TRANSPHORM

Transport related Air Pollution and Health impacts –

Integrated Methodologies for Assessing Particulate Matter

Collaborative project, Large-scale Integrating Project

SEVENTH FRAMEWORK PROGRAMME

ENV.2009.1.2.2.1 Transport related air pollution and health impacts

Deliverable D5.3.1

Ranking and assessment of options

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Organisation name of lead contractor for this deliverable:	USTUTT
Scientist responsible for this deliverable:	Rainer Friedrich

Contents

1. Introduction

In this report the set of policies and measures that were identified and systematically analyzed earlier in TRANSPHORM (cf. D5.2.1) will be assessed and ranked according to their positive impact on human health.

By carrying out an effectiveness analysis of the benefits of isolated measures it is possible to address questions about the impact of single measures for the years 2020 and 2030. By doing so, it is possible to determine whether the realization of an option would, in general, be a worthwhile pursuit in terms of reducing air quality impacts. The analysis yields a ranking of measures for two future years. The ranking is based on the potential of a measure in reducing the relative risk of the population to suffer from morbidity and premature mortality due to exposure to outdoor air.

As there are two dozen measures evaluated for two future years it was not possible to perform an analysis of each single measure using full atmospheric dispersion models. Therefore, the EcoSense integrated assessment model will be used.

The EcoSense model and the recent improvements to the assessment methodology are described in section 2, followed by the ranking of the options for the years 2020 and 2030 in section 3. Concluding remarks and an outlook are given in section 4.

2. Methodology for impact assessment of air quality measures

2.1. The EcoSense model

EcoSense is an integrated atmospheric dispersion and exposure assessment model applying the impact pathway approach. It was developed to support the evaluation of impacts on human health, crops and building materials resulting from the exposure to airborne pollutants.

Input for the EcoSense umbrella model are spatially disaggregated emissions of classical airborne pollutants such as SO_2, NO_x, primary particulate matter, NMVOC and NH_3. Chemical transport models are then used to calculate the average annual primary and secondary PM2.5 concentrations, SOMO35 values a.s.o. for predefined grids (in this case 0.5° x 0.25° for Europe). The most recent version of EcoSense uses source-receptor matrices derived from numerous runs of a recent version of the EMEP model. These source-receptor relationships link changes in the emissions of a country to changes in pollutant concentrations on the grid (Bickel and Friedrich, 2005; Friedrich et al., 2011).

For a more precise analysis of health impacts due to primary particulate matter in urban areas, the background concentrations derived from the source-receptor matrices are used for the calculation of a city specific increment. This approach captures higher pollutant levels commonly found within densely populated areas (Torras Ortiz and Friedrich, 2013). The urban increment values are then added to the background concentrations for the assessment of health impacts.

To assess the health effects due to concentration changes of simple pathway pollutants, impact functions, consisting of the concentration-response function (CRF, see e.g. WHO/HRAPIE (2013)), the background rate of disease within the population and the fraction of the population exposed, are applied. Resulting values for the different health endpoints can then be calculated using age-stratified population data along with the concentration delta (Friedrich et al., 2011). For aggregation or comparison of these results, the values derived in the previous step, given in cases or years of life lost (YOLL), have to be converted into a common metric, the DALY (Disability Adjusted Life Years). It combines information on both quality and quantity of life and indicates the number of healthy life years lost. To achieve this, morbidity is weighted for the severity of the disorder and the duration of the disease, mortality with years of life lost. Thus, this metric includes both effects. However, DALYs should be used to estimate the potential order of magnitude of health problems rather than being presented as representative absolute numbers (Friedrich et al., 2011).

2.2. Recent improvements of the methodology within TRANSPHORM

To perform a state-of-science assessment several substantial improvements have been incorporated into the integrated assessment methodology that is implemented in the EcoSense model. The most important of these improvements are:

(1) The incorporation of new, more fine-grained source-receptor matrices (SRMs) that were derived from the most recent version of the EMEP model at a resolution of 0.5° x 0.25°. The SRMs act as a parameterized version of the atmospheric model and represent a well-established trade-off between small losses in accuracy (due to linearization) for marginal changes in emissions and a huge gain in computing-time due to the simplified formulization.

(2) An enhanced representation of generally higher PM and NO_2 concentration levels in urbanized areas by evaluating and updating the urban increment (UI) model. A distinction in activities and emissions into non-urban and urban was made for about 900 cities covered (using the up-scaling method described in Deliverable D5.2.2). The importance of the urban increment is due to the fact that many emissions happen in urban areas and at low release heights, i.e. near surface, and the effect of more than half of the measures heavily depends on adequately representing their effect in cities.

(3) Incorporation of new concentration-response functions (CRFs) as recent findings of the REVIHAAP/HRAPIE projects (see WHO/HARAPIE (2013)). This affects especially the substantial but previously neglected health impacts due to exposure to ambient NO_2 (for which also an urban increment had to be developed).

