2025 Designing Storage Architectures

Total Cost of Ownership for Archival Storage

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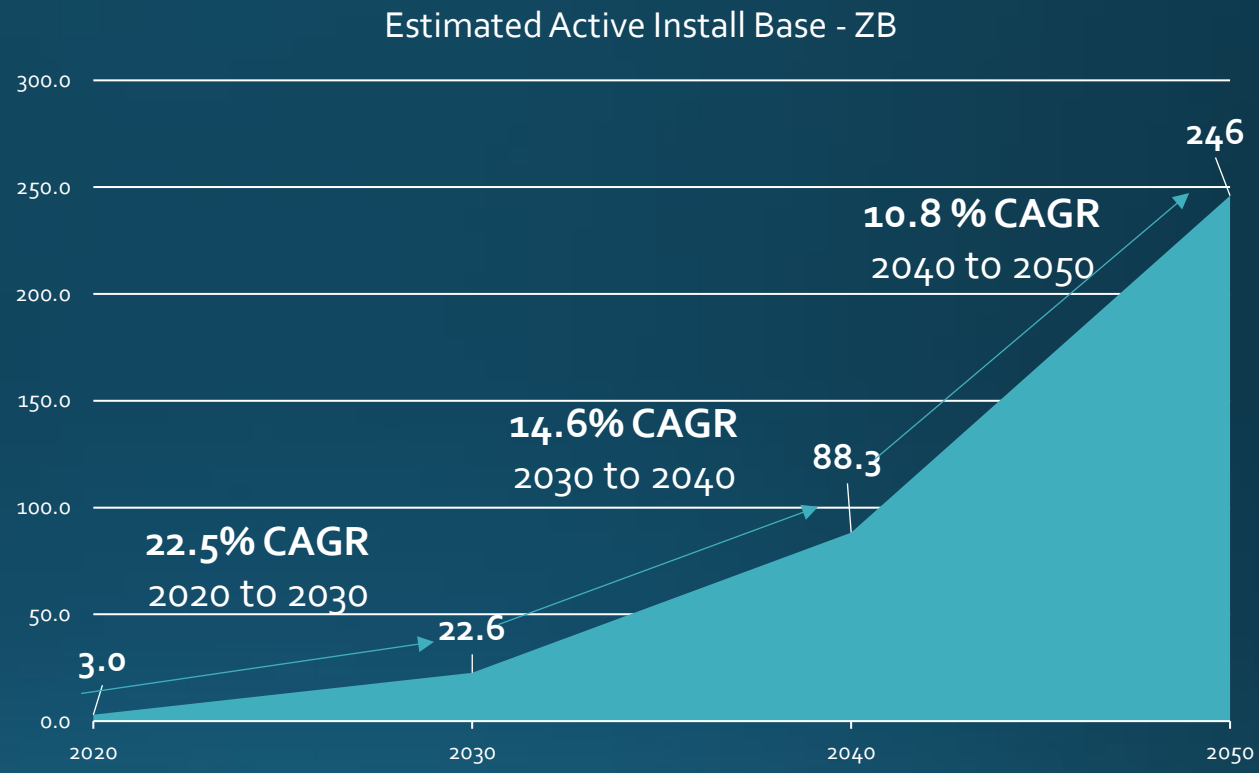
Highlights

- Storage industry shipments will continue to rise at a 22% CAGR through 2030.
  - GenAI a major contributor to the growth
- Growth moderates in the following decades but the 2050 active install base is still immense – 246 ZB
- Gen AI is driving increased demand for data center power
- Emerging storage technologies targeting archive data will likely emerge in the latter half of this decade – likely some form of optical
- New, innovative software eases implementation of tape infrastructure
- In the near term, tape continues to offer compelling TCO, energy, and sustainability advantages

The active storage install base is projected to grow significantly over this decade and is immense in outer years even with a lower growth rate

