



Technical Research Report



Choose High Data-Efficiency Technology for Lower Storage TCO

Prowess Consulting testing confirms the Dell™ PowerStore™ 1200T storage platform exceeds its data reduction ratio (DRR) guarantee of 5:1.¹ This storage solution uses fewer drives, less administration time, and less power to store the same amount of data as a competing vendor’s solution.

Executive Summary

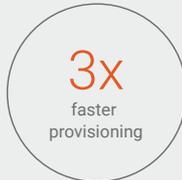
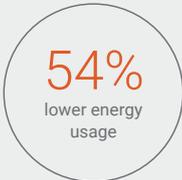
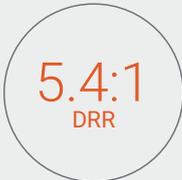
Successful businesses use data-driven decisions to increase sales, enrich customer experiences, and improve operational efficiencies. To get the insights they need, they run high-speed analytics on high-volume datasets. At the same time, they need to reduce total cost of ownership (TCO) and meet sustainability goals.

A cost- and energy-efficient storage solution is one way of resolving many of these challenges. To explore available options, Prowess Consulting compared two storage platforms. In a study commissioned by Dell Technologies, we tested storage solutions from two vendors: the Dell™ PowerStore™ 1200T solution and a product from a competitor we call Vendor A.

Dell Technologies guarantees a data reduction ratio (DRR) of 5:1 for reducible data with the PowerStore 1200T solution, whereas Vendor A guarantees a DRR of 4:1.^{1,2} We tested both platforms using a simulated dataset and observed that the PowerStore 1200T solution delivered a significantly higher DRR of 5.4:1, compared to the Vendor A solution’s DRR of 2.5:1. This higher data efficiency enables organizations to use fewer drives to achieve the same storage capacity. Fewer drives mean smaller infrastructure footprints, lower hardware costs, and less power used for storage and cooling.

Highlights

Side-by-side analysis with Vendor A reveals the following Dell™ PowerStore™ 1200T solution advantages:



The Benefits of Improved Storage Efficiency, Faster Provisioning, and Finer Controls

Manufacturers of all-flash storage platforms have responded to customer needs for lower price points by applying data-efficiency technologies. They use data services, such as compression and deduplication, to help reduce the amount of physical storage that is needed to save a given dataset. Higher data efficiencies have been used for years to lower costs, while granular controls are more critical than ever in today's dynamic business environments.

Organizations seeking to reduce the TCO of storage should look at storage solutions that can deliver these key benefits. A storage platform that delivers higher data efficiency requires fewer drives to store the same volume of data, which can help reduce power and cooling needs. Using fewer drives can also reduce data storage's physical footprint, which can lead to savings in floor and rack space. Easy to use, streamlined management controls help IT staff save time when provisioning storage, allocating workloads, and scaling storage volumes. The ability to identify workload details, such as reducible and unreducible data, gives IT staff valuable insights that allow them to manage their data storage as cost-effectively as possible. These cost- and space-saving capabilities can not only help organizations optimize their storage cost/TB, but they can also help them meet sustainability goals.

How We Tested, What We Found

For our testing, Prowess Consulting configured both the PowerStore 1200T storage solution and the Vendor A platform with the maximum number of internal drives supported in the base enclosure. We didn't use any externally connected shelves. (For complete details, refer to [Test Methodology](#) in the Appendix.)

We began our test setup by creating twelve 1 TB volumes on each array and then mapping these volumes to our servers through Fibre Channel connections. We tuned the storage and hosts according to each storage vendor's published best practices. We ran our data reduction validation three times and chose the median result for this report.

For testing purposes, we used a 12 TB dataset to ensure a manageable test time. However, because the DRR is not impacted by the quantity or size of the NVM Express® (NVMe®) drives used, the same data reduction results can be extrapolated over larger datasets.

Data Reduction

We started the test with each array containing empty volumes. Using the Vdbench tool, we simulated data migration into the arrays. The 12 TB dataset, which Vdbench created, had a 256 KB input/output (I/O) size, a 2:1 compression ratio, a 2:1 deduplication ratio, and a single thread per volume. We collected capacity and data reduction information before and after each iteration to assess the data reduction capabilities of both storage arrays.

A storage platform's usable or physical capacity represents the amount of data it can store out-of-the-box before data reduction is applied. Logical capacity is measured after the storage operating system (OS) applies data compression and deduplication to the reducible data. A DRR guarantee promises that using data compression and deduplication, the storage platform's logical capacity will be X times greater than its usable capacity. The latest PowerStoreOS release includes a new capability called intelligent compression. In the PowerStore platform we tested, the new OS delivered up to 20% higher data reduction compared to the previous OS release. According to our tests, this improved data efficiency delivered a DRR of 5.4:1 on the simulated dataset (see Figure 1), which supports Dell Technologies' updated DRR guarantee of 5:1.¹ The Vendor A platform offers a 4:1 DRR guarantee; however, its data efficiency fell short in our testing, with a DRR of 2.5:1.² See the [Appendix](#) for details on the test configurations and procedures.

