# Rio 2016 Carbon Footprint Report

July 2016

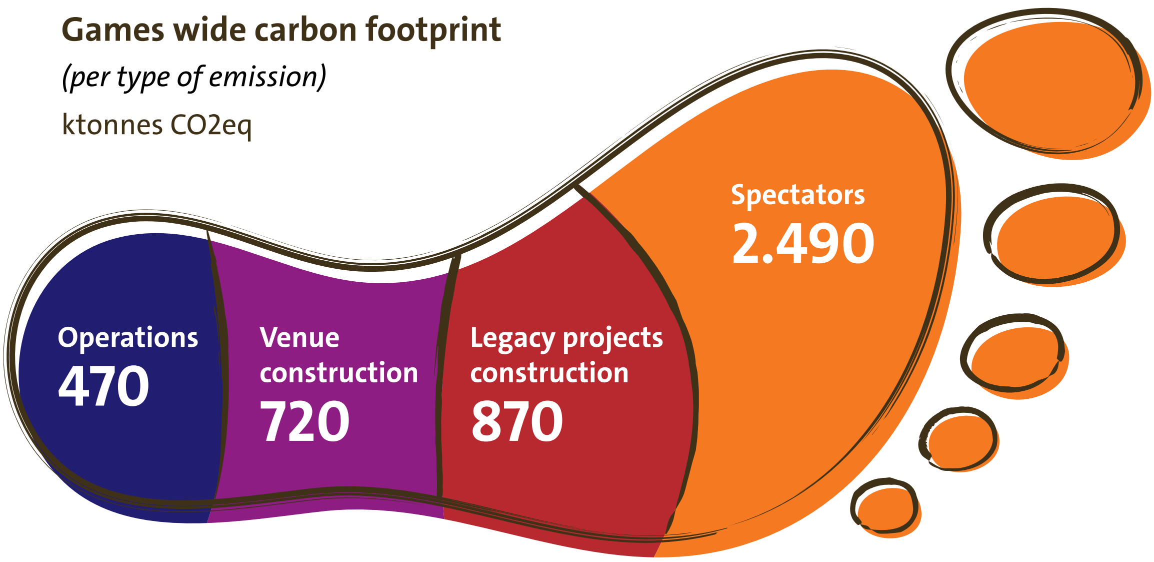
CARBON OFFICIAL PARTNER

Dow

Abraça SUSTAINABILITY

Rio2016


Games-wide emissions
4500 ktonnes $CO_2$eq
Rio 2016 owned emissions
580 ktonnes $CO_2$eq


Games wide carbon footprint
(per type of emission)
ktonnes CO2eq
Operations
470
Venue construction
720
Legacy projects construction
870
Spectators
2.490

# 1 The Rio 2016 sustainability approach

When we started drafting the Rio 2016 Sustainability Project, we realised that mobilising athletes from over 200 countries, inviting more than two million spectators and preparing the biggest sporting event in the world gave us the unique opportunity to use the Games as an agent for change.

The Olympic and Paralympic Games are unique in the way they can inspire and engage with large audiences for the adoption of sustainable behaviour. But at the same time, an event this size brings a significant social and environmental impact.

Rio 2016 is taking on board the lessons learnt from previous Games to set goals in a way where sustainability is not just an idea but a reality. This exercise has helped us develop our approach based on the following questions:

- How can we have clean and lean operations?
- How can we deliver the best sporting experience to the spectators, whilst at the same time using less non-renewable resources?
- How do we encourage people to adopt more sustainable behaviour?
- How do we use sustainability to drive changes in the Brazilian economy by using our supply-chain as a multiplier?
- How do we use technology to mitigate our environmental impact and create opportunities for other economic sectors?

The answers to these questions were transformed into goals and action plans. Taking care of our carbon footprint is one of the most important sustainability measures for the Games.

With each edition, this issue grows in relevance. Vancouver 2010 showed the importance of engaging people to adopt more sustainable behaviour in their daily lives; London 2012 developed a carbon footprint methodology that helped event organisers understand and reduce their carbon emissions; Sochi 2014 showed to a large audience the use of technological mitigation as an innovative way of compensating emissions. Rio 2016 will be the first edition of the Games to combine all these lessons into one single programme. To understand how this is going to happen, we must answer a few questions.

## WHAT IS CLIMATE CHANGE?

Greenhouse gas emissions (GHG) are responsible for climate change and the increase in the severity of extreme climate events. The overwhelming majority of climate scientists agree that human activities, especially those that involve the burning of fossil fuels (for example coal, oil and gas) are responsible for most of the climate changes currently being observed[1].

According to the Organisation for Economic Cooperation and Development (OECD), the concentration of GHG in the atmosphere could reach 685ppm[2] by 2050 (from 393ppm in 2012), threatening to disrupt the well-being of society and undermine economic development and alter the natural environment, making it one of the major issues of the 21st century.

According to the fifth report of the Intergovernmental Panel on Climate Change (IPCC), if greenhouse gas emissions continue to grow at the current rate, global temperatures may rise by 4.8°C this century.

Climate change affects us all, and the new risks it poses are and will continue to impact society and the global economy. However, within these risks lie opportunities for organisations to improve competitiveness through long-term strategic investment in low greenhouse gas emission technologies, sustainable products and energy efficient solutions[3].

1 Examining the Scientific Consensus on Climate Change. Available at: http://onlinelibrary.wiley.com/doi/10.1029/2009EO030002/pdf

2 Part per million (ppm) is used as a concentration measure. 685 ppm means for every one million molecules in atmosphere, 685 are carbon dioxide.

3 Energy Efficiency: A Compelling global resource', McKinsey & Company, 2010, and 'Sustainability in Business today: A cross industry Review', Deloitte, 2010.

## WHAT IS CARBON FOOTPRINT?

In order to track GHG emissions, an international standard was established using carbon as a parameter and is where expression carbon footprint comes from. Carbon footprint is a sort of "environmental accounting" of the GHG emissions, with many similarities to financial accounting: each activity is listed, and either the environmental credits/burdens or the financial income/expenditure are monitored and computed. All daily activities leave a carbon footprint, meaning these activities leave an environmental footprint. With an event like the Rio 2016 Games, there are thousands of activities, each contributing to the gas emissions. The carbon footprint is the sum of all these parts.

## WHY DO WE CARE ABOUT OUR CARBON FOOTPRINT?

The estimated carbon footprint of the Games is around 4.5 million tonnes of $CO_2$eq (carbon equivalent, the measure in which all gases of the greenhouse effect are converted into their average equivalent quality in $CO_2$). These are significant emissions. Therefore, Rio 2016 designed a carbon management plan to identify opportunities to reduce and compensate emissions (refer to section 2).

### HOW MUCH IS 4.5 MILLION TONNES OF $CO_2$EQ?

In order to make it easy for people to understand the size of our estimated emissions, we compared 4.5 million tonnes of $CO_2$eq with emissions from the city of Rio de Janeiro.

Rio de Janeiro city emissions:

- 25 million $CO_2$eq per year (data from 2012), or
- 2.05 million $CO_2$eq per month

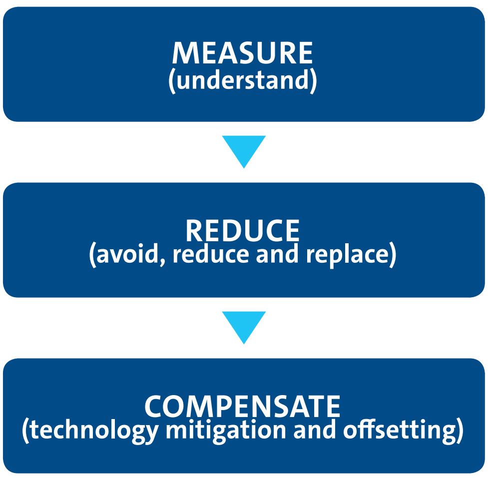
# 2 How do we take care of our carbon footprint?

Rio 2016 has adopted a comprehensive approach to addressing climate impact and taking care of the carbon footprint.

The principles adopted by Rio 2016 include:

- CUnderstanding and measuring the carbon footprint in a transparent and comprehensive way
- Reducing Rio 2016's own carbon footprint by avoiding emissions at source and reducing emissions through efficiency measures. Substitute conventional systems for lower carbon technologies
- Compensating emissions from operations and spectators through technological mitigation
- Compensating emissions from venues and infrastructure construction (around 1.6 million tonnes of $CO_2eq$) through environmental restoration projects and initiatives to promote green economy

RIO 2016 CARBON MANAGEMENT STRATEGY OF RIO 2016



This approach recognises that the Rio 2016 Games are a project rather than a conventional organisation. Therefore, all carbon emissions caused by the Games are arguably additional and the most important task is to avoid emissions as far as possible. This can be achieved through accurate scoping of the project and elimination of potential emissions through planning and procurement processes.

The reduction and replacement of elements are directly related to efficiency management and using low/zero-carbon technologies wherever feasible and cost-effective. These elements are no different from any other organisational approach.

In addition, the singularity of the Olympic and Paralympic Games in terms of scale and reach does, however, offer opportunities for different approaches for compensating emissions.

Instead of relying on conventional carbon offsetting schemes[4], the power of the Games to inspire change opens up a range of alternatives for the adoption of new initiatives that effectively reduce emissions at source. This can be achieved by encouraging the uptake of innovation and better practices, shaping the market through supply-chain interventions, inspiring behavioural change initiatives and promoting knowledge transfer.

Rio 2016 understands that a responsible approach to climate change requires the courage to avoid the temptation of using easy/quick-fix solutions. Rio 2016 strives to be "carbon neutral". However, since 2008, the climate change debate has progressed greatly and there is a growing consensus that "carbon neutrality" is a potentially misleading term[5]. It is especially true in the case of the Olympic and Paralympic Games, since there are no fixed boundaries on a project of this scale. Therefore, any claim of carbon neutrality would be arbitrary and unrealistic to prove.

For this reason, Rio 2016's objective is to implement measures to minimise greenhouse gas (GHG) emissions to deliver low-carbon Games, while creating lasting, beneficial legacies.
The underlying aim is to provide a broad spectrum of benefits over the long term, instead of simply pledging to be "carbon neutral" and walking away.

---

**4** Conventional carbon offsetting schemes are based on buying carbon credits in the market. A carbon credit is a generic term for any tradable certificate or permit representing the right to emit one tonne of greenhouse gas equivalent to one tonne of carbon dioxide.

**5** The term carbon neutral can lead to the overstating of green credentials and create an illusion about the scale, economic cost and complexity of the transition to a low-carbon economy. Neutrality claims based on conventional carbon offsetting schemes are often perceived as an opportunity to "greenwash" because it requires absolute precision in the calculation of both the original emissions and the compensation, which is technically impracticable.

## 2.1 MEASURING OUR CARBON FOOTPRINT

A standardised methodology for measuring, calculating and reporting the GHG emissions of major events does not currently exist and there are significant differences between methodologies used by different event organisers. For example, the definition of the system boundaries - what is and what is not included in the footprint – can vary significantly among various major international events[6]. The majority of the events' carbon footprint has either not included embodied impacts, such as the carbon emissions coming from the production of construction materials, or amortised[7] the carbon emissions over the lifetime of the venues and infrastructure used.

Vancouver 2010 and London 2012 used carbon footprint as a decision-making and reporting tool of their sustainability plan. London 2012 was very successful in defining a well-documented methodology, which was thought of and developed specifically for the Olympic and Paralympic Games (LOCOG 2012). The London 2012 methodology includes embodied carbon in a very extensive way (for example, it does not amortise carbon emissions over time, attributing them entirely to the event).

Rio 2016 is following the methodology created by London 2012 to understand and measure the Olympic and Paralympic Games carbon footprint. The first step is to anticipate carbon impacts so they can be avoided, reduced or compensated. However, technical parameters have been adapted to the Brazilian reality and updated according to recent scientific developments on the subject. This methodology refers to various international standards, particularly the GHG Protocol[8].

This report is based on the best data, assumptions and estimates available at the time of the reference footprint calculation (December 2015). While the overall methodology should remain largely unchanged, it is inevitable that certain elements of the Rio 2016 Carbon Strategy  and the quality of data necessary for the reference footprint calculation will continue to evolve prior and during to the Games.

**6** De Heer and Bochatay, 2011.

**7** Amortisation means spreading the impact of the emissions over time, rather than recording them up front.

**8** The Greenhouse Gas Protocol (GHG Protocol) is the most widely used international accounting tool for government and business leaders to understand, quantify and manage greenhouse gas emissions. It provides the accounting framework for nearly every GHG standard and programme in the world - from the International Standards Organisation to the Climate Registry - as well as hundreds of GHG inventories prepared by individual companies

The report takes into account not only the Games themselves, but all activities related to Games preparation, staging and disassembling since 2009, when the Games were awarded to Rio de Janeiro. Part of the emissions occur during the seven years of preparation, for example the construction of infrastructure required for the Games (venues, transport solutions, urban infrastructure, etc.). Operational activities (venue energy consumption, Olympic family transport) and emissions attributable to spectators will occur during the Games. And finally, some emissions will occur during a short period of time after the event for the dismantling of the Games.

## 2.2 REDUCING OUR CARBON FOOTPRINT

Rio 2016 aims to reduce its own emissions by 18.2 per cent in relation to the reference scenario. The target was decided using the Rio de Janeiro city reduction scenario for the year 2016 as a benchmark, following a recommendation made by our stakeholders[9] (see appendix).

Rio 2016 emission reduction efforts focus on:

- avoid emissions through careful planning and efficient processes
- reducing embodied carbon in materials through smart design and sustainable purchasing
- substituting fossil fuels for renewable and alternative fuels

Rio 2016 will report on overall carbon reduction immediately after the Games, but this should be viewed as an approximate estimate. There will also be specific case studies tracing the carbon savings of chosen materials, equipment and services.

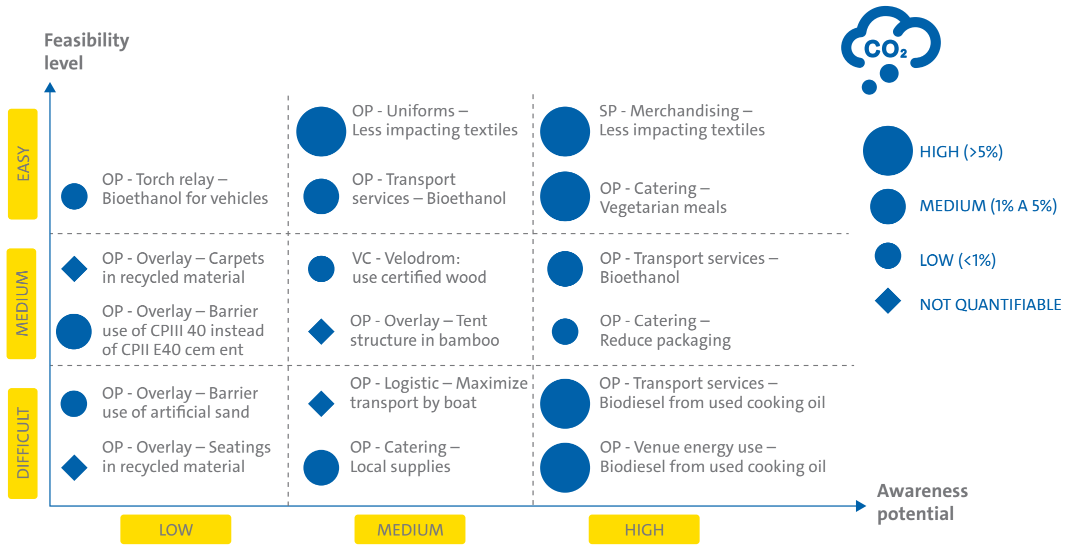
Rio 2016 worked with Quantis, a specialised life-cycle analysis firm, to assess alternative scenarios for carbon footprint reduction. The analysis looks at different measures for the stages of preparation for the Games and provides the potential of GHG emission minimisation compared to the reference scenario.

Owing to the size of the Games, even a measure with low relative potential of GHG emission can still generate important reductions in absolute value. Besides the relative and absolute potential of emission reduction, other parameters – such as viability, cost of implementation and awareness potential – were considered in the analysis.

**9** In December 2013, Rio 2016 organised a dialogue with Brazilian NGOs. Among the 20 priority recommendations was the establishment of an emission reduction target based on the carbon reduction scenarios of the city of Rio de Janeiro.

The figure below presents an analysis of the different scenarios according to three parameters: the GHG emission reduction potential, the awareness potential and viability. The GHG emission reduction is expressed relative to the total impact of the category.

**ALTERNATIVE SCENARIO DECISION MATRIX**




**Source: Quantis/ATA, 2014**

## Reducing emissions through careful power planning

We began by carefully planning primary and back-up electrical power for all venues. This will allow the reduction of GHG emissions by emphasising energy efficiency and lowering the overall amount of energy required to run the Games.

Typically, the power supply for Olympic and Paralympic Games venues, as in any large-scale event, is provided via a combination of utility electrical distribution (grid power) and temporary stationary generators.

Around 75 per cent of Brazilian electricity comes from renewable sources, mainly hydropower. Therefore, our target is to use as much grid energy as possible.

Rio 2016 has been working with the Rio de Janeiro electrical utility provider to provide the base power-supply capacity and primary back-up power to our key venues with energy from the grid. New electrical distribution lines have been installed from two different utility power substations to ensure power reliability and reduce the number of generators needed at the Barra Olympic Park[10].

However, the use of grid power is not feasible for temporary venues. Therefore, temporary generators are used to supply those sites and provide back-up power for critical activities in the event of a utility electrical distribution power outage[11].

Smart engineering on temporary generator use will result in significant reductions in GHG and operating costs. In addition, a number of the generators would be deployed in “cold standby” mode, meaning they would probably never need to run at all.

Rio 2016 also took on the challenge of powering the indispensable generators with renewable and alternative fuels. The target is to use a mix of 20 per cent biodiesel in all generators.

