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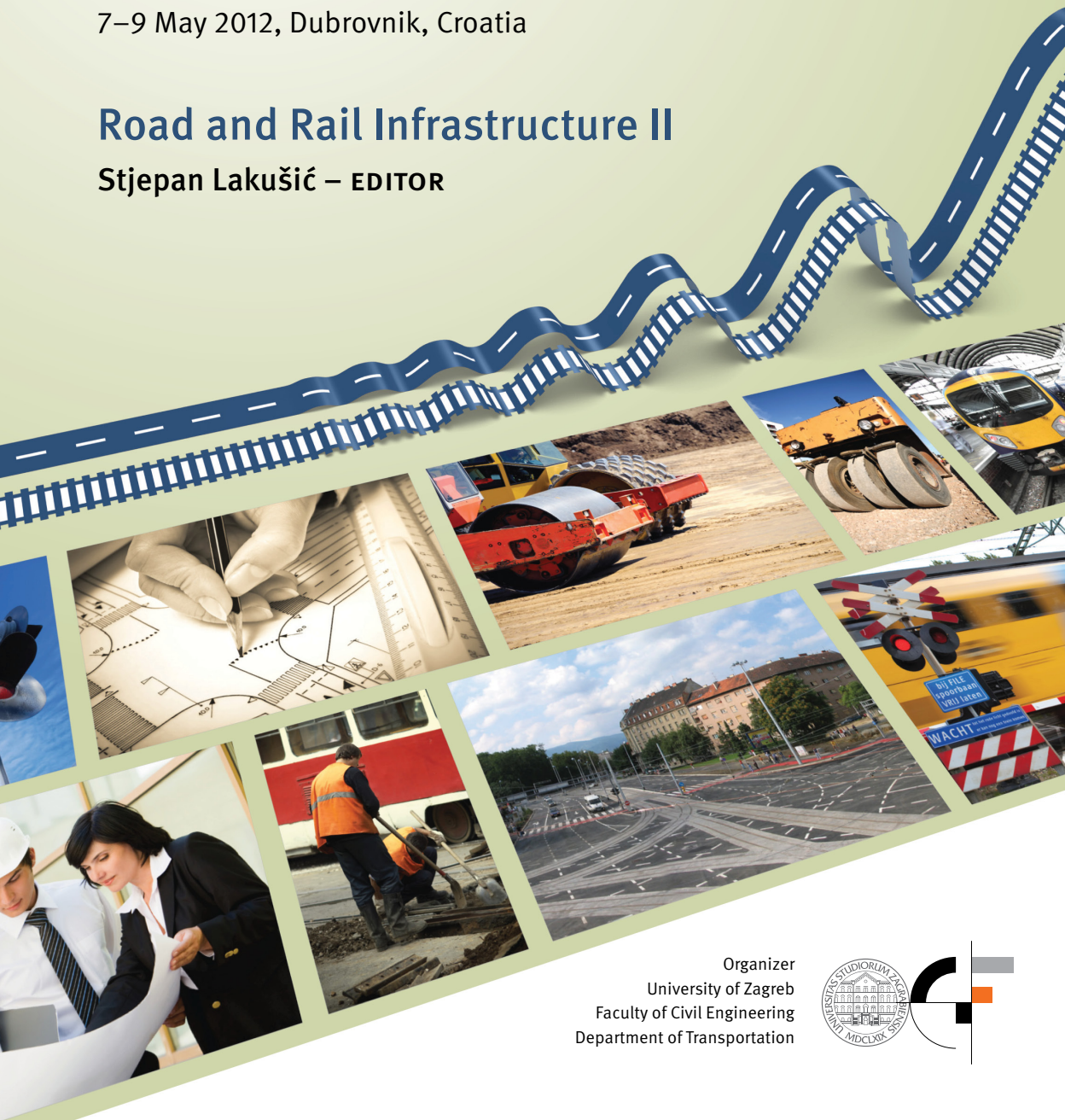
7–9 May 2012, Dubrovnik, Croatia

