SEAGATE

WHITE PAPER

Understanding life cycle assessment and embodied carbon

Exploring the environmental impact and sustainability of products.

8 minute read

In today's rapidly evolving technological landscape, it is crucial for industries to understand the environmental impact of their products. This white paper delves into the concepts of Life Cycle Assessment (LCA) and embodied carbon, offering a comprehensive analysis of their significance in evaluating and mitigating the environmental footprint of products—from creation to disposal.

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Life cycle assessment: an overview.

LCA is a systematic process used to evaluate the environmental impacts associated with all stages of a product's life. Often termed as a 'cradle-to-grave' analysis, LCA covers raw material extraction, manufacturing, distribution, use, and end-of-life disposal or recycling.

The LCA framework.

The LCA framework Seagate is using is structured around four key phases, as outlined in ISO 14040 and ISO 14044:

- Goal and scope. Define the purpose, boundaries, and functional unit of the assessment.
- Life cycle inventory (LCI). Collect data on energy, water, and material inputs and outputs.
- Life cycle impact assessment (LCIA). Evaluate the potential environmental impacts based on the inventory data.
- Interpretation. Analyze results to draw meaningful conclusions and identify opportunities for improvement.

Significance of conducting an LCA.

Conducting an LCA helps organizations identify and quantify the environmental impacts of their products, promoting informed decision-making to reduce their environmental footprint and enhance sustainability.

Impact categories in LCA.

Seagate assess our products' environmental impacts across several key categories relevant to storage products:

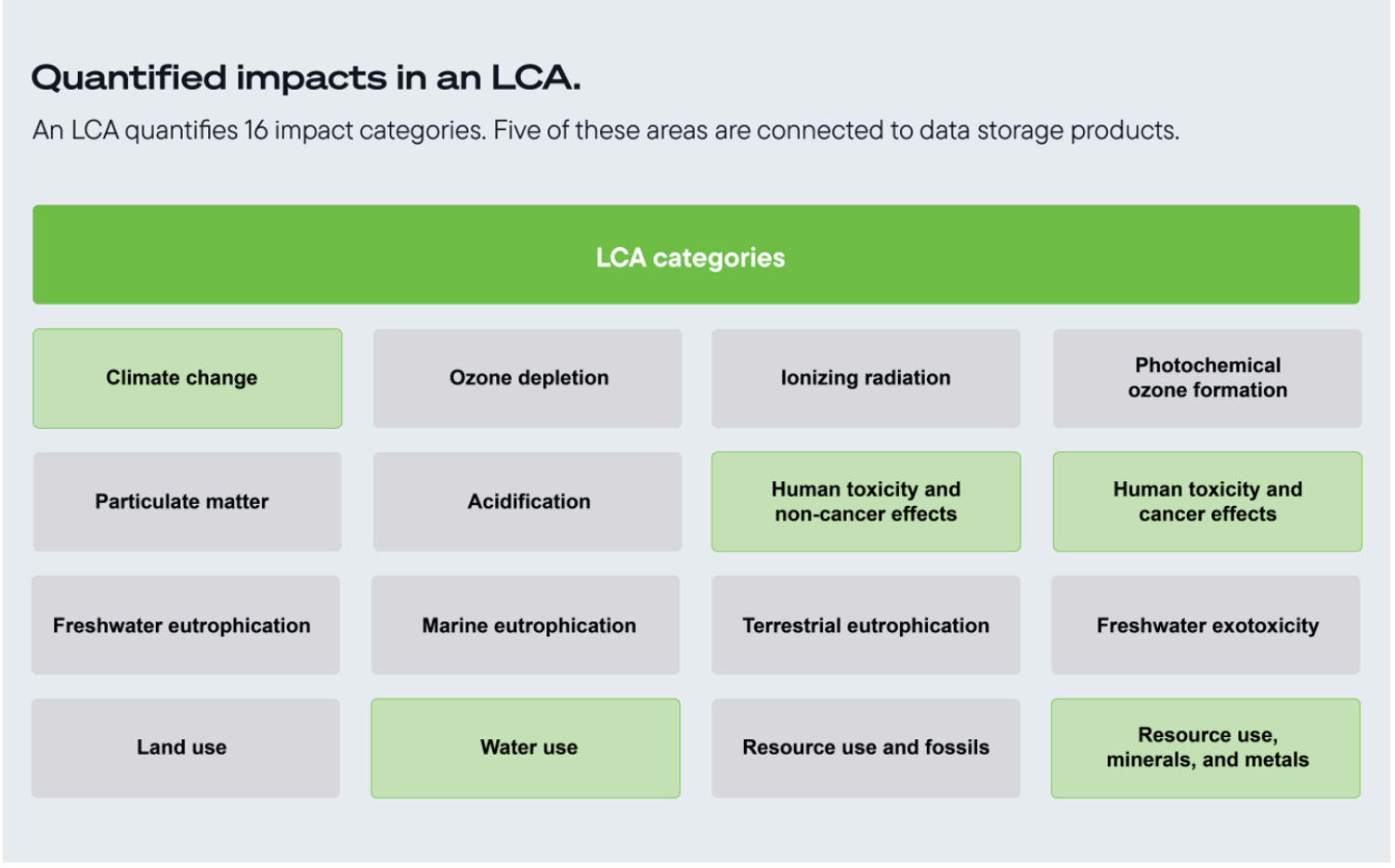
Global Warming: We assess our products' global warming impacts across the 213 elementary flows ReCiPe characterizes as GHGs, including the seven GHGs specified in the Greenhouse Gas Protocol Product Standard. These gases are commonly converted into carbon-dioxide equivalent (CO_2) to measure the global warming impacts of an activity. We do not assess emissions related to materials' natural carbon cycle (biogenic CO_2).

