Energy savings from public traffic management

The new streamSAVE Plus methodology to calculate energy savings from public traffic management

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General framework

- Traffic management is the **organization, arrangement, guidance and control of both stationary and moving traffic** including all the types of users (such as pedestrians, cyclists and all types of vehicles).
- The main objective is the **provision of safe, orderly and efficient movement** of persons and goods and the **protection of the quality of the local environment** on and adjacent to roads.
- The traffic management can be achieved through the application of **targeted traffic control measures**, within a defined policy framework, **over a length of road or an area**, in order to attain specified objectives.
- Traffic management is typified by its application over a **specific area or length of the route**. The application of a **traffic management measure is unique** creating difficulties during the development of a standardised bottom-up equation so as to calculate the triggered impacts.
- The conduction of **active transportation and demand management measures** is considered as a fundamental pillar of the traffic management measures aiming at the **dynamic management, control, and influence of travel demand, traffic demand, and traffic flow of transportation facilities**.
- **Active management of transportation and demand can include multiple approaches** such as spanning demand management, traffic management, parking management and efficient utilization of other transportation modes and assets.

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Impacts

Alleviate congestion and promote smoother traffic flow

Reduce stop-and-go driving and minimize the idling time leading to considerably lower fuel consumption for the affected vehicles

Reduce the travel distance and time (reduction in total vehicle-distance traveled) leading to improved energy efficiency (reduction of per-km energy consumption)

Encourage people to use public transport for a share of their journey leading to additional energy savings due to the fact that the users switch to a less energy-intensive transportation mode

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Challenges

Data collection

- The methodology provides useful insights for the specific energy consumption of the different categories of vehicles, the average yearly distance travelled of reference vehicles and the expected energy savings delivered by the traffic management measures.

Definition of baseline

- The methodology suggests indicative values to streamline baseline calculations for the different Member States, based on the actual energy consumption data, which are available.

Lack of standardized calculation methodologies

- The methodology allows the calculation of the delivered energy savings through a simplified approach based on the actual energy consumption data for each Member State separately.

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Traffic management measures

Active Traffic Management	The category of active traffic management includes measures to **dynamically manage recurrent and non-recurrent congestion** based on prevailing and predicted traffic conditions
Active Demand Management	The category of active demand management foresees measures to **reduce or redistribute travel demand to alternative modes or routes** through the provisions of rewards to drivers for travelling during off-peak hours with less traffic congestion
Active Parking Management	The category of active parking management includes measures to **affect the demand on parking capacity**
Traffic calming measures	The implementation of traffic calming measures aims at the **reduction of the vehicle speeds and traffic**

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Overview of the indicative measures

Active Traffic Management	Active Demand Management	Active Parking Management	Traffic calming measures
• Adaptive Ramp Metering • Adaptive Traffic Signal Control • Dynamic Junction Control • Dynamic Lane Reversal or Contraflow Lane Reversal • Dynamic Lane Use Control • Dynamic Merge Control • Dynamic Speed Limits • Part-Time Shoulder Use • Queue Warning • Transit Signal Priority	• Dynamic Fare Reduction • Dynamic High-Occupancy Vehicle (HOV) / Managed Lanes • Dynamic Pricing • Dynamic Ridesharing • Dynamic Routing • Dynamic Transit Capacity Assignment • On-Demand Transit • Predictive Traveler Information • Transfer Connection Protection	• Dynamic Overflow Transit Parking • Dynamic Parking Reservation • Dynamic Wayfinding • Dynamically Priced Parking	• New infrastructure development • Technical measures • Reduction of speed limits • Establishment of traffic restricted zones • Autonomous vehicles • Behavioural measures

Source: https://ops.fhwa.dot.gov/atdm/approaches/atm.htm

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Calculation of final energy savings (Article 8)

- The application of the traffic management measures can affect **all the various types of vehicles in the transport sector.**
- The actual determination of the affected types of vehicles can be performed based on the **design of the implemented traffic management policies** (e.g. specific area or length of the targeted route and the utilization of specific categories of vehicles).
- The boundary conditions are defined by the **application of each traffic management measure separately according to the design aspect**. The boundary conditions **are unique as they can be differentiated based on the design of the implemented traffic management measures** (e.g. specific area or length of the targeted route).

$$\boldsymbol{TFES} = \sum_i (n_i * DT_i/100 * \mathrm{sFEC}_{ref,i}) * S$$

TFES	Total final energy savings [kWh/a]
$sFEC_{ref,i}$	Specific final energy consumption of each type of affected vehicle [kWh/100 km]
n_i	Number of affected vehicles [number]
DT_i	Average distance travelled of affected vehicles [km/a]
S	Energy saving factor [%]
i	Index of the different types of affected vehicles

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Calculation of final energy savings (Article 8)

Indicative values for the specific final energy consumption of each type of affected vehicles (kWh/100 km)

