



# How the carbon calculator translates zero waste strategies into climate benefits

The case of Barcelona

Case study  
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# Contents

## **2 Introduction**

## **3 Background and context**

4 The carbon calculator tool

## **5 Applying the tool to Barcelona**

5 Baseline carbon emissions from waste management

6 Proposed zero waste strategy for Barcelona

8 Results and potential impact

9 Breakdown potential savings by activity

10 Overall impact

11 Monetising the carbon savings

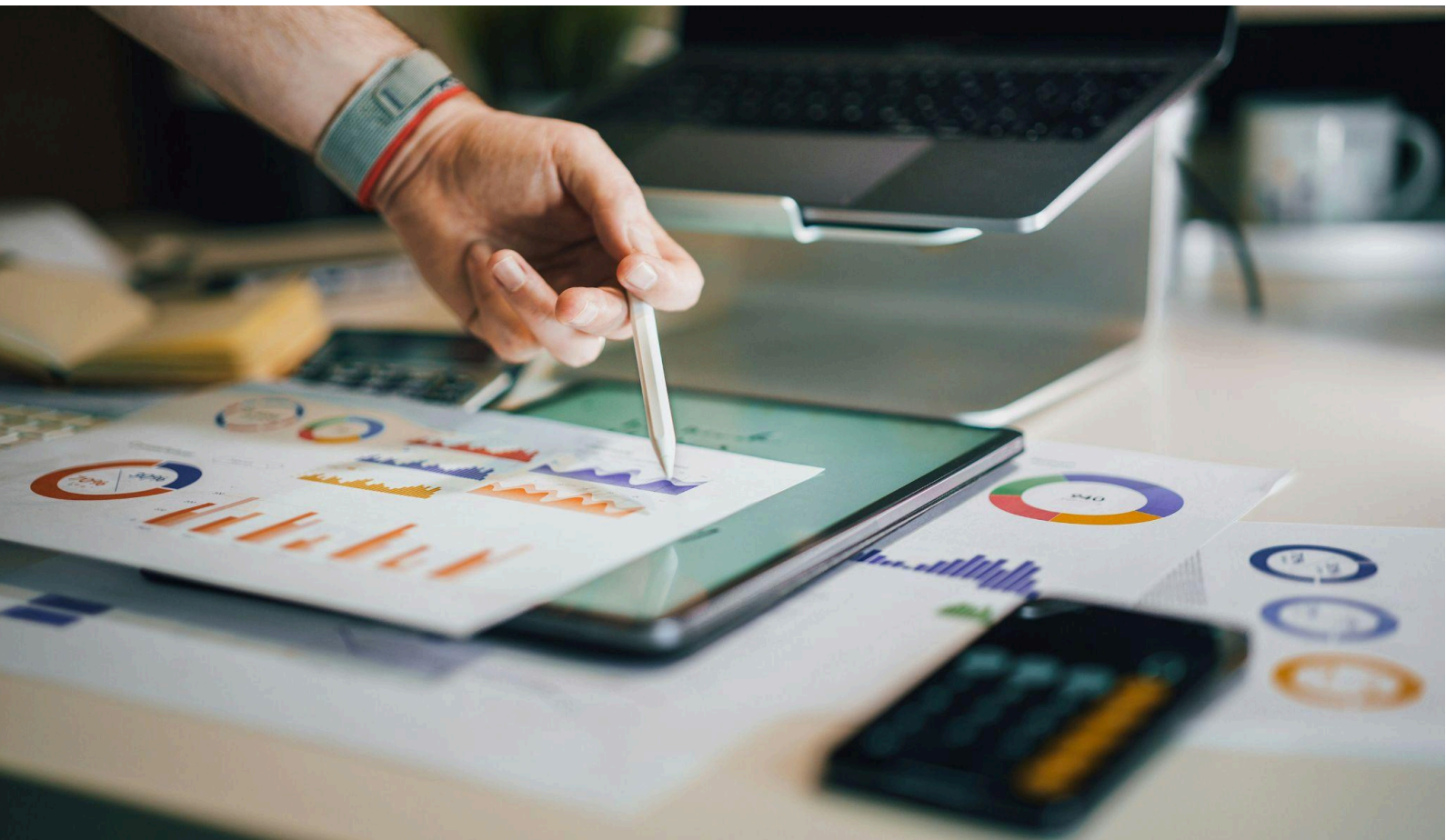
## **12 Conclusion**

# Introduction

In the global fight against climate change, cities stand at the forefront, grappling with complex waste management systems that significantly contribute to carbon emissions. Barcelona, a vibrant metropolis of 1.6 million inhabitants, is no exception.

