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Capacity Development Project on Nationally Appropriate Mitigation Actions (NAMAs) in the Republic of Serbia

Transport Sub-sector Projects

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1. Foreword

Basic facts (OECD):

- Transport-sector CO2 emissions represent 23% (globally) and 30% (OECD) of overall CO2 emissions from Fossil fuel combustion. The sector accounts for approximately 15% of overall greenhouse gas emissions.
- Global CO2 emissions from transport have grown by 45% from 1990 to 2007, led by emissions from the road sector in terms of volume and by shipping and aviation in terms of highest growth rates.

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- Global CO2 emissions from transport are expected to continue to grow by approximately 40% from 2007 to 2030 – though this is lower than pre-crisis estimates.
- In certain ITF member countries for which estimates can be made, road freight accounts for up to 30% to 40% of road sector CO2 emissions though the breakdown amongst freight vehicle classes varies amongst countries.

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2. Summary of Shortlisted SERBIAN NAMA-s:

– Energy Sub-sector – 10 Projects

– Building Sub-sector – 4 Projects

– Transport Sub-sector – 2 Projects:

- Rehabilitation of 19 arterial roads in Serbia
- Rehabilitation of 129 regional roads in Serbia

Implementing Entity: MIE, PE “Roads of Serbia”

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3. Road maintenance and GHG Reduction

References and conclusions:

EAPA & EUROBITUME, Environmental Impacts and Fuel Efficiency of Road Pavements, Industry Report, March 2004:

- Optimal maintenance of roads is a tool to reduce fuel consumption and greenhouse gas emission
- Reducing the rolling resistance loss can contribute significantly to the overall fuel need: **the smoother the road, the lower the fuel consumption!**

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- Different surface characteristics (pavement texture) provides a major contribution to the rolling resistance

Study in Sweden:

- An uneven road may increase fuel consumption by up to 12% relative to an even road.
- A rough macrotexture may increase fuel consumption by 7% relative to a very smooth macrotexture.
- Fuel consumption for a car may be influenced as much as 12% by road surface characteristics within the tested range.

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Study in USA:

- A decrease in pavement roughness decreased the fuel consumption of the trucks. Under otherwise identical conditions, trucks used 4.5% less fuel/km on smooth post-rehabilitation pavement than on rough pre-rehabilitation pavement.

- Different textures of road surfaces influence fuel consumption for passenger cars by up to 10%.

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GENERAL CONCLUSION:

- During construction, maintenance and operation of roads the energy consumption and the greenhouse gas emissions are lower for asphalt than for concrete pavements. But **it is the traffic on road that accounts for the major part** (> 95 or 98% depending on traffic volume) **of the total energy consumption and greenhouse gas emission**, and here the differences between pavement types as such (asphalt or concrete) are not significant.

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- More important for the fuel efficiency are pavements in good condition with good surface characteristics (texture and roughness).
- **Optimal maintenance of the roads is therefore the means to limit fuel consumption and greenhouse gas emission**.

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ADB Evaluation Study - Reducing Carbon Emissions from Transport Projects

- **Traffic management** and **speed optimization** can cut CO2 emissions. Reductions in CO2 of about 20% can be obtained by techniques to mitigate congestion, manage excess speeds, and smooth traffic flow.
- **Road maintenance** projects can significantly reduce Carbon Dioxide Emission Rates. ADB has funded many road maintenance projects (**periodic maintenance**) that involves surface and roughness improvement elements

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- **A rough road slows down traffic and reduces efficiency**, increasing fuel use and CO2 emissions by 5%–10% or more.
- Key Findings: **Periodic maintenance projects have a major impact on carbon emissions reductions**.
- ADB Road Maintenance Projects ensured **reducing of road user costs, discomfort, pollution, and travel time delays**.

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Road Rougness (IRI)

- Road roughness is an expression of surface irregularity, and affects ride quality and fuel consumption
- Table A5.2. captures the impact of roughness on fuel consumption. Roughness is measured in units of meters of deviation from a flat surface per km.

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Table A5.2: Impact of Road Roughness on Fuel Consumption[a]

Roughness (m/km)	Impact on Fuel Consumption
2	1.00
3	0.99
4	0.98
5	0.98
6	0.97
7	0.96
8	0.95
9	0.95
10	0.94
11	0.93
12	0.92
13	0.92
14	0.91
15	0.90

km = kilometer, m = meter.
[a] Multiplication factor for fuel consumption (kilometer per hour). It shows decrease in fuel efficiency with increasing roughness.
Source: Asian Development Bank. 2009. *Green Transport – Resource Optimization in the Road Sector in the People's Republic of China*. Manila.

