QLCを始めよう！これからのHPCを担う最強SSDを徹底解説

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Legal Disclaimer

All information provided here is subject to change without notice.

The New Paradigm of Solid-State Storage

Leadership NAND SSD Portfolio

Scale: 4 NAND Factories

Global Organization, HQ in California

- Solid-State Innovation Since 1987

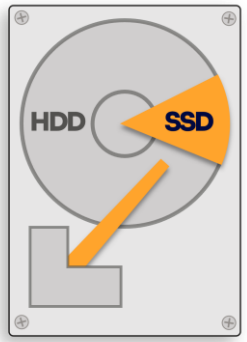
intel + SK hynix

- Enterprise, Cloud & Client Solutions
- Pace-setting innovation across Floating Gate & Charge Trap; TLC, QLC and PLC

Top Storage Challenges and Key Drivers

1 Aging gear

85–90% of all datacenter data still stored on HDDs[1]



Scalability challenges from core → mid-tier → edge

2 Lack of capacity

Data-rich services

High-speed networks

AI/ML

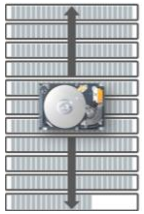
Big Data

Data-intensive workloads

3 High costs

SSD spending growing **4.5x faster** than compute[2]

Legacy storage drives higher TCO



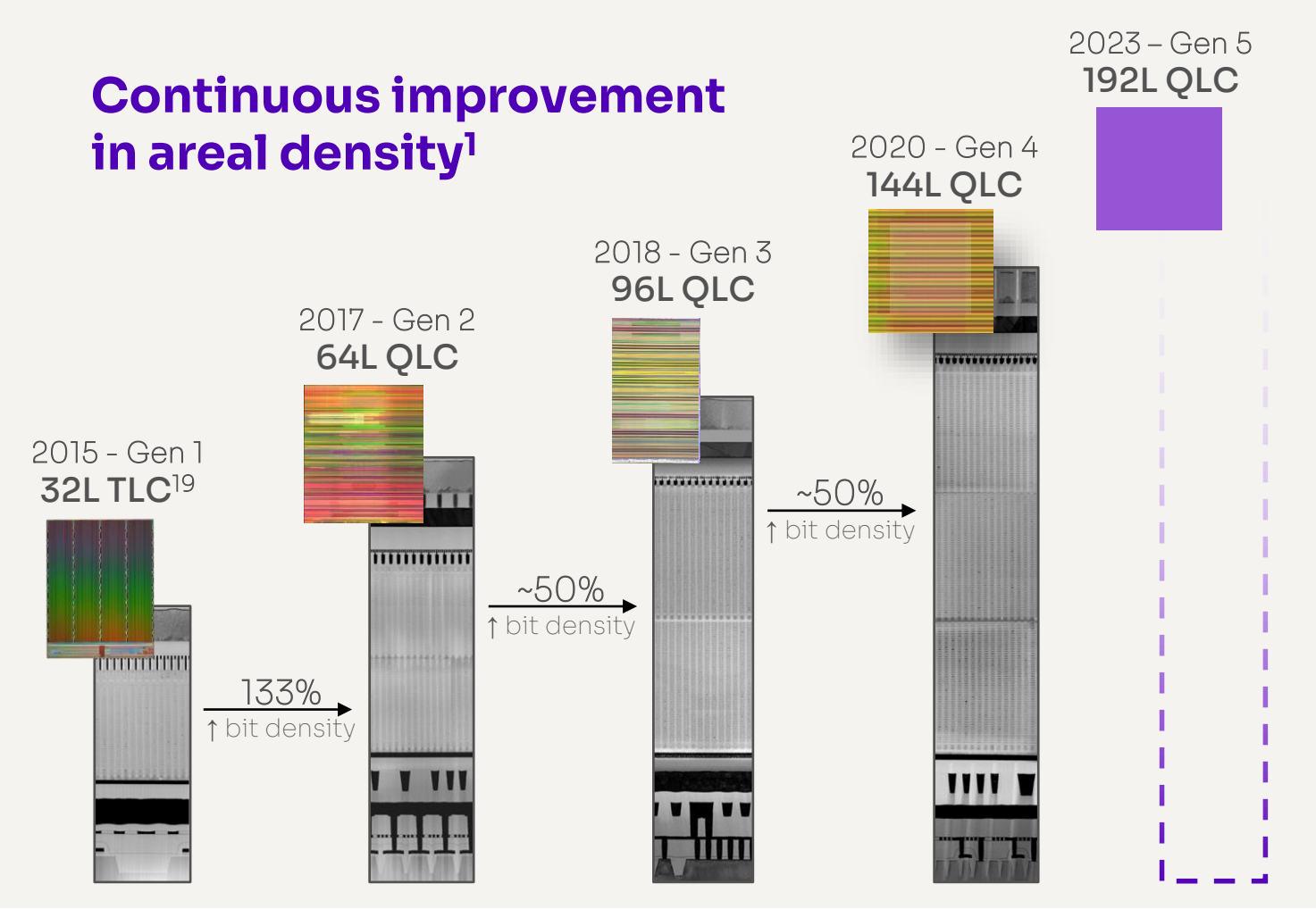
Power and sustainability concerns

Solidigm™ QLC NAND SSDs Address Key Storage Pain Points

Rapidly access | **More data** | **More efficiently**

Solidigm™ 3D NAND: mature and market-aligned

(formerly Intel®)



