



Cost Assumptions Update – Summary Report

NetZeroCities Planner

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1. Introduction

The NetZeroCities (NZC) planner is a model that assists European cities in calculating the costs necessary to achieve their climate targets. It serves as a foundational tool for teams developing City Climate Contracts and investment plans under the EU NetZeroCities Mission, providing comprehensive data across five core sectors: passenger transport, freight transport, electricity, waste, and buildings and heating.

The cost assumptions within the Net Zero Planner, which is based on the primary database developed by Material Economics (ME), have been updated for all relevant sectors where applicable. Due to its broad sectoral and geographical scope, the model employs strategic approximations and simplifications to provide a high-level overview and enable cross-city comparisons. This report summarises the reasoning behind the updated values.

It is important to note that these figures should be treated as primary indications rather than data points directly translatable to specific local projects. For tailored support regarding individual projects, cities are encouraged to contact the NZC Capital Hub team through their City Finance Specialist (CFS).

2. Sector Costs

2.1 Waste

The waste sector module models the economics of a city's waste system. On the cost side, it determines what it costs municipalities to treat each tonne of waste through landfill, incineration, composting, and sorting. On the revenue side, it estimates the value recovered from selling secondary materials — paper, metal, plastics, glass, and organic compost. The net of the two feeds directly into the city's climate investment plan and tells planners how much of the transition to higher recycling rates is self-funding versus how much requires new investment.

The waste assumptions divide cleanly into two groups, and each group has been updated using a different method. This is deliberate: the data quality and freshness available for the two sides of the ledger are not equivalent, and the methodology reflects that.

Why these values needed updating

The original waste figures were set when the model was built in 2019, drawing on two categories of sources. Secondary material prices (paper, metal, plastics, glass, organic) came from Eurostat's secondary material price indicator and the German steel scrap association BDSV, using 2017 average figures. Treatment costs (CAPEX and OPEX for each technology) came from the eucostwaste study, conducted by Eunomia and Ecotec for the European Commission. A source audit conducted during this update established something important: the eucostwaste fieldwork was carried out in 2001/02 across EU15 member states, with the final report published in 2003. When the 2019 model was built, those figures were taken directly without any inflation adjustment — meaning a 17-year gap was already embedded in the model at inception. By 2024, the gap from source data to the present is 23 years. This is materially longer than was previously understood and is the single most important fact to know about the treatment-cost figures in the model.

Several things have also changed in the market since 2019. Secondary material prices are inherently volatile: glass prices have risen by over 80% as EU separate-collection mandates have matured; metal prices experienced a post-energy-crisis correction; plastics went through a sharp collapse after China's 2018 import ban and have since partially recovered. None of these movements were reflected in the model. On the regulatory side, waste incineration's inclusion in the EU Emissions Trading System from 2028 will add a meaningful surcharge to incineration operating costs — a forward cost the model does not currently capture.

Two update approaches

The revenue side has been updated by direct replacement. Eurostat publishes an annual secondary material price indicator for glass, paper, and plastics using the same methodology as the original source; BDSV publishes monthly steel scrap prices, and the 2024 annual average has been used. No inflation adjustment is required because the replacement values are themselves 2024 prices. For organic compost, the European Compost Network's 2022 data report confirmed the original EUR 10 per tonne figure as still representative — a weighted average across EU compost markets — so the value has been retained.

The treatment-cost side has no comparable live data series. No EU-wide successor to the eucostwaste study has been published, and commissioning a fresh primary survey of municipal waste facilities across 27 member states was outside the scope of this update. The chosen approach has therefore been to apply sector-appropriate inflation factors to the

2001/02 base values using Eurostat indices. This is methodologically honest but limited: it bridges the 23-year gap defensibly but inherits whatever biases and limitations existed in the original survey, and it cannot capture genuine structural change in the cost of waste treatment (for example, from technology maturation, scale economies, or new regulatory layers like landfill taxes and the EU ETS).

CAPEX and OPEX are driven by different cost components and have therefore been inflated separately. For CAPEX, the Eurostat Construction Cost Index (CCI) for new residential buildings stood at approximately 68–70 in 2001/02 and approximately 148–150 in 2024 (index, 2015 = 100), giving a cumulative multiplier of $\times 2.14$. This residential index is used as a proxy because no EU27-level industrial waste facility cost index exists. For OPEX — which for waste facilities is dominated by labour (typically 50–60% of operational costs), with fuel, energy, and maintenance making up the rest — a blended multiplier of $\times 2.25$ is applied, drawing on the Eurostat Labour Cost Index for environmental services together with energy-cost movements over the same period (most notably the 2021–22 energy shock and partial normalisation since).

