Summary of Felix Bremicker's master thesis:

"Worldwide transport, CO_2-emissions and climate change"

In order to stop or to slow down the climate change, the importance of the worldwide transport must be taken into account. This thesis is focused on its development during the next 20 years, e.g. the period 2010-2030. Both the developed countries (OECD*-countries) as well as the developing and transition countries (non-OECD-countries), especially however the BRIC-countries Brazil, Russia, India and China, expect important changes due to projected high economic growth in the near future. This will also have a great impact on the world wide transport development.

According to the *World Oil Outlook* (WOO 2010) following the UN world population medium forecast, the world population in 2009 was 6, 840 million people. This number can be subdivided into 5,297 million inhabitants in Non-OECD-countries and 1,543 million inhabitants in OECD-countries, resulting in a population ratio of 3.43/1. In 2030 the world population will, according to WOO-2010, increase to 8,332 billion people with a shifted ratio 4.14/1 towards the Non-OECD-countries (6.711 mil.).

* OECD, Organization for Economic Cooperation and Development
OECD Pacific: Australia, Japan, Korea and New Zealand
OECD North America: Canada, Mexico and the United States

OECD Europe: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey and the United Kingdom

The world vehicle fleet of the year 2009 has an estimated number of 1.003 billion vehicles, among which passenger cars possess an 823 million contingent. Utility vehicles have a corresponding 180 million contingent of the entire world vehicle fleet. Today non-OECD-countries hold 323 million vehicles and OECD-countries 680 million units. Further, the world car production manufactured 70.8 million vehicles (e.g. 59.1 passenger cars and 11.7 million utility vehicles) in 2008; in the following depression year of 2009, however, this number was

decreased to 62 million vehicles. Germany for a long time had been a leader in car production, together with the United States of America and Japan. Today, Germany is merely in the number 4 position after China, Japan and the USA. German car producers built 12 million vehicles in 2008 and 10.4 million vehicles in 2009, among which almost 50% were built outside the German borders (see also: VDA). German car companies like Daimler, BMW, Volkswagen and Audi hold a strong position in the premium car sector due to their prestige, comfort and engine power, but until today their efforts in hybrid and electric vehicles are rather limited. Technical innovations are currently solely serving the improvement of luxurious décor or engine power. In order to reduce emissions, reducing vehicle weight would be adequate; however, air conditioning, innovative entertainment systems and new electrical assistance take up additional space and thus increase weight and also the demand for energy. Despite these tendencies, it is crucial to make the world rethink on this behalf: In order to avoid a climate collapse, the range of car types must change from fuel-wasting limousines to modern energy saving cars like hybrids and electric vehicles with range-extender.

Experts estimate that the worldwide car fleet will increase in the next twenty years from 1.03 billion today to 1.84 billion (WOO 2010 OPEC) up to 2.08 billion (Dargay et al.) by the year 2030. If all these cars will still be fueled by fossil fuels this would be counterproductive for a possible transport revolution.

Calculations by the IEA result in a yearly vehicle emission of 9.2 Gt CO_2 in their reference scenario for the year 2030. This already includes technical innovations. It equals 23% of the total emissions of 40.2 Gt CO_2. In their ecological scenario which strives for a maximum limit of 450 ppm CO_2eq at the end of this century, the transport related emissions are reduced to 7.65 Gt CO_2. According to this scenario, transport related emissions make up 29% of the global emissions of 26.4 Gt CO_2. The American Energy Information Agency EIA is limiting their emissions estimates to 7.1 Gt CO_2 in order not to threaten the 450 ppm goal (cf. IEA: *World Energy Outlook 2009*)

The QUANTIFY-study of the EU uses the scenarios from the *Second Report on Emission Scenarios* SRES (A1F, A1B, A1T, B1, A2 und B2). The CO_2-emissions of the total transport sector vary with scenario between 12.8 Gt CO_2 (A1B-scenario) and 8.9 Gt CO_2 (B1). The road transport still has the major part with a range from 9.8 Gt (A1B) to 6.8 Gt (B1). According to

the A1B scenario each of the one billion vehicles emits today on the average 5.5 tons of CO_2 every year.

