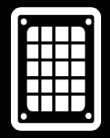
Navigating the Intersection of Data Growth, Sustainability, and Innovation in Data Centers

How technology helps with Sustainability

Different Storage Technologies, with fundamentally different approaches to reading and writing data



SSD/Flash

- Electric recording
- Printed circuit board
- Data retention varies by use-case
- Performance for realtime data processing

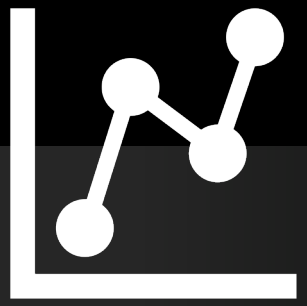
Hard Drive

- Magnetic recording
- Mechanical device
- High data retention
- Performance for general purpose workloads

Tape

- Magnetic recording
- LTO by IBM
- Mechanical device with Drive + Removable Media
- Cold archive storage
- Sequential Data Access
- Data retention 30 Years
- Media migration required

Opportunities AND Challenges



Explosive Data Creation

- Faster AI Productization
- New Revenue Opportunities
- Richer Customer Insights

VS

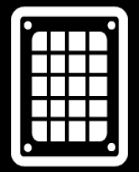
Resource Scarcity

- Space
- Electricity
- Budget

Enterprises must quickly increase storage capacity at an ever-decreasing per-TB cost and resource impact.

Embodied Carbon Emissions of Different Storage Technologies

Material Sourcing, Manufacturing, Assembly



160Kg[1] CO_2/TB

SSD

- Producted in places with limited renewable energy
- Growing storage density requires more energy.

<0.1 Kg[2] CO_2/TB

Hard Drive

- Higher storage desity per platter no significant impact
- Hard drives with same amount of platters have similar embodied carbon
- Use of recycled components
- High percentage of renewable energy

<2.6 Kg[3] CO_2 /TB

Tape + Media

- Complex mechanical device
- Tape Drive + Media
- 1 FH drive + 1 Media = 2.66 Kg CO_2
- 1 HH drive + 1 Media = 2.14 Kg CO_2
- CO_2 emission with corresponding Media attach rate
  - FH Drive: 0.4Kg CO_2 /TB
  - HH Drive: 0.5Kg CO_2 /TB

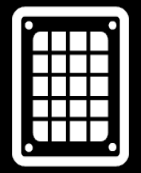
[1] [2207.10793] The Dirty Secret of SSDs: Embodied Carbon (arxiv.org); The Dirty Secret of SSDs: Embodied Carbon (youtube.com)

[2] Embodied carbon prediction for Seagate 32TB Mozaic Hard Drive

[3] Breakdown of the CO2e and Other Positive Sustainability Impacts of IBM Physical Tape Products

Data Management and Workload is key for Data Center Storage Sustainability

Operating power consumption permanent Write/Read operations



2 Watt/TB[3]

SSD

0.31 Watt/TB[2]

Hard Drive

1.1 Watt/TB[1]

LTO Tape Drive

0 Watt/TB

LTO Media

1 Power consumption and cooling requirements - IBM Documentation LTO 9: 37 Watt operating and 18 Watt idle power

2. Seagate 30TB Mozaic hard drive 9.4 Watt operating and 5.4 Watt idle power

3. 30.7TB SSD 15 Watt operating and 4 Watt idle power

Is The Energy Saving of SSDs a Reason to Replace Hard Drives, at Scale in a Data Center?

