C Series

CS100

ENVIRONMENTAL PRODUCT DECLARATION

BOMBARDIER
the evolution of mobility

C Series

Meet the only community-friendly aircraft family optimized for the 100- to 150-seat market

Fred Cromer,
President,
Bombardier Commercial Aircraft

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.

CS100 – Facts and figures

Commercial name	CS100
Type of aeroplane	Single-aisle
Type Certificate Data Sheet Number	A-236
Date of Certification	December 2015
Certification body	Transport Canada
Propulsion system	Turbofan
Engine trade name	Pratt & Whitney PurePower® PW1500G
Standard accommodation	108 passengers (dual class) 125 passengers (high-density single class)
Maximum passenger capacity	135 passengers
Maximum takeoff weight	60,781 kg (134,000 lb.)
Takeoff field length	1,219 m (Base) to 1,463 m (Max) 4,000 ft. (Base) to 4,800 ft. (Max)
Maximum cruising speed	871 km/h (0.82 Mach)
Maximum operating altitude	12,497 m (41,000 ft.)
Maximum range	5,741 km (3,100 NM)
Fuel efficiency	As low as 2 liters/100 km per passenger

Communicating Environmental Performance – ISO 14025

Bombardier communicates the environmental performance of its products through Environmental Product Declarations (EPDs) in accordance with the international EPD® system. The EPD is a document that is based on verified life-cycle analysis (LCA) data. It summarizes and communicates transparent and comparable information about the environmental impact of a product at each phase of its life cycle.

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.

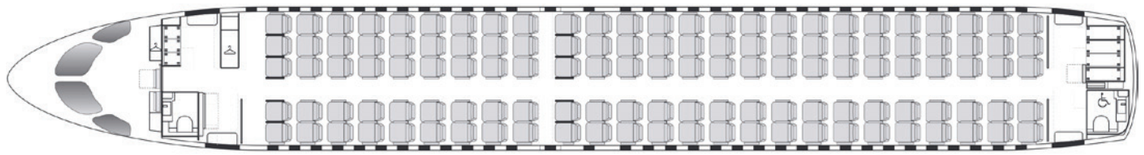
The external validation of the EPD was carried out by independent verifiers approved by the technical committee of the international EPD® system.

CS100 Configuration

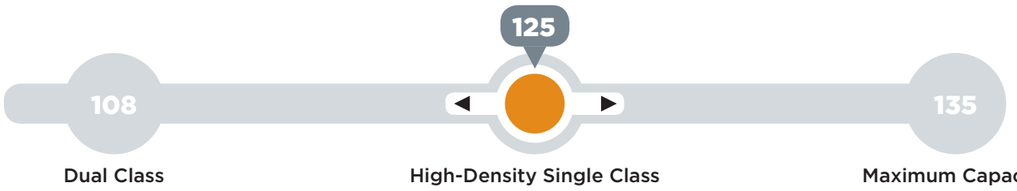
The C Series aircraft family offers a flexible cabin with a capacity that typically ranges from 100 to 160 passengers. The CS100 aircraft can offer a maximum capacity of 135 passengers. For the Environmental Product Declaration, Bombardier selected a 125-seat configuration for the CS100 aircraft.

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



CS100 Aircraft Capacity



MORE BAGGAGE CAPACITY
» The C Series aircraft's cabin configuration allows each passenger to store a bag in the overhead bins.