Data Reduction Ratio (DRR) Dell™ PowerStore™ 1200T Versus Vendor A Platform^{1,2}

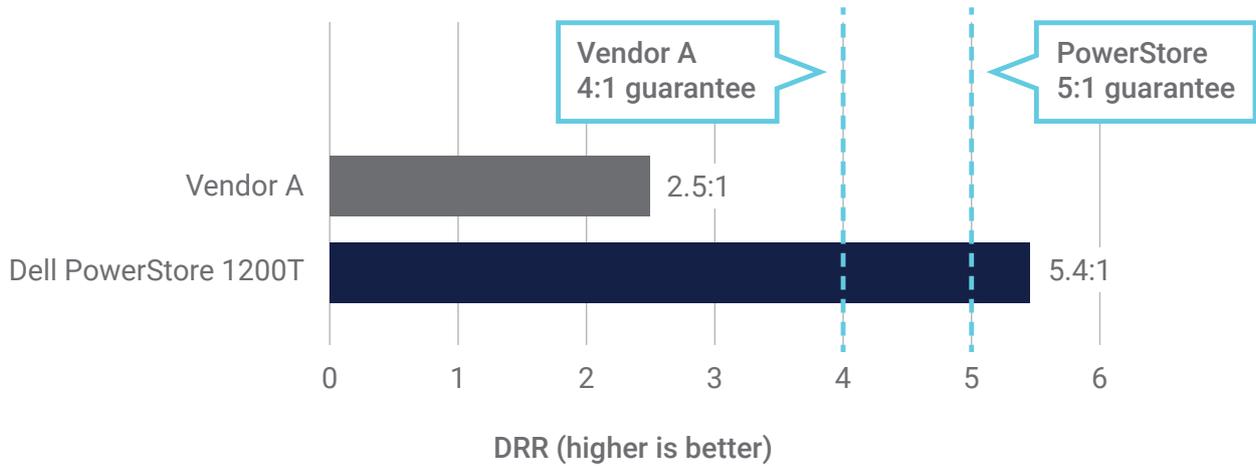


Figure 1 | Comparison of guaranteed and measured DRRs

We used the difference in DRRs to compute how many fewer drives would be needed in the PowerStore 1200T system to store the same amount of application data as in the Vendor A platform. (For details, see [System Comparison Calculations](#) in the Appendix.)

Effective Capacity for an Equivalent Number of Drives

Table 1 illustrates our calculations for effective capacity, which multiply the amount of usable capacity by the storage platform's DRR. In the test configuration, we read the usable capacity from each system's user interface (UI). We observed that the PowerStore 1200T solution used 23 drives for a total usable capacity of 31.9 TiB,³ whereas the Vendor A system used 24 drives for a total usable capacity of 32.5 TiB. Usable capacity is less than raw capacity because some storage space is needed for metadata, RAID, and other system overhead. We took usable capacity and each system's DRR and computed effective capacity. The effective capacity of the PowerStore 1200T was 172 TiB, whereas the effective capacity of the Vendor A platform was 81 TiB; this means the effective capacity of the PowerStore 1200T solution was more than 2x higher.

Table 1 | Effective capacity calculated from total usable capacity

Unit Under Test	A. Drive Quantity	B. Drive Size	C. Raw Capacity*	D. Reported Usable Capacity	E. DRR	F. Effective Capacity**
Dell™ PowerStore™ 1200T	23 drives	1.92 TB	44 TB	31.9 TiB	5.4	172 TiB
Vendor A platform	24 drives	1.92 TB	46 TB	32.5 TiB	2.5	81 TiB

* Calculated as A × B.
** Calculated as D × E.

The relationships between effective capacity, DRR, and usable capacity for each system are illustrated in Figure 2.

Data Storage Efficiencies

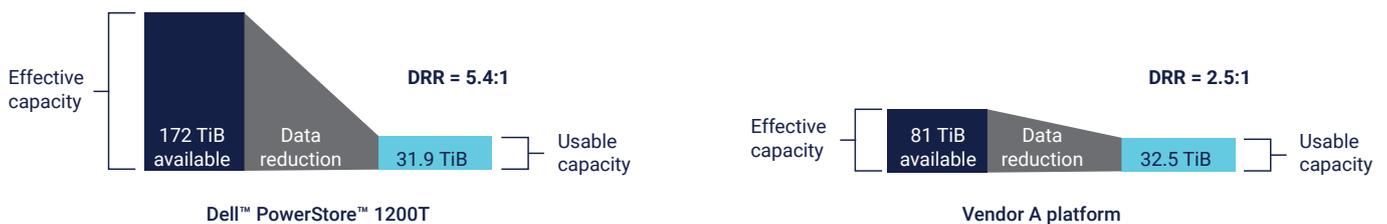


Figure 2 | The Dell™ PowerStore™ 1200T platform delivers greater than 2x higher DRR than the Vendor A platform

Number of Drives for an Equivalent Effective Capacity

To get an idea of how superior DRR can benefit an organization, we calculated how many drives it would take for each platform to store an effective capacity of 81 TiB. As shown in Table 2, we divided 81 TiB by each DRR value to calculate their respective usable capacities per system. We calculated the ratio of drive quantity (multiplier) using the values from Table 1. Twenty-three drives divided by the reported usable capacity of 31.9 TiB for the PowerStore 1200T solution and 24 drives divided by 32.5 TiB for the Vendor A solution gives us the drive quantity multipliers.

We used these multipliers to calculate the number of drives needed for an equivalent effective capacity. By our calculations, storing 81 TiB requires a minimum of 11 drives using the PowerStore 1200T platform and 24 drives using the Vendor A platform. Put another way, the PowerStore 1200T platform uses up to 54% fewer drives to store the same-sized dataset.

Table 2 | The number of drives needed to store an equivalent effective capacity

Unit Under Test	A. Effective Capacity*	B. DRR	C. Usable Capacity/Drive**	D. Multiplier***	E. Number of Drives****
Dell™ PowerStore™ 1200T	81 TiB	5.4	15 TiB	0.721	11 drives
Vendor A platform	81 TiB	2.5	32 TiB	0.738	24 drives

* See Table 1: Vendor A Platform, F. Effective Capacity.