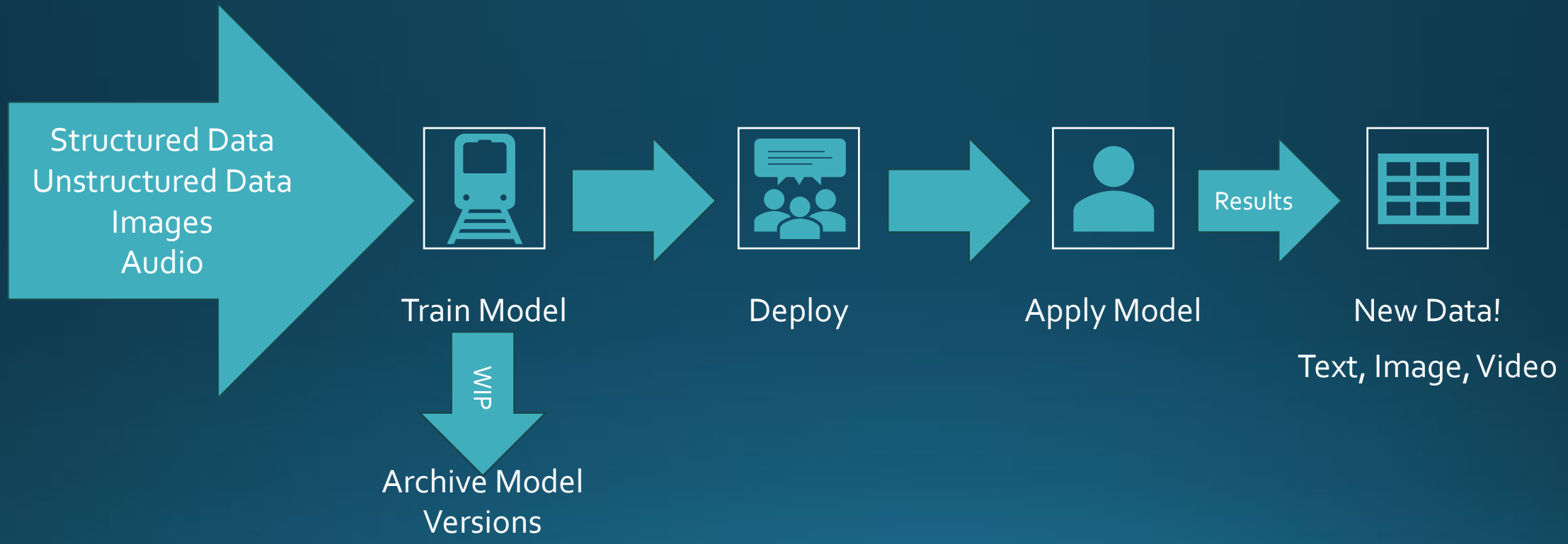
- Growth drivers include:
  - The Internet of Things (IOT)
  - 5G networks
  - Analytics
  - Social Media
  - Video
  - Scientific Research
  - Life Science
- And Now GenAI!



GenAI will challenge data storage power requirements, costs and sustainability

Source: Further Market Research , Brad Johns Consulting 2025

Artificial Intelligence is a significant new contributor to the growth of digital data



Artificial Intelligence is dramatically increasing data center power requirements

US Data Center Energy consumption more than doubled from 76 TWh in 2018 to 176 TWh in 2023 – LBNL 2024

