DumBO Green District project

Monitoring Environmental Sustainability: A comparison between two events held within the Multifunctional Urban District of Bologna / DumBO

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Summary

Introduction

Purpose

The purpose of this document is to conduct a comparative analysis of the environmental sustainability of two distinct events hosted at DumBO in Bologna. In preparing this document, special attention was given to identifying the strengths and weaknesses of these events, as well as elucidating the impact of the sustainability initiatives undertaken by Open Event Srl during its management.

Contesto

The "Distretto Urbano Multifunzionale di Bologna" (Multifunctional Urban District of Bologna) - DumBO is a temporary urban regeneration project born in 2019 in a former railway depot located near the city center and the Central Station of Bologna.

Thanks to the project, six buildings (with a total area of more than 18 thousand square meters and 20 thousand square meters of uncovered space) have been returned to the city's use after more than ten years of neglect: Today the area is a new, huge district destined for culture, art, social innovation, work, music and sport for transversal and ever-changing activities, in close relation with the territory.

In its spaces, DumBO houses offices and coworking areas, a bistro, an urban vegetable garden equipped with beehives and small shrubs, an outdoor basketball court, an urban sports hall and several event areas, which host events produced directly by the district or organized by third parties.

DumBO's spaces can adapt to an infinite number of events: corporate events, trade fairs, conferences, courses, workshops, live or streaming performances.

DumBO is therefore a complex and articulated ecosystem, hosting a plurality of events daily and with them a very large and diverse audience.

Introduction to Open Event S.r.l.

The responsibility for the management of DumBO is entrusted to Open Event, a company consisting of the soc. coop. Open Group and Eventeria. By this synergy, Open Event combines the skills and resources of both entities, working in an integrated manner to ensure the effective and complete performance of management activities. The company was created in 2019 and has been working on the regeneration of the area ever since, investing almost exclusively private financial resources. Today it employs 13 people in various capacities.

In 2023, the company was the beneficiary of a European contribution under the 'Music-Aire - An Innovative Recovery for Europe' call for proposals, aimed at developing a green strategy to reduce the ecological footprint of the activities hosted and organized at DumBO. Thanks to this contribution, the company, which has always been attentive to issues of environmental sustainability, was able to implement important improvements, raising awareness and actively involving its community of reference along the way - first and foremost the district community, but also the users of spaces and services.

Introduction

Introduction to Turtle S.r.l.

Turtle is a spin-off of the University of Bologna dedicated to the development of innovative and sustainable solutions for companies, operating as a bridge between the university and businesses, thanks to its solid engineering skills and the support of university professors and consultants with managerial experience.

Turtle was born in 2021 out of the collaboration between three professors who still represent the three main souls of Turtle: Prof. Eng. Augusto Bianchini (CEO of the start-up, specialized in industrial plants and circular economy); Prof. Eng. Giangiacomo Minak (specialized in additive manufacturing and composite materials); Prof. Eng. Marco Troncossi (specialized in Robotics and construction of machinery).

From the collaboration between the 3 professors and the research work carried out by Prof. Bianchini's group, the ViVACE® model was developed (prior to the start-up).

ViVACE® is a sustainability management and quantification model that can be used multi-sectorally. To date, it has already been used around 30 times for companies from very different sectors: automotive; foundries; hotels; food; fashion; sustainable events and other sectors.

The model is available in two versions: Environmental ViVACE and Social ViVACE. As can be easily guessed from their names, the two models differ on the subject of their analysis, namely environmental and social sustainability.

The social model will not be discussed in this paper, while in the next section there is a summary of the environmental part (explored further at the end of the report).

The environmental model involves the collection of environmental impact data in four macro-categories: energy, waste, water and transport. After the data are entered into the model, they are aggregated to generate three different levels of indicators (operational, tactical and strategic). Finally, by weighing both efficiency and management indicators, the impact of each category and the total value of kgCO2eq attributable to the reality under examination are calculated.

Turtle, having the exclusive right to use the model, produced a software solution with the same name as the model itself: the ViVACE platform. Turtle's product uses easy-to-implement technologies, in particular the Microsoft Suite. Depending on the application case, a structured database on the SharePoint system is generated and fed via manual data entry or via automation. The data, once on SharePoint, feeds a dashboard in PowerBI showing sustainability indicators for the four categories: energy, waste, water and transport.

Defining the relationship

Turtle was commissioned by Open Event to assess the progress of event management in terms of environmental sustainability by comparing two events held between April and November 2023. Both events were monitored through collaboration between Turtle and Open Event staff.

Event 1

Description

Conceived as a festival, the first event involved the public, the third sector and intermediate bodies in a large active workshop on sustainability issues and the UN Sustainable Development Goals. The event developed over three days full of events: talks, workshops, art, concerts, theatre, lots of information and entertainment.

During this three-day event, people had the opportunity both to become increasingly aware of sustainability issues and to acquire the tools with which to play an active role within a community that is committed to improving itself in compliance with the 17 UN Sustainable Development Goals. The event was a starting point to make citizens aware of the climate neutrality commitment that the city of Bologna has made for 2030 and the "Patto per il lavoro e per il clima" (a work and climate plan) that the Emilia-Romagna Region has signed with all the intermediate bodies in the territory.

Pre-event activities

In the preliminary phase of the sustainability analysis of the event, an in-depth study was conducted based on the guidelines provided by the reference standard: UNI ISO 20121 - Sustainable Event Management Systems.

The study included a literature review, which allowed us to examine academic articles related to measuring the environmental impact of diverse events. This phase provided a solid basis for understanding key evaluation criteria and best practices in the context of event sustainability, thus preparing us for the next steps of the analysis.