** Calculated as A ÷ B.

*** Calculated using drive quantity/reported usable capacity per drive from Table 1.

**** Calculated as C × D.

Management Ease of Use and Level of Detail

We suggest that provisioning fewer, larger LUNs offers better storage flexibility and easier management. For our testing, we provisioned 12 volumes, with capacities of 500 GB to 1 TB per volume. Our usage testing revealed that the PowerStore 1200T UI was more intuitive and easier to use than the Vendor A platform UI for managing high-capacity LUNs.

For example, the PowerStore 1200T offers a single window for volume management, whereas the competitive platform requires the user to switch back and forth between two windows (see Table 3). The PowerStore 1200T solution also allowed us to provision storage volumes faster than the Vendor A solution. The median time it took to provision 12 volumes was 30 seconds using 12 mouse clicks for the PowerStore solution, compared to 94 seconds using 28 mouse clicks for the Vendor A solution.

Table 3 | The number of seconds, clicks, and windows needed to provision 12 volumes

Unit Under Test	Total Time (Median)	Total Clicks (Median)	Total Windows Opened
Dell™ PowerStore™ 1200T	30 seconds	12 clicks	1 window
Vendor A platform	94 seconds	24 clicks	2 windows

We also observed that the PowerStore management UI delivered a more granular view into the unique data being stored. PowerStoreOS includes a new capacity accounting feature that delivers granular reporting and controls, which we suggest can be used to manage data storage more cost effectively. Capacity accounting lets you view the overall DRR (reducible and unreducible data combined) or DRR for reducible data only. The “volume family unique data” feature lets you view individual storage volumes, conveniently showing various details of the unique data in each column. Figure 3 shows capacity information displayed in the PowerStore 1200T dashboard; note that ratios are clearly illustrated, and data savings are pre-calculated. By contrast, the Vendor A UI did not offer a similar level of detail on its storage utilization.

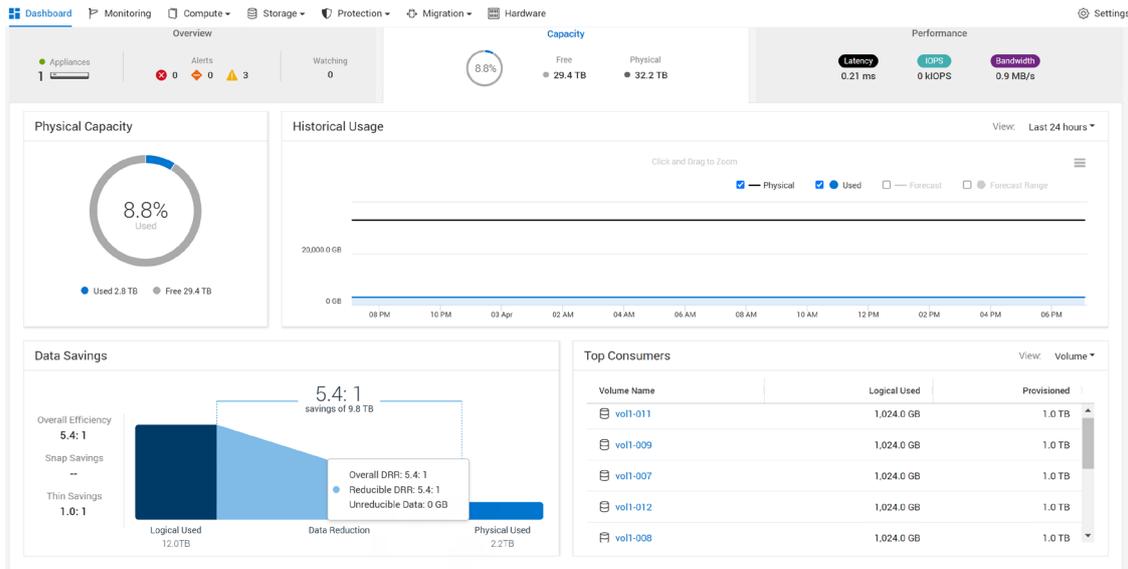


Figure 3 | The Dell™ PowerStore™ 1200T UI is intuitive and easy to use

Figure 4 shows what the display looks like after adding unreduceable data. (See the [Appendix](#) for details on the test configurations and procedures.) The dashboard lets you see the overall DRR value, the reducible DRR value, how much unreduceable data each volume family holds, and the amount of unique data for each volume family, indicating how much space would be freed up after a volume is deleted.

Name	Volume Family Unique Data	Logical Used	Provisioned	Family Overall DRR	Family Reducible DRR	Family Unreduceable Data
vol1-004	100.9 GB	251.1 GB	500.0 GB	2.5:1	6.5:1	74.0 GB
vol1-011	37.3 GB	251.5 GB	500.0 GB	6.6:1	6.6:1	0 GB
vol1-010	100.8 GB	251.8 GB	500.0 GB	2.5:1	6.6:1	73.9 GB
vol1-005	37.3 GB	251.9 GB	500.0 GB	6.6:1	6.6:1	0 GB
vol1-009	101.7 GB	252.1 GB	500.0 GB	2.5:1	6.5:1	74.7 GB
vol1-002	101.2 GB	252.5 GB	500.0 GB	2.5:1	6.5:1	73.9 GB
vol1-008	100.8 GB	252.7 GB	500.0 GB	2.5:1	6.6:1	73.8 GB
vol1-003	37.5 GB	253.4 GB	500.0 GB	6.6:1	6.6:1	0 GB
vol1-006	101.2 GB	253.6 GB	500.0 GB	2.5:1	6.5:1	73.8 GB
vol1-012	37.5 GB	253.8 GB	500.0 GB	6.6:1	6.6:1	0 GB
vol1-001	37.7 GB	254.4 GB	500.0 GB	6.6:1	6.6:1	0 GB
vol1-007	38.3 GB	256.8 GB	500.0 GB	6.6:1	6.6:1	0 GB

Figure 4. The Dell™ PowerStore™ 1200T UI reveals details of the unique data stored into each volume

Detailed reporting and controls enable IT staff to choose the optimal location for data volumes based on efficiency goals, rather than being dictated by volume capacity limits. For example, the PowerStore 1200T solution supports a scale-out architecture in which every appliance can scale out to its maximum capacity. The unified PowerStore UI lets IT staff migrate data volumes to cost-optimized arrays. These capabilities allow them to flexibly mix and match appliances to get optimal dollars per terabytes (\$/TB).

