Simulation and modelling of traffic policy impact assessment

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Abstract

In a period where environmental issues on local, interlocal and global scale become very important, the relation between transport and environment has to be clarified. Many noxious emissions are indeed caused by transport, particularly in urban areas. Also, in the field of rational use of energy, policy measures have to be defined, due to the finiteness of natural resources.

Within this scope, the use of alternative powered means of transport like electric and hybrid vehicles should be taken into consideration; the efficiency and the feasibility of this option has to be determined. For this purpose a simulation programme has been developed for the Belgian federal government, in order to assess a set of policies in favour of hybrid and electric vehicles. Their impact on energy usage, mobility and pollution are being investigated.

1 Objectives

In a first step a set of measures promoting the introduction of electric and hybrid vehicles, in regard of the specific case of the Brussels Capital Region, is defined.

In the second step the simulation tool is created. It has to be able to implement the possible policies and must give a clear overview of the results allowing the user to make a comparison to interpret the impacts of the different traffic measures, regarding emissions and energy consumption.

Finally a synthesis of all these aspects and a combination of technological and ecological aspects will be presented.

2 Definition of the policies

2.1 Restrictions on transport in certain areas

The closing of certain areas of the city centre for particular types of transport is a policy that can be implemented simply and without excessive costs. Several measures are possible:

- Fully closing of all traffic in the city centre, and make a possible exception for
  - public transport
  - environment-friendly transport (EV and HEV)

  whether time-dependent or not.

- Discouraging traffic in the city centre through
  - parking tolls for polluting vehicles
  - reserving available parking spaces for ZEV or ULEV
  - road pricing for non-ZEV when entering the centre.
- Interdiction of traffic in tourist and / or commercial zones in the city centre.

These measures can of course be implemented in combination with each other to obtain a bigger impact.

2.2 Car-sharing with EV's

This measure implies the development of a network of automatic rent-a-car stations in the Brussels Capital Region with the intention to create a basic structure for car-sharing. This means that centres, where electric vehicles can be rented, will be located near major transport interchanges. In a next stage it's possible to extend this measure with other environment-friendly vehicles and more centres.

The rent-a-car stations are located in strategically important areas: the connection with public transport should be easy and a fast access to the suburb area is necessary; there is also the need of enough parking space.

Car-sharing and public transport complement each other while car-sharing, a system of semi-public transport, maintains the privacy and flexibility of a private car, which are the main advantages of the concept. The reservation of parking space or privileged access to certain areas for the car-sharing vehicles will make the system even more attractive.