Subsequently, data on energy consumption (electricity and heat), water consumption and waste generation during events that took place during the same period, in previous years, in the DumBO space were collected and, from the insight developed by analyzing them, a consumption forecast was formulated for the event under analysis.

These data were normalized according to the number of openings of each building in the District for each month of the period analyzed. In this way, the average specific consumption (energy, water) and the average specific waste production for each building were extracted according to the number of opening days. The coefficients thus obtained were used to forecast consumption and waste production for the event under analysis.

In the post-event analysis, it became evident that the predictions made turned out to be in line with reality.

Intra-event activities

Several monitoring activities were implemented during the event. These included the control of thermal and electrical consumption through direct observation and the recording of values at the meters. Similarly, checks were carried out on water consumption by analyzing the meters.

The amount consumed was calculated by the difference between the values measured immediately before the start of the event and immediately after.

Concerning waste production, the individual bags generated were counted and subdivided by type (plastic, paper, organic, glass and undifferentiated) to assess their management impact.

Finally, to obtain a complete overview, an estimate was made of the number of participants at the event (which was free of charge and therefore did not require a ticket to enter) and their geographical origin, to subsequently calculate the transport impact associated with the event.

These monitoring approaches provided valuable data to assess ene

Event 1

Post-event activities

After the event, a comprehensive report was produced and shared with key stakeholders. The document provides a comprehensive and detailed overview of the work carried out during all phases of the project. Also included in the document is an in-depth analysis of the data collected during the event, highlighting energy consumption, waste production, water consumption, visitor transport and the overall environmental impact generated.

The distinctive element of the report was the insight developed, which combines a qualitative description of event sustainability with a numerical approach. Data was critically analyzed to provide an in-depth understanding of the overall environmental impact of the event. The results were expressed in quantitative terms, including the amount of energy used in kWh, the weight of waste produced in kg (estimated from the number of bags collected), liters of water used, kilometers for transport, and finally, the environmental impact expressed in kgCO2eq.

This approach allowed a clear and detailed view of the event's highest impact areas, enabling the formulation of improvement opportunities for future editions.

Environmental Footprint Analysis

During the event, which was attended by some 2.500 visitors, the overall environmental impact was quantified at 17.193 kgCO2eq, equivalent to 3,4 kgCO2eq per person.

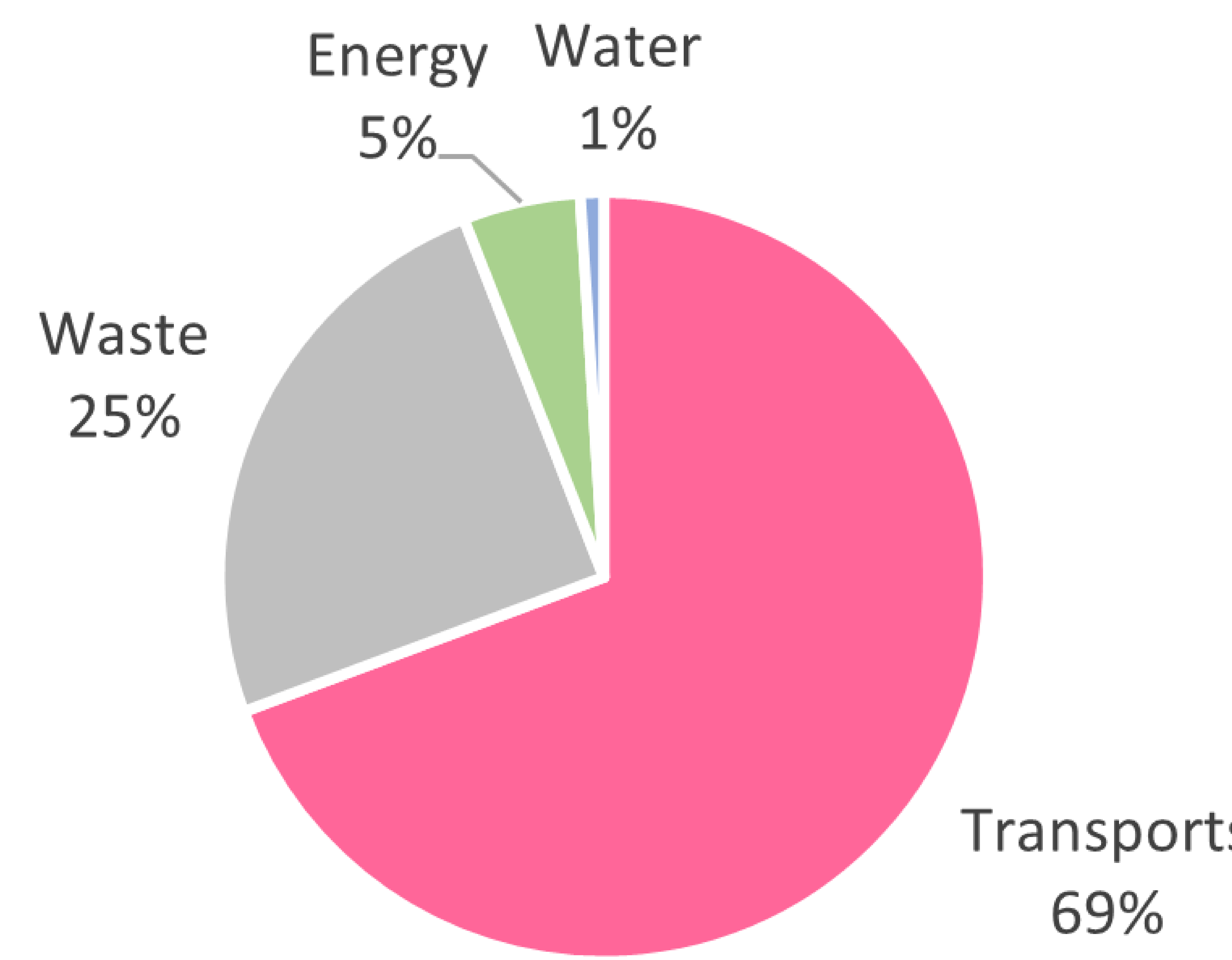

Chart 1. Breakdown of the carbon footprint associated with Event 1

The main sources of this impact are transport, responsible for 70%, followed by waste, with 25%, while energy and water contribute 5% and less than 1% respectively. These data provide a clear distribution of impact sources, identifying transport as the main factor to be addressed to reduce the overall environmental impact of the event.