Sustainability

Sustainability is becoming a key strategy for businesses as environmental issues intensify and energy costs rise. Data reduction technologies can help reduce the amount of physical data storage space required, thus reducing the amount of power and cooling used. We examined energy savings as part of our research.

The NVMe SSDs we tested use 20 W of active power. We multiplied this by the number of drives used to store an effective capacity of 81 TiB (see Table 1) and calculated that the PowerStore 1200T drives use 220 W of power and the Vendor A drives use 480 W (see Table 4).

Table 4 | Power consumption for each set of drives

Unit Under Test	A. Power per Drive	B. Number of Drives for 81 TiB	C. Total Power*
Dell™ PowerStore™ 1200T	20 W/drive	11 drives	220 W
Vendor A platform	20 W/drive	24 drives	480 W

* Calculated as A × B.

Figure 5 illustrates how using fewer drives in the PowerStore 1200T platform than the Vendor A solution to support the same-size dataset can correlate to energy savings of up to 54%.⁴ And by using fewer storage drives, we anticipate getting additional savings from reductions in physical rack space and power needed for cooling.

Drive Energy Usage and Savings Dell™ PowerStore™ 1200T Versus Vendor A Platform

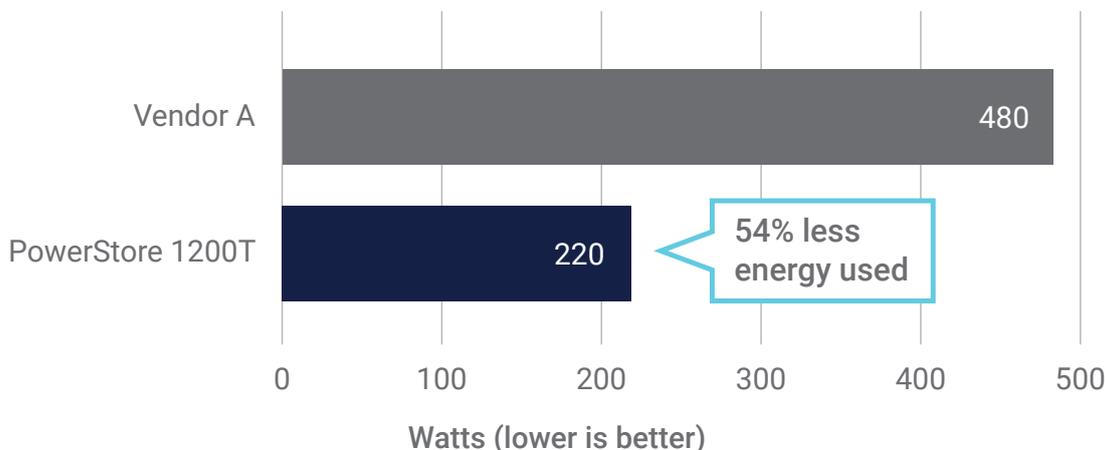


Figure 5 | Comparison of power usage for drives only

Analysis of usable capacity indicates that power reductions for PowerStore 1200T drives will increase in linear proportion to dataset sizes. Table 5 shows that, at a usable capacity of 128 TiB, the PowerStore 1200T drives alone can lower power consumption by up to 1,040 W compared to the Vendor A drives.

Table 5 | Power-consumption savings at scale

Usable Capacity	Number of Vendor A Drives	Number of Dell™ PowerStore™ Drives*	A. Power Consumption for Vendor A**	B. Power Consumption for PowerStore**	C. Power Savings for PowerStore***
32 TiB	24	12	480 W	220 W	260 W
64 TiB	48	24	960 W	440 W	520 W
96 TiB	72	36	1,440 W	660 W	780 W
128 TiB	96	48	1,920 W	880 W	1,040 W

* Number of PowerStore drives needed to achieve the same usable capacity as the Vendor A drives.
 ** Power consumption was calculated for NVMe® drives only and excluded other platform components.
 *** Calculated as A – B.

Scalability

The PowerStore 1200T solution supports highly flexible scale-out storage, whereas the Vendor A platform does not. As with previous releases, the latest PowerStore 1200T solution has the Dynamic Resiliency Engine (DRE) feature, which offers the ability to scale storage capacity in increments as small as one drive. Vendor A recommends scaling up using multiple drives because adding only one or two drives could reduce storage performance.

This difference in scalability indicates you can use the PowerStore 1200T platform to add one, two, three, or four drives without worrying about expanding with a bundle of drives and possibly overprovisioning storage volumes. This finely controllable scalability allows organizations to purchase only the amount of storage needed for a given workload, which helps minimize storage costs.

Total Cost of Ownership (TCO)

Our testing confirms the PowerStore 1200T solution offers many TCO-reducing capabilities. Fewer drives are needed to provide the same effective capacity compared to the Vendor A platform, allowing businesses to reduce total hardware and software infrastructure costs. A comprehensive dashboard that offers faster provisioning in fewer clicks helps streamline administration tasks. The capacity accounting feature provides a level of detail that allows IT staff to provision storage for optimal performance with an eye toward lowering hardware and energy costs while also improving sustainability. For example, you can move unreduceable, low-latency data workloads to arrays that use less power and memory. This helps lower TCO without impacting your users' computing experiences.

