The irony is that it was not the issue of health but the issue of air pollution that forced the ban of lead in fuels. Scientists did find irrefutable evidence that lead had damaging effects on the proper functioning of the catalytic converter, which became mandatory (with the Clean Air Act which was passed in 1970) to improve the air quality in California.” (Taminiau, 2006)

In a way, this is another proof of how important it is to pursue environmental issues on a broad scale. Introducing general standards on emissions led to the introduction of catalytic converters, which made leaded fuel unwanted by the car manufacturers, increased pressure on the oil industry and finally phased out leaded fuel. That same leaded fuel, which had been successfully safeguarded from “direct” attacks for long decades since early 1920s.

Likewise, the issue of reducing vehicles emissions shall be approached from several directions.

The most prevalent, and, probably, most effective approach so far has been the vehicle efficiency improvement, quite often expressed in reducing fuel consumption of the traditional internal combustion engines (ICE). The statement is based on the observation that, “The potential of conventional ICE vehicles is still substantial as they will continue to offer high cost-effectiveness and driving performance which can be hardly matched by alternative technologies.” (Ntziachristos & Dilara, 2012). The high cost of developing the alternative vehicle technology, its often non-existing infrastructure, and conservatively cautious consumer behaviour give the traditional ICE technology a substantial advantage indeed, which makes carmakers to continue investing in the improvement of the powertrain based on the conventional combustion engines. Here efficiency improvement can be achieved by the manufacturers through technological development like variable valve timing (VVT), automatic cylinder deactivation, idle start/stop, smart transmission, low-resistance tire technology, reduced weight through lighter materials, reduced drag coefficient through improved aerodynamics, smaller vehicles, better air-conditioning equipment, application of monitoring systems for assuring optimal technical conditions (e.g. tire pressure monitoring) and of

systems influencing driving habits (gear shifting reminders, economy evaluation gauges, etc.).

The latter closely relates to the use of technology to deliberately shape individual behaviour, thus trying to shift it towards environmentally responsible conduct. In this regard we can certainly add on-line navigational aids as systems influencing driving habits. Similarly, in his earlier mentioned work professor Michelberger shortly but clearly articulates that the “biggest reserve” for reducing fuel consumption lies in the “better management of vehicle traffic”. (Michelberger, 1986) A great observation! In other words, it is not the vehicles, but rather the humans that have to be improved. “Eco-driving campaigns aim to inform and educate drivers in order to induce them to drive in a fuel-efficient and thus environmentally friendly way. There seems to be some consensus in the literature that eco-driving could lead to reductions in CO2 emissions of around 10 per cent.” (Santos, Behrendt, & Teytelboym, 2010)

Apart from the natural urge to improve and the desire to meet public demand for green machinery, the greatest incentive to invest into new technology development is coming from national governments, when they decide to introduce fuel efficiency standards: “First, there seems to be sufficient evidence that if there were no FE [fuel economy] standards or targets in force, new-car fuel economy would not have improved at the rates that have been observed in Europe and Japan in recent years, and this would most probably have happened in the US as well; as a result, transportation energy use would have increased more rapidly. Second, in order to attain the desired FE improvements without imposing any further standards or voluntary targets in Europe, fuel taxes would have to increase by 50%. Third, without higher fuel prices and/or tighter FE standards, one should not expect