Event 1

	Energy	Waste	Water	Transports	Total
Overall Impact [kgCO2 eq]	692	3.314	1	9.180	17.193
Impact per Person [kgCO2 eq/person]	0,28	1,32	0,00	3,67	6,87

Tabella 1. Riepilogo dell'impatto monitorato per le 4 macrocategorie del metodo ViVACE

Detailed analysis

Of the 2500 visitors considered, it was estimated that approximately 25% came from the metropolitan city of Bologna, 50% from the province of Bologna and the remaining 25% from the Emilia-Romagna region. By the markedly local character of the event, the turnout from the rest of Italy and abroad can be considered zero. Due to the adverse weather conditions, the number of people arriving on foot or by micro-mobility is marginal.

Actual electricity consumption was 2.825 kWh, consistent with expectations (2.959 kWh).

Concerning thermal consumption, 27 Smc of natural gas was expected to be used, while in reality 0 Smc was consumed as heating was not used, given the mild temperatures.

As far as water is concerned, 1.5 m3 was consumed, contrary to expectations of 14 m3.

In the context of waste management, 37 bags of unsorted waste, 42 bags of paper, 53 bags of plastic, 29 bags of organic waste, and 33 bags of glass (values expressed in 120L bags) were expected. Even for waste, the actual figures do not deviate too much from the forecast, with 36 bags of unsorted waste, 49 of paper, 37 of plastic, 22 of organic and 17 of glass.

Strategic directions for improvement

The detailed analysis, carried out in the immediate post-event period, provided key information to optimize environmental management strategies, in particular:

→ **Energy:** reduce the use of fossil fuels and simultaneously provide for the installation of renewable energy production facilities;

→ **Waste:** in addition to existing waste reduction strategies, encourage mono-materiality in the type of waste produced, to facilitate recycling;

→ **Transports:** encourage public mobility and micro-mobility, as opposed to the use of private cars.

Water consumption is not particularly relevant for cultural/recreational events such as the one under analysis, as it is essentially limited to sanitary uses.

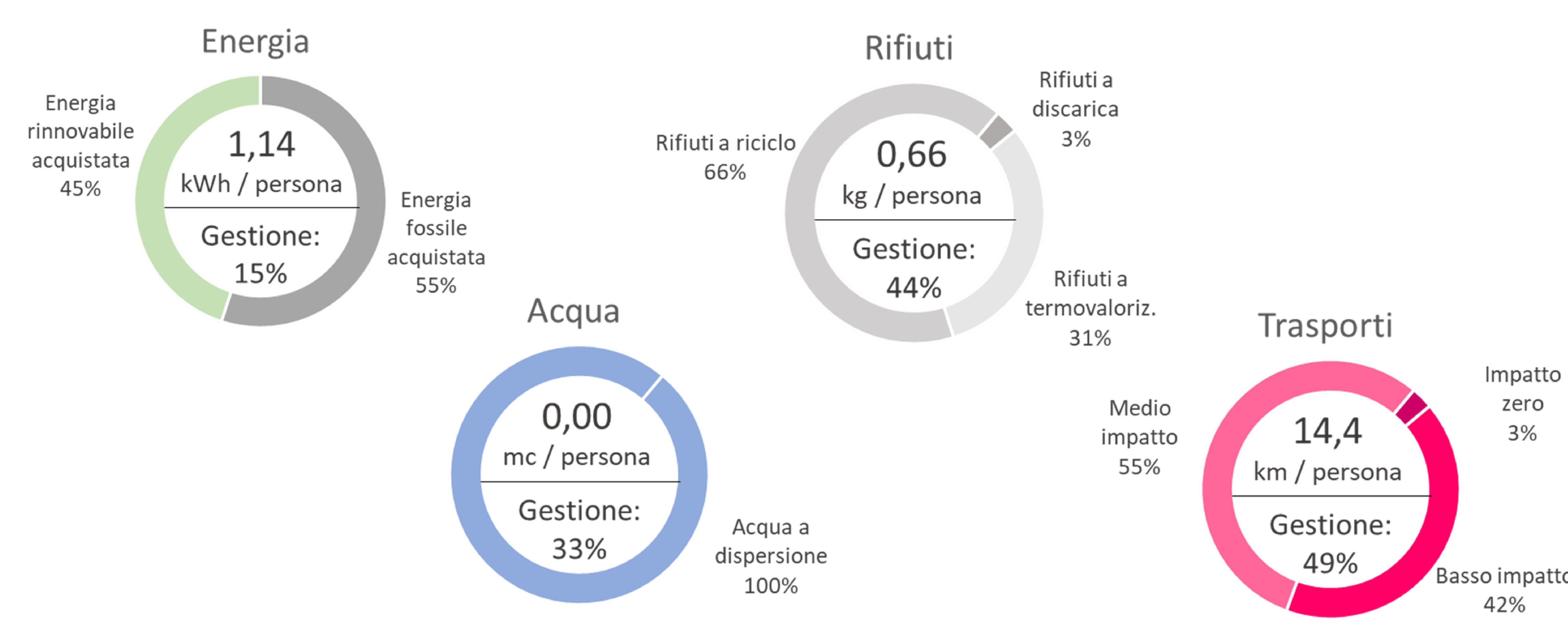

Chart 2. ViVACE sustainability management and efficiency KPIs for Energy, Waste, Water and Transports (Event 1)

Event 1

Iniziative implementate

Starting in June 2023, a series of improvements have been introduced to reduce the environmental impacts of event management, thanks in part to the contribution received from the European call for proposals MusicAire - An Innovative Recovery for Europe, aimed at the realization of the 'D.G.D. - DumBO Green District' project.

