AGENDA

- Carbon Emissions Landscape

- Datacenter Industry - Carbon Goals

- Storage – Capacity Growth & Carbon Growth

- Major Contributors of Storage Infrastructure Carbon

- Opportunities for Storage Carbon Footprint reduction

Carbon Emission Landscape

IT Communication & Tech (ICT) Industry's Contribution to Carbon Emissions

4X

Percentage %

16
14
12
10
8
6
4
3.6
2
0

2020 2025 2030 2035 2040

=

Half of entire Transportation sectors' current Emissions

Agriculture 10%

Commercial & Residential 13%

Transportation 28%

Industry 23%

Electric Power 25%
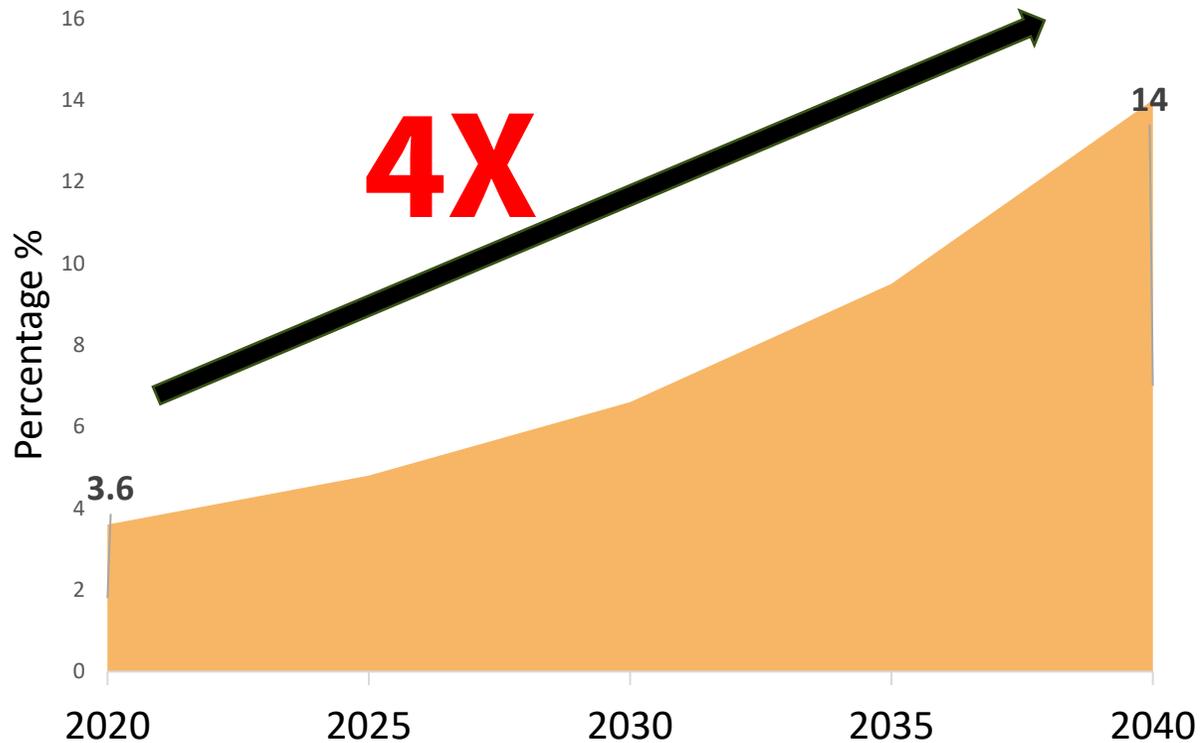
Sources: Science Direct: Assessing ICT global emissions footprint: Trends to 2040 & recommendations
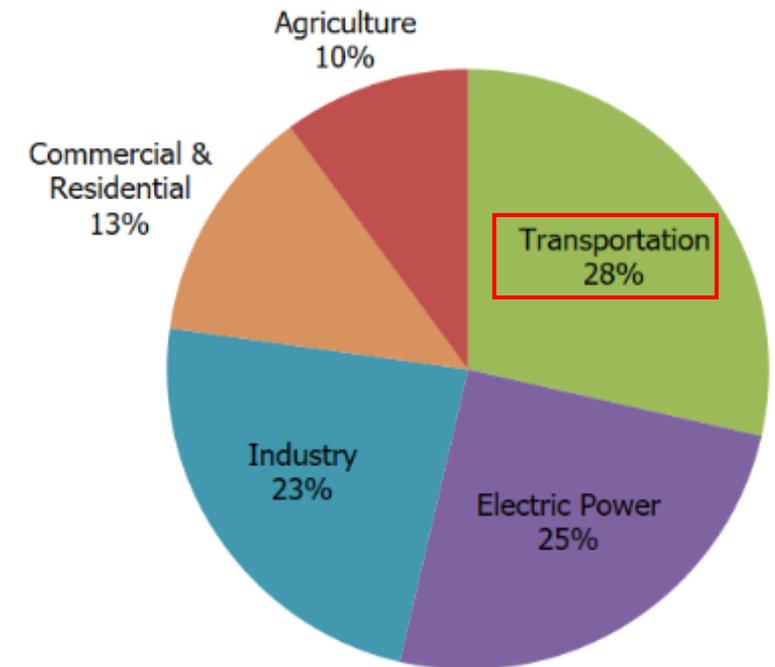
Source: US Environmental Protection Agency

