Calculation of the maximum weighted average infrastructure charge
Methodology and results

This appendix describes the used methodology and results of the preliminary calculation of the maximum weighted average infrastructure charge. An overview of the steps in the calculations can be seen in sub-appendix 1. In general, the methodology for calculation the road infrastructure cost is described in section 1. Section 2 covers the allocation of the costs to vehicles categories.

The calculation of the maximum weighted average infrastructure tariff is based on the guidelines and core principles outlined in the Eurovignette directive and follow the German methodology. Furthermore, knowledge and experiences from other countries (e.g., Germany), which have already implemented distance-based charging schemes for heavy goods vehicles (HGVs), have been taken into consideration. Regarding the method for allocating road infrastructure costs, the allocation principle is based on earlier analyses carried out by the Danish Road Directorate, on evaluations by expert professionals from the Danish Road Directorate and based on findings in the German studies (2007) carried out before implementation of the MAUT

The road network subject to a charge/tax has been decided by law (Lov nr 763 af 13/06/2023 om vejafgifter). It includes the state road network, especially the motorways (excl. The Great Belt Bridge and the Oresund motorway and bridge) and a number of municipal roads, which could be included to prevent traffic shifting away from the state road network to alternative routes. It also includes the low emission zones in Copenhagen, Frederiksberg, Odense, Aarhus and Aalborg.

Generally, data has been collected for the entire state road network. With regards to calculation of the maximum weighted average tariff, emphasis has been placed on cost calculations concerning the motorway network, since the average charges calculated for the motorway network (in accordance with the directive) can be applied to the other roads included in a charged network. As for the extent of the toll road network, it is currently also not decided whether all HGVs (e.g. HGVs below 12 ton) will be liable to the tax and whether HGVs will pay the same tariff on all parts of the toll road network regardless of location or road type.

It has been decided that Denmark will only seek to recover a smaller percentage of the infrastructure costs .

1. Road infrastructure costs

Road infrastructure costs are comprised of two primary elements:

- capital costs (see section 1.1)
- costs associated with the on-going operation and maintenance of the motorway network (see section 1.2).

Calculation of these costs for the reference year 2020 for the capital costs and projection of these costs for the base year 2025 (the planned “go-live”) are described below.

1.1 Capital costs

Capital costs consist of the annual interest costs and the annual depreciation of road assets.

- *The annual interest costs:* The return on the value of the *net stock* of infrastructure assets at the beginning of each fiscal year. This cost element is a measure for the yearly “opportunity costs” related to fact that public investments are tied up in road infrastructures which cannot be used elsewhere in society.

  Interest costs are calculated using the socio-economic discount rate determined by the Danish Ministry of Finance. The discount rate is used for socio-economic studies of new transport investment projects in Denmark. The national discount rate is currently 3.5 percent.

- *The annual depreciation:* The annual depreciation of the *gross stock* (value) of fixed assets assumes a linear depreciation of infrastructure assets over the lifespan of the asset.

1.1.1 Appraisal of state infrastructure assets
To be able to calculate capital costs it is necessary to estimate the gross and net capital value of road assets. The appraisal of road assets is carried out in two steps:

1. Current state road assets for the year 2020 are calculated. The Danish Road Directorate has evaluated the value of assets comprising the state road network and the motorway network for the year 2020 (as of January 1st, 2020), as a basis for calculating capital costs. 2020 is the latest appraisal.

   A description of the methodology for calculation of asset values is presented in the separate note *“Værdiansættelse af vejinfrastrukturen 2020”*, The Danish Road Directorate, December 2020.

2. Asset values have been projected for the base year 2025 by depreciating the capital values and by taking into account planned new road investments and reinvestments in the period 2020 – 2025. Any co-funding (subsidies) from the EU, have been deducted the investments.

The calculation of asset values has been based on a disaggregated appraisal of seven main infrastructure components:

- Land acquisition
  Covers acquisition of land, archaeology, plantation and soil-damages

- Earthworks and drainage
  Covers the lower layers of the road (sub-base layers embankments), drainage elements, cable works, fences, curbs

- Base and binder layers
  Covers the load-bearing part of the road below the surface layer

- Road surface
  Covers the upper road surface course (asphalt, road markings)

- Road equipment
  Covers guardrails, road marker posts, street lighting, skid warning stations, signals, signs, ITS-systems, noise barriers, signage portals

- Bridges and tunnels
  Covers bridges, tunnels and supporting walls

- Service areas and lay-bys
  Covers rest areas w/o toilets, “Info-teria”, petrol stations, bus bays, park-and-ride areas etc.

Each of these asset groups represent structural elements with similar physical or/and cost characteristics. The disaggregation of assets into homogeneous groups makes it easier to compile/value assets and is of importance for later allocation of costs to vehicle classes. All asset groups also entail costs related to project planning, design, construction site, management and oversight.

1.1.2 The compilation of the road capital value (gross and net) for the reference year (2020)

A key figure for calculating the average infrastructure charge is the capital value of the road network. The directive refers in that respect to the use of the PIM method (Perpetual Inventory Method). In the general outline of this method costs for road construction and major rehabilitation works, are considered over a period of 30 years back in time.

