CARBON EMISSION CATEGORIES

	DESCRIPTION *Cloud Storage Provider's Point-Of-View	SUB-CATEGORY OF INTEREST
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*

MAJOR CONTRIBUTORS OF DATACENTER IT INFRASTRUCTURE'S CARBON EMISSIONS

Cloud Storage Provider's Point-Of-View
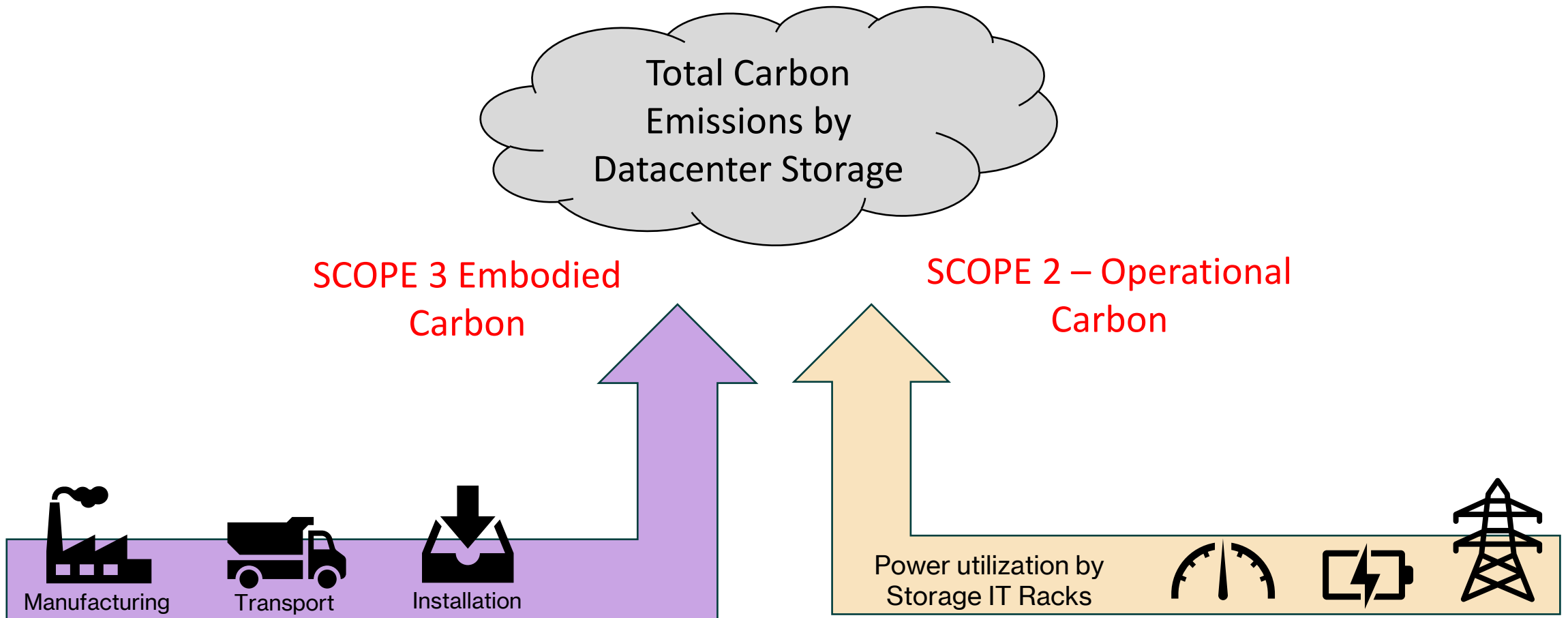
TOTAL CARBON COST OF OWNERSHIP (TCCO)

Total Cost of Ownership (TCO)

Total Carbon Cost of Ownership (TCCO)

