ENVIRONMENTAL
PRODUCT DECLARATION

C Series CS100
As the demand for air transportation continues to grow, the aviation industry faces global environmental challenges. Bombardier actively supports the industry’s climate change goals and objectives. We are proud to contribute to a more sustainable future for aviation with our C Series aircraft – the greenest single-aisle aircraft entering the 100- to 150-seat market in close to 30 years.

As a key player in the industry, we are leading the way with new solutions aimed at reducing our global environmental footprint. Our product innovation life-cycle process – from the design and manufacture of the aircraft to its end-of-life – was applied throughout the development of the C Series family of aircraft. This will minimize the airliners’ impact on the environment.

We are proud to be the first aircraft manufacturer releasing an Environmental Product Declaration based on ISO14025 framework and are thrilled to give you an overview of the C Series aircraft’s environmental performance.

Sustainability is a key factor guiding our thoughts and business processes, and the C Series family of aircraft is a testament to our commitment to a greener future for aviation.

The C Series is a game-changer from nose to tail. Yet this entirely purpose-built aircraft has been made possible thanks to a long line of industry-shaping aircraft in the Bombardier family. The C Series, which incorporates decades of experience in the aviation industry, is the natural progression and exciting future of Bombardier’s commercial aircraft.

With its unmatched environmental scorecard – including the lowest noise levels of any in-production commercial aircraft in its class – the CS100 aircraft is the ideal aircraft for urban operations.

The EPD for the CS100 aircraft was developed as per the Product Category Rules (PCR) for Passenger Commercial Aeroplanes (PCR 2015:02 CPC code 49623) as well as with the principles and procedures of ISO 14025:2006.

The external validation of the EPD was carried out by independent verifiers approved by the technical committee of the international EPD system.
CS100 Configuration

The C Series aircraft family offers a flexible cabin with a capacity that typically ranges from 100 to 160 passengers. The CS100 aircraft can offer a maximum capacity of 135 passengers. For the Environmental Product Declaration, Bombardier selected a 125-seat configuration for the CS100 aircraft.

Selected CS100 Aircraft Cabin Configuration
- Number of lavatories: 2
- Number of trolleys: 5.5
- Seat Pitch: 0.76 m/30 in.
- Number of seats: 125

In each of its interior configurations, the single-aisle C Series aircraft delivers a widebody feel. The cabin was intentionally designed from the inside out to provide space where it matters most, leading to an unrivaled passenger experience.
A Life Cycle Perspective
Environmental Profile of the CS100 Aircraft

At Bombardier, life cycle thinking is an integrated feature of the design process, highlighting the significance of different design options and the true overall environmental impact these options offer.

LIFE CYCLE ASSESSMENT
Resource efficiency, waste generation and overall environmental impacts were estimated throughout all life cycle phases of the CS100 aircraft, following ISO 14044:2006 methodology.

The results represent a functional unit of one passenger being transported on the aircraft over 100 km, based on a standard 926 km mission (500 NM). The aircraft is assumed to be full of passengers (100 per cent load factor).

We based the assessment on the following: the aircraft will fly 60,000 times over its entire lifetime (i.e. 90,000 hours) at a maximum of 12,497 m (41,000 ft) of altitude and a typical speed of 829 km/h (M0.78). It will consume 2,429 kg (5,354 lb) of fuel per 500 nautical mile (NM) mission and transport 1,351 kg (2,978 lb) of fuel for the reserves* with 125 passengers on board. The end-of-life phase of the life cycle is modeled according to technology available today.

MATERIAL PRODUCTION
The extensive use of advanced structural materials (advanced aluminium and composite) combined with the specific design point contributed to significant weight savings (up to 5,900 kg [13,000 lb] lighter versus re-engined aircraft in its class). The following figure shows the typical material composition of a CS100 aircraft.

* Fuel reserves are considered as a dead weight in the aircraft and are not considered as burnt during the flight.