Natural gas production

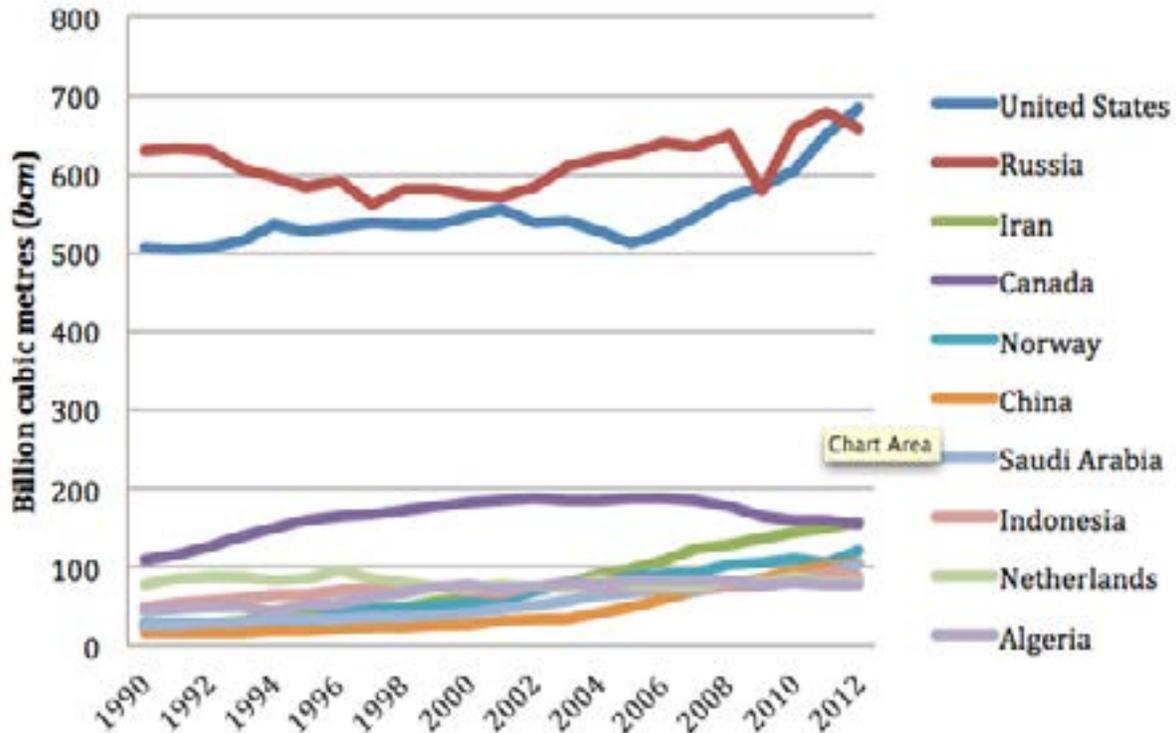


Figure 5 Natural gas production (Global Energy Statistical Yearbook 2013)

any marked improvements in fuel economy under ‘business as usual’ conditions. Potential fuel savings due to autonomous technical progress in the past have been counterbalanced by changes in consumer preferences towards more comfortable and powerful cars, and there is no reason to believe why this trend should not continue in the future in the absence of impressive technological breakthroughs or an economic recession.” (Zachariadis & Clerides, 2008) Indeed, consumer behaviour is not always based on long-term scientific wisdom, and as such shall be guided by proper governmental policies. In addition to the above conclusion, the authors address the issue of country specifics: “Our analysis shows that the question “standards or prices?” cannot be answered in a definite way for all world

regions. In the US tighter FE standards and higher gasoline taxes need to be carefully examined against their welfare impact, and a combination of both policy options should not be excluded in view of the many uncertainties about the effectiveness and the side-effects of each measure. Conversely, regulations seem to be a more feasible option for Europe and Japan as it is hardly possible to increase fuel taxes because of their already high levels; how these regulatory measures will be designed and implemented, however, is crucial in order to avoid welfare losses for producers or consumers.” (Zachariadis & Clerides, 2008)

If we wish to summarize the trends in the efforts of volume orientated carmakers, we can state that all

of them want to develop vehicles that would have a secure supply of fuel in the foreseeable future. At the beginning of the 21st century the prospectives of the renewable fuels were increasingly very highly evaluated, until the shale gas came into sight. “Shale gas rose from less than 1% of domestic gas production in the United States in 2000 to over 20% by 2010.” (Stevens, 2012) The increase in total US resources due to inclusion of shale gas was estimated to be 38%! (U.S. Department of Energy, 2013) In 2012 shale gas accounted for 39% of all natural gas produced in the United States. (The U.S. Energy Information Administration, 2013) This also made USA the largest producer of gas in the world (Figure 5).