2.3. Metric used for assessment and ranking

The metric used to rank the measures is Disability-Adjusted Life Year (DALY) and is described in detail in section 2. The reason for a reduction (or an increase) in DALYs is categorized. The rationale behind that categorization is described in Table 1.

Table 1: Categorization and description of sources of changes in health impacts (all measured in DALY).

Category	Description
NO2_ui	Results for NO2 (urban increment): Additional avoided health impacts (mortality) in selected cities caused by a decrease in annual mean NO2 concentrations over a threshold of 20 µg/m³, due to reduced emissions in urban areas, calculated using the urban increment model. A possible overlap with effects from PM2.5 has already been filtered out to avoid double counting.
PM25_ui	Results for PM2.5 (urban increment): Additional avoided health impacts in urban areas caused by a decrease in annual mean PM2.5 concentrations due to reduced emissions in urban areas, calculated using the urban increment model. This category includes health effects attributed to PM2.5 by mortality as well as morbidity-related endpoints.
PM10_ui	Results for PM10 (urban increment): Additional avoided health impacts in urban areas caused by a decrease in annual mean PM10 concentrations due to reduced emissions in urban areas, calculated using the urban increment model. This category includes health effects attributed to PM10, combining mortality and morbidity-related endpoints.
NO2_reg	Results for NO2 (regional model): Additional avoided health impacts caused by a decrease in regional annual mean NO2 concentrations above a threshold of 20 µg/m³, modeled using the source-receptor approach. As in the results for the urban increment model, possible overlap with effects from PM2.5 has already been removed to avoid double counting.
SOMO35_reg	Results for SOMO35 (regional model): Additional avoided health impacts caused by a decrease in Ozone concentrations, expressed in SOMO35 values, modeled using the source-receptor approach. This category includes health effects attributed to Ozone, combining DALYs from mortality and morbidity-related endpoints.
PM25_reg	Results for PM2.5 (regional model): Additional avoided health impacts caused by a decrease in regional annual mean PM25 concentrations, modeled using the source-receptor approach. This category includes DALYs from health effects attributed to PM25 by mortality as well as morbidity-related endpoints.
PM10_reg	Results for PM10 (regional model): Additional avoided health impacts caused by a decrease in regional annual mean PM10 concentrations, modeled using the source-receptor approach. This category includes health effects attributed to PM10, combining DALYs from mortality and morbidity-related endpoints.

3. Ranking of options for the years 2020 and 2030

This section describes the findings of the air quality impact assessment that was carried out by applying each of the measures individually on the future projections of 2020 (see Figure 1) and 2030 (see Figure 2). The metric used to rank the measures is Disability-Adjusted Life Year (DALY). It is described in more detail in section 2.

From an air quality perspective, clearly the measures on promoting bicycle usage and promoting Euro 7 cars stand out in both 2020 and 2030 (switching first and third place). The former is applied solely in urban areas and different penetration rates are assumed depending on the size of the city and on the level of bicycle usage already projected to prevail in the baseline scenario. Euro 7 is applied in urban and non-urban areas and there is a significant change in benefit from 2020 to 2030 (as the effect increases by a factor of about 4). This is due to the assumed penetration of vehicles into the fleet that are capable of meeting the standard. When focusing on air quality impacts only, promoting the use of bio-fuels has little to even negative effects on health due to largely increased use of fertilizers in agriculture when cultivating crops. However, this is likely to change when carrying out an integrated assessment that also considers effects of reducing emissions of heat-trapping carbon dioxide (cf. D5.3.2). Negative health impacts stem from an increase in emissions, often outside of cities. The effect is particularly apparent in the case of measures that promote the utilization of public transport systems including metro and tram, or in the case of promoting electric vehicles. But, it has to be emphasized that the positive health impacts of reducing air pollution by cutting back inner-urban car traffic largely outweighs the adverse effects of increased emissions of higher electricity demand.

It clearly stands out that the benefit of the top-four measures in 2030 is about two third of the summed up effects of all measures. While three of the measures tackle different sources of air pollution, i.e. car exhaust emissions (“Euro 7”), emissions from ships at berth (“shore-based electricity”) and reduced non-exhaust emissions of vehicles as well as road abrasion, there is a clear dependence of two of those measures with promoting bicycle usage. As aforementioned, the combined effect of measures cannot be determined by summing up the results of individual measures. This is due to the fact that promoting one mode of transport (here: bicycles) will reduce the utilization of another (here: passenger cars) and will consequently render the positive impacts assumed from lowered exhaust and non-exhaust emissions an over-estimation.