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Green Datacenter Market Revenue Prediction – 2022 to 2030
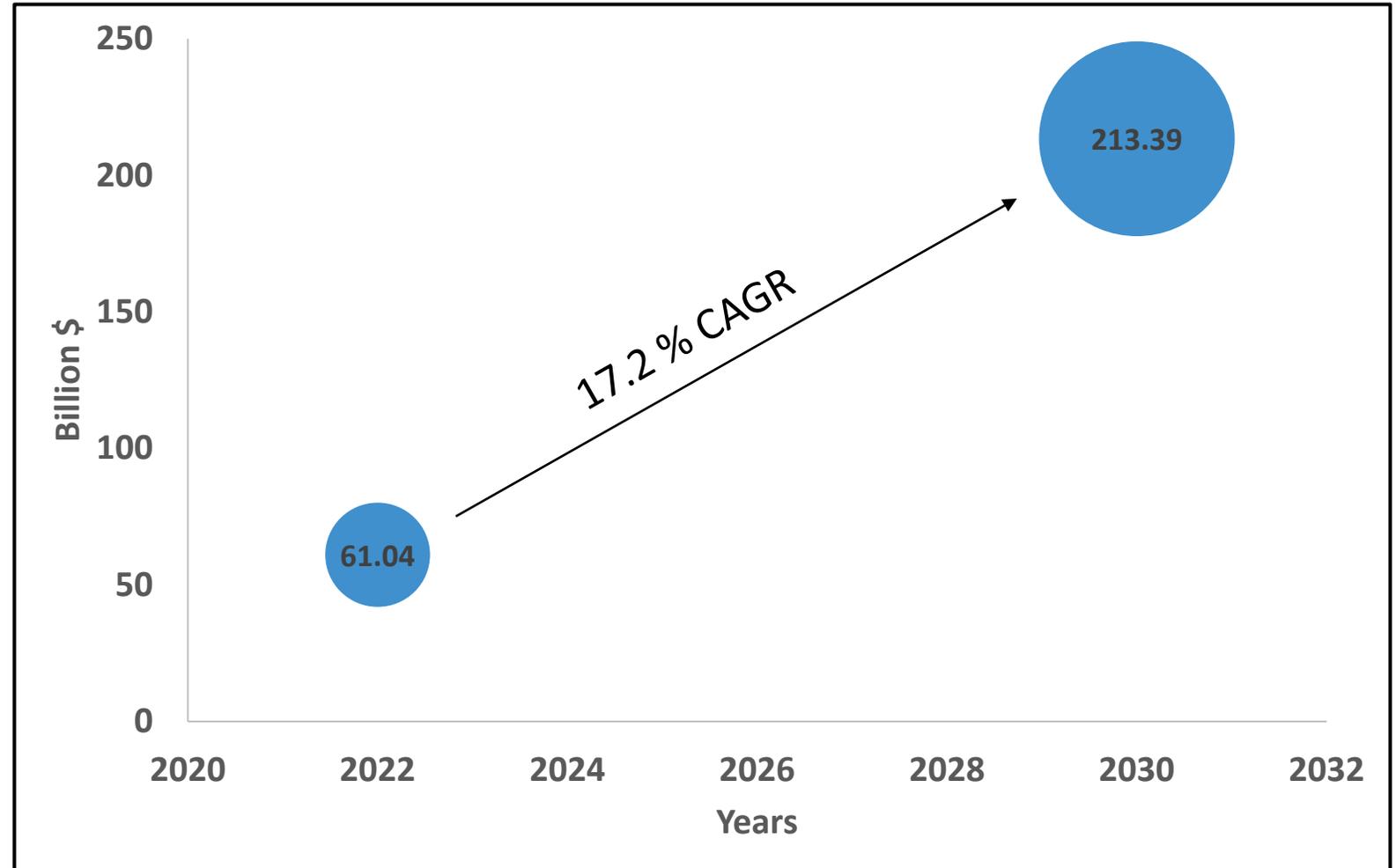
Sources: Fortune Business Insights