Furthermore, shale gas “has had a dramatic impact on US carbon emissions. Whereas the Europeans have been increasing the coal burn (and building new coal-fired power stations) the US has been switching from coal to gas in electricity generation. The result is that, contrary to Europe, and despite European’s economic crisis, it is the US not Europe which has sharply falling carbon emissions. Without much by way of energy or climate policies, the US is on course to meet its emissions reductions targets. Emissions in the major European countries (Germany in particular) are now rising.” (Helm, 2013) In the USA shale gas has brought forward distinct benefits like the above mentioned emissions reductions, like production boost and additional jobs. What is less conspicuous though, is the environmental threat in its many forms.

First comes the direct risk of the fracking technology itself, using huge quantities of water for pumping it underground, and thus creating waste water, which may contain potentially hazardous chemicals, causing groundwater contamination, and even triggering small earthquakes.

Second is the indirect negative impact generated by the appearance of the suddenly plentiful low cost gas. This reduces demand for carbon-free renewable energy sources, which makes them more expensive and further reduces demand, stalling environmental efforts. That is another reason to stress, that technology is not always pushing progress into the right direction.

When investigating the environmentally friendly effect of the technological improvement of vehicles I would group the different approaches as follows:

1. Improving fuel efficiency and user-friendliness of the common types of powertrains based on ICE - e.g. gasoline, diesel.
 - Over time this model leads to considerable efficiency improvement, but being based on fossil fuels it has never been the right solution.
2. Changing the fuel used in ICE - e.g. ethanol, CNG, LNG.
 - This model can only be considered a better solution, than the previous one, if the fuel is renewable - such as bioethanol, biodiesel and biogas. However, there are serious concerns, that an uncontrolled demand for biofuel and its ensuing mass production may have grave impact on world ecosystems.
3. Introducing hybrid systems - ICE powertrain together with electric engine.
 - In light of the previous two models the hybrids are only a dead-end street on the route to sustainable mobility. This transient model nevertheless has shown

its indisputable values through raising environmental awareness, accustoming consumers to electric drives and somewhat decreasing the current carbon footprint.

4. Building Electric Vehicles (EV) - either Battery Electric Vehicles (BEV) or Fuel Cell Electric Vehicles (FCEV) using hydrogen or ethanol to produce their own electricity.
- The electric powertrain, when using green sources of energy, can definitely become the most promising sustainable solution of the future mobility. But the massive growth of world population in the developing countries and their increasing appetite for mobility need to be closely monitored. What will happen, if the Indian consumers reach the same level of car ownership as in Hungary?

GROWING MOBILITY AND ITS LIMITS

Using your own personal car has its clear benefits - independence (freedom of movement), convenience, feeling of security within your own vehicle, non-intrusion on your personal space. At the same time, using your own personal car for transportation is apparently far from efficient, which has numerous negative side effects. Probably the main flaw of this mobility model is that most of the time a privately owned car is being parked, and when it is finally used, in the majority of cases it is used by one single person.

In 2009 in the United Kingdom there were 460 passenger cars per 1,000 people, as compared to 439 in the USA, 301 in Hungary, 35 in China and only 12(!) in India. (The World Bank, 2014). Here passenger cars refer to road motor vehicles, other than two-wheelers, intended for the carriage of passengers and designed to seat no more than nine

people, including the driver. For the year 2010 the source had no available data for India, but the UK, the USA and Hungary figures were 457 cars per 1,000 people (-0.76% compared to 2009 data), 423 (-3.64%), and 298 (-0.76%), respectively, while in China the indicator grew by 27.06% to reach 44 passenger cars per 1,000 people.

The figures were duly noticed by the automotive industry, causing Indian carmaker Tata's General Manager to openly state, "There exists a huge potential and India is viewed as a lucrative market by many" (Slym, 2013) The business case is really obvious, but let us look at this potential from another perspective.

The population of India from 1,171 million in 2009 - and 1,252 million in 2013 - is expected to grow further and by 2025 to reach 1,459 million people (Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, 2011). If the number of passenger cars per 1000 Indian people stays the same, there will be additional 3.46 million passenger cars in India. If we would imagine India to achieve the level of 44 passenger cars per 1,000 people as in China in 2010, then the number of additional cars would be over 50.14 million. Should India achieve the level of 298 passenger cars per 1,000 people as in Hungary in 2010, then the vehicle surplus would be 420.7 million. Just to park all these vehicles we would need 10,939 square km of open parking area, equal to 20.83 times the area of the city of Budapest. (Calculations based on (Chrest, Smith, Bhuyan, Monahan, & Iqbal, 2001))

Perhaps this area would be used for better purposes than parking, if the mobility of the population could be ensured by public transport.