Sustainable Mixed Mobility Plan: a discount system was launched to incentivize the public to reach DumBO by bicycle, taking advantage of the presence within the district of a major city hub of a well-known bicycle rental service. This allowed the public to reach some of the main events organized at DumBO with a very low transport impact.

Replacement of Disposable Packaging: a gradual replacement of disposable packaging in favor of reusable alternatives was initiated. Open Event has purchased a stock of PLA cups that have been tested for dispensing with the deposit mechanism at events with low attendance. This action contributes significantly to reducing the consumption of single-use plastic, reducing the impact of the production and disposal of plastic artifacts and promoting the responsible use of resources.

Waste sorting: thanks to an unambiguous signage system, placed at various points in the District, greater care and attention was stimulated among the public toward proper waste sorting.

Photo 1. Bicycles available for hire inside DumBO

Photo 2. Recycling containers and related information signage

Event 1

Water dispenser: In September 2023, a drinking water dispenser was permanently installed in one of the district's halls, where the public can fill their own reusable water bottle or glass, avoiding the need to buy bottled water and waste plastic.

Further activities related to waste management:

➔ the highest possible standardization of waste generated by catering activities;

➔ reducing the use of printed paper by dematerializing menus in all District cafeterias;

➔ the reduction, reuse and recycling of fittings and sets.

Selection of Sustainable Suppliers for Set-ups: a targeted selection of suppliers with certified sustainable practices in set-up management was sought. Criteria such as energy efficiency, use of recyclable materials, responsible waste management and geographical proximity were taken into account in the selection.

km0 services: where possible and appropriate, vegetarian and locally sourced catering and raw material suppliers were chosen.

The joint implementation of these solutions significantly contributes to improving the overall sustainability of events by reducing the environmental impact associated with transport, packaging and set-ups.

Photo 3. Micro-filtered drinking water tation installed inside one of DumBO's halls

Event 2

Description

The second event consisted of the final evening of a festival of international relevance that took place in November 2023. The event enjoyed great resonance as it was shared on the bill of a well-known electronic music festival in Bologna.

Artists from the national and international electronic scene performed during the event.

Pre-event activities

The pre-event activity in this second case was reduced, as no further analysis of the relevant regulations or bibliography on the topic of event sustainability was necessary.

The only activity that differed from the previous event was the preparation of two forms: one designed to record the collection of intra-event data (waste produced, energy used, etc.) and the other to be used during public registration to get a correct count of participants, as well as details on where they came from and what transport they used to reach the event. This survey, sent by email to all event ticket holders, was filled in by 53 people and helped to reconstruct the carbon footprint associated with transport.

Intra-event activities

During the event, the counter-monitoring activity took place in the same way as for the previous event. The form in which the measurements were tracked was slightly changed, as for the second event, formats were prepared to be filled in with intra-event measured data, as previously indicated.

A further difference between the two events lies in the fact that in this second event the measurement of waste was not the result of an indirect calculation (counting of bags and multiplication by an average weight per type of waste) but was obtained directly by weighing each individual bag.

Post-event activities

As with the first event, an analysis was performed on the measured data and a report was generated, shared with key stakeholders, highlighting the areas of greatest impact of the event. The report in question is the present one and contains not only the analysis of the second event, but also a comparison with the previous event and an in-depth look at the ViVACE methodology.

Environmental Footprint Analysis

During the event, which was attended by 1.715 visitors (more than 40% from outside Bologna), the overall environmental impact was quantified at 8.760 kgCO2eq, equivalent to 5,12 kgCO2eq per person.