Since the aim is to establish a current value of the road network, an estimate of depreciated construction costs must be calculated for each investment. In order to be able to do that assessment it is necessary to examine each past project individually for costs and commissioning years. Furthermore, the original cost of each project must be decomposed into elements with homogeneous lifetime expectances. This differentiation of costs is necessary to be able to estimate a fair and representative depreciated current total value.

The directive opens for life spans larger than 30 years if, at the time of construction, such lifetime spans were used for the planning of construction works.

The requirements for necessary data in case of the PIM method cannot be met in Denmark to such an extent, that reliable capital values can be deducted. Instead the so-called synthetic method has been chosen. In this case a replacement value of the existing network is estimated.

This, however, implies that lifetime spans of over 30 years are applied. To justify that, a study has been carried out on lifetime expectancies used for dimensioning of motorways. The distribution of costs turned out to have the following lifetime distribution: 4% of costs with a lifetime expectancy below 30 years, 25% of costs with a lifetime expectancy of 30-50 years and 71% with 100 years. This adds up to a cost weighted average of over 80 years, thus indicating, that dimensioning periods clearly exceeds 30 years.

The synthetic method might at first glance give the impression, that it will overestimate the average annual costs because it uses replacement costs based on price data reflecting current standards and stricter environmental standards. On the other hand, there are also factors which may contribute to the synthetic method underestimating the capital value:

- Current technical solutions are less expensive than previously due to on-going efficiency efforts and up to date research developments.
- Current construction works are to a larger extent than previously exposed to competition through tendering procedures which - alta paribus - lowers prices.
- The average replacement prices for motorways with more than four lanes used in the synthetic method may not entirely reflect the very high incremental costs of widening motorways from four to six lanes or from six to eight lanes with time lags of 15 to 20 years. These projects are becoming more common and are very costly since the motorway must continue to carry normal traffic during the construction work. Keeping traffic rolling during an expansion project will often be more costly than building a new motorway from scratch without existing traffic.

Comparisons between the two methods carried out as part of the IMPACT project[1] do not lead to conclusive findings.

It is the general view of the Road Directorate that the synthetic method is currently the most applicable for estimating the capital value of the existing state road network.

Investments for the period between 2020 and 2025 follows the PIM method since cost data are or will be available.

Gross capital value
The calculation of the gross capital value of the state road network for the reference year 2020 is based on the synthetic method using data regarding quantities and replacement prices for the various infrastructure elements.

- *The quantities* are calculated based on several sources.
    - The extensive Danish road management system, "Vejman.dk", containing data on road geometry, pavement characteristics, roadside facilities and equipment etc.
    - For bridges, the Road Directorate has a similar database, Danbro", containing information about all the bridges on the state road network.
    - For several infrastructure-elements it has been necessary to estimate quantities, as updated information about quantities was not available.

- *Replacement costs* have been retrieved from the Road Directorate procurement records where it has been possible.

Documentation of the methodology for determining quantities and replacement prices used for the calculations is presented in the separate note *"Værdiansættelse af vejinfrastrukturen 2020"*, The Danish Road Directorate, December 2020.

Net capital value

[1] Road infrastructure cost and revenue in Europe. (IMPACT) – Deliverable 2. April 2008

The economic lifespan (total service life) of different categories of assets is determined based on the official Danish guidelines/standards concerning construction of roads and the professional knowledge and experiences of the Road Directorate.

Examples of life spans for different assets are shown in table 1

Asset category	Lifespan
Land acquisition	Indefinite (100 years)
Earthworks and drainage	Earthworks: 100 years. Drainage: 40 years
Base and binder layers	50 years
Road surface	16 years
Road equipment	12 – 50 years. E.g., guard rails: 50 years, noise barriers: 40 years, signage: 25 years, cameras: 10 years
Bridges	100 years
Service areas and lay-bys	40 years

Table 1: Lifespan of different asset types

Annual depreciation is calculated as a linear depreciation based on the calculated gross values of the assets and their estimated life span.

When calculating the net capital value, it is necessary to provide an assessment of the average age of the different types of assets. For a number of assets this assessment is based on expert evaluation, as there is no recorded data about the average age. This applies to drainage elements, but also other types of road equipment e.g., traffic counting equipment, fences, and roadside posts.

For other asset types e.g., bridges and pavements, it is possible to use data from the Road Directorates different databases and management systems to estimate the average age of bridge assets on the state road network.

The total net value of road assets (net capital value) is defined as the gross value of assets deducted the estimated accumulated depreciation up until the reference year 2020.

Gross and net value calculations have been carried out for both the entire state road network and for the state motorway network. Only the latter has been used in the present calculations.

With regards to assessing the value of the motorway assets, the costs are generally based on specific price and quantity data for the motorway network.

For certain assets, the available quantity and price data for the state road network does not distinguish between motorways and other state roads and hence expert appraisals have been used to estimate an approximate split of quantities and costs between the two road types.

In table 2 estimates of the gross and net capital value of the motorway network in 2020 are presented.

