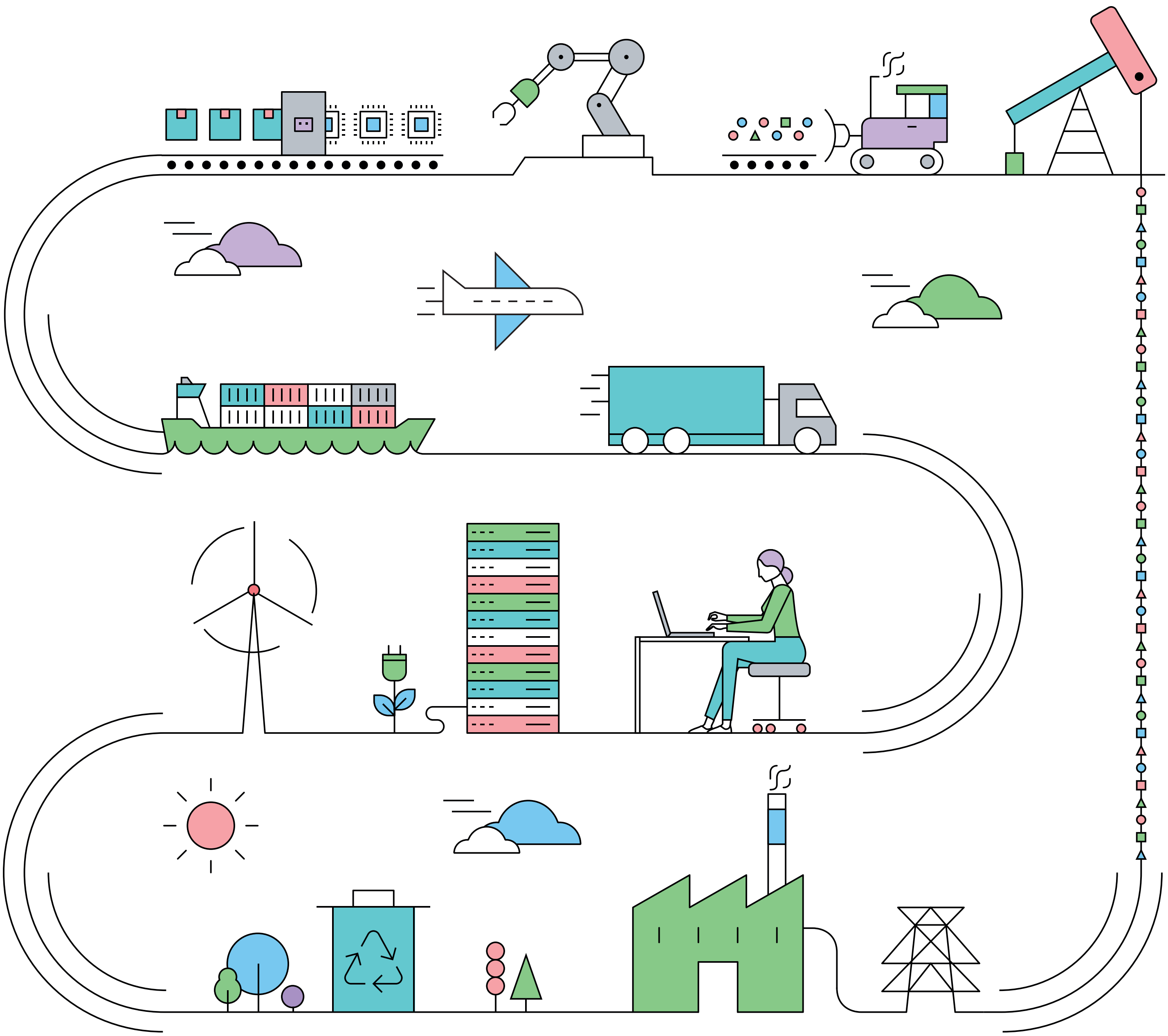
Assessment of lifecycle carbon footprints of products



Introduction

IBM is committed to environmental leadership in all of its business activities, from its operations to the design of its products and use of its technology. IBM's corporate policy on environmental affairs, first issued in 1971, is a key element of the company's efforts to achieve results consistent with environmental leadership and ensures the company is diligent in protecting the environment across all of its operations worldwide. For decades IBM has been a leader in addressing climate change through our energy conservation and climate protection programs.