Updated prices of collected materials

Paper, plastics, and glass have been updated directly from the Eurostat 2024 secondary material price indicator. Metal has been updated from BDSV's E40 shredded scrap grade — the standard output of a municipal solid waste metal-recovery line — using the 2024 annual average rather than the original single-month August 2019 reading. The updated approach is more robust, but this also means the year-on-year comparison slightly overstates the directional change for metal.

Material	2017/19 (EUR / t)	2024 (EUR / t)	Source
Paper	158	156	Eurostat secondary material price indicator, 2024
Metal	193	300	BDSV E40 shredded scrap, 2024 annual avg.
Plastics	315	321	Eurostat secondary material price indicator, 2024
Glass	52	95	Eurostat secondary material price indicator, 2024
Organic	10	10	European Compost Network Data Report 2022

The most striking movement is glass: an 83% rise from EUR 52 to EUR 95 per tonne. This is a genuine structural shift rather than volatility — the Waste Framework Directive's mandatory separate-collection requirements drove significant investment in European glass recycling infrastructure from 2018 onwards, and the higher price is supported by rising traded volumes. Paper has been essentially flat. Plastics has also moved only slightly on the year-on-year comparison, but the headline figure conceals real volatility underneath: in the 2020–24 period plastics prices ranged from EUR 248 to EUR 467 per tonne, with a sharp collapse after China's 2018 import ban followed by a 2022 spike and partial settlement back to current levels. Cities with material plastics-recycling revenue lines in their investment plans should treat the EUR 321 figure as a current point estimate rather than a stable long-run value.

Updated treatment costs

Treatment costs have been inflation-adjusted from the eucostwaste 2001/02 base using the $\times 2.14$ (CAPEX) and $\times 2.25$ (OPEX) multipliers described above. The table below shows the total per-tonne cost (CAPEX + OPEX combined) for each treatment technology.

Technology	2001/02 base (EUR / t)	2024 (EUR / t)
Landfill	29	64
Incineration	75	165
Composting	53	117
Sorting (general)	193	426
Sorting (plastics)	272	600

These figures pass plausibility checks against observed EU data: the updated landfill total of EUR 64 per tonne sits inside the EUR 40–120 range of observed EU landfill gate fees (EEA 2023), and the updated incineration total of EUR 165 per tonne is consistent with known waste-to-energy gate fees in Western European cities (typically EUR 90–180 per tonne). The sorting totals are at the upper end but directionally consistent with recent Zero Waste Europe modelling of mixed-waste sorting facility costs at 100kt scale.

2.2 Electricity

The electricity module estimates what it costs cities to expand renewable generation and what residents pay for the power they consume. Both the underlying generation cost data and the household electricity price have been refreshed.

The original model drew its renewable-technology costs from a mix of older industry references. For this update, the primary source has been switched to Lazard's Levelized Cost of Energy (2025) — the annual benchmark study widely used across the energy sector. Lazard's 2025 edition provides per-MWh capital and operating cost ranges for the full suite of generation technologies (solar PV, onshore wind, geothermal, gas, nuclear, coal) and reflects the substantial cost movements of the last five years. The household electricity price has been updated using Eurostat consumer-price data.

The most material movements come from solar and wind. Rooftop solar PV CAPEX has fallen sharply as panel and inverter costs have continued their long-run decline, while wind CAPEX has not fallen as quickly, leading to a higher assumed annual cost-reduction rate for wind going forward. Centralised solar and wind park CAPEX is broadly flat. Fossil-fuel generation costs have risen across the board, reflecting both higher fuel prices and tightening emissions regulation.

Key updated assumptions:

Assumption	Unit	Original	Updated
Average household electricity price	EUR / kWh	0.28	0.30
Solar PV — rooftop residential, CAPEX	EUR / kW	1,932	594
Centralised solar / wind parks, CAPEX	EUR / MWh	339	321
Solar PV — rooftop residential, OPEX	EUR / kW	25	16
Centralised solar / wind parks, OPEX	EUR / MWh	6	7
Annual CAPEX reduction — Solar PV	%	1.71%	0.8%
Annual CAPEX reduction — Wind	%	1.53%	3.8%
Other costs (e.g. flexibility)	EUR / MWh	20	13

Full per-technology levelized cost tables (CAPEX and OPEX in USD / MWh) for each renewable and fossil generation type are documented in the supporting workbook, sourced directly from Lazard's 2025 LCOE tables.