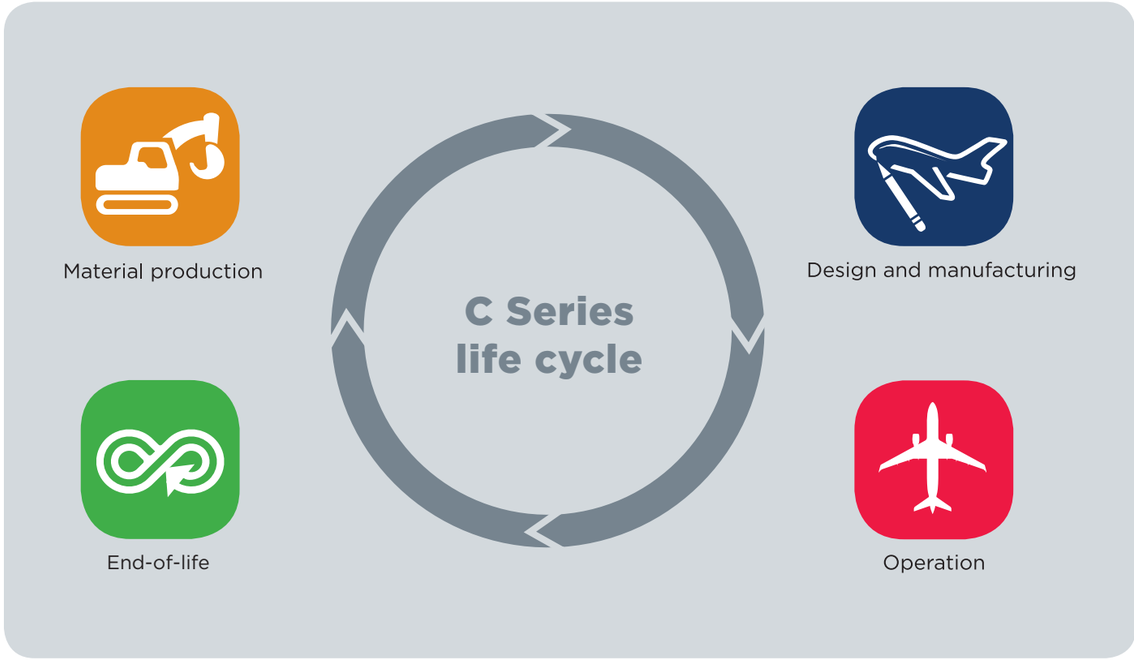
In each of its interior configurations, the single-aisle C Series aircraft delivers a widebody feel. The cabin was intentionally designed from the inside out to provide space where it matters most, leading to an unrivaled passenger experience.

LARGEST WINDOWS
» Up to 50 per cent larger windows

MORE PERSONAL SPACE
» More shoulder room

WIDEST ECONOMY SEATS
» Best living space and comfort with 19-inch wide seats

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).

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

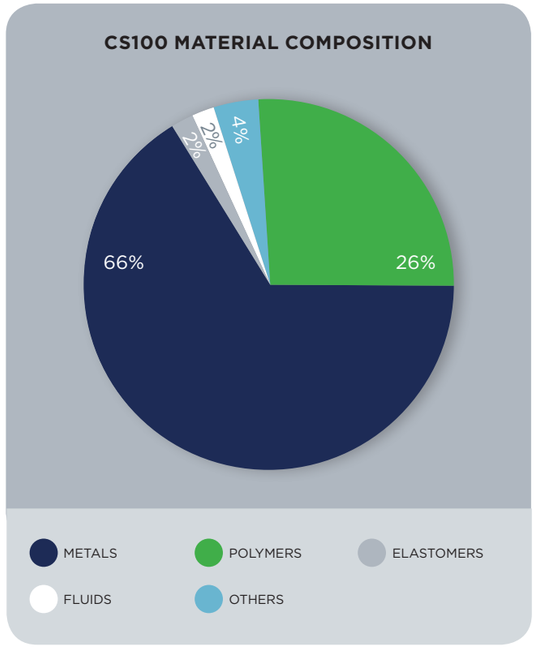
We based the assessment on the following: the aircraft will fly 60,000 times over its entire lifetime (i.e. 90,000 hours) at a maximum of 12,497 m (41,000 ft) of altitude and a typical speed of 829 km/h (M0.78). It will consume 2,429 kg (5,354 lb) of fuel per 500 nautical mile (NM) mission and transport 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.

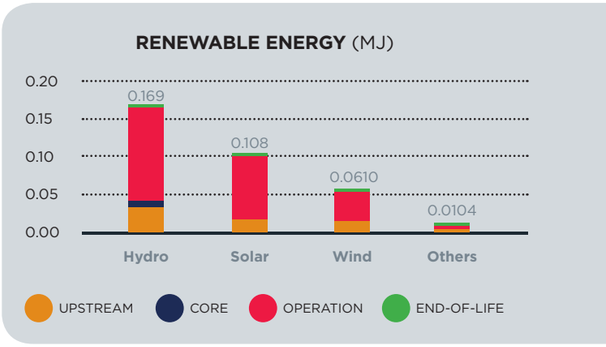
All Bombardier sites are ISO 14001-certified. The C Series aircraft final assembly line in Mirabel and the Belfast (Northern Ireland) site, where the C Series aircraft wing is manufactured, are both **LEED* certified**.

