SPC BENCHMARK 1/ENERGY™
EXECUTIVE SUMMARY

IBM CORPORATION
IBM FLASHSYSTEM™ 840

SPC-1/E V1.14

Submitted for Review: September 19, 2014
Submission Identifier: AE00007

EXECUTIVE SUMMARY

Test Sponsor and Contact Information

Test Sponsor and Contact Information	
Test Sponsor Primary Contact	IBM Corporation – http://www.ibm.com Bruce McNutt – bmcnutt@us.ibm.com IBM ARC 650 Harry Road San Jose, CA 95120 Phone: (408) 927-2717 FAX: (408) 927-2050
Test Sponsor Alternate Contact	IBM Corporation – http://www.ibm.com Andrew Lin – awlin@us.ibm.com 9000 Rita Road IBM Mail Drop 9042-2 Tucson, AZ 85744 Phone: (520) 799-2358 FAX: (520)799-2009
Auditor	Storage Performance Council – http://www.storageperformance.org Walter E. Baker – AuditService@StoragePerformance.org 643 Bair Island Road, Suite 103 Redwood City, CA 94063 Phone: (650) 556-9384 FAX: (650) 556-9385

Revision Information and Key Dates

Revision Information and Key Dates	
SPC-1 Specification revision number	V1.14
SPC-1 Workload Generator revision number	V2.3.0
Date Results were first used publicly	September 19, 2014
Date the FDR was submitted to the SPC	September 19, 2014
Date the Priced Storage Configuration is available for shipment to customers	currently available
Date the TSC completed audit certification	September 19, 2014

Tested Storage Product (TSP) Description

IBM FlashSystem 840 is designed to deliver high performance, efficiency, and reliability for shared enterprise storage environments, helping clients around the world address performance issues with their most critical applications and infrastructure. FlashSystem 840 may be used as data storage for important applications that need high performance and low latency. Such applications include databases supporting line of business applications, as well as virtualization platforms such as virtual servers and VDI. FlashSystem 840 can also be used as the top tier of storage alongside traditional arrays in tiered storage architectures, such as the IBM Easy Tier functionality available in IBM System Storage SAN Volume Controller and Storwize® V7000 storage virtualization platforms.

Summary of Results

SPC-1 Reported Data	
Tested Storage Product (TSP) Name: IBM FlashSystem™ 840	
Metric	**Reported Result**
SPC-1 IOPS™	369,994.84
SPC-1 Price-Performance™	$1.32/SPC-1 IOPS™
Total ASU Capacity	25,769.804 GB
Data Protection Level	Protected 1 *(RAID-5)*
Total Price	$486,660.36
Currency Used	U.S. Dollars
Target Country for availability, sales and support	USA

SPC-1 IOPS™ represents the maximum I/O Request Throughput at the 100% load point.

SPC-1 Price-Performance™ is the ratio of **Total Price** to **SPC-1 IOPS™**.

Total ASU (Application Storage Unit) **Capacity** represents the total storage capacity available to be read and written in the course of executing the SPC-1 benchmark.

A **Data Protection Level** of **Protected 1** using ***RAID-5***, which distributes check data corresponding to user data across multiple disks in the form of bit-by-bit parity.

> ***Protected 2:*** *The single point of failure of any* ***storage device*** *in the configuration will not result in permanent loss of access to or integrity of the SPC-1 Data Repository.*

Total Price includes the cost of the Priced Storage Configuration plus three years of hardware maintenance and software support as detailed on page 8.