2.3 Building & Heating

Built Environment Sector

The cost data for the built environment was originally taken from a study conducted across Europe: “ZEBRA2020: NEARLY ZERO-ENERGY BUILDING STRATEGY 2020”. The study was conducted from 2014 to '16 by the Vienna University of Technology. It covered 14 countries as mentioned above.

Therefore, for the model developed by Material Economics, sourcing this data was straightforward as it was clearly presented in 2 tables of the one of the study reports - ‘Deliverable 5.1: Nearly Zero-Energy Building (nZEB) technology solutions, cost assessment and performance’ as shown below.

Table 5 and Table 6 show the cost of construction of new nZEBs, the additional costs for nZEB construction and the costs for different levels of renovation (minor, moderate, deep and nZEB) in each analyzed country.

Table 5: Cost of nZEBs divided for countries (AT, BE, CZ, DK, FR, DE and IT).

Costs (€/m ²)	AT	BE	CZ	DK	FR	DE	IT
Minor renovation (15% energy savings)	410	100	96	400	130	149	101
Moderate renovation (45% energy savings)	456	200	153	1100	195	258	231
Deep renovation (75% energy savings)	484	500	219	1900	300	456	697
nZEB renovation (95% energy savings)	524	750	318	2500	640	860	910
New built according to nZEB standards	1824	1600	835	2150	1750	1601	1633
Additional funds for nZEB construction compared to new built	280	200	110	125	150	169	213



Deliverable 5.1: nZEB technology solutions, cost assessment and performance

Table 6: Cost of nZEBs divided for countries (LT, NO, PL, RO, SK, ES and SE).

Costs (€/m ²)	LT	NO	PL	RO	SK	ES	SE
Minor renovation (15% energy savings)	125	35	60	36	96	57	51
Moderate renovation (45% energy savings)	155	725	170	84	153	163	715
Deep renovation (75% energy savings)	238	750	220	197	219	288	735
nZEB renovation (95% energy savings)	286	830	330	376	318	695	920
New built according to nZEB standards	734	2365	1037	679	835	1074	3370
Additional funds for nZEB construction compared to new built	125	115	94	200	110	407	96

It may also be noted that for the base year of 2019/2020, the figures of the study conducted in 2016 were used.

Since the publication of the report, the concept of nZEB under EBPD in Europe has undergone a change of paradigm and become more ambitious. With the latest update Directive (EU) 2024/1275¹, the benchmark has moved up from zero energy (which focussed on only operational GHG emissions) to zero emissions on life-cycle basis.

Until more data is available on ZEB, the nZEB cost figures for the 14 countries from the earlier model are updated by applying construction index data published by Eurostat from 2020 to 2024.

¹ https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L_202401275&pk_keyword=Energy&pk_content=Directive

We refer to the Eurostat construction producer prices or cost index for new residential buildings. The index in the Eurostat data set is based on 2021 (2021 = 100), and the time frequency is quarterly.²

The baseline for each country is 2020 (averaged index figures per country). The defined cost update target year is 2024 (Q4). The cost update factor is calculated by dividing the latest index value (Q4 2024) by the baseline index (avg. of 2020). The table below displays the update factor for each country.

ESTAT, Construction producer prices, new residential buildings				
Country	Code	Baseline Index (Avg. 2020)	Latest Index (Q4 2024)	Update Factor
Austria	AT	92.6	125.1	1.35
Belgium	BE	94.6	125.5	1.33
Czechia	CZ	94.5	121.7	1.29
Denmark	DK	96.2	116.3	1.21
France	FR	95.5	113.6	1.19
Germany	DE	92.9	130.8	1.41
Italy	IT	98.2	109.4	1.11
Lithuania	LT	93.8	134.5	1.43
Norway	NO	92.0	119.3	1.30
Poland	PL	95.7	133.3	1.39
Romania	RO	88.8	142.3	1.60
Slovakia	SK	96.7	144.6	1.50
Spain	ES	92.2	118.1	1.28
Sweden	SE	94.1	119.8	1.27

The cost update factors can then be applied for “minimum building standard” and “additional cost of nZEB compared to new built” cost update for each country. The comparison of old and new costs is presented below.