Cost component	Gross capital value	Net capital value
	Bill. DKK	Bill. DKK
Land acquisition	20,3	20,3

Earthworks and drainage	40,2	35,9
Base and binder layers	20,8	8,8
Road surface	4,6	2,3
Road equipment	6,9	4,2
Bridges and tunnels	45,3	31,6
Service areas and lay-bys	1,9	0,8
Total	140,0	103,8

Table 2: Gross and net capital value of the motorway network 2020 (enumerated to 2024-prices).

1.1.3 Projection of capital value development 2020-2025

The next step in the calculations is projecting the gross and net capital values for the years 2020 - 2025 taking into account on-going and new investments and reinvestments made each year based on figures from the annual state budget.

Projection of the development of the gross and net capital value for the period 2020 - 2025 is carried out using the Perpetual Inventory Method. This method involves compiling the annual costs of on-going and new investments and reinvestments estimated for this period. The Eurovignette directive sets the framework for which expenses can be included as investment costs.

The calculation of future investment costs is primarily based on the 2024 state budget, including current budgets for future years (up till 2025). When estimating future investment costs for the motorway network, specific financial accounts from the state budget have been used:

- *§ 28.21.20.: Construction of highways, etc.* In addition to direct project costs for new construction, the account also covers salary, administrative and operating costs related to the construction projects. From the account, it is possible to specify the precise construction costs related to new infrastructure projects on the motorway network.

- *§ 28.21.30: Maintenance of the main road network:* The annual costs for reinvestment in pavements and bridges covered by this account are also regarded as an investment that helps prolong the life span of the road capital, and hence increase the net capital value.

For the latter account the Danish Road Directorate receives a yearly budget for the entire state road network, not specifically directed at either motorways or other roads. Hence there is not a specific way of dividing these costs between road types. However, experts within the Road Directorates constructions and operations department, have estimated based on experience from recent years, that 60 pct. of the annual budget for structural repair works of pavements for 2020 - 2025 will be used on the motorway network.

The structural repair of bridges is categorized for ordinary and special bridge structures. For the *ordinary structures* bridge experts have estimated that approximately 90 pct. of the budget is dedicated to bridges on the motorway network. For *special structures* the estimate is that 40 pct. of the funds will be used on the motorway network.

In the calculation of the capital value of the state road network for the beginning of the year 2020 investments in on-going construction projects, which will not open for traffic until 2020, have not been included in the compilation of the capital value of the state road network for the year 2020. Costs which have been allocated to these on-going investments in the period before 2020 are therefore included in the projections of how the capital value will develop in the period 2020 – 2025.

Interest costs are calculated each year for costs related to these on-going projects (funds are used/tied), but depreciation costs are first calculated for the subsequent year after the planned opening year of the project, because it is not reasonable to calculate depreciation of a project which is not yet open for traffic.

Sub-appendix 2 presents a table with on-going and new investments in the motorway network which have been included in the projection of the capital value for 2025. It should be noted that Denmark currently is at the end of an infrastructure investment plan from 2009. Therefore, the number of on-going construction projects is currently relatively low. A new investment plan for the years 2021-2035 was approved in the summer of 2021, thus the expenditures are expected to increase substantially in the coming years, especially after 2025 (this is not reflected in the calculations yet).

Taking into account on-going/new investment and reinvestments, the estimated capital value of the future motorway network for the year 2025 is presented in table 3.

Cost component	**Gross capital value**	**Net capital value**
	Bill. DKK	Bill. DKK
Land acquisition	21,4	21,4
Earthworks and drainage	37,2	37,1
Base and binder layers	7,8	7,3
Road surface	2,3	1,9
Road equipment	3,7	3,6
Bridges and tunnels	33,4	33,0
Service areas and lay-bys	0,6	0,6
Total	106,5	104,9

Table 3: Estimated gross and net capital value of the motorway network 2025 (2024-prices).

1.1.4 Annual capital costs 2025

The estimated total annual capital costs for the motorway network for the year 2025 are presented in table 4.

	Mill. DKK (mill. EURO)
Interest costs	3.726 (500)
Depreciation	1.581 (212)
Total	**5.307 (712)**

Table 4: Total annual capital costs for the motorway network 2025. (2024-prices).

Split on the seven main infrastructure cost components the annual capital costs are distributed as shown in table 4a.

Cost components		**Mill. DKK**
Land acquisition	C.	749
Earthworks and drainage	C.	1.304
	M.	151
Base and binder layers	C.	272
	M.	422
Road surface	C.	81
	M.	371
Road equipment	C.	130
	M.	172
Bridges and tunnels	C.	1.169
	M.	418
Service areas/lay-bys	C.	22
	M.	48
Total		**5.703**

C: costs related to construction (interest costs), M: costs related to maintenance (depreciation)

Table 4a: Total annual capital costs for the motorway network 2025 – split into infrastructure costs components. (2024-prices).

1.2 Costs of operation of the motorway network

Calculation of the cost of operations also relies on figures from the fiscal state budget for 2024, in particular the account:

- § 28.21.31. *Operation and winter service:* besides the daily running operations this also covers costs related to emergency preparedness, simple maintenance (guard rails, signs, lighting etc.), drainage, traffic management, statistics, winter maintenance etc.

The funds in this account are regarded as direct annual operating costs. For this account the Danish Road Directorate also receives a yearly budget for the entire state roads, not specifically directed at either motorways or other roads. Experts within the Road Directorates construction and operations department estimate from past experience, that 50 pct. of operating expenses can be attributed to the motorway network, while this is 60 pct. for the winter service expenses.