As urban centres worldwide seek innovative solutions to reduce their carbon footprint, the intersection of waste management and climate action has emerged as a critical battleground. Yet, amid the tangle of varying systems, regulations, and frameworks, one crucial aspect often remains overlooked: the carbon emissions benefits of waste prevention.

Thanks to the introduction of our groundbreaking [carbon calculator tool](#), cities like Barcelona have the opportunity to quantify and realise the immense potential of zero waste strategies in advancing their climate agendas and use climate mitigation financing to pay for them.





# Background and context

Barcelona, the capital of Catalonia, has long been recognised for its commitment to sustainability and innovation. In recent years, Barcelona has made significant strides in its climate commitments. The city's Climate Plan 2018-2030<sup>1</sup> sets forth a vision to reduce greenhouse gas emissions by 45% by 2030 (compared to 2005 levels) and achieve carbon neutrality by 2050. However, like many cities, Barcelona struggles to fully integrate its waste management strategies with its broader climate objectives.

The challenge lies not only in improving recycling rates but in fundamentally rethinking the city's approach to resource use and waste generation. Traditional waste management focuses primarily on end-of-pipe solutions, treating waste after it has been created. However, **the most significant carbon savings lie in prevention and reuse strategies that stop waste from being generated in the first place.**



*“The Barcelona City Council relied on [Rezero](#)'s expertise to develop the city's Zero Waste Plan 2021-2027. This plan, aimed at transitioning to a zero-waste future, introduces innovative measures that address the climate emergency through efficient resource use and smart waste management. It actively involves the local community and key stakeholders to ensure a successful transition. With this initiative, Barcelona has become a model for other big European cities pursuing the zero-waste path. By using the emissions' calculator, the city is leading the way in using metrics that assess both waste management emissions and strategies for reduction and reuse.”*

Alba Cabrera - Rezero

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<sup>1</sup> [www.barcelona.cat/barcelona-pel-clima/sites/default/files/climate\\_plan\\_maig.pdf](http://www.barcelona.cat/barcelona-pel-clima/sites/default/files/climate_plan_maig.pdf)

# The carbon calculator tool

This is where the carbon calculator tool, developed by [Zero Waste Europe](#) in collaboration with the Catalan consultancy [Inèdit](#) and implemented by the [Mission Zero Academy](#), comes into play. Launched in 2021, this innovative tool can calculate not only the emissions savings from better waste segregation and recycling but also factors in the impact of prevention and reuse activities. For a city like Barcelona, this comprehensive approach makes visible the true carbon footprint of its waste management systems and the potential savings achievable through zero waste strategies.

The tool's methodology is rooted in life cycle assessment principles, considering emissions across the entire waste management chain – from collection and transport to treatment and final disposal. It incorporates data on various waste streams, including organic waste, paper and cardboard, glass, plastics, and residual waste. By inputting city-specific data on waste generation, composition, and current management practices, the tool can establish a baseline emissions scenario.

**What sets this calculator apart is its capability to model various zero waste scenarios. Users can input potential changes in waste prevention, reuse initiatives, and improved recycling rates to see the resulting emissions reductions. This feature allows cities to experiment with different strategies and quantify their potential impact before implementation, facilitating data-driven decision-making in urban waste policy.**

Moreover, the tool goes beyond mere calculation. It serves as an educational instrument, helping city officials and the public understand the often-overlooked connection between waste management and climate change. By providing clear, quantifiable results, it bridges the gap between waste prevention strategies and climate action plans, demonstrating how seemingly small changes in waste management can lead to significant reductions in a city's overall carbon footprint.

The carbon calculator has been rigorously tested and refined through pilot projects in various cities, including Barcelona. These real-world applications have not only validated its accuracy but also demonstrated its versatility in adapting to different urban contexts and waste management systems.