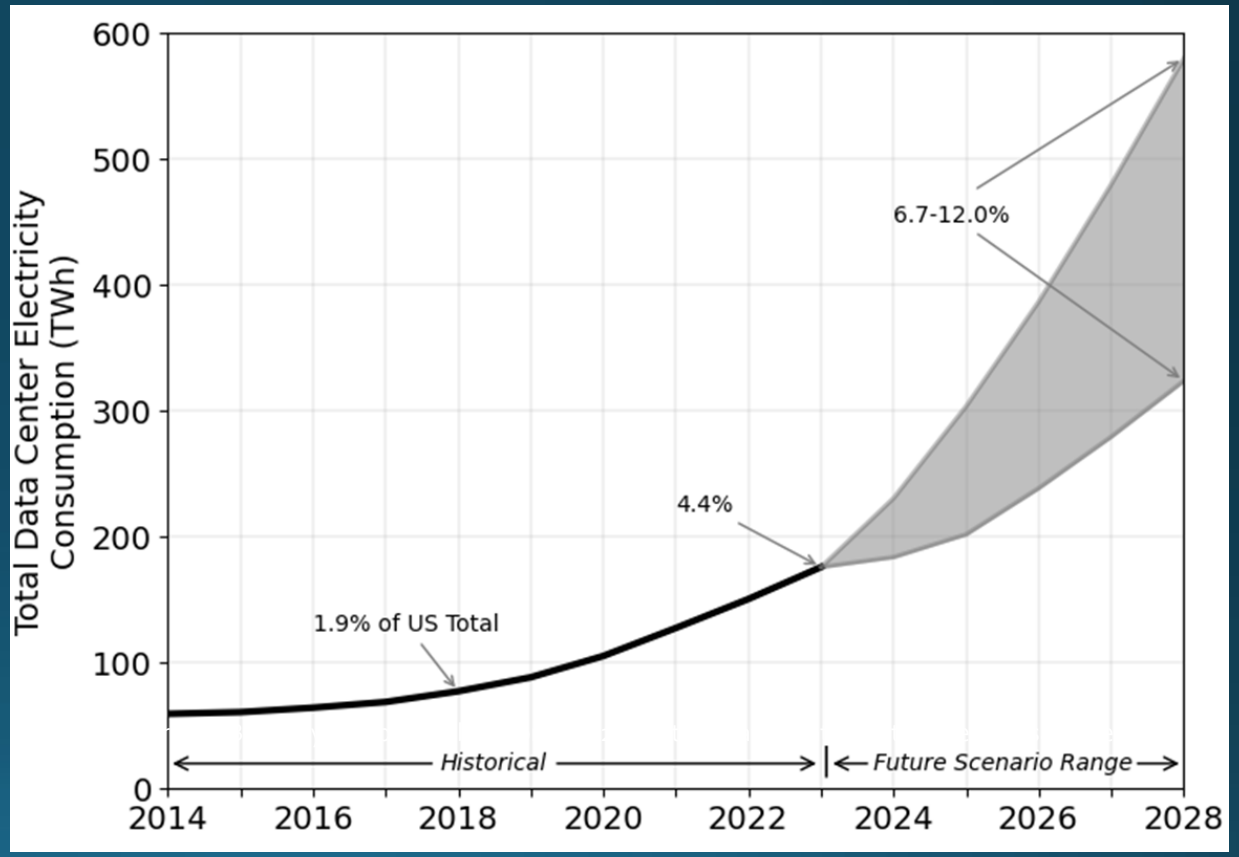
"AI workloads pushing the power per rack from 7 kW to 30 kW" – Yotta 2024 conference panelist

