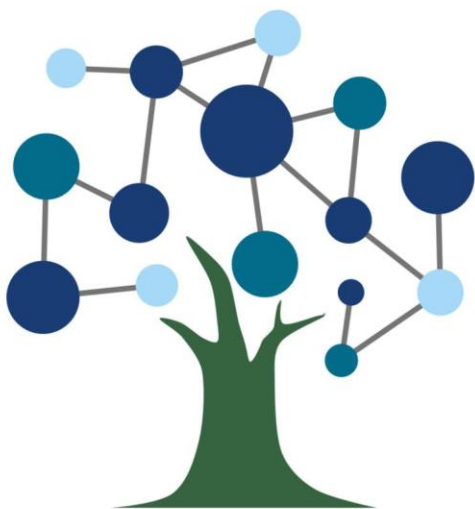




# EGDC Case study – Opsis Research: Bike sharing system

Mar 2026



**EUROPEAN GREEN  
DIGITAL COALITION**



**Funded by  
the European Union**

## 1 Introduction

The European Green Digital Coalition (EGDC) is an initiative of companies, supported by the European Commission and the European Parliament, based on the request of the EU Council, which aims to harness the enabling emission-reducing potential of digital solutions on all other sectors.

The main aim of the EGDC is to maximise the sustainability benefits of digitalisation within the ICT sector, while supporting sustainability goals of other key sectors such as energy, transport, agriculture, and construction. The Coalition recognises the need for science-based methods to estimate the reduction and avoidance of greenhouse gas (GHG) emissions by specific ICT solutions across sectors. This will accelerate the sustainability and circular transitions of these sectors while contributing to an innovative, inclusive, and resilient society.

To support the EGDC, a set of case study calculators are developed to provide a practical example of calculating the net carbon impact of a green digital solution in line with the European Green Digital Coalition (EGDC) methodology. This work aims to support the members of the EGDC with Action 2 of the [EGDC Declaration](#).

This case study methodology accompanies the ‘Opsis Research: Bike sharing system’ case study calculator and provides further details, additional context and transparency around the case study calculator to ensure the outcomes of the case study are interpreted and used correctly.



## Disclaimer for European Parliament Pilot Project – European Green Digital Coalition (EGDC) Case Studies

The following disclaimer is intended to provide clarity and context for the case studies prepared as part of the EP Pilot Project, which have showcased the net carbon impact of specific digital solutions using the EGDC ICT Methodology developed during the project:

### 1. Purpose of the Case Studies:

The case studies served multiple purposes, including:

- **Development of the Methodology:** They contributed to the development of the EGDC ICT Methodology. These case studies were conducted concurrently with the methodology's creation and served as a valuable testing ground for its initial formulation.
- **Application Examples:** They provided practical examples of how the methodology can be applied to real-life use cases. These case studies were essential in demonstrating the practicality and effectiveness of the methodology when applied to concrete situations.
- **Identification of Improvement Areas:** By conducting these case studies, we aimed to highlight parts of the calculation in need of improvement. They shed light on the challenges and limitations inherent in using available data and indicated the necessary steps to move towards best practices in assessing net carbon impacts.

### 2. Data Quality as a Key Determinant:

It is imperative to emphasize that data quality is a fundamental determinant of the quality and reliability of the case studies. The accuracy and completeness of the data used significantly influence the outcomes and findings of these case studies.

It is essential to acknowledge that the data available for each case study may differ in terms of accuracy, granularity, and coverage. As a result, the case studies may not necessarily represent the best practice application of the EGDC ICT Methodology. Instead, they reflect the application of the methodology at various stages of data availability.

### 3. Liability for Errors/Omissions:

While reasonable steps have been taken to ensure that the information contained within the case studies is correct, the EGDC gives no warranty and makes no representation as to its accuracy. We accept no liability for any errors or omissions that may be present in the case studies, methodology, or related information. Users and readers are advised to exercise their judgment and seek further clarification if needed, as the information provided may evolve over time and depend on external factors beyond our control.

### 4. Appropriate Use of the Case Study Calculators:

The case study calculators are intended for educational and informational purposes. They rely on certain assumptions and input data to generate results.