Products that have a high level of energy efficiency or that enable direct or indirect reductions in energy consumption will be used whenever possible. For products that are part of the Brazilian Labelling Programme (PBE), Rio 2016 will select products with an "A" rating on the National Energy Conservation Label (ENCE - INMETRO/PROCEL).

---

**10** Light, the electricity provider for Rio de Janeiro, has developed an investment plan of R$385M to ensure energy supply for the Games. The planning of additional power supply took post-Games demand into consideration. In addition to building the power substation dedicated to the Olympic Park, another six power substations are being upgraded – Itapeba, Recreio, Padre Miguel, Guadalupe, Curicica and Gardênia. For more information regarding Light please access: http://www.light.com.br

**11** According to the London 2012 Energy Level Data, the London Olympic and Paralympic Games used over 373 temporary generator units.

### Reducing emissions in the transport system and the vehicle fleet

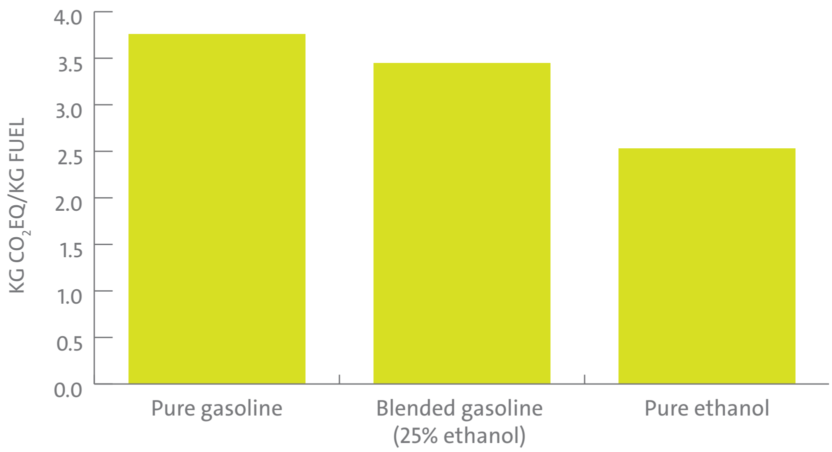
Rio 2016 has planned for an efficient, reliable, accessible and financially sound transport system for the Games.

This system includes the target of 100 per cent use of public transport by spectators and workforce, reinforced by the absence of spectator parking spaces at the venues. In 2009, less than 16 per cent of the city's population used public transport. With the investments made by municipal and state governments the expectation is that number will increase to 60 per cent by 2016 (refer to the Sustainability Management Plan for information on the legacy transport plan for Rio de Janeiro).

Another fundamental measure is the optimisation of the Rio 2016 Games-time fleet routing, composed of buses and light vehicles used to transport athletes, technical officials, media and the Olympic and Paralympic family. Optimised routing results in lower fuel use and fewer carbon emissions.

The substitution of fossil fuels for renewable and alternative fuels is another key feature of the Rio 2016 sustainable transport plan. For buses, Rio 2016 made the use of 20 per cent of biodiesel viable. For light vehicles, we will be using 80% per cent of the total fleet to be flex fuel compatible[12].

**GHG EMISSIONS OF THE COMBUSTION OF PURE GASOLINE, BLENDED GASOLINE AND PURE ETHANOL.**




**The direct emissions of the production, the distribution and the combustion are included.**
**Source: Quantis / ATA, 2014.**

12 Vehicles that can use up to 100 per cent of plant-based ethanol

Other initiatives:

- Providing information to encourage use of public transport, bicycles or walking for the spectators and workforce
- Encouraging the Olympic and Paralympic family to use public transport during the Games
- Using low-carbon materials for transport signage
- Encouraging the development of  mobile apps related to transport and accessibility
- Providing training in economic directives for drivers
- Encouraging the use of tyres with better rolling resistance
- Taking waste, water and energy efficiency measures at bus garages
- Hiring local workforce, allowing more people to use non-motorised transport

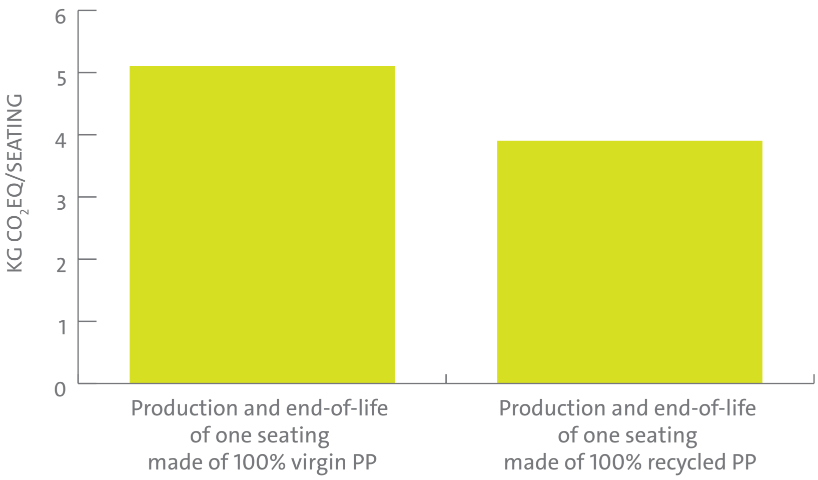
### Reducing emissions embedded in temporary structures

Rio 2016 design teams work with the challenge of reducing the physical footprint of the temporary structures of venues in relation to the initial design. For example, the floor area requirement for the temporary structures at the Olympic and Paralympic Village was reduced by 52% per cent.

Smart design choices also allow efficient use of existing materials, including modular structures, to reduce the amount of customised manufacture for the Games. This approach allows Rio 2016 to maximise the hiring of materials such as tents, seating, barriers and containers.

Rio 2016 has made a commitment to buy 100 per cent of wood from certified sources (commitment valid only to purchases made directly by Rio 2016). For example, the Velodrome requires 92$m^3$ of wood for the playing surface. By using certified wood, the GHG emissions of 1m3 of wood can be reduced from 204kg $CO_2$eq (non-certified wood) to 14kg $CO_2$eq per $m^3$. This commitment also has a significant impact on the calculation of the carbon footprint of temporary structures.

GHG EMISSIONS OF THE PRODUCTION AND END-OF-LIFE OF SEATS MADE OF 100 PER CENT VIRGIN MATERIAL AND 100 PER CENT RECYCLED MATERIAL.

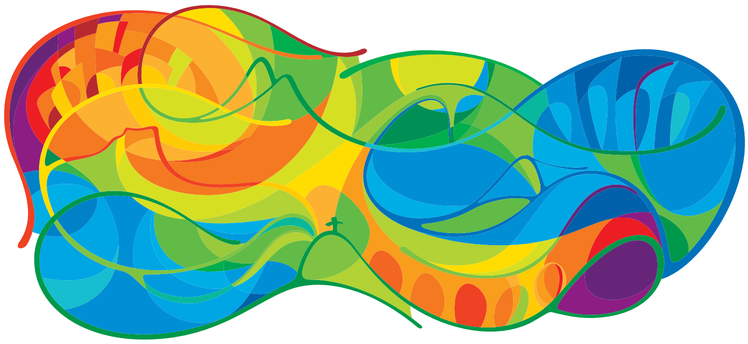



Source: Quantis/ATA, 2014.

Temporary civil works, such as hard surfacing for roads and parking (asphalt) are responsible for a large share of emissions. Therefore, substituting some hard surface areas with hired, temporary and/or lightweight surfacing could yield significant cost and carbon savings.

### Reducing emissions in other materials

The diverse graphic and design elements that compose the Olympic and Paralympic visual identity and signage, the so called "Look of the Games Programme", imply the use of a large amount of materials.

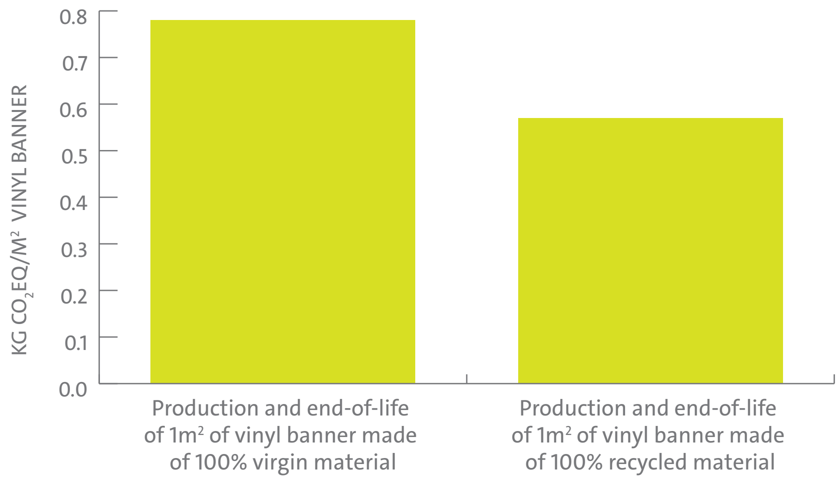


Rio 2016 Look

The design team for the Look of the Games programme has conducted a careful research of materials to identify options that could be used in the production of visual elements, considering their origin, composition, market availability and conditions to be recycled or reused.

An external consultant was hired to make a simplified life-cycle analysis of a list of several potential materials considering six criteria: renewable resources and/or recycled content, embodied carbon/energy, origin, toxicity and disposal.

**GHG EMISSIONS OF THE PRODUCTION AND END-OF-LIFE OF 1M² OF VINYL BANNER MADE OF 100 PER CENT VIRGIN MATERIAL AND OF 1M² OF VINYL BANNER MADE OF 100 PER CENT RECYCLED MATERIAL.**




**Source: Quantis/ATA , 2014.**

## Reducing emissions from catering

Catering is responsible for a significant part of the footprint of any event. This factor, coupled with Rio 2016's aim to provide food from traceable, sustainable and safe sources, presents a unique challenge and opportunity.

In recent years, one of the most significant changes in the global food industry has been the growing movement towards sustainable food production and consumption. It is now imperative that companies not only deliver high-quality food, drink and service, but do so reducing the global carbon footprint.

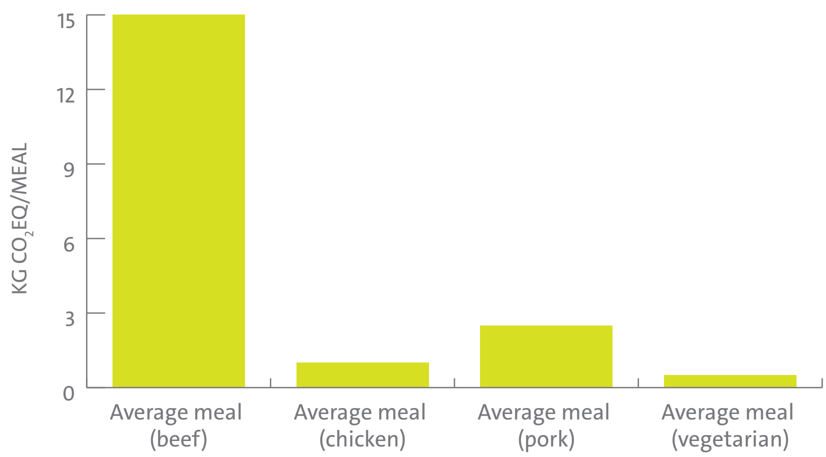
Until recently, the retail food sector was leading the development of sustainable food production alone, with little demand or incentive for the hospitality sector to engage with sustainability issues.

In early 2013, a group of 20 institutions met with Rio 2016 to discuss the potential for developing a food vision in Brazil, seizing the opportunity presented by the Olympic and Paralympic Games. It was the birth of the Rio Sustainable Food Vision Initiative, which consists of voluntary, independent institutions operating within Brazil.

The main goal of the group is to provide the Rio 2016 food and beverage team with a framework to source and supply healthy and sustainable food in addition to engaging with stakeholders and the government on the potential legacy for Rio de Janeiro and Brazil. Based on the consultation with the Rio Sustainable Food Vision Initiative, Rio 2016 defined a set of key targets on serving healthy and sustainable food, which are described in detail in the Rio 2016 Sustainability Report.

In reference to the carbon footprint of the catering operation, two points must be mentioned. The first involves the prioritisation of local suppliers and the manner in which their products can be used on Games menus. The second concerns red meat. Since red meat is the highest contributor of carbon emissions from food, an interesting alternative could be the reduction in the quantity of red meat and replacing it with alternatives that have lower impact, such as white meat or vegetarian options.

**COMPARISON OF THE GHG EMISSIONS OF DIFFERENT MEALS CONTAINING BEEF, CHICKEN AND PORK, AND A VEGETARIAN MEAL.**




**Source: Quantis/ATA , 2014**

Packaging and waste management are two other areas where reductions can be made.

Further commitments of Rio 2016 are to reduce the package generation during Games time and to increase the use of packaging that is recyclable, made with recycled material and, if possible, biodegradable and compostable. Rio 2016 has developed a Packaging Guide[13] to support the suppliers with sustainability commitments and best practices. This guide explains the types of packaging available and the Rio 2016 requirements.

Rio 2016 will also work closely with their menu designers, caterers and stakeholders to effectively reduce food waste. Ways in which this can be achieved are:

- Optimising portion sizes
- Optimising seasonal, local produce
- Efficient food stock management

Rio 2016 and their suppliers will be following detailed waste management plans not only for their operations but also for the planning phase. Initiatives such as the collection and reuse of cooking oil for biodiesel. All of Rio 2016's kitchen equipment will be hired, thereby reducing the potential for a flooded market post-Games. Any equipment which must be bought will be redistributed to a pre-determined destination.

## 2.3 BALANCING OUR CARBON FOOTPRINT

To help fulfill Rio 2016's goal to promote and stage carbon-balanced Games, Worldwide Olympic Partner Dow has committed to delivering third-party-verified, principal climate benefits of 500,000 tonnes CO2e by 2026 to be applied toward the mitigation of the Rio 2016 owned carbon footprint[14]. In addition, Rio 2016 and Dow also are collaborating to generate an additional 1.5 tonnes tons CO2e of climate benefits to be applied toward the associated footprint of Rio 2016, which includes, among other things, spectators' emissions[15]. The climate initiative is part of the Abraça sustainability program and uses the Games as an opportunity to spread innovative low-carbon solutions and energy-efficient technologies across key sectors of the Brazilian economy – leaving a lasting legacy for generations to come.

13 For further information about the Package Guide, please visit http://portaldesuprimentos.rio2016.com

14 Please refer to Chapter 3 for explanations on the meaning of the expression "Rio 2016 owned carbon footprint."

15 Please refer to Chapter 3 for explanations on spectators' emissions.

In 2014, Rio 2016 selected Dow as the Official Carbon Partner based on its expertise in managing its own emissions and delivering innovative energy efficiency and low-carbon solutions[16] . Building on the success of the carbon mitigation effort implemented at the Sochi 2014 Olympic Winter Games[17], Dow worked with Rio 2016 to design a tailor-made program to address the environmental, social and technology needs for Brazil. Dow has leveraged its deep relationships in Latin America and has put to work solutions to reduce GHG emissions and catalyze change in three important sectors of Latin America's economy – agriculture, industry and infrastructure.

To generate climate benefits, Dow has implemented projects aimed at:

- **Generating sustainable biomass energy.** Diversifying energy sources from fossil fuels helps save on GHG emissions. However, the challenge, especially for industrial manufacturers, is to find commercially viable means of using renewable energy on a large scale. This project adopts groundbreaking power and steam generation technologies from eucalyptus and sugarcane biomass to replace fossil fuels (mainly natural gas) and significantly reduces GHG emissions at two of Dow's sites in Brazil. In Aratu, State of Bahia, the eucalyptus biomass comes from dedicated farmlands and also includes a reforestation project of degraded lands. More than 12 MW of electricity is sent back to Bahia's grid. In Santa Vitoria, State of Minas Gerais, the plant produces 38 MW of power and 250 tons of steam per hour and consumes approximately 102 tons of biomass, meeting all the energy needs for Dow's local operations and producing excess energy for the grid. Dow and its partner also are working with The Nature Conservancy to identify priority land bank areas for conservation to ensure the protection and restoration of vital forests. Dow will plant 2 million trees by 2019. The plant operates a large nursery supporting sugarcane species and local reforestation producing an average of 500,000 seedlings per year.

**16** Dow has reduced its absolute energy use by 20 percent since 2005 (119 trillion Btu), and its energy intensity as measured by Btu per pound of product has improved by more than 40 percent – contributing to a cumulative savings of 5,500 trillion Btu. Additionally, Dow has avoided more than 320 million tons of emissions since 1990.

**17** The "Sustainable Future" program, implemented by Sochi 2014 Olympic and Paralympic Organizing Committee (SOCOG) and Dow, delivered 520,000 metric tons CO2e (verified by a third party) through in-country technology programs prior to the opening of the Games, surpassing the estimated owned emissions (of 360,000 metric tons CO2e). In addition, Dow retired carbon credits amounting to 160,000 metric tons CO2e from high-quality international projects to mitigate associated travel emissions. These results represent significant steps forward from previous Games, both in terms of the extent of mitigation achieved within the host country and timeliness of results delivered.

- **Implementing raw material reductions in the packaging industry.** Reducing the environmental footprint of food packaging can help reduce GHG emissions and contribute to the reduction of plastic waste. Working with plastic film manufacturers in five countries (Brazil, Argentina, Guatemala, Mexico and Colombia) Dow has introduced innovative microfoaming technology. Microfoaming reduces density in coextruded films through a physical foaming process; the result is more packaging material developed with the same amount of resin. This means creating GHG emission reductions per functional unit of packaging while maintaining the same functional properties. This collaboration will ensure broad application of the technology throughout Latin America.

- **Encouraging the recovery of degraded pastureland to improve range efficiency.** Partnering with a leading agriculture group, the project is providing expertise and technology to farmers in the Araguaia valley region to restore degraded pasturelands, increase livestock production and reduce GHG emissions. A model farm demonstrates a set of technologies including weed control and seeds solutions from Dow that enable soil to capture more carbon, thereby recovering pastureland and increasing productivity. Building on the learnings from the model farm, the project is offering education and consulting services to farms within the region to balance investments in pasture restoration with intensification of livestock production. Farmers are also introduced to carbon tracking methodology to quantify emission reductions. The goal is to monitor more than 50,000 hectares of pastureland. By participating in this project, farmers are able to incorporate more sustainable agricultural practices, intensify livestock production by raising more cattle with the same resources, improve their income and help contribute to the low-carbon legacy of the Rio 2016 Games.

