

Market Analysis Report

# Cold Storage 2022

## Storage Trends for Rapidly Growing Cold Data ~Optical Disc Storage Grows in Key Market China~

---

FUJIWARA-ROTHCHILD,LTD.



Planning, research, and editing  
Fujiwara-Rothchild, Ltd.

2-11-3 Higashi-Kanda, Chiyoda-ku, Tokyo 101-  
0032, Japan

TSR 2nd Building

Tel: 03-5821-3993

Fax: 03-5821-4030

E-mail: [info@fujiroth.com](mailto:info@fujiroth.com)

## Table of Contents

1.	Introduction.....	8
2.	Executive Summary.....	9
2.1.	The main contents analyzed by this report.....	9
2.2.	Summary of Analysis of Cold Storage Trends.....	9
3.	Storage Market Definition and General Trends .....	12
3.1.	Market definition (enterprise and client) .....	12
4.	Storage Capacity Supply Trends.....	15
4.1.	Overall storage market and storage composition .....	15
4.1.1.	Annual Capacity Supply Trend .....	15
4.1.2.	Actual storage in operation (accumulated capacity).....	17
4.2.	Client Market.....	20
4.3.	Enterprise Market.....	21
4.3.1.	Enterprise Market Annual Capacity Supply Trend.....	21
4.3.2.	Enterprise Storage Cumulative Capacity Trends .....	25
4.3.3.	Cumulative Enterprise Cold Storage Capacity Trends .....	26
4.4.	Storage Shipping Capacity Trend Tables.....	28
5.	Individual trends in future storage capacity supply .....	29
5.1.	HDD Enterprise Storage Type.....	29
5.2.	LTO Capacity Supply Trend (~LTO9).....	31
5.1.	Optical Disc Storage Capacity Supply Trends.....	34
5.1.1.	BD/AD for archive Trend.....	34
5.1.2.	BD/AD Total Cumulative Capacity Trend .....	35
5.1.3.	AD disc units trend .....	35
5.1.4.	Trend Analysis of AD Libraries.....	37
6.	Capacity roadmap and technology trends of various storage devices.....	41
6.1.	General trends of each storage .....	41
6.1.1.	Storage Trends in the Enterprise Market .....	41
6.1.2.	Average unit capacity of storage shipped for the enterprise market .....	43
6.1.3.	Capacity trends for each storage type .....	45
6.1.4.	Trend of increasing recording density for each storage.....	46
6.1.5.	GB cost trend for each storage.....	47
6.2.	HDD Technology Trends.....	47
6.2.1.	HDD related Terminology .....	47
6.2.2.	HDD Technology Roadmap .....	48
6.2.3.	HDD new technologies.....	48
6.2.3.1.	Seagate .....	49
●	Long-term roadmap for HDDs over 50TB.....	49
6.2.3.2.	Western Digital.....	51
●	Aiming for 22 TB in 2022.....	52

