

# Library of Congress

## 2026 Designing Storage Architectures for Digital Collections Improving Sustainability and Lowering Cost with Modern Tape

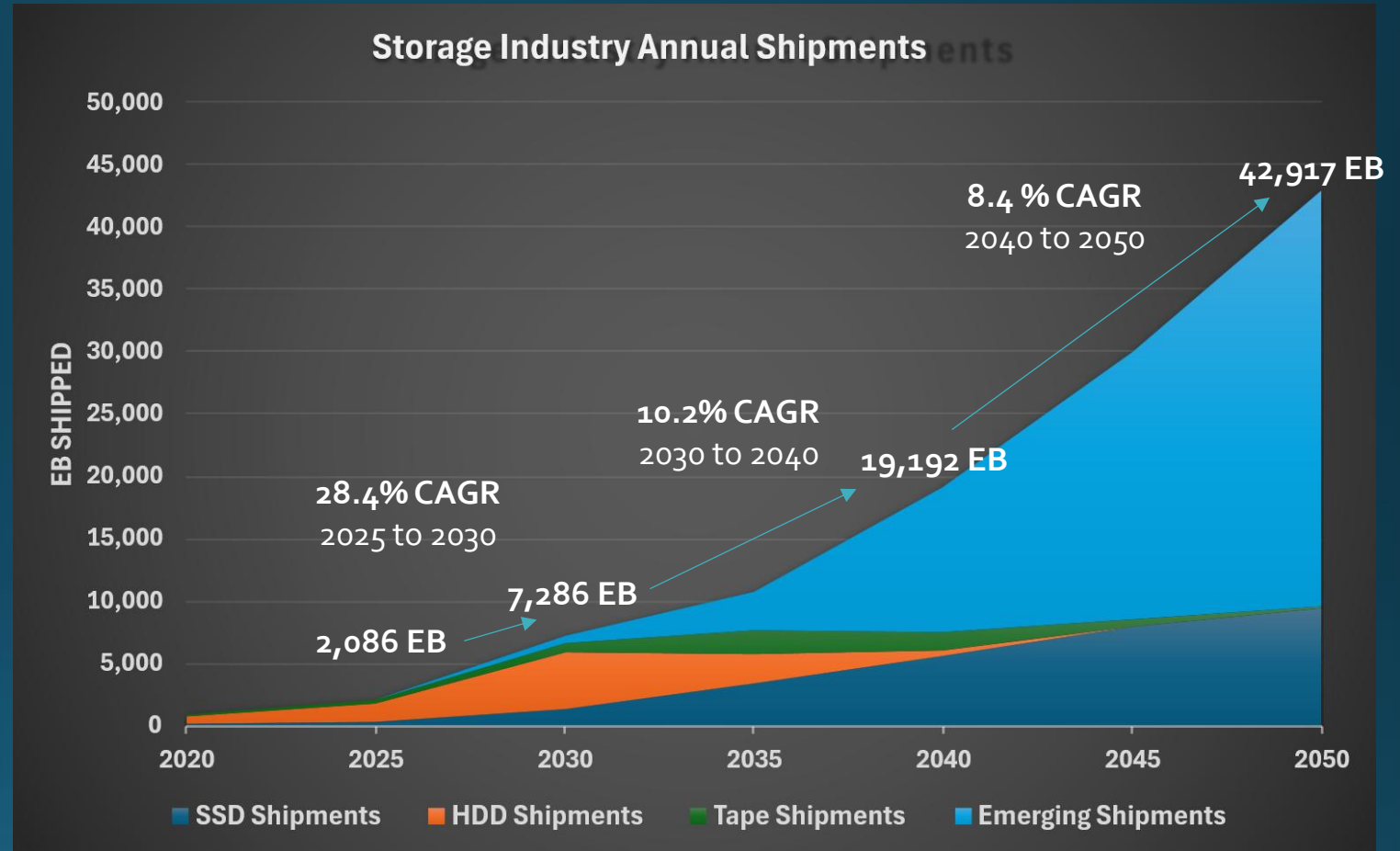


# Highlights

- GenAI continues to reshape the digital infrastructure
- Massive investments in data centers will be driven by AI – Over \$500 billion worldwide annually through 2030
- Data center energy and water demands are a large and growing issue
- Demand for Storage will continue to grow dramatically through the 2020s – the active install base growing from 7.8 ZB in 2020 to 22.8 ZB in 2030
- Emerging storage technologies are likely to become material in the latter half of the decade
- Today - for inactive data tape storage provides significant reductions in energy, lower carbon emissions and much lower TCO