DESIGN AND MANUFACTURING
Eighty per cent of the environmental impact of an aircraft is determined at the design stage. This influenced our decisions from the beginning of the program. The CS100 aircraft are assembled at Bombardier’s Mirabel facility (Quebec, Canada) where most of the energy comes from hydropower, a renewable energy resource.

All Bombardier sites are ISO 14001-certified. The CS100 aircraft final assembly line in Mirabel and the Belfast (Northern Ireland) site, where the aircraft wing is manufactured, are both LEED® certified.

* LEED: Leadership in Energy and Environmental Design
Environmental Impact in Detail

GaBi database v.6 was used to generate the results. Results are shown using the April 2013 version of the CML2001 impact methodology (https://www.universiteitleiden.nl/en/research/research-output/science/cml-ia-characterisation-factors). All specific data used refer to years 2012, 2013 and 2014, and are valid for a global market. The table shows that most of the environmental impact, and especially CO₂ emissions responsible for the global warming environmental impact, comes from the operation phase, which is expected to be the next 20 to 30 years for these aircraft. The C Series aircraft, with its unmatched fuel efficiency compared to other aircraft in its class, contributes to a significant reduction in CO₂ emissions. (up to 120,000 tonnes per aircraft, the equivalent of taking more than 32,000 mid-sized cars off the road for a year).

### Upstream Core Operation End-of-Life Total

<table>
<thead>
<tr>
<th>Acidification (kg SO₂-eq)</th>
<th>5.70E-5</th>
<th>1.24E-6</th>
<th>7.46E-3</th>
<th>3.64E-8</th>
<th>7.52E-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eutrophication (kg Phosphate-eq)</td>
<td>3.66E-5</td>
<td>6.03E-7</td>
<td>1.69E-3</td>
<td>1.12E-7</td>
<td>1.72E-3</td>
</tr>
<tr>
<td>Global warming (kg CO₂-eq)</td>
<td>7.52E-2</td>
<td>1.89E-3</td>
<td>7.70</td>
<td>8.41E-5</td>
<td>7.78</td>
</tr>
<tr>
<td>Photochemical ozone creation potential (kg Ethene-eq)</td>
<td>1.60E-5</td>
<td>3.48E-7</td>
<td>1.37E-3</td>
<td>2.59E-8</td>
<td>1.396E-3</td>
</tr>
<tr>
<td>Water consumption (kg)</td>
<td>7.50E1</td>
<td>1.31E1</td>
<td>2.10E2</td>
<td>2.38E-2</td>
<td>2.98E2</td>
</tr>
</tbody>
</table>

Note: These results are only valid for this range and this configuration. No linear assumption can be made to extrapolate environmental impact for another distance, another configuration or another aircraft type.

1 Raw material extraction and component production
2 Final assembly
3 Use and maintenance
4 2.59 kg of water are also emitted during the operation phase as part of the combustion

The operation phase appears to be the major consumer of material resources and non-renewable energy resources (kerosene production process). As shown in these graphs, the operation phase accounts for about 99 per cent of the aircraft life cycle impacts.

### Effect of flight mission length on fuel burn

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<th>Mission (NM)</th>
<th>Number of passengers</th>
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Lowest noise and emissions in its class

The noise signature of the C Series aircraft is comparable to smaller aircraft such as turboprop aircraft, and significantly less than its similar-sized competitors. With the lowest noise and emissions levels of any commercial aircraft in its class, the C Series aircraft is ideal for urban operations and noise-sensitive airports. To give a real feel on how quiet the CS100 is, the graph below compares the CS100 aircraft noise level to other urban sounds:

Community noise certification numbers

The noise of the aircraft varies according to the engine thrust and aircraft weight. Three examples are shown here below:

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<tr>
<td>Approach</td>
<td>90.8</td>
<td>91.5</td>
<td>91.5</td>
</tr>
<tr>
<td>Lateral</td>
<td>88.5</td>
<td>88.0</td>
<td>85.3</td>
</tr>
<tr>
<td>Flyover</td>
<td>75.5</td>
<td>78.8</td>
<td>82.0</td>
</tr>
<tr>
<td>Total</td>
<td>254.8</td>
<td>258.3</td>
<td>258.8</td>
</tr>
<tr>
<td>Margin to Stage 4</td>
<td>20</td>
<td>18</td>
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</tr>
</tbody>
</table>

Bombardier puts a strong focus on minimizing the use of hazardous materials and related toxic emissions. 99.99 per cent of waste quantity generated over the life cycle of the aircraft is non-hazardous as shown in the graph below:

\[ \text{Waste Generation (kg)} \]

\[ \text{Radioactive waste} \quad \text{Hazardous waste} \quad \text{Non-hazardous waste} \]

Bombardier is involved in research projects to improve the recoverability rate of its aircraft to 100 per cent by 2025.

End-of-life

Using materials featuring high recyclability rates maximizes the overall recoverability of the CS100 aircraft. Material recycling and energy recovery aggregate to an 83 per cent recoverability rate.

Glossary of terms

Life cycle assessment

Life cycle assessment (LCA) is the process used to measure a product’s environmental impact at any point for any activity or use over its whole lifetime from raw material extraction through materials processing, manufacturing, distribution, use, repair and maintenance, and disposal or recycling.

Acidification potential

The aggregate measure of the acidifying potential of some substances, calculated through the conversion factor of sulphur oxides and nitrogen and ammonia into acidification equivalents (SO₂).

Global warming potential

Global warming potential is the aggregate measure of the warming potential of greenhouse gases emitted over all phases of the life cycle. It is expressed in CO₂ equivalents.

Eutrophication potential

The aggregate measure of the inland water eutrophication potential of some substances, calculated through the conversion factor of phosphorous and nitrogen compounds (waste water discharges and air emissions of NOₓ and NH₃) into phosphorous equivalents.

Photochemical ozone creation potential

The aggregate measure of the ground level ozone creation potential of some substances, calculated through the conversion factor of ethylene equivalents that contribute to the formation of photochemical oxidants.

Recyclability and recoverability

The recyclability and the recoverability rate of a new aircraft vehicle are expressed as a percentage of the mass of the aircraft vehicle that can potentially be recycled (recyclability rate), or recovered, or both (recoverability rate).

Seat Pitch

Distance from any point on one seat to the exact same point on the seat in front.
Eco-Design

At Bombardier, integrating the core value of environmental sustainability into our product development function is fundamental to our process when designing our state-of-the-art aircraft.

Applying a complete life cycle perspective to aircraft design is central to our product responsibility strategy. Maximizing energy and resource efficiency, eliminating hazardous substances and related toxic emissions, as well as enhancing the overall product recoverability rate, is the result of a high quality working process applied to product design and cascaded to our supply chain. The Bombardier Eco-Design team, together with its network, acts as a catalyst by providing the essential tools, expertise and central coordination in projects worldwide.

PCR review was conducted by the technical committee of the international EPD® system:

The Technical Committee of the International EPD® System
email: info@environdec.com

Independent verification of the declaration and data, in accordance to ISO 14025:2006
☐ Internal  ☑ External

Third party verifier:
Rita Schenck
Executive Director
Institute for Environmental Research and Education
email: rita@iere.org

Approved by: The International EPD® System

Environmental Product Declarations within the same product category, but from different programs may not be comparable.

This EPD is valid until 2019-08-09.
Registration No. S-P-00921
UN CPC 49623
Date: 2016-09-27

More information on the international EPD® system is available at www.environdec.com

For more information on Eco-Design and Environmental Product Declarations at Bombardier:

For more information on Bombardier Commercial Aircraft’s unique portfolio and on the C Series aircraft:
http://cseries.com/environment

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