- **Improving crops productivity.** Dow is partnering with a leading precision agronomy service provider to provide precision agriculture and variable rate technology and expertise to farmers in Mato Grosso to optimize use of synthetic fertilizer to reduce nitrous oxide emissions. Participating farmers have access to technologies such as satellite imagery, precision harvest and profit maps, intensive soil sampling and laboratory analysis, weather monitoring, and detailed review of cropping plans and goals with variable rate technology experts. Dow is also offering seeds and crop protection solutions to farmers to help optimize production and increase yields. Implementation started in August 2015 and spans 25,000 hectares across seven farms to cover two crop seasons – one summer crop (soy) and one winter crop (corn, cotton or sunflowers). The objective is to help farmers increase yield through advanced and more sustainable agricultural practices, while reducing GHGs. Climate benefits will be realized over five years – far beyond the Olympic Games.

- **Educating the construction value chain about energy efficiency.** Designing buildings with better insulation reduces the demand on heating and cooling systems, which, in turn, reduces the buildings' energy consumption during their lifetime. Dow is engaging with stakeholders across the entire construction value chain on the importance of integrating energy efficiency into their decision-making as an essential way to reduce their environmental impact and help property owners lower their energy costs. In November 2015, Dow launched a program in partnership with the three largest polyurethane-panel producers in Brazil.

Key criteria of the projects are that they are economically viable within the Brazilian and Latin American reality and go "beyond business as usual" (BBAU) to deliver GHG emission reductions. The projects are introducing innovations, overcoming barriers and catalyzing long-term change in market practices. Ultimately, the projects are designed to enable industries to do more with less, switch to lower-carbon energy sources, conserve energy and enable material efficiency through state-of-the-art solutions.

| PROJECT NAME | COUNTRY | CATEGORY | OPERATIONAL STARTING DATE |
|---|---|---|---|
| **Aratu biomass cogeneration project** | Brazil | Renewable energy | April 2014 |
| **Microfoamed-core flexible packaging production** | Brazil, Argentina, Colombia, Mexico, Guatemala | Raw material mass reduction | March 2016 |
| **Precision agriculture nitrogen emission management** | Brazil | Nitrous fertilizer optimization | August 2015 |
| **PU insulation in construction** | Brazil, Argentina | Energy efficiency | November 2015 |
| **PU foamed-core door blowing agent conversion** | Mexico | Carbon footprint reduction | June 2016 |

| | | | |
|---|---|---|---|
| **PU sandwich panel blowing agent conversion** | Argentina | Carbon footprint reduction | November 2016 |
| **Restoration of pastureland to improve range efficiency** | Brazil | Soil carbon sequestration | November 2015 |
| **Santa Vitoria cogeneration project** | Brazil | Renewable energy | June 2015 |

Carbon mitigation project overview. Source: Dow, 2016.

The program implemented by Rio 2016 and Dow is based on the Dow Climate Solutions Framework described in Appendix 4. Working with NatureBank as its carbon consultant, Dow developed the Climate Solutions Framework, quantified the emission reductions associated with the projects and demonstrated how these emission reductions are BBAU. NatureBank specializes in advisory, technology and project investment services with a primary focus on carbon. All mitigation projects are to become operational before December 31, 2016 (Implementation Period). The climate benefits shall be accounted for from the launch of each project through the end of 2026 at the latest (Realization Period)[18]. An independent third party, Environmental Resources Management (ERM), was selected to validate the Project Plans against the Climate Solutions Framework and verify GHG emission reductions. In addition, ERM has conducted an assessment of forecasted generation of climate benefits based on verified evidences.

ERM has determined the validity as a Primary or Secondary Emission Reduction Project[19] for each project. Project designs were validated and implementation verified based upon criteria that includes:

- Clear demonstration of the additionality of the projects and fulfillment of the BBAU condition

- Use of existing GHG accounting methodologies and/or protocols

**18** Some projects have a Realization Period shorter than 10 years.

**19** Please refer to Appendix 4 for explanations on the meaning of Primary or Secondary Emission Reduction Project.

- Contractual conditions showing that the climate benefits generated by each of the projects during the crediting period will be exclusively attributed to the carbon partnership of Dow and Rio 2016

- Detailed conservative calculations of baseline emissions and project emissions forecasted

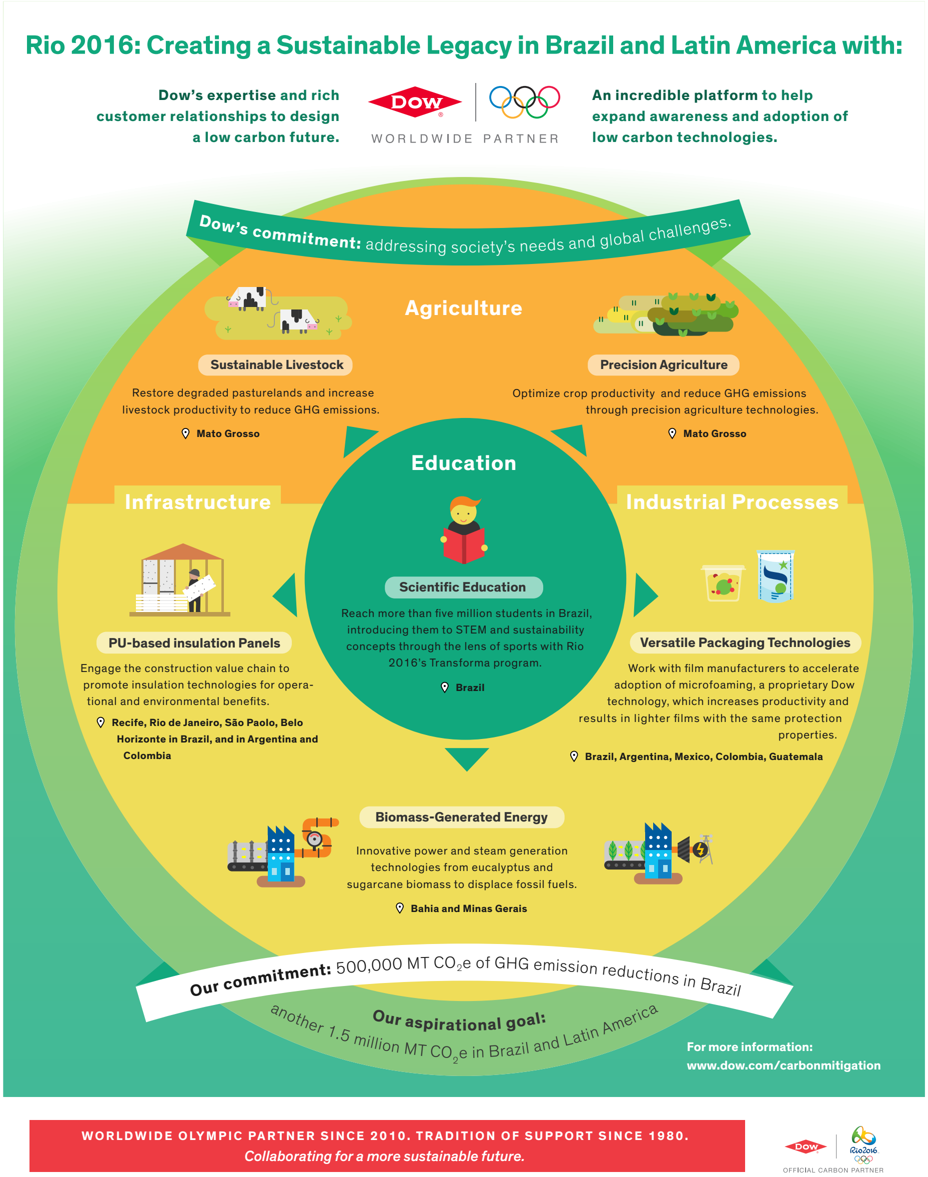
- Evidence of individual project implementation based upon site visits, invoices for purchasing new equipment or machinery, and contractual agreements between Dow and its partners, for example

As of July 12,  2016, ERM determined that to the best of its knowledge a total of 684.591 tonnes of CO2e from Principal Emission Reduction Projects in Brazil and a total of 1.519.671 tonnesof  CO2e from Societal Emission Reduction Projects in Brazil and the rest of Latin America are expected to be achievable through the full implementation of the Project Portfolio during a 10 years' crediting period.

As the *Abraça* carbon mitigation program technology projects are being implemented, Rio 2016 and Dow are committed to reporting the updates and learnings frequently. Beyond complying with reporting standards, both partners want to make sure that information and intelligence are readily available to event organizers and other key stakeholders to learn and leverage.

Dow and Rio 2016 also are working together to reach 500,000 people in Brazil by integrating strong engagement and awareness components into the mitigation program. In order to achieve this important goal, Dow became the first and major corporate partner of Transforma, Rio 2016's education program, introducing science-related content to the platform. Dow scientists partnered with Rio 2016 educators to develop nine classes, covering chemistry, physics, biology and environmental education, using the world of sports and Olympic and Paralympic themes as the thread to teach scientific concepts. As of June 2016, Transforma has reached more than 15,521 schools and 7 million students in Brazil.

The infographic below has been developed to provide a practical, visual overview of the carbon mitigation strategy being implemented by Dow and Rio 2016:




## 2.4 OTHER COMPENSATION INITIATIVES

The Rio de Janeiro State Government is responsible for the offset of 1.6 million tonnes of carbon dioxide equivalent to be applied towards the compensation of the emissions from Games related construction and infrastructure. Please refer to "*Estrategia de Sustentabilidade*" (document available at http://www.apo.gov.br) for more information.

# 3 How much is Rio 2016 Olympic and Paralympic Games carbon footprint?

Rio 2016 worked with two companies to calculate the carbon footprint of the Rio 2016 Olympic and Paralympic Games: Quantis and ATA. Quantis[20] is an international leading life-cycle assessment (LCA) consulting firm specialising in supporting companies in measuring, understanding and managing the environmental impacts of their products, services and operations. ATA[21] is an independent Brazilian consultancy focused on supporting companies operating in Brazil, particularly in the construction sector, in adapting to a low-carbon economy.

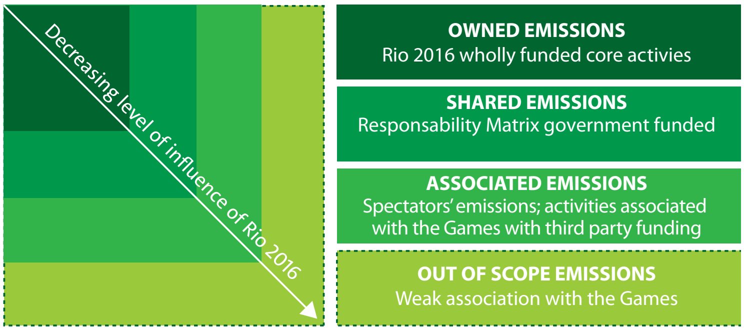
## 3.1 WHAT ARE WE MEASURING?

The most fundamental accounting principle for measuring carbon footprint is that of organisational boundary setting. It should include all activities relevant to understanding the impact of the activity on climate change. For Rio 2016 it means determining where activities relating to the Olympic and Paralympic Games start and finish, specifying which activities should be included in our calculation and which should not.

The emissions are in scope if they are either funded, controlled or influenced by Rio 2016 or another agency directly involved in Games preparation. The emissions are categorised as owned, shared or associated, according to the criteria below.

**20** For further information, please visit: www.quantis-intl.com.
**21** For further information, please visit: http://www.atapart.com.br.

DEFINITION OF "OWNED", "SHARED" AND "ASSOCIATED" CATEGORIES




This category definition follows the model created by London 2012, but is adapted to the reality of the Rio Games. It captures different, but equally important, aspects of the Games-wide[22] footprint.

The Responsibility Matrix contains information on responsibility sharing between Rio 2016, the three levels of government (municipal, state and federal) and third parties, and was used to determine and allocate the carbon footprint, as explained in the table below.

ALLOCATION RULES FOR OWNED, SHARED AND ASSOCIATED IMPACTS

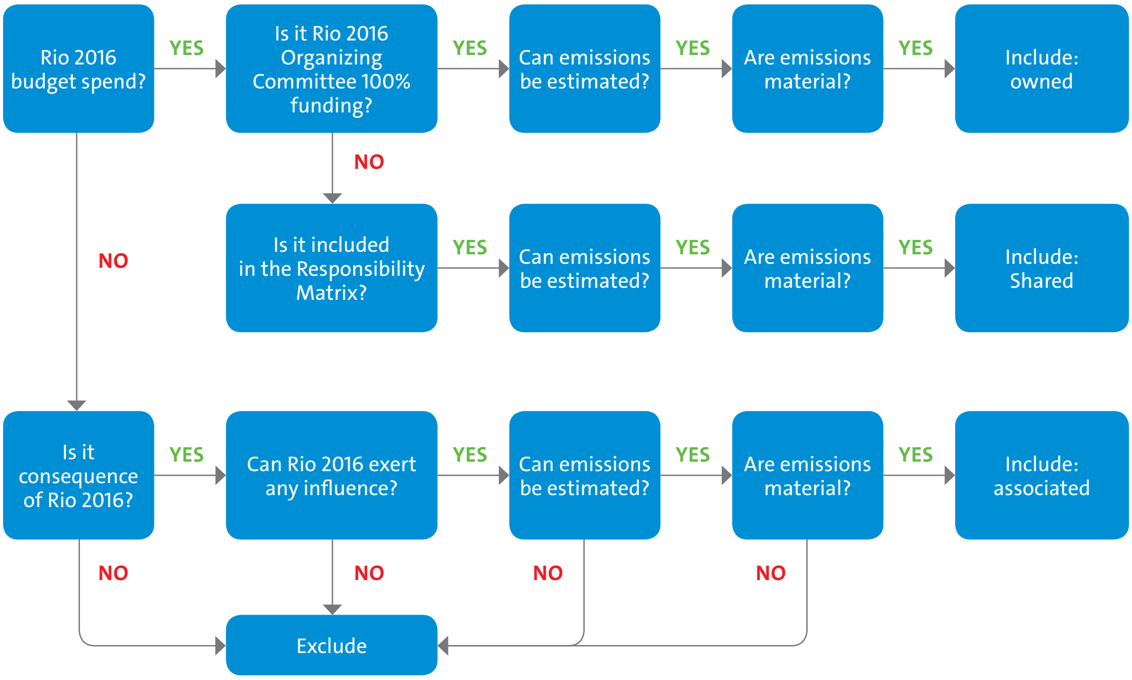
| RESPONSIBILITY CATEGORY | RIO 2016 INFLUENCE LEVEL | FINANCIAL RESPONSIBILITY | EXAMPLE |
|---|---|---|---|
| **Owned** | **High**: control | Core activities wholly funded by Rio 2016 | Fuel consumption during the Games |
| **Shared** | **Medium**: activity only takes place because of the Games, but Rio 2016 has no control over it, just influence | Activities funded by other delivery bodies (government-funded activities included in the Responsibility Matrix) | Construction of competition venues |
| **Associated** | **Low**: activity would take place anyway, even without the Games, or activity only happens because of the Games but depends fully on decisions from people not related to Games organisation | External funding (privately funded or government-funded, but not included in the Responsibility Matrix) | Spectator travel. |
| **Construction of transport infrastructure** | **Insignificante**: Rio 2016 não possui nenhuma influência | Financiamento externo ao Rio 2016 | Consumo de energia dos telespectadores |
| **Out of scope** | **Negligible**: Rio 2016 and other delivery bodies have no influence | External funding | Power consumption from TV viewers |

22 Throughout this report, we will refer to the full emissions of the Rio 2016 Olympic and Paralympic Games with the expression "Games-wide" footprint. "Rio 2016 owned emissions" will be used to designate the direct emissions of the Organising Committee for the Rio 2016 Olympic and Paralympic Games.

Activities are defined as "out of scope" when they are linked to the Games in some way, but over which Rio 2016 or other official partners have no influence. Some activities and processes will not be integrated into the carbon footprint, for the following reasons:

- Impact is considered insignificant
- Emissions cannot be estimated due to lack of data or excessive uncertainty
- Activities are not identified
- Rio 2016 influence is extremely low

The flowchart below provides several helpful decision points to assist in determining whether something is in or out of scope.



As explained previously, the study accounts for direct and indirect emissions[23], without geographical boundaries[24], over a period of seven years from 2009 (the year in which the Games were awarded to Rio de Janeiro) to 2016 (the year of the Games).

Below are listed all the activities included in the scope which are also within the system's boundaries. They are split into four main categories:

- **Operations**: includes the "Operations of the Games", which are under the responsibility of Rio 2016 before, during and after the event
- **Venue construction**: includes the construction of the permanent and temporary venues, mainly under governmental or private entities' responsibility. The GHG emissions occur prior to the Games
- **City infrastructure**: includes the construction of infrastructure such as transport networks and urban improvements, and the purchase of transport equipment (trains, buses, etc.), mainly under governmental responsibility
- **Spectators**: includes the activities of spectators, such as the travel from their place of origin to Rio de Janeiro and expenses incurred at the venues

**CATEGORIES: ACTIVITIES INCLUDED IN THE SCOPE**

OPERATIONS | VENUS CONSTRUCTION | INFRASTRUCTURE CONSTRUCTION | SPECTATORS

23 Emissions from scope 1, scope 2 and scope 3.

24 Emissions are accounted for regardless of where they have been produced, not limited to emissions inside Brazilian territory.