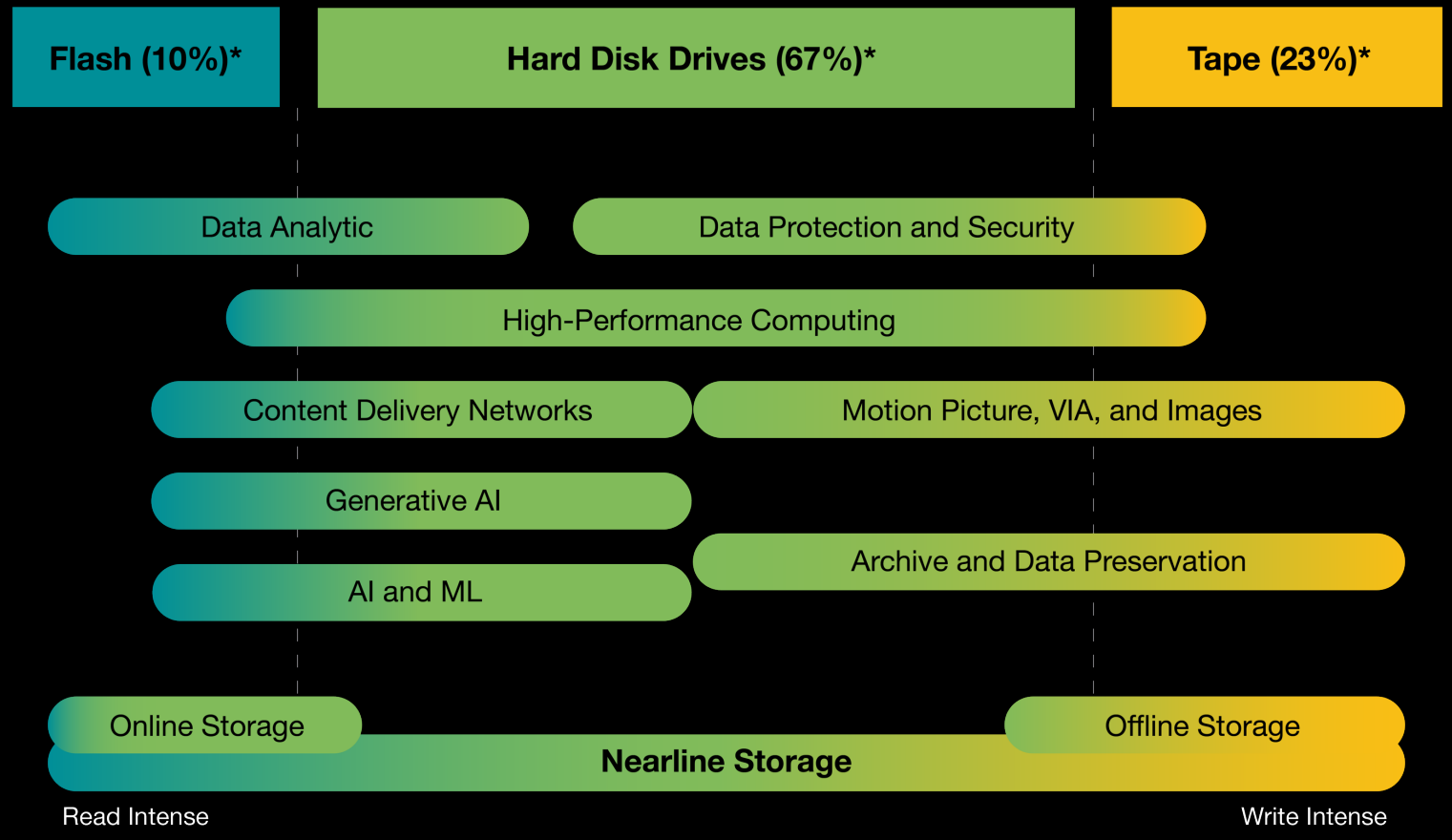
Power consumption of flash systems (W/TB) is higher compared to hard disk systems due to overhead and data protection activities.

Hard Drive Systems lead Terabyte per Rack Unit. Another consideration for data management workloads.

By far the weightiest element of TCO per purchased TB is device acquisition (in green). This was true even in 2023, when costs of NAND dropped temporarily. In contrast, power (OpEx, in teal) is a small factor. Other costs (CapEx of rack hardware per raw TB and OpEx of replacement servicing per raw TB, in yellow) are also significantly smaller than device acquisition costs. Source: SNIA.