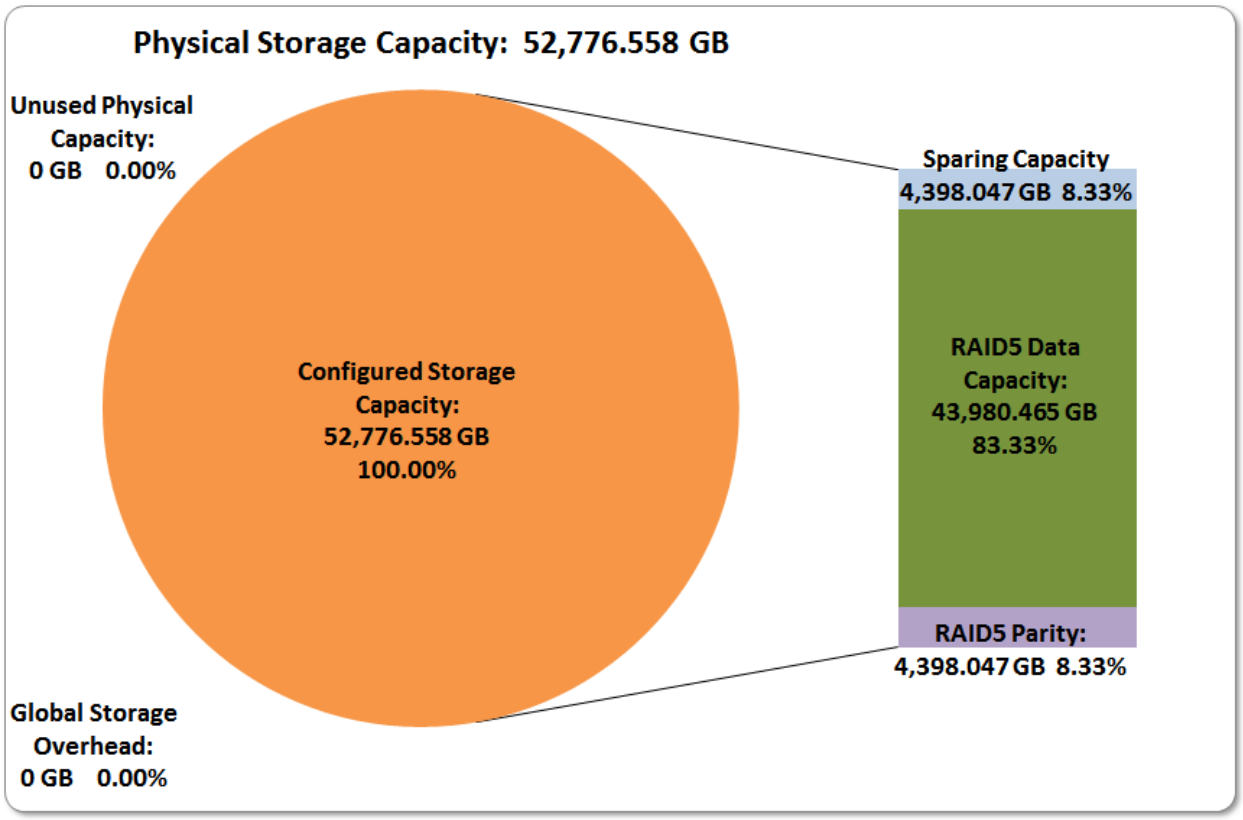
Currency Used is formal name for the currency used in calculating the **Total Price** and **SPC-1 Price-Performance™**. That currency may be the local currency of the **Target Country** or the currency of a difference country *(non-local currency)*.

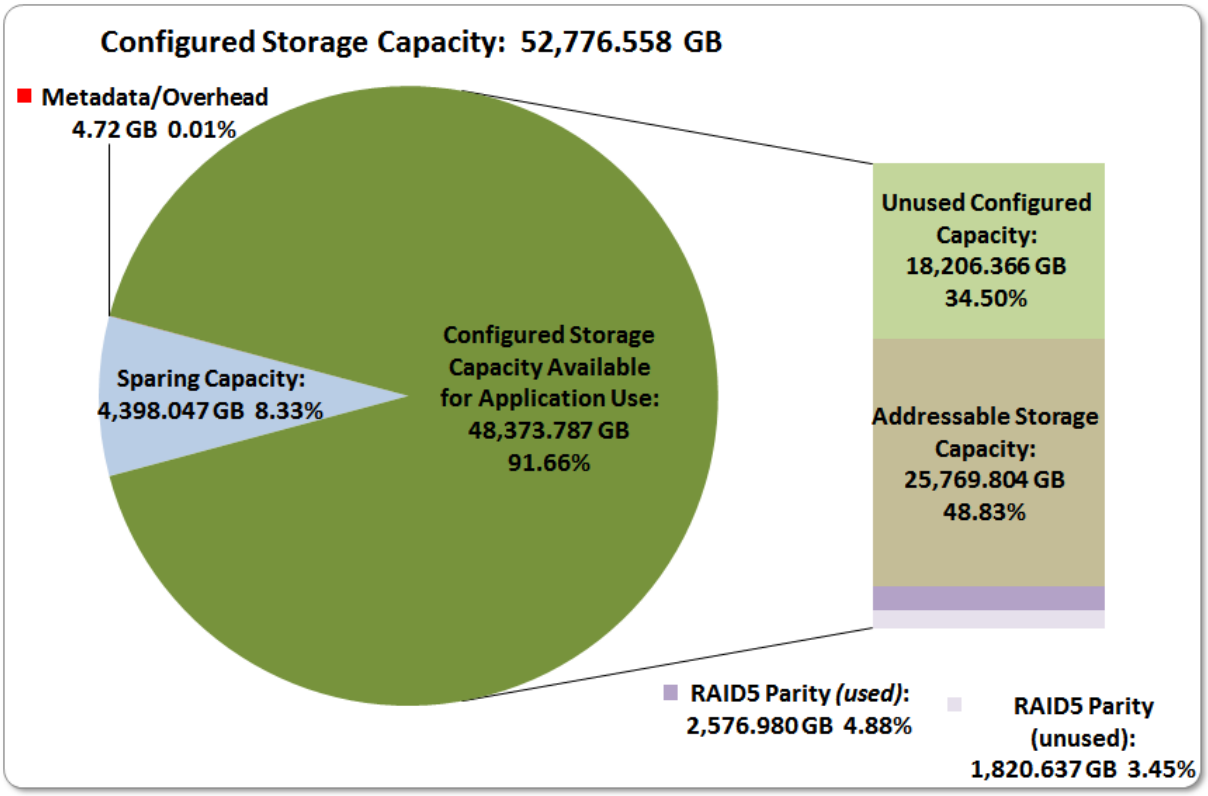
The **Target Country** is the country in which the Priced Storage Configuration is available for sale and in which the required hardware maintenance and software support is provided either directly from the Test Sponsor or indirectly via a third-party supplier.