IBM's product design for the environment (DfE) program was established in 1991 to bring additional focus on product environmental design and performance. Today, the DfE program is incorporated into IBM's worldwide environmental management system (EMS). IBM's proactive initiatives and its vision in incorporating hardware development and product design processes into a globally certified ISO 14001 EMS attest to its legacy of environmental leadership.

The DfE program provides IBM's business organizations with direction and goals, infrastructure, tools, and expertise to apply environmental life cycle considerations to IBM's products, from concept through end-of-life management. The objectives of IBM's DfE program include developing products that:

- Are durable, and with consideration for their ability to be repaired, upgraded, refurbished, or remanufactured to extend product life
- Include products with consideration for their reuse, dismantle-ability, recyclability and recoverability at the end of product life
- Can safely be disposed of at the end of product life, including the ability to easily remove hazardous components and assemblies prior to scrapping and disposal
- Use recycled or renewable materials where they are technically and economically justifiable
- Are increasingly energy efficient
- Minimize resource use and environmental impacts through selection of environmentally preferred materials and finishes

What are life cycle assessments?

There is no doubt that businesses today have an increased awareness of the importance of environmental sustainability.

Sustainability heavily influences vendor and partner selection. There is also an increasing interest in product carbon footprints (PCF) in public policy and labeling initiatives. A Life Cycle Assessment (LCA) is one tool that can help better understand environmental impacts of products and services. As defined by ISO 14040:2006[1], LCA is “a compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle.” IBM recognizes that approximations of lifecycle greenhouse gas (GHG) emissions, through tools such as LCA, can help entities recognize where the greatest amounts of GHGs may be generated during the lifecycle of a typical process, general product, or service on a macro level.

This can be helpful when assessing, for example, what phases of a product’s design, production, use, and disposal provide the best opportunities for enhancement. A PCF, generated through a LCA sums up the total greenhouse gas emissions generated by a product over the various phases of its life cycle:

Manufacturing and assembly: The emissions generated during the extraction, production, and transport of raw materials, the manufacture and transport of components and subassemblies (including the product packaging) and product assembly.

Transportation: The emissions generated during the air, land, or sea transport of finished IBM products between IBM facilities to customers.

Use: The emissions associated with the electricity consumption which is calculated according to the expected use of the product over its lifetime. Calculated electricity consumption is then used in combination with average emissions factors for the designated country of use to calculate emissions.

End-of-life: It is assumed that a designated portion of the product or specific components are recycled and reused at the end of the use period. It is also assumed that the balance of the product waste materials is disposed of by landfill or incinerated. Emissions generated during the mechanical destruction, separation and transport of end-of-life materials are included in the calculation.

1 https://www.iso.org/standard/37456.html

Most PCF numbers published by today are gross estimates of the emissions associated with generic product types. Performing a detailed LCA for electronic equipment is very resource intensive, requires large amounts of data from both direct and sub-tier suppliers, and is seldom practical for each product. Research has shown that the results of a detailed LCA still have high levels of uncertainty since primary data are scarce and the products are complex, both in their design and supply chain.

In 2010, IBM completed a PCF LCA case study with Carnegie Mellon University[2]. The case study investigated the uncertainty and variability associated with the calculation of the greenhouse gas emissions associated with the life cycle of a rack-mount server product. The analysis of the carbon footprint information for servers showed that typically more than 90% of the carbon footprint associated with a server occurs in the use phase as opposed to production, transport, or end-of-life. This finding confirmed the importance of IBM's ongoing efforts to increase the energy efficiency of its server and storage products and the data centers where these are used.

Carbon footprint uncertainty in the product use phase is highly dependent on the product's projected use profile and the greenhouse gas emissions associated with the client's electricity grid. Variability in the electricity mixes of different markets leads to vastly different impacts of using the product similarly in different places. Assumptions of the product's expected useful life also significantly affect the results. Estimating the production carbon footprint with any accuracy is extremely difficult due to the large number of parts and components and the number of suppliers where parts and components are procurred.