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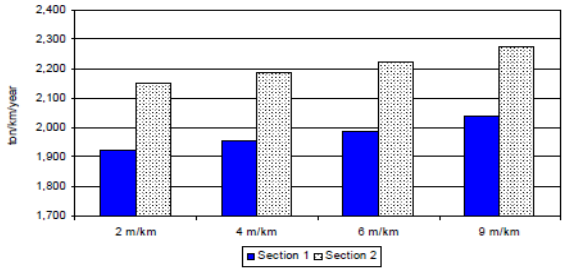
- The emissions (CO2 tons/km/year) increased by 1.6% when the road roughness increased from 2 to 4 m/km. When the road roughness increased from 2 to 9 m/km, the emissions increased by 5.8%.

Figure A5.1: Impact of Road Roughness on Carbon Dioxide Emissions for Two Sections of Controlled Access Highway in India



km = kilometer, m = meter.
Source: Independent Evaluation Department estimate based on review of National Highway Authority of India project documents and reports for Salem–Namakkal highway.

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- Roughness also indirectly affects fuel consumption by altering vehicle travel speeds. However, models currently used for project appraisal (whether for expressways, rural roads, or urban roads) mostly rely on the Volume–Capacity ratio to estimate traffic speeds, disregarding the impact of roughness on speed. A proper evaluation of CO2 emissions and other speed-dependent parameters needs to consider how roughness can indirectly affect CO2 by affecting traffic speeds.

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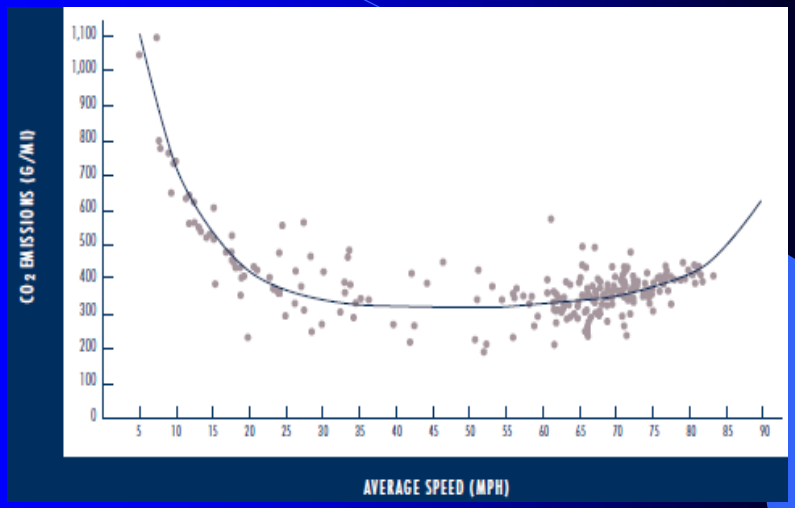
- Very low average speeds generally represent stop-and-go driving, and vehicles do not travel far. Therefore, the emission rates per mile are quite high. (When a car's engine is running but it is not moving, its emission rate per mile reaches infinity.) Conversely, when vehicles travel at much higher speeds, they demand very high engine loads, which require more fuel, and which therefore lead to high CO2 emission rates. As a result, this emissions-speed curve has a distinctive parabolic shape, with high emission rates on both ends and low emission rates at moderate speeds of around 40 to 60 mph.



- If congestion reduces the average vehicle speed below 45 mph, CO2 emissions increase. Vehicles spend more time on the road, which results in higher CO2 emissions. Therefore, in this scenario, **congestion mitigation programs** will directly reduce CO2 emissions.
- If moderate congestion brings average speeds down from a free-flow speed over 70 mph to a slower speed of 45 to 55 mph, this moderate congestion can reduce CO2 emissions.

- If congestion mitigation raises average traffic speed to above about 65 miles per hour, it can increase CO2 emissions.
- **Smoothing the stop-and-go pattern of traffic so that cars move at a relatively constant speed will reduce CO2 emissions**.

4. CO2 Emission Calculation Methods

COPERT 4

- COPERT 4 Software is used for determining of Fuel consumption and CO2 Emissions. COPERT 4 is a software tool used world-wide to calculate air pollutant and greenhouse gas emissions from road transport. The development of COPERT is coordinated by the European Environment Agency (EEA), in the framework of the activities of the European Topic Centre for Air Pollution and Climate Change Mitigation.