STORAGE TECHNOLOGY SYNERGIES

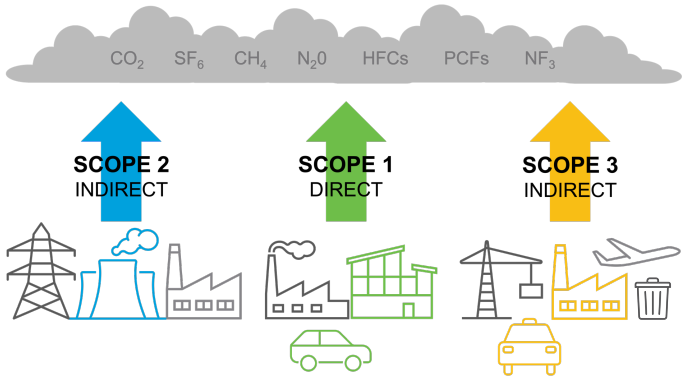
Use Case, Storage Technology, and Workload



Data center workloads and use cases ideal for NAND, hard drive, and tape storage.
Source: Seagate analysis of average workloads in *IDC Global StorageSphere Forecast, 2023–2027* Doc. #US50851423, June 2023.

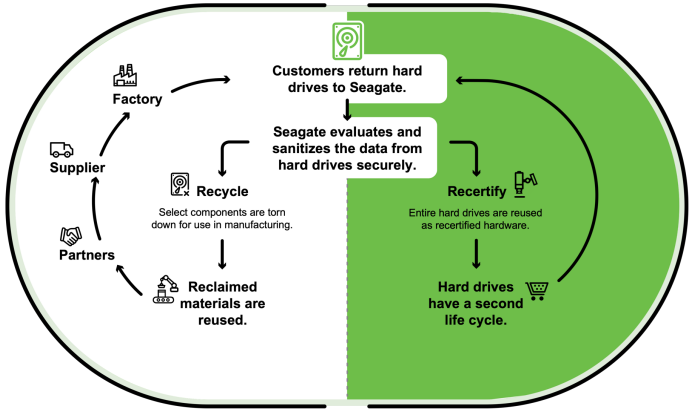
Seagate Strategies to Create a Sustainable Datasphere

Sustainable Operations



Sustainable Products

Sustainable Circularity



Sustainable Products

Design with increased drive capacity, ease of recycling, power efficiency, and security.

- Eco design standards
- Design for circularity
- Secure encryption/erase
- Lower power solutions
- Ethical sourcing
- Increase recycled content
- Hazardous material reduction

Typical data center upgrade

EXOS™ X10

10TB, 7 platters
AD = 1.42TB/platter

0.84 Watt/TB

>60%
Power Savings*

>70%
Embodied Carbon* Reduction

mozaic 3+

30TB, 10 platters
AD = 3.0TB/platter

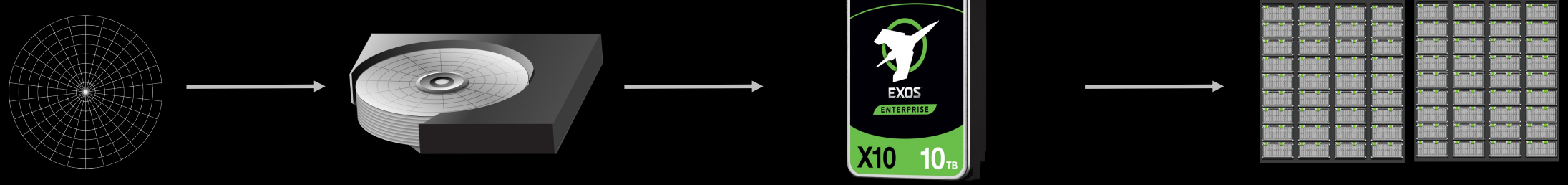
0.32 Watt/TB

*Savings calculated per TB. Method: 10TB to 30TB capacity upgrade, comparing Exos X10 10TB to Exos X 30TB Mozaic drive, max operating power,

The impact of areal density at scale is profound

Upgrading a fleet of 10TB with 30TB drives delivers **3x** the data center capacity in the same floor space

PLATTER	HARD DRIVE	HARD DRIVE CAPACITY	DATA CENTER
1.42TB per platter	7 platter	10TB	1 EXABYTES
3TB per platter	10 platter	30TB	3 EXABYTES 4 EXABYTES with CORVAUT



Data Durability & Sustainability

ADAPT + ADR technology reduces human intervention and e-waste.