For the year 2025 operating costs for the motorway network have been forecasted to **451 million DKK**. Thus – the annual total infrastructural costs in 2025 is estimated to **5.759 million DKK**.

2. Allocation of road infrastructure costs to vehicle classes

2.1 Method for allocating road infrastructure costs
The cost of road infrastructure is allocated to different vehicle types/categories (users) based on a number of parameters. The allocation principle is based on earlier analyses carried out by the Danish Road Directorate, on evaluations by expert professionals from the Danish Road Directorate and based on findings in the German studies (2007) carried out before implementation of the MAUT.

Road users are divided into four main vehicle categories:

1. Passenger cars, vans up to and including 3.5 tonnes gross vehicle weight (GVW) and motorcycles
2. Busses and coaches
3. Vans and heavy goods vehicles over 3.5 tonnes and below 12 tonnes GVW
4. Heavy goods vehicles at or exceeding 12 tonnes GVW

The distribution of road costs to the above-mentioned road user categories are handled separately for each of the following cost categories:

1. Land acquisition
2. Earthworks and drainage
3. Base and binder layers
4. Road surface
5. Road equipment
6. Bridges and tunnels
7. Service and rest areas
8. Road operations, routine maintenance, and winter maintenance

For category 2 – 7 the distribution of costs is further divided into construction (annual interests) and maintenance (annual depreciation). The division of costs into categories has been established in order to be able to reflect, that each cost category is differently linked to the vehicle categories i.e., in what ways costs from each cost category can be related to the different road users. Such a relation is directly or indirectly presupposed, when planning for a road construction or a maintenance operation. It is readily understandable that costs for road winter maintenance should not be allocated in the same way as e.g., costs for base and binder layers.

Each of the cost components is allocated to the different road user categories based on a cost relationship with one or more of the following traffic volume parameters as explanatory variables:

Vehicles-kilometres
Vehicle kilometres driven for each vehicle category is the most neutral parameter used for allocation. When using this parameter there is no distinction between different vehicle types. The estimated vehicle-kilometres are based on models runs of scenarios including a toll-scenario, using the Green Mobility Model (GMM). The toll-scenario run in GMM are not in full accordance with the determined tolls, but reduces the traffic mileage for HGVs with 12 pct.

PCU kilometres (Passenger car unit kilometres)
The PCU kilometres driven for each vehicle category is oriented against the different needs for capacity for each vehicle category. A standard passenger car is used as the reference meter with a capacity (space) requirement of 1 PCU by definition. Other types of vehicles need more

space primarily due to the length of the vehicle and to its ability to overtake and to be overtaken.

As an example, the gradient of a road section has considerable influence on the PCU factor for a heavy goods vehicle. In class 1 of gradients a heavy goods vehicle exceeding 12.5 meter has an average PCU of 2.5. In gradient classes 2, 3 and 4 such a heavy goods vehicle will have PCU's of 2.5, 5.0 and 8.0 respectively.

However, in this context we are only working with standard cases and with no reference to detailed topography and other parameters that can influence the PCU factor.

The applied PCU factors are in accordance with Danish National Road Standards and verified by expert professionals from the Danish Road Directorate.

Vehicle class	PCU factor
Passenger cars and vans	1.0
Busses	2.2
Heavy goods vehicles >3,5 – <12,0 tonnes	1.9
Heavy goods vehicles ≥ 12 tonnes	2.4

Table 5: PCU (passenger car units) factors for different vehicle types

ESAL kilometres (Equivalent Single Axle Load kilometres)
Parallel to the PCU factor that cover space requirements, the ESAL factor covers the damaging consequences of loads from axles to the different bearing layers in the road.

The reference for this factor is a 10-ton axle which by definition makes 1 ESAL. The ESAL value of other values of axle loads is calculated as an exponential function relative to the 10-ton axle. A 12-ton axle will have a ESAL of (12/10) raised to a power - normally set to 4,0. With 4,0 as the power a 12-ton axle will have an ESAL of 2,07. Similarly, an axle of 8 tonnes will have an ESAL of 0,4.

For a heavy goods vehicle there will be an ESAL from each axle. Such ESAL's are added to give the total ESAL of the vehicle. This ESAL is multiplied with the kilometres driven. Summing up for all vehicles on the network we get the total ESAL kilometres driven for each vehicle class.

The average equivalent single axle load factors are based on axle load registrations from a number of weighing stations on the Danish road network.

Vehicle class	ESAL factor
Passenger cars and vans	0
Busses	0.8
Heavy goods vehicles >3,5 – <12,0 tonnes	0.3
Heavy goods vehicles ≥ 12 tonnes	1.3

Table 6: ESAL (single standardized load application) factors for different vehicle type

Overall allocation of costs
In addition to the above-mentioned traffic indicators used for distribution of costs, there are some costs associated directly to specific vehicle types. Such costs are handled as vehicle specific or system specific costs. Table 7 below shows the factors used for allocating costs. A more

detailed description of the allocation principles for the different cost components is presented in sub-appendix 3.

