HDD & Storage System Trends

EPA ENERGY STAR and SNIA Data Center Storage Stakeholder Meeting

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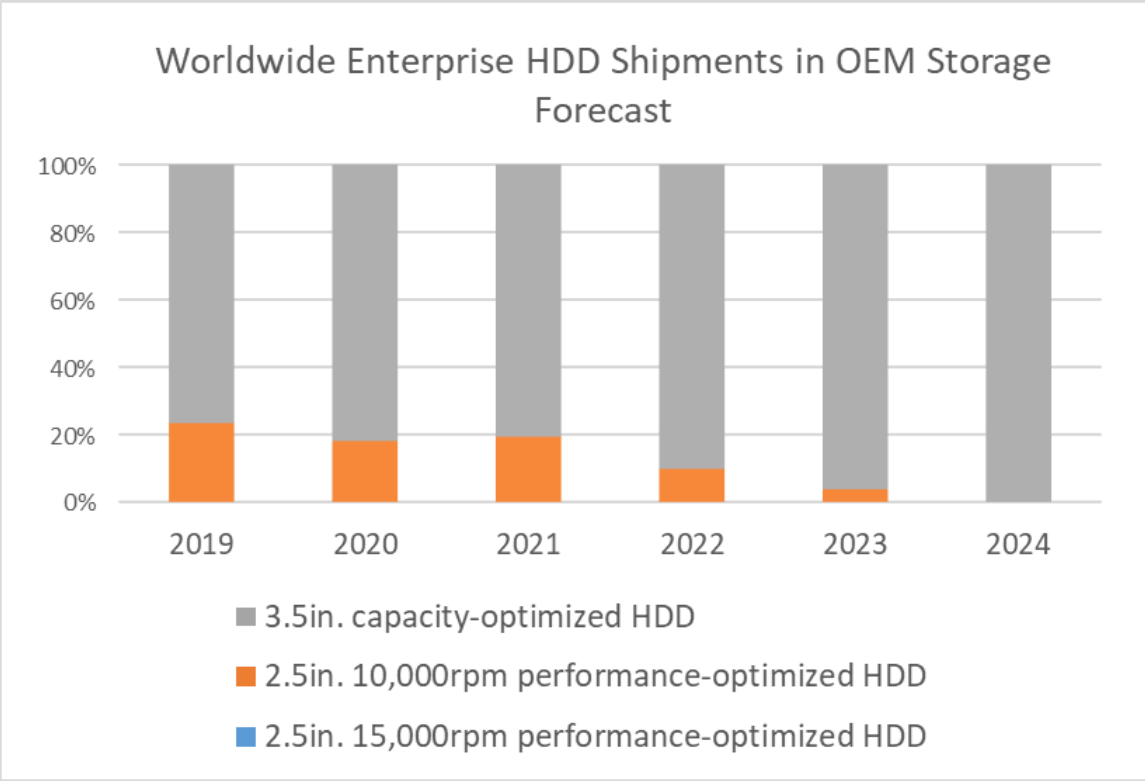
HDD Trends (2020 Updates)

- 10K and 15K HDD markets are declining – being replaced by SSDs
  - Falling SSD prices have resulted in SSDs replacing 15K HDDs in External Storage
  - By 2024, IDC estimates SSDs will also have replaced 10K HDDs in External Storage
- 7.2K capacity growth continues with Energy Assisted Magnetic Recording (EAMR)
  - 18 and 20TB HDDs based on EAMR released
  - MAMR (microwave assisted recording) & HAMR (heat assisted magnetic recording) in development
- 7.2K HDDs get non-volatile write caching
  - Improving random write performance in some cases
- 7.2K HDDs get multi-actuators
  - First dual-actuator HDD released
  - Conceptually two ½ capacity HDDs in one drive - delivering ~2X IOPs and BW of a single actuator

IDC HDD Mix Forecast



Source: IDC Worldwide Hard Disk Drive Forecast Update, 2020–2024, December 2020

HDD Trends – Drive Level Efficiency* Improvements

- 10K and 15K HDD markets are declining – being replaced by SSDs
  - SSDs may use 2-3x the power but provide as much as 1000x > IO/s and 10x > MB/s of 10K/15K HDD
  - SSDs may be 6x or more > capacity than 10K/15K HDD => fewer drives required for a given capacity
  - Yielding significantly **improved IO/s/W and MB/s/W and Idle GB/W**
- 7.2K capacity growth continues with Energy Assisted Magnetic Recording (EAMR)
  - Higher capacity at ~ the same power consumption => **improved Idle GB/W**
- 7.2K HDDs get non-volatile write caching
  - Improving random write performance => **Improved IO/s/W** for some cases
- 7.2K HDDs get multi-actuators
  - The performance of ~2 7.2K HDDs without a 2X power increase => **Improved IO/s/W and MB/s/W**