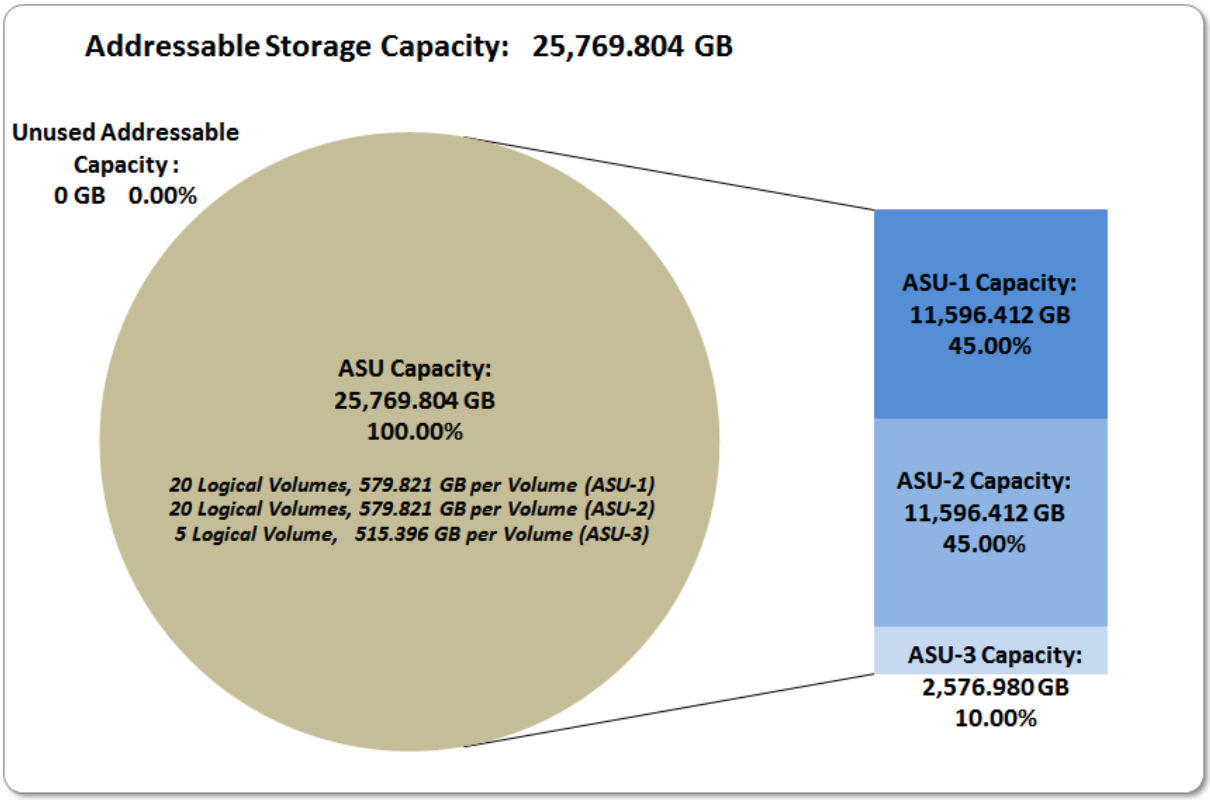
Storage Capacities, Relationships, and Utilization