		Propor-tionally attributed costs (km)	System-specific costs for HGVs ≥12 tonnes GVW	Capacity dependent costs (PCU)	Weight dependent costs (ESAL)	Total
Land Acquisition	C.			1,00		1,00
Earthworks and drainage	C.			1,00		1,00
	M.			1,00		1,00
Base and binder layers	C.	0,20			0,80	1,00
	M.	0,20			0,80	1,00
Road surface	C.			0,25	0,75	1,00
	M.			0,25	0,75	1,00
Road equipment	C.	0,50		0,50		1,00
	M.	0,50		0,50		1,00
Bridges and tunnels	C.		0,15	0,85		1,00
	M.		0,15	0,85		1,00
Service areas and lay-bys	C.	0,50	0,50			1,00
	M.	0,50	0,50			1,00
Road operations, rou-tine maintenance, winter maintenance etc.		0,50		0,50		1,00

C: costs related to construction (interest costs), M: costs related to maintenance (depreciation)

Table 7: Allocation principles for cost components

Land acquisition is set as capacity driven since the area needed is related to the capacity needs from traffic. The same reasoning goes for earthworks and drainage.

Base and binder layers are primarily related to weight dependant factors. However, a small portion is allocated to vehicle kilometres since a road need a certain stability in the base layers no matter what types of vehicles are passing. The surface layers are handled in a similar way.

Bridges and tunnels are to a large extent capacity driven, but a small portion is allocated to heavy goods vehicles since bridges must be dimensioned for worst caseloads form heavy goods vehicles.

Costs for road equipment and road operations are equally distributed between vehicle kilometres and capacity while service and rest areas are equally distributed between vehicle kilometres and heavy goods vehicles. Heavy goods vehicles have special requirements in relation to space and layout of service and rest areas. Together with the traffic volume parameters, mentioned above, table 7a shows the applied kilometres.

	Cars/Vans	Buses	HGVs 3,5 - <12T	HGVs ≥ 12t	Total
Km (mill.)	17483	75	43	1286	18887
Km share	0,926	0,004	0,002	0,068	1,00
PCU factors	1	2,2	1,9	2,4	
PCU km (mill.)	17483	166	82	3087	20817
PCU share	0,840	0,008	0,004	0,148	1,00
ESAL factors	0,0	0,8	0,3	1,4	
ESAL km (mill.)	0	56	5	1742	1813
ESAL share	0,000	0,031	0,008	0,961	1,00

Table 7a: Applied traffic mileage, PCU- and ESAL-shares

2.2 Infrastructure costs allocated to vehicle types

Infrastructure costs have been allocated based on the distribution principles described in section 2.1.

The following tables show the resulting allocation of infrastructure costs for the motorway network by vehicle type.

Mill. DKK.		**Cars/vans**	**Buses**	**HGVs**	**HGVs**	**Total**
Cost element				**>3,5 - <12 t**	**≥12 t**	
Land acquisition	C.	629	6	3	111	749
Earthworks and drainage	C.	1.095	10	5	193	1.304
	M.	126	1	1	22	151
Base and binder layers	C.	50	7	2	212	272
	M.	78	11	3	330	422
Road surface	C.	17	2	1	61	81
	M.	78	9	3	281	371
Road equipment	C.	115	1	0	14	130
	M.	151	1	1	19	172
Bridges and tunnels	C.	834	8	4	323	1.169
	M.	299	3	1	116	418
Service areas and lay-bys	C.	10	0	0	11	22
	M.	22	0	0	25	48
Operation and routine maintenance		398	3	1	49	451
Total		**3.904**	**62**	**24**	**1.768**	**5.759**

C: costs related to construction (interest costs), M: costs related to maintenance (depreciation)

Table 8: Estimation of annual infrastructure costs for the motorway network for the year 2025 at a discount rate of 3.5 %. (2024-prices).

As an example, the value for land acquisition allocated to HGWs >12 ton (111 mill. DKK) has been calculated as the sum of:

1) 'The kilometre share' (table 7a) x 'Proportionally attributed costs' (table 7) x 'annual costs' (table 4a)

+
2) ‘System-specific costs for HGVs ≥12 tonnes GVW’ x ‘annual costs’
+
3) ‘The PCU share x Capacity dependent costs’ x ‘annual costs’
+
4) ‘The ESAL share’ x ‘Proportionally attributed costs (km)’ x ‘annual costs’

The next table sums up the share of costs for each cost element, which has been allocated to heavy goods vehicles at and over 12 tonnes GVW.

Cost element		**HGVs ≥12 tonnes Share costs**
Land acquisition	C.	15%
Earthworks and drainage	C.	15%
	M.	15%
Base and binder layers	C.	78%
	M.	78%
Road surface	C.	76%
	M.	76%
Road equipment	C.	11%
	M.	11%
Bridges and tunnels	C.	28%
	M.	28%
Service areas/lay-bys	C.	53%
	M.	53%
Operation and routine maintenance		11%
Total		**31%**

C: costs related to construction (interest costs), M: costs related to maintenance (depreciation)

Table 9: Share of annual costs for each cost element allocated to truck over 12 tonnes GVW (for calculations using 3.5 % discount rate)

Table 10 presents the total annual infrastructure costs 2025 by vehicle type.