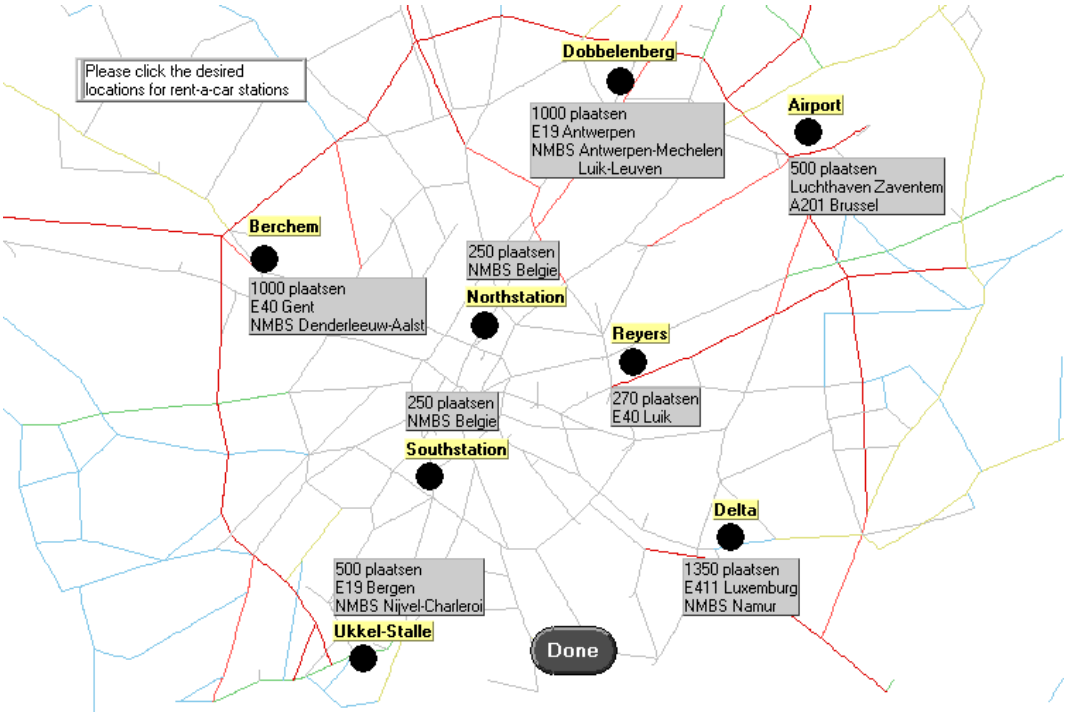

Figure 1 : Rent-a-car stations

2.3 Goods distribution with EV's

The presence of heavy lorries in the city centre reduces the quality of life and causes many traffic problems. A solution for this problem can be found in the use of electric vans for the distribution of goods in the Brussels Region, removing lorries from the city streets.

The purpose of this measure is to develop goods distribution centres at the edge of the city. This allows transshipment from lorry to electric van for distribution to the centre. Like this heavy traffic will decrease in the city and will eventually be completely eliminated, and environmental pressure and noise will be reduced. The location where these centres will be established is very important and can be done on two levels:

- Near the crossings of the outer ring road and the main approach roads to Brussels, at the edge of the Brussels Capital Region. In this way heavy traffic can not only be removed out of the city centre, but also for a big part out of the area within the outer ring road, which is more or less equal to the whole Brussels Capital Region.
- Some of the distribution centres can be located in the industrial zone within the Capital Region. This area roughly encompasses a north-south belt following the canal. This gives the possibility of intermodal transport of goods - through train stations, the canal and the airport. The opportunity of intermodal transport means undoubtedly a surplus value for these centres.

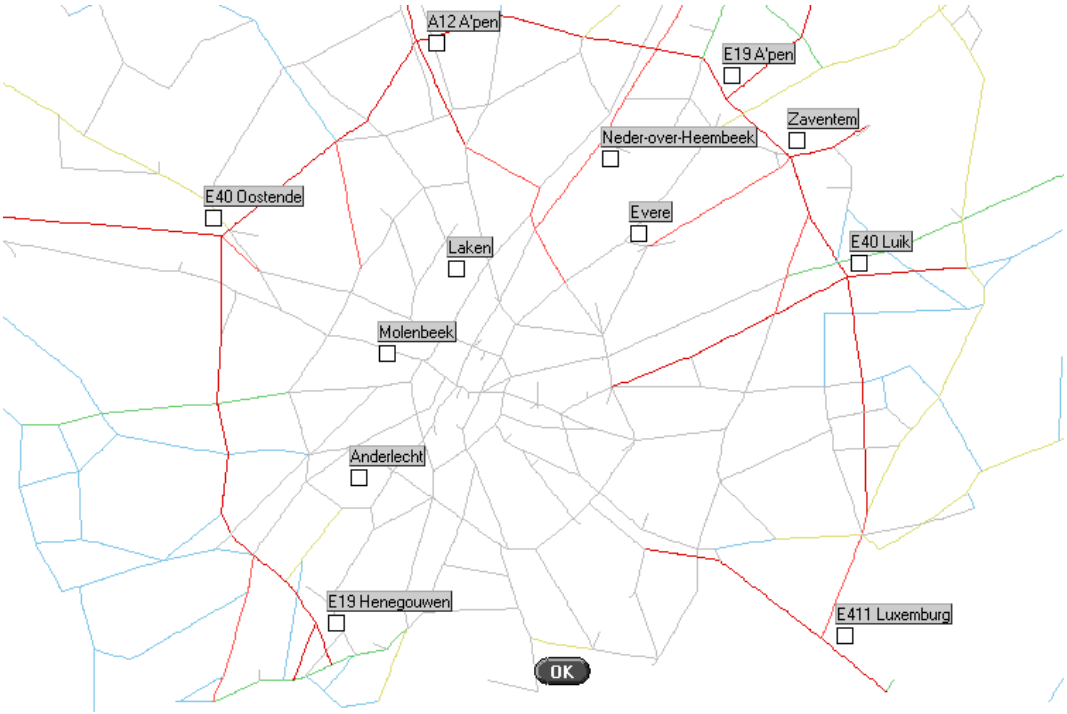

Figure 2 : Goods distribution centres in the Capital Region

2.4 Public transport

The public transport network can be adjusted on different levels in order to reduce environmental pressure and to make public transport more attractive:

- An introduction of electric and hybrid vehicles in the public transport fleet can be realised. A large variety of drive trains is available: various energy sources (oil, natural gas, hydrogen) can be used, the structure of the drive train has to be considered.
- Creating reserved sites for selected bus roads and tram routes, with the aim to serve passengers faster.
- The public transport network of Brussels can be expanded with new lines, stations, increased frequencies,…
- A connection of Brussels with its hinterland through a fast regional railway network (RER), serving a lot of stops in the city itself could be established.

Some of these measures need to be elaborated in consultation with the public transport company, the railway company and the regional governments. A lot of research and evaluation will be needed.

3 Implementation in scenarios

It is not sufficient to define a number of stand-alone measures: single measures will only have limited effects. Therefore it is important to implement a comprehensive package of measures through a scenario which synthesises and tunes different aspects of these measures.

The best way to achieve this is by dividing Brussels into three parts:

- *Centre*: The city centre, that contains the main tourist, historical, commercial and administrative areas and which will be the subject of restrictions in various scenarios.
- *Brussels Region*: The area between the inner and outer ring road, roughly equivalent to the remainder of Brussels Capital Region. This area is important for the implementation of car-sharing stations and good distribution centres.
- *Outside*: The area outside the outer ring road. It represents the rest of Belgium and is important because more than 25% of the vehicles in the Brussels Capital Region have their origin in this area. The percentage of lorries having their origin in this area is even bigger.

The scenarios can be divided into different levels to get a clearer overview of the impact of the several policies:

Level 0 Default scenario

In this first level the current situation in the Brussels Capital Region can be investigated. The data available concern the period between 7.30 and 8.30 AM, which means around 200 000 vehicles on the Brussels' roads.

In general the following subdivision can be made:

Private transport:	88 % cars	8.5 % delivery vans	and	3.5 % trucks
Cars:	26 % diesel	74 % petrol		
	(others are too small in percentage to be taken into account)			
Vans:	69 % diesel	31 % petrol		
	(others are too small in percentage to be taken into account)			
Lorries	100 % diesel			

These values can be tuned according to changes in traffic or according to the wishes of the user (introduction of LPG, CNG,…).

In this level no electric nor hybrid vehicles are taken into account (only a few are currently present).

Level 1 Introduction of electric and hybrid vehicles

This category indicates the arbitrary introduction of electric and hybrid vehicles without additional measures. The importance of these scenarios is to illustrate direct connection between the number of electric and hybrid vehicles and the decrease of emissions and energy consumption.

The introduction can be done differently in the 3 areas:

	Centre	*Brussels Region*	*Outside*
Electric Vehicles	X1 %	X2 %	X3 %
Hybrid Vehicles	Y1 %	Y2 %	Y3 %
Thermal Vehicles	100 – (X1+Y1) %	100 – (X2+Y2) %	100 – (X3+Y3) %

Table 1 : Introduction of electric and hybrid vehicles

Where X1 → X3 and Y1 → Y3 can be tuned according to the wishes of the user or the expectation for the future. It is clear that the penetration of electric vehicles will be bigger in the city centre than outside.

Following figures will be used as indicating values:

X1, Y1, Y2, Y3	0 → 100	(steps of 10 %)
X2	0 → 60	(steps of 10 %)
X3	0 → 20	(steps of 5 %)

This introduction scenario will always be the basic scenario for the policies to be taken. Additional measures, as described in level 2, can be defined to see their influence on situations, defined in this level.

Level 2 Additional measures

These measures can be taken as stand-alone measures but preferably they are taken in combination with other measures from this level. They always have a base scenario, defined in level 1 and their influence can be derived and compared per base scenario.

(a) Tolls

The aim of this measure is, in the first instance, to discourage traffic (mainly non-ZEV) to the city centre and stimulate them to make use of environment-friendly transport instead. In this case people will have the following options: keep going with their usual car and consequently pay a serious additional cost, change to public transport, or make use of car-sharing. These tolls will be introduced in the *Centre* area and are programmed in TRIPS.