Human Toxicity: Evaluates the harmful effects of chemicals and heavy metals on human health, considering environmental persistence and accumulation in the food chain. Impacts are measured in Disability-Adjusted Life Years (DALY), representing health years lost due to disease or disability.

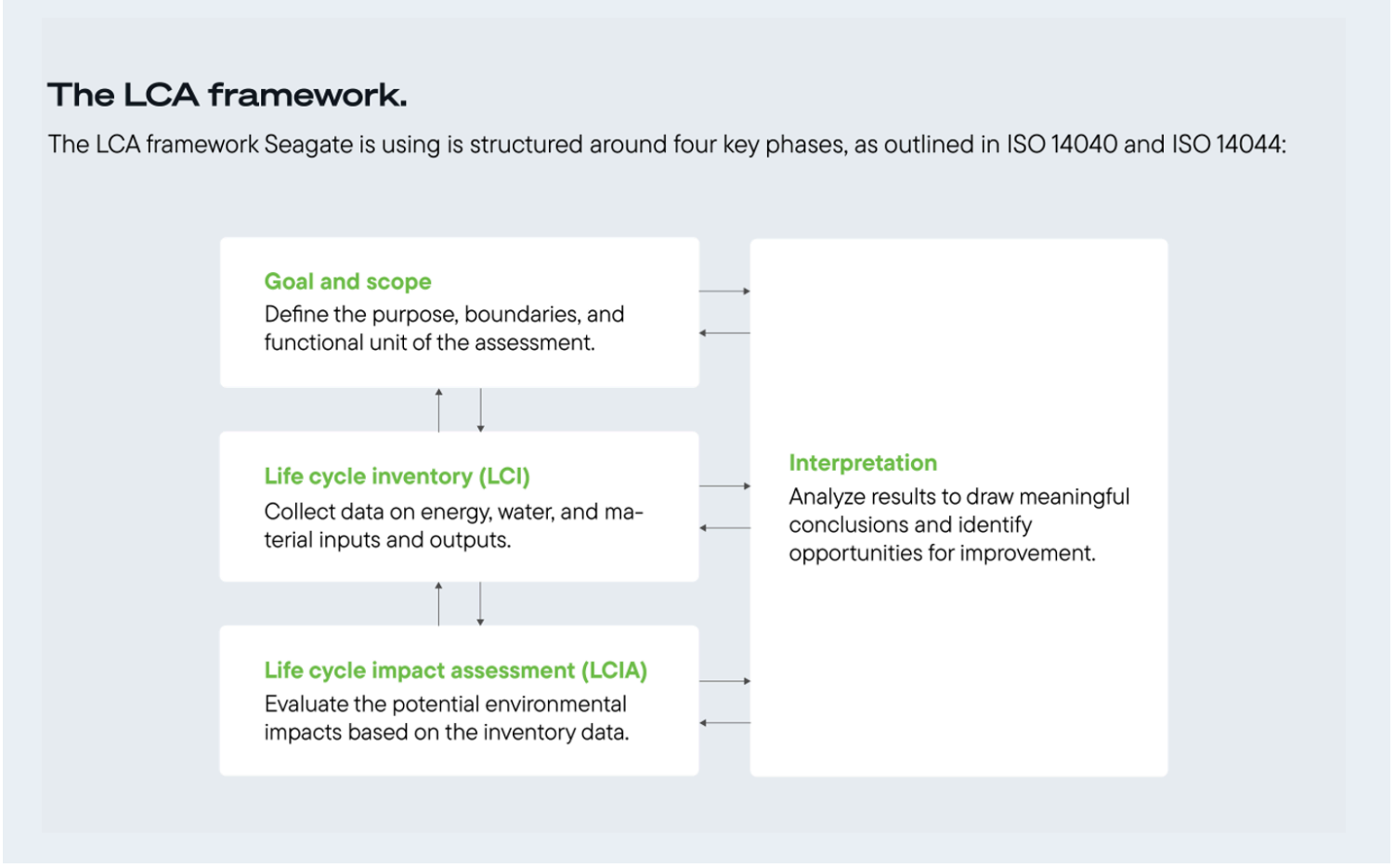
Water Consumption: Reflects the volume of freshwater (m^3) withdrawn to support production activities, without considering water quality or regional scarcity.