The results of the calculators are specific to the implementation of the ICT solution and may not be representative for other implementation contexts.

As such, it is imperative for users to refrain from directly extrapolating these results to ICT solutions or implementation contexts that may seem conceptually similar.

Instead, users are advised to use the calculators as a means to understand the practical application of the EGDC ICT Methodology, thereby equipping themselves with the knowledge required to develop customized calculators specifically tailored to their unique ICT solutions and implementation circumstances.

In conclusion, these case studies provide valuable insights into the calculation of the net carbon impact of digital solutions through the practical application of the EGDC ICT Methodology. However, it is vital to exercise caution when interpreting the results, considering the variances in data quality and the evolving nature of the methodology. The findings are indicative of the methodology's potential and its room for refinement as we work towards more accurate and comprehensive assessments of net carbon impacts.





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## 2 Results

ICT Solution and assessment overview	Organisational contribution
<p>Opsis Research has developed an application and bike sharing solution to provide safe and accessible bicycles that can be unlocked, used, and relocked at various points around a given city. A pilot study was run in Botosani in Romania and data was collected using the application use as well as a questionnaire to residents.</p> <p>This involved utilising 15 bicycles provided by the municipality and 5 docking stations with Bluetooth locks to lock bikes between users.</p> <p>This case study is an ex-post assessment carried out in Botosani, Romania, between January 1<sup>st</sup> 2024 and 30<sup>th</sup> June 2024.</p>	<p>Opsis Research is responsible for deploying the solution, creating the application and operation of the bike sharing system. This aligns with A-level classification as defined by ITU-T L.1480 (contribution of the integrated solution or the innovation of the solution).</p>
<p style="text-align: center;"><b>Quantified impacts</b></p>	<p><b>Other identified impacts</b></p>
	<p>Implementation and use of this bike sharing solution can yield additional, harder to measure benefits for both residents of the city and the municipality. The solution encourages more cycling in cities and specifically aims to reduce car trips taken, this reduces traffic and congestion in cities. This has knock on effects of improving air quality, pedestrian experience in cities, and improved road safety.</p>
	<p>This solution also contributes to EU policy priorities by supporting the mitigation of Transport Poverty through improved access to affordable mobility options and aligns with the objectives of the EU Emissions Trading System for buildings and road transport (ETS2), and the national Social Climate Plans.</p>
	<p>Assessment period: 6 months</p>
	<p>Net carbon impact range per user per year: -0.6 to -1.4 kgCO<sub>2</sub>e/user/year</p>
<p>Net carbon impact per user per year: -0.94 kgCO<sub>2</sub>e</p>	
<p>Total net carbon impact per year: -176 kgCO<sub>2</sub>e/year</p>	



## 3 Methodology

<b>Opsis Research: Bike sharing system</b>	
<b>Assessment Objective</b>	<p>The objective of this assessment is to quantify the avoided emissions from Opsis Research’s bike sharing pilot in Botosani, Romania. The outputs from the bike sharing solution calculator can then be used to indicate the potential future avoided emissions of similar or larger scale implementation contexts. These can be treated as future ex-ante assessments.</p> <p>The calculator has been developed from a single pilot study already undertaken and as such is an ex-post assessment.</p>
<b>Solution Description</b>	<p>OPSIS has developed an application and bike sharing system to create an alternative to road transport (primarily car transport) in European cities. The bike-sharing solution has been implemented at municipal level in Botosani as a pilot deployment. Access to the service is provided through a mobile application available on iOS and Android devices. The implementation involved using 15 shared bicycles placed at selected locations within the municipality, mainly near residential areas and local activity points.</p> <p>The scale of deployment was intentionally small, focusing on testing user behaviour, technical performance, and operational aspects rather than achieving wide coverage. During the initial implementation period, the number of registered users remained relatively low, reflecting the early testing phase of deployment.</p> <p>The solution calculator is predominantly limited by its small-scale pilot and more robust results could be attained from further pilot studies.</p>
<b>Implementation context</b>	<p>Botoşani is a medium-sized city located in north-eastern Romania and serves as the administrative centre of Botoşani County (94,856 inhabitants approximately). The city has a compact urban structure, with short average trip distances (less than 3km) and mixed residential, educational, and commercial land uses. These characteristics make Botoşani suitable for cycling and shared micro-mobility, particularly for short urban trips.</p> <p>Daily mobility in Botoşani is dominated by private cars and public transport, even for trips of only a few kilometres. Cycling exists mainly as a leisure activity and is not widely used for everyday commuting. Dedicated cycling infrastructure is limited and</p>