Datacenter Industry – Carbon Goals

Industry Carbon Emission Reduction Goals

2050

Dell
HPE
Microsoft
Samsung

2040

AWS
Google Cloud
HPE
Intel
Meta
Microsoft
Pure Storage
Schneider Electric
Seagate

2030

Dell
Google Cloud
HPE
IBM
Meta
Microsoft
Schneider Electric
Seagate

2025

AWS
Google Cloud
Microsoft
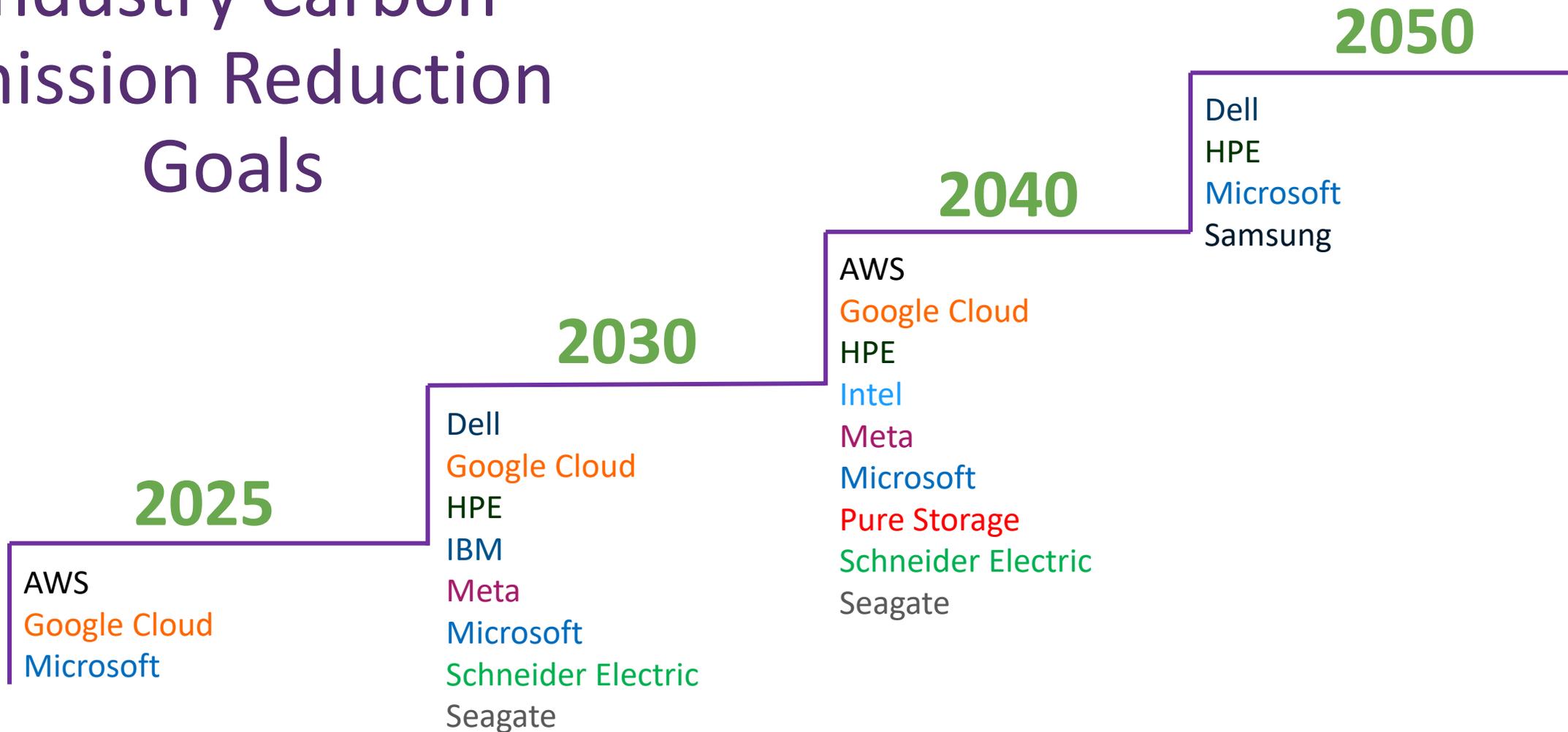
Microsoft Sustainability Goals 2030