2 Weber, C. 2012. Uncertainty and Variability in Product Carbon Foot printing: Case Study of a Server. Journal of Industrial Ecology, Vol. 16, No. 2, pgs. 203 – 211.

Product attributes to impact algorithm

The Product Attributes to Impact Algorithm (PAIA)[3], developed by the Massachusetts Institute of Technology in concert with Arizona State University, and University of California at Berkeley, is an approach to streamlined LCA.

The PAIA method can be used to identify the major drivers of impact, known as hotspots, within the materials acquisition, manufacturing, use, and end-of-life of a generic product.

The PAIA tools aim to provide an efficient and cost-effective estimate of the carbon impact of a product class, including servers, storage, network switches and other electronic devices. The PAIA tools can also provide an estimate of the uncertainty of the results. However, PAIA results are not designed to differentiate between products at the level of stock keeping unit (SKU) but are instead used to offer a high-level estimate of the impact of a product's lifecycle, along with the associated uncertainty of the results for product classes.

The PAIA tools conforms with the requirements of the International Electrotechnical Commission Technical Report (IEC TR) 62921, which "provides specific guidance for the use of streamlining techniques that minimize cost and resources needed to complete GHG emissions quantifications."

PAIA uses data sources from participating companies and emission factors from third party data sources (such as Ecoinvent). PAIA uses these databases, in lieu of requiring original data sources, which is impractical. PAIA tools contain data that are of varying quality (age, source, sample size, etc.).

PAIA enables the PCF to be estimated without the need to calculate it from scratch. The results are therefore based on hardware characteristics and may not capture the specifics of the production process. Statistical analysis generates an estimate of the carbon impact at a component level together with the standard deviation.

IBM primarily uses the PAIA server and storage tools, which are intended to represent tower, rack, blade servers and storage array products manufactured between 2013 and 2016. Because of the highly variable nature of product configurations, quite a lot of input about the product configuration is required to be specified by IBM, including, but not limited to:

- Server type
- Number of power supply units and fans
- Server weight
- Assembly location
- Motherboard PWB area
- DRAM capacity
- Mainboard assembly location
- Quantity of SSDs, HDDs, and ODDs
- Transport distances and modes
- Hardware annual typical electricity consumption, server lifetime, server use location
- End of life handling

As is the case will all the PAIA tools, the streamlined analysis identifies the impact categories with the greatest importance to the PCF. For example, PAIA identified that the use phase dominates for server products, so the tools do not require as much detail about other server aspects such as component materials, manufacturing, etc. Users of PAIA are also limited to using the inputs that PAIA makes available. For example, countries of manufacturing and receiving are limited. Additionally, the data in PAIA lags innovations that the manufacturer might have implemented, such as lighter, more sustainable packaging materials.

3 PAIA, https://quantis-intl.com/paia-a-sector-driven-tool-to-drive-transformation-in-ict/

What does IBM provide?

IBM develops PCFs for representative IBM products using PAIA. IBM reports the 95th percentile of the carbon footprint estimates to reflect the uncertainty in the calculation. The 95th percentile means that 5% of the time the carbon footprint will exceed the value provided. The PCF is also reported as a Mean ± Standard Deviation. The results are reported using the units of kilograms of carbon dioxide equivalent (kg CO_2 eq.). This represents the amount of global warming caused by a quantity of GHGs (CO_2, CH_4, N_2O, HFCs, PFCs and SF_6) at a specific point in time, expressed in terms of the amount of CO^2 which would have the same instantaneous warming effect.

IBM's carbon footprint reports also provide a figure showing the estimated impact for each phase of the product's life cycle. This figure is generated using the assumptions listed in the individual product report.