The subcategories included in the scope for each of the four main categories are shown in the figure below:

**In scope:**

**OPERATIONS**
- Overlay
- Catering
- Transport to Rio and football cities (OF)
- Media activities
- Venue energy use
- Accomodation
- Sporting equipment
- Transport services (OF)
- Logistics
- Rio 2016™ headquartes
- Electronic equipment and IT servives
- Torch relay
- Uniforms
- Security
- Cerimonies ans culture
- Transport  within Ri and football cities (workforce)
- Waste management

**VENUE CONSTRUCTION**
- Sport venues
- Training venues
- Non-sport venues

**INFRASTRUCTURE CONSTRUCTION**
- Transport networks
- Urban improvement

**SPECTATORS**
- Transport to Rio and football cities
- Accommodation
- Merchandising
- Transport do  torch relay
- Catering (at venue)

Within each of these activities, the study includes all identifiable "upstream" emissions, to account for the life-cycle footprint of the product or service. For example, when considering the environmental impacts of transport, not only are the emissions of trucks or aeroplanes considered, but the impact of additional processes and inputs needed to produce the fuel are also included. This way, the production chain of all inputs are traced back to the original extraction of raw materials.

### 3.2 THE REFERENCE FOOTPRINT

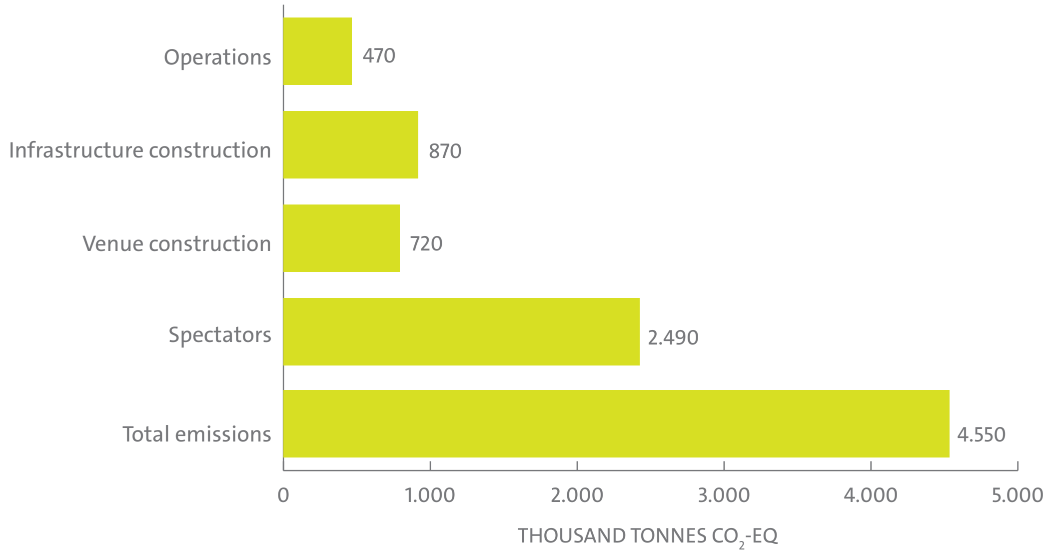
The Games-wide reference footprint is a baseline assessment of what the total footprint (owned, shared and associated) of the Games would have been before the efforts to reduce it. It assumes a "business-as-usual" approach to emissions, based on one or more of the following:

- Brazilian legal compliance (e.g., building and planning regulations)
- Adoption of standard practices of the Brazilian industry (e.g., approach to waste management, type of cement used)
- Expected spectator and Olympic and Paralympic family behaviour (e.g., catering demand)
- Similarity with past Games (e.g., ceremonies and media demand)
- Estimate of average sectorial emissions per R$ (Brazilian reais) spent (based on historical data)
- Use of relevant host city baseline data (e.g., modal transport split)

**Based on the chosen methodology, the reference carbon footprint of the Rio 2016 Olympic and Paralympic Games is estimated at 4.5 million tonnes of carbon dioxide equivalent (4.5Mt$CO_2$eq).**

**The following figure x illustrates the GHG emissions of the four main categories: spectators, building infrastructure, venue construction and operations. These include all "owned", "shared" and "associated" emissions.**

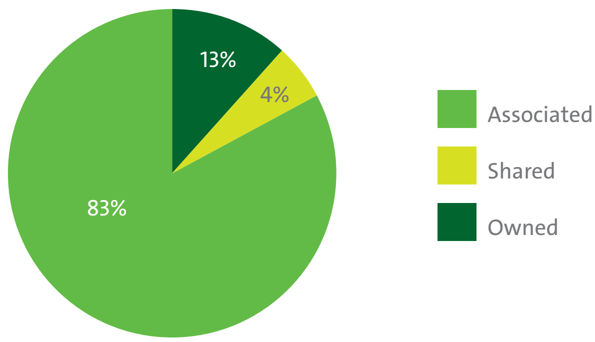
**CARBON FOOTPRINT - RIO 2016 - BAU SCENARIO**




It is already known that 35 per cent of emissions will occur pre-Games. These arise from venue construction and city infrastructure. The remaining 65 per cent will occur at Games-time. They refer to the emissions attributable to spectators and operational activities.

The diagram below indicates the division of the total GHG emissions according to the different responsibility categories.

**CARBON FOOTPRINT RIO 2016 - BAU SCENARIO**



The following table presents the details of the GHG emissions according to the responsibility category.

| | SPECTATORS | INFRASTRUCTURE | VENUE CONSTRUCTION | OPERATIONS | TOTAL (ktonnes CO2-eq) |
|---|---|---|---|---|---|
| Owned | 47 | - | 149 | 384 | 580 |
| Shared | - | 42 | 137 | - | 179 |
| Associated | 2.445 | 825 | 429 | 85 | 3.784 |
| Total | 2.492 | 867 | 715 | 469 | 4.543 |

### CARBON INTENSITY

**Lower level KPIs[25] (referred to as "ratio indicators" by the GHG Protocol)**

- total predicted GHG emissions/spectator: 1.64
- total predicted GHG emissions/athletes: 306.13
- total predicted GHG emissions/m² of competition venue: 1.71

**25** Key performance indicators

## Spectators

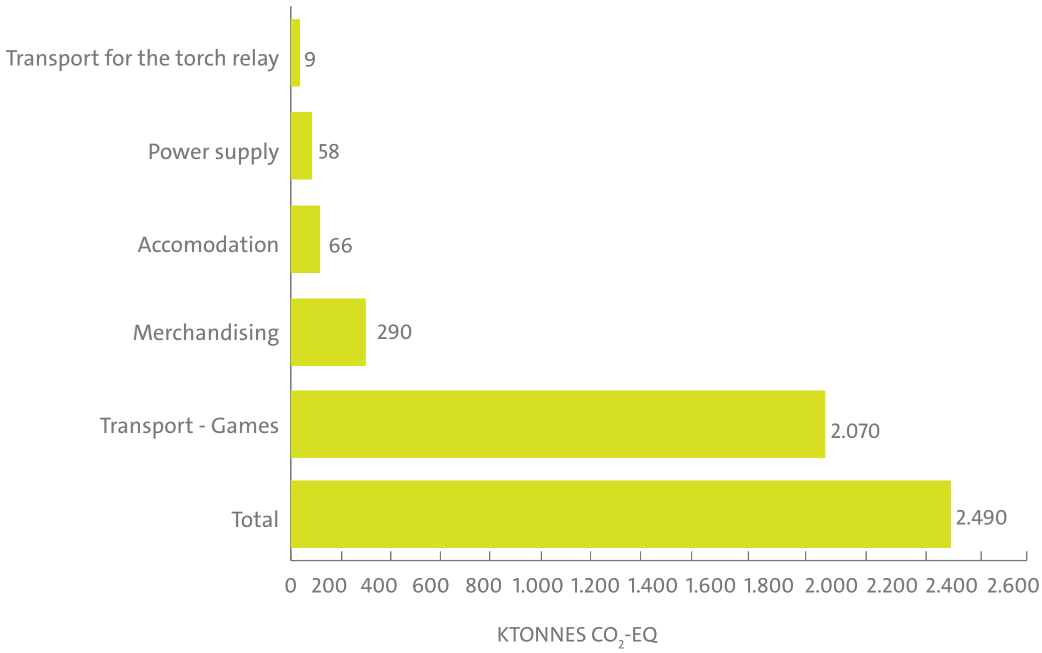
Approximately 7.5 million tickets will be available for the Olympic Games, and around 3.3 million will be available for the Paralympic Games. Regarding the origin of spectators, it is estimated that 50 per cent will be Rio residents or inhabitants of football cities, 35 per cent will be from Brazil, and the remaining 15 per cent will be international visitors. Additionally, it is estimated that over 6.7 million spectators will attend non-ticketed events.

**The total spectator GHG emissions are estimated to be 2,492kt of $CO_2$-eq.**

The activities of spectators represent the largest contribution to the total carbon footprint reference scenario (around 55 per cent). They contribute 32 per cent of the "associated" emissions and include international and domestic travel from their homes to Rio and football cities, local transport for Rio residents, transport from home to the Torch Relay, accommodation related to the Games and merchandising.

The following graph presents the GHG emissions of the different subcategories compared to the total spectator emissions.

**SPECTATORS' FOOTPRINT - BAU SCENARIO**



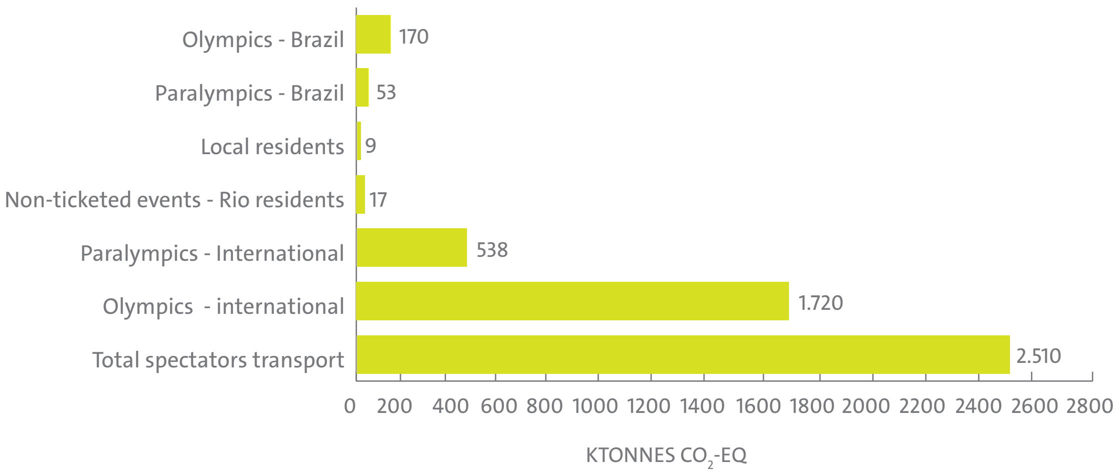

The travel spectator emissions to Rio de Janeiro are extremely high. However, they have a low reduction potential because Rio 2016 has little influence over this emission. The transport GHG emissions depend on the following parameters:

- Number of spectators per origin
- Mode of transport
- Distance travelled

The emission factors are presented in the appendix.

The following table indicates the spectator transport GHG emissions. Approximately 80 per cent of the emissions are due to travel by international spectators (30 per cent of the Olympic visitors and 20 per cent of the Paralympic visitors). The high impact is related to the long distances international visitors will travel to reach Rio (the average distance was calculated to be greater than 9,000km one way), as well as to the high emission factor for plane transport.

SPECTATORS - TRANSPORT TO GAMES - RIO 2016 - BAU SCENARIO




**GHG emissions by activity subcategory "transport spectators"**

For Brazilian spectators (70 per cent of Olympic visitors and 80 per cent of Paralympic visitors), excluding Rio residents and football city residents,  an average distance of 700 to 900km per spectator was estimated. Brazilian residents represent the second highest contribution to the GHG emissions of spectator transport.

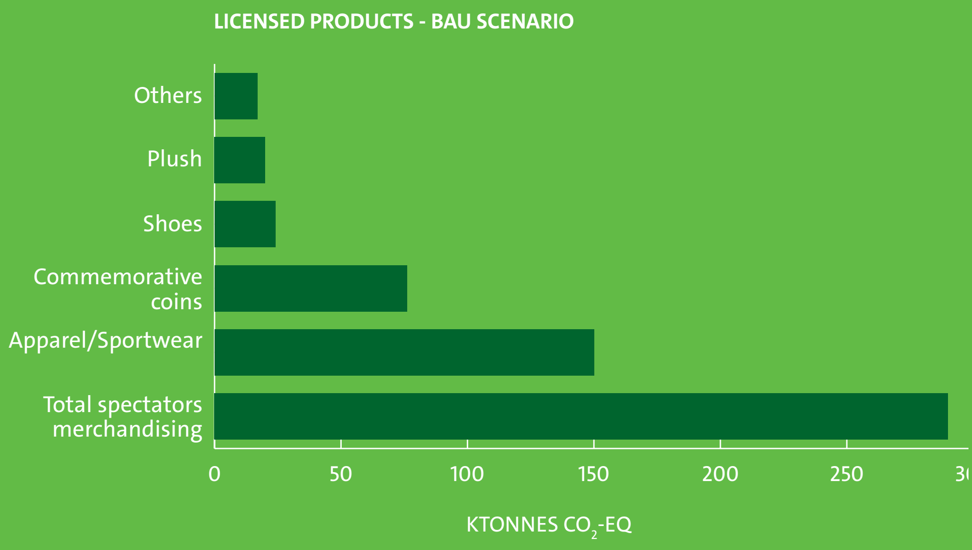
The high impact is related to the long distances domestic visitors travel to reach Rio as well as the lack of alternative means of transport, such as long-distance rail mode.

Despite the high number of Rio and football citiy residents coming to venues (Rio de Janeiro with 31 per cent of Olympic visitors and 56 per cent of Paralympic visitors), their contribution to the transport GHG emissions remains low. This relates to the short distances travelled and the high use of public transport and walking/biking in the Rio modal transport split.

The visitors coming to non-ticketed events are essentially Rio residents. However, despite the relatively short distance to travel to events and the high use of public transport and walking/biking, their impact is relatively high, due to the large number of visitors (6.7 million).

Rio 2016 can influence the nature and scale of the resulting emissions of licensed products and accommodation. This will be achieved through work with suppliers, licensees and sponsors. In addition, significant opportunities will be created to involve spectators in the adoption of more sustainable behaviour before, during and after the Games.

The following figure presents the details of the merchandising GHG emissions. Approximately 53 per cent of the emissions are due to clothing and sports accessories: 3,600 tonnes of cotton and 3,600 tonnes of polyester textile. The impact is related to material production, but also to the high energy consumption of the textile transformation processes.




**GHG Spectators emissions – Merchandising**

The second most important contributor is the production of 22,000 tonnes of commemorative coins. It is interesting to note that, although it produces three times more material than textiles on a weight basis, its impact is twice as low, due to a much lower emission factor for coin production (steel) than for textile production.

The GHG emissions of shoes and plush refer to 1,600 tonnes of shoes and 2,500 tonnes of plush toys (plastic and textile). The other items represent lower impacts.

### Operations

To organise and deliver the Games, 50,000 volunteers will be recruited. In addition, 90,000 staff members and contractors, and more than 24,000 media members from all over the world will attend the event. Over 28,000 athletes and officials will come to the Games by plane.

Running the Games at the venues requires a large amount of energy, with 23 GWh of electricity and almost 5.4 million litres of fuel.

The total GHG emissions of operations are estimated at 470kt of $CO_2$-eq.

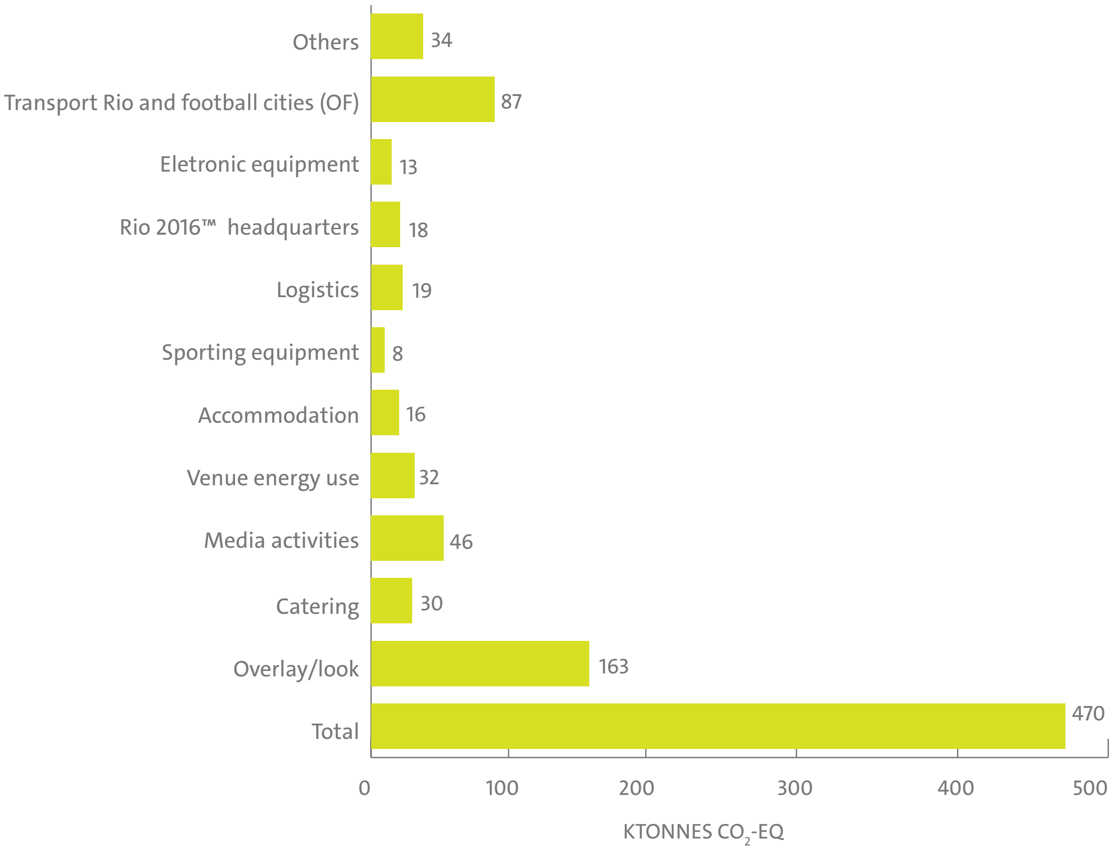
Despite the fact that operating the Games is a major logistical exercise requiring large-scale coordination of people, venues and consumables, the emissions caused by staging the Games are small when compared to the emissions caused by spectators.