# Applying the tool to Barcelona

Barcelona, a city of 1.6 million inhabitants and a major tourist destination, faces significant challenges in managing its municipal solid waste. In 2021, the city generated<sup>2</sup> approximately 42,431.35 tonnes of waste, equivalent to 1.23 kg per person per day<sup>3</sup>. The city's separate collection rate stands at 41.65%, which, while above the Spanish average, falls short of the EU's 2025 recycling target of 55% and is far from Barcelona's ambitious goal of 67% by 2027. Most of the separately collected waste is recycled, with organic waste being composted or treated in anaerobic digestion facilities. The residual waste is primarily sent to mechanical-biological treatment plants, with a small portion going to incineration and landfill.

While Barcelona has significantly improved its waste management over the past decade, further progress is essential to meet European Union recycling and preparation for reuse targets and the city's own climate goals.

## Baseline carbon emissions from waste management

Applying the carbon calculator tool to Barcelona's current waste management system reveals the significant climate impact of the city's waste. **Based on the 2019 data, the baseline carbon emissions from Barcelona's waste management activities amount to approximately 172,770 tonnes of CO<sub>2</sub> equivalent per year, that is the equivalent of the annual emissions of 30,000 Europeans.** This figure accounts for emissions from waste collection, transport, treatment, and final disposal, as well as avoided emissions from recycling and energy recovery.

The breakdown of emissions by waste stream shows **that organic waste and residual waste are the largest contributors, accounting for 40% and 35% of total emissions respectively.** This is due to the high methane potential of organic waste in landfills and the energy-intensive processes required to treat residual waste. Recycling activities, particularly for paper and cardboard, contribute to avoided emissions, but the current recycling rates are not sufficient to offset the emissions from other waste streams.

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<sup>2</sup> [estadistiques.arc.cat/ARC/#](https://estadistiques.arc.cat/ARC/#)

<sup>3</sup> [www.idescat.cat/pub/?id=resmc&n=6997&geo=mun:080193,prov:08](https://www.idescat.cat/pub/?id=resmc&n=6997&geo=mun:080193,prov:08)

# Proposed zero waste strategy for Barcelona

To address these challenges and significantly reduce carbon emissions, the carbon calculator tool has been used to model 7 concrete actions of Barcelona's zero waste strategy among the many more that could be added. This targeted strategy, aligned with the principles of the waste hierarchy and the city's climate goals, includes the following key components:

## 1. **Waste prevention<sup>4</sup>:**

- Implement a city-wide food waste reduction campaign.
- Introduce a ban on single-use plastics.
- Promote reusable packaging systems in retail and hospitality sectors.

## 2. **Reuse and repair:**

- Establish a network of repair cafes and second-hand shops.
- Create a municipal reuse centre for furniture and household items.
- Develop a digital platform for sharing and exchanging goods.

## 3. **Enhanced separate collection:**

- Expand door-to-door collection systems to cover 80% of the city.
- Introduce pay-as-you-throw schemes to incentivise waste reduction.
- Implement a deposit return system for beverage containers.

## 4. **Improved organic waste management:**

- Increase separate collection of organic waste to capture 80% of what's generated.
- Upgrade composting facilities to produce high-quality compost.
- Promote home and community composting.

## 5. **Optimised recycling:**

- Invest in advanced sorting technologies at recycling facilities.
- Develop local markets for recycled materials.
- Implement extended producer responsibility schemes.

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<sup>4</sup> [ajuntament.barcelona.cat/neteja-i-residus/en/presentation/waste/zero-waste-plan](https://ajuntament.barcelona.cat/neteja-i-residus/en/presentation/waste/zero-waste-plan)



## 6. Residual waste reduction:

- Gradually phase out incineration and landfilling.
- Invest in mechanical and biological treatment facilities.
- Implement strict controls on commercial and industrial waste.

## 7. Education and community engagement:

- Launch a comprehensive zero waste education program in schools.
- Organise community events and workshops on waste reduction.
- Develop a mobile app for waste sorting and recycling information.





