Guidance Paper on Effective Infrastructure Investments

26. August 2025

For internal use[1]

TABLE OF CONTENTS:

[1] This document was developed to provide members of the Industry Working Group on Plastics (Tobacco Europe members and Philip Morris International) with guidance and information for the setting up of specific infrastructure under the Single-Use Plastics Directive (SUPD). This document is intended for internal use only and not to be shared **with external audiences**.

1. Introduction

The Single-Use Plastics Directive has been transposed with proportionate EPR fees in most EU Member States now. Despite, some Member States have imposed excessive EPR fees (e.g., Germany, Sweden, the Netherlands etc.) under Article 8(3), which also references that "costs may include the setting up of specific infrastructure for the waste collection for those products, such as appropriate waste receptacles in common litter hotspots"[2]. So far, the costs for the setting up of specific infrastructure was **no priority for policymakers** in markets, yet. Nevertheless, e.g., in Finland, the regulation has set a mandatory infrastructure target of one waste bin per 300 inhabitants from 2026 onwards[3].

The objective of this guidance paper is to assess the impact of setting up (specific) infrastructure on i) **littering behavior** and ii) **waste management costs**. Apart from evaluating opportunities to reduce EPR fees for manufacturers, the assessment of litter reduction is considered in isolation important to prepare for EU's call for evidence and public consultation on the setting of **mandatory litter reduction targets** (*see* Article 16 of the SUPD). The following document gives guidance on i) data and literature, ii) cost-benefit analysis for setting up infrastructure, and iii) empirical evidence from Germany. This guidance document concludes with a recommended approach iv) for markets.

2. Data research and literature review

The following chapter provides an i) overview on available data on infrastructure in EU Member States and ii) reviews the existing literature, which evaluates the effects of infrastructure on littering behavior and waste management costs. While the effects of infrastructure on littering behavior are very well understood and investigated, **further research is needed to assess the effects of infrastructure on waste management costs** (and corresponding EPR fees under the SUPD).

2.1 Data on infrastructure

There are hardly any (accessible) data or studies on public infrastructure for the waste collection, e.g., waste bins or ashtrays. Despite, some cities have very precise geodata on public waste infrastructure (*see* Amsterdam (Netherlands)[4] or Münster (Germany)[5]). The best global data base is **OpenStreetMap**[6]. Table 1[7] shows processed data for all EU Member States (*note*: data can also be processed for non-EU countries, but since OpenStreetMap is an open-source project, data availability is limited). Table below shows five indicators: i) number of bins, ii) number of inhabitants, iii) **inhabitants per bin**, iv) area in km², and v) **bins per km²**.

---

[2] European Parliament and the Council of the European Union (2019): "Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment", in: *Official Journal of the European Union* L 155/12.

[3] Tampere (2024): "Tampere increases the number of cigarette butt bins in public areas".

[4] Gemeente Amsterdam (2025): "Afvalcontainers op de kaart".

[5] Stadt Münster (2025): "Standorte der Papierkörbe".

[6] Public data on waste infrastructure: "OpenStreetMap"; analyzed via data mining tool "Overpass turbo".

[7] Note: Besides the indicator inhabitants per bin, the first-best indicator is **bins per cleaning km**. The challenge is that these data are only available in municipal street statuses. Extracting and processing these data for a country or even the entire EU is almost impossible. In addition, in many countries the responsibility for cleaning up streets is transferred to the property owners (in large cities 50% of streets are cleaned by property owners in theory). In general, aggregated data for bins on a country level are always misleading, since bins are for high-density residential structures.