Mineral Resource Scarcity: Quantifies the consumption of mineral resources, normalized to copper extraction (kg Cu equivalent).

Understanding these categories helps us grasp the broader environmental ramifications of product design, material selection, manufacturing processes, and end-of-life options. Although our analysis encompasses 18 impact areas, our sustainability reports concentrate on the previously mentioned categories, as these are of greatest importance to our stakeholders.



Quantified impacts in an LCA.
An LCA quantifies 16 impact categories. Five of these areas are connected to data storage products.
LCA categories
Climate change
Ozone depletion
Ionizing radiation
Photochemical ozone formation
Particulate matter
Acidification
Human toxicity and non-cancer effects
Human toxicity and cancer effects
Freshwater eutrophication
Marine eutrophication
Terrestrial eutrophication
Freshwater exotoxicity
Land use
Water use
Resource use and fossils
Resource use, minerals, and metals



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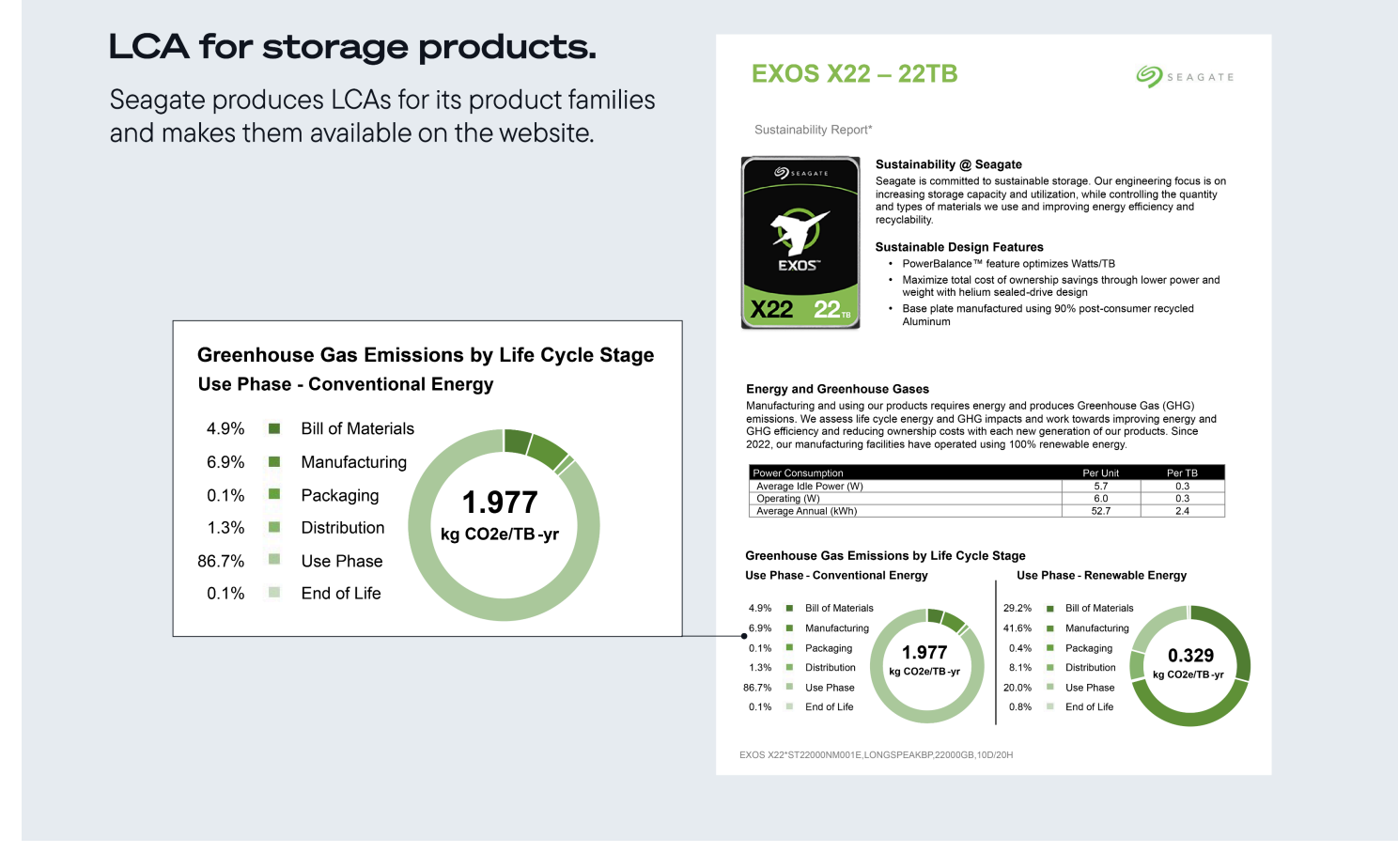
Evaluate the potential environmental impacts based on the inventory data.
Interpretation
Analyze results to draw meaningful conclusions and identify opportunities for improvement.

Case study: LCA for Seagate storage products.

At Seagate, transparency and sustainability are core values. To ensure the accuracy and reliability of our Life Cycle Assessments (LCAs), we engage a third-party auditor to independently verify our findings. We produce LCAs for our product families and make them available on our website, empowering our customers to make informed purchasing decisions based on the environmental impact of our products. For more information, visit our sustainability page: www.seagate.com/circularity.



LCA for storage products.
Seagate produces LCAs for its product families and makes them available on the website.
Greenhouse Gas Emissions by Life Cycle Stage
Use Phase - Conventional Energy
4.9% Bill of Materials
6.9% Manufacturing
0.1% Packaging
1.3% Distribution
86.7% Use Phase
0.1% End of Life
1.977
kg CO2e/TB-yr
EXOS X22 – 22TB
SEAGATE
Sustainability Report*
Sustainability @ Seagate
Sustainable Design Features
Energy and Greenhouse Gases
Greenhouse Gas Emissions by Life Cycle Stage
Use Phase - Conventional Energy
Use Phase - Renewable Energy
0.329
kg CO2e/TB-yr

Understand the concept of embodied carbon.