Mill. DKK (mill. EURO)	**Annual infrastructure costs**
Cars and vans	3.904 (524)
Busses	62 (8)
HGVs >3.5 - <12 tonnes	24 (3)
HGVs ≥ 12 tonnes	1.768 (237)
Total	**5.759 (773)**

Note: Exchange rate 100 EURO = 745 DKK.

Table 10: Total annual infrastructure costs 2025 for the motorway network by vehicle type (2021-prices).

2.3 Maximum weighted average infrastructure cost
The maximum weighted average infrastructure cost is calculated by dividing the annual motorway costs allocated to HGVs ≥ 12 tons in 2025 by the estimated HGV mileage on the motorways in 2025.

Maximum weighted average cost (HGVs ≥ 12 tonnes)	Base scenario
DKK/km	1.37
Euro/km	0.18

Table 11: Maximum weighted average infrastructure costs per kilometre (2025). 2024-prices.
Note: Exchange rate 100 EURO = 745 DKK.

It should be noted that the Eurovignette directive only applies to motorways/TEN-T roads and that the tolls on other roads therefore falls under national competence. These tolls do not discriminate against international traffic and do not result in any distortion of competition between operators.

According to the Eurovignette directive the administrative cost of the charging scheme can be regarded as an integrated element in the infrastructure cost and thereby add the costs of the road charging system to the maximum weighted average cost for the chosen vehicle categories. The annual cost of road charging system is estimated to 275 million DKK. Divided with the traffic mileage for HGVs ≥12 tonnes on the motorway network this cost adds approximately 0.21 DKK/km to the maximum weighted average cost, as shown in table 12.

Administrative costs (HGVs ≥ 12 tonnes)	**Base scenario**
DKK/km	0.21
Euro/km	0.03

Table 12: average administrative costs per kilometre (2025). 2024-prices.
Note: Exchange rate 100 EURO = 745 DKK.

Maximal charge per vehicle class with infrastructure cost
Given the above preliminary calculations the total maximum weighted average costs per km for HGV ≥12 tons on the motorway network in 2025 will be the following:

Total maximum weighted average cost (HGVs ≥ 12 tonnes)	**Base scenario**
Infrastructure costs, DKK	1.37
Administrative costs, DKK	0.21
Total, DKK	**1.58**
Total, EURO	**0.21**

Table 13: Maximums infrastructure cost per kilometre (2025). 2024-prices.
Note: Exchange rate 100 EURO = 745 DKK.

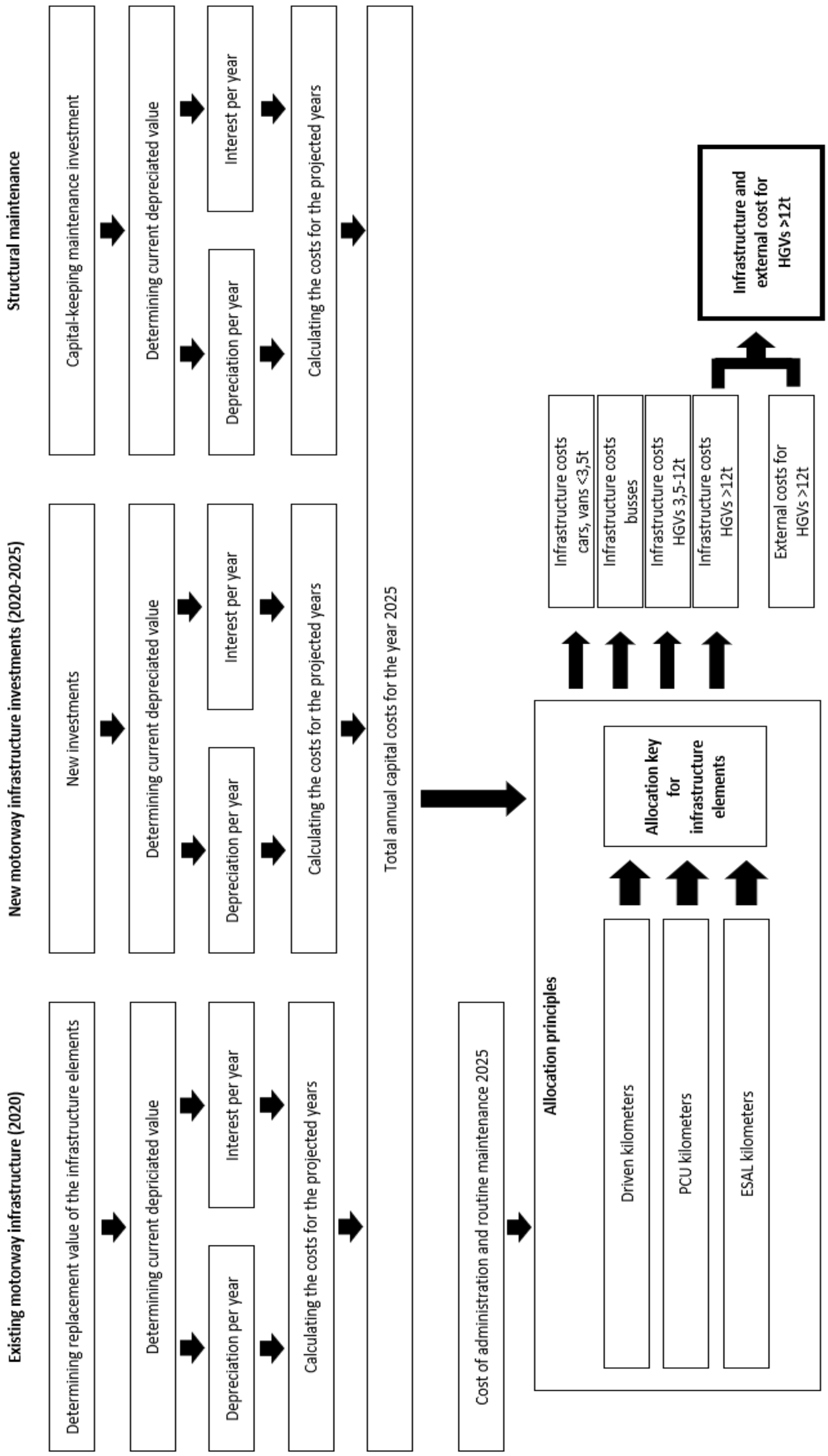
Sub-appendix 1: Overview of cost calculation steps

