Emissions count

Linking PTV's Visum with HBEFA 3.1 will help planners to improve the increasingly important environmental assessments, through emissions calculation

Words | **Dr Klaus Nökel & Timo Hoffmann, PTV, Germany**

In a world of dwindling resources and changing climate, transportation planning can no longer be a simple exercise of matching supply to demand. Intelligent solutions to today's traffic problems need to demonstrate that they are environmentally sound, in addition to providing the desired mobility. Recent legislation, and the findings from environmental research, define a framework against which the sustainability of a given planning scenario can be measured quantitatively in terms of capacity, from the traffic engineering perspective.

Among different measures of effectiveness, traffic-related emissions and immissions (the materials that contaminate the air and have an effect on people, animals, and buildings) of various greenhouse gases and other pollutants remain the focus of environmental assessments. In practical terms planners take the traffic volumes predicted by a demand model and compute first emissions per network link, then aggregate in space, or feed the emissions into a second model for immissions.

The formula

The basic approach for emission calculation follows a very straightforward equation:

Emission = Traffic Volume x Emission factor

In this equation 'emission' stands for the total mass of a pollutant species such as CO_2 or NOx emitted by the vehicles on a network link during a given time interval. The traffic volume is the number of vehicles that traverse the link within that time interval. Demand models, such as those developed in VISUM (PTV's flexible software system for transportation planning, travel demand modeling, and network data management), yield traffic volumes, either as totals or broken down by vehicle type such as cars, light trucks, and heavy trucks. These volumes are then multiplied by emission factors, the 'unit costs' in emission modelling. Obviously, emission factors are not constants, but functions of several factors. Speed, link type (such as motorway versus city street), engine type, gradient, even temperature – all have a considerable impact. The functional relationship is determined through a vast amount of empirical work, measuring actual emissions in the field and in the lab, taking a variety of driving patterns into consideration.

Mapping the fleet

How does the VISUM-HBEFA 3.1 link simplify life for the transportation planner? The first step is mapping the vehicle types used in the demand model to those used in HBEFA. Demand models typically distinguish only a very small number of different vehicle types, termed transportation systems, often only cars and trucks. This is much too aggregate for emission calculations. In fact, each transportation system represents a mix of many vehicle types that behave similarly in terms of demand modeling, but have very different emission factors. The providers of HBEFA offer ready-made mixed fleets for different countries and years as part of the database. For a national model of a region in Austria, the planner might map the VISUM transportation system 'car' to the HBEFA standard fleet-mix 'Car Austria 2015', composed of dozens of specific vehicle types. For applications in countries not covered by HBEFA, or for specific technology scenarios, users can take a standard-fleet mix as a starting point and then modify it.

Mapping traffic situations

Emission factors depend not only on the vehicle type, but also on the traffic situation in which the vehicle is operating. In terms of emissions, coasting at 100km/h on a motorway is dramatically different from stop-and-go in front of a traffic signal on an urban arterial. HBEFA captures these differences by the traffic situation descriptors recommended by Artemis.

Each traffic situation is defined by four descriptors, three of which relate to facility type and location (urban/rural, functional road class, free-flow speed). These three descriptors have an immediate counterpart in a VISUM model, as they are attributes of links (or link types).

The fourth descriptor (LOS) is a qualitative four-step scale describing the traffic-flow state from free to traffic jam. Finding a proxy for it in a demand model is less straightforward, but a classification of volume-capacity (v/c) ratio or of actual-to-free-flow speed ratio are natural choices. Guidance on threshold values for the four LOS classes is the subject of ongoing research, and users will be able to customize the relationship.

With the two mappings in place, emission calculation becomes a very easy post-processing of an assignment result from the demand model. For each network link VISUM breaks down the volume to the HBEFA fleet mix, looks up the traffic situation and its emission factor, corrects for gradient, and multiplies the result.

Cold-start emissions

All the above relates to warm emissions and ignores one particularly important part of total emissions: those on the first few kilometers. Cold-start emissions are often

Why HBEFA 3.1?

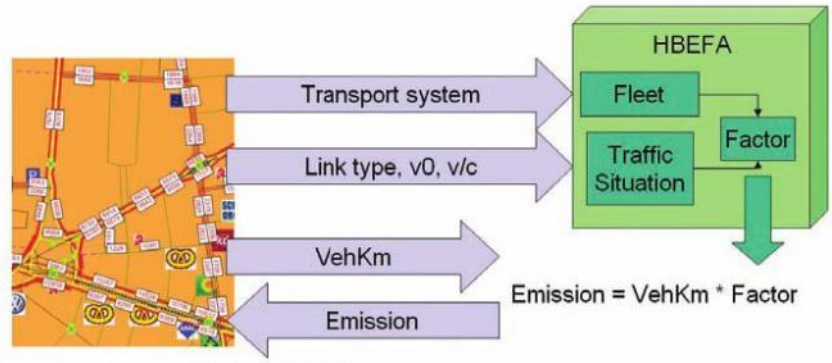
This type of research project consumes vast resources, making a supranational approach desirable, and more than 10 years ago the German, Swiss, and Austrian environmental agencies pooled their resources to compile a comprehensive database of emission factors. The result was published as *the Handbook of Emissions Factors* (HBEFA). After several revisions, the HBEFA now faces the next major revision in which the emission factors will be updated to take into account new engine concepts and emission standards, including the findings from the EU-funded Artemis research project on transport emission models and inventory systems.