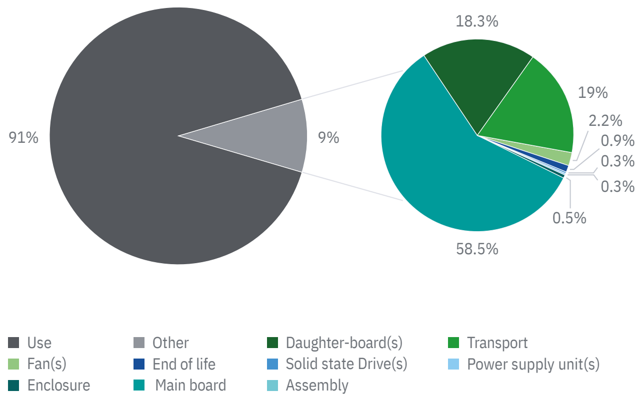


Figure 1:
An example showing the impact of the carbon footprint by phase of the lifecycle.

Considering the importance of the use phase to the carbon footprint, IBM also provides web-based power estimation tools for its products to assist clients in understanding the electricity use of their specific configuration.

IBM Systems Energy Estimator Tool A web-based tool that calculates energy consumed (Watts) and cooling requirements (BTU/hour) for IBM Power Systems™.

Power Estimation Tool A web-based tool that allows you to estimate the power consumption for specific configurations of your IBM Z® server.

IBM Storage Energy Estimator A web-based tool to assess the environmental characteristics of IBM storage products, such as FlashSystem™.

Typical electricity consumption and product lifetime are the two most significant factors in the estimation of product carbon footprints for electronics. IBM uses the intended design life as the assumption in the calculation of the product carbon footprint. This parameter is reported clearly on the PCF report. This could vary for a client's specific product and use case. However, it also points to the importance of using the most energy efficient products for your workloads. One of IBM's product energy efficiency goals is to improve the computing power delivered for each kilowatt-hour of electricity consumed for new server and storage products as compared to equivalent, previous-generation products.

Lastly, as part of the PCF report, the uncertainty in the most significant aspects of the product carbon footprint is provided in a box-and-whiskers plot. This plot shows the median, upper and lower quartiles and maximum and minimum values for PCF based on the simulations done by PAIA.

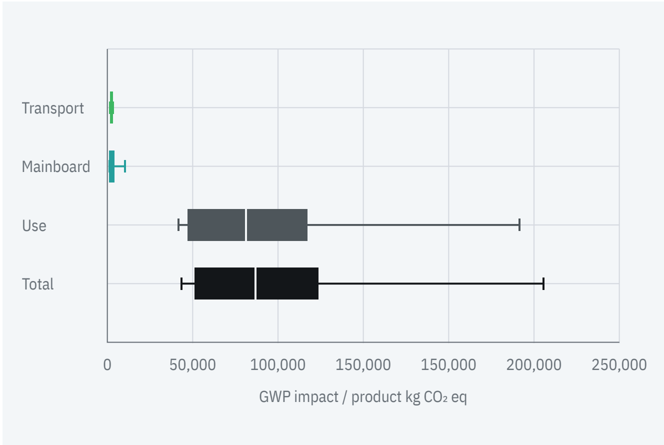


Figure 2:
An example showing the uncertainty in the PCF estimate.

Intended uses and limitations

While streamlined LCAs, such as PAIA, can be used to get a high-level estimate of emissions, they are not suitable for differentiation of products or year-to-year tracking. Comparisons of LCA results, particularly those developed separately using differing methodologies, assumptions, and data sets, are fraught with challenges and it is difficult to draw meaningful conclusions. LCA results are strongly influenced by the assumptions made by the analyst; if those assumptions are inconsistent, comparisons are not likely meaningful. Therefore, IBM does not recommend that PAIA results be used comparatively. The table below highlights the intended uses and limitations of the PAIA tools, which apply to everyone publishing this information, including IBM.