QLC is a proven fit for today's value-based workloads

Solidigm QLC NAND (formerly Intel) has been in **volume production since 2017**

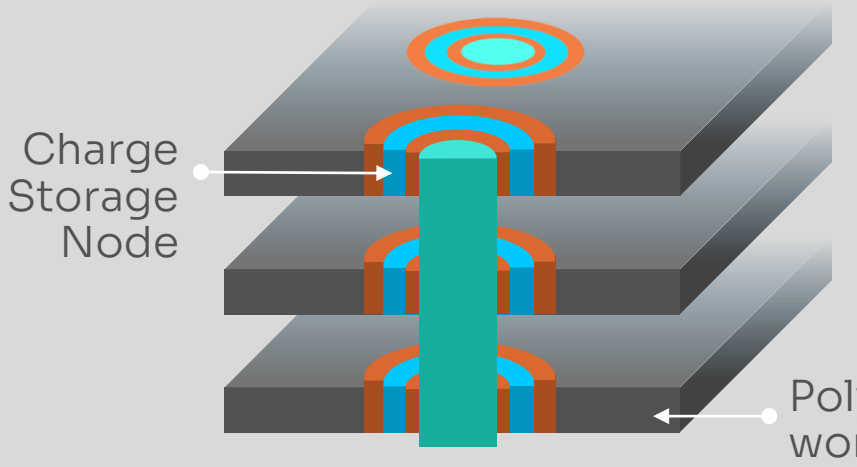
Ongoing QLC areal density improvements deliver **improved value and higher storage capacities**

Stay tuned for details!

[1]Dates are based on Intel technology announcements.

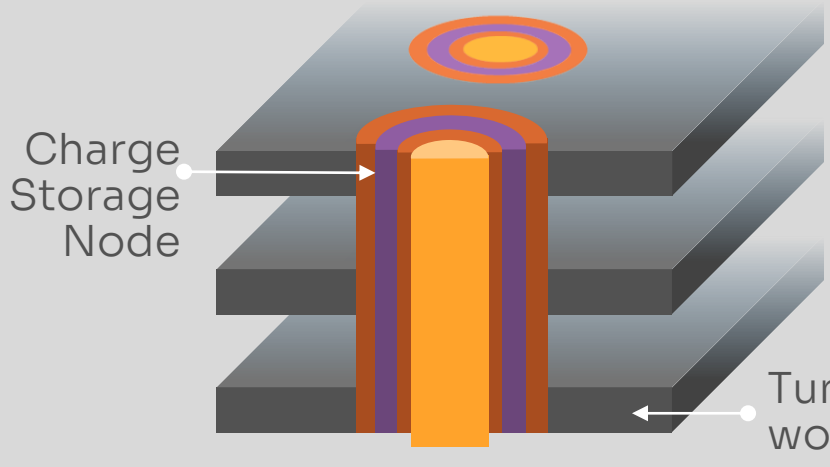
Complementary NAND Technologies

Floating Gate NAND Technology



- Discrete charge storage node
- Good P/E voltage threshold window and strong cell isolation
- Better fit for **high density die/drives**
- **Proven scalability to higher bits/cell**

Charge Trap Flash NAND Technology



- Continuous charge storage node
- Metal word line
- Better fit for **low density die/drives**
- Excels at **low density performance**

Enabling optimal solutions for all Datacenter segments

Introducing the Solidigm™ D5-P5430

Advancing QLC NAND technology with drop-in storage value

Next-generation Intel® QLC 3D NAND

5th generation

read-optimized performance and reliability

2x greater bandwidth[1]

PCIe 4.0

with enhanced NVMe 1.4 feature set

Expanded form factor options[1]

U.2

E3.S

E1.S[2]

greater deployment flexibility

Greater capacity range

3.84TB

7.68TB

15.36TB

30.72TB[1]

up to 4x larger maximum capacity[1]

Greater lifetime total bytes written

P5430 27 PBW[1,2]

P4420 5.6 PBW

larger max capacity for more lifetime writes[2]