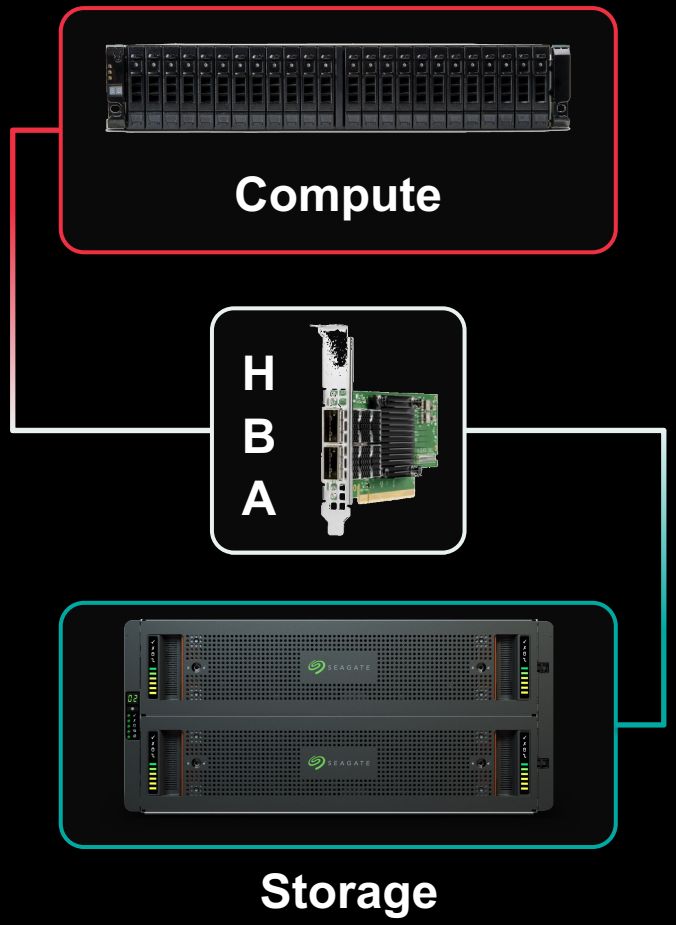
ADAPT: Spare Pool: Drives & Capacity

ADR: Spare Pool: Drives & Reduced Capacity

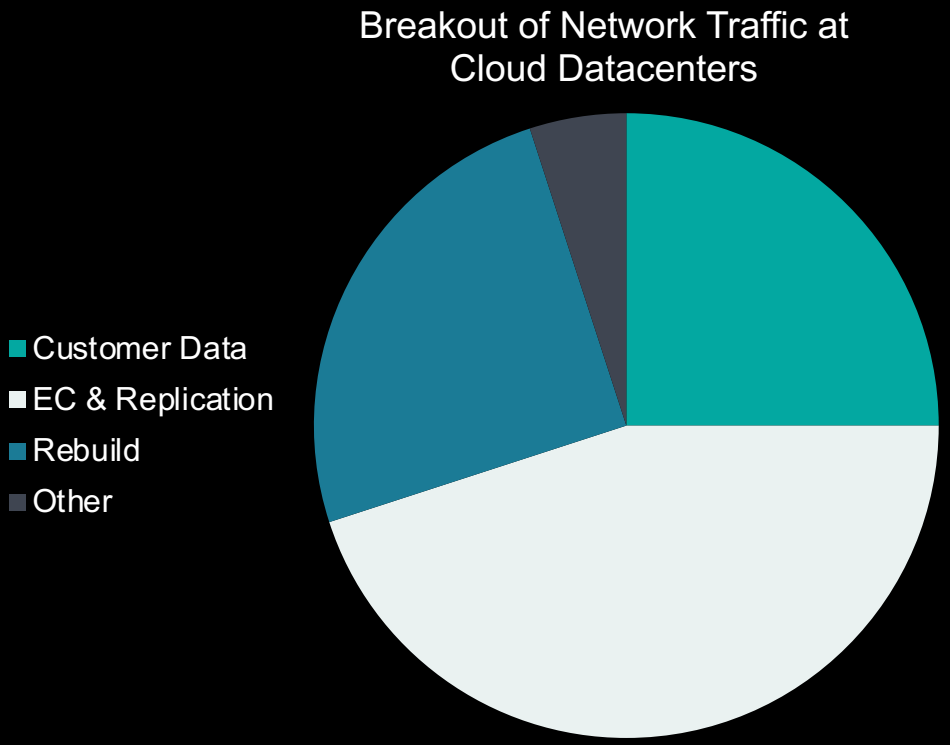
- Extending HDD lifetime saves 275x more CO^2 than recycling and avoids e-waste[1]
- Drive replacements cost data centers over $1,000 per device replacement
- All HDDs feature Instant Secure Erase for easy reuse or retirement
- Additional benefits: compute + networking, software licenses savings and faster hard drive rebuild time without performance impact.