# Results and potential impact

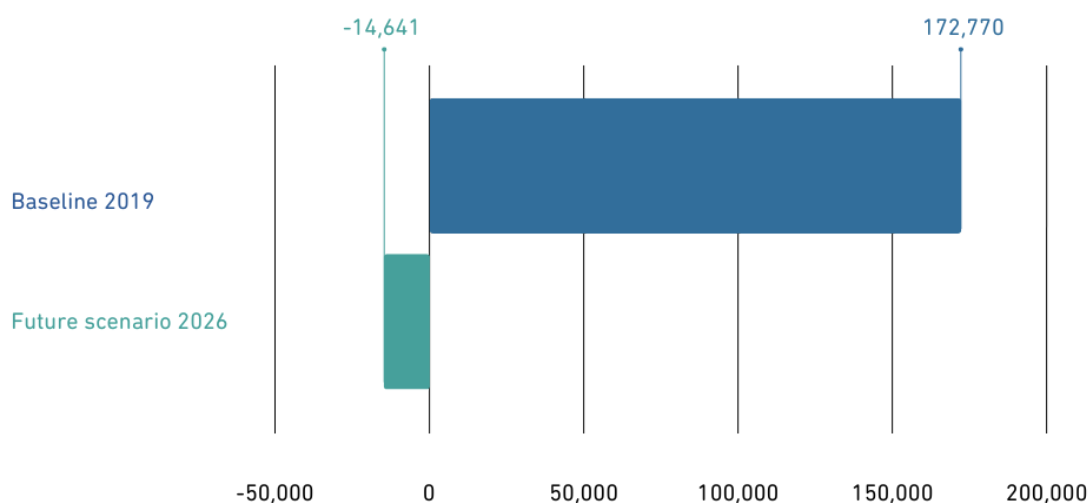
By implementing these 7 actions of a zero waste strategy, the carbon calculator projects that Barcelona could massively reduce its waste-related carbon emissions, bringing the annual emissions down more than 187,000 of CO2 equivalent per year. That is the equivalent of the average emissions of 32,000 Europeans or 28 million trees.

This would see a significant decrease for the city's climate impact. It would completely change the dynamic, to one where the city no longer is a net emitter of emissions but rather brings 14,641 tonnes of CO2 equivalent additional savings per year compared to the baseline. This reduction would be achieved through a combination of decreased total waste generation, increased recycling rates, and more efficient treatment of organic and residual waste.

*Fig. 1-2: Carbon emissions projection of the city of Barcelona.*

Scenario	Waste management generated emissions	Waste management avoided emissions	Emissions due to the zero waste strategies		TOTAL	Unit
			Added	Avoided		
Baseline situation 2019	337,912	- 165,143			<b>172,770</b>	Tonnes CO2eq
Future scenario 2026	262,142	- 215,940	44,677	- 105,520	<b>-14,641</b>	Tonnes CO2eq

### Overall GHG emissions (tonnes CO<sub>2</sub>eq)



These results highlight the potential long-term cumulative impact of these measures. If the measures continue to be applied over a 10-year period, the implementation of this zero waste strategy could prevent the emission of up to 2 million tonnes of CO<sub>2</sub> equivalent.

The application of the carbon calculator tool to Barcelona's waste management system reveals significant potential for reducing greenhouse gas emissions through the implementation of a comprehensive zero waste strategy. The results demonstrate not only the scale of possible reductions but also pinpoint the most effective areas for intervention.

## Breakdown of potential savings by activity

### 1. Waste prevention:

The most impactful activity in terms of emissions reduction is waste prevention. By implementing measures to reduce overall waste generation, particularly in organic and plastic waste, Barcelona could avoid approximately 80,000 tonnes CO<sub>2</sub>e annually. **This accounts for about 42% of the total potential savings.**

### 2. Increased recycling:

Enhancing recycling rates from current 39% to 50% (current EU recycling target) across all waste streams could lead to a reduction of around 50,000 tonnes CO<sub>2</sub>e per year, or 26% of the total savings. This includes both avoided emissions from landfill/incineration and the benefits of recycling materials.

### 3. Improved organic waste treatment:

Optimising the treatment of organic waste through increasing composting and anaerobic digestion from 122,847 tonnes in 2019 to 189,437 tonnes in 2026 could result in a reduction of 35,000 tonnes CO<sub>2</sub>e annually, representing 19% of the total savings.

### 4. Optimised residual waste treatment:

Shifting from incineration to more efficient mechanical and biological treatment for residual waste could contribute to a reduction of about 24,000 tonnes CO<sub>2</sub>e per year, or 13% of the total savings.

## Overall impact

This level of reduction would make a significant contribution to Barcelona's climate goals. It would represent approximately 15% of the total emissions reduction needed for the city to meet its 2030 target of 45% reduction compared to 2005 levels.