ARTEMIS proposes a new set of systematic descriptors for traffic situations that simplifies mapping from transportation models to emission models. Sweden, the UK, and France have now joined the HBEFA consortium, so that the revised HBEFA should, eventually, become a truly European emission-factors' standard. Against this background, VISUM developers took the logical decision to make HBEFA 3.1 the emission model to be integrated with VISUM.

> "With the two mappings in place, emission calculation becomes a very easy post-processing of an assignment result from the demand model"

neglected or explained away, because ordinary traffic counts can be broken down by vehicle type, but obviously not by 'time since engine start'. The picture changes completely if traffic volumes are taken from a demand model.

Modern software packages such as VISUM store the full trajectory for each assigned trip, so by inverting this information it is, indeed, possible to tell which fraction of the volume on a given network link corresponds to vehicles within the first few hundred meters of their trip. After adjusting for cordoning effects near the model boundary, this information can be used to make a calculation, derived from the model, rather than being a pure guesstimate of cold-start emissions. Such a capability may alter the total emissions distribution considerably.

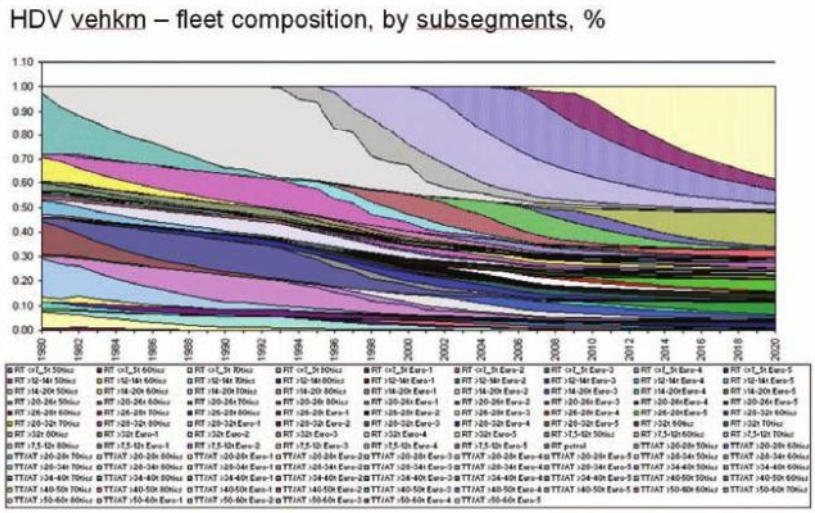


Data flow between VISUM and HBEFA

Link to immissions

Emissions are often not the end of the processing pipeline. In order to compare the environmental impact with thresholds imposed by legislation, they have to be converted to immissions first – materials which contaminate the air and have an effect on people, animals, and buildings. This conversion, taking into account dispersal around detailed 3D topography and air chemistry, is the realm of specialized software outside the transportation planning suites. The good news is that due to open GIS standards, interoperability is not a problem, and in packages such as VISUM it is a snap to export emissions per link such as ESRI Shapefiles to any GIS-enabled immission model.

The VISUM development team is now preparing the software for the integration of HBEFA, and PTV has announced that the link will be available very shortly after the official release of HBEFA 3.1.



Above: Example of changes of the fleet composition in Sweden. Each color represents a HBEFA vehicle type. The HBEFA database includes the vehicle-type share of the entire fleet for each year between 1990 and 2020

Traffic count-data management

PTV's traffic count-management system is another advanced solution which enables transportation planners and traffic engineers to compare traffic and environmental data for evaluation purposes. Traffic-

count data is a vital component for traffic and transportation planning. It provides the basis for the design of road infrastructure and pavement-management systems. Moreover, it assists in calibrating and updating traffic models and supports decision-making processes in the field of urban construction.

There is an enormous amount of count data from traffic count sites using state-of-the-art sensing instruments. Past experience has shown that handling these extremely large data volumes is often very time-consuming. However, data-quality assessment is essential for traffic planning and control.