●	Up to 30TB with ePMR and OptiNAND .....	53
●	30TB or more .....	53
6.2.4.	Innovations in multiple technological vectors .....	53
6.2.4.1.	He gas filling .....	54
6.2.4.2.	Triple Stage Actuator (TSA) .....	54
6.2.4.3.	Shingled Magnetic Recording.....	54
6.2.4.4.	EAMR technology: Enables more Bits per Inch (BPI) .....	55
6.2.4.5.	Toshiba Device & Storage Corporation ("Toshiba").....	56
6.2.5.	Summary of current status and future direction of the three companies.....	58
6.2.6.	HAMR .....	59
●	Seagate HAMR Drive .....	61
●	Materials for heat-assisted magnetic recording.....	61
6.2.7.	MAMR.....	67
●	Western Digital MAMR Tech Pushes Future HDDs Beyond 40TB .....	68
●	WD Announces MAMR Breakthrough That Will Bring 40TB Hard Drives By 2025....	69
6.3.	LTO Technology Trends.....	72
6.3.1.	LTO Roadmap.....	72
6.3.2.	LTO compatibility.....	74
6.3.3.	LTO Technology Trends.....	75
6.4.	Optical Disc Storage (AD) Roadmap.....	77
6.4.1.	AD 500GB Major Manufacturers.....	78
●	Panasonic.....	78
●	Sony.....	78
6.4.2.	Optical Disc Storage Technology Trends and Issues .....	78
6.4.3.	Future optical memory in excess of 100 TB.....	79
7.	Cold Data and Storage Selection .....	80
7.1.	Future storage configuration changes.....	80
7.1.1.	Challenges in the current trend of increasing cold storage operating capacity .....	80
7.1.2.	Storage Shift Trends in the Enterprise .....	81
7.1.3.	Actual storage capacity in relation to total data distribution volume (free space considered).....	83
7.2.	Role of Optical Disc Storage in Hierarchical Storage .....	87
8.	Potential for Expansion of the Optical Disc Archiving Market in Cold Storage.....	90
8.1.	Optical Disc Archiving Contributes to Cold Storage Expansion Application .....	90
8.2.	Applications and Business Models.....	91
8.3.	Current status of major applications of optical disc archiving .....	93
8.3.1.	Off-line archive .....	93
●	Off-line Archive Storage Configuration.....	94
●	Broadcast station use .....	95
8.3.2.	Cold Storage for DC.....	95
8.3.3.	Optical Disc Storage in Big Data Applications.....	96
9.	Optical Storage Trends in China.....	98
9.1.	Enterprise Storage Trends in China .....	98
9.2.	Current Status of Optical Disc Storage in the Chinese Enterprise Storage Market.....	98

9.2.1.	Market Size of Optical Disc Storage in China Enterprise Storage Market .....	98
9.2.2.	Major Players of Optical Disc Storage in the Chinese Enterprise Storage Market.....	99
9.3.	Optical Disc Storage Applications in China .....	100
9.3.1.	Examples of major government archive data .....	101
9.3.2.	archives.....	102
9.3.3.	Optical disc supply system for professional use.....	103
9.3.4.	AD Storage Company Trend .....	103
9.3.5.	Examples of major groups of related companies in China .....	106
9.4.	Chinese government policies and trends related to storage.....	109
9.4.1.	Chinese Government Policy on Data Storage.....	109
9.4.2.	green data center .....	110
9.4.3.	Chinese Government Policy on Big Data.....	111
9.4.4.	2017 China Big Data Industry Park Case Study Report (China CITIC Industrial Research Institute).....	113
9.4.5.	Science, Technology and Innovation 2030 Guidelines for 2021 .....	114

FIGURE.

FIG. 1	Operating Capacity (ZB) Estimation by Cumulative capacity .....	8
FIG. 2	Executive Summary.....	9
FIG. 3	Enterprise / Client market.....	12
FIG. 4	Total Storage Yearly Capacity Shipping Trend (EB) by Type .....	16
FIG. 5	Total Storage Yearly Shipping Capacity Trend (EB) by Type, by client/enterprise .....	17
FIG. 6	Total Accumulated Storage Capacity Trend (EB) by Type.....	18
FIG. 7	Total Accumulated Storage Capacity Trend (EB) by Type, by client/enterprise .....	19
FIG. 2. 8	Yearly Capacity ratio trend between Client and Enterprise by Type(%) .....	20
FIG. 9	Client storage yearly shipping capacity trend .....	21
FIG. 10	Enterprise storage yearly shipping capacity trend.....	22
FIG. 11	Enterprise yearly shipping capacity trend by Hot/Cold storage .....	23
FIG. 12	Enterprise Storage Yearly units shipping trend (M units) .....	24
FIG. 13	Enterprise Hot/Cold/Frozen: Yearly Capacity Shipping Ratio Trend (%) .....	25
FIG. 14	Enterprise accumulated capacity trend .....	26
FIG. 15	Accumulated Enterprise Cold storage Capacity trend (EB).....	27
FIG. 16	HDD-NL : Gloss capacity & Average capacity per drive Trend (EB/GB).....	29
FIG. 17	HDD-NL : Impact of 2019 Ave.Cap./Drv. decline on future.....	30
FIG. 18	LTO: uncompressed Capacity Yearly Shipment Trend (EB).....	32
FIG. 19	LTO: Units Shipping & Capacity Shipment Trend .....	33
FIG. 20	Combination of Storage used for Backup .....	33
FIG. 21	BD disc trend for archive.....	34
FIG. 22	Enterprise Optical Disc Storage Accumulated Capacity Trend (EB) .....	35
FIG. 23	AD Yearly Capacity Shipment Trend (PB) .....	36