Sub-appendix 2: Ongoing and future investments 2020-2025 (mill. DKK)

Sub-appendix 3: Allocation principles used to distribute costs to vehicle categories

Separate note: "Værdiansættelse af Statsvejnettet 2020", Vejdirektoratet 2020 (Methodology for calculation of the gross and net value of the state road network 2020).

Sub-appendix 1: Overview of cost calculation steps



Sub-appendix 2: Ongoing and future investments 2020 – 2025 (mill. DKR)

Igangværende og nye investeringer i motorvejsnettet, jf. Finanslovens konto 28.21.20 (Anlæg af hovedlandeveje mv. (Anlægsbev.)

28.21.20	Registrered expenses						Budgetary projections / grants				
Mio kr.	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Udvidelse af motorvej E20 på vestfyn	0,0	0,0	0,0	40,7	203,1	272,1	300,5	336,6	581,3		
Kalundborgmotorvejens 3. etape								22,4	56,6	193,6	345,9
Udbygning af E45/E20 ved Kolding									15,6	10,9	220,1
Udbygning af E45, Vejle (Hornstrup) - Skanderborg S								67,4	343,3	728,8	969,7
Udbygning af E45, Aarhus S - Aarhus N								40,8	202,0	408,2	620,5
Ombygning af tilslutningsanlæg på E45 Aarhus N - Randers N								14,1	31,5	86,1	136,1
Udvidelse af Hillerødmotorvejens forlængelse til motorvej								18,7	42,0	85,9	227,1
3. Limfjordsforbindelse										3,6	71,8
Frederikssundsmotorvejen, Tværvej - Frederikssund											1,9
Øget kapacitet på Motorring 3									18,2	144,9	234,3
Holmene									1,5	32,8	189,4
Udbygning af Fynske Motorvej, syd om Odense										1	21,0
Forbedringer af Helsingørmotorvejen ved Klampenborg/DTU										1,6	31,6
Udbygning af Rute 54, Næstved - Rønnede											1,5
Midtjysk Motorvej (Give - Billund og Løvel - Viborg V - Klode Mølle)											0,3
I alt (mio. kr)	**0,0**	**0,0**	**0,0**	**40,7**	**203,1**	**272,1**	**300,5**	**500,0**	**1.292,0**	**1.697,4**	**3.071,2**

Sub-appendix 3: Allocation principles used to distribute costs to vehicle categories

The allocation principles reflect how the different infrastructure cost components relate to the use of the road and to the cause of the cost. Table 1 presents the distribution key used to allocate costs. A short explanation of the specific distribution key used for each cost component is presented below the table.

It should be noted that the keys are established under considerable uncertainty. Cost allocation procedures are not part of routine data collection and analysis in the transport sector. Likewise, research in the area is not an ongoing discipline from which the keys more or less can be extracted.

	Construction/ Maintenance	Proportionally attributed costs	System-specific costs for trucks > 12 tonnes GVW	Capacity-dependent costs	Weight-dependent costs	Total
Land Acquisition				1,00		1,00
Earthworks and Drainage	C.			1,00		1,00
	M.			1,00		1,00
Base and Binder Layers	C.	0,20			0,80	1,00
	M.	0,20			0,80	1,00
Surface Layer	C.			0,25	0,75	1,00
	M.			0,25	0,75	1,00
Bridges and Tunnels	C.		0,15	0,85		1,00
	M.		0,15	0,85		1,00
Road Equipment	C.	0,50		0,50		1,00
	M.	0,50		0,50		1,00
Service and Rest Areas	C.	0,50	0,50			1,00
	M.	0,50	0,50			1,00
Road Operations, Rutine Maintenance Road Winter Maintenance		0,50		0,50		1,00

C: costs related to construction (interest costs)
M: costs related to maintenance (depreciation)

Table 5.3 Allocation principles for cost components

Land acquisition
Land acquisition is seen as 100% dependent upon the necessary road capacity, since the area needed is directly related to traffic volumes.