1: Jin, H., Frost, K., Sousa, I., Ghaderi, H., Bevan, A., Zakotnik, M. and Handwerker, C., 2020. Life cycle assessment of emerging technologies on value recovery from Hard Drives. *Resources, Conservation and Recycling*, 157, p.104781.

Hidden cost of data management



- I/O Customer Data
- Data Protection
- Drive Regeneration
- Security
- Storage Management



Storage providers are forced to sacrifice host resources to protect their customers data.

Superior Scale-Out TCO

Best In-Class Data Center Efficiency with EXOS CORVAULT™

20PB Solution

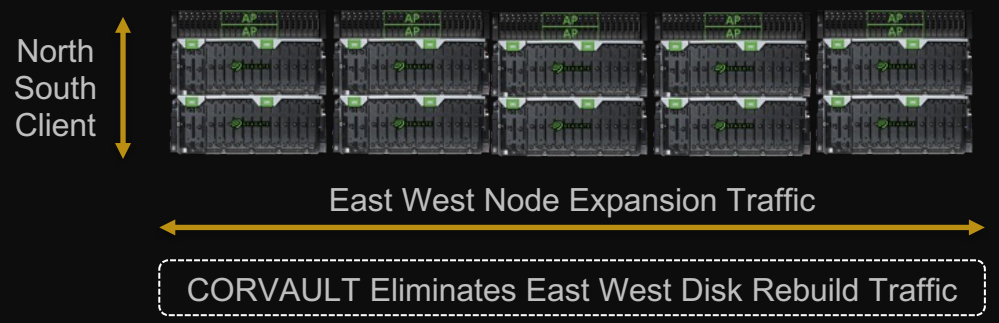
256 CPU Cores

4,096 GB RAM

⬇ 60% Less CPU

⬇ 40% Less RAM

Scale-Out CEPH w/ Seagate AP and CORVAULT



Multi-Layer EC

- Disk rebuild traffic is localized to each CORVAULT
- Rebuild Traffic is eliminated
- 14 nine's data durability
- CEPH [16+2] + ADAPT