FIG. 2. 24	Archival disc yearly UNITS shipment trend (M units) .....	37
FIG. 25	PANASONIC freeze-ray specification .....	38
FIG. 26	Freeze-ray Roadmap .....	39
FIG. 27	SONY Optical Disc Archive: Roadmap & Cartridge Compatibility .....	39
FIG. 28	SONY Optical Disc Archive .....	40
FIG. 29	2021/2026 Enterprise yearly storage capacity supply ratio by cold storage device ..	42
FIG. 30	2020 / 2026 Enterprise Accumulated Storage Capacity supply ratio by Cold device	42
FIG. 31	Average Capacity Shipment Trend of HDD, LTO, Optical disc.....	44
FIG. 32	Capacity Roadmap of each cold storage device.....	45
FIG. 33	Areal density trend of HDD, LTO, AD.....	46
FIG. 34	Storage bit cost \$/GB .....	47
FIG. 35	HDD Capacity Growth Outlook .....	48
FIG. 36	Seagate 20TB HDD .....	50
FIG. 37	HDD Mass Capacity Storage Innovation .....	50
FIG. 38	Seagate HDD Capacity Trend .....	51
FIG. 39	WD Ultrastar He-filled HDDs.....	51
FIG. 40	WD Ultrastar 20TB .....	52
FIG. 41	WD Triple Stage Actuator and Shingled Magnetic Recording.....	55
FIG. 42	WD Energy Assisted Magnetic Recording (EAMR) technology .....	56
FIG. 43	Toshiba 18TB HDD.....	57
FIG. 44	Toshiba MAS-MAMR .....	58
FIG. 45	High Capacity HDD Road map.....	58
FIG. 46	HAMR technology-1.....	59
FIG. 47	HAMR technology-2.....	60
FIG. 48	HAMR technology: New material requirement .....	62
FIG. 49	MAMR : Spin Torque Oscillator (STO) .....	68
FIG. 50	Spin Torque Oscillator .....	69
FIG. 51	Comparison between MAMR and HAMR .....	70
FIG. 52	Energy assisted head reliability MAMR/HAMR .....	70
FIG. 53	Key values of MAMR technology .....	71
FIG. 54	Cost : HDD vs SSD.....	71
FIG. 55	LTO Previous Roadmap .....	73
FIG. 56	LTO New RoadMap.....	74
FIG. 57	LTO Compatibility.....	75
FIG. 58	LTO of 580TB using SrFe magnetic particles .....	76
FIG. 59	AD Roadmap & Future Technology of Archival disc.....	77

FIG. 60	AD disc Technologies for capacity increasing (OCP Japan 2016)	79
FIG. 61	An example of over 200TB capacity disc technology	79
FIG. 62	Enterprise Storage Accumulated Capacity Trend	81
FIG. 63	Enterprise storage expansion to cold storage (DIRECTION)	82
FIG. 64	Enterprise storage expansion towards Cold storage (2017-2026)	82
FIG. 65	Estimation of real operating capacity (2026)	84
FIG. 66	Estimation of Real operating Capacity (2021-2026)	86
FIG. 67	3.5" HDD Shipping Units Trend (2017-2026)	87
FIG. 68	Target of Optical disc cold archive	89
FIG. 69	Business models of optical storage	92
FIG. 70	Examples of optical storage application	93
FIG. 71	Example of archive system configuration 1	94
FIG. 72	Example of archive system configuration 2	95
FIG. 73	Example of SNS optical disc archive configuration	96
FIG. 74	Example of an Archive system solution for Big data	97
FIG. 75	China Enterprise Storage Yearly Capacity Supply Trend	98
FIG. 76	China Enterprise Optical Storage Market Trend	99
FIG. 77	Optical archive solution providers in China	100
FIG. 78	Optical Disc Storage Applications in China: Potential Market	101
FIG. 79	Professional Optical Disc Supplier	103
FIG. 80	Optical archive system companies in China	106
FIG. 81	Major players of each category	106
FIG. 82	SNS related major companies	107
FIG. 83	Amethystum Library products	108
FIG. 84	Netzon product list	109
FIG. 85	Big Data related companies in China	114