Road and Rail Infrastructure II

Stjepan Lakušić – EDITOR



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E–MOBILITY IN URBAN AREAS AND THE IMPACT OF PARKING ORGANISATION

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Abstract

In this paper we explore the preconditions and requirements to enable the renewal of the vehicle fleet towards e–cars without weakening eco–mobility (public transport, cycling, walking). We follow a combined approach of arranging charging infrastructure and parking space regulations. We analyze the results of this approach by modelling different scenarios for the case study city of Vienna with the LUTI (land–use transport interaction) model MARS (Metropolitan Activity Relocation Simulator). Four different policy scenarios are modelled and the results presented. We look at changes in transport behaviour (modal split and vehicle kilometres), the emissions and the impact on public transport ridership.

Keywords: e–mobility, parking organisation, modal split, dynamic modelling, human behaviour

1 Introduction

E–mobility is currently facing a promising boom, which readjusts both the requirements and possibilities of organizing a future transport system. The chances of individual e–mobility to reach certain transport policy goals are obvious – minor dependency on fossil fuels and the reduction of greenhouse gases and air pollutants. However, lower user–specific operational expenses, exclusion of certain classes of vehicles from environment–based cordons (e.g. low–emission–zones) and the omission of 'environmental reasoning' for certain user groups can lead to counterproductive system effects and a net–growth of private motorized transport (PMT). Various urban administration authorities have set themselves objectives such as the strengthening of public and non–motorized transport.
We show what kind of organizational structures are necessary for enabling the renewal of the vehicle fleet towards e–cars without weakening public transport (PT), cyclists and pedestrians. We describe and present four different scenarios which were influenced by different transport policies.

2 Method

The analysis was carried out with three models. Two models (SERAPIS) served for calculating the fleet composition for conventional & hybrid (in the following named as cars) and electric vehicles (e–cars) for the city of Vienna and its hinterland.
SERAPIS (Simulating the Emergence of Relevant Alternative Propulsion technologies in the car and motorcycle fleet Including energy Supply) is a dynamic model that simulates fleet

developments and the shares of different propulsion technologies. Hence the demand for the electricity economy and the potentials for reducing CO_2 emissions are derived.
With the land–use transport model MARS the traffic behaviour in the model region was simulated. The MARS (Metropolitan Activity Relocation Simulator) model was developed at Vienna University of Technology's Research Center of Transport Planning and Traffic Engineering [1]. It is a land–use transport interaction model which simulates the mutual interactions between the land–use and the transport system [2–4]. The model zones from the model described in this paper cover the 23 Viennese districts and the Vienna hinterland.
The MARS model was connected to SERAPIS via two variables: the operating costs, calculated in MARS, served as input variable for the SERAPIS models; and the fleet development as an output of SERAPIS served as input for MARS.

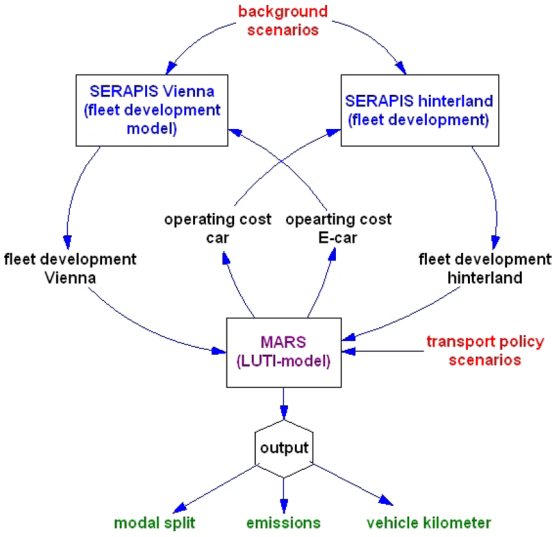

Figure 1 Links of the three models and external input.

The data basis covers demographical data for the case study area, transport relevant data (level of motorization, modal split, etc.) and transport policy goals.

3 Scenario overview

Besides the extrapolation existing trends of relevant traffic indicators (Business as usual – BAU), we designed three different transport policy scenarios (E–car, Equidistance, Equidistance + E–car). The background scenarios cover the development of crude oil price and subsidies for e–cars as well as different fleet developments for e–cars which are the basis for each scenario. We combined the transport policy scenarios with different background scenarios in order to define and model four policy runs.
Table 1 shows the assumptions for our four scenarios (subsidies for e–cars, transport policies).