Country	Cost of new built according to Minimum nZEB standard (EUR / m ²)		For Better than nZEB building standard: Additional cost compared to minimum new nZEB building (EUR / m ²)	
	Earlier cost	Updated cost	Earlier cost	Updated cost
AT	1,824	2,464	280	378
BE	1,600	2,123	200	265
CZ	835	1,075	110	142
DK	2,150	2,601	125	151
FR	1,750	2,082	150	178
DE	1,601	2,255	169	238
IT	1,633	1,820	213	237
LT	734	1,052	125	179
NO	2,356	3,055	115	149

² [Eurostat, Construction producer prices or costs, new residential buildings – quarterly data \[sts_copi_q_custom_19771858\], Last Updated 22/01/2026](#)

Country	Cost of new built according to Minimum nZEB standard (EUR / m ²)		For Better than nZEB building standard: Additional cost compared to minimum new nZEB building (EUR / m ²)	
	Earlier cost	Updated cost	Earlier cost	Updated cost
PL	1,037	1,445	94	131
RO	679	1,088	200	320
SK	835	1,249	110	165
ES	1,074	1,376	407	521
SE	3,370	4,289	96	122

In a final step the data is averaged over the 14 countries (analogous to the methodology in the existing model). It shows a price increase of 564 EUR per m² for minimum building standards and 56 EUR per m² in additional cost of nZEB compared to new built, as detailed in the table below:

Category	Unit	Existing model (2020)	New (data as of Q4 2024)
Minimum building standard	EUR / m ²	1,534	1,998
Additional cost of nZEB compared to new built	EUR / m ²	171	227

Heat Generation

The Material Economics model draws on cost data from the 2017 IRENA REmap (Renewable energy roadmaps) study³ for the heat generation calculation. This study provides levelized heating cost data and has a global scope, covering nine countries, including four in Europe (Denmark, Germany, Poland, and Switzerland), alongside the US, China, Japan, UAE and Kuwait.

The IRENA sourced data provided a *levelized cost per unit for 2030*. Therefore, the model of Material Economics includes an intermediary step for the previously determined CAPEX (fixed cost components) to further convert it into total capital cost (un-levelized cost) per unit. The calculation applies a reversed annual capital cost (ACC) formula and assumes asset lifecycles of 20 years for heating technologies and 50 years for network infrastructure. Furthermore, it applies a 4% Weighted Average Cost of Capital (WACC). These total costs are then applied to the years preceding and following 2030.

The data from IRENA report are retained for the NZC planner for two primary reasons. First, while the report was published in 2017, its methodology explicitly includes scenario calculations projected through to the year 2030, which is the target horizon of the NZC planner. Second, there is a lack of newer, comparable data sources or comprehensive pan-European studies. For these reasons, continuing to utilize the IRENA REmap 2030 scenario provides the most consistent foundation for the current model.

The summary table below presents the Material Economics Model unit costs:

OPEX, district heating	Cost in EUR / MWh
Fossil (oil, coal, gas)	66
Electric heat pumps / geothermal	41
Bio (biogas, biomass)	82
Waste (fossil & non-fossil waste)	-17
OPEX, local heating	
Fossil	74
Electric heat pumps / geothermal	61
Biomass	47
CAPEX, district heating	
Fossil (oil, coal, gas)	446
Electric heat pumps / geothermal	347
Bio (biogas, biomass)	370
Waste (fossil & non-fossil waste)	460
Network infrastructure	1'431
CAPEX, local heating	
Fossil	238
Electric heat pumps / geothermal	320
Biomass	219

³ [Renewable Energy in District Heating and Cooling – A Sector Roadmap for REmap](#)

2.4 Transport

The transport sector cost assumptions cover a broad set of subtopics falling under general assumptions, passenger transport assumptions and freight transport assumptions.

Passenger transport includes cars, buses, trains, metros, and active transport, while freight transport mainly focuses on heavy-duty vehicles (HDVs) and light commercial vehicles (LCVs). The assumptions also account for related infrastructure costs, including charging infrastructure for electric vehicles and infrastructure associated with walking and cycling. Overall, the updated categories include fuel prices, vehicle operating costs, public transport costs, lifecycle costs, electrification costs, and supporting infrastructure costs.

Since the previous revision, the sector conditions have changed significantly due to technological developments, market shifts, inflation, changes in energy prices, and evolving EU policy priorities. This update focuses on consistency across cost categories, aligns assumptions more closely with current EU market and policy conditions, and ensures reproducibility where data and code are concerned. Concerning data sources specifically, the revised methodology prioritises recent EU-specific data, and is backed by official statistical sources, peer-reviewed studies, industry reports, and market-based evidence.