Ranking by Capacity Density (CMR)		
#1	Exos CORVAULT	625 TB per rack unit

CAPEX Savings

- ❑ Racks
- ❑ Switches
- ❑ Cabling

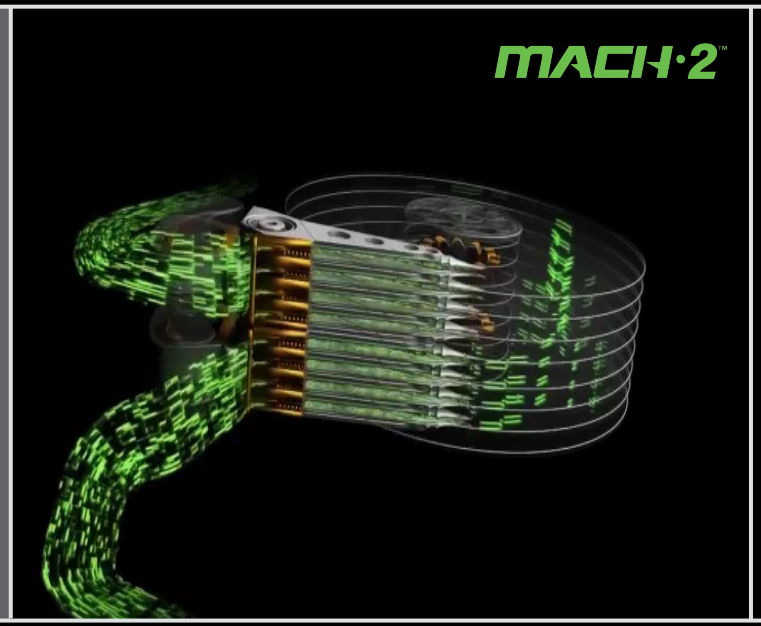
OPEX Savings

- ❑ Power & Cooling
- ❑ Real Estate

Power-Efficient Data Accessibility

Parallel data streams enable performant deployment of dense storage

2X
BANDWIDTH



< 25%
INCREMENTAL
POWER

MULTI-ACTUATOR TECHNOLOGY

SEAGATE

Circularity Program

SUSTAINABILITY DRIVEN

A Sustainable Datasphere Requires a New Mindset

Today's Widespread Hard Drive Shredding

>200 million drives
disposed each year

Take-Make-Waste consumption model is unsustainable.

SEAGATE
CIRCULARITY PROGRAM

Recertify, Repair, Recycle

Stop Hard Drive Shredding

Minimizing e-waste

Product Design, Life Cycle, Data Durability and Security

Data Sanitization Methods

Clear

Uses logical techniques to remove data on all addressable storage.

Prevents against non-invasive data recovery.

Purge

Uses logical or physical techniques to remove all data on addressable and non-addressable storage.

Infeasible data recovery with state-of-the-art techniques leaving device in usable state.

Destruct

Infeasible data recovery with state-of-the-art techniques.

Disintegrate, incinerate, and melt leaving device in unusable state.

Data Security and Sustainability

Enabling the circular economy.

Provides secure data sanitization

Provides secure disposition of data and devices leading to refurbish, reuse, recover, and recycle

Data Sanitization Standards

NIST NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY U.S. DEPARTMENT OF COMMERCE

ISO

NIST SP 800-88R1 ISO/IEC 27040

- Created standards for purge sanitization level
- Purge is a process that renders target data recovery infeasible using state-of-the-art laboratory techniques

IEEE

IEEE 2883 Standard for Sanitizing

- The IEEE 2883 Standard for Sanitizing Storage, a modernized version of ISO/IEC 27040, published in March 2022
- Seagate's Jim Hatfield is Chair and Editor of the working group
- Seagate drove formation of the NIST SP800-88R1 data sanitization standards in mid-2010s

Reuse: 275× Larger Impact than Recycling

Seagate.com/Circularity

Jin, H., Frost, K., Sousa, I., Ghaderi, H., Bevan, A., Zakotnik, M. and Handwerker, C., 2020. Life cycle assessment of emerging technologies on value recovery from Hard Drives. *Resources, Conservation and Recycling*, 157, p.104781.

Let’s Drive To Do Better. Together.