AI query uses 10X the power of a Google search – Goldman Sachs

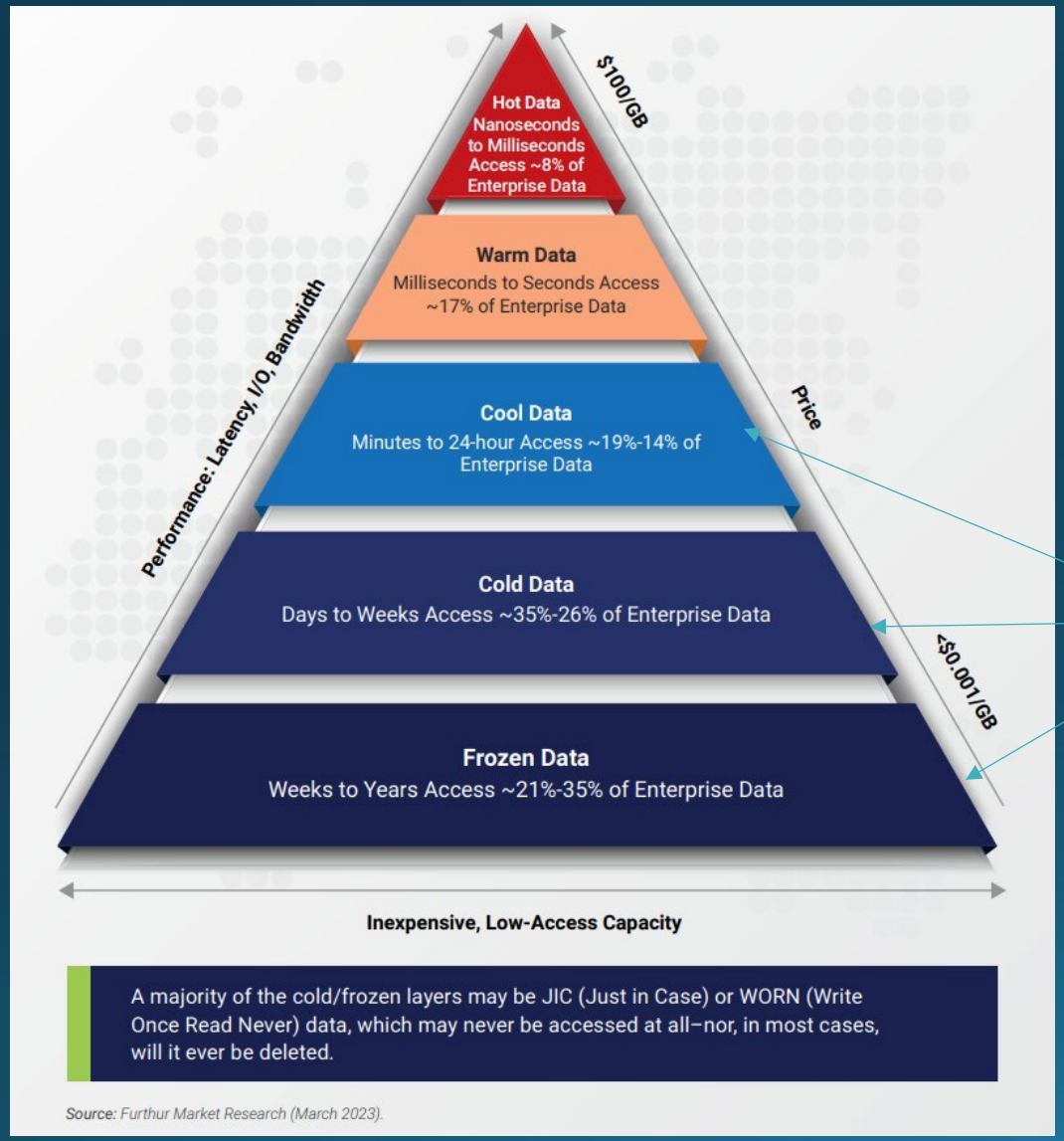
Hyperscale speaker - Storage accounts for 33% of operational and 61% of embodied emissions in our DCs

Hyperscalers investing in nuclear SMR (Small Modular Reactors) to meet energy demands while avoiding CO_2 emissions

- Microsoft, Amazon and Google, all investing in startup SMRs
- Companies developing SMR include NuScale Power, TerraPower, Westinghouse, BWXT and Kairos Power, Oklo



The vast majority of data is infrequently accessed yet continues to be stored on HDDs and SSDs



61% to 84% of stored data is infrequently accessed with access frequency from minutes to years

Source: Further Market Research March 2023 https://furthurdata.com/

An example highlights the environmental and cost benefits of moving "cold data" to tape storage

- 1 EB of HDD resident data is identified as being "cold data"
- 1%/month retrieval rate
- Configuration highlights
  - Tape estimates based on LTO 9, 120 Cartridges/Drive
  - Disk estimates based on 16-22 TB HDD External Controller based disk systems
  - Cloud estimates based on Glacier Deep Archive, Batch Retrieval
  - PUE of 1.4
- Technology Refresh
  - Replace the initial storage after five years
  - Assume five years for all technologies
- What would be the TCO savings from storing the data on tape versus HDD or Cloud over this period?
  - Using the Fujifilm TCO model