	EU27
Total vehicles	**98.4**
Passenger transport	**79.5**
Powered two-wheelers	**41.1**
Passenger cars	**75.1**
Gasoline engine	76.4
Diesel oil engine	74.3
LPG engine	79.9
Natural gas engine	80.5
Plug-in hybrid electric	41.3
Battery electric vehicles	16.8
Motor coaches, buses and trolley buses	**637.2**
Gasoline engine	204.3
Diesel oil engine	641.6
LPG engine	519.8
Natural gas engine	638.6
Battery electric vehicles	355.1
Freight transport	**197.7**
Light commercial vehicles	**104.2**
Gasoline engine	99.8
Diesel oil engine	104.5
LPG engine	115.8
Natural gas engine	103.8
Battery electric vehicles	21.8
Heavy goods vehicles	**424.1**
Domestic	391.5
International	503.6

Indicative values for the energy saving factor

Energy saving factor	[%]
Traffic management measures	Range from 2% to 70% depending on the design of the measure 17% of energy savings as median value

Indicative values for the lifetime of savings

Lifetime of savings	[years]
Traffic management measures	5-10 years or the actual duration of the measures

Data sources for indicative calculation values:

- The **specific final energy consumption of each type of affected vehicle ($sFEC_{ref}$)** was derived from the JRC-IDEES database taking into consideration the available data in the period 2010-2021 at EU level.
- **Indicative energy saving factors (S)** of the different traffic management measures were collected from different studies, reports, papers and plans after the conduction of a bibliographical review.

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Database with studies, reports, papers and plans

Parameters	Measures	Country	Impact estimates	References
Work zone management border control for both passengers and cargo	Longer freight trains	Norway	Energy savings of 2.6% on average, while a 3.6% decrease in CO2 emission was recorded	Pinchasik, D. R., Hovi, I. B., Mjøsund, C. S., Grønland, S. E., Fridell, E., & Jerksjö, M. (2020). Crossing Borders and Expanding Modal Shift Measures: Effects on Mode Choice and Emissions from Freight Transport in the Nordics. Sustainability, 12, 894. doi:10.3390/su12030894
	Combined longer trains and rail ecobonus	Norway	Energy savings of 3.1% on average, while a 3.6% decrease in CO2 emission was recorded	
	Road-rail intermodal freight transport	Europe	Energy savings of 43% on average, while a 77% decrease in CO2 emission was recorded	https://trimis.ec.europa.eu/documents/using-road-rail-intermodal-freight-transport-reduce-ghg-emissions
Adaptive Ramp Metering	Ramp Metering with Fuel Consumption Objective	Netherlands	Energy savings of 15%-29.6% on average	Vreeswijk, J. D., Woldeab, Z., de Koning, A., & Bie, J. (2011). Ramp metering with an objective to reduce fuel consumption. In 8th European Congress and Exhibition on Intelligent Transport Systems and Services, Lyon, 6–9 June, 2011 (On CD-ROM) (pp. 1–10). ITS. https://research.utwente.nl/en/publications/ramp-metering-with-an-objective-to-reduce-fuel-consumption
Adaptive Traffic Signal Control	Adaptive Traffic Signal Control (SCATS)	-	Energy savings of 2% on average	Stevanovic, A., Stevanovic, J., & Kergaye, C. (2012). Environmental Benefits of Adaptive Traffic Control System: Assessment of Fuel Consumption and Vehicular Emissions. Transportation Research Board 91st Annual Meeting. https://trid.trb.org/view/1128863
	Smart traffic lights at a single intersection	-	A 32%-40% decrease in CO2 emission was recorded	Santos, O., Ribeiro, F., Metrôlho, J., & Dionísio, R. (2023). Using Smart Traffic Lights to Reduce CO2 Emissions and Improve Traffic Flow at Intersections: Simulation of an Intersection in a Small Portuguese City. Applied System Innovation. https://doi.org/10.3390/asi7010003

Collection of data

- The **affected vehicle distance-travelled and the number of the affected vehicles** can be assessed through the conduction of a **detailed study of the targeted route** in the base year before the implementation of the traffic management measure.
- The **study** should include the following steps:
  - Document the study area including layout and design features
  - Detail the traffic and parking conditions
  - Assess the total travel characteristics of the study area (all modes)
  - Determine the distribution of this traffic (directions of approach and departure) and the utilized routes
  - Identify paths and routes used by non-car traffic (deliveries, pedestrians, cyclists, buses etc.)
  - Assess effects on traffic operation and circulation, including intersections
  - Assess traffic operations within the study area
  - Determine the level of traffic generation using specific KPIs (e.g. number of affected vehicles, composition of vehicles, average vehicle distance-travelled, energy consumption etc.)