Drop-in storage solution

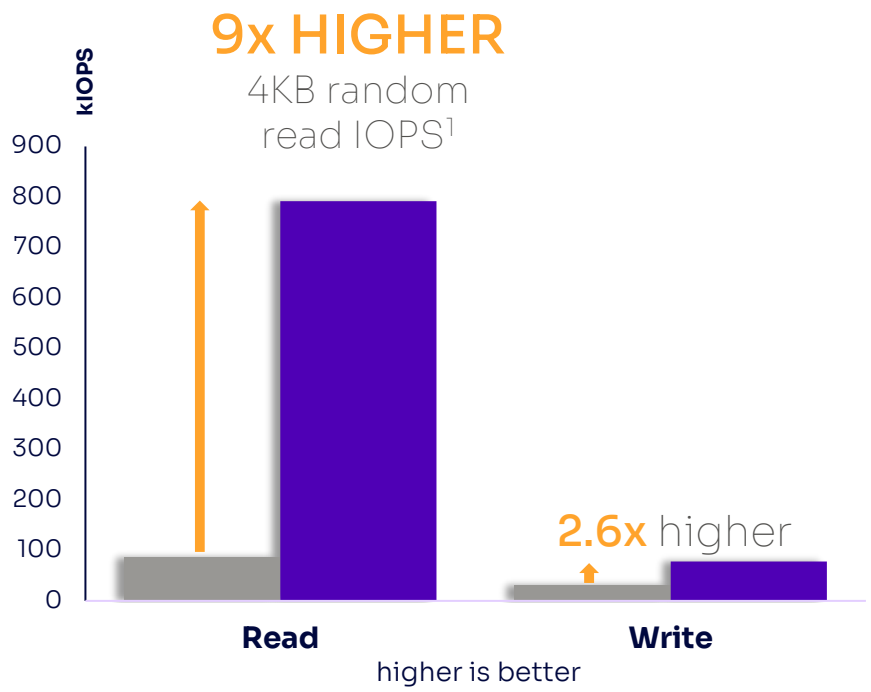
4k block size

no host-side write shaping needed

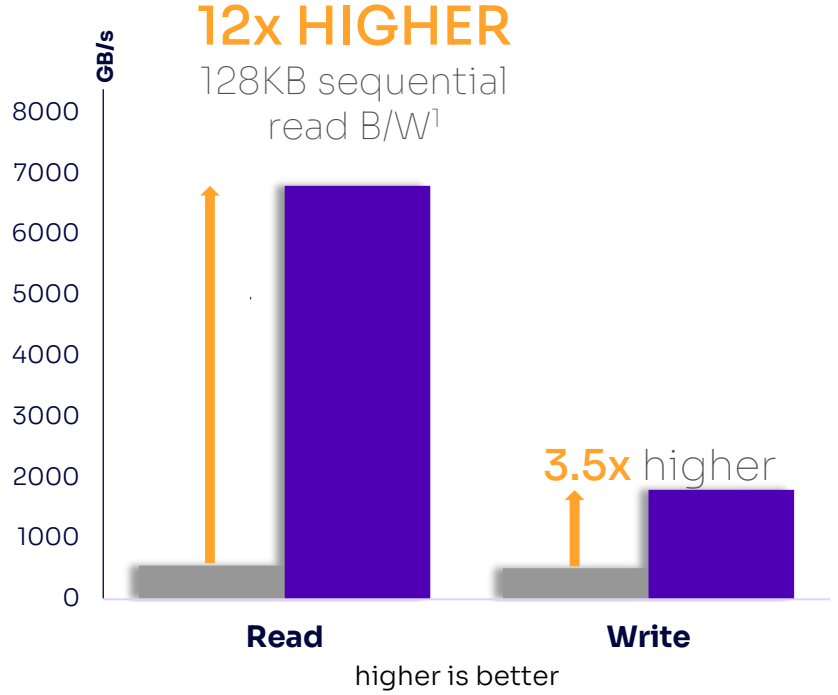
[1] As compared to previous gen Intel® SSD D5-P4420 with capacity of 7.68TB versus D5-P5430 30.72TB. PBW rating for 30.72TB SSD based upon 8KB transfer 100% random write workload.
[2] Based on planned future roadmap product. All product plans and roadmaps are subject to change without notice.

QLC Performance: Transition from SATA

4KB Random Workload



128KB Sequential Workload



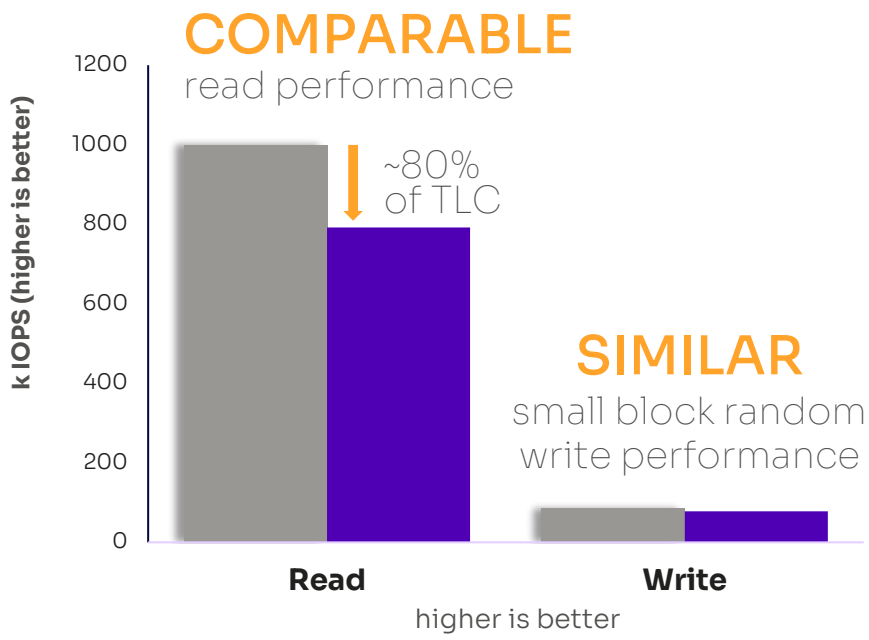
PCI Gen4 read performance and major **write performance gains** versus legacy SATA