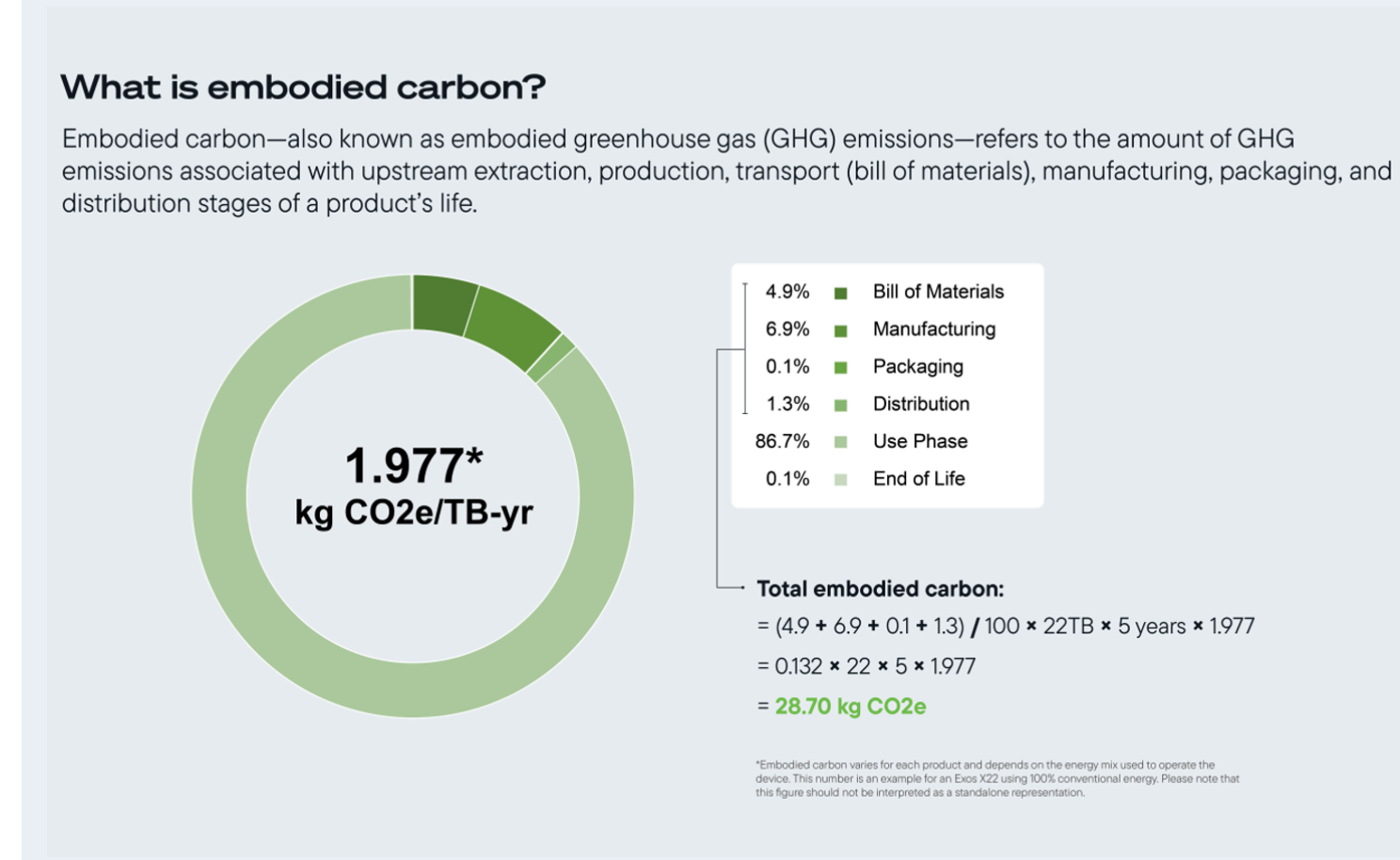
Embodied carbon—also known as embodied greenhouse gas (GHG) emissions—refers to the total GHG emissions associated with the upstream extraction, production, transport, manufacturing, packaging, and distribution stages of a product's life. Essentially, it encompasses all the emissions that are 'embodied' in the product before it even reaches the consumer.

Calculating embodied carbon: a practical example.