The tolls can be defined in three different ways:

- Parking tolls: these insert extra costs to reach the destination in the city centre. This can be done separately for thermal and other vehicles (e.g. no parking tolls for ZEV) and also in the form of reserved parking zones for ZEV.
- Traffic tolls: these are the result of a 'road pricing' policy and introduce extra costs to enter the centre, or the area in the outer ring road (for all traffic or separately for thermal and other vehicles).
- Traffic restriction: this practically means the closing of some city centre areas or roads to all traffic or to non-ZEV.

(b) Automatic rent-a-car stations and goods distribution centres

These measures are well described above. The scenarios differ in the number and the location of stations and centres, two parameters which are defined by the user.

(c) Public transport

- Introduction of hybrid buses on different bus lines: by progressively increasing the number of bus lines that are served by hybrid buses, one can study not only the environmental impact of these introductions, but also the performances in comparison with the classic diesel buses.
  This improvement in life quality is best seen in combination with other measures.
- Implementing some of the former scenarios can result in a noticeable increase of the use of public transport and the need to modify some bus, tram or underground lines (adaptation of time schedule, new lines…). This forms part of more situation-specific scenarios and can be considered as a way of fine-tuning the scenarios.

4 Simulation tool

To be efficient the simulation tool needs to fulfill some requirements:

- User friendly - the interface with the user must be easy to understand and to work with;
- Integration of different modules in a simple and straight structure;
- Acceptable calculation time;
- Accurate and reliable simulation algorithms and/or use of validated software;
- Flexible - the implementation of new scenarios must be easy;
- Correct representation and easy overview of results.

The tool consists of the following components:

- A traffic simulation programme TRIPS;
- A dynamic vehicle simulation programme VSP, which is developed at the Vrije Universiteit Brussel and contains a database of various vehicles (thermal as well as electric and hybrid);
- A database with the static emission factors of COPERT II;
- The previous components are coupled through a user interface SCENARIO, developed at the VUB, and a graphical interface in which the results can be represented.

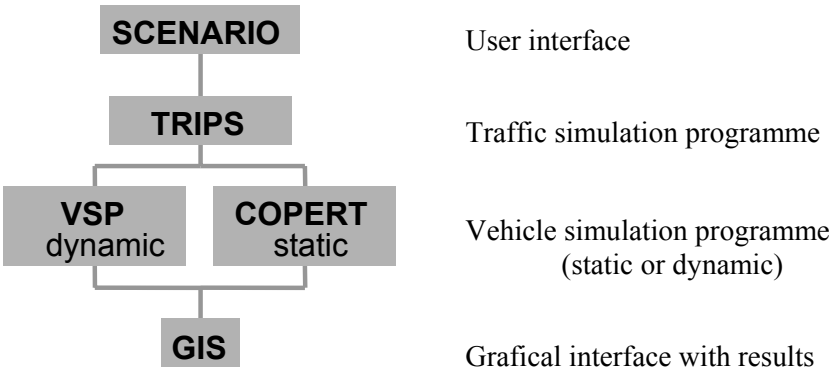

Figure 3 : Overview of the simulation tool

4.1 SCENARIO

This module represents the interface with the user. The scenarios can be implemented in a simple and easy way. Here also the decision has to be taken whether to calculate static (COPERT) or dynamic (VSP) emissions.

The user has the choice to modify the default set up (the actual situation in Brussels) by clicking on the submodules.

If the choice was made to calculate dynamic emissions, the next modifications can be done:

- *Subdivisions*: in this module the user can change the partition between different kinds of road transport means, used for private transport
  - Traffic: partition car - delivery van - truck
  - Cars: partition electric - hybrid - thermal
  - Vans: partition electric - hybrid - thermal
  - Trucks: partition hybrid - thermal

- *Traffic restrictions*: in this module the user can introduce certain restrictions such as parking tolls, traffic tolls (road pricing) and closing of certain city centre areas for all traffic or for specific kinds of vehicles.
- *Automatic rent-a-car*: this module offers the opportunity to introduce car-sharing stations on strategic locations.
- *Goods distribution:* this module offers the opportunity to introduce goods distribution centres on strategic locations, according to the needs.
- *Public transport*: in this module the user can modify the public transport.

If, on the other hand, the choice was made to calculate static emissions, the next modifications can be done:

- *Subdivisions*: in this module the user can change the partition between different kinds of road transport means - passenger cars - light duty vehicles - heavy duty vehicles - buses - mopeds - motorcycles – which can be further subdivided by fuel type, vehicle size and emission class.
- *Traffic restrictions*: in this module the user can introduce certain restrictions such as parking tolls, traffic tolls (road pricing) and closing of certain city centre areas.
- *Public transport*: in this module the user can modify the public transport.