The reader and practitioner should always keep a few things in their mind. Relying on EU wide statistics allows for variables to come from a consistent source, but can erase nuances appearing on regional scales, particularly for cities that are not in EU member countries. Similarly, when an updated study dealing with exactly our variables is unavailable, using proxy variables can help explain a precise phenomenon, though it risks causing inconsistencies with previous methodologies. Furthermore, while fitting a curve to data helps interpolate or extrapolate values, past projections demonstrate how easily these can disagree with reality due to shifting policy landscapes and unexpected externalities. The revised methodology actively addresses these limitations not by claiming precision, but by remaining transparent, minimizing the time between known and unknown data points, weighing values by subcategories, and treating specific vehicle models or infrastructure configurations as representative estimates rather than values applicable to all contexts.

General Costs

This category includes the cost of fuel variable, which has been updated using the official EU publication Weekly Oil Bulletin. (European Commission, 2026) Its update frequency (weekly) and geographic scope (all EU) allow for close price tracking. Additionally, they publish national consumption data which has been used to weight price values to ensure that the final price reflects the larger group. The code used for revising this variable has been pushed to a GitHub repository and can be reproduced to arrive at the updated values.⁴

Passenger Transport

Within passenger transport, we can distinguish between private vehicle transport, public transit, and non-motorized transport.

Private vehicle transport

Previously assumed price parity by 2025 of battery electric vehicles (BEVs) with internal combustion engine vehicles (ICEVs) has not materialized in the EU EV market. (Lutsey & Nicholas, 2019) On the contrary, despite battery cost decrease as well as decrease in price of other components, the purchase price of EVs experienced growth for a few years due to

⁴ NZC-Costs-Assumptions. <https://github.com/alexlecka/NZC-Costs-Assumptions>

manufacturers' strategic focus on larger vehicles, the absence of binding CO2 target regulations, and reluctance to introduce price-competitive Chinese EVs onto the EU market. (IEA, 2025) In line with tighter introduced CO2 targets, manufacturers have rushed to make EVs more affordable, with price gaps being most drastic in small and medium segment EVs. (Transport & Environment, 2026) Consequently, 2025 prices showed the first decrease in years, and prices are projected to continue decreasing. This is a good example of a shifting policy landscape that, together with the price decrease predictions, has informed the revised purchase price of an EV.

Despite the EV cost decrease stagnation, EV charging infrastructure in the EU has been steadily improving. According to European Automobile Manufacturers Association (2022), approximately 75% of charging happens at home and remaining quarter at a public or work charger. The European EV Charging Infrastructure Masterplan discusses how the EV infrastructure system should support the transition to e-mobility until 2030 and is based on proposed EU regulatory targets for CO2 emissions reduction. It states (projected) capital expenditure (CAPEX) values for different types of chargers. (European Automobile Manufacturers Association, 2022) This includes costs covering hardware, installation, planning and engineering, and administration. Together with the 2025 Global EV Outlook report, it informs the revised passenger car (PC) charging infrastructure costs.

For the updated costs of driving a car per kilometre, the revised assumptions lean on recent EU sources offering a breakdown of total cost of ownership by vehicle segment (BEV and ICEV). (Sainz, 2025)

Key passenger transport assumptions:

Assumption	Unit	Original Value	Updated Value
Average cost of petrol/diesel	EUR/l	1,22	1,51
Cost of driving a car per kilometer - Fuel	EUR/km	0,0305	0,045
Cost of driving a car per kilometer - Maintenance	EUR/km	0,0184	0,029
Cost of driving a car per kilometer - Tires	EUR/km	0,0053	0,007
Cost of driving a car per kilometer - Depreciation	EUR/km	0,0369	0,084
Home charging infrastructure cost	EUR/EV	432	667
Public & workplace charging infrastructure cost	EUR/EV	254	731
Price of mid-range EV	EUR/vehicle	26274	31000
Price of ICE	EUR/vehicle	26274	28000

Public transit

Public transport costs for trains, metros, and buses were originally based on 2018 values sourced from the report Kollektivtrafikens kostnadsutveckling – en överblick by Sveriges Kommuner och Landsting (2017), which provided baseline total cost of ownership (TCO) metrics per wagon-kilometre. In the updated methodology, bus TCO data is updated using a recent study by Carbone et al. (2025). However, finding equivalent 2024 data for trains and metros proved difficult because most modern literature calculates costs by train-kilometre or seat-kilometre rather than by wagon. The new approach utilizes an Italian study by Avenali et al. (2025) alongside industry data from CAF Mobility (2026) to calculate the number of wagons in a typical multi-seat train and arrives at a comparable cost per wagon-kilometre.