When the fleet increases to two billion units in 2030 in the A1B-scenario with a total amount of 9.8 billion tons of CO_2 emission, each vehicle emits 4.9 tons of CO_2; this is an enhancement in efficiency in twenty years of 11%. The ecological scenario B1 claims a total emission of 6.8 billion tons of CO_2, which equals an average emission of 3.4 tons of CO_2 per vehicle.

The focus of this thesis is on the road transport, predominately dealing with private transport as well as transport facilities of utility vehicles which are handling both goods and passengers. An additional analysis of other transport sectors compares road transport to rail transport, the inland navigation, shipping transport, pipeline transport and aviation. The EU-Project QUANTIFY offers a comparison of those sectors (except the sector pipelines) with the worldwide road transport regarding the CO_2-emissions for the scenarios A1B und B1.

To sum it up, road transport emissions in 2010 are 5,555 Gt CO_2, while aviation follows with 868 Mt CO_2, almost equal to shipping traffic with a fraction of 801 Mt CO_2. The subsequent sector of rail transport is indicated with 116 Mt CO_2, finally followed by inland navigation with an additional 33 Mt CO_2 emissions. In 2030, road transport is still leading in global emissions with 9,860 Mt, followed by aviation with 1,474 Mt, shipping traffic with 1393 Mt, the rail transport with 162 Mt and finally inland navigation with 31 Mt CO_2 (all data calculated in A1B-Scenario).

If the time period 2010 to 2030, as represented in the A1B-scenario, was to be expressed by an exponential function, the result for the annual growth in atmospheric CO_2 (calculated by LN (9860/5555)/20) is equal to 2.9% for road transport and 2,6% for aviation. The values for shipping transport and aviation are fairly similar. Here, the rather small increase in emissions from rail transport is quite remarkable, which are specified with 1.7 %.

However, the extension and improvement of public transport alone is not solving the problem, because private mobility also means individual freedom for a lot of people. With your own car, you can conveniently choose destination, speed, duration and route of your travels according to your own wishes and physical predispositions. Thus, our general attitude

towards mobility has to change first before real measures can be made to save the environment.

In Germany for example, each of the 82.5 million citizens has traveled an average of 14,700 kilometers in the year 2000, resulting in 1,213 billion Pkm (Person-kilometers). Private vehicles held a major part of 10352 kilometers (70.4%); 921 km were traveled by bus, 861 km by train, 1503 km by airplane, 182 km by local trains, 218 km by powered two-wheeler, 291 km by bike and 376 km by foot (DIW: Verkehr in Zahlen, pages 155,221). The personal transport demand of 14,700 kilometers will probably stay the same in the future, but the car fraction could be reduced from 70.4% to an approximate 50%, providing alternative means of transportation. The positive impact on the environment could be enormous. Of course, it needs some efforts to achieve this milestone.

The study from Dargay, Gately und Sommer: **"**Vehicle Ownership and Income Growth, Worldwide: 1960-2030", published 2007 in the *Energy Journal*, analyzed 45 countries with historic data from 1960 to 2002. Hereby, the gross domestic product per capita (GDP/cap) and the number of vehicles per 1,000 inhabitants (veh/1,000) were represented in a Gompertz-Function (s-shaped asymptotic function with 3 parameters). With the help of this function, the authors could calculate the development of vehicle ownership to the year 2030, making some assumption on GDP growth.

This paper in environmental sciences is primarily based on sciences, but cannot ignore the economic backgrounds concerning the problems of climate change, climate adaptation and climate mitigation. In a global study like this thesis, it was astonishing to experience how positive the economic experts like the World Bank or the International Monetary Fund judge the economic development for the next 20, 40 and even 90 years. The real GDP per capita (cf. World Business Council for Sustainable Development WBCSD 2004) increases for OECD North America, OECD Pacific and OECD Europe in their estimates from 19,000-26,000 US$ in the year 2000 to 45,000- 58,000 US$ in 2050, for China from 5,000 US$ in 2000 to 28,000 US$ in 2050, and for the global average from 7,000$ in 2000 to 17,000 US$ in 2050.