Make a Difference

Be an Industry Conservation Leader

Move at the Speed of Trust

Enhance TCO

Thank you

SEAGATE CIRCULARITY PROGRAM

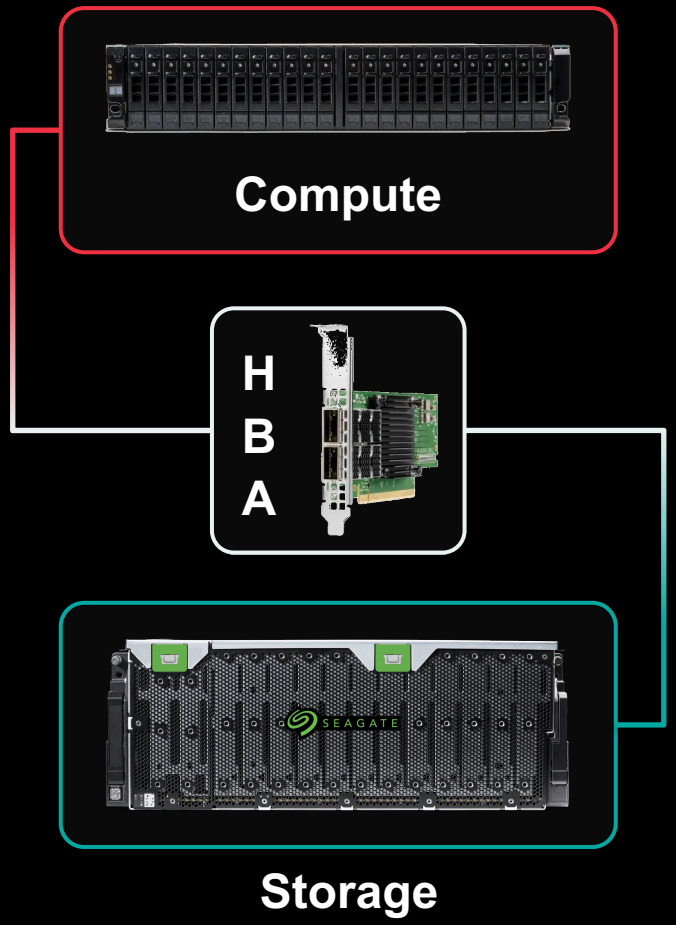
The **Seagate Circularity Program** creates a secure, sustainable way to retire Seagate hard drives, moving the datasphere towards a more responsible and efficient model that reduces carbon emissions and electronic waste by extending the product life cycle.

IEEE 2883 Standard for Sanitizing Storage

- **Sanitization:** A process or method to render access to target data on storage media infeasible for a given level of effort.
- Defines sanitization methods and techniques for specific storage media types
- Specifies interface-specific techniques (SATA, SAS, NVMe)
- Align industry on terminology and modern techniques for media sanitization
- Target all logical and physical locations for data – including user data, old data, metadata, overprovisioning, etc.

Defines purge method of sanitization that is secure, fast, and enables device reuse!

Hidden cost of data management



I/O Customer Data

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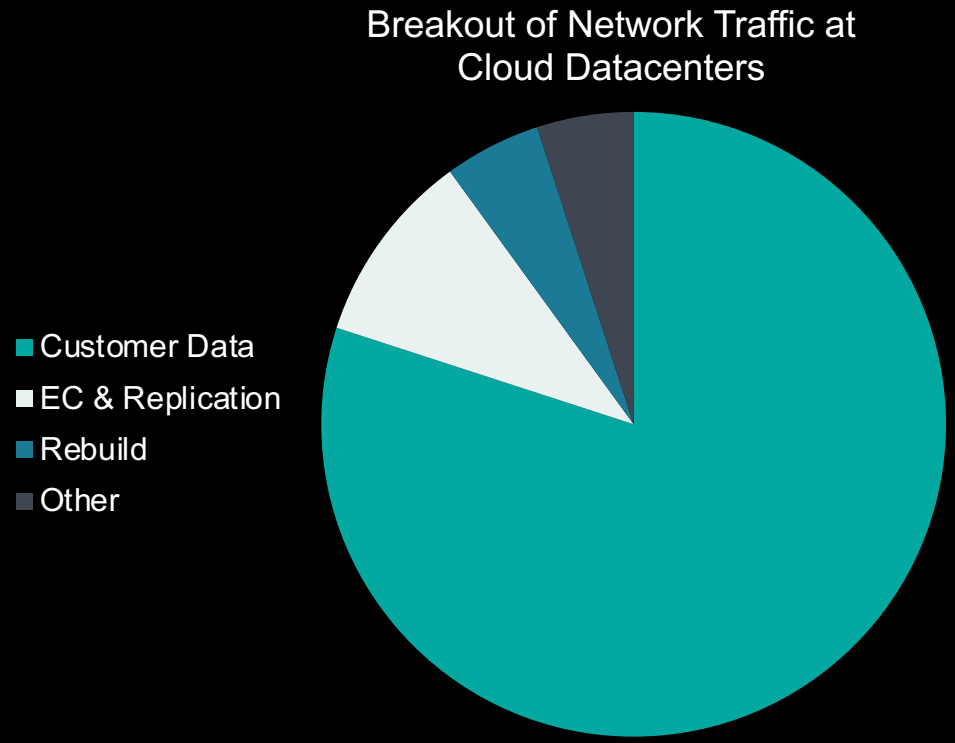

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