Upfront Cost

+

Operational Cost

Per unit Ability

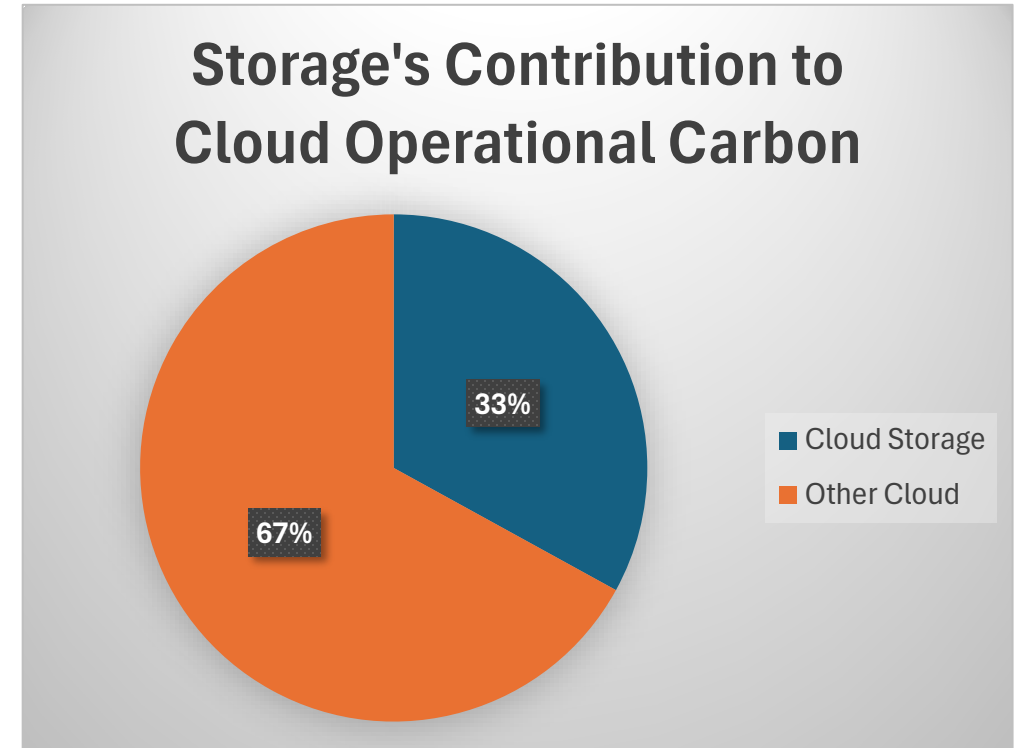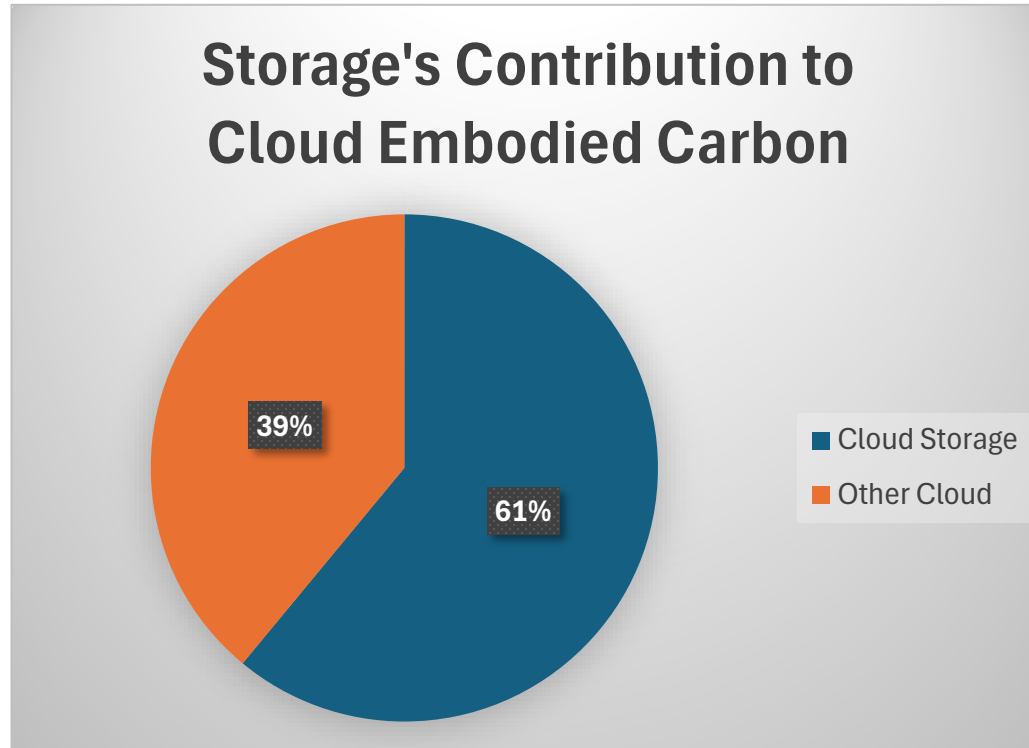| Embodied Carbon |
|:---:|

+

Operational Carbon

Per unit Ability

Normalized Carbon Metric example : Net Carbon / Device Capacity

STUDY OF CARBON IN DATACENTER STORAGE

"Call for Research on Storage Emissions", Microsoft, Carnegie Mellon University

Storage's Contribution to Cloud Embodied Carbon

- 39%
- 61%

Cloud Storage
Other Cloud

Storage's Contribution to Cloud Operational Carbon

- 33%
- 67%

Cloud Storage
Other Cloud

Storage racks and local storage devices — **make up 33% of operational and 61% of embodied emissions.**

Embodied Carbon is a major problem for Storage Systems/Devices

EMBODIED CARBON IN DATACENTER STORAGE

Where do Embodied Carbon Emissions come from?

Embodied Emissions	CPU	DRAM	SSD	HDD	Other
Compute Rack	4%	40%	30%	0%	26%
SSD Rack	1%	9%	**80%**	1%	9%
HDD Rack	2%	11%	14%	**41%**	33%

Table 3: Embodied emission breakdown for Azure racks.

Where do Operational Carbon Emissions come from?

Operational Emissions	CPU	DRAM	SSD	HDD	Other
Compute Rack	42%	18%	19%	0%	21%
SSD Rack	32%	8%	**38%**	1%	21%
HDD Rack	26%	5%	7%	**41%**	21%

Table 2: Operational emission breakdown for Azure rack types.

OPPORTUNITIES FOR CARBON REDUCTION IN STORAGE

This comprises denser drives resolving IO constraints

Adopt Denser Drives

Archival Storage Media is seen to have lower Embodied Carbon impact

Adopt More Archival Media

Power Efficiency & Interoperability

Design for Longer Lifespan

Circular / Reuse of Storage Systems

Helping Operational Carbon

Helping Embodied Carbon

Thank You

Questions?