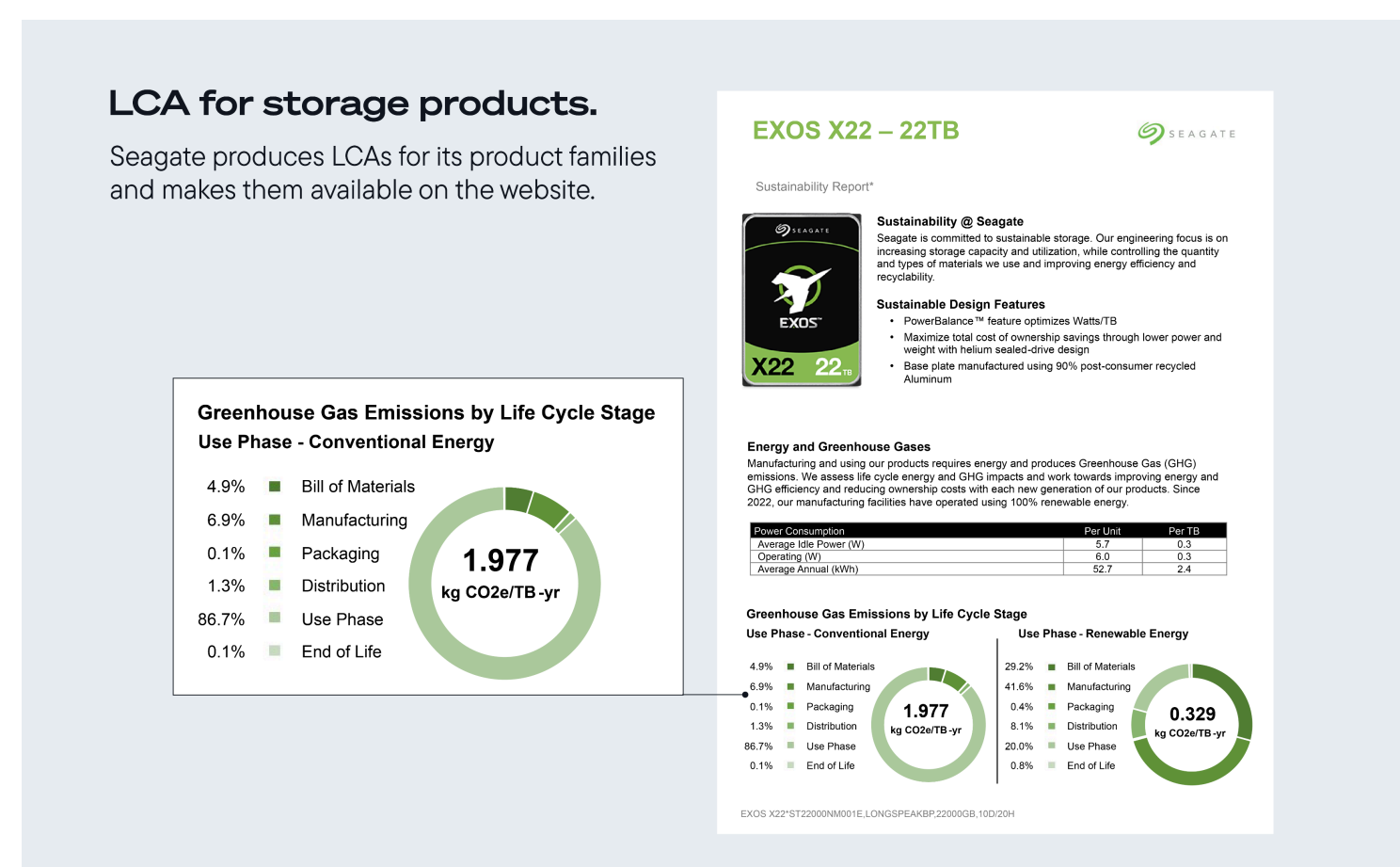
To illustrate the concept of embodied carbon, let's look at Seagate Exos® X22 storage product. The total embodied carbon for the Exos X22 can be calculated using the following formula:

Total embodied carbon
= (4.9+6.9+0.1+1.3)/100 × 22TB × 5 years × 1.977
= 0.132 × 22 X 5 × 1.977
= 28.70 Kg CO_2

This calculation considers the various stages from raw material extraction to distribution, accounting for the emissions associated with each step.