# Storage industry annual shipments will grow significantly through 2030 and experience moderating growth in the outer years

- GenAI drives volumes through 2030
- End-user spending grows dramatically through 2030, resulting in financial constraints
- Storage Industry CapEx becomes a constraint in the outer years
- AI may be implemented to reduce stored data volumes
- Emerging technologies become a major component of the storage architecture in the 2030s



Source: Further Market Research , Brad Johns Consulting 2026

# What are the Emerging Storage Technologies?

## DNA

26 companies researching the use of DNA as a storage medium including:

- Twist Bioscience
- Catalog
- Molecular Assemblies
- DNA Script



SNIA has formed a DNA Data Storage Alliance

### Potential Benefits

- Extreme High Density – 1 gram could store 455 EB
- Very Long Life (000's of years)
- Very low energy requirements

### Inhibitors:

- Very slow retrieval speed
- Cost – Storing 1 PB could cost \$1 Trillion

### Outlook:

- Likely first availability in 2030s at the earliest

## Optical

Many companies researching including:

- Cerabyte - Ceramic on Glass – Target 10 PB/Rack by 2027
- Folio Photonics – Optical Disk – Target \$3/TB
- Group 47 - DOTS
- University of Southampton -5D memory crystal
- HoloMem – Holographic Tape – Target of 200 TB/ Cartridge by 2027
- Optera – Target of 10 TB/Platter @ \$.10/TB

### Potential Benefits

- Long Life
- Very low energy requirements
- Random Access

### Inhibitors:

- Capacity ~ 1 TB /platter today – Folio, 5D memory crystal – 500 TB
- Systems support
- Cost unknown

### Outlook

- Early shipments expected in 2026
- Must compete on cost, integration, ease of operation