❖ **Storage system design choices will affect the drive energy efficiency gains at the storage system level - e.g. max configuration, performance targets, data service choices, etc.**

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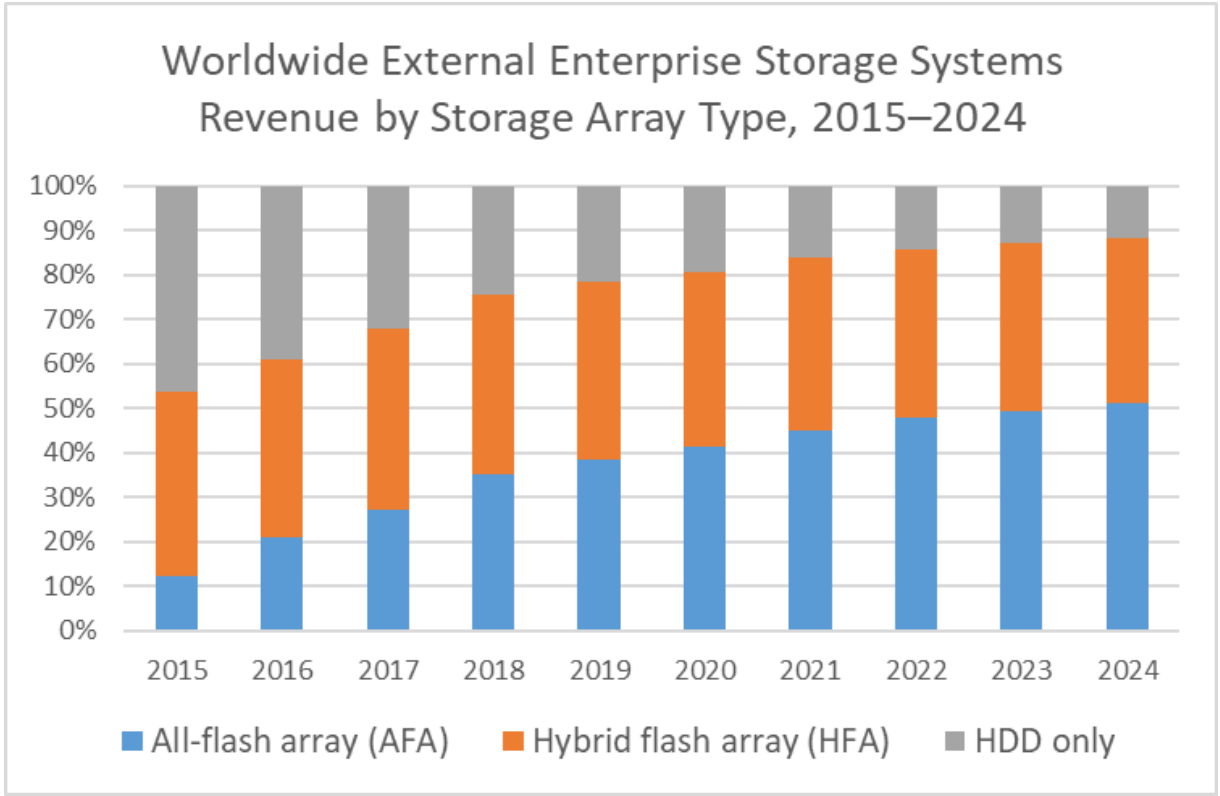
IDC Array Type Definitions

- All-flash array (AFA).
  - An AFA is defined as a network storage system that can **only support flash media** as persistent storage and is available under a unique SKU.
- Hybrid flash array (HFA).
  - An HFA is defined as an external storage system that **can (but does not necessarily) use a mix of CFMs or SSDs and HDDs** to meet performance and capacity requirements.
- HDD-only array
  - HDD-only external storage systems **only support HDDs** as persistent media.