Summary of Test Results

Our testing revealed that the latest version of the PowerStore 1200T platform is a highly flexible, easily managed, and extremely energy-efficient data storage solution that delivers one of the highest DRRs in the industry. Based on the following results, we conclude that the PowerStore 1200T platform delivers a powerful combination of high data efficiency, powerful controls, easy scalability, and low power consumption:

- The latest PowerStore 1200T platform offers a higher DRR guarantee, 5:1, compared to the previous release's guarantee of 4:1.¹
- For the tested platforms, the PowerStore 1200T solution's guaranteed and actual data efficiencies were superior to that of Vendor A. The PowerStore solution's guaranteed DRR is 5:1 and measured DRR is 5.4:1, whereas the Vendor A guaranteed DRR is 4:1 and measured DRR is 2.5:1.^{1,2}
- The PowerStore management UI was more intuitive and easier to use than the Vendor A system UI. The PowerStore platform also provisioned storage volumes faster and with fewer mouse-clicks than the Vendor A platform.
- The PowerStore management UI delivered deeper views into, and finer control over, storage volumes' unique data, such as reducible and unreduceable data, than the Vendor A solution.
- The PowerStore 1200T supports storage scaling in increments as small as one drive. Vendor A advises scaling up using multiple drives.
- Based on the test configurations, our calculations indicate the PowerStore 1200T platform will use up to 54% less energy than the Vendor A solution to store the same-size dataset, which offers the potential of substantial energy savings over time and with scale-outs.

Conclusion

Organizations need high-speed storage to support modern business initiatives. At the same time, they are under pressure to cut costs and use less energy. To explore the options available for businesses, Prowess Consulting evaluated the data reduction, management UI, and power usage of the Dell PowerStore 1200T platform against a platform from a leading competitor, Vendor A.

The PowerStore 1200T solution offers a DRR guarantee of 5:1, and our testing measured a DRR of 5.4:1, exceeding the Dell Technologies guarantee.¹ The Vendor A platform's DRR fell short of its guarantee of 4:1, measuring only 2.5:1 during our testing.² We observed that the easy-to-use PowerStore 1200T UI not only provisioned storage faster but also delivered deeper insights into unique data, all of which can improve efficiencies of space, power, and administration. For our sustainability assessment, we calculated the PowerStore 1200T solution could deliver energy savings of up to 54% percent compared to the Vendor A platform to store the same amount of data.

Based on these findings, we conclude that the PowerStore 1200T solution can help organizations get the value they need from their data while reducing costs and energy use in an easy-to-manage, scalable platform.

Appendix

This section contains system comparison calculations, storage platform test configurations, our test methodology, and the Vdbench configuration file.

System Comparison Calculations

Table A1 | Comparing total capacity and effective capacity

Unit Under Test	Drive Quantity	Drive Size (TB)	Total Capacity (TiB)	Effective Capacity	DRR
Dell™ PowerStore™ 1200T	23	1.92	31.9	172	5.4
Vendor A platform	24	1.92	32.5	81	2.5

Effective Capacity Calculation

We computed the effective capacity of the PowerStore 1200T platform using total capacity and DRR: $31.9 \text{ TiB} \times 5.4 = 172 \text{ TiB}$. We computed the effective capacity of the Vendor A platform using total capacity and DRR: $32.5 \text{ TiB} \times 2.5 = 81 \text{ TiB}$.

Usable Capacity Calculation

To compare the two systems, we used the effective capacity of 81 TiB and 5.4 DRR to compute the usable capacity of the PowerStore 1200T platform: $81 \text{ TiB} \div 5.4 = 15 \text{ TiB}$. For Vendor A, we used the same effective capacity of 81 TiB and 2.5 DRR to calculate the usable capacity: $81 \text{ TiB} \div 2.5 = 32 \text{ TiB}$.

Number of Drives Calculation

Given a usable capacity of 15 TiB, we used a proportional calculation to determine the number of PowerStore 1200T drives required. If it previously took 23 PowerStore 1200T drives to get 31.9 TiB of total usable capacity, we can compute the number of drives needed for 15 TiB: $(23 \text{ drives} \div 31.9 \text{ TiB}) \times (15 \text{ TiB}) = 11 \text{ drives}$. For Vendor A, we computed the number of drives needed for 32 TiB: $(24 \text{ drives} \div 32.5 \text{ TiB}) \times (32 \text{ TiB}) = 24 \text{ drives}$.

Storage Platform Testing Configurations

Table A2 | Testing virtual machine (VM) description and storage platforms under test configuration

Component	Testing VM	Dell™ PowerStore™ 1200T	Vendor A Platform
CPU Clockrate	Not applicable (N/A)	2.4 GHz	2.4 GHz
Cores/Threads per CPU	N/A	10/20	12/24
Core/Threads Total	N/A	20/40	12/48
Drive 1	Thin-provisioning lazy zeroed 500 GB	NVMe® NVRAM	–
Drive 1 Count	1	2	–
Drive 2	1 TB RDM LUN	NVMe® SSD	NVMe® SSD
Drive 2 Count	12	23	24
Memory	VMware® memory	–	–
Number of Memory DIMMs	N/A	24	12
OS	Oracle® Linux® Server	Dell™ PowerStore™ OS	Storage OS
OS Version	8.3	4.0.0.0	Vendor A platform release X.X.X from December 2023
OS Kernel	5.4.17-2102.201.3.el8uek.x86_64	–	–

Summary

The following test methodology outlines the steps that we used to test the deduplication capabilities of the Dell PowerStore and Vendor A storage solutions utilizing Vdbench on VMware ESXi™ Linux® VMs.