Operations represent only 10 per cent of the total GHG emissions of the updated baseline scenario. However, they are the largest contributor to the “owned” emissions of the Games: over 66 per cent. They consist of everything that is needed to run the Games, such as catering, uniforms, accommodation and transport for the workforce and Olympic family, temporary venues, sporting equipment, energy consumption and waste management.

In general, 88 per cent of the emissions due to operations are considered “owned”, the rest being considered “associated” (transport travel and accommodation, whose costs are not supported by Rio 2016).

The following table indicates the GHG emissions of the different subcategories compared to the total operation GHG emissions.

OPERATIONS FOOTPRINT - RIO 2016 - BAU SCENARIO




**GHG emissions of the different subcategories of "Operations"**

Overlay is the highest contributor to the total GHG emissions of operations.

Overlay means temporary structures built within and aside competition and support venues to cater for the Games operational needs. They are typically tents, containers, additional stands, portable toilets and other light structures. The subcategory was calculated based on a preliminary estimate of the temporary materials and equipment needed to enable the operation of the Games.

Overlay emissions have a considerable potential for reduction through smart design (for example, reducing the building area and the quantity of materials) and the use of low-carbon materials.

Other important observations:

- The impact of transporting by plane the 28,000 athletes and officials from their respective countries to Rio and the football cities is the main contributor to operational transport emissions. This is due to the large distances involved in travelling to and from Rio de Janeiro.
- The impact of media activities is almost entirely related to their transport to the Games, while the 76 tonnes of paper for publications represent a relatively low impact. It is worth noting that accommodation and catering for media are included in the subcategories “accommodation” and “catering” respectively.
- More than 75 per cent of energy emissions are related to the use of diesel for generators, followed by electricity consumption.
- Accommodation includes accommodation for the Olympic family, workforce, media, marketing partners and technical officials. Transport services for the Olympic and Paralympic family include the total distance travelled by the different types of vehicles.
- “Logistics” include the transport (inbound and outbound) of materials for the venues, the electricity consumption for storage in warehouses and the fuel consumption specific for logistics. The transport of competition horses by plane represents more than 50 per cent of the logistics emissions.
- Staff trips by plane represent more than 80 per cent of “Rio 2016 headquarters” emissions, followed by the electricity consumption for offices, which represents 12 per cent. Paper consumption and catering represent lower impacts.
- Approximately 60 per cent of the electronic equipment and IT services emissions are related to the production of television sets (more than 19,000 television sets will be used during the Games).

The emission factors used to calculate all the subcategories are presented in the appendix.

### Venue construction

Around 200 venues will be used for Games activities. These include not only the sport venues for competition and training, but also the support venues (offices, warehouses, meeting areas, etc.), the buildings for accommodation and the roads and bridges inside the zones.

The total GHG emissions of venue construction are estimated at 715 kt of $CO_2$-eq. This calculation includes the emissions for the construction of new venues, the refurbishment of existing ones and the building of temporary venues. The GHG emissions from the construction of existing facilities that will be used for the Games without any refurbishment or modification have not been accounted for[26].

The category "venue construction" represents only 16 per cent of the total baseline scenario, and almost the entire "shared" carbon footprint. Seventy-two per cent of those emissions are related to the construction of new venues, followed by the refurbishment of existing venues (28 per cent) and temporary venues (14 per cent). Venue construction includes not only the construction or refurbishment of buildings, but also the earthworks, the landscaping and the construction or refurbishment of roads and bridges inside Games areas.

The numbers may appear surprisingly low to those familiar with the carbon footprint of previous Olympic and Paralympic Games. This is due in part to the fact that Rio is using a large number of existing venues.

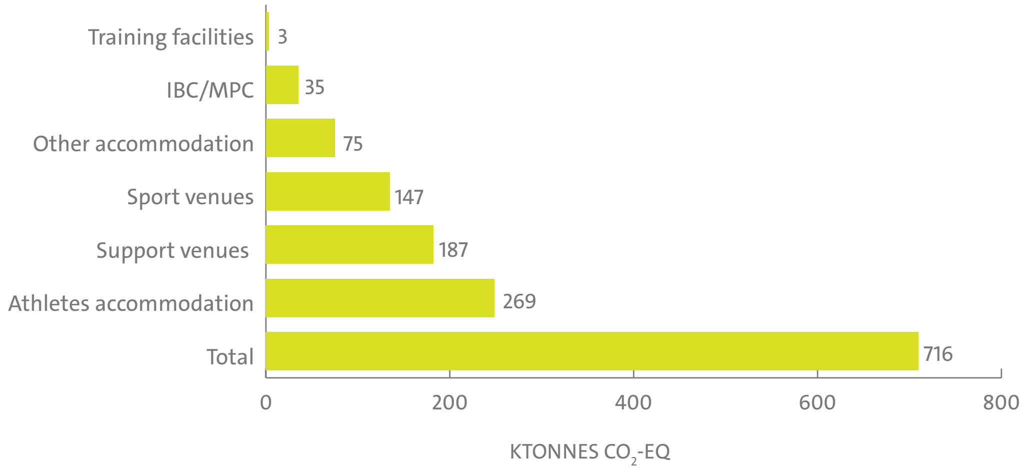
For example, the stadium built for the 2007 Pan American Games will be used for the athletics competitions, making the construction of an Olympic Stadium unnecessary. The only emissions accounted for the stadium are those that took place after the Pan American Games, i.e. structural reinforcement of the roof. The opening and closing ceremonies will be hosted at the Maracanã, fully refurbished for the 2014 FIFA World Cup.

The relatively low emissions of constructions are a result of the Brazilian energy matrix. Many emissions embedded in construction materials depend directly on the energy consumption during the production process, such as the fuel and electricity required to produce steel and concrete.

**26** The emissions from energy use of the venues during the competition days are included in "Operations".

Sixty per cent of the emissions caused by venue construction are considered “associated”, 9 per cent are considered “shared”, and 21 per cent are considered “owned”.

**VENUE CONSTRUCTION - BAU SCENARIO**




**GHG emissions of the main venue groups compared to the total of emissions of “Venue construction”**

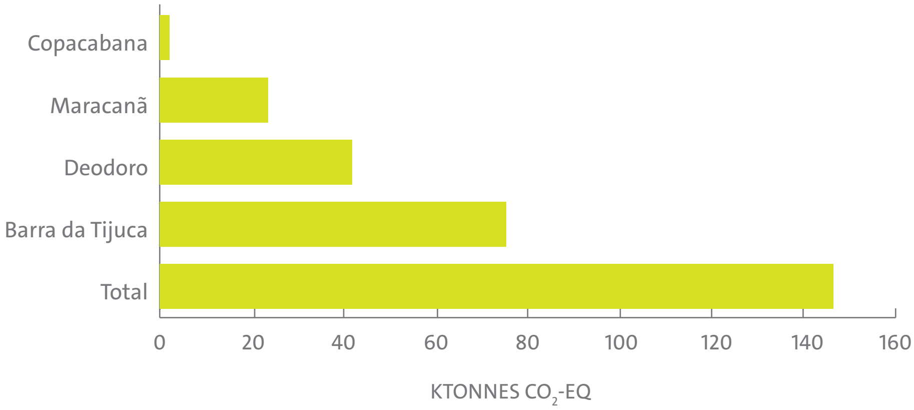
The Olympic and Paralympic athletes will be accommodated in a new neighbourhood, a private real estate development that, despite having been accelerated in order to accommodate the athletes, would have been built even without the Games. Therefore, it is allocated to the associate category. Rio 2016 will rent the residential complex from the private developer during the Games operational period. Located within walking distance of the Barra Olympic Park complex, in an area of 90 hectares, it will include 31 buildings of 12 floors each, a lodging capacity with over 17,000 beds, as well as restaurants, support areas, shopping, leisure and parking.

Other important information related to Games construction:

- The support venues are located mainly in Rio de Janeiro, but also in other cities around Brazil. They include meeting areas, the Main Operations Centre, the Rio 2016 offices, the Technology Operations Centre, the Uniform Distribution Centre, ceremony areas, volunteer recruitment centres, data centres, technology areas, warehouses, intelligence centres and the doping control laboratory. Most of these venues already exist. Some will be temporary venues and others will be restored.

- Sport venues include all facilities where Games competitions will take place. Their em¬¬issions have been calculated at 147kt CO2-eq. The GHG emissions of the football stadiums are not included in the calculation, since the Rio 2016 Games will use the stadiums built for the 2014 FIFA World Cup.

**SPORT VENUES – BAU SCENARIO**




**GHG emissions of sport venues**

- The International Broadcasting Centre (IBC) and the Main Press Centre (MPC), built inside the Olympic Park, represent 35 per cent of the total GHG emissions of venue construction.

- The relatively low impact of training facilities is due to the fact that among the 23 that will be used, only four are newly built. Most of them will be used as they are.

## City infrastructure (legacy)

To host the Games, Rio is accelerating the conclusion of more than 100 infrastructure projects. They include the construction of BRT (bus rapid transit) lines in Rio de Janeiro, the improvement of suburban train and metro lines, the acquisition of train and metro rolling stock, the urbanisation of areas around the main venues and the installation of electricity, water, sewage, gas and telecom facilities.

As an example, around 90km of new BRT lanes will be constructed along two lines (*transoeste* and *transolímpica*).

However, the task of attributing legacy infrastructure projects to the Games is a very challenging one from the carbon footprint viewpoint. To distinguish Games-related schemes from those that would have happened without the Games is not a simple task. Other factors, such as the economic effects related to the oil and gas industry boom and the staging of the 2014 FIFA World Cup cannot be easily distinguished from the influence of the Games.

The reference scenario was calculated based on the publication of the “Public Policies Matrix”[27]. The Matrix is the document that officially classifies the infrastructure projects as being “anticipated” or “accelerated” because of the Rio 2016 Olympic and Paralympic Games.

The total GHG emissions of infrastructure projects have been calculated to be almost 870kt $CO_2$-eq. However, it is important to note that these emissions are provisional and they need to be revised for the reason explained above.

The infrastructure projects account for almost a quarter (19 per cent) of the total GHG emission of the baseline scenario. They represent 22 per cent of the “associated” emissions of the Games.

These infrastructure projects related to “mobility” (which includes air, train, metro and road structures), account for 67 per cent of carbon emissions. Urbanisation improvements, which contribute to more than 31 per cent of emissions, and “Others” (which include water, electricity, gas, telecom installations and traffic control facilities), account for less than two per cent. Almost all infrastructure facilities have been classified as “associated”.

The “metro structure” includes the construction of stations, terminals, control centres and access to metro lines 1, 2 and 4 (west and south).

“Urbanisation” includes the construction and refurbishment of squares, meeting points, bus stops, buildings, floodwater retention reservoirs and the renovation of pavements on a large number of streets and avenues.

**27** Public Policies Matrix available at http://www.apo.gov.br/wp-content/uploads/2014/01/matrix_20140128_eng.pdf

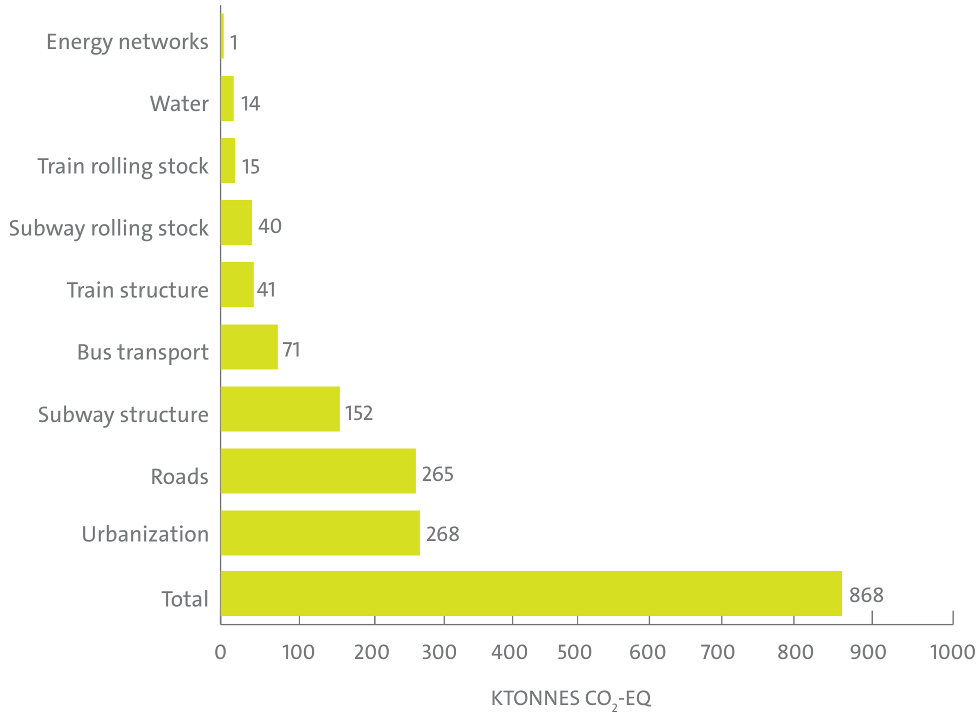
"Train structure" is the construction, refurbishment and revitalisation of stations, terminals, accessibility, signalling and traffic control equipment.

"Bus transport" consists of the construction and refurbishment of BRT (bus rapid transport) lanes, as well as their respective stations and terminals[28].

"Roads" encompass the duplication or widening of avenues and viaducts and the requalification of paving.

"Water" refers to the construction of stormwater galleries around the Olympic Stadium, and "electricity supply" and "traffic" refer to the installation of cables and substations for the main venues and electronic control equipment respectively.

**CITY INFRASTRUCTURE - BAU SCENARIO**




**28** The Transcarioca BRT construction is allocated to the 2014 FIFA World Cup, and is considered as "existing" for the purposes of staging the Rio 2016 Olympic and Paralympic Games.

# Appendix 1: Methodology

## PRINCIPLES

The following principles adopted in the London 2012 (LOCOG 2010 Carbon Footprint Report) methodology were adopted in the Rio 2016 Carbon Footprint Studies.

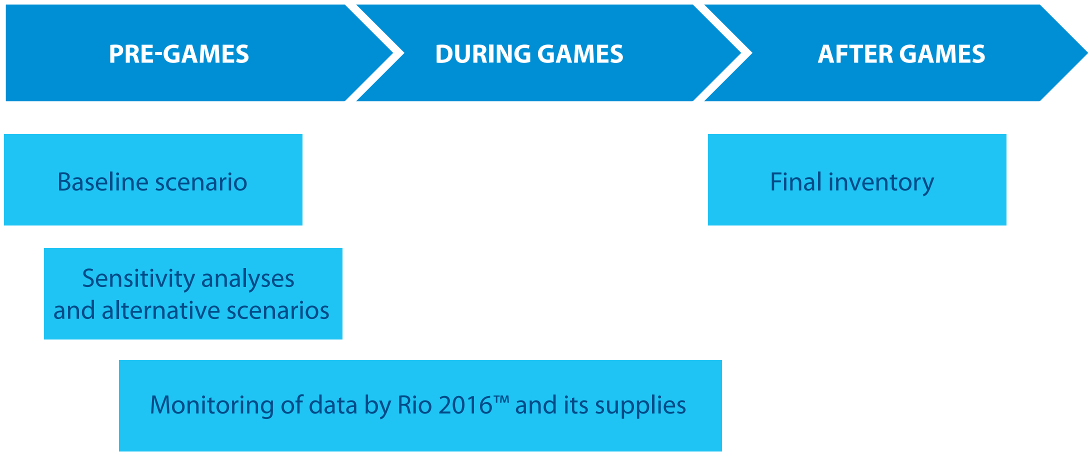
| LONDON 2012 ACCOUNTING PRINCIPLE | RIO 2016 ADOPTION |
|---|---|
| Comply with the underpinning principles of the Greenhouse Gas Protocol and ISO 14064-1: relevance, completeness , consistency, accuracy and transparency. | Yes |
| Account direct and indirect emissions (Scopes 1, 2 and 3). As far as possible, account for all Kyoto Protocol Greenhouse Gases. Report all results in tonnes of carbon dioxide equivalents or $tCO_2eq$. | Yes |
| Set the study boundaries widely to include those elements over which the Games have control or influence. As far as possible, allocate the emissions into three categories: "owned", "shared" or "associated" based on who is responsible for generating them. | Yes |
| Establish a consistent method for deciding what is inside and outside the scope. | Yes |
| Account emissions in the year they occur, allocating them to pre-Games, Games and legacy phases, as appropriate. Responsibility for these emissions should be established and documented. | Yes (legacy emissions calculations are limited by data availability) |
| Legacy benefits represent lasting carbon savings as a result of Games-funded projects or initiatives. To count towards legacy, savings must be additional. | Yes |
| Establish a well-documented reference scenario against which reductions can be accounted. Ensure the data used to construct the reference scenario is relevant, plausible and justifiable. | Yes |
| Reduction measures must be transparently documented, additional and linked to a defined period. Double counting should be avoided. The reference scenario premise should be clearly identifiable. | Yes |

| LONDON 2012 ACCOUNTING PRINCIPLE | RIO 2016 ADOPTION |
|---|---|
| Use the financial framework within the Candidature File to help identify projects and activities that could generate a carbon emission. | Yes |
| Identify a consistent dataset of carbon conversion factors for use in management strategy preparation. Ensure these cover all Kyoto Protocol greenhouse gases, direct and indirect emissions, and include a data quality assessment. Use commonly available, standard datasets where possible, as well as tools to support and facilitate integrated planning. | Yes |
| Identify contentious carbon accounting issues early on to allow time for research, debate and consensus building. Document the decision-making process. | Yes |
| The carbon conversion factors used should be responsive to local circumstances. Rules about how to account, for example, renewable energy, are not universal. These can change as new guidance emerges and may differ within, and between, countries. | Yes |
| Annually report the carbon footprint. Clearly document any data, methodology or scenario changes. | Yes |
| Document levels of uncertainty attributable both to poor quality data and uncertainty in the carbon conversion factors used. Implement quality control measures. | Yes |
| Establish key performance indicators to allow comparison within and between Games, allowing the overall effect of specific reduction measures to be quantified. | Yes |

## PROJECT PHASES

The carbon footprint calculation follows successive steps. When calculating its footprint, a typical organisation will produce an annual retrospective GHG inventory related to the previous year. Following the methodology created by London 2012, Rio 2016 seeks to predict future emissions with the primary aim of avoiding and reducing them.