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

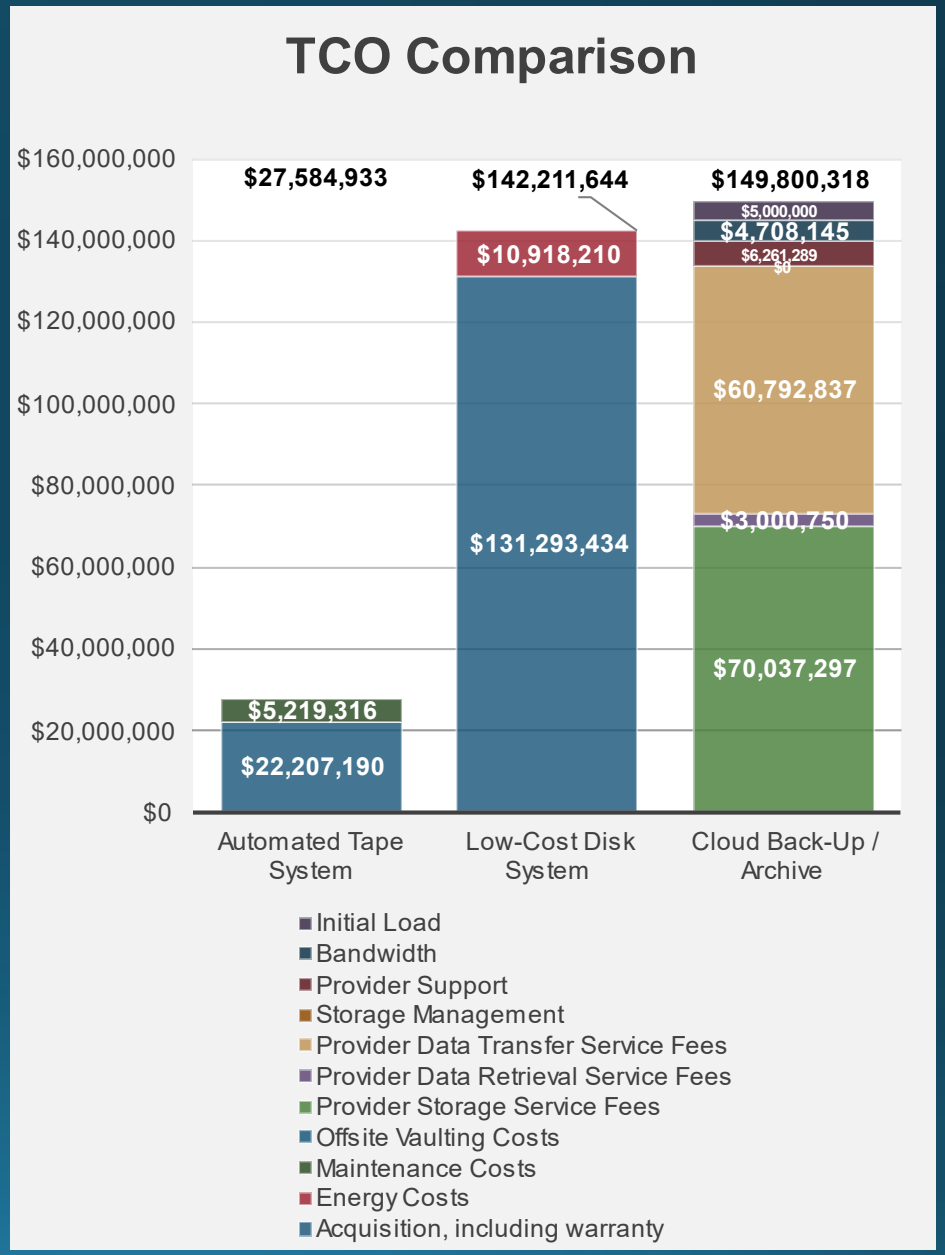
<u>What's not included</u>

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

Storing 1 EB of cold data to tape storage instead of disk or cloud results in substantial savings