Table 1 Scenario setting in Vienna.

Scenario			BAU	E–car	Equidistance	Equidistance + E–car
Sub–sidies	Funding for e–cars	low	X		X	
		high		X		X
Transport policies	Density of charging stations	low	X		X	X
		high		X		
	Availability of public parking spaces	low			X	X
		high	X	X		
	Parking fees for e–cars	yes	X		X	X
		no		X		
	Fuel duty	low	X	X		
		high			X	X

3.1 Background scenarios

In this paper we assume a progressive increase of the crude oil price until the year 2030. Compared to the base year 2010 the price will double. Our assumed crude oil price development was compared with several studies [5–10] and projects and for two scenarios (BAU, E–Car) the fuel duties equal Austria's 2010 levels (0.43 EUR/litre for petrol, 0.30 EUR/litre for diesel) and remain constant. In both equidistance scenarios the fuel duty increases constantly over time up to +30 % in the year 2030 (0.59 EUR/litre for petrol, 0.41 EUR/litre for diesel).
We distinguished between the subsidy levels for e–cars of the E–car and Equidistance scenarios. In the E–car scenario the subsidies increase rapidly in the first year to 5,000 EUR/vehicle and then decrease until the year 2021. Further we distinguish between the development of the gross and net purchase prices of e–cars. The net purchase price disregards differences in sales tax, engine related insurance tax and standard fuel consumption tax.

4 Transport policies

We modelled four different transport policy scenarios varying in the following parameters:
a Spatial arrangement of the charging infrastructure and parking places for e–cars.
b Walking time from trip origin to the charging stations, respectively the parking place.
c Parking fees (level and location).
d Fuel duty for diesel and gasoline cars. E–cars were excluded.
Each scenario was calculated separately for e–cars and cars for the case study area of Vienna and its hinterland.

4.1 BAU scenario

The BAU scenario extrapolates the current development. No massive infrastructure changes are considered. The charging infrastructure for e–cars in Vienna is organized in collective parking garages provided with a low density (‹5 %). In this scenario charging infrastructure is not provided in public streets. In comparison to conventional cars the walking time to charging & parking places for e–cars is therefore very high (~5 min.). Both, e–cars and conventional cars need to pay inner city district parking fees. In the urban hinterland the private car is easily accessible.
The scenario is based on the fact that in the surroundings of Vienna people can park and charge their car nearby their house or their apartment. The access time is short (about 0.5 minutes). A lot of detached houses have their private parking place (minimal walking time to the car) and most of the communities have no parking fee.

4.2 E–car scenario

The E–car scenario is based on a strong increase in the density of charging infrastructure in public spaces in Vienna (›30 %). Therefore the walking time from trip origin to the charging infrastructure alternatively to the parking place for e–cars is equal to the access time for cars (~1 min.). Parking for e–cars is free (the parking fees in parking garages are reduced) and no taxes similar to the fuel tax are levied. The parameters for the Vienna hinterland remain similar to the BAU scenario.

4.3 Equidistance scenarios

4.3.1 Principle of equidistance

Pedestrians in their walking behaviour follow a certain function of attractiveness [11]. Short walks offer 100 % attractiveness – longer walks far less. Pedestrians assess time subjectively and therefore value their walks considering their surrounding areas.
Walther [12] found that the access walks of pedestrians to PT stops and the access and egress times to parking places play an important role in transport mode choice. Humans do not perceive access and egress time linearly but exponentially. With increasing walking distance the perception thereof increases disproportionately. If it is possible to park a car in the basement parking garage of one's house, or in the public space directly in front of one's home or work place, the car presents a 100 % attractive accessibility. A PT stop 400 meters away holds less than 20 % of attractiveness in inner city surroundings. Thus people are going to prefer their car over the bus, if somehow possible.
To create equal opportunity conditions between PMT and PT, equidistance between parked cars and adjacent PT stops for all activities needs to be introduced.
Cars and other PMT need to be parked in centrally organized parking garages distributed over the city, resulting in at least a distance equal to the distance of frequently operating PT stops.