Furthermore, as Rio 2016 is geared towards delivering a specific event, the emissions occur in peaks, without a stable level or gradual growth. As a result, the principle of annual monitoring of emission trends are of little practical value. Instead, emissions are grouped into three principal phases: Pre-Games – Games – Post-Games (legacy).




## PRE-GAMES

Three years before the Games, the GHG emissions were calculated for a baseline scenario, taking into account business-as-usual practices in Brazil. These calculations provided a first estimate of the expected GHG emissions for the Games. As some required data can only be estimated or is unknown, the level of uncertainty is relatively high.

Despite these caveats, this first step is necessary to understand the carbon footprint of the Games and measures were put in place to reduce it. Due to the maturity level of the projects, the initial reference scenario is sufficiently robust to identify the major areas (hotspots) of GHG emissions associated with the Games. Suppliers and partners are involved in the process to provide data and identify the best practices.

When an activity or a product is identified as a hotspot, alternatives must be found based on priorities. The alternatives are included in the model to perform sensitivity analysis, to calculate and compare their potential for reduction of GHG emissions. Alternative scenarios taking into account the implementation of some of those actions are currently being considered, and their total GHG emissions will be calculated before the Games and published at the same time as the revision to the Reference Footprint.

These steps are necessary to support the sustainability strategy defined by Rio 2016. The preliminary calculation of the GHG emissions is also used a few years ahead of the Games to define the carbon mitigation and compensation plans.

### DURING THE GAMES

Key data will be monitored by Rio 2016, its suppliers and partners. In this way, the model designed previously can therefore be adapted with actual data to calculate the effective emissions.

### POST-GAMES

Emissions from activities related to the dismantling of temporary structures will be included. Activities beyond the dismantling phase will not be taken into account. The final GHG emission inventory will be reported after the Games.

Like London 2012, emissions from the long-term use of the venues and wider legacy benefits through behavioural changes inspired by the Games will not be measured, due to major challenges in data collection. Instead, they will be noted as notional benefits within our wider compensation strategy.

### COMPLIANCE WITH INTERNATIONAL STANDARDS

According to ISO 14064 and the GHG Protocol, it is fundamental to follow some key principles when accounting for and reporting GHG emissions. Rio 2016 follows the principles established by these standards.

The GHG Protocol formulates five principles, as presented in the table below.

| PRINCIPLE | DEFINITION |
|---|---|
| **Relevance** | Ensure the inventory appropriately reflects the GHG emissions of the company and serves the decision-making needs of users – both internal and external. |
| **Honesty** | Account for and report all GHG emission sources and activities within the chosen inventory boundary. Disclose and justify any specific exclusion. |
| **Consistency** | Use consistent methodologies to allow for meaningful comparisons of emissions over time. Transparently document any changes to the data, inventory boundary, methods, or any other relevant factors in the time series. |
| **Accuracy** | Ensure as far as possible that, systematically, the quantification of GHG emissions is neither over nor under actual emissions and that uncertainties are reduced. Achieve sufficient accuracy to enable users to make decisions with reasonable assurance as to the integrity of the reported information. |
| **Transparency** | Address all relevant issues in a factual and coherent manner, based on a clear audit trail. Disclose any relevant assumptions and make appropriate references to the accounting and calculation methodologies and data sources used. |

**Completeness**

**All Kyoto Protocol GHG emissions**

The source of most emission factors is the life-cycle impact assessment methodology, IMPACT 2002+ v2.2. This method uses the Global Warming Potentials (GWP) for a 100-year period from the IPCC list. This list includes all Kyoto Protocol gases, in particular carbon dioxide ($CO_2$), methane ($CH_4$) and nitrous oxide ($N_2O$).

**Direct and indirect emissions**

The definition of the system boundaries includes all direct and indirect emissions related to the Games, corresponding to scopes 1, 2 and 3 of the terminology of the GHG protocol.

**Geographical boundaries**

There are no geographical boundaries. The processes are taken into account wherever the activities take place. This is a major difference when compared to the carbon footprint of events that include geographical boundaries. For example, the 2006 FIFA World Cup in Germany only included emissions from national transport.

**Time limits**

Regardless of when the activities related to the Games occur, their emissions are accounted for.

**Transparency**

The baseline scenario is described in this report. All sources of information, assumptions, data and details on customised emission factors are part of a Quantis technical report that can be obtained from Rio 2016 on request by email sustentabilidade@rio2016.com.

## CONTROL AND SHARE APPROACHES

The GHG protocol proposes two distinct approaches to set organisational boundaries: the equity share approach and the control approach. Both are based on financial accounting rules and apply to most organisations. However, neither of them fully applies to events such as the Olympic and Paralympic Games, where the situation is more complex.

Rio 2016 follows the London 2012 methodology of drawing boundaries more widely than would be the case when conducting an organisational footprint. Indeed, if a purely organisational approach was taken, many emissions would not be accounted for due to the fact that Rio 2016 and the governmental delivery bodies have neither control nor a financial stake in some activities that are essential to the Games, such as spectator travel to and from Rio or hotel accommodation booked by accredited media.

The delivery of the Rio 2016 Olympic and Paralympic Games involves four bodies:

- The privately funded Rio 2016 Organising Committee (Rio 2016), which is responsible for promoting and staging the Games.
- Four publicly funded agencies or companies (EOM at municipal level, EGP at state level, the Sport Ministry at federal level and the APO, a consortium of the three levels of government), which are responsible for constructing competition venues and infrastructure directly required for the Games. The responsibilities of each of these four organisations are defined by the Responsibility Matrix.
- Third parties, mainly private companies responsible for constructing competition venues and infrastructure directly and indirectly required for the Games through public-private partnership (PPP) agreements, as listed in the Legacy Matrix.
- Broadcasters and sponsors, which have sizeable footprints directly related to the Games but are not under direct control of Rio 2016.

The Rio 2016 Olympic and Paralympic Games budget actually comprises three separate budgets:

- The Rio 2016 Organising Committee (Rio 2016) budget, funded from private sources such as sponsorship deals, transfers of TV transmission rights from the IOC, merchandising and ticket sales.
- The Responsibility Matrix budget, funded from both public and private resources from PPP agreements for projects directly associated to the Games.
- The Public Policies Plan, also known as Legacy Matrix, funded from both public and private resources from PPP agreements; it comprises projects that were scheduled to happen anyway, but were accelerated because of the Games.

### Allocation approach

The LCA methodologies follow different approaches, where the emissions of each activity related to the project are fully or partially allocated to the investigated system.

However, allocation methods are difficult to implement for events such as the Olympic and Paralympic Games. There is no perfectly satisfactory way to allocate all the infrastructure required for the Games. For example, the construction of a gymnasium, a venue that is required for the Games but will be used for several decades after 2016 by other sporting events, cannot easily be allocated partly to the Rio 2016 Olympic and

Paralympic Games and partly to future events. Indeed, any allocation method would be controversial, since the gymnasium would not have been constructed at all if the Games were not staged in Rio.

The solution is to take **100 per cent of the emissions** into account, even where the level of control or the financial interest of Rio 2016 is low, and subsequently attribute them to three categories – owned, shared and associated.

### INVENTORY DATA AND METHODOLOGY CALCULATION

Ecoinvent v2.2, together with IMPACT 2002+ vQ2.2, is the main emission factors database used in the project. This database provides hundreds of emission factors, including GHG, for the thousands of processes available.

The ecoinvent v2.2 database provides a complete life-cycle inventory (LCI) of substances that are taken from or emitted to the environment for each process.

Each GHG emission is converted into kilograms of carbon dioxide equivalent (CO2-eq), applying the life-cycle impact assessment (LCIA) methodology IMPACT 2002+ vQ2.2, which uses the GWP for a 100-year time horizon provided by the IPCC list.

IMPACT 2002+ vQ2.2 uses the most current science regarding global warming. The exclusion of biogenic carbon dioxide and carbon monoxide, as well as a reduced emission factor for biogenic methane, avoids a misleading combination of short-cycle carbon emissions (absorbed and released by vegetation) and carbon emissions from fossil fuels, previously stored underground.

Detailed information about the IMPACT 2002+ vQ2.2 method and its indicators are available at: http://www.impactmodeling.org.

It should be noted that the majority of the datasets in ecoinvent are of European origin, and thus represent European industrial conditions and processes. However, ecoinvent is internationally recognised as one of the most complete LCI databases available, from both a quantitative (number of included processes) and a qualitative (quality of the validation processes, data completeness, etc.) perspective.

Despite the large number of processes available in ecoinvent v2.2, other sources are needed to provide missing information. Some processes are not directly available in ecoinvent v2.2, but they can either be modelled using other ecoinvent processes or they may be available in different databases:

- **Other process databases and the customised Quantis Rio 2016 database**: these databases include datasets that need to be adapted to fit the Brazilian context, in particular for energy emission factors (electricity mix, fuel, etc.) or for construction norms
- **Input/output (I/O) database**: particularly for the baseline scenario, which began to be modelled three years prior to the Games, some data is not available in physical units and is derived from financial data based on the budget of the Games. Therefore, the emissions are estimated using I/O analysis. The accuracy is generally not as good as with process analysis, as I/O databases provide emissions factors under a highly aggregated form.

### Data sources and assumptions

Primary data was collected directly from Rio 2016. It is expressed in physical or financial units, which was provided by the *ad-hoc* Functional Area (department). Rio 2016 documents and data from project teams are the main sources of information.

The data was collected prior to the Games, therefore much of the information used for the baseline scenario is subject to change. Nevertheless, data and assumptions obtained were sufficient to estimate GHG emissions. Even with estimated data, the methodology is sufficiently robust to map out the main elements of the footprint and serve as a decision-informing tool.

Missing data is estimated using various secondary sources, such as documentation from previous editions of the Games or from the city, state or federal government and agencies. Further assumptions are based on the expert judgment of the life-cycle analysts and other experts.

### Calculation tool

Quantis SUITE 2.0 (http://www.quantis-intl.com/software.php) was used for the development of the model. The baseline scenario and the final inventory are calculated combining primary data (intermediate products and elementary flows) with generic datasets, providing cradle-to-grave background elementary flows to create a complete inventory of the systems.

### General approach to carbon footprint assessment

| STEPS | EXAMPLE |
|---|---|
| **Define the activity to be assessed** | Selling T-shirts (official merchandising) |
| **Determine the adequate process to model the activity** | Production and weaving of organic cotton |
| **Determine the amount required for the Games** | 5,000kg of T-shirts<br>(Source: Rio 2016) |
| **Model the associated impact with databases and impact assessment methodology** | 15kg CO2-eq /kg yarn cotton<br>12kg CO2-eq /kg weaving<br>(Source: ecoinvent v2.2 together with IMPACT 2002+ vQ2.2 ) |

This approach is extended to all activities that take place within the delimited system boundaries of the project.

### Emission factors

The following table presents the emission factors used in the model, as well as the source for each emission factor. Most emission factors are calculated based on the LCI data from the ecoinvent database v2.2, and using the LCIA methodology IMPACT 2002+ vQ2.2 (Jolliet et al. 2003, adapted by Quantis). The rest of the emission factors were calculated specifically for the Rio 2016 Games, based on specific life-cycle inventory data, to be as close as possible to the Brazilian context (for example, the Brazilian electricity mix or Brazilian biofuels), or when processes were not available in the ecoinvent database.

In addition, input/output emission factors were used as an ultimate proxy when only monetary data was available (for temporary venues and sporting equipment, for example). The factors used are the same as in LOCOG 2010, i.e., sourced from Simmons et al. 2006 and using the input/output tables of the OECD.

**EMISSION FACTORS USED IN THE MODEL WITH CORRESPONDING SOURCES (SPECTATORS, OPERATIONS)**

| PROCESS - NAME (ECOINVENT ID) [UNIT] | EMISSION FACTOR [KG CO2-EQ/UNIT FOR PROCESS] | SOURCE |
|---|---|---|
| **alcoholic beverages [l]** | 1.37E+00 | Quantis custom database for Rio 2016 |
| **aluminium product manufacturing, average metal working (8312) [kg]** | 3.39E+00 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| **aluminium, production mix, at plant (1056) [kg]** | 8.71E+00 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| **beef, at slaughterhouse 2 [kg]** | 2.50E+01 | Quantis custom database for Rio 2016 |
| **beef, steak, at consumer [kg]** | 7.40E+01 | Quantis custom database for Rio 2016 |
| **building, multi-storey (549) [m³]** | 2.11E+02 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| **butter, at consumer [kg]** | 1.04E+01 | Quantis custom database for Rio 2016 |
| **chicken, at slaughterhouse [kg]** | 7.91E+00 | Quantis custom database for Rio 2016 |
| **copper, at regional storage (1074) [kg]** | 1.90E+00 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| **corrugated board, fresh fibre, single wall, at plant (1687) [kg]** | 9.97E-01 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| **desktop computer, without screen, at plant (6991) [unit]** | 2.72E+02 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| **diesel, burned in building machine (559) [MJ]** | 9.23E-02 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| **diesel, burned in cogen 200kWe diesel SCR (1531) [MJ]** | 9.37E-02 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| **disposal, municipal solid waste, 22.9% water, to sanitary landfill (2223) [kg]** | 5.63E-01 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| **electricity, low voltage, at grid, BR - Adjusted with ANEEL 2011 [kWh]** | 2.48E-01 | Quantis custom database for Rio 2016 |
| **electricity, low voltage, at grid, CN (6680) [kWh]** | 1.52E+00 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |

| PROCESS - NAME (ECOINVENT ID) [UNIT] | EMISSION FACTOR [KG CO2-EQ/UNIT FOR PROCESS] | SOURCE |
|---|---|---|
| electricity, low voltage, at grid, JP (6686) [kWh] | 5.93E-01 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| electricity, low voltage, at grid, US (6683) [kWh] | 8.42E-01 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| electricity, low voltage, production RER, at grid (7207) [kWh] | 5.65E-01 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| electricity, medium voltage, at grid, BR - Adjusted with ANEEL 2011 [kWh] | 1.94E-01 | Quantis custom database for Rio 2016 |
| ethylene vinyl acetate copolymer, at plant (1818) [kg] | 2.14E+00 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| ethylene vinyl acetate, foil, at plant (1819) [kg] | 2.74E+00 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| extrusion, plastic film (1850) [kg] | 5.26E-01 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| extrusion, plastic pipes (1851) [kg] | 3.79E-01 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| garment, polyester fibre [kg] | 1.46E+01 | Quantis custom database for Rio 2016 |
| gold, at regional storage (10121) [kg] | 1.33E+04 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| heat, light fuel oil, at boiler 10kW, non-modulating (1586) [MJ] | 9.49E-02 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| injection moulding (1853) [kg] | 1.34E+00 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| keyboard, standard version, at plant (6997) [unit] | 2.60E+01 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| kraft paper, unbleached, at plant (1732) [kg] | 8.53E-01 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| laptop computer, at plant (6994) [unit] | 2.11E+02 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| LCD flat screen, 17 inches, at plant (6993) [unit] | 3.39E+02 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| mouse device, optical, with cable, at plant (6998) [unit] | 5.09E+00 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| non-alcoholic beverages [l] | 3.74E-01 | Quantis custom database for Rio 2016 |
| nylon 6, at plant (1821) [kg] | 9.42E+00 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| nylon 66, at plant (1823) [kg] | 8.16E+00 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| operation, coach, blended diesel [vkm] | 9.80E-01 | Quantis custom database for Rio 2016 |

| PROCESS - NAME (ECOINVENT ID) [UNIT] | EMISSION FACTOR [KG CO2-EQ/UNIT FOR PROCESS] | SOURCE |
|---|---|---|
| operation, lorry 16-32t, blended diesel [vkm] | 7.87E-01 | Quantis custom database for Rio 2016 |
| operation, lorry 3.5-7.5t, blended diesel [vkm] | 3.57E-01 | Quantis custom database for Rio 2016 |
| operation, lorry 7.5-16t, blended diesel [vkm] | 6.03E-01 | Quantis custom database for Rio 2016 |
| operation, passenger car, natural gas, w/o tyres and break abrasion emissions, per MJ [MJ] | 7.33E-02 | Quantis custom database for Rio 2016 |
| operation, passenger car, petrol, fleet average, w/o abrasion emission, per kg of petrol [kg] | 4.04E+00 | Quantis custom database for Rio 2016 |
| operation, passenger car, fleet average [vkm] | 2.33E-01 | Quantis custom database for Rio 2016 |
| operation, regular bus, blended diesel [vkm] | 1.35E+00 | Quantis custom database for Rio 2016 |
| operation, scooter (11351) [km] | 1.24E-01 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| operation, van < 3.5t, blended diesel [vkm] | 2.87E-01 | Quantis custom database for Rio 2016 |
| overlay - Sector OECD "Manufacturing (including furniture)" - I/O [USD] | 4.90E-01 | Simmons et al. 2006 |
| packaging film, LDPE, at plant (1854) [kg] | 2.75E+00 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| packaging glass, white, at regional storage (829) [kg] | 7.06E-01 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| paper, wood-containing, LWC, at regional storage (1716) [kg] | 1.53E+00 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| paper, wood-free, coated, at regional storage (1723) [kg] | 1.28E+00 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| paper, wood-free, uncoated, at regional storage (1727) [kg] | 1.33E+00 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| passenger car (1936) [unit] | 4.29E+03 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| pasta, at consumer [kg] | 1.15E+00 | Quantis custom database for Rio 2016 |
| plywood, outdoor use, at plant (2486) [$m^3$] | 6.52E+02 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| polycarbonate, at plant (1826) [kg] | 7.98E+00 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| polyester resin, unsaturated, at plant (1674) [kg] | 7.52E+00 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |

| PROCESS - NAME (ECOINVENT ID) [UNIT] | EMISSION FACTOR [KG CO2-EQ/UNIT FOR PROCESS] | SOURCE |
|---|---|---|
| polyethylene, HDPE, granulate, at plant (1829) [kg] | 1.99E+00 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| polypropylene, granulate, at plant (1834) [kg] | 2.02E+00 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| polyvinyl chloride, at regional storage (1840) [kg] | 2.02E+00 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| pork, at consumer [kg] | 5.38E+00 | Quantis custom database for Rio 2016 |
| potatoes, at consumer kg | 1.08E-01 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| printer, laser jet, b/w, at plant (6995) [unit] | 6.71E+01 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| printer, laser jet, colour, at plant (6996) [unit] | 6.72E+01 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| sandwich with ham [unit] | 7.01E-01 | Quantis custom database for Rio 2016 |
| sheet rolling, steel (1174) [kg] | 3.64E-01 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| silver, at regional storage (10153) [kg] | 1.01E+02 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| soya, at consumer [kg] | 1.63E+01 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| steel, converter, low-alloyed, at plant (1150) [kg] | 2.12E+00 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| steel, low-alloyed, at plant (1154) [kg] | 1.78E+00 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| sweet snack, 120g [unit] | 3.71E-01 | Quantis custom database for Rio 2016 |
| tap water, at user (2288) [kg] | 3.20E-04 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| textile, woven cotton, at plant (10177) [kg] | 2.74E+01 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| tomatoes, at consumer [kg] | 1.25E-01 | Quantis custom database for Rio 2016 |
| toner module, laser jet, colour, at plant [unit] | 1.01E+01 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| transport, aircraft, freight, intercontinental (1894) [tkm] | 1.07E+00 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| transport, aircraft, passenger (1895) [pkm] | 1.26E-01 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| transport, aircraft, passenger, intercontinental (1897) [pkm] | 1.08E-01 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| transport, average train (11308) [pkm] | 7.44E-02 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |

| PROCESS - NAME (ECOINVENT ID) [UNIT] | EMISSION FACTOR [KG CO2-EQ/UNIT FOR PROCESS] | SOURCE |
|---|---|---|
| transport, bicycle (11342) [pkm] | 9.63E-03 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| transport, coach [pkm] | 4.67E-02 | Quantis custom database for Rio 2016 |
| transport, ferry boat 2 [pkm] | 1.16E-01 | Quantis custom database for Rio 2016 |
| transport, lorry > 32t, blended diesel [tkm] | 8.34E-02 | Quantis custom database for Rio 2016 |
| transport, lorry 16-32t, EURO4 (7304) [tkm] | 1.66E-04 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| transport, metropolitan train, SBB mix (11330) [pkm] | 9.44E-03 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| transport, regular bus, blended diesel [pkm] | 9.64E-02 | Quantis custom database for Rio 2016 |
| transport, scooter (11350) [pkm] | 1.26E-01 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| transport, transoceanic freight ship (1968) [tkm] | 1.08E-02 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |
| transport, van < 3.5t, blended diesel [tkm] | 1.52E+00 | Quantis custom database for Rio 2016 |
| upper-medium average meal (with tomatoes, heated greenhouse) [unit] | 1.53E+01 | Quantis custom database for Rio 2016 |
| upper-medium average meal (with tomatoes, open field) [unit] | 1.52E+01 | Quantis custom database for Rio 2016 |
| wheat, at consumer [kg] | 6.28E-1 | ecoinvent v2.2 & Impact 2002+ vQ2.2 |

EMISSION FACTORS USED IN THE MODEL WITH CORRESPONDING SOURCES (FOR VENUE AND INFRASTRUCTURE CONSTRUCTION)

| CONSTRUCTION AND INFRASTRUCTURE PROCESS - NAME [UNIT] | EMISSION FACTOR [KG CO2-EQ/UNIT FOR PROCESS] | SOURCE |
|---|---|---|
| aluminium, general [tonne] | 9.16E+03 | Bath University |
| art works, new [m²] | 4.02E-01 | Quantis custom database for Rio 2016 |
| art works, refurbished [m²] | 1.61E-01 | Quantis custom database for Rio 2016 |
| bleachers, new [m²] | 3.50E-01 | Quantis custom database for Rio 2016 |
| bleachers, refurbished [m²] | 1.75E-01 | Quantis custom database for Rio 2016 |

| CONSTRUCTION AND INFRASTRUCTURE PROCESS - NAME [UNIT] | EMISSION FACTOR [KG CO2-EQ/UNIT FOR PROCESS] | SOURCE |
|---|---|---|
| bleachers, temporary [$m^2$] | 2.10E-01 | Quantis custom database for Rio 2016 |
| buildings, new [$m^2$] | 3.50E-01 | Quantis custom database for Rio 2016 |
| buildings, refurbished [$m^2$] | 1.75E-01 | Quantis custom database for Rio 2016 |
| buildings, temporary [$m^2$] | 2.10E-01 | Quantis custom database for Rio 2016 |
| cement CPII E 32 [tonne] | 6.01E+02 | ABNT, InterCement, ATA calculation |
| cement dough [$m^2$] | 2.61E+02 | ATA calculation |
| ceramics, general [tonne] | 7.00E+02 | Bath University |
| clinker [tonne] | 8.66E+02 | Cement Sustainable Initiative |
| closed arenas, new [spectator] | 1.09E+00 | Quantis custom database for Rio 2016 |
| closed arenas, refurbished [spectator] | 5.43E-01 | Quantis custom database for Rio 2016 |
| closed arenas, temporary [spectator] | 6.52E-01 | Quantis custom database for Rio 2016 |
| competition areas, new [$m^2$] | 1.75E-02 | Quantis custom database for Rio 2016 |
| competition areas, refurbished [$m^2$] | 8.75E-03 | Quantis custom database for Rio 2016 |
| competition areas, temporary [$m^2$] | 1.05E-02 | Quantis custom database for Rio 2016 |
| concrete FCK 15 MPa, with cement CPII E 31 [$m^3$] | 1.63E+02 | InterCement, ATA calculation |
| concrete FCK 20 MPa, with cement CPII E 31 [$m^3$] | 1.82E+02 | InterCement, ATA calculation |
| concrete FCK 30 MPa, with cement CPII E 32 [$m^3$] | 2.11E+02 | InterCement, ATA calculation |
| copper, virgin [tonne] | 3.81E+05 | Bath University |
| glass, primary [tonne] | 9.10E+02 | Bath University |
| high resistance flooring [$m^3$] | 2.55E+02 | ATA calculation |
| internal roads, new [$m^2$] | 1.97E-02 | Quantis custom database for Rio 2016 |
| landscaping [$m^2$] | 3.60E-03 | Quantis custom database for Rio 2016 |

| CONSTRUCTION AND INFRASTRUCTURE PROCESS - NAME [UNIT] | EMISSION FACTOR [KG CO2-EQ/UNIT FOR PROCESS] | SOURCE |
|---|---|---|
| office, new [$m^2$] | 2.80E-01 | Quantis custom database for Rio 2016 |
| office, temporary [$m^2$] | 1.68E-01 | Quantis custom database for Rio 2016 |
| open arenas and stadium, new [spectator] | 5.74E-01 | Quantis custom database for Rio 2016 |
| open arenas and stadium, refurbished [spectator] | 2.87E-01 | Quantis custom database for Rio 2016 |
| open arenas and stadium, temporary [spectator] | 3.44E-01 | Quantis custom database for Rio 2016 |
| roads, new [$m^2$] | 3.28E-02 | Quantis custom database for Rio 2016 |
| roads, refurbished [$m^2$] | 1.64E-02 | Quantis custom database for Rio 2016 |
| sand, general [tonne] | 5.10E+00 | Bath University |
| sheds, new [$m^2$] | 1.75E-01 | Quantis custom database for Rio 2016 |
| sheds, temporary [$m^2$] | 1.05E-01 | Quantis custom database for Rio 2016 |
| sidewalks and parking areas, new [$m^2$] | 2.62E-02 | Quantis custom database for Rio 2016 |
| steel, general [tonne] | 2.20E+03 | ArcelorMittal, 2010 |
| stone gravel/chippings [tonne] | 1.70E+01 | Bath University |

# Appendix 2: How do the Rio 2016 Olympic and Paralympic Games compare with other events?

Comparing the carbon footprint of different events is a very challenging task. Firstly, a standardised methodology for measuring, calculating and reporting the GHG emissions of major events does not currently exist. Therefore, calculations rarely consider the same criteria or variables.

Some events include more activities in their scope. For example, the 2014 FIFA World Cup carbon footprint did not include the construction of the 12 stadiums used in the tournament – it only included the temporary constructions. The Rio 2016 Olympic and Paralympic Games-wide footprint considers the construction of competition and support venues, the legacy infrastructure projects' construction and the temporary constructions, thus having a significantly larger scope.

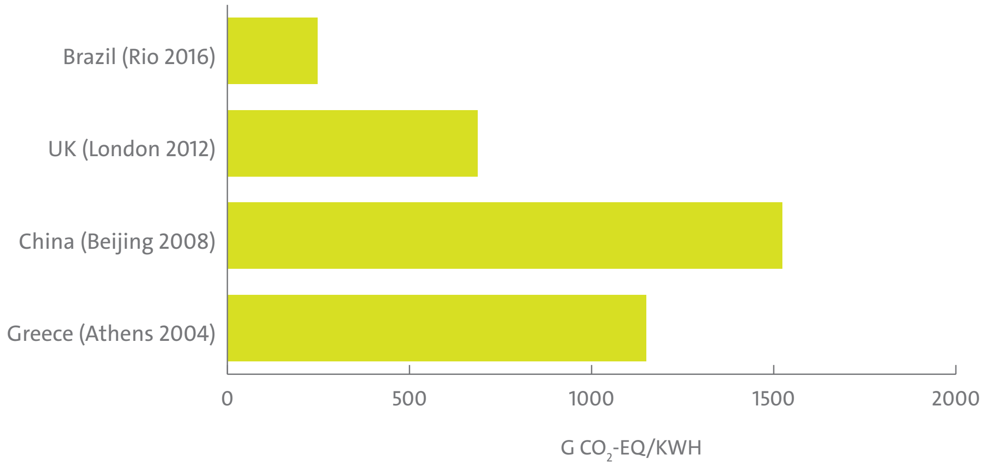
Since Vancouver 2010, Olympic and Paralympic Games have included inventories for construction among their emissions. However, different events have different scales, which also affect the carbon footprint. For example, the summer Olympic and Paralympic Games are considerably bigger than the winter Olympic and Paralympic Games, and it shows in their carbon footprint. In addition, even only comparing summer Games or winter Games, some editions build more extensively than others.

Moreover, even when the methodology is fully aligned, as is the case with the London 2012 and Rio 2016 Games, the absolute results cannot be compared, because some parameters strongly influence emission factors and the activities scale, and they give either comparative advantage or disadvantage that cannot be controlled or altered by the local organising committee of the event.

Many emissions depend directly on energy consumption, such as fuel and electricity. Therefore, the predominant energy mix of the host country will impact the carbon footprint calculation of the event.

The following table shows the GHG emissions of the electricity consumed in Brazil and in the host countries of the last three editions of the summer Games. The analysis shows that the GHG emissions of the Brazilian mix are significantly lower than those of the other three countries.

**GHG EMISSIONS OF THE ELECTRICITY CONSUMED IN BRAZIL AND OTHER HOST COUNTRIES**




The specific energy mix is an example of a factor that contributes to lower the GHG emissions for the energy-intensive activities of Rio 2016, compared to previous host cities.

Travel distances also substantially affect the footprint. The Games generate a lot of national and international travel. The location of the host city is therefore a key parameter that will determine the shorter or longer trips directly associated to the Games, whether that be on the part of athletes or spectators.

## LONDON 2012 AND RIO 2016

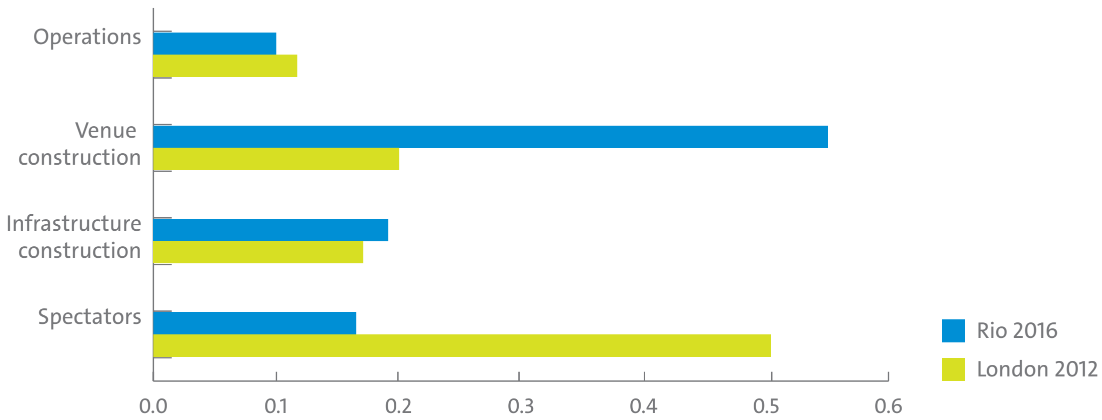
London is the capital city of a country that is 60 times smaller in surface area than Brazil and has a fifth of the Brazilian population. On a continental scale, Europe has only a quarter of the surface area of Brazil.

Indeed, the preliminary estimates indicate a higher number of intercontinental flights to reach the Games in Rio compared to the London 2012 and the Athens 2004 Games; the percentage of spectators coming from other continents will be larger than London 2012 and Athens 2004. In addition, the number of European athletes is larger than the number of Latin American athletes. Therefore, travel distances are an example of a factor that contributes to the increase of GHG emissions for the Rio Games, compared to previous host cities.

As expected, London 2012 and Rio 2016 present big differences in the composition of their respective carbon footprints. On the one hand, Brazil has the advantage of a cleaner energy mix and the use of an existing Olympic stadium. On the other hand, Brazil suffers from higher travelling distances, which increase spectator emissions.

Therefore, although the Rio and London Games' methodology is fully aligned, any comparison between the two needs to be conducted with extreme caution. The comparisons below are based on relative rather than absolute numbers.

REFERENCE CARBON FOOTPRINT



Owned emissions clearly prevail for London 2012, which gave the organisers greater control over the carbon footprint. It also resulted in a strategic choice of focusing on reduction rather than compensation measures.

In Rio's case, associate emissions – from spectators and city infrastructure – clearly prevail. The Rio 2016 Organising Committee has less control over these types of emission, making technological mitigation and compensation measures more relevant than they were for London.

## 2014 FIFA WORLD CUP COMPARISON

Comparing emissions between the Rio 2016 Games and the 2014 FIFA World Cup requires caution.

While we can compare the 2014 FIFA World Cup and Rio 2016, since they are staged in the same country, in terms of the influence of local parameters such as the energy mix and travel distances, the methodologies used in the estimation of the carbon footprint have key differences that need to be taken into account.

Accounting principles and emission factors used in both carbon footprint measurements are similar. However, footprint boundaries, i.e. the scope of activities included in the calculations, vary significantly, as shown in the following table.

| TYPE | 2014 FIFA WORLD CUP | RIO 2016 GAMES-WIDE |
|---|---|---|
| **Permanent venue construction** | NO | YES |
| **Legacy infrastructure projects** | NO | YES |
| **Spectator transport** | YES | YES |
| **Catering and accommodation** | YES | YES |
| **Temporary construction** | YES | YES |
| **Operations** | YES | YES |
| **Merchandising** | YES | YES |

The 2014 FIFA World Cup was hosted in 12 cities, while Rio 2016 will be hosted in six (besides Rio, five further cities will host the football tournament). Approximately three million tickets were available for spectators at the 2014 FIFA World Cup, while eleven million tickets will be available for the Rio 2016 Games.
This means that, while spectators travelled more inside Brazil during the 2014 FIFA World Cup, international trips to Brazil for the Rio 2016 Games will be higher.

The Olympic and Paralympic Games are a bigger event than the FIFA World Cup, with more venues, people, technology, transport, equipment, catering, etc.

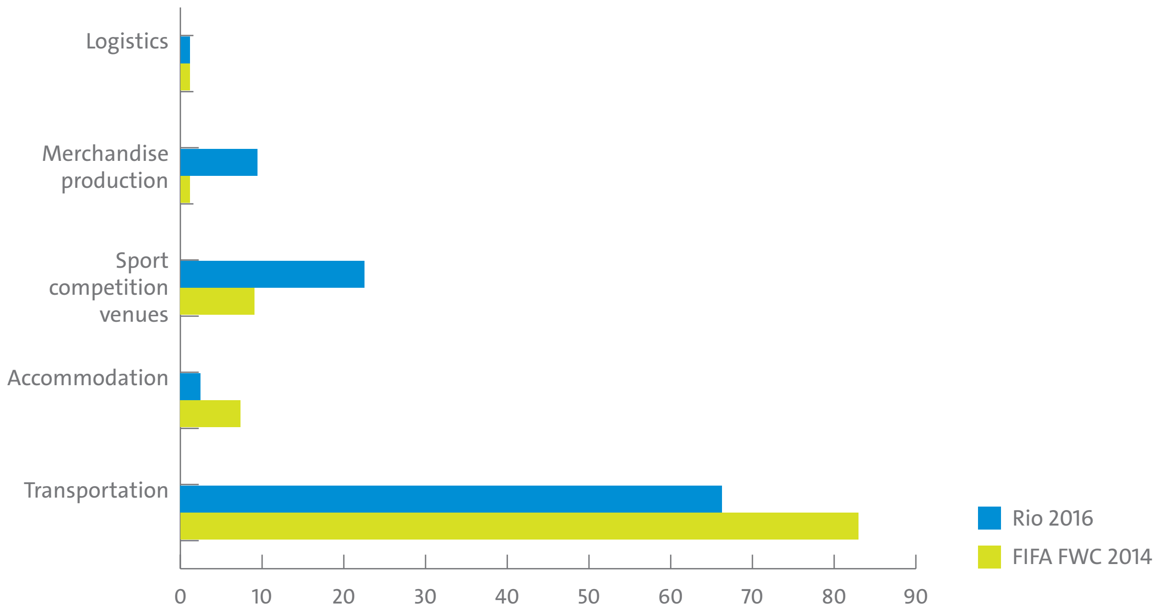
In addition, the World Cup carbon footprint is an ex-ante estimate, while Rio 2016 Games are a business-as-usual reference scenario. Therefore, the focus will not be in looking at the absolute numbers, but comparing relative numbers.