Event 2

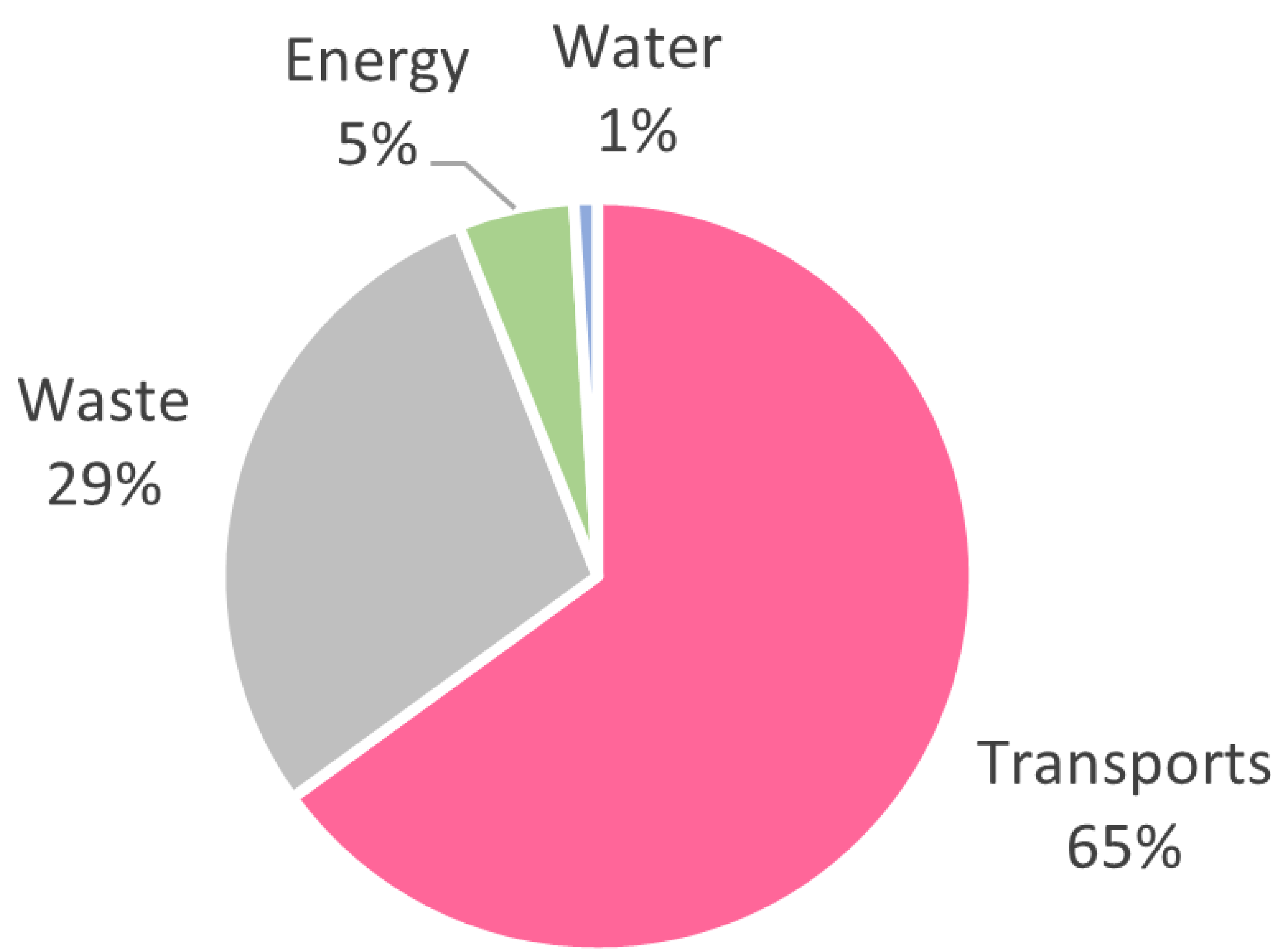

Chart 3. Breakdown of the carbon footprint associated with event 2

The main sources of this impact are transport, responsible for 65%, followed by waste with 29%, while energy and water contribute 5% and less than 1% respectively.

Similar to the first event, these data provide a clear distribution of sources of impact, identifying transports as the main factor to be addressed to reduce the overall environmental impact of the event.

Detailed analysis

Of the 1715 visitors, 53% came from the city of Bologna, 12% from the province of Bologna, 23% from the Emilia-Romagna region and the remaining 12% from outside the region. 40% of the participants traveled on foot or by micro-mobility, 38% by car and 23% by public transport.

The electricity consumption was estimated to be 480 kWh, as it was not possible to extrapolate the exact consumption of the event from the rest of the complex using the general electricity meter.

There has been no consumption for heating in the first event, but in this one approximately 125 L of heating oil was consumed for space heating.

As for water consumption, 48 m3 were consumed.

In terms of waste, 30 bags of undifferentiated waste, 25 of paper, 57 of plastic, 39 of organic waste and 41 of glass were produced. On this occasion, the bags of waste were weighed on time.

	Energy	Waste	Water	Transports	Total
Overall Impact [kgCO2 eq]	472	2.586	14	5.708	8.780
Impact per Person [kgCO2 eq/person].	0,28	1,51	0,01	3,33	5,12

Table 2. Summary of the monitored impact for the 4 macro categories of the ViVACE method

Event 2

	Number of sacks	Total waste mass [kg]	Average weight per bag [kg/bag]	Associated Carbon Footprint [kgCO2 eq].
PAPER	25	109	4,36	218
PLASTIC	57	331	5,81	662
ORGANIC	39	236	6,05	472
GLASS	41	423	10,32	846
UNDIFFERENTIATED	30	194	6,47	388