Member State	Number of bins	Number of inhabitants	Inhabitants per bin	Area in km^2	Bins per km^2
Austria	24,871	9,158,750	368	83,884	0.296
Belgium	24,944	11,832,049	474	30,528	0.817
Bulgaria	1,185	6,445,481	5,439	110,372	0.011
Croatia	3,693	3,861,967	1,046	56,594	0.065
Cyprus	612	933,505	1,525	9,251	0.066
Czech	15,912	10,900,55	885	78,866	0.202
Denmark	6,004	5,961,249	993	43,075	0.139
Estonia	4,330	1,374,687	317	45,227	0.096
Finland	10,422	5,603,851	538	338,424	0.031
France	125,734	68,401,997	544	632,786	0.199
Germany	215,340	83,445,000	388	357,386	0.603
Greece	2,525	10,397,193	4,118	131,990	0.019
Hungary	14,896	9,584,627	643	93,023	0.160
Ireland	4,725	5,342,805	1,131	70,723	0.067
Italy	37,230	58,989,749	1,584	301,338	0.124
Latvia	4,537	1,871,882	413	64,589	0.070
Lithuania	1,520	2,885,891	1,899	65,200	0.023
Luxembourg	3,215	672,050	209	2,586	1.243
Malta	413	563,443	1,364	316	1.307
Netherlands	35,537	17,942,942	505	41,543	0.855
Norway	3,453	5,500,203	1,607	384,482	0.009
Poland	54,396	36,620,970	673	321,685	0.174
Portugal	4,745	10,639,726	2,242	92,212	0.051
Romania	1,554	19,064,409	12,268	238,397	0.007
Slovakia	7,603	5,424,687	713	49,035	0.155
Slovenia	1,470	2,123,949	1,445	20,273	0.073
Spain	26,762	48,610,458	1,816	505,983	0.053
Sweden	12,045	10,551,707	876	447,425	0.027

Table 1: Data on infrastructure and infrastructure density for EU Member States

Considering the indicator **inhabitants per bin** a very large range from 209 (Luxembourg) to 12,268 (Romania) can be observed (low values for high infrastructure density and high numbers for low infrastructure density). Unsurprisingly, the indicator **bins per km^2** is highest in small and relatively densely populated countries e.g., Malta (1.2) or Luxembourg (1.3). The fewest bins per km^2 are in Romania (0.007) and Norway (0.009). Germany and France show the highest total number of bins (215,340 and 125,734 respectively), while Malta (413) and Cyprus (612) show the fewest.

In a next step, we review the existing literature and try to link the 'backbox' infrastructure with littering behavior and waste management costs.

2.2 Dimensions of infrastructure

The following subchapter structures the reviewed literature along **three dimensions**: i) availability of infrastructure, ii) infrastructure volumes per time, and iii) and public awareness. Especially the latter has demonstrated significant effects on littering behavior.

2.2.1 Availability of infrastructure

In general, there seems to be a **positive correlation** for **non-specific infrastructure** (total numbers of bins) and littering behavior (less littering). Nevertheless, there is also evidence that **infrastructure**

reduction is also associated with positive effects on waste management costs[8]. Evidence from India shows that reducing the number of collection points by 15%, results in a 25% decrease in idling costs as well as a 35% reduction in carbon emissions[9]. Other studies come to similar conclusions: Evidence from Serbia shows, that a 24% decrease in the number of collection points and a 33.5% reduction in the number of waste bins not only hasn't compromised service quality and availability of waste infrastructure for citizens but has also led to absolute savings of EUR 26,000 per year for a single municipality (Kragujevac)[10].

Looking at **specific infrastructure** for the post-consumption waste of tobacco tells a different story. Results from the U.S. suggest an average decrease of general littering by 1% per additional bin compared to a 9% decrease in cigarette littering per additional cigarette bin[11]. A national study from the U.S. finds that only 2.4% of cigarette butts were disposed of in regular trash cans, while 50.4% were properly disposed of in ashtrays and 37.4% were littered. At the same time, 58.9% of U.S. residents state the lack of convenient waste disposal as the most common reason for littering[12]. For example, in Germany only around 25% of public bins include cigarette disposal possibilities[13]. Insights from Germany indicate that only 6% of littering is motivated by a lack of disposal options and 45.7% occurs even when a disposal unit is within a radius of 10 meter[14]. Installing waste bins and ashtrays at highly frequented **hotspots** has been subject of a wide range of studies and is shown to be especially effective in curbing littering behavior and volumes (*see* Almost et al. (2019)[15], Smith and Novotny (2011)[16], or Pazzaglia and Castellani (2023)[17]). Identified hotspots include pedestrian crossings, building entrances, underground and bus stations. The setting up of **tobacco-specific infrastructure** for the waste collection is therefore of high importance to reduce littering.

2.2.2 Infrastructure volume per time

In general, **higher frequencies of emptying leads to higher costs** for waste management services. Nevertheless, there is empirical evidence that the frequency of emptying is associated with less littering[18]. Less frequently emptied bins tend to overflow, which not only results in additional trash being automatically **considered as 'littered'**, but also significantly decreases proper waste disposal

---

[8] Chaudhary et al. (2021): "Littering behavior: a systematic review", in: *International Journal of Consumer Studies*, 45(4): 478-510.