The original framework used a Columbia University report to model diesel bus life-cycle costs over a twelve-year operational window under fixed baseline energy prices. (Aber, 2016) The updated approach shifts to a combination of newer sources because recent literature focuses

on itemized unit costs rather than total life-cycle figures. Investment costs are sourced from a study by Fantin et al. (2026), whose specific vehicle profile directly matches the model's required vehicle type. To determine ongoing operational expenses, fuel and maintenance costs were simulated using the Bus CMMS calculator and subsequently validated against independent findings by Šoštarić et al. (2025), Carbone et al. (2025), and Tagua Navarrete et al. (2025). (Bus CMMS, 2026)

In the original methodology, the allocation shares for capital expenditures and operational expenditures within the metro life-cycle framework were drawn from a study by Rong et al. (2016) that focused on urban metro networks within China. The updated methodology replaces this dataset with baseline lifecycle cost assumptions from a newer study by Yeboah and Kaewunruen (2025). Because this contemporary source evaluates Very Light Rail (VLR) systems rather than traditional heavy metro infrastructure, the updated approach operates under the explicit baseline assumption that VLR systems and conventional metro lines run within a tight, highly comparable economic and life-cycle cost range.

Key public transit assumptions:

Assumption	Unit	Original Value	Updated Value
Cost of public transport - Buses	EUR/km	3,3	2,3
Cost of public transport - Trains (metro)	EUR/km	2,89	2,54
Life cycle cost- buses - CAPEX	%	41	36
Life cycle cost- buses - OPEX	%	59	64
Life cycle cost- metro - CAPEX	% of lifecycle cost	61	65
Life cycle cost- metro - OPEX	% of lifecycle cost	39	35

Non-motorized transport

For walking and cycling infrastructure, examples of recently funded EU projects have been used to estimate cost per person kilometre. (Directorate-General for Mobility and Transport, 2025) The Confederation of the European Bicycle Industry publishes yearly statistics including the costs of new bicycles across the EU. Reports up until and including 2021 area available free of charge and were used to interpolate prices. (CONEBI, 2018) (CONEBI, 2019) (CONEBI, 2020) (CONEBI, 2021)

Freight Transport

Originally, the premium for electrifying a LCV was calculated by comparing a single baseline model pair, the diesel Nissan NV200 and electric e-NV200, using manufacturer data from a study by Lebeau et al. (2015). While the core concept of calculating the price premium remains unchanged, the updated methodology emphasizes a market-reflective approach. Through leveraging market shares from the 2025 International Council on Clean Transportation (ICCT) report, the model now evaluates sub-3.5 tonne baseline models from all top manufacturers. Localized market prices are weighted by each brand's market share and then converted to Euros to derive an industry-wide average premium.

A similar evolution from isolated baseline reports to broader industry aggregates applies to HDVs. The original framework relied on a 2018 European Climate Foundation report to estimate the 2018 component premium for a specific 700-kWh battery truck, utilizing the same source to project an annual compound annual growth rate (CAGR) through 2030. Maintaining this procedural logic, the updated approach transitions to a 2026 ERM International Group report to determine current costs. Because this newer literature

synthesizes data across major manufacturers like Scania, Mercedes-Benz, Daimler, and Traton, the resulting figures are treated as an industry average rather than a single vehicle baseline. Finally, the narrative of future cost trajectories is updated by calculating the CAGR from the International Energy Agency's (IEA) Global EV Outlook 2025.

The broader pattern of adapting shifting industry data structures also defined the approach to charging infrastructure. Originally, the model drew truck charging costs from the same 2018 European Climate Foundation report, which categorized infrastructure strictly under the definition of localized electronic system requirements. Finding recent data that matched this specific definition proved difficult, forcing the updated methodology to pivot toward overarching CAPEX station estimates.