4.3.2 Equidistance scenario

In the Equidistance scenario the charging and parking for e–cars and parking cars are organized in collective parking garages. The charging infrastructure for e–cars is provided in collective parking garages (›5 %). Thereby the access time (walking) is increased for conventional cars to 3 minutes in the city equal to e–cars in this scenario.
Parking space management is in action area–wide in Vienna. Parking fees for cars are increased until the year 2020, they have to be paid city–wide and are compulsory for e–cars too. The fuel duty is increasing over time until the year 2030 (+30 % of the base value), but is not assigned to e–cars. A similar energy consumption tax for e–cars is not implemented. The conditions for the hinterland do not change in reference to the previous scenarios.

4.3.3 Equidistance + E–car scenario

There are two major differences between the Equidistance and the Equidistance + E–car scenario:

1 The increased number of e–cars in the fleet due to higher subsidies.
2 The organizational form of parking space and charging is equal (collective parking garages) but more garages are equipped with charging facilities in this scenario (›30 %).

The other settings remain the same.

5 Evaluation of the results

The scenarios were modelled under consideration of the transport policy goals of the city of Vienna for the year 2020. The Vienna transport master plan defines the following modal split objectives for Vienna in the year 2020:

- Reduction of PMT trips to 25 % of all trips.
- Increase in bicycle share to 10 %.
- Increase in PT share from 34 % to 40 %.
- For commuting flows from the Vienna hinterland the distribution between public transport and PMT should shift from 35 % / 65 % to 45 % / 55 %.

6 Results

We analyzed the results of the scenarios concerning the changes in transport behaviour by looking at the changes in modal split.

6.1 Changes in transport behaviour

The scenario E–car shows no relevant change in transport behaviour compared to the BAU scenario. Some car users switch to e–cars, but the share of eco–mobility modes remains constant. The sole increase in funding of e–cars without changing the organizational structures for parking does not change the modal split very much (see Figure. 2).
The scenarios Equidistance and Equidistance + E–car show crucial changes. Figure 2 and 3 depict the modal split for the year 2020 for Vienna citizens and in–commuters to Vienna. The combination of equidistance with an increased funding of e–cars is the most effective way of changing transport behaviour.
The modelled measures in these two scenarios also enable the achievement of Viennese transport politics objectives. Basically shifts from car to public transport occur.
The picture looks different for the in–commuters. Many people living in Vienna's hinterland have the possibility to park their car or e–car close to their home respectively on private ground. Due to the policy that only destination locations in Vienna include a charged parking organization the modal split changes are modest (see Figure 3).

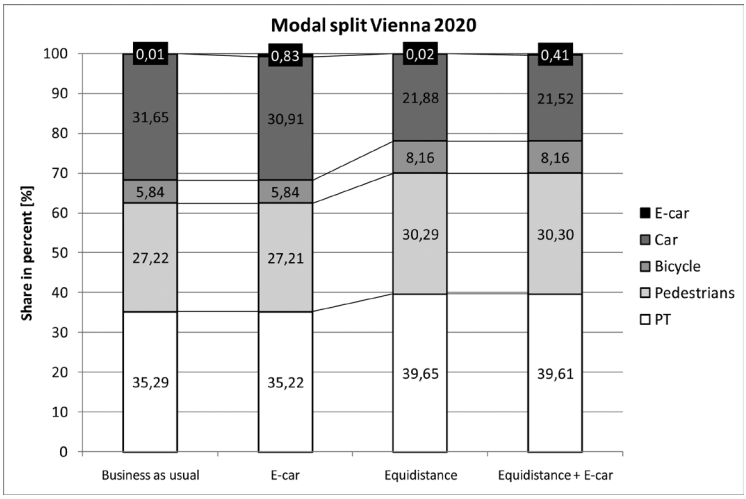

Figure 2 Modal split Vienna 2020 – comparison of the scenarios.