IDC Array Type Mix Forecast

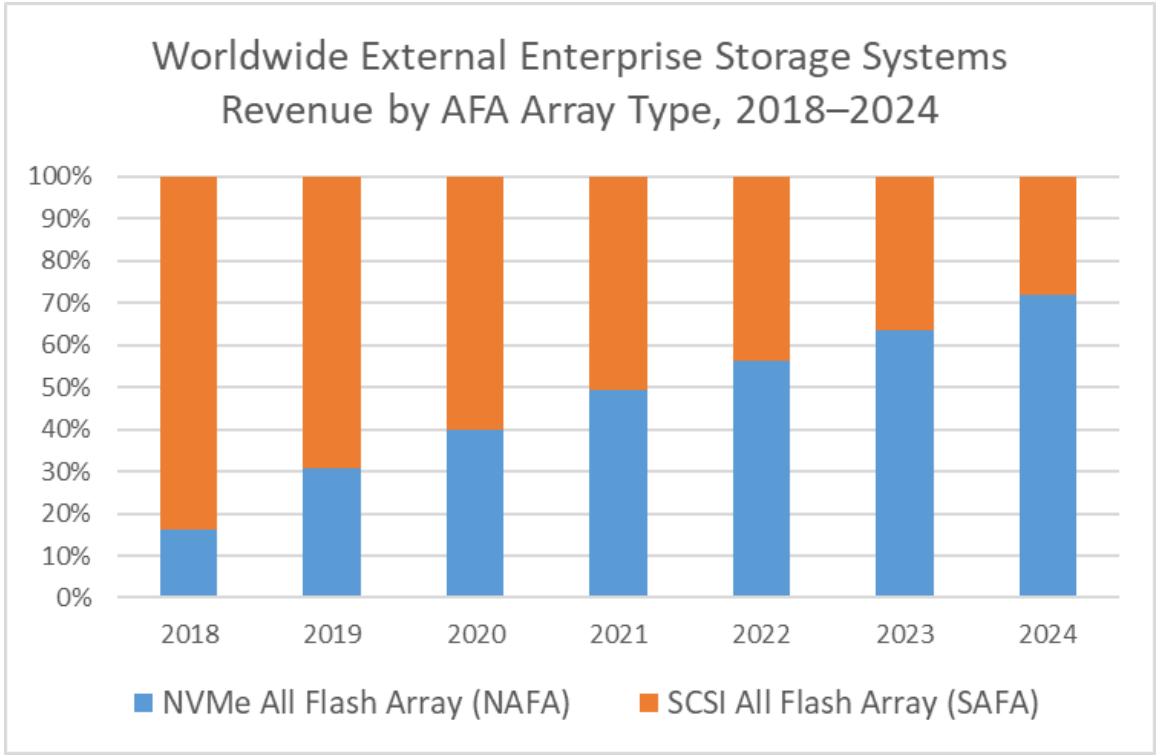


Source: IDC Worldwide and U.S. External Enterprise Storage Systems Forecast Update, 2020–2024 December 2020

Storage System Trends – Efficiency Improvements

- AFA growing rapidly to 51% of revenue by 2024
  - AFA => huge efficiency gains over 10K/15K based storage especially with data reduction
  - Many fewer drives, enclosures, fans, etc + much greater performance
- HDD-only declining rapidly to only 12% of revenue by 2024
  - 7.2K HDD only arrays may not meet Energy Star 2.0 IO/s/W targets
- HFA declining slowly and still 37% of revenue by 2024
  - SSD price erosion => larger SSD content => improved IO/s/W, MB/s/W, idle GB/W

IDC AFA Type Mix Forecast



Source: IDC Worldwide NVMe-Based All-Flash Array Forecast, 2020–2024: Market Developing Faster than Originally Anticipated, August 2020

Vendor Example – Dell NAFA Arrays

- In 2019, Dell announced PowerMAX NVMe SSD based storage systems
- In 2020, Dell announced PowerStore, PowerScale (F600), and ECS (EXF900), NVMe SSD based storage systems
- PowerStore NAFA – Higher power => more performance/more space efficiency
  - More powerful CPUs and more memory for more performance from NVMe SSDs
  - Hardware compression offload improves data reduction efficiency

PowerStore Model	1000	3000	5000	7000	9000
CPU per Array	4 x Intel CPUs, 32 cores, 1.8 GHz	4 x Intel CPUs, 48 cores, 2.1 GHz	4 x Intel CPUs, 64 cores, 2.1 GHz	4 x Intel CPUs, 80 cores, 2.4 GHz	4 x Intel CPUs, 112 cores, 2.1 GHz
System Memory/Cache per Array	384 GB	768 GB	1,152 GB	1,536 GB	2,560 GB

NAFA Trend – Energy Implications

- NAFA generally are higher power AND higher performance than SAFA
  - U.2 NVMe SSDs may reach 25W vs U.2 SAS SSDs more typically reaching 15W
  - Some future EDSFF NVMe form factors support up to 40W operations
  - This additional SSD power delivers additional performance
  - Additional controller power required to deliver additional SSD performance
- NVMe SSD drive capacities will exceed SAS SSD capacities
  - 15TB is a common high cap SAS SSD offered with a few 30TB SAS SSDs on the market
  - Vendors are already shipping 38TB and 49TB NVMe SSDs
- EDSFF form factor is more dense than U.2 form factor
  - For example, E3 thin are approximately ½ the width of a U.2 drive
  - As many as 2x E3 as U.2 fit in the same chassis => more power AND performance from the chassis
- New interface, e.g. PCIe Gen 4/5, deliver faster busses enabling > IO/s and MB/s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