Solidigm D3-S4520 7.68TB (SATA, formerly Intel®) **Solidigm D5-P5430 7.68TB (QLC)**

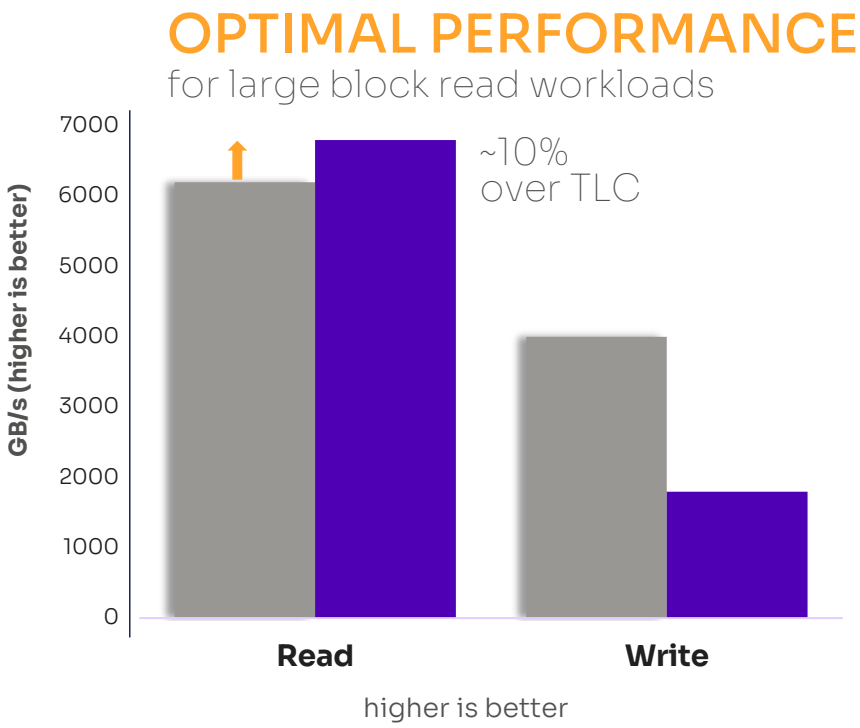
[1] Source – Solidigm. D5-P5430 results have been estimated or simulated. Results may vary.

QLC Performance: Transition from entry-TLC

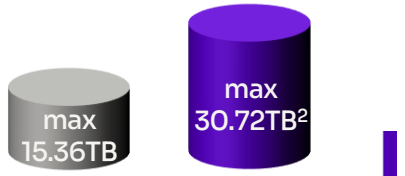
4KB Random Workload[1]



128KB Sequential Workload[1]