However, the validity of setting the focus on reducing (fine) particulate matter and emissions of its precursors becomes apparent from the figures when comparing the effects of reduced levels of ozone due to reduced emissions of nitrogen oxides and volatile organic compounds. Overall, reducing ambient levels of $PM_{2.5}$ and NO_2 concentrations shows to have highly positive impacts on human health.

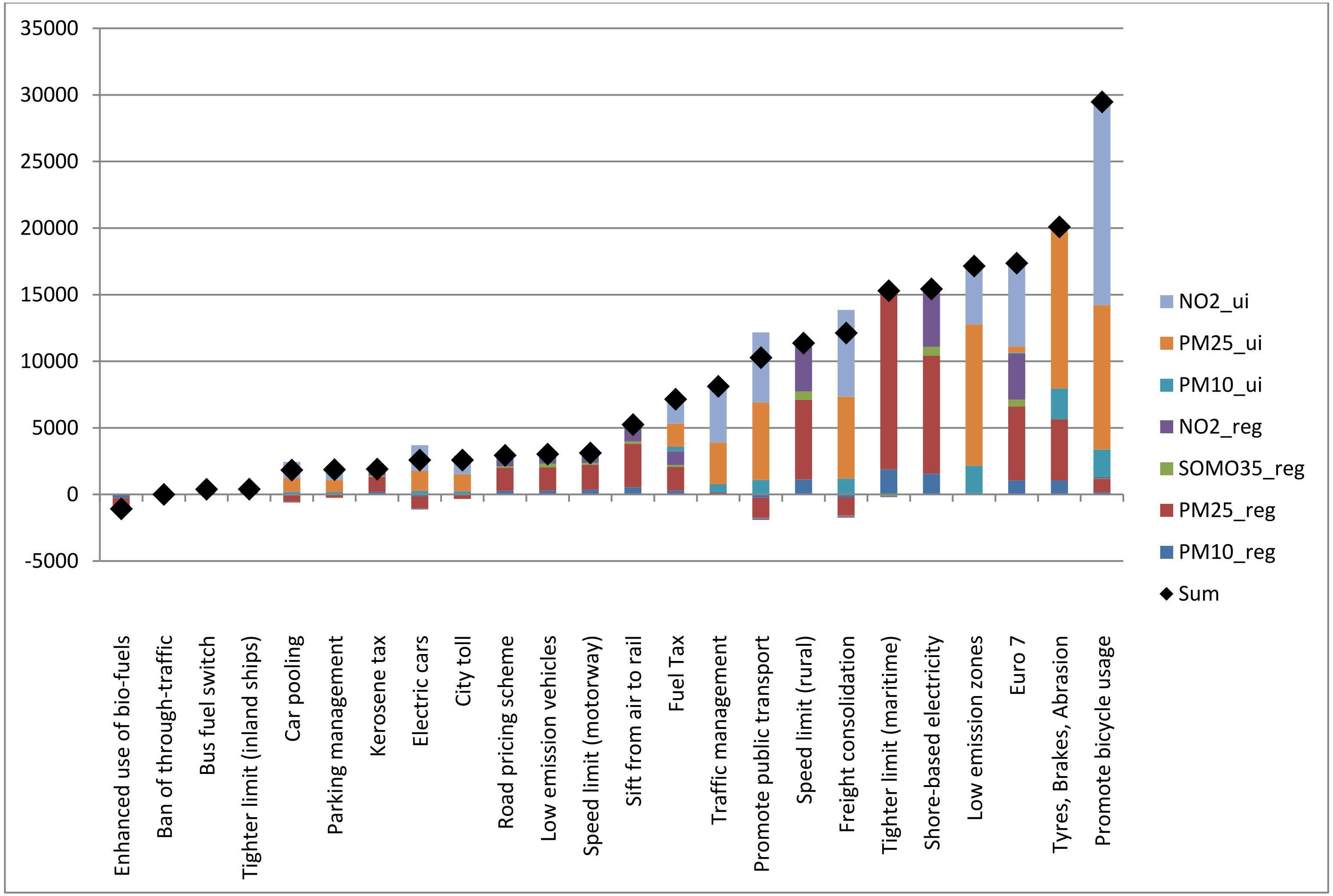

Figure 1: Avoided health impacts in 2020 (measured in disability-adjusted life years, DALYs)