Table 3. Summary of Separate Waste Generation and its Carbon Footprint

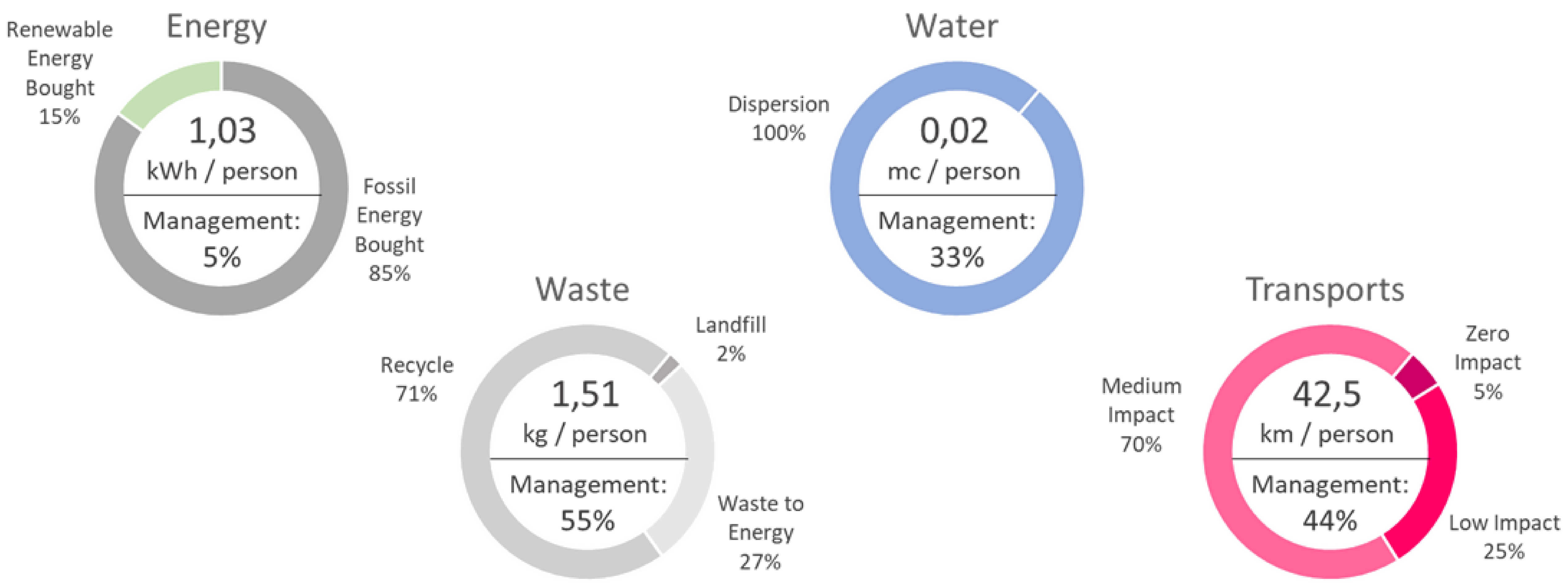

Chart 4. ViVACE sustainability management and efficiency KPIs for Energy, Waste, Water and Transports (Event 2)1)

Strategic directions for improvement

The detailed analysis carried out in the immediate post-event period confirms the environmental improvement strategies identified earlier.

Direct comparison of the two events

To properly compare the two events, it is necessary to list the distinctive features of each event.

	Event 1	Event 2
TYPE	Cultural/Recreational	Recreational
DURATION	3 days	Half a day
PERIOD	Spring	Winter
GEOGRAPHICAL TARGET	Regional	National
SPACES INVOLVED	Two buildings	One building

Table 4. The main differences in settings between the two events

In particular, the first event was a festival related to sustainable development issues designed for Bologna and its provincial district, while the second event was a music festival with a national scope. The different settings of the event contributed to attracting a very different audience for each event, with a different background and different cultural consumption habits.

Results of the environmental impact comparison

More people participated in the first event than in the second, but it is also true that the first event saw 2.500 participants in three days, compared to 1.700 in a single evening for the second event.

Between the first and second event, the management score inherently decreased due to the use of fossil fuels for heating, which, while it was off in April 2023, became necessary in November 2023. However, due to the shorter duration of the event, per capita energy consumption decreased, as did the carbon footprint associated with energy consumption.

The second event saw an improvement in the waste management score, thus indicating an improvement in waste management. At the same time, the second event had a significantly higher specific waste production value (kg of waste per person), probably caused by the highly recreational nature of the event.

The second event, which was a national event, attracted participants from different regions of Italy, thus involving greater kilometers traveled than the first event. Approximately 50% of the participants from outside the region arrived by car, resulting in a reduction in the management score according to ViVACE methodology (further information available in the methodological appendix).

However, it appears that participants who arrived by car organized themselves to share the journey (reducing the associated carbon dioxide emissions). In addition, the number of participants arriving on foot or by bicycle increased slightly. In doing so, the overall carbon footprint associated with transport decreased.

There are no significant differences in the use of water. In both events, a minimum amount of water per participant was used and the related environmental impact can be considered negligible.

Conclusions

Main environmental issues of the events

As identified in the literature review, the results of the analysis conducted on the two events examined shows that transport is the main cause of the carbon footprint directly associated with a public event.

The following area, in order of criticality (and therefore priority for improvement) is waste production. Energy and water consumption, on the other hand, are of marginal importance.

Sustainability of DumBO

Given its geographical location, from a transport point of view DumBO is certainly a logistically virtuous place for the organization of sustainable events, as it is easily accessible by public transport.

Furthermore, the on-site presence of a major hub of Bologna's main bike-sharing service contributes to a greater influx of visitors coming to DumBO via shared micro-mobility. This is further stimulated by the agreements that Open Event has made with the bike-sharing company itself. For example, such an agreement was used in the second event by 47 visitors, who thus reduced the impact of their travel to zero. In the first event, such an agreement was not yet active.

Concerning waste management, the second most critical area, remarkable results were achieved from the first event analyzed, as careful sorting resulted in a high recycling rate. Thanks to the implemented initiatives, waste management was further improved in the second event.

Final suggestions

A further reduction of the transport impact can be achieved by encouraging public mobility, e.g. through conventions with Bologna public transport (for local events) and regional public transport. Where it is not possible to enter into an agreement, discounts or free gifts could be provided for those who show up with the ticket used to get to DumBO at particular events.

Concerning waste, the homogenization of the various categories of waste produced is suggested, in favor of mono-materiality. Also, given the high production of waste glass caused by the bar service, one could favor the purchase of drinks and alcohol in drums, preferably reusable and locally sourced. This would find particular synergy with the use of reusable glasses, currently being tested by Open Event. A further measure could be to use recycled paper for tax receipts instead of thermal paper, which contains chemicals that do not make receipts recyclable.

Finally, implementing a continuous environmental monitoring system by Open Event could lead to new opportunities to reduce the environmental impact of the activities and events organized and hosted at DumBO.