Read-intensive value with scalability for footprint consolidation



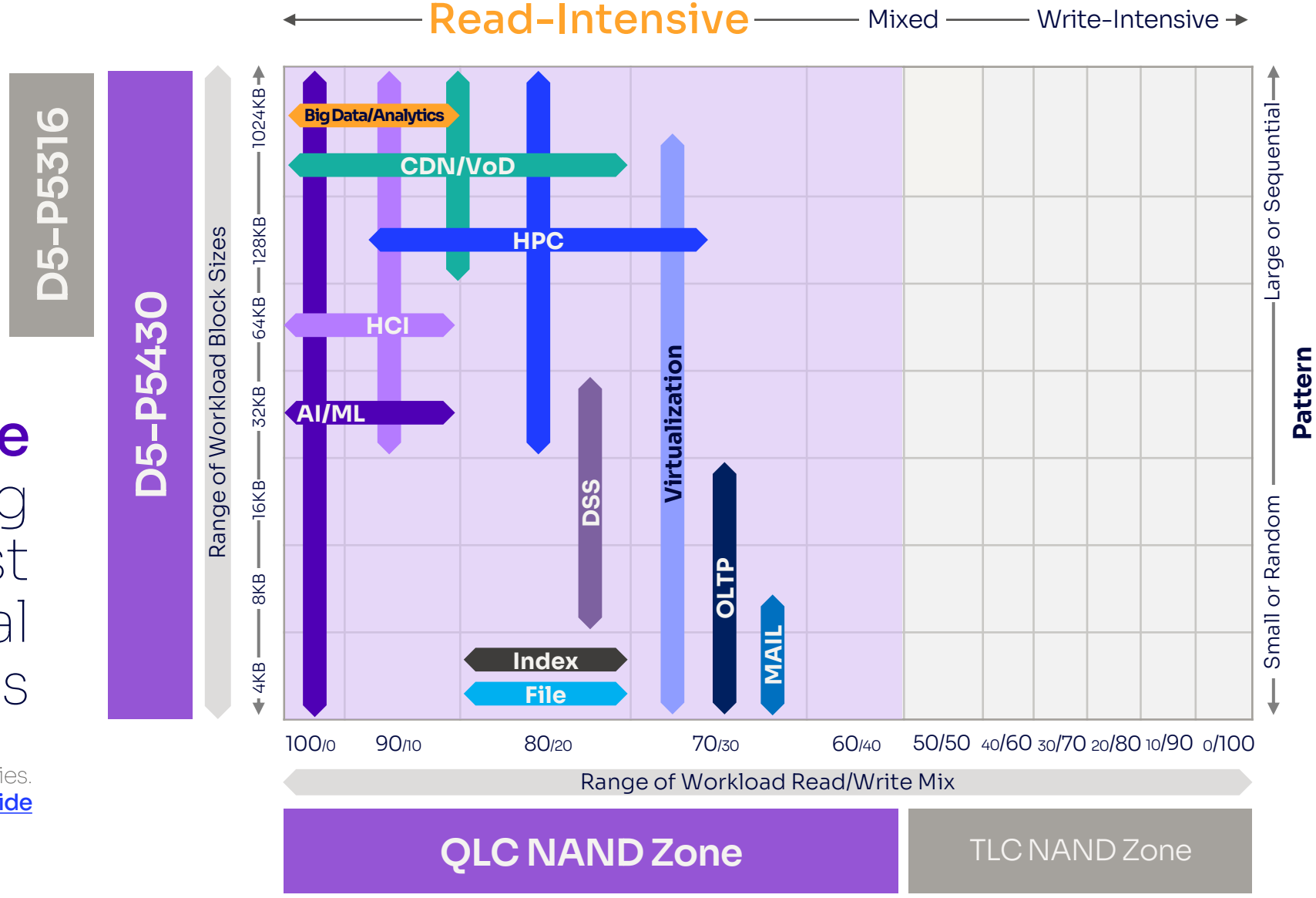
■ **Kioxia CD6-R 7.68TB[3] (TLC)** ■ **Solidigm D5-P5430 7.68TB (QLC)**

[1] Source – Solidigm. D5-P5430 results have been estimated or simulated. Results may vary.
[2] Based on planned future roadmap product. All product plans and roadmaps are subject to change without notice
[3] Source - Kioxia. Published data as of Feb 9, 2022. See https://business.kioxia.com/content/dam/kioxia/shared/business/ssd/doc/dSSD-CD6-R-product-brief.pdf

Characterizing read-intensive segments and workloads

Read-intensive workloads needing rapid access to vast datasets are an ideal fit for QLC SSDs

Examples may not represent all QLC fit opportunities.
For more information see the QLC Workload Guide

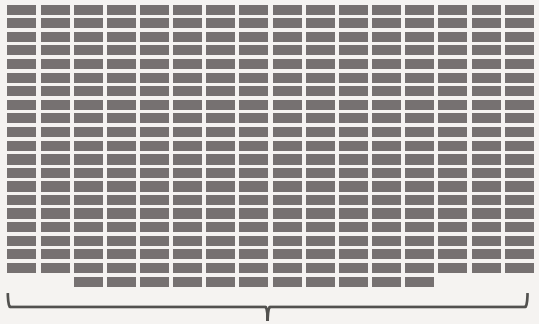


DENSE STORAGE ADVANTAGE #2

QLC enables a **smaller physical footprint**

Higher capacities with effective performance can deliver a **massive reduction in data center footprint**

CDN/Content Delivery Network Footprint



331 servers

Hybrid Array (TLC+HDD)

(7.68TB SSD + 8TB HDD)

67 servers

all-QLC NAND

(30.72TB SSD)

4.9x

reduction in solution server footprint

Solution requirements: A mid-tier CDN solution delivering **BOTH 480TB of total capacity and 190 Gbps throughput per node**. Source - Solidigm. https://www.intel.com/content/dam/www/central-libraries/us/en/documents/replace-legacy-storage-in-cdn-with-qlc-ssd-brief.pdf. See solution configuration details in Slide#15 and Appendix A.