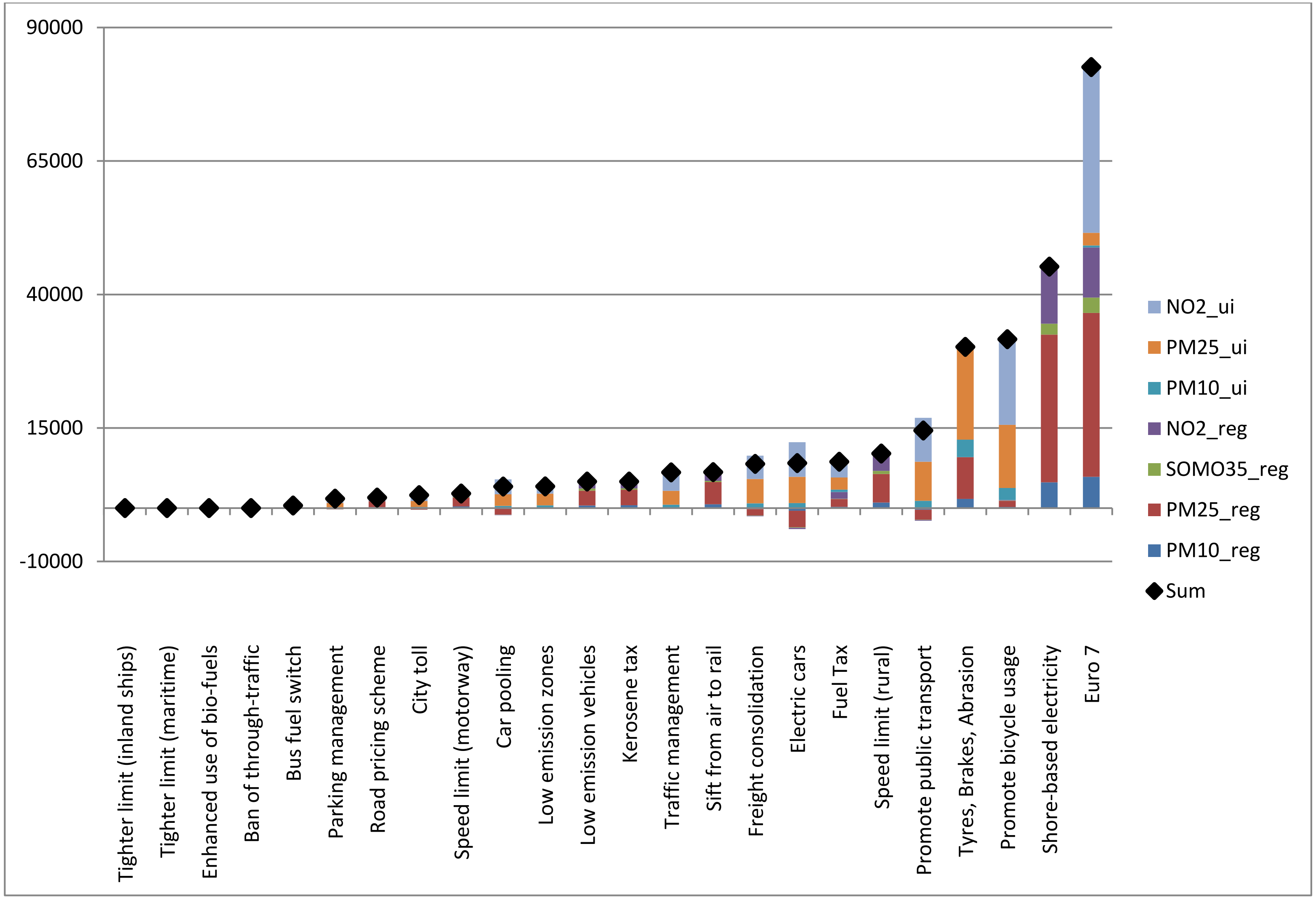

Figure 2: Avoided health impacts in 2030 (measured in disability-adjusted life years, DALYs)

4. Conclusion and outlook

Policy measures were identified and categorized earlier in the project (cf. D5.1.3). Their costs were estimated and their effects on activities and emission factors were analyzed (cf. D5.2.1). An up-scaling method was developed to apply regional and urban measures EU-wide (cf. D5.2.2). This document describes the methodology of the assessment of single transport-related measures and the resulting changes in air quality over Europe.

This section will summarize the findings described above and intends to give an outlook on the tasks necessary to provide an *integrated* assessment of the policies and measures.

Several improvements have been made to the methodology including finer spatial resolution, enhanced assessment of urban increment and incorporating latest scientific findings about concentration-response functions. Also, this report shows the results of a ranking of the transport-related measures that is based on the performance of a measure with respect to improvements in air quality when being implemented isolated from other measures.

For a more complete view on the impacts of the proposed policies several further analyses have to be conducted for the reasons briefly explained in the following. First, climate change impacts have to be considered for integrated assessment to cover synergies among measures or identify potential countervailing effects. Subsequently, to compare the benefits of reduced health impacts and avoided climate impacts a common measure has to be defined. Often money acts as this common measure as it serves another purpose in being the unit to measure the implementation costs. This allows for an assessment that determines the social welfare optimum by maximizing the overall benefit for society. The assessment will be conducted and reported on in D5.3.2 and will allow to draw conclusions and give recommendations to policy-makers.

References

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