# HDD and Tape Sustainability Comparison

## HDD

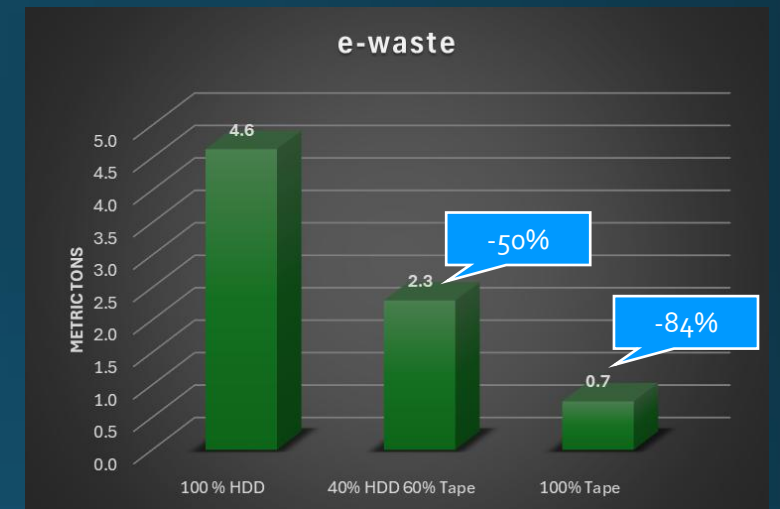
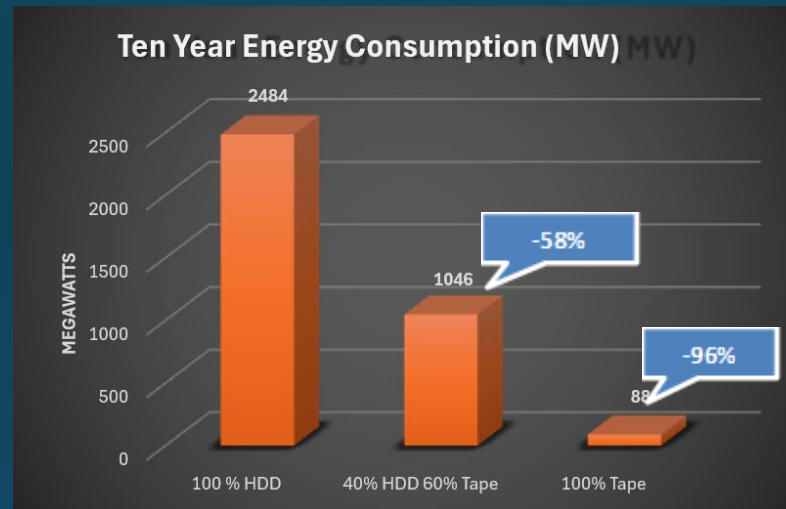
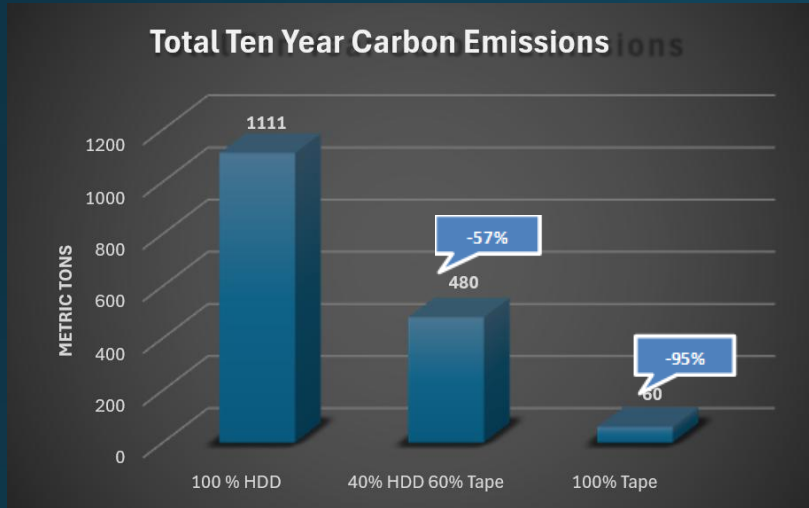
- Seagate Mozaic 3+
- 30 TB capacity
- Refresh 50 TB Capacity
- Erasure Coding Efficiency 1.25
- Embedded CO<sub>2</sub> – 29.7 KgCO<sub>2</sub>

## Tape

- LTO 10 Tape Media and Drive
- 30 TB uncompressed capacity
- 120 Cartridges/Drive
- Embedded CO<sub>2</sub>
  - Media – 7.94 KgCO<sub>2</sub>
  - Drive – 48 KgCO<sub>2</sub>

What is the environmental impact of storing 100 PB for ten years?

# Storing 100 PB of inactive data on tape substantially reduces energy consumption and carbon emissions



## Three scenarios

- 100 % of data resides on HDD
- 40% of data resides on HDD and 60% on tape – an active archive
- 100% of the data is inactive and resides on tape

# There are also substantial financial benefits of storing “cold data” to tape storage

- 100 PB of inactive HDD resident data
- 1%/month retrieval rate
- Configuration highlights
  - Tape estimates based on LTO 10
  - Disk estimates based on 12-24 TB HDD External Controller-based disk systems
  - Cloud estimates based on deep archive
- Costs include initial acquisition, extended warranty or maintenance, power, and cooling
- Disk systems and tape drives and media replaced after five years.
- What would be the TCO savings over this period from migrating this data to tape storage?
  - Using the Fujifilm TCO model