	<p>fragmented, and bike ownership is relatively low compared to larger European cities with established cycling cultures.</p> <p>Prior to the implementation of the bike-sharing solution, there was no permanent, app-based public bike-sharing system operating at city level. Access to bicycles for residents without private ownership was therefore limited. In this context, a bike-sharing system supported by a mobile application provides an alternative for short trips and supports a gradual shift towards more sustainable urban mobility.</p> <p>Further studies can be deployed in similar geographies and contexts and on a larger scale.</p>
<p><b>Functional Unit</b></p>	<p>kgCO<sub>2</sub>e per user per year</p> <p>This has been chosen as the functional unit to measure the net carbon impact of the solution because:</p> <ul style="list-style-type: none"> <li>- Using kgCO<sub>2</sub>e is the most appropriate metric of carbon emissions and impact of greenhouse gases</li> <li>- By measuring emissions per user, it is easier to understand and estimate the solution's net impact regardless of the deployment size/scale, as well as compare it to other avoided emissions solutions</li> <li>- Measuring the impact per year of implementation removes the temporal constraints of the emissions calculator, such as the sunk upfront emissions involved in creating the solution infrastructure (bicycles, docking stations etc.)</li> </ul>
<p><b>Calculation Boundary</b></p>	<p>The solution was implemented for 6 months between 1st January 2024 - 30 June 2024, after the previous 6 months when reference scenario measurement was taking place. This consisted of a questionnaire being asked to residents and gave an estimation of how many trips during the reference period were taken using different modes of transport.</p> <p>The calculation involved 15 bicycles provided by the municipality and 187 users of the application.</p>
<p><b>Reference scenario</b></p>	<p>Without the bike sharing application, urban residents in many European cities often use cars and other modes of transport to make short &lt;3km trips within the city. These are predominantly taken by cars with a proportion of these trips able to be taken using bicycles. Emissions are therefore produced from fuel or electricity consumption from these car/bus trips and can subsequently be avoided by implementation of the solution. The reference scenario is treated as the emissions occurring during the 6 months prior to implementation, after which a</p>



	<p>questionnaire was rolled out asking respondents to estimate how many trips &lt;3km they made in a day using each of the following forms of transport (Car, Bus, Walking, Train) as well as a total for number of trips per day.</p> <p>The reference scenario emissions were then calculated using the <b>actual</b> distances travelled by bicycle using the solution and splitting these cycled distances into those that replaced car trips, bus trips, train trips and walking trips. This split is based on the questionnaire answers taken regarding the previous 6 months of travel.</p> <p>The reference scenario emissions are therefore the estimated emissions from short trips taken using cars and buses (walking is treated as zero emission and there were no train trips as part of the questionnaire answers), that were replaceable by bicycle using the bike sharing application solution.</p> <p>This reference scenario combines the actual data of distance cycled, with the normal distances that would be travelled using car/bus for short trips based on real responses from residents to Opsis Research's questionnaire. It is challenging to collect data for only car/bus distances that are only for trips deemed 'cyclable', when said trips have not actually been cycled. Therefore, this estimation for reference emissions, only relating to those trips that would have been otherwise driven/bussed, is deemed representative.</p>
<p><b>Description of 1<sup>st</sup> order effects</b></p>	<p>All first order calculations can be found in the model 'First Order Effects' tab:</p> <p><b>Non-digital:</b></p> <p><u>Bikes purchased solely for the solution</u> and not provided by the municipality (embodied emissions including production).</p> <p><u>Bike end of life emissions</u> for those bikes purchased solely for the solution.</p> <p><u>Bike maintenance</u> of all bikes deployed as part of the solution (including van trips to travel to the bikes requiring fixing). Maintenance has been calculated as replacing both tyres every six months for each bike as well as two van trips to travel to bikes and fix their spokes. These assumptions have been made as conservative estimations of how much CO<sub>2</sub>e will be emitted by bike maintenance.</p> <p><u>Bluetooth locks</u> – these have been treated separately to the docking stations despite being part of the same units, for easier</p>