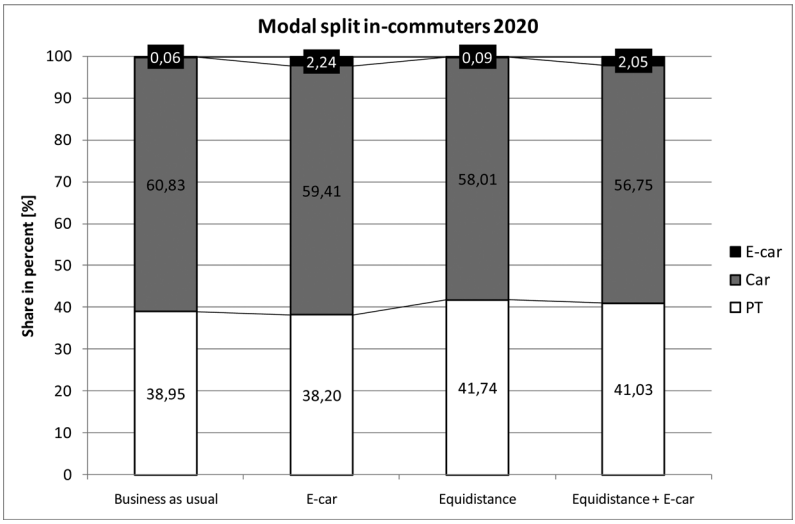

Figure 3 Modal split in–commuters 2020 – comparison of all scenarios.

6.2 Emissions

Table 2 shows the reduction of vehicle kilometres, NO_x and CO_2 emissions in the year 2020 compared to the BAU scenario. It's clearly visible that the most effective emission reduction scenario is the Equidistance + E–Car. More than half of Vienna's primary emissions can be reduced in this scenario.

Table 2 Vehicle kilometres, NO_x and CO_2 emissions in the year 2020 compared to the BAU scenario.

Reduction of vehicle–km, NO_x and CO_2 emissions in the year 2020 in relation to the BAU scenario [%]			
Parameter	**E–car**	**Equidistance**	**Equidistance + E–car**
Veh–km Vienna	-2.1	-29.3	-30.4
Veh-km in-commuters	-1.7	-6.6	-8.2
NO_x Vienna	-16.4	-31.2	-41.6
NO_x in-commuters	-15.9	-8.1	-22.0
CO_2 (total)	-3.8	-14.9	-17.9

6.3 Impact on ridership in public transport

Whereas the ridership in public transport increases in the Equidistance scenario in Vienna as well as in its hinterland the percentage decreases in the hinterland in the scenario Equidistance + E–car. The massive one–way advancement of e–cars (near parking places and charging stations) has negative effects on the transport policy goals and takes effect especially in the car–oriented suburban areas of the city. The promotion of PMT and its infrastructure decreases the ridership of PT. In the city of Vienna these negative effects can be diminished because of the parking organization based on the principle of equidistance.

Table 3 Ridership in PT changes for the 3 policy scenarios.

Increase/Decrease of ridership in public transport [%]			
Region	**E–car**	**Equidistance**	**Equidistance + E–car**
Vienna	-0.2	2.0	2.0
Hinterland	-4.4	1.2	-2.5
Total	-1.5	1.7	0.5

7 Conclusions

We show in this paper that the one–way promotion of e–cars contradicts the transport policy goals of the city of Vienna. The results can be applied to other cities which plan to organize traffic in a more efficient and sustainable way. One of the key measures to strengthen the modal split of non–motorized traffic and public transport lies in the parking organization. As soon as car drivers have to park their cars in collective parking garages a more equitable choice of means of transport is possible. The principle of equidistance and collective garages fits perfectly into the requirements for a liveable city structure. E–cars are able to support these needs as far as the charging infrastructure is allocated in central parking garages and not in public space. Structures which permit short access and egress times to the car, promote PMT. Some negative effects of fossil fuel powered cars, like carbon dioxide emissions, can be reduced by e–cars.

The problems of congestion, use of space, energy consumption and accidents cannot be solved by e–cars. In order to benefit from e–cars without counterproductive effects, an implementation of charging infrastructure under consideration of the principle of equidistance is necessary.

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