[9] Rathore et al. (2019): "Location-allocation of bins in urban solid waste management: a case study of Bilaspur city, India", in: *Environment, Development and Sustainability*, 22: 3309-3331.

[10] Boskovic et. al. (2015): "Fast methodology to design the optimal collection point locations and number of waste bins: A case study", in: *Waste Management & Research*, 33(12): 1094-1102. Note: Study results are difficult to interpret without analyzing raw data, since it is important to know from which level of infrastructure density percentage changes are derived. In addition, in many countries there is **no door-to-door collection of household waste**. Household waste and public street litter is collected in collectively used waste bins.

[11] Schultz et al. (2013): "Littering in Context: Personal and Environmental Predictors of Littering Behavior", in: *Environment and Behavior*, 45(1): 35-59.

[12] Keep America Beautiful (2021): "2021 National Litter Study".

[13] Verband Kommunaler Unternehmen (2020): "Littering: Kommunale Maßnahmen für Stadtsauberkeit".

[14] Verband Kommunaler Unternehmen (2020): "Littering: Kommunale Maßnahmen für Stadtsauberkeit".

[15] Almost et al. (2019): "Littering Reduction: A Systematic Review of Research 1995-2015", in: *Social Marketing Quarterly*, 23(3): 203-222.

[16] Smith, E., and Novotny, T. (2011): "Whose Butt is it? Tobacco Industry Research about Smokers and Cigarette Butt Waste" in: *Tobacco Control*, 20 (Suppl. 1).

[17] Pazzaglia, A., and Castellani, B. (2023): "Review of the Policy, Social, Operational, and Technological Factors affecting Cigarette Butt Recycling Potential in Extended Producer Responsibility Programs", in: *Recycling*, 8(6), 95.

[18] Ryan et al. (2020): "The Impact of the COVID-19 Lockdown on Urban Street Litter in South Africa", in: *Environmental Processes*, 7: 1303-1312.

behavior[19]. When individuals encounter overflowing bins, their sense of responsibility to keep the environment clean shrinks dramatically[20]. The decisive factor is the **bin volume per time**. This can be achieved by i) an increased number of bins in highly frequented zones, ii) a larger volume per bin or iii) an increased frequency of emptying. The latter can be considered as the **most expensive** variant.

Most municipalities rely on **static emptying routes** that don't adapt to fill levels of infrastructure, resulting in unnecessary waste management costs. San Francisco has implemented a very promising approach using a **smart sensor system** supplied by Norwegian company Nordsense. As of 2023, more than 1,000 sensors have been installed that led to an 80% decrease in overflowing bins, a 66% decrease in street cleaning service requests as well as a 64% decrease in illegal dumping. By optimizing the frequency of emptying the city of San Francisco "was able to achieve **significant waste management cost reductions**"[21]. Other projects with smart sensors show similar results. The city of Netanya (Israel) realized a reduction of collection services by 30%, with 81% of infrastructure being serviced just in time[22].

2.2.3 Public awareness of infrastructure

Another important dimension of infrastructure is public awareness. Optimizing the **design and attractiveness** of infrastructure aims to increase the public awareness in order to reduce littering behavior. Empirical evidence suggest that consumer prefer i) low openings, ii) sealed lids to reduce odor and iii) aesthetically pleasing containers[23]. In general, high-visibility properties, such as bright colors, which increase the contrast of waste disposal infrastructure from the surrounding context, are more effective than decorative elements, such as children's drawings, or purely environmental messaging[24]. Results from Paris (France) show that a **changed color coding** of trash bags (from standard grey to a brighter blue or red) has increased detectability by 35-40%[25].

A **best-practice example** for tobacco-specific infrastructure is Australia[26], which has evaluated four different strategies: i) Creating a sense of pride and ownership among smokers at a specific location, ii) pathways that lead to specific disposal units, iii) positive social norming of correct disposal behavior and the iv) enforcement of fines (AUD 200[27]). All strategies have significantly increased correct disposal behavior, while the **'pride-and-ownership'** strategy can be considered as most effective with increased binning rates of up to 124%. In contrast, installing pathways to disposal units has been identified as the most cost-efficient approach, especially for parks[28]. In the light of the high fines, the results may be biased.

---

[19] Schultz et al. (2013): "Littering in Context: Personal and Environmental Predictors of Littering Behavior", in: *Environment and Behavior*, 45(1): 35-59.