Appendix A

Deepening Environmental ViVACE Methodology

Per quantificare l'impatto ambientale degli eventi si è scelto di utilizzare il modello ViVACE.

Il modello prevede che le emissioni vengono suddivise in:

→ **Scope 1:** direct emissions from installations within the boundaries of the analysis;

→ **Scope 2:** Indirect emissions from the production of the electricity used;

→ **Scope 3:** Direct process emissions..

Within this pillar there is a further subdivision into four categories:

→ **Energy:** includes all energy sources that are used for the event.

→ **Waste:** includes all residues produced by the event.

→ **Water:** includes all forms in which water is supplied and disposed of.

→ **Transports:** includes all types of vehicles that are used to participate in the event..

The choice of indicators to be included necessarily depends on the availability of data, the need for monitoring the indicator and the ease of data acquisition. An overview of data acquisition sources is shown below

Energy Database

Purchased Energy (Gas and Electricity)

The data can easily be retrieved from paper bills, and are:

(i)Consumption;
(ii)Consumption bands;
(iii)Power factor;
(iv)Employed power;
(v)Energy Mix.

If the bill cannot be found, it is suggested to observe the values at the meter before and after the event under consideration.

For a correct estimation of the impact in terms of CO2 eq and/or compensatory factors resulting from the use of renewables, it is crucial to know the composition of the energy mix.

Energy consumption is covered by distributed sources according to a precise energy mix, of which the GSE ("Gestore dei Servizi Energetici") provides the composition. The reference energy mix is that nation, which is composed of 56% from fossil fuels and 44% from renewable sources in 2021. If not specified by the operator, the model takes the national mix as a reference.

In the reported case, the energy mix was derived from the energy bill and consumption was measured from observations on electricity and gas supply meters.

Appendix A

Energy Produced

The data can be retrieved from documents sent by the network operator, and are:

(i)En. Produced;
(ii)En. Consumed;
(iii)En. Transferred to the network;

In the case being reported, there are no plants for the production of renewable en.

Waste Database

Waste Products

The data can be retrieved from the MUD (if special waste) or from the TARI (municipal waste). In particular:

(i)Weight of waste;
(ii)Type of waste;

If documents cannot be found, or if more detailed data is desired, it is suggested to weigh the sorted waste.

In the case being reported, bags were counted per type of waste and multiplied by the weight of a different reference bag for each type of waste.

Disposal

Data can be retrieved from websites or documents of disposers:

(i)% of waste to recycling by waste type;
(ii)% of waste to waste-to-energy by type of waste;
(iii)% of waste to landfill by waste type;

For a correct estimation of the impact in terms of CO2 eq, multiplicative coefficients (derived from the literature) were used, linked to the impact generated by the type of disposal depending on the waste under consideration.

In the reported case, the data and coefficients of a local disposer were used.

Water Database

Refuelling

Data can be found from utility bills and on-site meters. In particular:

(i)m3 of water from aqueducts;
(ii)m3 water from secondary sources (wells, rainwater tanks, ...);

If the bill cannot be found, it is suggested to observe the values at the meter before and after the event under consideration.

In the reported case, there are no secondary sources of supply and consumption was measured from observations on drinking water supply meters.

Transports Database

Type of transports

Data can be found through questionnaires to participants. In particular, each participant may have arrived at the event via:

(i)Private means of transport;
(ii)Public transport;
(ii) Without a motor vehicle;

For a correct estimation of the impact in terms of CO2 eq, multiplicative coefficients

Appendix A

(derived from the literature) related to the impact generated by the type of vehicle were used.

In the case of this report, the means were estimated for the first event, while for the second event a report was compiled by the participants.

Distance

Data can be found through questionnaires to participants:

(i)Place of departure;

Given the high impact of transport, it is advisable to avoid using estimates unless necessary due to lack of information.

In the case of this report, origins were estimated for the first event, while for the second event a report was compiled by the participants.

Management Indicators - Energy

The operational indicators that the model uses to calculate the tactical energy category indicator, ACE, are as follows:

Class name	Level	Description
SELF-GENERATED RENEWABLE ENERGY	3	Self-produced renewable energy consumed by the company
RENEWABLE ENERGY FED INTO THE GRID	2	Renewable energy self-produced by the company but not consumed and fed back into the grid
PURCHASED ENERGY MIX	1	Purchased renewable energy
PURCHASED NON-RENEWABLE ENERGY	0	Purchased fossil energy

The indicators of the selected classes are calculated in percentage terms, with the denominator being the total sum of the category.

Purchased non-renewable energy: This represents the worst case and refers to energy produced using fossil sources (such as coal, oil, etc.) or produced from nuclear sources. Fossil energy sources are not reusable, are destined to run out and are the main source of greenhouse gas emissions worldwide. There is evidence that about two-thirds of global greenhouse gas emissions are related to the use of fossil fuels for energy purposes [1].

Purchased Energy Mix: Energy consumption is covered by sources distributed according to a precise energy mix, of which the GSE (Gestore dei Servizi Energetici) provides the composition. The reference energy mix is the national one, which is composed of 56% from fossil sources and 44% from renewable sources in 2021 [2]. If not specified by the operator, the model takes the national mix as a reference.

Renewable energy fed into the grid: this category contains the use of energy that has been sold to the GSE or other entities and fed back into the grid, following an economic fee that the operator pays to the producer. The model does not reward this mode to the fullest since feeding energy back into the grid causes a considerable loss of efficiency in the energy balance. The main causes are transport, storage and transformation.

Self-produced renewable energy: the model assigns maximum points to self-produced renewable energy sources, ensuring the best utilization efficiency and lowest environmental impact. The model uses kWh as the unit of measurement of the energy quantity.