According to (Dargay & Hanley, The demand for local bus services in England., 2002) and (Bresson,

Dargay, Madre, & Pirotte, 2004), there is a negative relationship between the number of bus trips and income level, and a positive relationship between income and car use (cited by (Souche, 2010)). While investigating the structural determinants of urban travel demand, I would rather support the findings on the positive relationship between income and car use, showing that higher income - in countries with public transport - shifts the preferences of the individual towards car travel, as opposed to using the less expensive and presumably more environmentally friendly public buses.

“To reach CO₂ and other sustainability targets shifts in travel patterns and reduction in growth will be needed in both the OECD and non-OECD, in parallel that social and economic conditions, particularly in non-OECD, are progressively improved... In non-OECD countries it will require major investments in public transit systems, better maintenance of roads with retrofits to increase access and safety for non-motorized modes, and better land-use planning. It will require that informal transport services, which service urban poor in inaccessible areas at affordable prices, are recast and maintained as mobility resources linked to accountable incentives for social entrepreneurship in transport. Cost effective, high capacity, energy efficient, rapid, affordable and integrated bus systems, and other PT services that accommodate the surging passenger demand. It will require that subsidies for fuels and new private motor vehicles are reduced, with financial incentives toward the most sustainable vehicles and modes of transport.” (Figueroa, Fulton, & Tiwari, 2013)

Which leads to the issue of modern vehicles and their level of sustainability.

Another viewpoint is presented by Orsato and Wells, depicting the average car used by most of the consumers: “Basically, these cars can carry one to

five passengers, reach speeds of more than 160 km/h (although the legal limit is 110 km/h and the average traffic speed is approximately 70 km/h), and have sufficient fuel capacity for approximately 400 km. Cars therefore, embody a high degree of redundancy in design, a feature that carries efficiency and environmental costs. Most trips do not demand such performance but the vast majority of cars currently available in the market present these characteristics. The average drive in cities - the place where most cars spend the largest part of their time - requires less than 20% of such performance capacity, and the average occupancy (1.2 people per car) is also much lower than the capacity of these cars to comfortably accommodate five people. For the vehicle manufacturers, high volumes of sales (and therefore production) are more likely to be assured by general-purpose designs that approximate to several user needs; in other words, market offerings of this type are a form of risk reduction. One could question the reasons for consumers to keep buying over-dimensioned and over-specified cars.” (Orsato & Wells, 2007)

Although European speed limits may be higher - from 140 km/h in Bulgaria and Poland, through 150 km/h in Italy, 160km/h in Austria, up to the no-limit highways of Germany, the authors have a very strong point. The cars we use are oversized and overpowered, but most people prefer to have “more”, than “less” - just in case the need may arise! An exaggerated example is when a car is maintained by the private individual for the same “just in case” reason, although it is rarely used at all, or out of prestige considerations only, e.g. when the person actually has another - company - car as well for everyday use (with presumed zero cost for the user, as it is absorbed by the employer).

“Strategies for ‘sustainable mobility’ adopted by planners now often include – in addition

to the promotion of non-motorized and public transportation and efficiency improvements – measures to reduce the sheer need to move.” (Frändberg & Vilhelmson, 2011)

“Many quite small European cities such as Graz (Austria) and Freiburg (Germany) have very high rates of green mode usage because they are dense and planned around these non-auto modes. Conversely, virtually all US cities of similar population size are mostly totally automobile dependent because they have almost no public transport systems and are too low density and spread out for walking and cycling to be viable modes.” (Klinger, Kenworthy, & Lanzendorf, 2013)

Here we see a clear message, that municipalities have a major influence on human mobility trends. If the city is planned to be “non-auto”, then green-thinking citizens will be happy not to use their cars, while less green-thinking administration will force upon consumers a strong reason to rethink their habits.