The impact extends beyond just carbon emissions. The zero waste strategy would also lead to:

- Reduced air and water pollution from waste treatment facilities.
- Conservation of natural resources through increased recycling and reuse.
- Replacing synthetic fertilisers with the natural soil improver that is compost.
- Creation of green jobs in the recycling and repair sectors.
- Improved urban cleanliness and quality of life for residents.
- Cost savings for the municipality through reduced waste treatment needs.

It's important to note that achieving these results would require significant investment in infrastructure, policy changes, and public engagement campaigns. However, the carbon calculator tool provides a powerful argument for making these investments, clearly demonstrating the substantial environmental benefits that can be achieved through a comprehensive zero waste approach.

By quantifying the potential impact in this way, Barcelona's city planners and policymakers have a strong case for prioritising waste reduction and management as a key component of the city's climate strategy. The results underscore the often-overlooked potential of waste management in addressing the climate crisis and provide a roadmap for transforming Barcelona into a more sustainable, low-carbon city.



# Monetising the carbon savings

A "carbon price tag" concept involves assigning a monetary value to the carbon emissions reduced or avoided through zero waste strategies. This approach allows cities to quantify the climate impact of their waste management decisions in financial terms, making it easier to justify investments in sustainable practices.

For Barcelona, using the current EU Emissions Trading System (ETS) price of around €80 per tonne of CO<sub>2</sub> (as of 2024)<sup>5</sup>, the annual emissions reduction of 187,000 tonnes would equate to a carbon price tag of approximately €15 million per year. **Over the 10-year implementation period, this amounts to a potential cumulative value of €150 million in avoided carbon costs. An important amount which could finance a good part of the investment needed to implement all the proposed changes.**

However, it's important to note that this figure likely underestimates the true value of carbon reduction. Many experts argue that the social cost of carbon (which includes broader environmental and health impacts) is much higher, potentially in the range of €150–200 per tonne. Using these higher estimates, the value of Barcelona's emissions reductions could be as high as €37.5 million annually (375 million over 10 years).

Potential for climate funding instruments to finance the transition monetising the carbon savings of zero waste strategies:

The substantial carbon price tag associated with Barcelona's zero waste strategy opens up opportunities for climate funding to finance the transition. Potential funding sources include:

1. **Green bonds:** Barcelona could issue municipal green bonds specifically tied to zero waste initiatives, attracting impact investors interested in supporting projects with a social and environmental return.
2. **Carbon credit markets:** while cities currently can't participate directly in carbon markets, there's growing interest in urban carbon credit schemes. Barcelona could potentially monetise its emissions reductions through future urban carbon market mechanisms in the form of local carbon off-setting tools for citizens in and outside Barcelona.
3. **National climate funds:** as countries ramp up their climate commitments, national-level funding for municipal climate action is likely to increase.
4. **Public-private partnerships:** collaborations with private sector entities interested in enhancing their environmental credentials could provide additional funding streams.

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<sup>5</sup> [sandbag.be/carbon-price-viewer/](https://sandbag.be/carbon-price-viewer/)

# Conclusion

The carbon calculator is a powerful tool that enables cities to assess the climate impact of their zero waste initiatives. The case of Barcelona highlights how significant emission savings, particularly on prevention and reuse, underscore the importance of these strategies.

If the city manages successfully monetise the emissions savings linked from zero waste strategies, it can be a game changer, setting a strong precedent for many other municipalities to radically change their relationship with resources and phase out waste.

At the time of writing this case study, other European cities are using the tool to understand the climate impact and benefits of their zero waste strategies. Zero Waste Europe will continue to develop case studies showcasing other cities' carbon emission saving potentials, made possible using the carbon calculator.

[Visit our website for more information on the carbon calculator and how to use it yourself.](#)



Mission Zero Academy (MiZA) is the capacity – building hub for local decision-makers, SMEs, and other organisations wanting to take a step forward in their zero waste strategies and circular economy implementation. With a focus on evidence-based and expert-approved methods, MiZA supports public and private sector professionals.



Zero Waste Europe (ZWE) is the European network of communities, local leaders, experts, and change agents working towards a better use of resources and the elimination of waste in our society. We advocate for sustainable systems; for the redesign of our relationship with resources; and for a global shift towards environmental justice, accelerating a just transition towards zero waste for the benefit of people and the planet.



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