Key freight transport assumptions:

Assumption	Unit	Original Value	Updated Value
Additional costs for an electrified light truck	EUR/truck	16150	13179
Net additional cost increase for electrified HDV	EUR/truck	47003	61357
CAGR for heavy-duty trucks	%/truck	-8	-6,63
Cost for charging infrastructure HDV	EUR/truck	14511	39954
CAGR for charging infrastructure HDV	% per year	-2	-6,63
Cost for LCV, as % of EV infrastructure costs	%	150,00	71,56
Charging infrastructure cost LCV	EUR/truck	1297	1000
Average CAGR for EVs	%/year	-3,70	-5,56

2.5 Co-Benefits

Co-benefits are the positive side-effects of climate action that go beyond emissions reduction itself. When a city improves public transport, encourages cycling, or retrofits buildings, it also improves air quality, reduces road accidents, and supports public health. These effects have real economic value, and the co-benefits module assigns a monetary figure to each one so that they can feed directly into investment decisions alongside the cost-side numbers in the other sectors.

Five categories are covered: the cost of air pollution (valued per tonne of pollutant emitted), the cost of transport noise, the cost of traffic accidents, the health benefits of walking and cycling, and the social cost of CO₂. The original values were drawn from the European Commission's Handbook on the External Costs of Transport (van Essen et al., 2019), which used 2016 as its reference year. This update brings each category up to a 2024 evidence base and a EUR 2024 price level.

Why these values needed updating

Four developments since 2016 made this update necessary. Each affects different categories of co-benefits in different ways, and the methodology applied to each value reflects which combination of forces is in play for that category.

First, the science on fine particulate matter has moved. A major international meta-analysis published in 2020 (Chen and Hoek) found that long-term exposure to PM_{2.5} is more harmful to human health than was assumed in 2016, with a relative risk per 10 µg/m³ of 1.08 rather than the 1.062 figure that underpinned the previous analysis. This single change pushes the per-tonne damage value for PM_{2.5} up substantially. The science on NO_x and PM₁₀, by contrast, has not moved as much, and the underlying science on noise damage and on the dose-response relationship between physical activity and mortality has not materially changed.

Second, incomes across the EU have risen since 2016. The values used throughout this module — the Value of a Statistical Life (VSL), the Value of a Life Year (VOLY), and related health-cost-based quantities — are linked to what people are willing to pay to reduce risks to their health. Willingness to pay rises with income, and so do these monetary values. This income effect feeds into every health-cost-based category.

Third, EU road safety has improved materially. Road fatalities across EU member states fell by approximately 23% between 2016 and 2022 according to the European Transport Safety Council. Because the per-kilometre cost of accidents is the product of (accident rate × cost per accident), this falling rate directly reduces the per-kilometre cost — partly offsetting the VSL uplift in the same category.

Fourth, the EU's climate target has tightened. The 2019 analysis assumed a 65% emissions reduction by 2050; the EU now targets full climate neutrality. More ambitious abatement raises the marginal cost of carbon reduction, which in turn raises the social cost of CO₂.

The primary source for this update is the CE Delft Environmental Prices Handbook 2024 (EU27 version). CE Delft is the same research organisation responsible for the underlying methodology in the 2019 handbook, making the 2024 publication a direct methodological successor rather than a methodological break. For walking and cycling specifically, the source has been changed from the Victoria Transport Policy Institute (a Canadian organisation whose values were applied via exchange-rate conversion) to the WHO Health Economic Assessment Tool (HEAT, 2024 edition), which is calibrated to European country-

specific health statistics and is the standard reference for European transport-and-health planning agencies.

How the values were rebuilt

Each updated value is the product of up to three multipliers applied in sequence. The first is a science-and-policy multiplier capturing what has changed in the underlying evidence (for example, the stronger PM2.5 dose-response, or the 23% road safety improvement). The second is an income/VSL uplift of approximately $\times 1.20$, which reflects the rise in EU willingness-to-pay between the 2018 and 2024 editions of the CE Delft handbook. The third is a price-base conversion of $\times 1.22$ from EUR 2021 to EUR 2024, derived from EU27 nominal GDP per capita growth (the 2021 figure was approximately EUR 32,500; the 2024 figure approximately EUR 39,680).

The choice of price-base conversion matters. A general consumer price index (HICP) would be the wrong tool for most of these values, because the dominant cost component in each is not a consumer good — it is the economic value of human health and life. These values are driven by willingness to pay to reduce health risks, and willingness to pay rises with income, not simply with consumer prices. EU27 nominal GDP per capita captures both real income growth and price-level change in one figure, which is consistent with how CE Delft and the OECD derive and update VSL estimates. In practice, over the 2021–24 period the numerical difference between the GDP-per-capita approach ($\times 1.22$) and the EU HICP ($\times 1.23$) is under 1%, but the GDP approach is the methodologically appropriate one.