What is embodied carbon?
Embodied carbon—also known as embodied greenhouse gas (GHG) emissions—refers to the amount of GHG emissions associated with upstream extraction, production, transport (bill of materials), manufacturing, packaging, and distribution stages of a product's life.
1.977*
kg CO2e/TB-yr
4.9% Bill of Materials
6.9% Manufacturing
0.1% Packaging
1.3% Distribution
86.7% Use Phase
0.1% End of Life
Total embodied carbon:
= (4.9 + 6.9 + 0.1 + 1.3) / 100 × 22TB × 5 years × 1.977
= 0.132 × 22 × 5 × 1.977
= 28.70 kg CO2e



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kg CO2e/TB-yr
EXOS X22 – 22TB

Product Sustainability | Seagate US

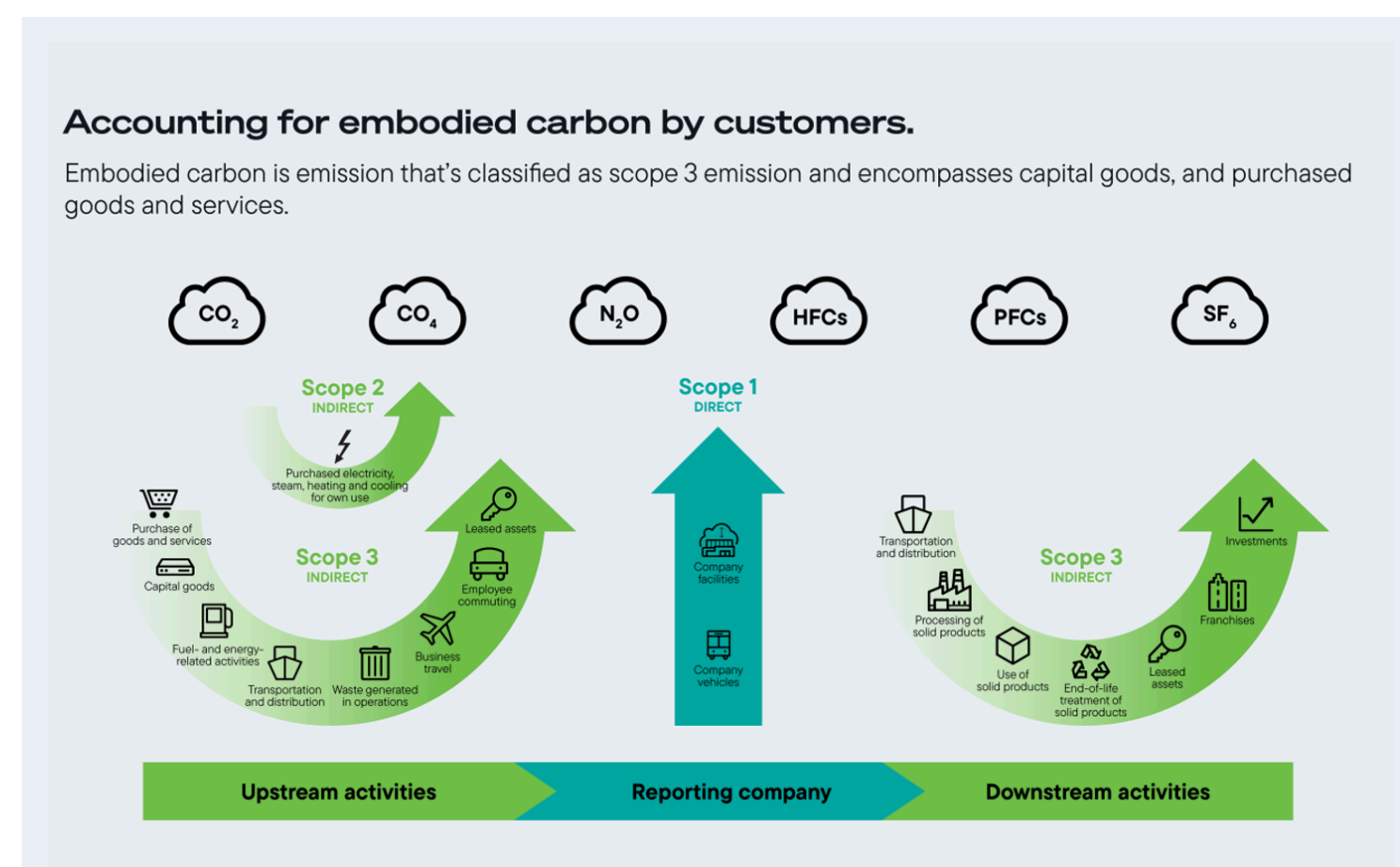
This table compares the embodied carbon of SSDs, hard drives, and tape by examining different capacities, usage, and lifespans over a 5-year period. It shows the embodied carbon per device and TB per year for this duration. Power consumption is also included to demonstrate how improper storage media choices can boost total data center emissions. Thus, selecting the appropriate storage media mix is vital for both TCO and sustainability.