CARBON NEGATIVE

2030: Offset or remove more carbon from the atmosphere than we emit

2050: Remove an equivalent amount of carbon Microsoft has emitted, since we were founded in 1975

WATER POSITIVE

2030: Replenish more water than our global consumption

ZERO WASTE

2030: Reducing, Reusing and Recycling to drive no waste direct-to-landfill

Source: [MSFT Sustainability Report 2022]

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Carbon Emission Categories

CATEGORIES OF EMISSIONS	DESCRIPTION	SUB-CATEGORY OF INTEREST **Cloud Storage Provider's Perspective*
Scope 1 Carbon Emissions	**"BURN"** Carbon emission due to direct combustion / burning of fuel purchased. (Direct sources of emission)	
Scope 2 Carbon Emissions	**"BUY"** Carbon emissions associated with purchased electricity/energy. (Indirect sources of emission)	*Operational Carbon (Power)*
Scope 3 Carbon Emissions	**"BEYOND"** Carbon emissions due to all the other products, machinery, services, etc. that one uses or powers.	*Embodied Carbon*

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Carbon Emissions – Microsoft - 2022

Scope 1   **Scope 2**   **Scope 3**

<1%

~28%

~71%

- Operational Carbon

- Largest section of emissions
- Includes "Embodied Carbon" as a major contributor
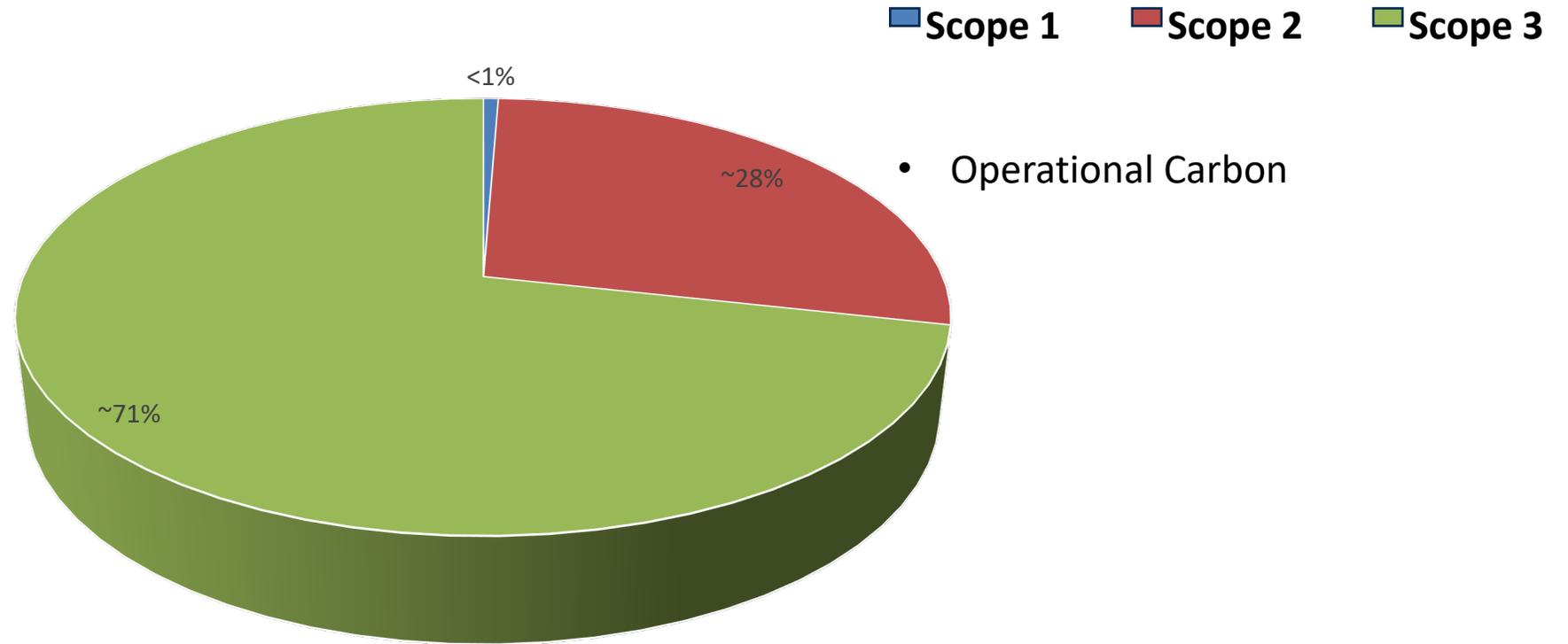
Detailed 2030 Sustainability Goals:

- **Scope 1,2** : Near Zero Emission Target
- **Scope 3**: Reduce by more than half from 2020 baseline

Source: [MSFT Sustainability Report 2022]

Storage – Capacity Growth & Carbon Growth

Nearly **~175** Zettabytes Data Created - 2025

~5 zettabytes storage media installed base - 2025

~17% compound annual growth of installed capacity

Annual Size of the Global Datasphere

175 ZB
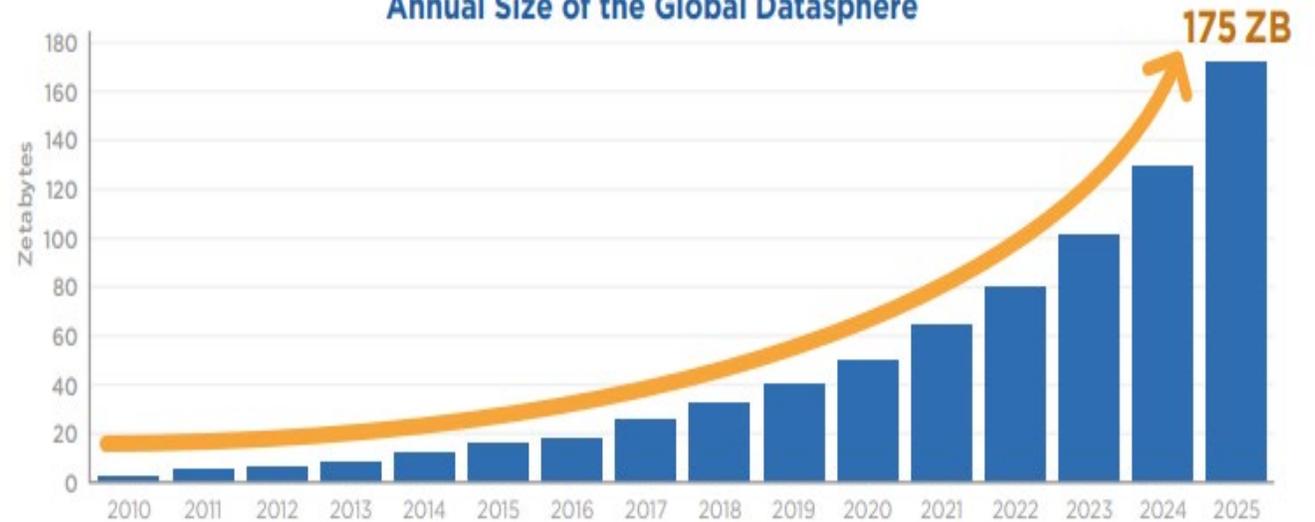
Source: Data Age 2025, sponsored by Seagate with data from IDC Global DataSphere, Nov 2018