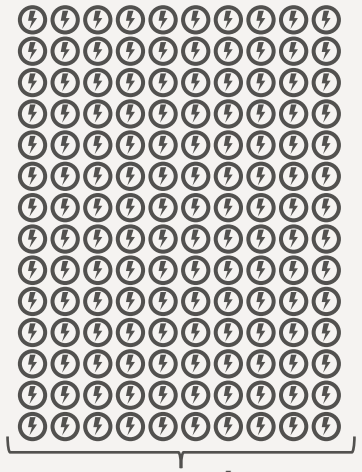
DENSE STORAGE ADVANTAGE #3

QLC drives **reduced power consumption**

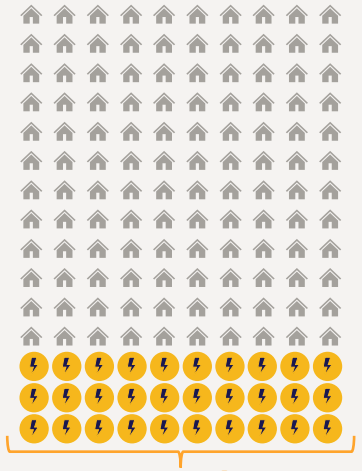
A smaller data center footprint drives **enormous power savings**

CDN/Content Delivery Network Solution Power

Watts Per Usable Terabyte of Capacity



6.46W/TB
Hybrid Array (TLC+HDD)
(331 total servers required)



1.40W/TB
all-QLC NAND
(67 total servers required)

4.6x
lower Watts/TB across solution

Solution requirements: A mid-tier CDN solution delivering **BOTH 480TB of total capacity and 190 Gbps throughput per node**. Source - Solidigm. https://www.intel.com/content/dam/www/central-libraries/us/en/documents/replace-legacy-storage-in-cdn-with-qlc-ssd-brief.pdf. See solution configuration details in Slide#15 and Appendix A.

TCO - mid-tier CDN with QLC SSDs

Mid-tier CDN Performance and Capacity Solution[20]

(Required mid-tier servers based on 480TB capacity, 190 Gbps throughput targets per node)

Hybrid TLC SSD + HDD Arrays

111TB capacity and 51Gbps per server,
331 total servers required

Cost per server	**$17,419**
Servers needed for 6 regions	**331**
Total server cost	**$5,765,834**
5-year Estimated TCO	**$9,718,632**

Solidigm™ (formerly Intel™) QLC

614TB capacity and 190Gbps per server,
67 total servers required

Cost per server	**$113,187**
Servers needed for 6 regions	**67**
Total server cost	**$7,583,552**
5-year Estimated TCO	**$8,383,665**

Efficient scaling with greater per server capabilities

nearly

4.9x

Greater server consolidation[20]

up to

14%

Lower estimated TCO[20]

See CDN Solution Brief

Source – Intel. https://www.intel.com/content/dam/www/central-libraries/us/en/documents/replace-legacy-storage-in-cdn-with-qlc-ssd-brief.pdf. Micron 9300 SSD pricing as of September 20, 2021, https://www.newegg.com/micron-9300-pro-series-15-36tb/p/N82E16820363104?Description=micron%209300&cm_re=micron_9300-_-9SIA4S8C2V8931-_-Product. https://www.serversupply.com/products/part_search/query.asp?q=ST8000NM001A&gclid=Cj0KCQjwxtSSBhDYARIsAEn0thQalvH8hLy4jF54pmlQG5z-10Y-N6B38_LQsbWdSMNRNYBaT5Dj08IaAvbtEALw_wcB; Intel SSD pricing shown based on Intel Recommended Customer Price (RCP) as of September 20, 2021. Actual price can vary and may not reflect the pricing used in the TCO model.

サプライチェーン排出量とは？

- 事業者自らの排出だけでなく、事業活動に関係するあらゆる排出を合計した排出量を指す。つまり、原材料調達・製造・物流・販売・廃棄など、一連の流れ全体から発生する温室効果ガス排出量のこと
- サプライチェーン排出量＝**Scope1排出量**＋**Scope2排出量**＋**Scope3排出量**
- GHGプロトコルのScope3基準では、Scope3を**15のカテゴリに分類**

○の数字はScope３のカテゴリ

Scope1：事業者自らによる温室効果ガスの直接排出(燃料の燃焼、工業プロセス)
Scope2：他社から供給された電気、熱・蒸気の使用に伴う間接排出
Scope3：Scope1、Scope2以外の間接排出(事業者の活動に関連する他社の排出)

DENSE STORAGE ADVANTAGE #1

QLC produces **less CO_2 in manufacturing**

Higher density media results in a **smaller NAND manufacturing carbon footprint**

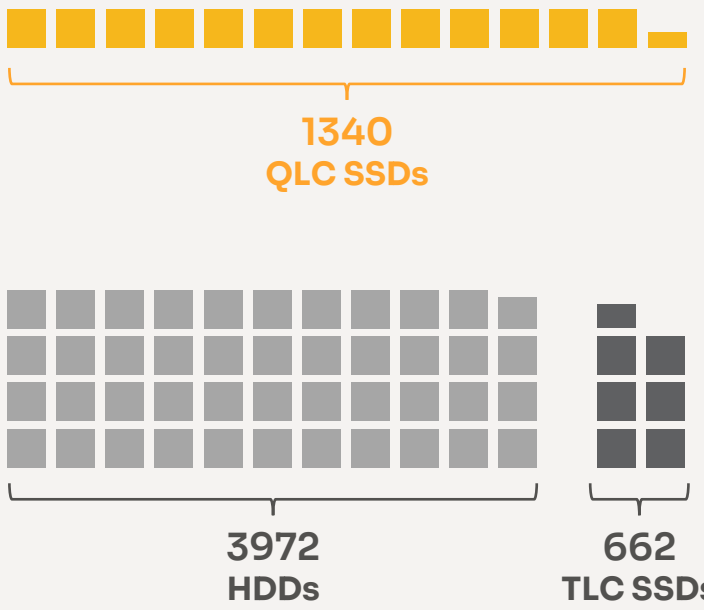
Source – Intel® Corporation on behalf of Solidigm™: Compares max single die capacity for Solidigm TLC and QLC NAND products on same technology node across Process, Heat Transfer Fluid and Scope 2 emissions using IPCC2006 Tier 2a & IPCC2019 Tier 2c calculation methods.