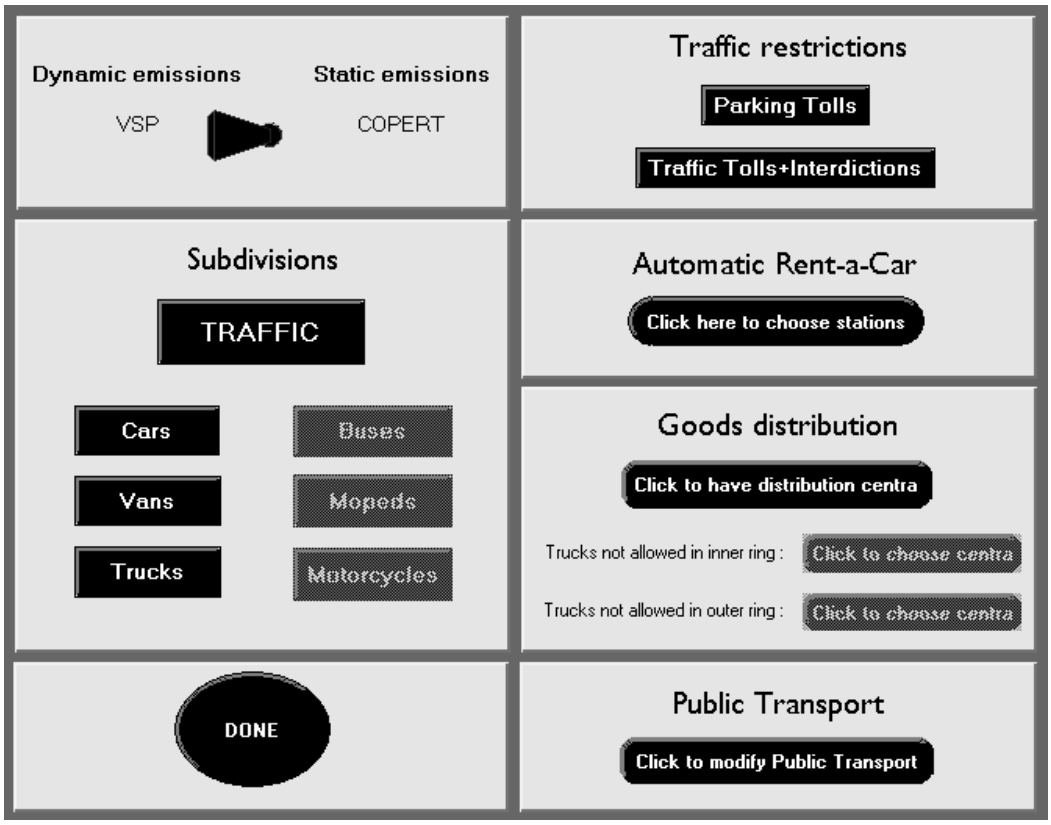

Figure 4 : Front panel SCENARIO

4.2 TRIPS

When the user has defined his input, different origin-destination matrices are created for the different kind of transportation means. TRIPS (a world-wide used, validated simulation tool) will then perform the traffic simulation, loading the vehicles onto the network, taking into account the details and properties of the network and the desired measures, as defined by the users in SCENARIO.

Paths are then built, using the following generalised cost function for each link:

$$GC = (TCOST * T) + (DCOST * D) + (TLCOST * TL)$$

where T = time D = distance TL = toll

TCOST, DCOST en TLCOST are weighting coefficients that are set by the user and represent the importance the user gives to the different cost parameters.

As an output TRIPS releases the used paths, speeds, distances, number of cars… which will be used to calculate emissions, energy consumption and mobility aspects.

4.3 VSP

If was chosen for the dynamic emissions, VSP, the vehicle simulation program, created at the Vrije Universiteit Brussel, will perform these calculations. This is done based on speed cycles, derived from the output of TRIPS and remodelled into real traffic situations (accelerations, stand still, driving behaviour…).

VSP offers as an output the emissions and the energy consumption for each type of vehicle in each particular part or area of the city.

4.4 COPERT

If on the other hand was chosen for static emissions, the COPERT methodology will be applied to calculate emissions and energy consumption, based on average speed which was calculated in TRIPS.