In summary, Prowess Consulting engineers performed the following actions in an offsite lab:

1. Created logical unit numbers (LUNs) and exposed the LUNs to the VMware ESXi host on the Dell PowerStore and Vendor A storage platforms.
 - a. We measured the amount of clicks and time needed to create the LUNs.

2. Added the LUNs as raw device mappings to a dedicated VMware Linux VM exclusive to each storage platform.
3. Used Vdbench, an application that simulates a controlled I/O load, to generate data on the LUNs.
4. Measured the reduced storage using a deduplication chart on both storage platforms.
5. Determined the power savings for each platform by extrapolating from the storage saved.

Prowess Consulting also collected the following data points on the Dell PowerStore and Vendor A systems to determine management ease of use:

- How many seconds it took for the volumes to create
- How many mouse-clicks it took to create volumes

Test Methodology

Prowess Consulting engineers used the following methodology for our testing. Our engineers performed all tests remotely, accessing the Dell PowerStore 1200T and Vendor A systems in an offsite lab.

Configuring and Loading the Dell PowerStore 1200T Storage Platform

1. Sign in to the Dell PowerStore Manager graphical user interface (GUI).
 - a. Under the **Storage** tab, select **Volumes** from the drop-down menu.
 - b. Click **+Create**.
 - c. In the **Create Volumes** pop-up, provide the following configuration details:
 - i. **Name (or Prefix): vol1**
 - ii. **Description:** (leave blank)
 - iii. **Category: Other**
 - iv. **Application:** (leave blank)
 - v. **Quantity: 12**
 - vi. **Size: 1TB**
 - vii. **Additional Volume Group: None Selected**
 - viii. **Volume Protection Policy: None**
 - ix. **Volume Performance Policy: Medium**
 - d. At the bottom-right of the window, click **Next**.
 - e. On the **Host Mappings** page, select the IP address of the host for the testing VM, and then click **Next**.
 - f. On the **Summary** page, click **Create**.
2. Sign in to the VMware vSphere® client for the VMware testing environment.
 - a. On the **Configure** page, **Storage Adapters** view, for the VM host selected in step 1, click **Rescan Storage**.
 - b. Select the test VM, click **Actions**, and then click **Edit Settings**.
 - i. On the **Edit Settings** page, select the **Add New Device** drop-down menu in the top right.
 - ii. Under **Disks, Drives and Storage**, click **RDM Disk**.
 - iii. On the **Select Target LUN** page, select one of the LUNs from the PowerStore 1200T platform.
 - iv. Repeat this process for all 12 LUNs.
 - c. Click **OK** to apply the new settings.
3. Use Secure Shell (SSH) to access the testing VM:
 - a. Navigate to the directory with Vdbench data, and then run the following command:

```
./vdbench -f test12.vdb -o test1-out
```
 - b. Wait for Vdbench to complete.

4. After the Vdbench test is complete, wait 12–16 hours to replicate the same time needed for Vendor A to complete deduplication processing.
5. Sign in to the PowerStore Manager GUI.
 - a. On the **Dashboard** page, click the **Capacity** card and record:
 - i. The **Overall Efficiency** ratio
 - ii. The **Snap Savings** ratio
 - iii. The **Thin Savings** ratio
 - iv. The **Combined Ratio** at the top of the chart
 - v. **Logical Used**
 - vi. **Physical Used**
 - vii. **Overall DRR** (visible with cursor hover)
 - viii. **Reducible DRR** (visible with cursor hover)
 - ix. **Unreducible Data** (visible with cursor hover)
6. Sign in to the vSphere client for the VMware testing environment.
 - a. Select the test VM, click **Actions**, and then click **Power Off the Guest OS**.
 - b. Select the test VM, click **Actions**, and then click **Edit Settings**.
 - i. In the **Edit Settings** pop-up window, expand the section labeled **Hard Disks**.
 1. For the first LUN from the PowerStore 1200T platform, select the **Cross/Close** icon next to the disk.
 - a. Select the **Delete files from Datastore** checkbox.
 2. Repeat step 1 for each LUN (12 times total).
 3. Click **OK**.
7. Sign in to the PowerStore Manager GUI.
 - a. Click the **Storage** tab, and then select **Volumes** from the drop-down menu.
 - b. Select the checkbox below the **Create** button to select all created LUNs.
 - c. From the **Provision** drop-down menu, click **Unmap**.
 - d. On the **Unmap Hosts** page, select the checkbox next to the **Testing VM Host** name.
 - i. Click **Apply**.
 - e. On the **Volumes** page, select the **More Actions** drop-down menu.
 - i. Click **Delete**.
 - ii. On the **Delete Volumes** pop-up, select **Skip Recycle Bin and Permanently delete**, and then click **Delete**.
8. Repeat steps 1–7 three times to complete validation.
9. To validate Dell PowerStore non-zero unreducible data reports, sign in to the Dell PowerStore Manager GUI.
 - a. Under the **Storage** tab, select **Volumes** from the drop-down menu.
 - b. Click **+Create**.
 - c. In the **Create Volumes** pop-up, provide the following configuration:
 - i. **Name (or Prefix): vol1**
 - ii. **Description:** (leave blank)
 - iii. **Category: Other**
 - iv. **Application:** (leave blank)
 - v. **Quantity: 12**
 - vi. **Size: 500GB**
 - vii. **Additional Volume Group: None Selected**
 - viii. **Volume Protection Policy: None**