## TABLES

Table 1	Applications and Storages .....	13
Table 2	Average shipping capacity/unit of each HDD types.....	13
Table 3	Total Storage Yearly Capacity Shipping Trend (EB) by Type .....	15
Table 4	Total Storage Yearly Shipping Capacity Trend (EB) by Type, by client/enterprise.....	17
Table 5	Total Accumulated Storage Capacity Trend(EB) by Type .....	18
Table 6	Total Accumulated Storage Capacity Trend by storage, by Type, by client/enterpris..	19
Table 7	Yearly Capacity ratio trend between Client and Enterprise by Type(%) .....	20
Table 8	Client storage yearly shipping capacity trend.....	21
Table 9	Enterprise storage yearly shipping capacity trend .....	22
Table 10	Enterprise yearly shipping capacity trend by Hot/Cold storage .....	23
Table 11	Enterprise Storage Yearly units shipping trend (M units).....	24
Table 12	Enterprise accumulated capacity trend.....	26
Table 13	Accumulated Enterprise Cold storage Capacity trend (EB).....	27
Table 14	Yearly Shipping Capacity (EB) .....	28
Table 15	Accumulated Storage Capacity (EB).....	28
Table 16	HDD-NL : Gloss capacity & Average capacity per drive Trend (EB/GB).....	30
Table 17	LTO: uncompressed Capacity Yearly Shipment Trend (EB) .....	32
Table 18	LTO Units Shipping Trend .....	32
Table 19	BD disc trend for archive .....	34
Table 20	Enterprise Optical Disc Storage Accumulated Capacity Trend (EB) .....	35
Table 21	AD Yearly Capacity Shipment Trend (PB) .....	36
Table 22	Archival disc yearly UNITS shipment trend (M units) .....	37
Table 23	Average Capacity/units Trend of HDD, LTO, Optical disc .....	44
Table 24	Capacity Roadmap of each cold storage device .....	45
Table 25	Enterprise Cold Storage Accumulated Capacity2021 - 2026CAGR .....	81
Table 26	Accumulated Enterprise Cold storage Capacity trend.....	82

## 2. Executive Summary

### 2.1. The main contents analyzed by this report

This report provides a detailed analysis of the following topics and aims to show the role, position, importance, and future expansion trends of optical disc storage in cold storage, which accounts for most of the enterprise market.

- Overall storage market supply trends for SSDs, HDDs, optical disc storage, LTO, etc.
- Detailed Analysis of Cold Storage Trends in the Enterprise Market
- Analysis of individual market trends and technology trends for each storage product and analysis of capacity supply capabilities for future markets
- Storage Tier Shift and Storage Choice in the Enterprise Market
- Analysis of the relationship between free space capacity and new shipment capacity in the enterprise cold storage market
- Trend analysis of the enterprise storage market in China, the main market for optical disc storage
- Direction of the Optical Disc Storage Business with Emphasis on Profitability and Continuity

### 2.2. Summary of Analysis of Cold Storage Trends

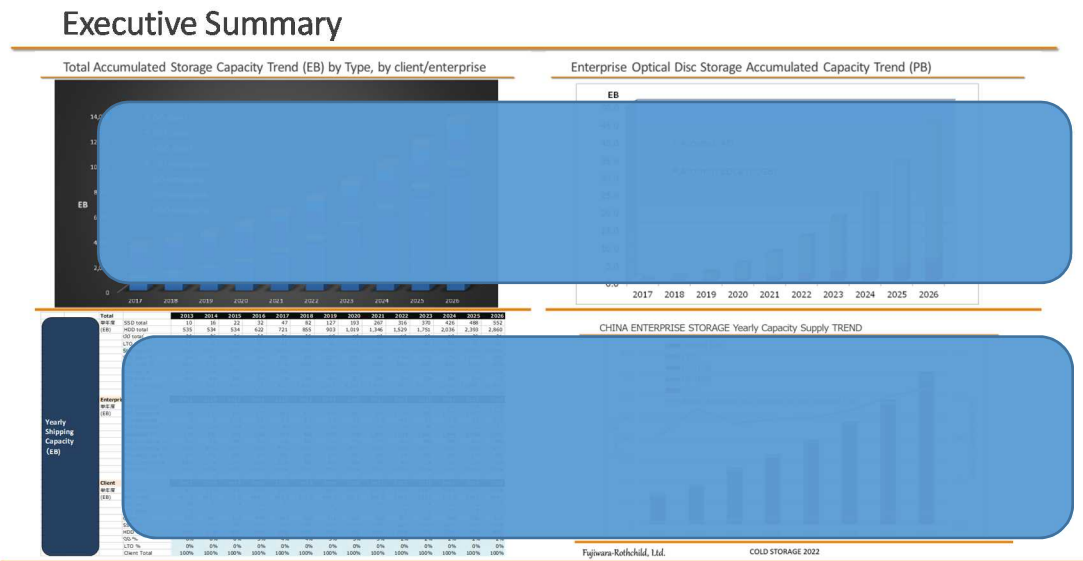
FIG. 2 summarizes the main points in this report