Although COPERT is widely used, it's not possible, contrary to VSP, to take driving behaviour into account, as well as new technolgies like electric and hybrid vehicles can't be simulated. But the advantage of COPERT is that less data are needed and all necessary data are available. This gives the possibility to create a frame of reference.

4.5 EMICON (GIS)

This module, written in TRIPS, provides a graphical interface to view and compare the results of the different scenarios.

This is illustrated in Figure 5 where the emission of CO (caused by traffic) in the centre of Brussels is visualised for 4 different scenarios.

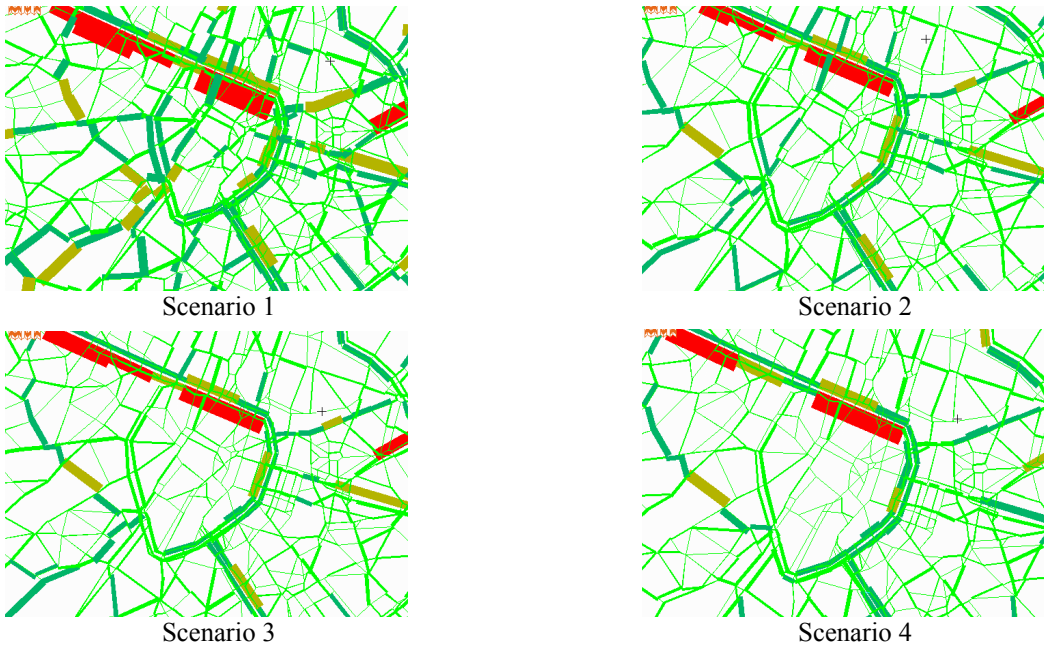

Figure 5 : Graphical comparison of some scenario's, regarding the emission of CO

The more red and the thicker the lines, the more CO that is emitted by traffic. The light green parts represent the cleaner areas.

Scenario 1 represents the current situation. One can notice the big amount of emissions in the approach roads to the city centre.
Scenario 2 is the result of the introduction of 10 % electric vehicles in city traffic. We notice a clear decrease of the CO-emissions on the roads.
Scenario 3 introduces heavy parking tolls for non-ZEV in the area within the inner ring road. We notice that the emissions within the pentagon are reduced heavily.
Scenario 4 is the result of a parking interdiction for non-ZEV in the area within the inner ring road. CO-emissions are almost reduced to zero (since most of the traffic is ZEV). Only on the north-south axe one can see a small amount of emissions, caused by thermal vehicles crossing the pentagon to avoid the traffic jam on the inner ring road.

5 Conclusion

A powerful simulation tool has been developed, being able to implement a wide range of possible scenarios (constituting of various measures to introduce electric and hybrid vehicles in the Brussels Region). The user has the ability to compare different traffic policies, regarding emissions and primary energy consumption. The final results will be shown on the symposium and will be available in paper format.

The simulation tool is user-friendly, fast and very flexible: when the data are available, it takes few additional work to implement new cities and new strategies, which makes it available for a wide range of possible studies on cities (or more expanded, countries or more detailed, city areas) regarding the impact of electric and hybrid vehicles on the environmental and energetic level. It is also very simple to add additional forms of alternative vehicles.

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