- COPERT 4 estimates emissions of all major air pollutants produced by different vehicle categories (passenger cars, light commercial vehicles, heavy duty trucks, busses, motorcycles, and mopeds) as well as greenhouse gas emissions (CO2, N2O, CH4).

Inputs:

- AADT (Average Annually Daily Traffic) ... veh/24h
- AAT (Average Annual Trip for each vehicle categories) … km
- SFC (Specific Fuel Consumption for each vehicle categories) …… gr/km

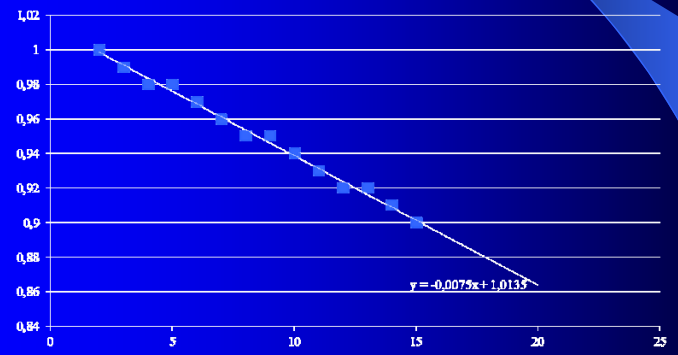
- Main equation: E, CO2 = C * FC , where
- E, CO2 (CO2 Emission) ……. ton/year
- C (group of constant values)
- FC (fuel consumption) ……...ton/year

Key Conclusion:

CO2 Emission is in direct proportion with Fuel Consumption!

CO2 savings after rehabilitation, by using ADB method for modeling

Impact of Road Roughness (IRI) on Fuel Efficiency:



Inputs:

- IRI (for each road section) …….. mm/m

Main equation: **FC, with rehab = FC, bau * FE** , where

- FC, with rehab (fuel consumption after rehabilitation) ……...ton/year
- FE = f(IRI) (fuel efficiency)
- FC, bau (fuel consumption in case of no rehabilitation) ……...ton/year

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CO2 savings after rehabilitation, by using CMP method for modeling - increasing traffic speed from 40km/h to 80 km/h

- CMP – Congestion mitigation program
- Method is based on conclusions presented in "Traffic Congestion and Greenhouse Gasses" publication, Center for Environmental research and Technology at the University of California

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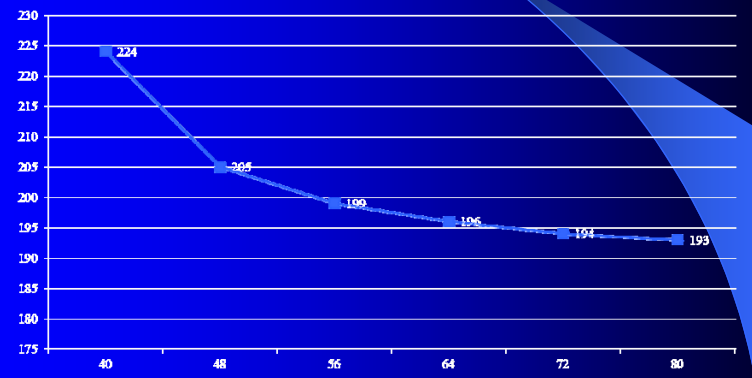
CO2 Emission / Average SPEED plot



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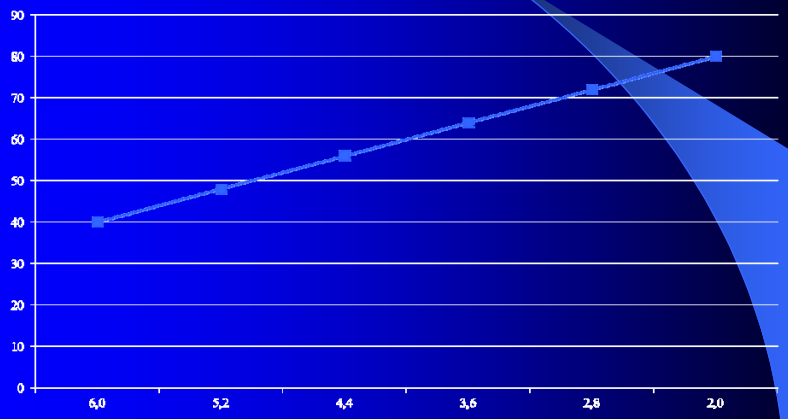
IRI / Average SPEED plot