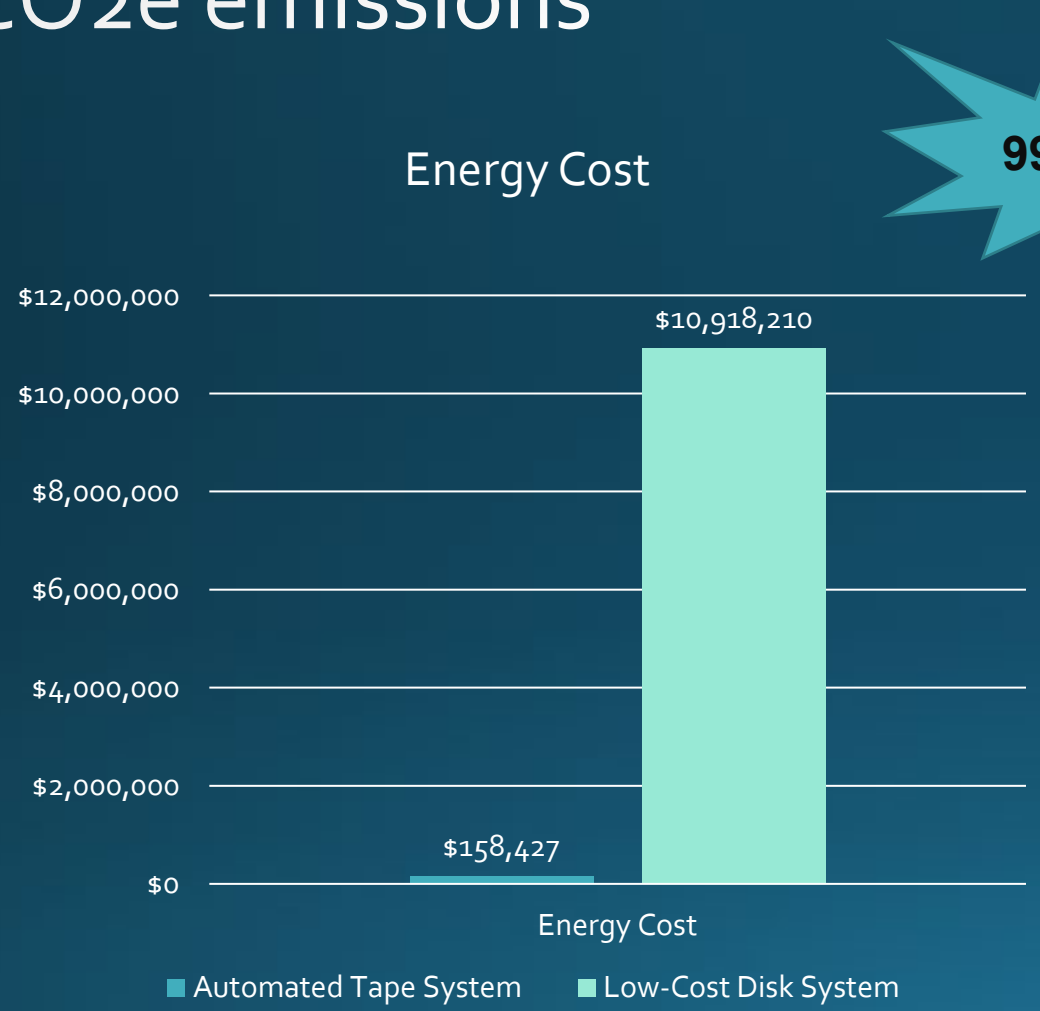
- Saves $114 million over ten years versus HDD
  - 81% cost reduction
- Saves $122 million over ten years versus Cloud
  - 82% cost reduction

Your mileage will vary!