* LEED: Leadership in Energy and Environmental Design



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 C Series aircraft are assembled at Bombardier's Mirabel facility (Québec, Canada) where most of the energy comes from hydropower, a renewable energy resource.



OPERATION

Over the last 40 years, the average fuel efficiency of commercial aircraft improved by 70 per cent. However, while this is an impressive achievement for the industry, the environmental footprint of aircraft must continue to be reduced. As fuel burn directly relates to CO_2 emissions, it is essential to target minimal fuel consumption per passenger.

Bombardier has designed the only single-aisle aircraft family optimized for the 100- to 150-seat market using best-in-class technologies. The C Series aircraft have unmatched fuel efficiency, as low as 2 liters per 100 km per passenger. The tables here provide examples on how fuel consumption varies in accordance with the number of passengers as well as the flight length.

AS LOW AS 2 LITERS / 100 KM PER PASSENGER

(Equivalent to 118 MPG or 50 km/L)

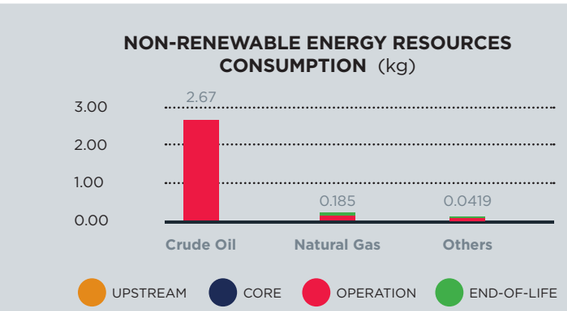
Effect of flight mission length on fuel burn

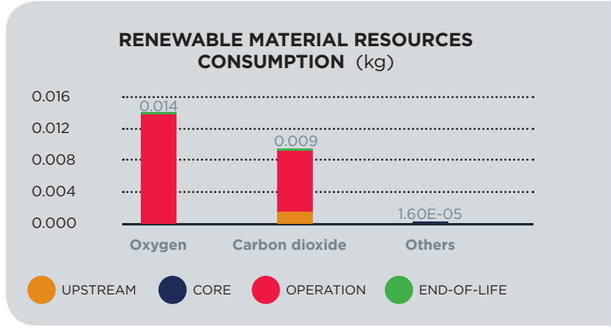
Mission (NM)	Number of passengers	Fuel Burn (L/100 km per passenger)
500	**125**	**2.57**
1,000	125	2.28
1,500	125	2.20
2,000	125	2.17

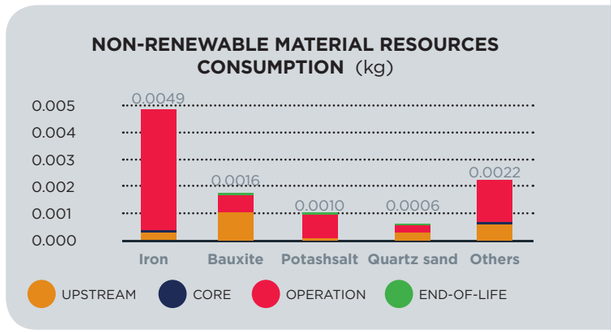
Effect of number of passengers on fuel burn

Mission (NM)	Number of passengers	Fuel Burn (L/100 km per passenger)
2,000	108	2.44
2,000	125	2.17
2,000	**135**	**2.05**

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.







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 CO_2 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 CO_2 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.).