“Despite the growing global motorization, bike-sharing systems’ demand, as a sustainable alternative transport mode, is continuously increasing. Such systems combine the advantages of bike usage, such as low cost, autonomy, flexibility, accessibility and health benefits, with the advantages of renting (as opposed to owning). Significant experience has already been gained regarding security, insurance and liability concerns, bicycle redistribution, applications of information technology systems, planning, management and pre-launch considerations.” (Efthymiou, Antoniou, & Waddell, 2013)

In 2008 David Banister suggested that, “Broad coalitions should be formed to include specialists,

researchers, academics, practitioners, policy makers and activists in the related areas of transport, land use, urban affairs, environment, public health, ecology, engineering, green modes and public transport. It is only when such coalitions form that a real debate about sustainable mobility can take place.” (Banister, *The sustainable mobility paradigm*, 2008) Three years later he admitted that, “At present the scale and nature of the changes necessary in the transport sector to address climate change have not been seriously debated. Pricing for the external costs of transport would help, as would regulations on emissions and heavy investment in clean technology. But even here, the price rises necessary to create real change are not politically acceptable, as both industry and the electorate are powerful pro car lobbies.” (Banister, *Cities, mobility and climate change*, 2011) Despite this somewhat pessimistic note of the author, his earlier cited suggestion for a broad coalition is very much in line with my idea of how important it is to pursue environmental issues on a broad scale.

Due to the rebound effect efficiency gains often lead to higher demand and higher consumption. “Can we afford cost-saving energy efficiency? The answer is ‘yes’ only if efficiency gains are taxed away or otherwise removed from further economic circulation. Preferably they should be captured for reinvestment in natural capital rehabilitation.” (Wackemagel & Rees, 1997) The idea is worth investigating. The gains in efficiency and/or growing income often make consumers say to themselves, “Now we can afford to drive more”... Unless, of course, they decide not to drive any more than they do already, even if they can afford it. The reason “not to drive more” could be either physical - if the consumer has reached the saturation level of his demand for daily travel, or psychological - he can substitute this daily travel with something better, without reducing his productivity or quality of life.

“If one accepts that social and cultural forces play an important role in transportation decisions, then the public needs better information about the consequences of their driving. This information can take two forms: improved vehicle instrumentation and increased public awareness. Rather than merely listing current fuel economy for vehicles in miles or kilometers per gallon, for example, instruments in vehicles could display how fuel economy is affected by driving patterns and suggest ways of improvement. Such real-time feedback could enhance driving performance, especially if it also includes retrospective information after a trip is completed” (Sovacool, Early modes of transport in the United States: Lessons for modern energy policymakers, 2009)

This is already a reality. Even more so, modern telematics allow us to collect and store real-time data about almost everything in the vehicle, so if we take our travel needs as constant, and decide to reduce fuel consumption, we can start doing so by eliminating engine idling, speeding and harsh driving - the latter including not only braking and acceleration, but cornering as well. Those companies, who have big fleets and, consequently, high fuel costs, can greatly benefit from a monitoring system and a properly introduced management approach. For example, according to Masternaut, a UK-based provider of telematics solutions which operates in 32 countries, as a result of greater “vehicle utilisation visibility” and the subsequent rectification of their drivers’ driving styles, their clients achieve up to 70% daily reduction in vehicle idling and considerable savings in fuel cost (Masternaut, 2013).

This approach can lead to responsible driving, and it has been called to life by simple business prudence. Insurance companies have also discovered the wisdom of telematics from their own point of view: “Telematics insurance uses data that describes

how, when and where a vehicle is actually driven to calculate the risk presented by the driver. The data is collected by an electronic device fitted to the vehicle and is transmitted to the insurer via a telecommunications network.” (Asquith, Mills, & Forder, 2012) In the same paper the authors cite data by (Quality Planning report in National Underwriter Online News Service, 2010) according to which in the UK “Norwich Union reported a 30 percent accident frequency reduction in its pilot in the consumer market and Pepsi reduced its fleet crash rates by 80 percent”. Another advantage of the telematics insurance is that it helps to reduce fraud, and as such has the full support of the UK government. Evidently, environmental concerns may not be on the top of the insurers’ priorities list, but - again - this is another proof of how important it is to pursue environmental issues on a broad scale. Particularly when, “Recent market research suggests that there is also a consumer appetite for telematics insurance. According to research conducted in 2012 by Gocompare.com, 57 percent of all UK drivers expect to switch to a telematics-based car insurance policy by 2017.” (Asquith, Mills, & Forder, 2012)

In broader terms, “The opportunity is now ripe to capitalize on society’s naturally elevated motivation to change (given recent and predicted energy price increases).” (Dowd & Hobman, 2013)

Consumers are becoming increasingly aware of the environmental necessity to stop energy waste, and all policies shall take that into consideration.