Appendix A

Management Indicators - Waste

The VIVACE model provides for a subdivision of the waste indicator into four classes, which are fed by the corresponding operational indicators from among those illustrated above:

Class name	Level	Description
BY-PRODUCTS	3	Production residues that are used as new raw material
CLOSED-LOOP MATERIAL RECYCLING	2	Residues managed from an industrial symbiosis perspective
SENDING TO THE WASTE-TO-ENERGY PLANT	1	Residues that are exploited for energy production
LANDFILL DISPOSAL	0	Residues that are not valorized but disposed of in landfills

The indicators of the selected classes are calculated in percentage terms, with the denominator being the total sum of the category.

Landfilling: landfilling represents the worst case as far as the disposal of a residue is concerned. As early as 2008, the European legislature indicated this form of disposal as the last option for waste management [3]. Landfilling involves multiple pollution phenomena, such as damage to the subsoil, surface water, air, etc.

Sending to waste-to-energy: referring again to European legislation [4], waste-to-energy is a tool for the ecological transition, although its use does not prejudice the achievement of prevention, reuse and recycling, the highest levels of the defined waste hierarchy.

Closed-loop material recycling: closed-loop material recycling refers to the collection and reprocessing of goods without losing the integrity of the original material. By defining the concept of recycling in this way, the model excludes the possibility of goods and materials reaching the level of landfill disposal by clearly separating the categories. The concept of closed-loop recycling, by its very nature, also involves design aspects and the choice of materials from which goods are made. In this way, by the hierarchy defined by the European Union, higher levels, such as prevention, are implied.

By-products: obtaining by-products is the most virtuous way to manage process residues. In this way, it is possible to close, with circularity, the value chain. This category implies the highest aspects of the waste hierarchy, first and foremost prevention.

Management Indicators - Transports

The quantification is made based on the total distance traveled, to enhance increasingly sustainable transports and at the same time allow companies to access state incentives for fleet renewal. An approach in line with state incentives is adopted to determine the transport classes, and they are fed by some of the operational indicators seen above. Incentives for the year 2021 were taken as a reference and are divided according to the type of transport: incentives for passenger cars [5] and incentives for lorries [6] with a mass of more than 3.5 tonnes. Based on the incentive bands, it was decided to introduce the following classes:

Appendix A

Class name	Level	Description	Units of Measurement	Criterion cars	Vehicle criterion
NEAR ZERO IMPACT	3	High-efficiency vehicles	Km	0-60 grCO2/Km	Hybrid or electric vehicles
LOW IMPACT	2	Recent low-emission vehicles	Km	61-120 grCO2/Km	Alternative traction vehicles (LNG, CNG)
MEDIUM IMPACT	1	Recent medium-emission vehicles	Km	>= Euro 6	>= Euro 6
HIGH IMPACT	0	High-emission vehicles	Km	< Euro 6	< Euro 6

The indicators of the selected classes are calculated in percentage terms, with the denominator being the total sum of the category.

High impact: this class includes all vehicles, both cars and motor vehicles, below Euro 6, i.e. all those that are highly polluting, not only in terms of CO2 emitted but also in terms of pollutants.

Medium-impact: This class includes all vehicles of Euro 6 or higher, but which are found to have such CO2 emissions that they do not fall into the more efficient upper classes.

Low-impact: as far as passenger cars are concerned, this class includes all vehicles characterized by efficient engines with an alternative drive such as natural gas or LPG, or equipped with a light hybridization system. Concerning incentives, the threshold has been lowered from 135 to 120, a proactive reduction of 10% aimed at rewarding more efficient vehicles. As far as heavy vehicles are concerned, this class includes all Euro 6 or higher vehicles with an alternative drive, such as compressed natural gas (CNG) or liquefied natural gas (LNG).

Near zero impact: as far as passenger cars are concerned, this class includes electric vehicles, vehicles with a high degree of hybridization and those with a kilometer emission of less than 60 gCO2/km. As far as heavy goods vehicles are concerned, this class includes all hybrid or electric vehicles.

Management Indicators - Water

To better evaluate the management of the water resource, it was decided to divide the category into classes concerning the end of life of the resource. The four classes that were identified are:

Class name	Level	Description	Units of Measurement	Criterion
REUSE	3	Treated and reused water	L	Water that is used again in a business process and would otherwise have to be drawn from the source
REINTEGRATION	2	Water returned to the environment	L	Suitably treated water that is returned to the environment in the same state in which it was withdrawn
DISPERSION	1	Water dispersed in the environment	L	Water that is dispersed into the sewerage system or the environment without control, e.g. in the form of steam
DISPOSED WATER	0	Contaminated water	L	Water that is managed as waste and disposed of in landfills

The indicators of the selected classes are calculated in percentage terms, with the denominator being the total sum of the category.

Disposed water: this class includes contaminated water, sludge, and sewage that is handled through an external disposer, who carries out a disposal process, thus not reusing it; no distinction is made between hazardous and non-hazardous waste.

Dispersion: This class includes water that is dispersed, uncontaminated, directly into the sewer or into the environment through evaporation, without a recovery system. This

Appendix A

is because the steam does not replenish the water in the same system.

Reintegration: this class includes water that is voluntarily returned to the environment after appropriate treatment, in the same physical state in which it was originally taken from the source. Irrigation or reintegration into groundwater, lakes or rivers is considered in this category. The inclusion of water in this category must be justified by data assuring the quality of the water.

Reuse: this class includes water that is reused by the company, after appropriate treatment, within the same process or, possibly, in a different process: in this way, the company makes the most of its resources, as it avoids taking more from its source.

NB: For reasons of space and simplicity, it was decided not to share the model in depth and in full. For further details, please contact the person responsible for this report.

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