[20] Tesfaldet et al. (2022): "Assessing face mask littering in urban environments and policy implications: The case of Bangkok", in: *Science of The Total Environment*, 806(4).

[21] Nordsense (2025): "Website: Sensors Used in Waste Management".

[22] Nordsense (2025): "Website: Sensors Used in Waste Management".

[23] Moqbel et al. (2019): "Littering in Developing Countries: The Case for Jordan", in: *Polish Journal of Environmental Studies*, 28: 3819-3827.

[24] Linder et al. (2023): "Managing waste behavior by manipulating the normative appeal of trash bins: Lessons from an urban field experiment", in: *Resources, Conservation and Recycling Advances*, 19.

[25] Sater et al. (2023): "A Zero-Cost Attention-Based approach to Promote Cleaner Streets: A Signal Detection Theory Approach in Parisian Streets", in: *PLOS One*, 18.

[26] Environment Protection Authority (2019): "Identifying Effective Strategies to Reduce Cigarette Butt Litter: Findings from the NSW EPA-led Cigarette Butt Litter Prevention Trial".

[27] Government of Western Australia (2025): "Litter laws".

[28] Environment Protection Authority (2019): "Identifying Effective Strategies to Reduce Cigarette Butt Litter: Findings from the NSW EPA-led Cigarette Butt Litter Prevention Trial".

3. Cost-benefit analysis

The previous chapter has shown that infrastructure investments in general, have a positive effect on littering behavior but only under some special conditions' positive effects on waste management costs, which are the basis for calculating EPR fees. The industry is now facing the question of whether to invest voluntarily in public infrastructure or not. This depends on the result of a cost-benefit analysis.

Formally speaking, if the **sum of the saved EPR fees** (Δ EPR) exceeds **the initial infrastructure investment** (I) **plus the sum of marginal costs for emptying** (Δ MCE) it makes sense from an industry perspective to invest voluntarily in public (specific) infrastructure (*see* footnote[29] for the investment condition; for completeness, it is necessary to discount the periods by a discount factor r and for simplicity it is assumed that saved waste management costs are identical with saved EPR fees for the industry). In practice, the question can only be answered empirically and therefore depends on the **availability of data**.

We know from an Austria study (2021)[30] that the annual costs for the procurement and maintenance of public collection facilities (waste bins) are estimated at around EUR 20 per bin per year (purchase and installation EUR 160 for an 8-year lifecycle). This results in infrastructure costs of EUR 0.40 per inhabitant and year or EUR 3.5 million per year for Austria in total. Table 3 illustrates how to conduct a simplified cost-benefit analysis without discounting. If the sum of saved EPR fees (second column; last row) is greater than the sum of the other two rows, then public infrastructure investments are yielding.

Years	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Σ**
Saved EPR (**Δ EPR**)									
Initial infrastructure investment (**I**)	160	0	0	0	0	0	0	0	160
Marginal costs for emptying (**Δ MCE**)									

Table 3: Cost-benefit analysis with data from Austria

4. Empirical evidence from Germany

Looking into the German UBA study (2022) provides information about the **relative costs of different waste types**. UBA data do not allow a cost-benefit analysis (waste management dynamics) but nevertheless show some insightful waste management statics. Table 4 shows the **absolute shares** of SUP products in waste bins (2.1%), manual street cleaning (1.2%), manual green space cleaning (0.2%), and mechanical street cleaning (2.0%). In total, SUP products contribute to 5.5% of all collected waste by weight. Bins contribute to 17.8% all collected waste. The concentration of SUP products – the **relative share** – is **highest in bins (37.8%)**, followed by mechanical street cleaning (35.7%).

Waste type	**Bins**		**Manual street cleaning**		**Manual green space cleaning**		**Mechanical street cleaning**		
Total		17.8%		13.4%		3.3%		65.5%	Sum
SUP	11.7%	**2.1%**	9.1%	**1.2%**	7.5%	**0.2%**	3.0%	**2.0%**	**5.5%**
Plastics (others)	2.8%	0.5%	2.3%	0.3%	2.6%	0.1%	0.4%	0.3%	1.2%
Packaging	31.6%	5.6%	22.7%	3.0%	35.5%	0.8%	7.6%	5.0%	14.5%

[29] Investment condition: $\sum_{t=1}^{n} \frac{\Delta EPR_n}{(1+r)^n} > I_{t=1} + \sum_{t=1}^{n} \frac{\Delta MCE_n}{(1+r)^n}$

[30] Technisches Büro Hauer Umweltwirtschaft GmbH (2021): "Littering im Sinne der EU-Richtlinie 2019/904 Artikel 8: Erweiterte Produzentenverantwortung, Ermittlung von Kennzahlen hinsichtlich Aufwand und Kosten für Straßenreinigung", p. 15.