	<p>and more accurate emissions calculations. The locks are activated through the app and allow users to unlock and relock bikes at docking stations to be able to use them. The calculations use 1 lock per bike.</p> <p><u>Docking stations</u> – these are where the bikes can be left while not in use. They have been assumed to be purchased and installed for the solution and as such fall within the calculator boundary. A representative source has been used to estimate the weight of steel used in the docks and therefore the emissions from producing them. The end-of-life emissions have also been included to account for the emissions from recycling/landfilling the steel (the Emission Factor (EF) for both are the same). The emissions from installing them have not been included due to inaccuracy of estimating these emissions and the conservative estimations already within the calculations.</p> <p><b>Digital</b></p> <p><u>Cloud processing</u> – the emissions associated with transmitting location-based data from the app users while they are taking the journeys. Based on estimated time spent cycling, data transmitted per hour of GPS tracking (most conservative option chosen: turn by turn data transmission), the mobile and data centre energy usage relating to this data transmission, and the emissions per kWh of energy used for this data transmission based on Romanian energy grid EF.</p> <p><u>Cloud data download</u> – the emissions associated with users downloading the 39.3 MB app download using mobile data. Based on the same assumptions as above but just relating to the energy usage of mobile data network download (no data centre usage).</p>
<p><b>Description of 2<sup>nd</sup> order effects</b></p>	<p>Implementation of the solution allows users of the app to use shared bikes to take short trips within the city, that would have previously been taken using a car, bus or walking.</p> <p>The second order effects are the emissions from cycling minus the estimated car and bus emissions for driving the same distance using both car and bus passenger.km emission factors. Cycling has been treated as zero emission due to the complexity of estimating the calorific intake required to ‘power’ the bicycle and the associated emissions of these calories (see source: <a href="https://www.climatiq.io/data/emission-factor/cdd5551d-389a-4b0b-be15-27071ba093ae">https://www.climatiq.io/data/emission-factor/cdd5551d-389a-4b0b-be15-27071ba093ae</a>).</p> <p>Therefore, the second order effects can be seen to be the negative emissions (those avoided) by cycling the given trips.</p>