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- IRI (current value, for each road section) …….. mm/m
- IRI, ar (value after rehabilitation, = 2 mm/m)
- AS (current average traffic speed, for each road section) ……..km/h
- AS, ar (requested average traffic speed, after rehabilitation, = 80 km/h)

Calculation of Emission:

- ECO2, bau (CO2 Emission, in case of no rehabilitation) = f (AS) ……. gr/km
- ECO2, ar (CO2 Emission, after rehabilitation) = f (AS, ar) ……. gr/km

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Serbian Arterial / Regional road selection

- Data for each selected road section were taken from "Program Analyses of State Road Network and Transport Rehabilitation Project Performance Indicators", PERS, 2011. Data analyzed by using software HDM-4 and HIMS
- Mostly road sections with IRI greater than 6 were selected, due to the COPERT 4, ADB and CMP Emission Calculation Methods.
- Road database already prepared by PERS as a source of relevant data (AADT, vehicle by type, IRI)
- Roughness detection is measured on each road section

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Project details, modeling results and CO2 reduction potential

- Arterial Road Rehabilitation Project should take place on 19 different arterial road sections throughout the country. Total length of all proposed road sections is 324 km. Estimated cost of the Project is **65 Mil.€**
- Regional Road Rehabilitation Project will take place on up to 129 different regional road sections throughout the country. Total length of all proposed road sections is 2.768 km. Estimated cost of the Project is **500 Mil.€**

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- Mitigation Target is improved fuel consumption level by all vehicles that is achieved by running speed of 80 km/h, or the International Roughness Index (IRI) of the proposed roads are improved up to the value of 2.0 m/km
- Type of GHGs reduced: CO_2
- Annual reduction, arterial road rehabilitation project: **2,617 tCO_{2e}** (av. 3.62%)
- Total reduction, arterial road rehabilitation project: **52,340 tCO_{2e}** (20 years)

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- Annual reduction, regional road rehabilitation project: **6,476 tCO_{2e}** (av. 3.1%)
- Total reduction, regional road rehabilitation project: **129,520 tCO_{2e}** (20 years)

Basic Financial Feasibility Comments (in NAMA Short List Projects) shows that although the total investment cost is large, program analysis and financial analysis concludes that the **justification of the investment in the set of actions is confirmed**!

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5. Current Project Status

- Detailed Financial Analysis – Commercial Profitability
- Discounted Cash-Flow (DCF) Method, including Net present Value (NPV) and Internal Rate of Return (IRR) for each candidate project
- Economic Analysis – National Profitability
- Determining of Project Benefits as inputs for Financial Analysis (VOC Savings, Time saving, CO2 Emission Reduction, etc.)

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6. Remaining Steps (in case of ensuring investment in NAMA Transport Sub-projects)

- Producing of Detailed design and adequate Monitoring Program
- Rehabilitation Permit obtained from Ministry incharged
- Zero Monitoring of CO2
- Road rehabilitation works
- Monitoring of CO2 after rehabilitations

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7. Reasons for investing in Serbian NAMA Transport Sub-Projects

- Air pollution from transport, manufacturing industries and construction increases;
- The total annual damage caused by air pollution and greenhouse gas emissions is estimated to range between 1.8%-5.5% of GDP.
- Serbia ratified the Kyoto Protocol during the fall of 2007.

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- Insufficient financing of environmental investments: Financing the implementation of the National Environmental Strategy is a key challenge. According to the estimates in the NES, annual expenditures to reduce negative impacts on the environment will need to increase from on average 0,3% of GDP between 2001 and 2005 to around 2% of GDP during the coming years. This increase would be in line with the levels in other transition countries.
- **The highest expenditure will be** required in the following sectors: energy (29%), waste (24%), water (21%), and **transport (12%).**

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Expected CO2 Savings in NAMA Transport Projects are:

- For Serbian Arterial Road Rehabilitation Project (19 arterial road sections in Serbia)
  up to 11% (av. 3.6%), 52.340 tCO_{2e}
- For Serbian Regional Road Rehabilitation Project (129 regional road rsections in SerbiA
  up to 8% (av. 3.1%), 129.520 tCO_{2e}

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- Traffic Congestion and Greenhouse Gases, Matthew Barth and Kanok Boriboonsomsin
- Serbia Environmental and Climate Impact Analysis, School of Economics and Commercial Law, Goeteborg University, 2008
- COPERT IV Model for calculation of GHG in road transport, Traffic Engineering Faculty, Belgrade University, 2010

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Хвала на пажњи!

Thank You!

- Питања:
- *Questions:*