Cost for land acquisition is allocated to all vehicles collectively. The key for allocating these costs is the number of passenger car units and kilometers driven for each vehicle category.

Earthworks and drainage
Earthworks and drainage is seen as 100% capacity driven, since the area needed for earthworks and drainage is directly related to traffic volumes.

The cost of both construction and maintenance of the earthworks and drainage is allocated to all vehicles collectively. The key for allocating these costs is the number of passenger car units and kilometers driven for each vehicle category.

Base and binder layers
The function of the base and binder layers is primarily to be load-bearing, i.e. to absorb and spatially distribute static and dynamic forces from axle loads downwards into the layers.

One principle for allocating costs for base and binder layers might be a calculation of marginal costs for consecutively added vehicle classes starting with passenger cars since they have the lowest weight. For each new vehicle class added, a corresponding extra and marginal construction cost can be calculated. However such a principle presupposes that some vehicle classes are marginal to others, but that is not the case. If it was the case, the principle might as well have been applied in the opposite order of calculation starting with the heaviest vehicles as the baseline, giving a completely different result.

Taking these considerations into account it seems adequate to choose a more simple principle of allocation. There is plenty evidence and research stating, that tear and wear from heavy axle loads eventually causes damage to base and binder layers. However joint costs cannot be neglected as part of an allocation principle since these layers must be well functioning in order to facilitate high quality traffic conditions for all types of vehicles. At least 80% of the cost is assessed to be weight dependant. As a conservative estimate the allocation keys accordingly have been set to 80% weight dependant and 20% dependant on kilometers driven. This distribution applies for construction costs and maintenance costs as well.

Surface layers
The surface layer serves several purposes: It brings the vertical forces from axle loads down into the layers beneath. Through friction properties it resists horizontal forces from tyres when a vehicle brakes or accelerates. Furthermore the top layer serves as a shield to prevent precipitation from seeping down into the sub layers, where water might cause severe damage to the bearing capacity of the road.

Due to chemical reactions and climatic impacts the surface layer will gradually change its technical properties and e.g. loose some of its elasticity over time. This implies that a surface layer must be replaced after a span of years since its designed properties will decay over time making it more and more vulnerable against tear and wear.

The cycle of replacement of a surface layers depends very much on specific local conditions. However the following situation can be seen in standard cases:
Year 0: A new motorway is constructed. *Year 15*: A new surface layer is laid out in the slow lane (with heavy vehicles). *Year 30*: All lanes will be given a new surface layer.
For a 6-lane motorway with the two inner lanes restricted for light vehicles only, this implies roughly, that 80% can be allocated to heavy vehicles. For a 4-lane motorway with practically no heavy vehicles on the two inner lanes, this reasoning implies that roughly two thirds can be allocated to heavy vehicles.

In the light of such considerations, 75% of the surface layer cost is allocated to axle loads and 25 % to capacity expressed as the number of passenger car units for each vehicle type and to kilometres driven.

Tunnels and bridges
The dimensioning of tunnels and bridges is primarily capacity driven, since the dimensions/width is directly related to traffic volumes. However, especially in the case of bridges some of the costs are related to weight of vehicles as well. A bridge must be dimensioned for a worst-case situation in respect of loads from heavy goods vehicles. A bridge with no access for heavy goods vehicles can be designed with more slim dimensions compared to the case with no access restriction.

The costs for marginal necessary bearing capacity due to heavy goods vehicles is assessed to no less than 15% of total construction costs. Thus - as a conservative estimate - 15% is allocated as a system specific cost to heavy goods vehicles. The remainder 85% of the cost is allocated to capacity. This split of costs is used for construction costs and maintenance costs as well.

Equipment
Road equipment comprises a variety of different technical installations, support, guidance and restrictions with the purpose to make traffic flows efficient and to reduce the number of accidents and environmental impacts.

Part of this is directly aimed at giving each driver assistance and guidance. In this light cost can be seen as a proportional cost. Another part of it is capacity driven such as gantries with traffic signs above the lanes. Under these varying circumstances the keys are set to 50% to kilometres driven and 50% to capacity.

Service and rest areas
From time to time all motorway drivers will make use of service and rest areas. Heavy goods vehicles however play a special role in that respect; since they have specific needs and conditions, which must be reflected. First of all heavy goods vehicles occupy substantially more space when parked compared to a passenger car. Secondly heavy goods vehicles tend to park for longer times while the driver might take a mandatory rest, or if the driver waits due to certain slot times at the next destination, new assignments etc.

Taking these considerations into account 50% of the costs are allocated with to kilometres driven. The remainder 50% is allocated as a system specific cost to heavy goods vehicles.

Road operations, routine maintenance and road winter maintenance
Road operations comprise running costs for various technical equipment, e.g. traffic signals, automatic detecting equipment, road lighting, temporarily traffic restrictions etc. Routine maintenance comprises small-scale road works conducted regularly. The aim is to ensure the daily passability and safety of existing roads in the short-run and to prevent premature deterioration of the roads. Road winter maintenance is carried out to prevent icy roads by means of spreading deicers on the surface before expected snowfall or ice storms. In case of substantial snowfall snowplows are used for removal of snow.