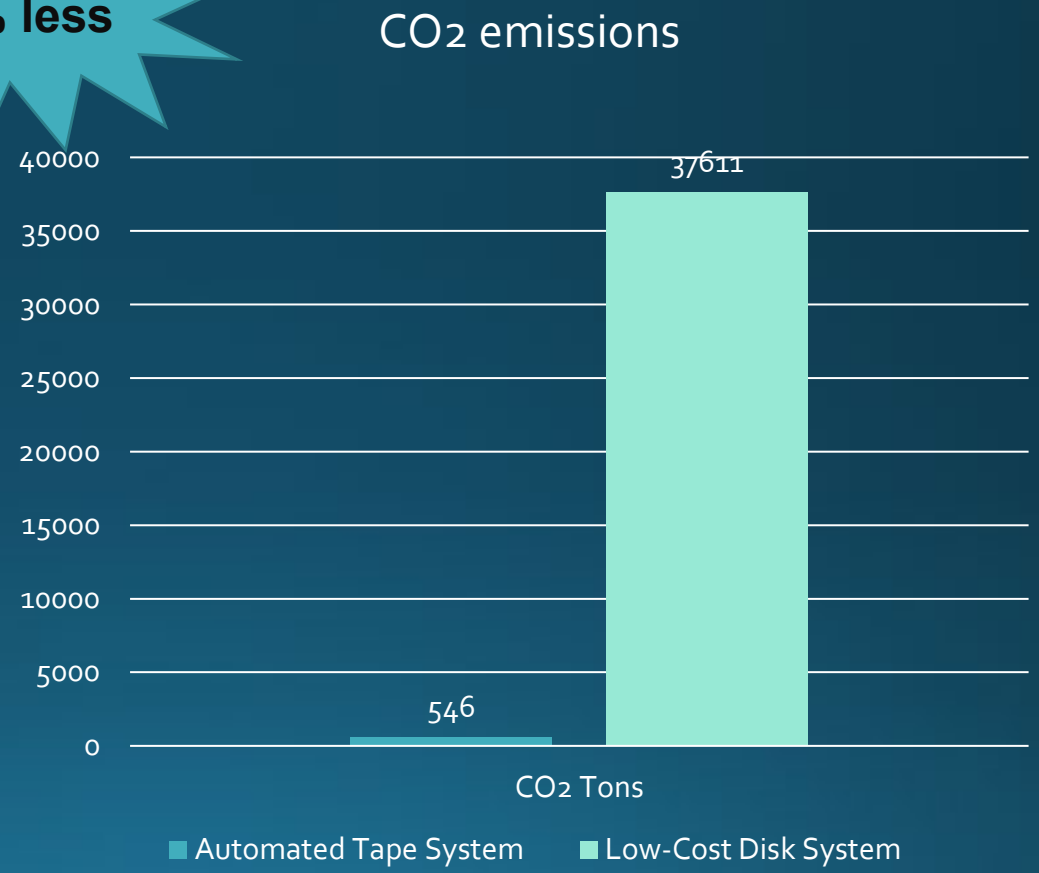


Source: https://www.fujifilm.com/us/en/business/data-storage/resources/tco-tool

It also dramatically reduces ten-year energy cost and CO_2e emissions

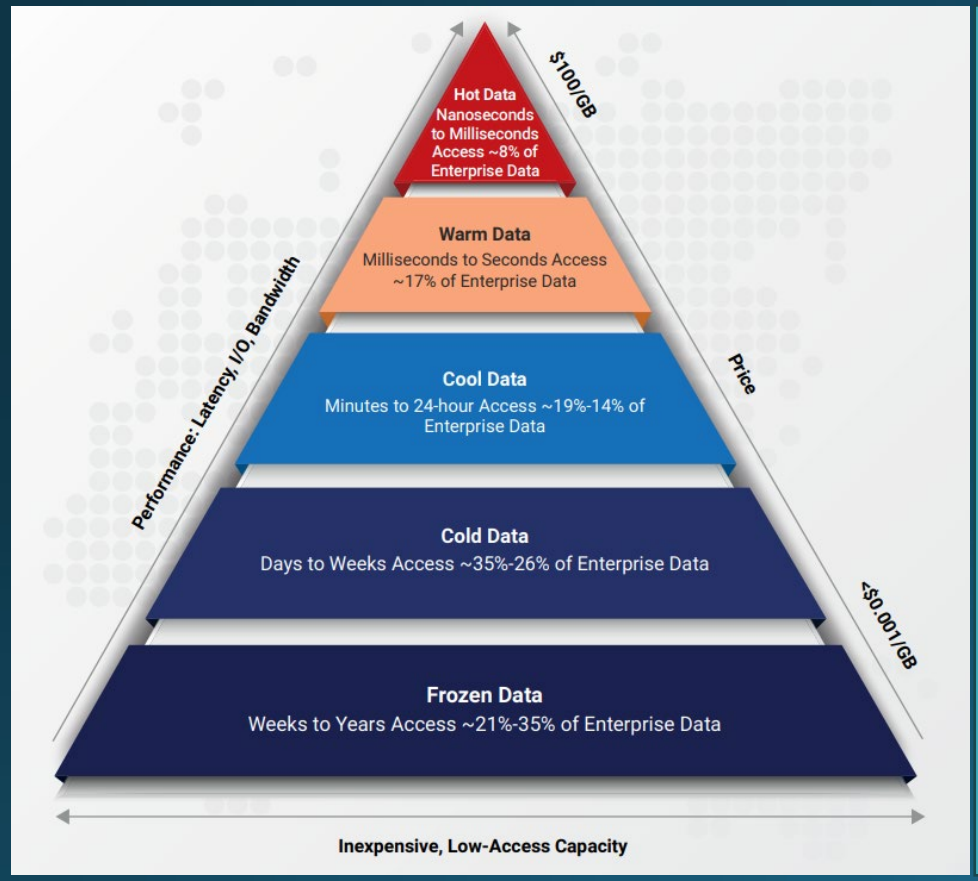


99% less



Per US EIA: US Average 2022 CO_2/kWh - .86, Natural Gas -.97, Coal - 2.30, Petroleum - 2.38. Renewables, Nuclear, Hydroelectric would be zero.

Emerging data management software leverages objects, metadata, and AI to implement policy-based movement of inactive data to lower cost storage



Intelligent Storage Management (AI & Meta Data)

S3

Archive Storage Software

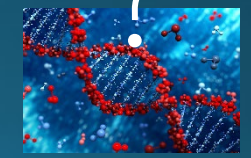
Applications

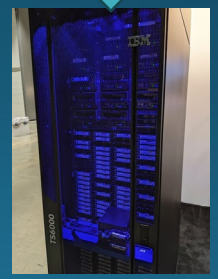
S3

Cloud

S3

Future Technology





Tape Library

In conclusion

THE ACTIVE INSTALL BASE IS PROJECTED TO GROW TO OVER 22 ZB BY 2030

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

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

NEW INNOVATIVE SOFTWARE EASES POLICY BASED MANAGEMENT OF INACTIVE DATA

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

Questions

Resources

- Furthur Market Research - https://furthurdata.com/
- International Storage Industry Consortium - https://insic.org/
- Fujifilm TCO Tool - https://www.fujifilm.com/us/en/business/data-storage/resources/tco-tool