Top left: Worldwide accumulated total storage capacity trend

Lower Left: Yearly Shipping Capacity (EB) Data Table

Top right: Enterprise Optical Disc Storage Market Capacity Trends

Bottom Right: China Enterprise Storage Market Capacity Trend Forecast



Fujiwara-Rothschild, Ltd.

COLD STORAGE 2022

FIG. 2 Executive Summary



- **Analysis of overall storage market supply trends for SSD, HDD, optical disc storage, LTO, etc.**

The storage with the highest capacity supply growth will be SSDs in client and enterprise and HDD-NL in enterprise, with an overall storage CAGR of 22.5% in 2021-2026.

- **Detailed analysis of cold storage in the enterprise market**

The main device for cold storage is HDD-NL, which will be about 9ZB in actual capacity in the CY2026, accounting for a 96% capacity share of total enterprise cold storage. Optical disc storage is expected to become 45EB in 2021-2026, with a 0.5% capacity share.

- **Analysis of individual market trends and technology trends for each storage product and analysis of capacity supply capabilities for future markets**

HDDs are experiencing delays in the introduction of HAMR and MAMR to the market, and LTOs are experiencing downward revisions in capacity trends that could affect their ability to supply capacity to the market in the future. Without the delay, the market capacity could have been more than 100 EB larger than the current forecast in 2023. For optical storage, both AD/BD are in a situation where capacity supply forecasts for the market are being revised from strong to slightly weaker.

- **Storage Tier Shift and Storage Choice in the Enterprise Market**

In the enterprise market, the long-term HDD-NL capacity supply is in a rapid expansion trend: Tier 2 as cold storage (HDD-NL) including Warm is showing extremely rapid growth. On the other hand, Tier 3, which is Deep Archive (LTO + Optical), is showing slower capacity growth than expected. In other words, HDD-NL is still expected to dominate the market. In other words, the Tier 3 ratio is shrinking relatively, while HDD-NL continues to expand into Tier 3 applications.

- **Optical Disc Storage Application Analysis and Expected Market Sharpened by Actual Results**

As 3 major applications for optical disc storage, off-line archiving, cold storage in data centers, and big data storage are expected markets in the future, and the potential market size is extremely large. In the context of optical disc storage in 2019 and beyond, for both BD and AD, steady expansion of on-premise off-line storage and expansion of data center applications are seen. The expansion of optical disc storage in data centers is still in its infancy in terms of securing a firm position, but the ongoing challenge in the Chinese market has resulted in a marked aggressiveness, and this expansion will continue for the time being.

- **Optical Disc Storage Business Direction**

Under the circumstances, there are also glimpses of an intended stagnation of business entry in the cold storage market for optical disc storage. The temporary very aggressive business strategy of the optical storage business is being curbed, and a shift is being made to a more sustainable business form that will ensure profitability.

## Cold Storage 2022

Published March 2022

116 pages.

Fujiwara-Rothschild, Ltd.  
TSR 2nd Building, 2-8-1,  
Higashi-Kanda, Chiyoda-ku, Tokyo 101-0031, Japan

Tel: 03-5821-3993  
Fax: 03-5821-4030  
Email: [info@fujiroth.com](mailto:info@fujiroth.com)

All rights reserved

Price: 500,000 yen for electronic files only

With hard copy 550,000 yen