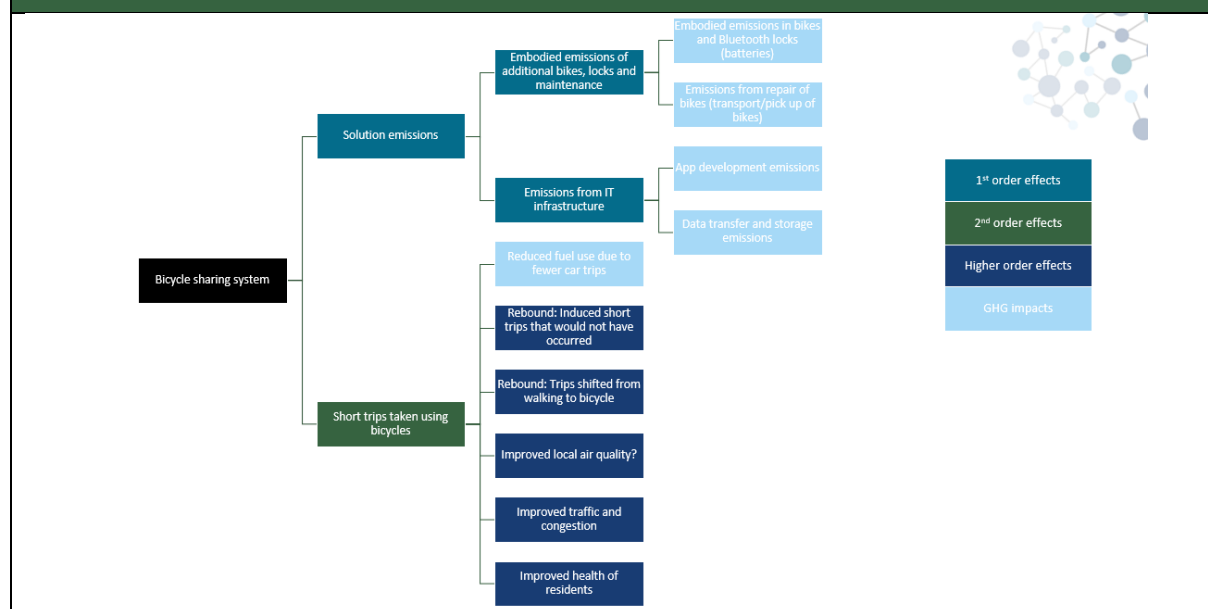


## Description of higher order effects

Some higher order (rebound) effects have been noted; however, none have been included in the actual carbon emission calculations due to their qualitative nature.

- Increased overall number of trips due to improved accessibility: Improved access to bicycles may encourage some additional short trips that would not have occurred otherwise.
- Operational activities related to system monitoring: Minor administrative and monitoring activities associated with operating the system. These activities do not involve significant additional travel or energy use.

## Mapping of all effects



## Description of calculation

First order effects have been calculated to include all aspects of the solution that result in emissions from its implementation.

Second order effects are the avoided emissions of cycling over using car/bus for the same short trips.

Higher order effects have not had a quantitative impact on the calculation.

Therefore, the net carbon impact is the First order effects (+ve) + the second order effects (-ve).

All effects have been calculated using the functional unit described above and then the overall pilot study emissions have been calculated from this for transparency.



<p><b>Net Carbon Saving Impact of the Solution</b></p>	<p>Total carbon saving impact: <b>-87.39 kgCO<sub>2</sub>e</b></p> <p>Saving per functional unit: <b>-1.78 kgCO<sub>2</sub>e per user per year</b></p>
<p><b>Uncertainty and sensitivity analysis</b></p>	<p>Calculated Net Avoided Emissions per functional unit: <b>-0.94 kgCO<sub>2</sub>e</b></p> <p>Lower uncertainty range: <b>-0.58 kgCO<sub>2</sub>e</b></p> <p>Higher uncertainty range: <b>-1.39 kgCO<sub>2</sub>e</b></p> <p><b>Uncertainty &amp; sensitivity</b></p> <p>The uncertainty analysis shows moderate uncertainty boundaries for the net carbon impact per functional unit. The analysis was done qualitatively initially and then used the ‘Greenhouse Gas Protocol, Quantitative Inventory Uncertainty’ data quality criteria to create quantitative uncertainty results based on data quality assessments.</p> <p>The factors with the largest contribution to the uncertainty bounds due to data quality are the: car trips taken (km/year/user), bike maintenance and bus trips taken (km/year/user). This is mainly due to their importance in the net carbon impact calculation with the car and bus trips making up all the second order effects and which are twice as large as the first order effects when totalled. Despite the emission factors for both effects being robust, the uncertainty due to the questionnaire answers being broad and not giving specific car/bus trip data for the reference scenario means their uncertainty is high.</p> <p>Other effects have the potential to be a significant source of uncertainty, however in the case of this study, are found to be a zero contribution. These include the embodied emissions of the bicycles purchased for the solution, which in the pilot were zero new bikes. If this were to change this would not only increase the first order emissions greatly but also impact the upper bound as part of the uncertainty analysis.</p> <p>This impact on the uncertainty can be seen in the sensitivity analysis tab of the calculator, with the largest gaps between upper and lower bounds showing which effects have the most uncertainty.</p> <p>Additionally, all emission factors related to the physical parts of the solution (bicycles, maintenance, locks, docking stations) have been scored as poor in terms of data quality on the uncertainty</p>