Storage media	Embodied carbon by product (Kg CO_2)	Embodied carbon per TB (CO_2/TB)	Embodied carbon per TB per year (CO_2/TB/year)	Operating power in watt	Watt/TB
SSD	160[1]	32[1]	32[1]	15[4]	0.5[4]
Hard Drive[3]	29,7	<1	<0.2	9.6	0.32
LTO Tape[3,5]	48	2.66	<0.6	37	1.1

1. [2207.10793] The Dirty Secret of SSDs: Embodied Carbon (arxiv.org); The Dirty Secret of SSDs: Embodied Carbon (youtube.com)
2. Embodied carbon prediction for Seagate 30TB Mozaic Hard Drive per TB for five-year life cycle
3. Breakdown of the CO_2 and Other Positive Sustainability Impacts of IBM Physical Tape Products 1 LTO 9 drive + 1 LTO 9 Media using total embodied carbon with 5 Years life cycle for all technologies
4. 30.7TB SSD 15 watt operating and 4-watt idle power
5. Power consumption and cooling requirements - IBM Documentation LTO 9: 37 Watt operating and 18-watt idle power; Watt/TB assumes that LTO9 can write 34.5TB per day or 1.9 tape media

Scope 3 emissions and embodied carbon.

Embodied carbon is classified as a scope 3 emission, which includes those emissions from asset operations not produced, owned, or controlled by the business. This includes purchased goods and services, capital goods, and other indirect emissions. Understanding and accounting for these emissions is crucial for reducing the overall environmental impact.



Accounting for embodied carbon by customers.
Embodied carbon is emission that's classified as scope 3 emission and encompasses capital goods, and purchased goods and services.
CO2
CO4
N2O
HFCs
PFCs
SF6
Scope 2
INDIRECT
Purchased electricity, steam, heating and cooling for own use
Scope 3
INDIRECT
Purchase of goods and services
Capital goods
Fuel- and energy-related activities
Transportation and distribution
Waste generated in operations
Business travel
Employee commuting
Leased assets
Scope 1
DIRECT
Company facilities
Company vehicles
Scope 3
INDIRECT
Transportation and distribution
Processing of solid products
Use of solid products
End-of-life treatment of solid products
Leased assets
Franchises
Investments
Upstream activities
Reporting company
Downstream activities

Reducing embodied carbon recommendations and best practices.

To effectively manage and reduce embodied carbon, companies should consider the following recommendations:

- Product design. Optimize product design to use fewer materials and energy.
- Sustainable materials. Select sustainable and low-impact materials.
- Energy efficiency. Improve energy efficiency in manufacturing processes and transition to renewable energy sources to further reduce embodied carbon.
- Product end-of-life management. Implement effective recycling and disposal strategies.
- Supplier engagement. Work with suppliers to reduce upstream emissions.

The path to a greener, sustainable future.

The concepts of LCA and embodied carbon are central to Seagate's journey toward sustainability. By thoroughly assessing the environmental impacts of products from cradle to grave and understanding the emissions associated with every stage of a product's life, we can make more informed and responsible choices. Seagate remains dedicated to fostering transparency and sustainability, ensuring our products meet the needs of our customers and align with our commitment to a greener and more sustainable future.

Incorporating LCA and embodied carbon assessments into our decision-making processes is not just beneficial for the environment but essential for the long-term viability of our business and society. As we continue to innovate and adapt, these tools will play a critical role in guiding us toward more sustainable practices and reducing our overall environmental footprint.

The Seagate Circularity program is another key element of our sustainability strategy. It aims to prolong the life of our products through reuse, refurbishment, and recycling, thereby reducing waste and increasing resource efficiency. By choosing Seagate Circularity, customers support a brand dedicated to environmental stewardship and contributing to a circular economy. In addition to reducing environmental impacts, this strategy helps our products deliver value throughout their entire lifecycle, promoting more responsible consumption habits. For further details about Seagate Circularity, please visit: www.seagate.com/circularity.

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