“Information has to be taken to the customer, rather than assuming that they will find it themselves. Individualised marketing is a good example of this dialogue-based technique for promoting the use of public transport, cycling and walking as alternatives to the car. It has been developed and applied in several European and Australian cities with positive

outcomes (reductions in car use of around 10%), and more importantly, it seems that changes in travel behaviour are maintained over time.” (Banister, The sustainable mobility paradigm, 2008)

What will happen, if the government decides to replace the existing car purchase tax and the annual road taxes by kilometre-based charging differentiated by location, time of day and environmental performance of the vehicle? The results of a study conducted in the Netherlands show that even if the new charging scheme will be cost neutral for the average car driver, “abolishing the Dutch car purchase tax while at the same time introducing a kilometre charge will lead to 2.2% rise in car ownership”. (de Jong, Kouwenhoven, Geurs, Bucci, & Tuinenga, 2009) If the purchase tax is high, then customers decide to buy a vehicle only if their expected mileage justifies this investment, but if the “entry cost” to the vehicle ownership drops, many citizens may ignore the longer term costs and choose the “joy of possession”. Although in the longer run customer attitude may change, this is a warning to policy makers. After the consumers are provoked to become car-owners, even a reversed policy will have difficulties to remedy the situation. This threat shall be taken seriously: “The acquisition of a car is seen as a luxury, but once acquired the car becomes a necessity, so that disposing of a car is much more difficult. Car ownership is clearly associated with habit and resistance to change. Once the habit of motoring is acquired, it is not so easy to abandon, even if the economic consequences - in terms of alternative consumption foregone - are greater than previously.” (Dargay, The effect of income on car ownership: evidence of asymmetry, 2001)

While examining the urban transport in Latin America, Hidalgo and Huizenga provide an interesting observation, that “with the notable exception of Brazilian cities and Santiago, public

transport is dominated by small private operators, using medium size vans (combis) or minibuses under dispersed ownership (one vehicle - one owner). These operators compete for passengers in the street (competition in the market), under informal economic rules. This causes severe negative externalities: congestion, pollution, and accidents.” (Hidalgo & Huizenga, 2013) The phenomenon is not exclusive to Latin America. The ‘one vehicle - one owner’ model is also quite common for taxi drivers in the city of Budapest. One of the reasons to stick to this model is that a privately owned taxi car gives the taxi driver the opportunity to work extremely extended shifts - up to 12 or more hours a day. When their income depends on daily revenues, they are easily tempted to prolong the working hours.

This is somehow an exaggerated model of multi-player inefficiency, the opposite of a centrally organized public transport company with employed drivers. The advantages of the latter model are quite obvious. But if we compare it to a taxi example, we can see a thought-provoking similarity of relationship between the following business models:

- “One taxi - one driver”, where the driver owns or rents the vehicle.
- “One taxi - many drivers”, where the vehicle is driven in shifts by different employees.

In the first case the vehicle is under-utilized, even if the driver is tempted to work overtime; the average maintenance and other costs are much higher, etc. Still, this model apparently does not attract any attention from the municipalities, which leads to taxi oversupply, overpricing and operational inefficiency. Perhaps, taxis shall be integrated into the public transport system? Back in 1996 Richard Arnott gave his article the following straightforward title: “Taxi Travel Should Be Subsidized”. Following a thorough mathematical analysis his conclusion

makes a serious point: “Taxi service provides many of the advantages of the automobile - flexibility, privacy, and convenience - without significant capital costs. Providing taxi travel at its shadow price might therefore contribute significantly to solving the urban transportation problem.” (Arnott, 1996)

If we shall design the most efficient Budapest taxi company ever, perhaps the guidelines shall be as follows:

- Optimal choice of vehicles (to reduce pollution, decrease redundancies and improve cost efficiency)
 - a. The taxi cars shall have the most efficient engines made especially for the city. E.g. electric engines with enough driving range for one working shift and/or replaceable batteries to ensure continuous operation of the vehicles.
 - b. They shall not need to reach speeds of more than 75km/h, as the maximum legal speed within the city limits is 70km/h anyway.
- Optimized operation management (to reduce overspending and improve the return on investment)
 - c. The financing, purchasing and servicing/maintenance processes shall be subject to public tenders and made transparent in order to minimize their costs.
 - d. All vehicles shall be operated on a constant driver-rotation basis by multiple drivers.
 - e. The city taxi company shall work as a non-profit organization, reinvesting its operational profit into its own fleet and systems.

The city municipality shall strongly consider incorporating taxi services into its public transportation system.

A taxi service from a company like that shall offer personal mobility on demand, complementing the public transport on a higher individual level and making private car ownership unnecessary for a growing part of the city dwellers. For those, who may occasionally need to travel longer distances, a scheme of rent-a-car service could be designed on similar public efficiency principle. For those, who would stick to their own cars, the growing costs of parking or the alternative creation of no-parking city areas will lead to decreased use of their own cars within city limits, making it a weekend car or recreational vehicle. This shall make the city a better place to live, eliminating traffic jams and pollution, and reducing the number of cars being parked everywhere. The increased use of city taxi with highly professional employed drivers can also contribute to better road safety - decrease of traffic accidents and injuries.

Carpooling (also known as car-sharing, ride-sharing, lift-sharing and covoiturage) is another way of reducing car ownership and improving the efficiency of use. Different definitions are available, but the basic meaning is either travelling together (sharing a trip in one car instead of using two or more cars - a model present in every prudent family) or sharing a car (using it in turns, instead of using their own cars in parallel).

“Carpooling is one of the many travel alternatives promoted by transport policies to reduce the amount of vehicles on the road. It was promoted during World War II to deal with oil and rubber shortages and during the oil crisis of the 1970s. More recently, carpooling was also advocated during the 2008

Olympics in Beijing as a response to driving restrictions. Nowadays, carpooling is promoted by mobility management policies to put more emphasis on the issue of sustainable transport.” (Vanoutrive, et al., 2012)

“While carsharing services have been around for over two decades, the industry has recently gained momentum, as several large car manufacturers entered the market, indicating that carsharing has moved into a period of commercial mainstreaming.” (Schaefer, 2013)

“Urban carsharing services allow individuals to gain the benefits of private vehicle use without the costs and responsibilities of vehicle ownership.” (Costain, Ardron, & Habib, 2012) Here the emphasis is on cost efficiency and reduced burden. Similar opinion on car-sharing is expressed by Efthymiou et al., but from a slightly different perspective: “Unstable fuel prices and increasing maintenance costs, as well as the insurance and purchase cost of a car, make car ownership a luxury that not many people can afford. Under these circumstances, car-sharing attracts more and more people. Users can enjoy the privacy of any type of car (e.g. compact car, SUV, van, and luxury) depending on their current needs, without the need and commitment of a purchase.” (Efthymiou, Antoniou, & Waddell, 2013)

The difference is that the latter approach emphasizes improved standard of living for those, who would not be able to afford owning a vehicle. If we examine this situation together with the case of “oversized and overpowered” vehicles, mentioned earlier, we can naturally reach the conclusion, that car-sharing schemes are bridging together different consumer segments, allowing to improve the efficiency of car use, reduce redundancy, and provide cost efficient transport solutions with simultaneous reduction of car ownership. This reduction is confirmed by

(Millard-Ball, Murray, & ter Schure, 2006), as well as by Martin et al.:

“Evidence from this North American carsharing member survey demonstrates that carsharing facilitates a substantial reduction in household vehicle holdings, despite the fact that 60% of all households joining carsharing are carless. Households joining carsharing held an average 0.47 vehicles per household. Yet the vehicle holding population exhibited a dramatic shift towards a carless lifestyle. Based on assumptions with respect to the active member population, it is estimated that carsharing has removed between 90,000 to 130,000 vehicles from the road (9 to 13 vehicles per carsharing vehicle, including shed and postponed car purchases) in North America to date. The vehicles shed are often older, and the carsharing fleet average is 10 mpg more efficient than the fuel economy of vehicles shed.” (Martin, Shaheen, & Lidicker, 2010)