- ix. **Volume Performance Policy: Medium**
 - d. At the bottom-right of the window, click **Next**.
 - e. On the **Host Mappings** page, select the IP address of the host for the testing VM, and then click **Next**.
 - f. On the **Summary** page, click **Create**.
10. Sign in to the vSphere client for the VMware testing environment.
 - a. On the **Configure** page, **Storage Adapters** view, for the VM host selected in step 1, click **Rescan Storage**.
 - b. Select the test VM, click **Actions**, and then click **Edit Settings**.
 - i. On the **Edit Settings** page, select the **Add New Device** drop-down menu in the top right.
 - ii. Under **Disks, Drives and Storage**, click **RDM Disk**.
 - iii. On the **Select Target LUN** page, select one of the LUNs from the PowerStore 1200T platform.
 - iv. Repeat this process for all 12 LUNs.
 - c. Click **OK** to apply the new settings.
11. Use SSH to access the testing VM:
 - a. Navigate to the directory with Vdbench data, and then run the following command:

```
./vdbench -f test12reducible.vdb -o test1-out
```
 - b. Allow Vdbench to run for 5–10 minutes.
12. Use SSH to access the testing VM:
 - a. Navigate to the directory with Vdbench data, and then run the following command:

```
./vdbench -f test12noreducible.vdb -o test1-out
```
 - b. Allow Vdbench to run for 5–10 minutes.
13. Sign in to the PowerStore Manager GUI.
 - a. On the **Dashboard** page, record:
 - i. The **Overall Efficiency** ratio
 - ii. The **Snap Savings** ratio
 - iii. The **Thin Savings** ratio
 - iv. The **Combined Ratio** at the top of the chart
 - v. **Logical Used**
 - vi. **Physical Used**
 - vii. **Overall DRR** (visible with cursor hover)
 - viii. **Reducible DRR** (visible with cursor hover)
 - ix. **Unreducible Data** (visible with cursor hover)
14. Sign in to the vSphere client for the VMware testing environment.
 - a. Select the test VM, click **Actions**, and then click **Edit Settings**.
 - i. In the **Edit Settings** pop-up window, expand the section labeled **Hard Disks**.
 1. For the first LUN from the PowerStore 1200T, select the **Cross/Close** icon next to the disk.
 - a. Select the **Delete files from Datastore** checkbox.
 2. Repeat step 1 for each LUN (12 times total).
 3. Click **OK**.
15. Sign in to the PowerStore Manager GUI.
 - a. Click the **Storage** tab, and then select **Volumes** from the drop-down menu.
 - b. Select the checkbox below the **Create** button to select all created LUNs.

- c. On the **Provision** drop-down menu, click **Unmap**.
- d. On the **Unmap Hosts** page, select the checkbox next to the **Testing VM Host** name.
 - i. Click **Apply**.
- e. On the **Volumes** page, select the **More Actions** drop-down menu.
 - i. Click **Delete**.
 - ii. On the **Delete Volumes** pop-up, select **Skip Recycle Bin and Permanently delete**, and then click **Delete**.

Configuring and Loading the Vendor A Platform

1. Sign in to the Vendor A Platform Storage OS System Manager GUI.
 - a. From the left-side menu, select **LUNs**.
 - b. From the **LUNs** page, click **Add**.
 - c. On the **Add LUNs** page, provide the following configuration information:
 - i. **Name: vol1**
 - ii. **Number of LUNs: 6**
 - iii. **Capacity per LUN: 1 TiB**
 - iv. **Host Operating System: VMware**
 - v. **LUN format: VMware**
 - vi. **Initiator Group:** Select the testing VM host from the drop-down menu.
 - d. Click **Save**.
2. Once the LUNs have been added, repeat steps 1c–d to create a second set of LUNs (required to ensure the 12 LUNs are load-balanced across the controller).
3. From the left-side menu, select **Tiers**.
4. Under each storage node, click **More Details** to view which controller the LUNs were created on.
5. Sign in to the vSphere client for the VMware testing environment.
 - a. On the **Datastores** page for the VM host selected in step 1, click **Rescan Storage**.
 - b. Select the test VM, click **Actions**, and then click **Edit Settings**.
 - i. On the **Edit Settings** page, select the **Add New Device** drop-down menu in the top right.
 - ii. Under **Disks, Drives and Storage**, click **RDM Disk**.
 - iii. On the **Select Target LUN** page, select one of the LUNs from the Vendor A platform.
 - iv. Repeat this process for all 12 LUNs.
 - c. Click **OK** to apply the new settings.
 - d. Click **Actions**, and then click **Power on the Guest OS**.
6. Use SSH to access the **Testing VM**.
 - a. Navigate to the directory containing the Vdbench tool data, and then run the following command:

```
./vdbench -f test12.vdb -o test1-out
```
 - b. Wait for the Vdbench test to complete.
 - c. After the Vdbench test is complete, wait 12–16 hours for the deduplication process to finish.
 - d. Sign in to the **Storage OS System Manager** GUI.
 - e. On the **Dashboard**, in the **Capacity** box, click the image for the capacity usage.
 - f. In the **Cluster Capacity** pop-up window, record the following data:
 - i. **Logical Used Data Size**
 - ii. **Physical Used Data Size**

7. Sign in to the vSphere client for the VMware testing environment.
 - a. Select the test VM, click **Actions**, and then click **Edit Settings**.
 - i. In the **Edit Settings** pop-up window, expand the section labeled **Hard Disks**.
 1. For the first LUN from the **Vendor A** system, select the **Cross/Close** icon next to the disk.
 - a. Select **Remove Device and Data**.
 2. Repeat step 1 for each LUN (12 times total).
 3. Click **OK**.
8. Sign in to the Vendor A system manager GUI.
 - a. On the **Volumes** page, select the checkboxes next to both created volumes.
 - i. Click **Delete**.
 - b. On the **Delete Volumes** page, select all checkboxes, and then click **Delete**.
 - i. Allow the **Volumes** page to update.
 - c. On the updated page, click **More**, and then navigate to the **Deleted Volumes** page.
 - d. On the **Deleted Volumes** page, select both volumes, and then click **Purge**.
 - i. On the **Purge Volumes** page, confirm by clicking **Purge**.
9. Repeat steps 1–8 three times to complete the testing.