The first step in making a fair comparison is to resize the Rio 2016 footprint to the same scope of the World Cup. This can be done by excluding the emissions related to permanent venue construction and city infrastructure from the Rio 2016 Games-wide carbon footprint. So, considering Rio 2016 operations and spectator emissions, we obtain a carbon footprint that is comparable in scope to that of the World Cup.

The second step is to allocate emissions from the two events in a similar way, as per the table below.

| TYPE | 2014 FIFA WORLD CUP | RIO 2016 GAMES |
|---|---|---|
| **Transport** | Transport | Espectadores, operações |
| **Catering and accommodation** | Accommodation, venues | Operações |
| **Temporary construction** | Venues (temporary) | Operations (overlay) |
| **Operations** | Venues, logistics | Operations |
| **Merchandising** | Merchandise production | Spectators |

COMPARISON BETWEEN RIO 2016 AND FIFA FWC 2014




## CARBON FOOTPRINT MITIGATION AT PREVIOUS OLYMPIC AND PARALYMPIC GAMES

In recent years, Olympic and Paralympic Games committees have been accepting increased ownership to compensate or mitigate direct and some associated emissions, and have implemented different strategies for this purpose.[29] Generally, two principal approaches have been taken:

- Acquisition of carbon credits/certified emission reductions from different global projects
- Implementation of low-carbon technologies within the host country or region, leading to reductions in emissions

Both approaches are valid and complementary, providing they meet specific requirements of transparency and efforts to be "beyond business-as-usual", in addition to being verified by a third party (see appendix 3).

The Rio 2016 Olympic and Paralympic Games are unique in the way they can engage with a large audience, including big companies. This potential includes innovation in the face of the threat of climate change.

**29** http://www.olympic.org/documents/commissions_pdffiles/sportandenvironment/sustainability_through_sport.pdf

The Torino 2006 Games developed a technology programme named HECTOR (HEritage Climate TORino), aimed at mitigating the owned emissions of the 2006 winter Games. Seventy per cent of the owned emissions were mitigated or offset by investing in forestry, energy efficiency and renewable energy schemes, both within the country and abroad.[30]

The Beijing 2008 Games implemented measures, including restrictions on vehicles and industries, to reduce emissions during Games time. The single most effective emissions reduction measure was the traffic control measure on roads.[31]

Vancouver 2010 offset the owned emissions (118,000 tonnes of $CO_2$-eq) through the Canadian company Offsetters, by removing carbon credits from the market in the two years following the Game.[32]

London 2012 engaged British Petroleum (BP) as a Carbon Offset Partner to address part of the spectator emissions (99,000 tonnes of $CO_2$-eq) through international offset projects.

On behalf of Sochi 2014, Dow implemented a mitigation programme in Russia, with projects targeted at air sealing solutions for buildings (to enhance energy efficiency), new technologies to enhance industrial processes, use of low-weight and high-strength materials (for structural integrity and durability of civil infrastructure), and a global project to increase crop yield and instruct local producers on how to reduce emissions and conserve energy in agricultural and farming practices.

As a result of all combined efforts implemented since March 2013, Sochi 2014 became the first Olympic and Paralympic Games to have the entire owned emissions mitigated prior to the opening ceremony. To date, over 900,000 tonnes of $CO_2$eq of greenhouse gas reductions were verified by third-party international experts ERM, and applied to the mitigation of the Games GHG footprint.

Additionally, the programme enabled over 650,000 MMBTU (million metric British thermal units) in annual energy savings – a result that can be translated into over US$70 million in savings over 10 years for homeowners (considering the costs related to domestic natural gas consumption in Russia).

**30** http://www.un.org/apps/news/story.asp?NewsID=20787&Cr=sports&Cr1=unep

**31** http://www.unep.org/pdf/BEIJING_REPORT_COMPLETE.pdf

**32** Vancouver 2010 Sustainability report: http://www.olympic.org/Documents/Games_Vancouver_2010/VANOC_Sustainability_Report-EN.pdf

In order to support this new approach to carbon mitigation, Dow partnered with Offsetters and other international experts to develop an innovative GHG accounting framework. The aim was to allow economically viable projects to deliver climate benefits for the footprint mitigation of a large-scale event. Dow's Climate Solutions Framework[33] was launched at the United Nations' COP 19/CMP 9 event in Warsaw, Poland, in November 2013.

**33** Further information on The Framework is available at https://businesspartnershiphub.org/climate-energy/projects/view/60/; A copy of Dow's Climate Solutions Framework for Events is available through Dow Olympic Operations

# Appendix 3: Reduction benchmark

The city of Rio de Janeiro's GHG reduction scenario 2011 was used as a benchmark.

**Reference scenario (A)**: includes all emissions which are the responsibility of the city of Rio de Janeiro, considering a situation in which no specific reduction policies are put in place.

**Low-reduction scenario (B)**: includes all emissions which are the responsibility of the city of Rio de Janeiro, considering emission reductions already planned in 2011.

**High-reduction scenario (C)**: includes all emissions which are the responsibility of the city of Rio de Janeiro, considering emission reductions already planned in 2011 and additional reduction measures that are still in discussion or under technical analysis. Generally speaking, the high-reduction scenario includes measures that are bolder than those included in the low-reduction scenario.

# Appendix 4: Mitigation framework

City of Rio de Janeiro Emission Reduction Scenarios

| YEAR | REDUCTION SCENARIO B RELATED TO SCENARIO A | REDUCTION SCENARIO C RELATED TO SCENARIO A |
|---|---|---|
| **2012** | 8.3% | 12.0% |
| **2016** | 13.5% | 18.2% |
| **2020** | 13.0% | 18.7% |
| **2025** | 11.8% | 17.5% |

Source: Prefeitura da Cidade do Rio de Janeiro. Inventário e Cenário de Emissões dos Gases de Efeito Estufa da Cidade do Rio de Janeiro. Resumo Técnico. Rio de Janeiro: 2011.

The purpose of the Climate Solutions Framework is to provide clear guidance on the options available for greenhouse gas mitigation at large scale events, and was designed to assist organisations wishing to mitigate their impact on the climate.

This framework was based on various existing documents and standards to provide a set of event-specific current best practices for specific events. It offers details on how to establish mitigation projects to support the commitment to reduce the greenhouse gas impacts of large scale events and complements existing standards.

The concept of leaving a positive legacy is an important aspect of this framework. Therefore, this approach helps event organisers to not only mitigate GHGs, but to actively contribute to the sustainable development of the economy in the region in a way that allows the work done to mitigate greenhouse gases and have a broader impact on society.

The framework builds upon existing GHG accounting practices and standards for both climate impacts and benefits. Broadly, the term climate impact refers to the GHG emissions that fall under the responsibility of an organisation, as well as those that are directly impacted by the actions of this organisation. Climate benefit is a term that refers to the reduction of GHG emissions due to specific initiatives undertaken by an organisation.

To encourage action in the business community, however, there is a need to quantify and communicate GHG emission-reducing initiatives that are outside the scope of traditional approaches. The primary objective of this framework is to provide a methodology for quantifying and communicating the results of these initiatives, so that organisations are encouraged to continue developing low GHG emission solutions within their operations.

The concept of beyond business-as-usual (BBAU) is central to the generation of all types of climate benefits.

***Organisations must demonstrate that they have implemented voluntary GHG mitigating initiatives that face real or perceived barriers and result in GHG emission reductions that go beyond existing or expected market practices.***

To ensure that low GHG initiatives are not simply the by-product of normal operations, but rather the result of pushing for innovation and change, the framework includes an assessment of whether the activity is BBAU.

The framework broadly identifies two climate benefit types:

- **Primary climate benefit units (PCBUs)**
- **Secondary climate benefit units (SCBUs)**

Primary climate benefit units (PCBUs) are composed of two types of emission reduction:

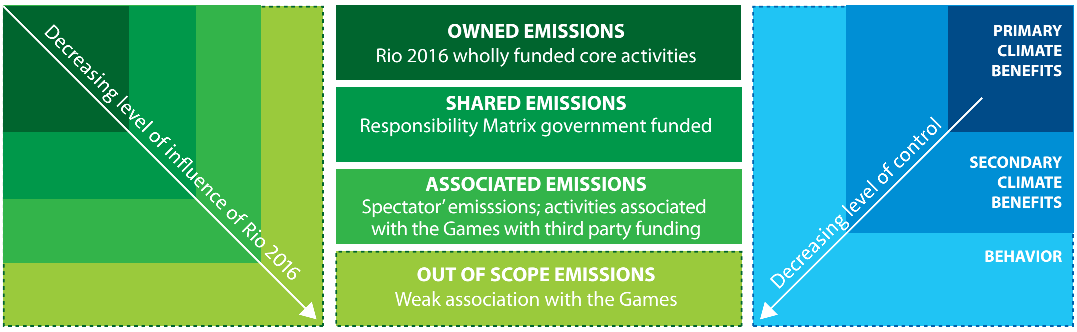
- **Carbon offsets:** a carbon offset is a financial instrument that represents the reduction of one metric tonne of carbon dioxide equivalent from the atmosphere.
- **Primary emission reduction programme (PERP):** occurs when an initiating entity (IE) voluntarily implements a programme with the intention of reducing greenhouse gas through demonstrable and measureable climate initiatives.

Secondary climate benefit unit is a catch-all term used to describe projects that meet some, but not all, of the criteria for primary climate benefit units. The framework identifies two types:

- **Secondary emission reduction programme (SERP):** an emission reduction programme where the uncertainty associated with the reductions precludes it from producing primary emission reductions.
- **Emission reductions from product comparisons (ERPC):** generates emission reductions by comparing the embodied GHG emissions of a new product and the embodied GHG emissions of a functionally equivalent incumbent product in the marketplace.

The following diagram illustrates how primary and secondary climate benefit units will be applied to mitigate the owned or associated emissions.

ADDRESSING EMISSIONS (AFTER REDUCTION PROJECTS) THROUGH A MITIGATION STRATEGY




A primary emission reduction project (PERP) does not generate tradable or profitable financial instruments, i.e. these instruments cannot be sold or traded on carbon markets for financial gain. As a result, revenue from carbon funding does not help a project overcome a barrier, as is the case with carbon offsets. Instead, the requirement of BBAU is assessed at the programme level, where the IE must demonstrate that the programme was a voluntary climate initiative with a demonstrable cost that resulted in the reduction of GHG emissions.

Like carbon offsets, a **PERP** must also meet pre-defined criteria:

- **Real:** emission reductions from identifiable actions that result in an absolute net reduction after accounting for all relevant SSRs (sinks, sources and reservoirs).
- **Beyond business-as-usual:** the organisation must demonstrate that it has implemented voluntary GHG mitigating initiatives that face real or perceived barriers and result in GHG emission reductions that are beyond existing and expected market practices.
- **Permanent:** emission mitigation projects must keep GHG stored for a suitable period of time, as defined by the GHG programme, to be considered permanent.
- **Verifiable:** to ensure all the criteria have been met, carbon offset projects need to be audited by an independent third party at both the validation and verification phases of project development[34,35].
- **Counted once:** the organisation must take steps to ensure that the GHG emission reductions are not sold or traded in other markets and that no other entity may lay claim to the emission reduction. However, because the GHG emission reduction is applied directly against the GHG impact, the organisation needs to guarantee that the carbon will not be traded on the open market.

All potential projects should first evaluate whether a carbon offset protocol from a recognised GHG programme exists. A suitable protocol is defined as a quantification methodology and development guidance that has undergone third-party assessment by a programme such as the VCS or CDM.

If no such protocol exists, project proponents may develop their own, which must be audited by an independent third party to ensure its reliability. Protocols may be adapted to specific project conditions if: it can be justified that the adaptation is based upon sound science and GHG accounting does not lead to an overstatement of the GHG reductions; it is in keeping with the intention of the protocol.

**34** In addition to meeting the criteria described above, all projects are expected to follow the six principles that underpin all aspects of the accounting, quantification and reporting of project-based GHG reductions: 1) relevance; 2) completeness; 3) consistency; 4) transparency; 5) accuracy; 6) conservativeness. Source: WRI GHG Protocol for Project Accounting.

**35** In certain situations where data is difficult to obtain, assumptions that are shown to be conservative may be used. The role of the auditor during validation is then to check the validity of those assumptions.

It is worth re-emphasising that while a certain degree of flexibility is afforded to the quantification of a secondary emission reduction project (SERP), the projects should still be validated against the following criteria:

- **Real:** emission reductions from identifiable actions that result in an absolute net reduction after accounting for all relevant SSRs.
- **Beyond business-as-usual:** project proponents must demonstrate they have implemented voluntary GHG mitigating initiatives that face real or perceived barriers and result in GHG emission reductions that are beyond existing and expected market practices.
- **Permanent:** emission reduction mitigation projects must keep GHG stored for a suitable period of time, as defined by the GHG programme, to be considered permanent.
- **Verifiable:** to ensure all the criteria have been met, carbon offset projects need to be audited by an independent third party at both the validation and verification phases of project development[36,37].
- **Counted once:** the organisation must take steps to ensure that the emission reductions are not sold or traded in other markets and that no other entity may lay claim to the emission reduction.

A key aspect of the mitigation protocol is that the emission reductions (whether primary or secondary) have to be directly measured in a conservative fashion, or estimated using conservative assumptions. In this case, the likelihood is that the programmes are high-performance. Furthermore, this gives all parties comfort that the emission reductions as reported are truly achieved, and this is confirmed by a reputable third party.

**36** In addition to meeting the criteria described above, all projects are expected to follow the six principles that underpin all aspects of the accounting, quantification and reporting of project-based GHG reductions: 1) relevance; 2) completeness; 3) consistency; 4) transparency; 5) accuracy; 6) conservativeness. Source: WRI GHG Protocol for Project Accounting.

**37** In certain situations where data is difficult to obtain, assumptions that are shown to be conservative may be used. The role of the auditor during validation is then to check the validity of those assumptions to ensure they are not overstated.

In the application of the framework for Brazil, ERM is the Dow partner for third-party validation and verification partner.

CLIMATE BENEFIT UNITS AND LEVEL OF ASSURANCE

| BENEFIT UNIT | LEVEL OF ASSURANCE | COMMENT |
|---|---|---|
| **Carbon offsets** | Reasonable level of assurance | Validation and verification |
| **PERP** | Reasonable level of assurance | Validation and verification |
| **SERP** | Limited level of assurance | Validation only for *ex-ante* assertions. Verification required for *ex-post* assertions. |
| **ERPC** | Critical review | Reductions will always be a forecast, so critical review is appropriate |

To mitigate the footprint of an event, the owned emissions must be offset using primary climate benefit units (PCBUs). It is acceptable to expand beyond the owned emissions and apply PCBUs to the associated emissions.

The framework encourages organisations to quantify and communicate the secondary climate benefit units (SCBUs) as they report the impacts associated with the event. However, there are also restrictions on how certain climate benefits are related to the climate impacts. SCBUs may only be related to associated emissions. That is to say, secondary climate benefits projects may not be applied against the emissions under the control of the event's organisers as a means to achieve the commitment to deliver low-carbon Games (as illustrated in the table below).

| IMPACTS | BENEFITS | |
|---|---|---|
| | Primary climate benefits units | Secondary climate benefits units |
| **Owned emission** | Yes | No |
| **Shared emissions** | Yes | Yes |
| **Associated emissions** | Yes | Yes |

Rio2016™

PATROCINADORES OLÍMPICOS MUNDIAIS
*WORLDWIDE OLYMPIC PARTNERS*

Coca-Cola · Atos · Bridgestone · Dow · GE · McDonald's
Omega · Panasonic · P&G · Samsung · Visa

PATROCINADORES OFICIAIS
*OFFICIAL SPONSORS*

Bradesco · Bradesco Seguros · Correios
Embratel · Claro · Nissan

APOIADORES OFICIAIS
*OFFICIAL SUPPORTERS*

Cisco · Estácio · EY · Sadia · Batavo · Skol

FORNECEDORES OFICIAIS
*OFFICIAL SUPPLIERS*

EF Education First ISDS Nielsen Nike Manpower Group

FORNECEDOR
*SUPPLIER*

EMC

PARCEIROS GOVERNAMENTAIS
*GOVERNMENTAL PARTNERS*

Rio Prefeitura · Governo do Rio de Janeiro · Governo Federal Brasil – País rico é país sem pobreza

PATROCINADOR PARALÍMPICO MUNDIAL
*WORLDWIDE PARALYMPIC PARTNER*

PATROCINADORES OFICIAIS
*OFFICIAL SPONSORS*

APOIADORES OFICIAIS
*OFFICIAL SUPPORTERS*

FORNECEDOR OFICIAL
*OFFICIAL SUPPLIER*

EF Education First    Ottobock

PARCEIROS GOVERNAMENTAIS
*GOVERNMENTAL PARTNERS*

**07.2016**



Comitê Organizador dos
Jogos Olímpicos e Paralímpicos Rio 2016

**rio2016.com**