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Calculation of impact on energy consumption (Article 4)

$$EPEC = \sum_i (n_i * DT_i/100 * sFEC_{ref,i} * f_{PE,i}) * S$$

EPEC	Effect on primary energy consumption [kWh/a]
$sFEC_{ref,i}$	Specific final energy consumption of each type of affected vehicle [kWh/100 km]
n_i	Number of affected vehicles [number]
DT_i	Average distance travelled of affected vehicles [km/a]
S	Energy saving factor [%]
i	Index of the different types of affected vehicles
$f_{PE,i}$	Final to primary energy conversion factor based on the affected vehicles

Conversion factors from final to primary energy

	EU27
Total vehicles	1.113
Passenger transport	1.114
Powered two-wheelers	1.116
Passenger cars	1.114
Gasoline engine	1.115
Diesel oil engine	1.112
LPG engine	1.119
Natural gas engine	1.008
Plug-in hybrid electric	1.599
Battery electric vehicles	2.281
Motor coaches, buses and trolley buses	1.113
Gasoline engine	1.115
Diesel oil engine	1.112
LPG engine	1.119
Natural gas engine	1.010
Battery electric vehicles	2.281
Freight transport	1.112
Light commercial vehicles	1.112
Gasoline engine	1.115
Diesel oil engine	1.112
LPG engine	1.119
Natural gas engine	1.008
Battery electric vehicles	2.281
Heavy goods vehicles	1.112
Domestic	1.112
International	1.112

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Overview of costs

Investment costs

- The upfront costs are triggered by the procurement and installation of the required equipment within the context of the selected traffic management measure. The investment costs constitute one-time expenditure and include the capital equipment costs and other soft costs linked with the design and installation of the selected equipment. The investment cost can include both the basic "backbone" infrastructure equipment and the installation of additional roadside elements.

Operating and maintenance costs

- The operating and maintenance costs are required on annual basis in order to run and maintain the traffic management measures. The operating costs includes the required staffing for the continuous operation of the selected traffic management measures. The maintenance costs can include the costs for additional maintenance staff, ongoing training, upkeeping and replacing minor system components.

Replacement costs

- The replacement costs include the periodic costs of replacing and/or redeploying system equipment in the case that their technical lifetime will end to ensure the continuation of the applied traffic management measures.

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Overview of costs

- The estimation of the costs related to the traffic management measures is not easy and standardized, as it **depends on the actual characteristics of the applied traffic management measure** (e.g. specific area or length of the targeted route).
- Indicative values have been collected resulting in a median value equal to **1.8 million $ per directional mile**.

Location (Year)	Measure	Cost
United Kingdom M42 (2008)	Dynamic Speed Limit, Dynamic Lane Assignment and Dynamic Shoulder Lane with shoulder treatments	15 million $ per route mile - equates to 7.5 million $ per directional mile
Washington State I-5 (2010)	Dynamic Speed Limit, Dynamic Lane Assignment and Queue Warning	23 million $ for 7-mile northbound segment - equates to 3.2 million $ per directional mile for three-lane section and 4 million $per directional mile for five-lane section
Washington State I-90 and SR 520 (2010-2012)	Dynamic Speed Limit, Dynamic Lane Assignment and Queue Warning	38.4 million $ for 17-mile segment (both directions) - equates to 1.1 million $ per direction mile
Minnesota I- 35W (2010)	Dynamic Speed Limit, Dynamic Lane Assignment and Dynamic Shoulder Lane	21.5 million $ for 10-mile stretch - equates to 1.1 million $per direction mile
Minnesota I-94 (2010)	Dynamic Speed Limit, Dynamic Lane Assignment and Queue Warning	15 million $ for 4-mile stretch - equates to 3.75 million $ per route mile or 1.9 million $ per direction mile
Philadelphia I-95 (2014)	Dynamic Speed Limit and Dynamic Lane Assignment	950 thousand $ per directional mile
New Jersey (2015)	Dynamic Speed Limit, Dynamic Lane Assignment and Queue Warning	1.8 million $ per directional mile

Source: https://ops.fhwa.dot.gov/atdm/approaches/atm.htm

Calculation of greenhouse gas savings

$$GHGSAV = \sum_i \left(n_i * DT_i/100 * sFEC_{ref,i} * {f_{GHG,i}}/{10^6}\right) * S$$

GHGSAV	Greenhouse gas savings [t CO_2 p.a.]
$sFEC_{ref,i}$	Specific final energy consumption of each type of affected vehicle [kWh/100 km]
n_i	Number of affected vehicles [number]
DT_i	Average distance travelled of affected vehicles [km/a]
S	Energy saving factor [%]
i	Index of the different types of affected vehicles
$f_{GHG,i}$	Emission factors of affected vehicles [t CO_2/kWh]

Emission factors (g CO_2/kWh)

	EU27
Total vehicles	**246.6**
Passenger transport	**245.1**
Powered two-wheelers	**242.2**
Passenger cars	**245.0**
Gasoline engine	240.2
Diesel oil engine	250.2
LPG engine	227.2
Natural gas engine	191.7
Plug-in hybrid electric	238.4
Battery electric vehicles	133.3
Motor coaches, buses and trolley buses	**246.8**
Gasoline engine	241.0
Diesel oil engine	250.4
LPG engine	227.2
Natural gas engine	178.9
Battery electric vehicles	133.3
Freight transport	**250.0**
Light commercial vehicles	**249.3**
Gasoline engine	241.0
Diesel oil engine	250.3
LPG engine	227.2
Natural gas engine	193.2
Battery electric vehicles	133.3
Heavy goods vehicles	**250.4**
Domestic	250.3
International	250.5

Thank you for your attention!

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Thank You

Get in touch for more information!

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