Vdbench Configuration Files

The following sections provide the details of the Vdbench configuration files utilized during our testing.

Vdbench Configuration 1

The first Vdbench configuration file was used to generate load on 12 devices, setting the compression and deduplication ratio to two.

```
compratio=2
dedupratio=2
dedupunit=4096

hd=default,shell=ssh,user=root,jvms=1
hd=hd5,system=PM_005

sd=default,openflags=o_direct
sd=sd1,hd=hd5,lun=/dev/sdb
sd=sd2,hd=hd5,lun=/dev/sdc
sd=sd3,hd=hd5,lun=/dev/sdd
sd=sd4,hd=hd5,lun=/dev/sde
sd=sd5,hd=hd5,lun=/dev/sdf
sd=sd6,hd=hd5,lun=/dev/sdg
sd=sd7,hd=hd5,lun=/dev/sdh
sd=sd8,hd=hd5,lun=/dev/sdi
sd=sd9,hd=hd5,lun=/dev/sdj
sd=sd10,hd=hd5,lun=/dev/sdk
sd=sd11,hd=hd5,lun=/dev/sdl
sd=sd12,hd=hd5,lun=/dev/sdm

wd=default,sd=*
wd=wd_prefill1,sd=sd*,xfersize=256k,seekpct=eof,rdpct=0
```

```
rd=default
rd=rd_prefill,wd=wd_prefill,elapsed=20h,interval=10,iorate=max,forthreads=(1)
```

Vdbench Configuration 2

The second Vdbench configuration file was used to generate load on 12 devices, setting the compression and deduplication ratio to three.

```
compratio=3
dedupratio=3
dedupunit=4096

hd=default,shell=ssh,master=192.168.1.200,user=root,jvms=1
hd=hd1,system=PM_001
sd=default,openflags=o_direct
sd=sd1,hd=hd1,lun=/dev/sdb
sd=sd2,hd=hd1,lun=/dev/sdc
sd=sd3,hd=hd1,lun=/dev/sdd
sd=sd4,hd=hd1,lun=/dev/sde
sd=sd5,hd=hd1,lun=/dev/sdf
sd=sd6,hd=hd1,lun=/dev/sgd
sd=sd7,hd=hd1,lun=/dev/sdh
sd=sd8,hd=hd1,lun=/dev/sdi
sd=sd9,hd=hd1,lun=/dev/sdj
sd=sd10,hd=hd1,lun=/dev/sdk
sd=sd11,hd=hd1,lun=/dev/sdl
sd=sd12,hd=hd1,lun=/dev/sdm
wd=default,sd=*
wd=wd_prefill,sd=sd*,xfersize=256k,seekpct=eof,rdpct=0
rd=default
rd=rd_prefill,wd=wd_prefill,elapsed=20h,interval=10,iorate=max,forthreads=(1)
```

Vdbench Configuration 3

The third Vdbench configuration file was used to generate non-reducible load on 12 devices.

```
#compratio=3
#dedupratio=3
#dedupunit=4096
hd=default,shell=ssh,master=192.168.1.200,user=root,jvms=1
hd=hd1,system=PM_001
sd=default,openflags=o_direct
sd=sd1,hd=hd1,lun=/dev/sdb
sd=sd2,hd=hd1,lun=/dev/sdc
sd=sd3,hd=hd1,lun=/dev/sdd
sd=sd4,hd=hd1,lun=/dev/sde
sd=sd5,hd=hd1,lun=/dev/sdf
sd=sd6,hd=hd1,lun=/dev/sgd
#sd=sd7,hd=hd1,lun=/dev/sdh
#sd=sd8,hd=hd1,lun=/dev/sdi
#sd=sd9,hd=hd1,lun=/dev/sdj
#sd=sd10,hd=hd1,lun=/dev/sdk
#sd=sd11,hd=hd1,lun=/dev/sdl
#sd=sd12,hd=hd1,lun=/dev/sdm
```

```
wd=default,sd=*  
wd=wd_prefill,sd=sd*,xfersize=256k,seekpct=eof,rdpct=0  
rd=default  
rd=rd_prefill,wd=wd_prefill,elapsed=20h,interval=10,iorate=max,forthreads=(1)
```

¹ Dell Technologies. Storage Data Reduction Guarantee: Requires customer signature and purchase of a Dell ProSupport™ for Infrastructure four-hour or next-business-day (NBD) support agreement, a ProSupport Plus for Infrastructure support agreement, or a valid support contract with a valid Dell Technologies support partner. Applicable products include all-flash storage products only. For more information, see www.dell.com/en-us/shop/scc/sc/storage-products.

² Vendor A 4:1 DRR guarantee for NVM Express® (NVMe®) as of 2024.

³ The Dell™ PowerStore™ 1200T platform in our testing had a total of 25 drives. Two of these were used as NVRAM. For specifications, see: Dell Technologies. "[Dell PowerStore Hardware Information Guide for PowerStore 1000, 1200, 3000, 3200, 5000, 5200, 7000, 9000, and 9200](#)." Accessed June 2023.

⁴ Calculated as 12 Dell™ PowerStore™ drives or 24 Vendor A drives using 20 W per drive, running 24 hours/day, 365 days/year, with an energy cost of US \$0.173/kWh. Pricing source: U.S. Bureau of Labor Statistics. "[Average energy prices for the United States, regions, census divisions, and selected metropolitan areas](#)." Accessed February 2024.



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