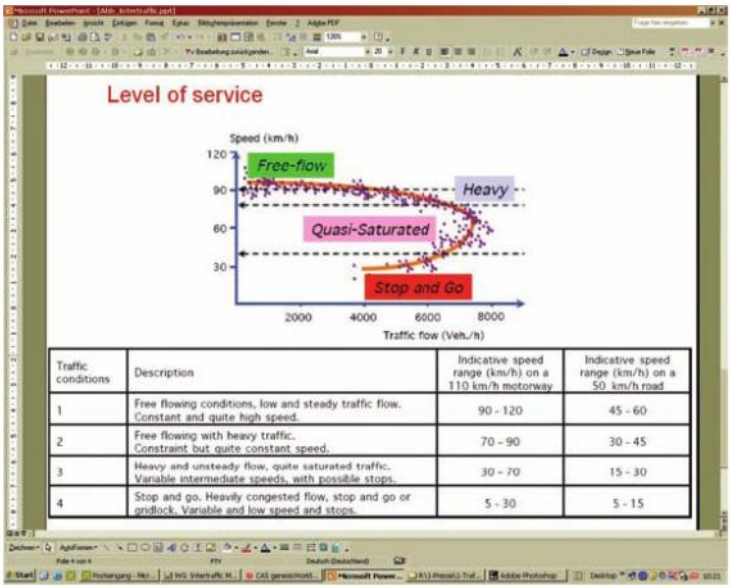
The PTV TrafficCountManagement software system copes with the ever increasing amounts of data and delivers current and historical values and key reports within seconds. The visualization of the measured traffic counts ensures a complete overview of the traffic situation and increases its quality by additional automatic plausibility checks and manual adjustment options. Its centralized database and state-of-the-art graphic user interface provide easy access to all data. Several systems are being used in Europe and North America – some with more than a billion count values stored in the database.

The great variety of information provided by the PTV TrafficCountManagement system is based upon individual raw data supplied by the detector. This data ranges from classic regular time series for separate lanes, directions or cross-sections, and data on different classes of vehicle and speed, or weight, categories to complex reports of peak traffic volumes per vehicle-type and day of the week.

Data import and export of reports follow an automatic workflow, minimizing the system time needed to process and summarize the data. Moreover, the system enhances results-data quality, leading to a more reliable basis for the entire transportation planning process.

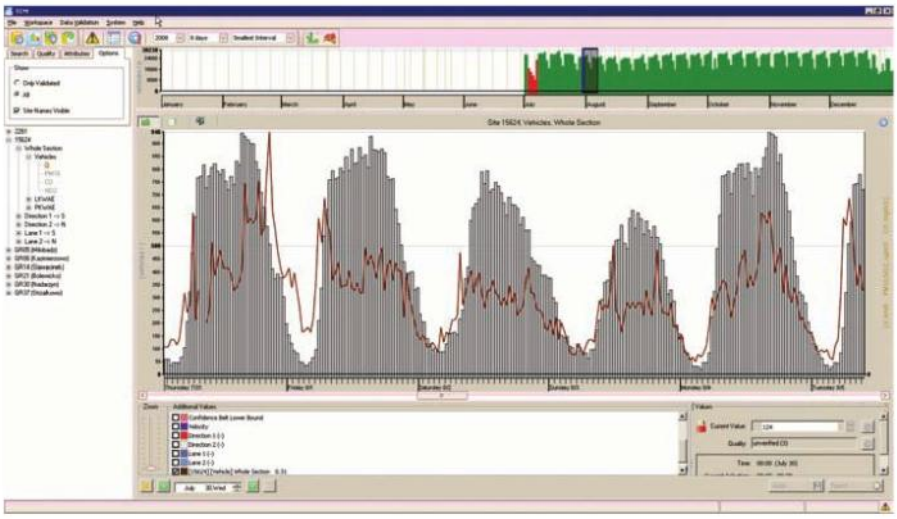
Comparing traffic data

The scope of data types supported by PTV TrafficCountManagement includes both primary traffic-count data and environmental data. Pollution values for air pollutants such as NOx, CO, and particulate-matter emissions can be imported into the PTV TrafficCountManagement database for further evaluation. In particular, the visualization of the environmental data together with traffic volumes, or speed characteristics, enables users to evaluate relationships between the following two factors: the amount and speed of traffic.



Traffic conditions	Description	Indicative speed range (km/h) on a 110 km/h motorway	Indicative speed range (km/h) on a 50 km/h road
1	Free flowing conditions, low and steady traffic flow. Constant and quite high speed.	90 - 120	45 - 60
2	Free flowing with heavy traffic. Constraint but quite constant speed.	70 - 90	30 - 45
3	Heavy and unsteady flow, quite saturated traffic. Variable intermediate speeds, with possible stops.	30 - 70	15 - 30
4	Stop and go. Heavily congested flow, stop and go or gridlock. Variable and low speed and stops.	5 - 30	5 - 15

Left: Comments on LOS descriptors for traffic situations and recommendation on threshold values



Above: PTV TrafficCountManagement offers a flexible and comprehensive visualization of traffic count data in combination with environmental data

These usually have a direct impact on the occurrence of certain environmental pollutants at a given location.

The PTV TrafficCountManagement software therefore helps to assess not only the traffic implications, but also the environmental effects of traffic management measures, such as driving restrictions or speed limits, temporary or permanent adjustments, regulations for all vehicles or specific vehicle types, and stationary traffic regulations.

In recent years, the effectiveness of traffic management has been judged on its impact on flow and on its contribution to the reduction of the traffic's environmental footprint. This dual emphasis is likely to be increasingly important and the TrafficCountManagement is a comprehensive system to quantify these effects. ■