Worldwide Byte Shipments by Storage Media Type

- HDD
- SSD
- NVM-NAND
- NVM-Other
- Optical
- Tape
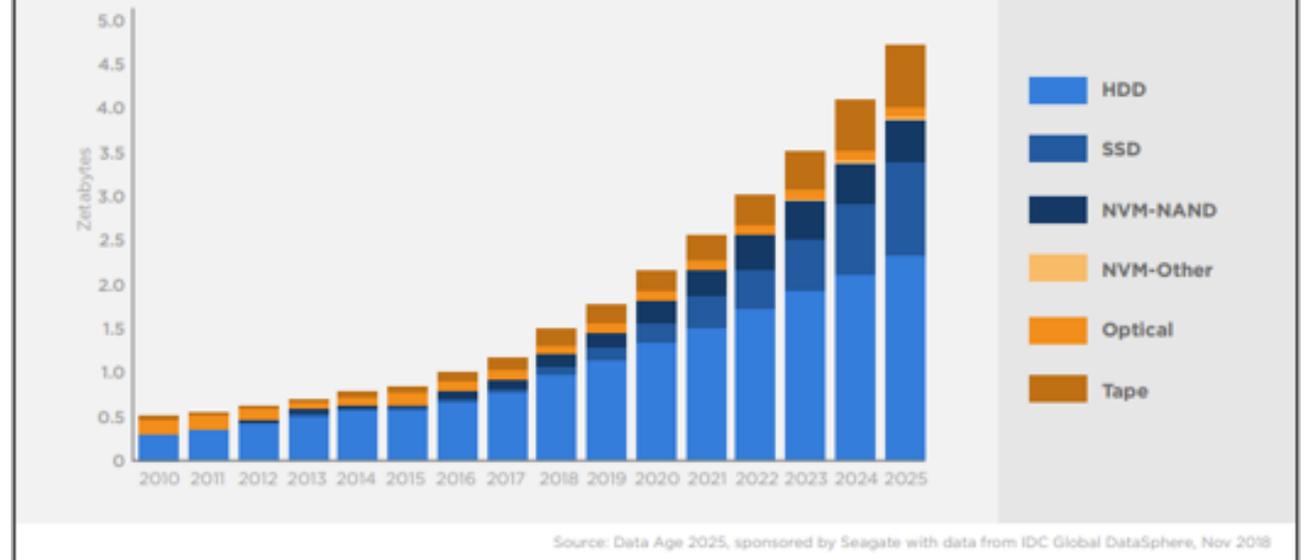
Source: Data Age 2025, sponsored by Seagate with data from IDC Global DataSphere, Nov 2018

Major Contributors of Storage IT Infrastructures' Carbon Emissions

Cloud Storage Provider's Perspective

Total Carbon Emissions by Storage Infrastructure

SCOPE 3 Embodied Carbon

SCOPE 2 – Operational Carbon

Manufacturing   Transport   Installation

Power utilization by Storage IT Racks
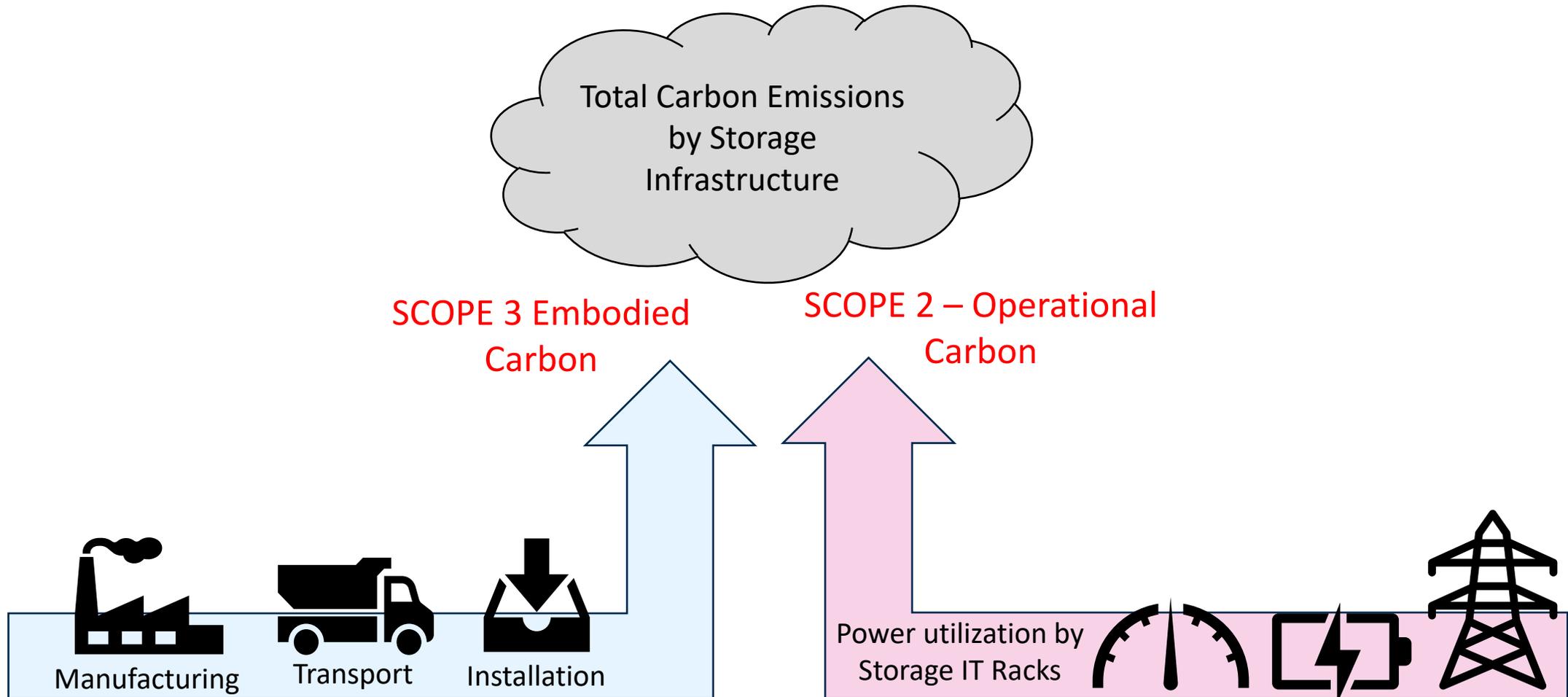
Total Cost of Ownership (TCO)