As cited by (Efthymiou, Antoniou, & Waddell, 2013), (Rodier & Shaheen, 2003) states that carsharing policies lead to the reduction of Vehicle Miles/Kilometers Traveled (VMT/VKT) and the GHG. In North America the reduction is 44% per car-sharing user (Shaheen, Cohen, & Chung). According to (Lane, 2005) car-sharing participants report increased environmental awareness after joining the program. Finally, households can save more money for their development (Ciari, Balmer, & Axhausen, 2009)

“As of May 2012, there were 33 personal vehicle sharing operators worldwide, with 10 active or in pilot phase, three planned, and four defunct in North America. Personal vehicle sharing could provide a model that overcomes some of the financial constraints and geographic limitations of fleet ownership and distribution, as in traditional carsharing. Interestingly, all personal vehicle sharing

and traditional carsharing experts interviewed in this study agreed that personal vehicle sharing holds the potential to notably expand the shared-use vehicle market.” (Shaheen, Mallery, & Kingsley, 2012)

This efficiency of use is closely connected to the public transport network:

“It needs to be emphasised that any car-sharing system should be developed complementarily to public transportation, as only integrated mobility systems satisfy the variety of individual transportation needs, which is a necessary condition for a large-scale reduction of private vehicle usage.” (Firnkorner & Müller, 2011) “In order to meet urban mobility needs, a sustainable urban mobility concept must be multi-modal, integrating different modes of public transport, private cars, and walking and cycling.” (Santos, Behrendt, & Teytelboym, 2010)

In some cases the efforts can cause negative effect: “A noteworthy piece of Australian evidence is that the new parking lots at Sydney suburban stations are tending to attract individuals who already use the rail system, but who now drive and park rather than use the local bus service to and from the station.” (Hensher, 2007)

The idea of trip-sharing is not as fully supported as it might be expected, and can become a source of controversy. In 2012 it drew the close attention of the Hungarian tax authorities, which prompted an interpellation by Endre Spaller, a member of the Hungarian Parliament. State Secretary Zoltán Cséfalvay in his answer called it a ticklish question - on the one hand the carsharing effort shall be supported for environmental and efficiency reasons, but on the other hand those who engage in it on a regular basis might be charged with tax evasion. (Demokrata, 2012) A clear confession, that the obsession with additional revenues by

the governmental bodies can threaten this great environmental initiative.

As mentioned previously, reducing excessive weight in the vehicle can become another source of fuel saving: “Every kilo of luggage costs you fuel. To be precise: a weight of 100 kg can increase fuel consumption by up to 0.3 l/100 km. So inspect the contents of your luggage compartment on a regular basis. With today’s network of filling stations there is no point in keeping a full fuel canister in the car. And nobody needs more than one road atlas. And the bag with the golf clubs doesn’t have to be carted around all year – neither does the picnic basket in winter or the can of antifreeze in summer.” (Volkswagen AG, 2010) Certainly, scientific research in fuel consumption can sometimes find hidden reserves for improving vehicle efficiency rates in quite unexpected areas, like the human bodies: “As many as one billion gallons or more of fuel consumed in the US each year can be attributed to excess weight in the US population.” (Jacobson & King, 2009)

CONCLUSION.

The mass production of the automobiles made mobility so affordable, that we have reached a point, where most people in the developed countries (and not only there) cannot imagine a day without driving. The evolution of the automobile, finely influenced by the subtle power of the oil lobby, together with the stable growth of living standards lead to our present addiction to vehicles using fossil fuels. This addiction is so serious, that apart from threatening human health it is steadily depleting the energy reserves of the planet. Some of the lessons we should be able to learn from our predecessors: Technology is not always pushing progress into the right direction.

To make human development sustainable, we shall pursue environmental issues on a broad scale.

If we want to achieve sustainable personal mobility, it is not the vehicles, but rather the humans that have to be improved.

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