Intended uses of PAIA	Limitations of PAIA
• PAIA is a streamlined LCA methodology. • The current application of the method, the PAIA tools, can provide a reasonable estimate of the range of carbon impact of a product class. • The PAIA tools can provide the user with an estimate of the uncertainty of the results. • The PAIA method can be used to identify the major drivers of impact, known as hotspots, within the materials acquisition, manufacturing, fulfillment, and use of a generic product. • Transportation fulfillment impact of products via ground, ocean, and air shipment • The PAIA method can be used to relate attributes of a product to its environmental impact. • The results of the method and tools could be used to inform OEMs on areas in which to target additional data collection within the supply chain. • The results from the hot spot/what if analyses could be used to initiate conversations related to sustainability with suppliers or to innovate new processes/materials uses. • PAIA meets IEC TR 62921 requirements.	• PAIA may not be compliant with the primary data requirements of some LCA standards depending on the definitions and interpretations of those requirements. • The results of the PAIA tools are not designed to differentiate between products at the SKU level. The tools can offer a high-level estimate of impact along with the associated uncertainty of the results for product classes, but not for specific products. • The results of the PAIA tools should not be used for a regulated carbon footprint disclosure program • In the case of a major shift in technology or improvement in manufacturing, the PAIA tools may need to be reconfigured • Data within the tools are of varying quality (age, source, sample size, etc.). • The results of the PAIA tools are not intended to be applied to cradle-to-gate or component-level assessments • The results from the PAIA tools are liable to change over time as the methodology is improved and data is updated.

IBM and the environment

At IBM, our approach is twofold: we are working to make our existing products and processes more efficient for both the environment and for business, while also developing new innovations that can help the world become smarter, drive economic and operational improvements, increase accountability and lessen environmental impact.

IBM's first formal environmental and energy corporate policies date back to 1971 and 1974 respectively, and corporate-wide programs supporting them have been embedded within the company's global environmental management system (EMS), which is certified to the ISO 14001 EMS standard and ISO 50001 for Energy Management Systems. When ISO issued the ISO 50001 standard on energy management systems in June 2011, IBM initiated activities to achieve verification of conformity of our EMS against this newly published standard. Within one year of the issuance of the ISO standard, we achieved ISO 50001 registration of our energy management program at the corporate level as an integral component of IBM's global EMS. Our approach recognizes and leverages the fact that IBM's existing EMS addresses environmental, energy and chemical management programs.

IBM has been a leader in addressing climate change through our energy conservation and climate protection programs for decades. In February 2021, IBM announced its third successive goal for the use of renewable electricity, fifth successive goal to reduce greenhouse gas emissions, and set a new goal to achieve net zero greenhouse gas (GHG) emissions.

While climate change and greenhouse gas emissions have become some of the most broadly reported environmental issues of our times, IBM recognizes that we have a responsibility to manage all of our environmental intersections and setting voluntary goals has long been an integral part of IBM's Environmental Management System. In 2021, IBM also announced 21 goals for environmental sustainability. Many of the goals are new, some have been updated and others are continuing. Goals specific to the IBM Product Design for the Environment include:

1. For server products with a valid upgrade path, reduce power consumption per unit of delivered work versus the previous generation
2. Establish, by year-end 2021, individual baselines for fleet carbon intensity with each key carrier and shipment supplier involved with IBM's product distribution globally. Starting in 2022, convene with each supplier to set a fleet carbon intensity reduction target covering the services they provide to IBM
3. Source paper and paper/wood-based packaging directly procured by IBM from forests that are sustainably managed and certified as such.
4. Send no more than 3 percent (by weight) of end-of-life product waste to landfill or to incineration for treatment. Recycle or reuse at least 97 percent (by weight).
5. Eliminate nonessential plastic from the packaging of IBM logo hardware by year-end 2024. For essential plastic packaging, ensure they are designed to be 100 percent reusable, recyclable, or compostable; or incorporate 30 percent or more recycled content where technically feasible. (Examples of essential plastic packaging include electrostatic bags and certain cushions.)
6. Require all first-tier suppliers to maintain their own environmental management system; set goals regarding energy management, GHG emissions reduction, and waste management; and publicly disclose progress.
7. Require key suppliers in emissions-intensive business sectors to set an emissions reduction goal by 2022, addressing their Scope 1 and Scope 2 GHG emissions, that is aligned with scientific recommendations from the UN IPCC to limit Earth's warming to 1.5 degrees Celsius above pre-industrial levels.

For more information about IBM's 21 commitments, please see our 2020 IBM and the Environment Report.

IBM Corporation
New Orchard Road
Armonk, NY 10504
U.S.A.

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