	<p>analysis due to the quality of sources and assumptions used. However, due to their lower emissions relative to the second order effects, their sensitivity to the overall net carbon impact is low.</p>
<p>Assumptions</p>	<ol style="list-style-type: none"> <li>1. Bicycle use phase emission factor is 0 kgCO<sub>2</sub>e per km based on a number of sources that treat cycling as zero emission during use phase. These exclude diet based emissions related to powering the bicycle, which depending on diet, can contribute to full lifecycle emissions. Additional sources: <a href="#">1</a>, <a href="#">2</a>, <a href="#">3</a>.</li> <li>2. All bicycles provided by the municipality are out of the boundary for first order emissions and only those bicycles purchased for the solution have production emissions associated. This is because these bikes already existed and were repurposed for this pilot.</li> <li>3. Bicycle end-of-life emissions are accounted for regarding <b>deployed</b> bikes, these use assumptions on the material make up of bikes into: aluminium, steel and rubber</li> <li>4. Bicycles are maintained twice a year</li> <li>5. Maintenance is conservatively assumed to be replacement of two tyres per maintenance</li> <li>6. Maintenance also accounts for van trips to collect/access bikes. Based on actual data this equates to four trips per year to fix bikes (e.g. fix spokes)</li> <li>7. The source for the bluetooth lock emission factor is an environmental product declaration. This is used as a proxy due to it being a similar product and a likely conservative estimation</li> <li>8. The bluetooth locks and docking stations are in reality combined, however are calculated separately for ease of calculation</li> <li>9. The lifetime of the docking station is assumed to be the same as for the bluetooth locks (from the proxy Environmental Product Declaration (EPD))</li> <li>10. Docking stations are assumed to be able to lock 3 bikes each based on source for mass of steel having multiple bays</li> <li>11. The average trip time for cycling is taken as 10 minutes (value from Opsis Research)</li> <li>12. Only emissions relating to the transmission and processing of location data and data downloaded in the form of the application are accounted for as part of 'Cloud processing' emissions. The energy used in app</li> </ol>



	<p>design and manual data manipulation have not been included, however these are likely immaterial.</p>
<p><b>Data sources</b></p>	<p><b>Provided by Opsis Research:</b></p> <ul style="list-style-type: none"> <li>- All data in 'Raw Data' tab has been taken from Opsis Research's data submission and is either from the questionnaire responses or app data.</li> </ul> <p><b>All first order data sources have been linked within the model:</b></p> <ul style="list-style-type: none"> <li>- Bicycle production emission factor. Despite the age of this source, this is the most representative publically available factor for bicycle production when compared to other factors.</li> <li>- Bicycle materials used for end of life emission factor</li> <li>- Bicycle tyre emission factor</li> <li>- Bluetooth lock proxy lifetime emission factor</li> <li>- Mass of steel in bike docking station</li> <li>- Data usage for GPS tracking while cycling</li> <li>- Data transmission rates</li> <li>- Network transmission energy intensity</li> <li>- Data centres energy intensity</li> </ul> <p>Where possible, reputable public data sources have been used, such as IEA and BEIS.</p>
<p><b>Input adjustments and key considerations for usage of results</b></p>	<p>Optional adjustments that can be altered to calculate emissions savings for larger scale/longer studies.</p> <p><b>Start date of data collection</b>  <b>End date of data collection</b>  <b>Application users (persons)</b></p>
<p><b>'Do no significant harm' criteria</b></p>	<p>Do not foresee any negative impacts on any of the EU Taxonomy's environmental nor social objectives and strongly supports objective 1.</p> <p>Climate change mitigation. The bike sharing solution is scalable, while also having the potential to improve quality of life.</p>
<p><b>Key areas for improvement</b></p>	<p>The key areas of improvement for the calculator centre around adding additional pilot study data and improving the data quality of sources and proxy data used.</p> <p>The pilot study used for this calculator is of a relatively small scale and implementing this solution in a larger city with more</p>



bicycles deployed would greatly improve the net carbon calculation and its accuracy.

The most reliable and appropriate sources have been used where possible, however they form a significant part of the uncertainty and improving the data of the first order effects would greatly improve the robustness of the first order emissions.

Additional improvements could be made to the calculator by incorporating other types of travel to those considered e.g. taxis. Furthermore more accurate life cycle emissions of the locked docking stations based on product emissions and more accurate assumptions would improve the robustness of these emissions calculations.