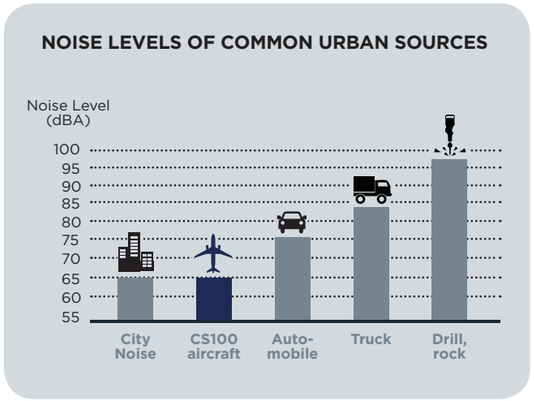
	Upstream[1]	Core[2]	Operation[3]	End-of-Life	Total
Acidification (kg SO_2-eq)	5.70E-5	1.24E-6	7.46E-3	3.64E-8	7.52E-3
Eutrophication (kg Phosphate-eq)	3.66E-5	5.03E-7	1.69E-3	1.12E-7	1.72E-3
Global warming (kg CO_2-eq)	7.52E-2	1.89E-3	7.70	8.41E-5	7.78
Photochemical ozone creation potential (kg Ethene-eq)	1.60E-5	3.48E-7	1.37E-3	2.59E-8	1.39E-3
Water consumption (kg)[4]	7.50E1	1.31E1	2.10E2	2.38E-2	2.98E2

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

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:

Noise (EPNdB[1])	Config. A	Config. B	Config. C
Approach	90.8	91.5	91.5
Lateral	88.5	88.0	85.3
Flyover	75.5	78.8	82.0
Total	254.8	258.3	258.8
Margin to Stage 4	20	18	18

Configuration A
MTOW: 115,000 lb. | MLW: 106,000 lb. | Engine: PW1524G (23.3K lbf.)

Configuration B
MTOW: 134,000 lb. | MLW: 115,500 lb. | Engine: PW1524G (23.3K lbf.)

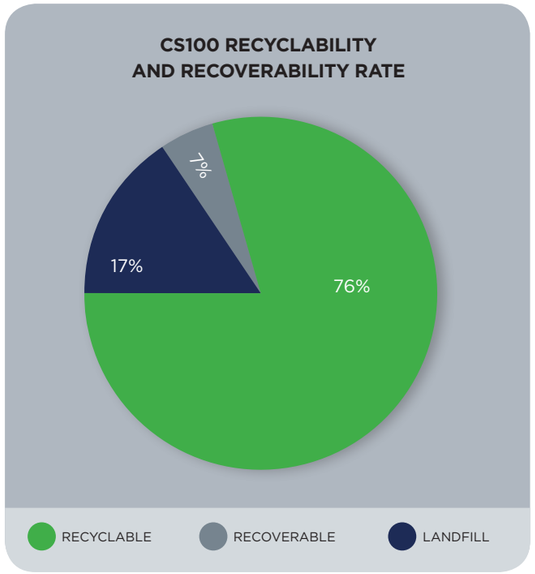
Configuration C
MTOW: 134,000 lb. | MLW: 115,500 lb. | Engine: PW1519G (18.9 K lbf.)

[1] Community noise certification is regulated by the International Civil Aviation Organization (ICAO) and expressed in Effective Perceived Noise in Decibels (EPNdB).

END-OF-LIFE

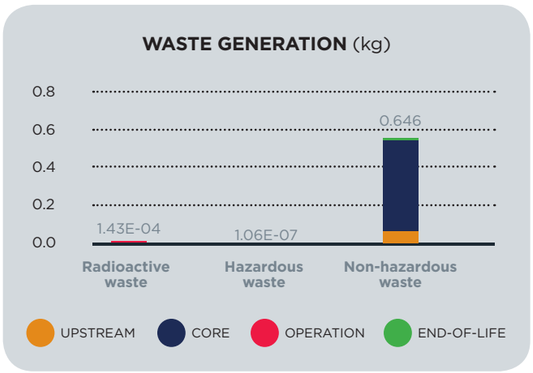
Using materials featuring high recyclability rates maximizes the overall recoverability of the CS100 aircraft. Material recycling and energy recovery aggregate to an 83 per cent recoverability rate.

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



Bombardier puts a strong focus on minimizing the use of hazardous materials and related toxic emissions.

99.98 per cent of waste quantity generated over the life cycle of the aircraft is non-hazardous as shown in the graph below:



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 (SO_2).

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 CO_2 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 NO_x and NH_3) 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**

EPD®

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:
http://www.bombardier.com/en/sustainability.html

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

Bombardier Commercial Aircraft
13100, Boulevard Henri-Fabre
Mirabel, Qc, J7N 3C6
Canada
E-mail address: bca.marketing@aero.bombardier.com

BOMBARDIER
the evolution of mobility