The estimates for individual countries do not look very differently; an estimated economic growth of about 3 % is only partially compensated by a population growth of about 1%. With the projected rapid economic growth, the development of road and air traffic of the order of 3.0 to 3.5% becomes comprehensible. But in line with economic growth hope for additional

financial support to combat climate change is created. Together with human sanity, scientific understanding, technical progress and a changing attitude among people a political consent could possibly be achieved to make funds available to pay for environmental and climate protection. Today in 2009, the global GDP amounts approximately to 58 trillion US $. If it took (only) 1% of the world GDP, i.e. 580 billion US $, for climate protection each year for the next 20 years, and if that sum needed to be provided by the OECD countries alone, an amount of 400 US$/capita were to be paid by the citizens of the developed world, equal to 8 US-Dollars or 6 Euro/capita and week (4 Euro/week was stated in an interview with Lord Stern and Ottmar Edenhofer in Nov. 2009, just before the Copenhagen conference). The International Energy Agency (in Special Early Excerpt WEO 2009 for Copenhagen) estimated the amount of 12,100 billion US$ for the next 20 years or 600 billion US$ per year, a number very similar to the previous estimates. These funds shall be used for improvements in the efficiency of power plants and net energy use (63%), renewable fuels (23%), biofuels (3.3%), nuclear energy (5.1%) and in Carbon-Sequestration-and-Storage CCS-Technologies (5.8%).

In the discussion of climate change, environmental pollution, population growth and economic growth, the focus is always on China, India, Brazil and Russia. Indeed these countries have a key role, but the developed industrial countries should rather act like a role model and not as a judge. The GAINS-study predicts for China 724 million vehicles by the year 2030, equal to a global fraction of 36%. Today, China has approximately 76 million vehicles, with an annual growth rate of 10%. In other words: Every seven years, Chinas fleet is being doubled. If the car fleet is increasing with a 3.5% annual growth from 1 to 2 billion vehicles (*Two billion Cars Driving towards Sustainability* by D. Sperling Und D. Gordon), it is evident and essential that the car production will increase from today 70 million to 140 million cars per year.

In the developing countries these vehicles are, to the most part, additional new vehicles on the road, which do not replace old ones, and therefore the progress in vehicle construction is felt immediately. In the industrial countries only 5-10% of the car fleet is exchanged every year by new technologies, which means that there is retardation between the launching of a new technological innovation and its implementation. This is why it is so important that apart from the production of premium cars in countries like Germany, France and Italy with improved efficiencies but still far from the 90 to 120 g CO_2/km goal, vehicles in the medium

in small class are produced both for the home front and for the export (including the production in a developing country) while showing the highest environmental standards.

To the climate problems mentioned above, the two-billions-cars-scenario displays another problem: the lack of road and parking space. Worldwide, there are not enough roads and highways to let all these cars travel fluently. This is especially problematic in big urban agglomerations. Furthermore, a car needs space for parking. A VW Polo 4 for example has a projected surface to the road of 6,47 m²(length*width); if we calculate with an imaginary amount of 1,3 billion VW Polo in 2030, they would take up a total surface of 8,400 km², which equals 20% of the surface area of Switzerland (cf. http://de.wikipedia.org/wiki/VW_Polo_IV). If you extend that scheme to a lattice design xy, where one or rather two spaces to the front and to the right are vacant to simulate the tightest traffic flow possible, the required surface increases with a coefficient 4 or 9 to 75,600km². This would equal almost the surface area of the Czech republic (78,864 km²).

Finally, the following conclusion can be drawn: To solve the problems evolving around the worldwide transport, CO_2-emissions and climate change, politics have to be put on the spot. There must be an intensive interaction between sciences, industries und society, because the attitude towards mobility and energy in our society must change, before the climate collapses completely. That means that everyone needs to think over his definition of mobility and cancel the thought: “It is not my car which is wasting energy and polluting the environment and air, it’s the others’ ”. Better to cite the German philosopher Immanuel Kant and his categorical imperative "Act only according to that maxim whereby you can, at the same time, will that it should become a universal law."[1]