- Lawrence Berkely Lab Data Center Energy Report - lbnl-2024-united-states-data-center-energy-usage-report.pdf
- LTO TCO Tool - https://www.lto.org/

TCO Assumptions

Key Assumptions

The TCO calculations are for 5 and 10 years of operation. Capacity is acquired as needed based on the growth rate above. The assumptions below are based on historical trends and published research as well as the capacity you have specified above

Cost Component	Comments	Year 1 Cost (US Dollars)	Annual Cost Decline
Tape media cost (per TB)	*Fujifilm LTO Ultrium 9 market pricing*	$4.61	20%
Tape hardware - drives & automated libraries (per TB)	*Includes tape drives and fully-automated tape libraries including extended warranty*	$14.50	0%
Tape energy cost (per TB per year)	*Offline nature of tape requires minimal power*	$0.03	13%
Disk acquisition cost (per TB)	*Market pricing for low-cost disk including extended warranty*	$82.55	10%
Disk energy cost (per TB per year)	*Published data on average energy usage and costs*	$1.37	10%
Cloud storage annual cost (per TB)	*Based on lowest available published pricing of leading cloud storage providers for archive storage*	$11.88	13%
Cloud retrieval and transfer fees (per TB)	*Based on lowest available published pricing of leading cloud storage providers for archive storage*	$54.09	0%
Bandwidth (monthly cost per Mbps)	*U.S. Industry average business bandwidth*	$0.45	10%