The CO₂ value is the one exception to this framework. It is held in real EUR 2021 prices, in line with the convention for abatement-cost-based climate values: these costs are derived from the marginal cost of low-carbon technology pathways and are presented in constant prices by international climate-economics convention. Layering a nominal price-base conversion on top would be methodologically inconsistent with how the source itself (CE Delft EPH2024) and the European Commission's own policy work present the value.

The table below shows the net multiplier applied to each category — the product of all three steps where they apply.

Category	Net multiplier	What this captures
Air pollution — PM2.5	$\times 2.562$	Stronger dose-response (Chen & Hoek 2020), income/VSL uplift, and EUR 2021→2024 conversion
Air pollution — PM10	$\times 2.038$	EPH2024 update plus EUR 2021→2024 conversion
Air pollution — NOx	$\times 1.587$	EPH2024 update plus EUR 2021→2024 conversion
Noise	$\times 1.464$	Income/VSL uplift plus price-base conversion; underlying science unchanged
Traffic accidents	$\times 1.134$	VSL uplift ($\times 1.20$) partly offset by 23% road safety improvement ($\times 0.77$), then price base
Walking / cycling	$\times 1.464$	Source switched to WHO HEAT 2024; income/VSL uplift plus price base
CO₂	Direct replacement	EUR 100 → EUR 130 per tonne (EPH2024 central estimate, held in real EUR 2021 prices)

What changes for each category

Air pollution costs (PM2.5, PM10, NOx). These values express the monetary damage of each tonne of pollutant emitted and are used wherever a sector releases air pollution. PM2.5 sees the largest increase — a net multiplier of $\times 2.562$ — driven primarily by the stronger Chen and Hoek (2020) dose-response relationship layered on top of income and price effects. PM10 and NOx see smaller increases ($\times 2.038$ and $\times 1.587$ respectively), reflecting primarily income and price-level changes rather than science changes. The model's existing differentiation between metropolitan areas, within-city locations, and outside-city locations has been preserved: the same tonne of pollution causes more harm where more people are exposed to it, and atmospheric dispersion physics and population density have not changed.

Noise costs. These values represent the cost of transport noise per person-kilometre or tonne-kilometre, derived from documented health effects (cardiovascular disease, sleep disturbance, impaired cognitive development in children) and property-value impacts. The underlying science of noise damage has not changed materially since 2016, and EU ambient noise exposure has been broadly stable. The update therefore applies the income/VSL uplift and the price-base conversion only, giving a net multiplier of $\times 1.464$.

Traffic accident costs. These values capture the external cost of road traffic accidents per vehicle-kilometre — costs borne by people other than the driver at fault. The dominant component is the economic value of lives lost, measured through VSL. Two forces act in opposite directions here: VSL has risen with incomes ($\times 1.20$), but EU roads have become substantially safer (a 23% fall in fatalities between 2016 and 2022, applied as $\times 0.77$). The net effect, after the price-base conversion, is a modest $\times 1.134$ — a much smaller increase than the other health-cost categories. This reflects genuine EU road-safety progress.

Walking and cycling health benefits. When people shift from motorised transport to walking or cycling, they become more physically active, which reduces the risk of premature death from cardiovascular disease, stroke, and related conditions. The original values came from the Victoria Transport Policy Institute (Canadian) and were converted via the prevailing USD/EUR exchange rate. The primary source has been switched to the WHO Health Economic Assessment Tool (HEAT) 2024, which is widely used by European cities — including London, Vienna, Helsinki, and Paris — and is calibrated to EU country-specific health statistics. The HEAT dose-response function has not changed since 2019, so only the income/VSL uplift and price-base conversion are applied (net $\times 1.464$).

Social cost of CO₂. The 2019 figure of EUR 100 per tonne has been directly replaced by EPH2024's central estimate of EUR 130 per tonne, based on IPCC 1.5°C scenario abatement costs with limited overshoot. The handbook also provides a lower and upper range of EUR 50 and EUR 160 per tonne. As noted above, this value is held in real EUR 2021 prices rather than converted to nominal 2024 prices, which is the methodologically correct treatment for abatement-cost-based CO₂ valuations.

Finally, users working with nominal 2024 planning budgets should note that the CO₂ value (EUR 130 per tonne) is held in real EUR 2021 prices and is not converted to nominal 2024. This is the methodologically correct treatment, but it means a direct numerical comparison between the CO₂ co-benefit and other cost assumptions expressed in nominal 2024 prices require care.

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