Others	53.9%	9.6%	65.9%	8.8%	64.4%	2.1%	89.0%	58.3%	78.9%
SUP share		**37.8%**		**22.1%**		**4.5%**		**35.7%**	100%

Table 4: SUP shares for different waste types in Germany[31]

Considering costs of different waste types shown in Table 5 highlights that costs for emptying bins is **more than half the price** (EUR 4.18 per year and inhabitant) than mechanical street cleaning (EUR 8.64 per year and inhabitant) or manual street cleaning (EUR 9.21 per year and inhabitant).

Costs for different waste types	**Costs per year and inhabitant in EUR**
Costs of emptying bins	4.18
Costs of manual street cleaning	9.21
Costs of street cleaning using machines	8.64

Table 5: Cost data from German UBA study[32]

Table 6 combines the costs and SUP share for different waste types. The **SUP-cost share is almost half for emptying bins** (1.58) compared to mechanical street cleaning (3.09). As a result, SUP products can be collected **with relatively little money** by bins.

	Bins	**Manuel street cleaning**	**Mechanical street cleaning**
SUP share for different waste types	0.378	0.221	0.357
Costs for different waste types	4.18	9.21	8.64
SUP-cost ratio	1.58	2.04	3.09

Table 6: SUP-cost ratios for different waste types in Germany

Nevertheless, this **does not allow to conclude** that more bins (more volume per time) may contribute to lower mechanical or manual street cleaning costs. We do not know if costs for mechanical or manual street cleaning will decrease by more than costs for emptying bins (plus initial investments) have increased. In a **best-case scenario**, bin infrastructure effects litter collection (manual street cleaning), as this only takes place on sidewalks and frequented areas in high-density residential structures. A **realistic assumption** would be to consider costs for mechanical and manual street cleaning as **fixed**, since waste management services would be carried out with the **same amount of input factors** (machinery and personal). Without data on changing input factors the question, whether infrastructure investments do have a positive effect on waste management costs or not, can therefore not be answered conclusively.

31 Umweltbundesamt (2022): "Erarbeitung eines Kostenmodells für die Umsetzung von Artikel 8 Absatz 2 und 3 der EU-Einwegkunststoffrichtlinie".

32 Umweltbundesamt (2022): "Erarbeitung eines Kostenmodells für die Umsetzung von Artikel 8 Absatz 2 und 3 der EU-Einwegkunststoffrichtlinie", p. 34. Note: The UBA study differentiates between cost of emptying litter bins on public streets (2.7 EUR per year and inhabitant) and cost of emptying litter bins in green spaces (1.48 EUR per year and inhabitant). In total, costs for emptying bins are EUR 4.18 per year and inhabitant.

5. Conclusion and recommendations

This is the **first version** of a guidance paper on effective infrastructure investments, which has tried to answer a very complex question. Further research (workshop with waste experts) is needed to substantiate this draft guidance paper for markets. Nevertheless, there are some robust findings and preliminary recommendations for markets. In a nutshell, (specific) infrastructure is a **good instrument to curb littering**, but a **poor instrument to decrease waste management costs**.

- **Firstly**, infrastructure has a significant effect on littering behavior. This is true for all dimensions of infrastructure. However, less littering does not necessarily contribute to lower waste management costs. The most promising approach is to provide (i) **high-volume bins** for (ii) **litter hotspots**, which has the most likely leverage to reduce municipal waste management costs.
- **Secondly**, the emptying of tobacco-specific infrastructure is very expensive. From an industry perspective, there is no interest in extending the separate collection of littered tobacco filters.
- **Thirdly**, investments in public infrastructure should always be based on a cost-benefit analysis, if data are available. In case of no data availability, it is essential to plausibilize whether and how cost savings could be materialized.
- **Fourthly**, the German case study has demonstrated that bin infrastructure can be considered as cost-efficient in collecting SUP products. Yet, this does not imply that 'more' or 'advanced' infrastructure is a cost-effective approach for markets.