## What's not included

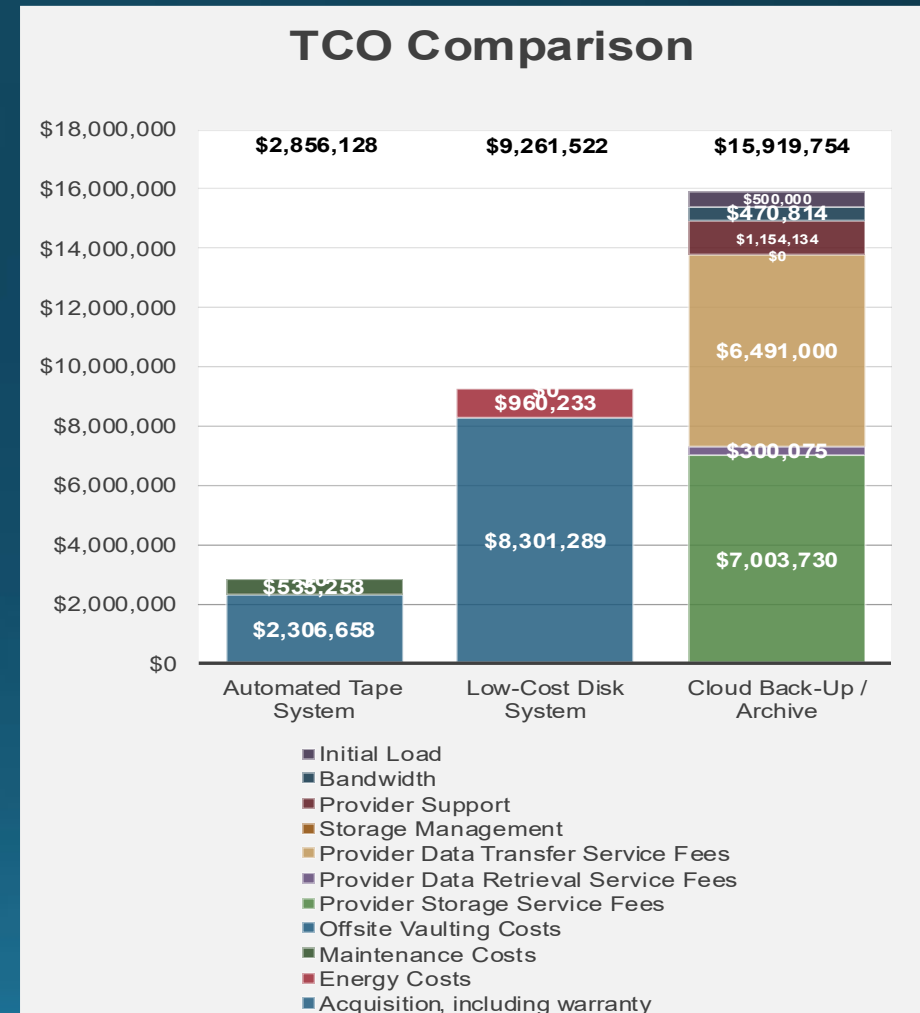
- Floor space
- Servers
- On-site storage infrastructure
- Software licenses

Source: <https://www.fujifilm.com/us/en/business/data-storage/resources/tco-tool>

# Moving 100 PB of cold data to tape storage results in substantial TCO savings

- Saves \$6.4 million over ten years versus HDD
  - 69% cost reduction
- Saves \$13 million over ten years versus Cloud
  - Deep Archive
  - 82% cost reduction

Your mileage will vary!



Source: <https://www.fujifilm.com/us/en/business/data-storage/resources/tco-tool>

# In conclusion



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THE AMOUNT OF STORED DATA IS PROJECTED TO GROW TO OVER 22ZB BY 2030

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DATA CENTER ENERGY CONSUMPTION HAS BECOME A MAJOR ISSUE DUE TO THE EXPLOSION OF GENAI

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MUCH OF THE DATA STORED ON HDDS IS "COLD DATA"

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NEW INNOVATIVE SOFTWARE EASES IMPLEMENTATION OF TAPE STORAGE

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CARBON EMISSIONS AND ELECTRONIC WASTE CAN BE DRAMATICALLY REDUCED BY MOVING COLD DATA TO TAPE MEDIA

# Resources

- Furthur Market Research - <https://furthurdata.com/>
- Brad Johns Consulting - <https://www.bradjohnsconsulting.com/>
- McKinsey Quarterly - <https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/the-cost-of-compute-a-7-trillion-dollar-race-to-scale-data-centers>
- Fujifilm TCO Tool - <https://www.fujifilm.com/us/en/business/data-storage/resources/tco-tool>
- Seagate Decarbonizing Report - <https://www.seagate.com/content/dam/seagate/assets/resources/decarbonizing-data-report/decarbonizing-data-report-040325.pdf>