Upfront Cost

+

Operational Cost

Per unit performance

Total Carbon Cost of Ownership (TCCO)

Embodied Carbon

+

Operational Carbon

Per unit performance

Major Carbon Contributors of Storage IT Infrastructure
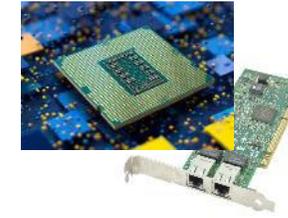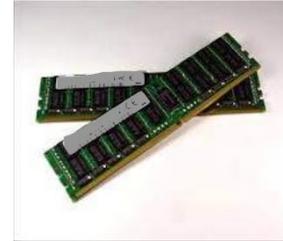
	HDDs	SSDs	Memory	Processors / NICs / ICs	Chassis / Enclosure

Limitations - in Comparing Carbon Reports from various devices / vendors:
- Lack of ready Carbon Assessment reports (via LifeCycle Assessment (LCA))
- LCA methodologies not industry standardized

Attempt – To run a similar assessment methodology for comparison on all device categories

Major Carbon Contributors of Storage IT Infrastructure

	HDDs	SSDs	Memory	Processors / NICs / ICs	Chassis / Enclosure
Embodied Carbon (Scope 3) Contribution	Med	High	High	Med	High
Operational Carbon (Power - Scope2) Contribution	Med	Low	Med	High	--
% of Storage Fleet Infrastructure	High	Med	Low	Low	High

Storage – Carbon Reduction Opportunities

Opportunities – Design For Sustainability

High Embodied Carbon

- Design for longer device Lifespan — Extend lifespan for devices while delivering to key product metrics & power
- Design for reuse enablement (Circularity) — Ability to confidently & securely wipe stored data & reuse (Circular Economy)
- Design for recycle enablement — Enable easy recycle of components / Sub-components

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Opportunities – Design For Sustainability

High Operational Carbon (Power)

Design for better power telemetry on device	Closer monitoring of power & utilization of devices
Design for better low power states & idle states	Enable usage of low power states with manageable latencies for systems
Design for efficient active power usage	Minimizing device power usage to reduce the aggregate power

Additional - Continuous Effort to use Renewable Energy for Power Usage

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Longer Term Opportunities –
New media with lower Carbon Footprint

SILICA

DNA / Molecular

Recyclable media material
No power used in the Storage phase (after writing data)
Less data refreshes needed as the storage media lasts longer

CALL TO ACTION

With rapid growth of Cloud Storage,

- Design for reducing embodied carbon
- Design for reducing operational carbon
- Explore new media with lower carbon footprint

THANK YOU!