DENSE STORAGE ADVANTAGE #4

QLC delivers a **reduced disposal impact**

Fewer drives needed means **fewer drives to dispose of** (or otherwise disposition)

CDN/Content Delivery Network EOL Disposition

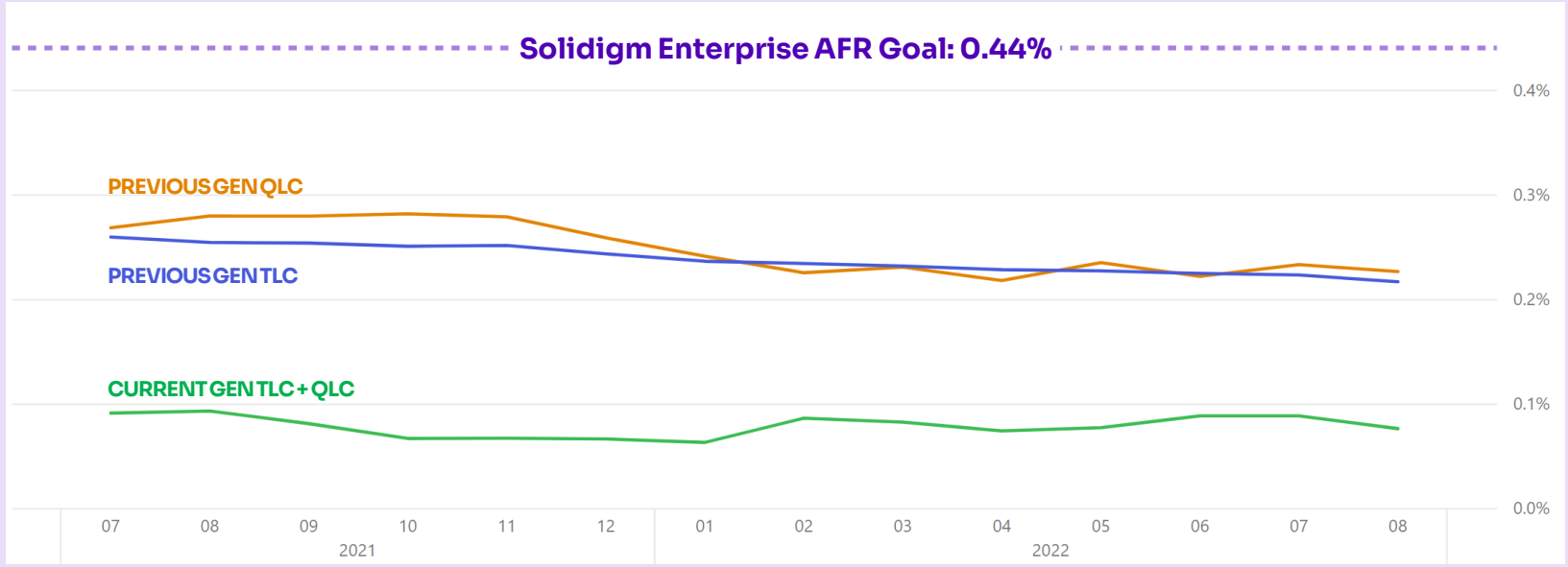


3.5x
fewer drives to disposition at end-of-life

Solution requirements: A mid-tier CDN solution delivering **BOTH 480TB of total capacity and 190 Gbps throughput per node**. Source - Solidigm. https://www.intel.com/content/dam/www/central-libraries/us/en/documents/replace-legacy-storage-in-cdn-with-qlc-ssd-brief.pdf. See solution configuration details in Slide#15 and Appendix A.

Deploy Solidigm™ QLC SSDs With Confidence

Annual Failure Rate (AFR) Performance vs Solidigm Goal[1]



Solidigm D5-P4510 (TLC) **Solidigm D5-P4326 (QLC)**

Solidigm D7-P5510 (TLC) + Solidigm D5-P5316 (QLC)

Solidigm QLC AFR significantly better than our own high standards

Measured customer field failure data shows **industry-leading reliability** and **gen:gen improvements** for both Solidigm QLC and TLC SSDs.

[1] Source – Solidigm AFR data s of Aug 19, 2022. Annual Failure Rate (AFR) is defined by Solidigm as customer returns less units which upon evaluation are found to be fully functional and ready for use.

ありがとうございました。

Appendix A

1.Modern QLC vs Legacy Storage Performance: Source – Solidigm. Comparing Intel 3D NAND QLC SSD, such as Intel® SSD D5-P5316, to enterprise HDDs in the market like Western Digital Gold, Intel 3D QLC NAND SSDs performs better on all 4 corners of performance (random read, random write, sequential read, sequential write), QoS, endurance, and TB/RU. With its PCIe high bandwidth interface, you can get more performance than HDD. Slide 10 and 13 on this deck shows the true advantage of performance and endurance when you compare Intel 3D NAND QLC SSD to HDDs. With its U.2 and E1.L form factor, you can also save on rack space compared to HDD 3.5inch , enabling up to 1PB/IU. https://documents.westerndigital.com/content/dam/doc-library/en_us/assets/public/western-digital/product/data-center-drives/ultrastar-dc-hc600-series/data-sheet-ultrastar-dc-hc650.pdf

2.Content Delivery Network (CDN) Solution: Source – Solidigm. See solution configuration details at https://www.intel.com/content/dam/www/central-libraries/us/en/documents/replace-legacy-storage-in-cdn-with-qlc-ssd-brief.pdf. See Table 1 for calculations used towards determining drive requirements based on achieving target capacity and bandwidth, with higher number determining quantity of drives needed per server.

Table 1

	Calculations towards Target Storage Capacity		Calculations towards Target Network Bandwidth		Aggregate Math w/ Storage + Network	Inputs for Target Server Count Requirement Math				
Storage Type	Single drive capacity (TB)	Disks Required To meet Capacity per server	Effective Throughput per Disk (Gbps)	Disks Required to meet Network BW per server	Disks per server	Server form factor	#HDDs per Server	#NVMe per Server	Total Server Capacity (TB)	Server Throughput Delivered (Gbps)
NVMe QLC (6.8GBps Seq read) P5316	30.72	16	54.4	3	16	2U	0	20	614.4	190
Hybrid: TLC+HDD	8	60	17.7816	11	60	2U	12	2	111.36	51.14

QLC: 67 servers * 20x Solidigm D5-P5316 30.72TB = 1340 drives

Hybrid: 331 servers * (12x Seagate Exos 8TB HDD + 2x Solidigm D7-P5510 7.68TB) = 4634 drives (3972 HDD + 662 SSD)

Appendix A – CDN solution Power

Configuration data source - https://www.intel.com/content/dam/www/central-libraries/us/en/documents/replace-legacy-storage-in-cdn-with-qlc-ssd-brief.pdf

	Hybrid Array Seagate Exos 7E8 8TB (capacity) Solidigm™ D7-P5520 7.68TB (cache)	all-QLC NAND Solidigm D5-P5316 30.72 U.2 (capacity)
Number of servers	331	67
Power per server	430	360
Total server power	142330	24120
Drives per server (storage)	12	
Avg. power per drive (storage)	12.81	
Total drive power (storage)	50881.32	
Drives per server (cache)	2	
Avg. power per drive (cache)	18	
Total drive power (cache)	11916	
Drives per server		20
Drive power (active)		25
Drive power (idle)		
Avg. power per drive		25
Total drive power		33500
TOR switch power	150	150
Total power consumption	205277.32	57770
Capacity per drive	8	30.72
Total capacity	31776	41164.8
Power per capacity (W/TB)	**6.46013721**	**1.403383473**

Appendix B

1. **Modern QLC vs Legacy Storage Performance**: Comparing Intel 3D NAND QLC SSD, such as Intel® SSD D5-P5316, to enterprise HDDs in the market like Western Digital Gold, Intel 3D QLC NAND SSDs performs better on all 4 corners of performance (random read, random write, sequential read, sequential write), QoS, endurance, and TB/RU. With its PCIe high bandwidth interface, you can get more performance than HDD. Slide 10 and 13 on this deck shows the true advantage of performance and endurance when you compare Intel 3D NAND QLC SSD to HDDs. With its U.2 and E1.L form factor, you can also save on rack space compared to HDD 3.5inch , enabling up to 1PB/IU. https://documents.westerndigital.com/content/dam/doc-library/en_us/assets/public/western-digital/product/data-center-drives/ultrastar-dc-hc600-series/data-sheet-ultrastar-dc-hc650.pdf

2. **Modern QLC vs Legacy Storage Performance**: Comparing Intel 3D NAND QLC SSD, such as D5-P5316, to SATA TLC SSD, such as D3-S4510, Intel 3D NAND QLC SSD performs better on all 4 corners of performance (random read, random write, sequential read, sequential write), QoS, and TB/RU. PCIe supersedes SATA as the latest high bandwidth interface which allows for better performance and QoS. With QLC technology, Intel 3D NAND QLC SSD can scale up to 30.72TB allowing the drive to have better TB/RU enabling 1PB/IU. https://www.intel.com/content/www/us/en/products/docs/memory-storage/solid-state-drives/data-center-ssds/dc-d3-s4510-s4610-series-brief.html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