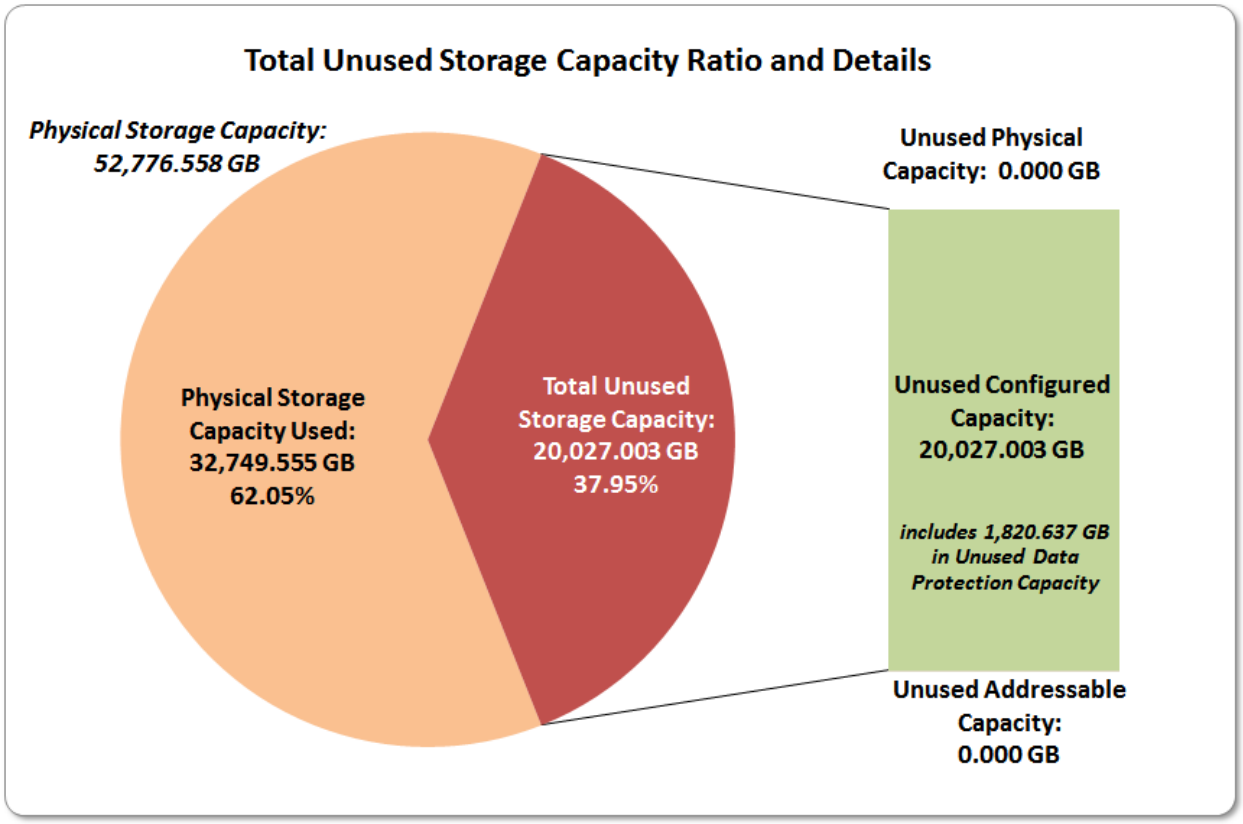
The following four charts and table document the various storage capacities, used in this benchmark, and their relationships, as well as the storage utilization values required to be reported.

The capacity values in each of the following four charts are listed as integer values, for readability, rather than the decimal values listed elsewhere in this document.




Configured Storage Capacity: 52,776.558 GB
Metadata/Overhead
4.72 GB 0.01%
Sparing Capacity:
4,398.047 GB 8.33%
Configured Storage Capacity Available for Application Use:
48,373.787 GB
91.66%
Unused Configured Capacity:
18,206.366 GB
34.50%
Addressable Storage Capacity:
25,769.804 GB
48.83%
RAID5 Parity (used):
2,576.980 GB 4.88%
RAID5 Parity (unused):
1,820.637 GB 3.45%


Addressable Storage Capacity: 25,769.804 GB
Unused Addressable Capacity:
0 GB 0.00%
ASU Capacity:
25,769.804 GB
100.00%
20 Logical Volumes, 579.821 GB per Volume (ASU-1)
20 Logical Volumes, 579.821 GB per Volume (ASU-2)
5 Logical Volume, 515.396 GB per Volume (ASU-3)
ASU-1 Capacity:
11,596.412 GB
45.00%
ASU-2 Capacity:
11,596.412 GB
45.00%
ASU-3 Capacity:
2,576.980 GB
10.00%



SPC-1 Storage Capacity Utilization	
Application Utilization	48.83%
Protected Application Utilization	53.71%
Unused Storage Ratio	37.95%

Application Utilization:

Total ASU Capacity *(25,769.804 GB)* divided by Physical Storage Capacity *(52,776.558 GB)*

Protected Application Utilization: Total ASU Capacity *(25,769.804 GB)* plus total Data Protection Capacity *(4,398.047 GB)* minus unused Data Protection Capacity *(1,820.637 GB)* divided by Physical Storage Capacity *(25,769.804 GB)*

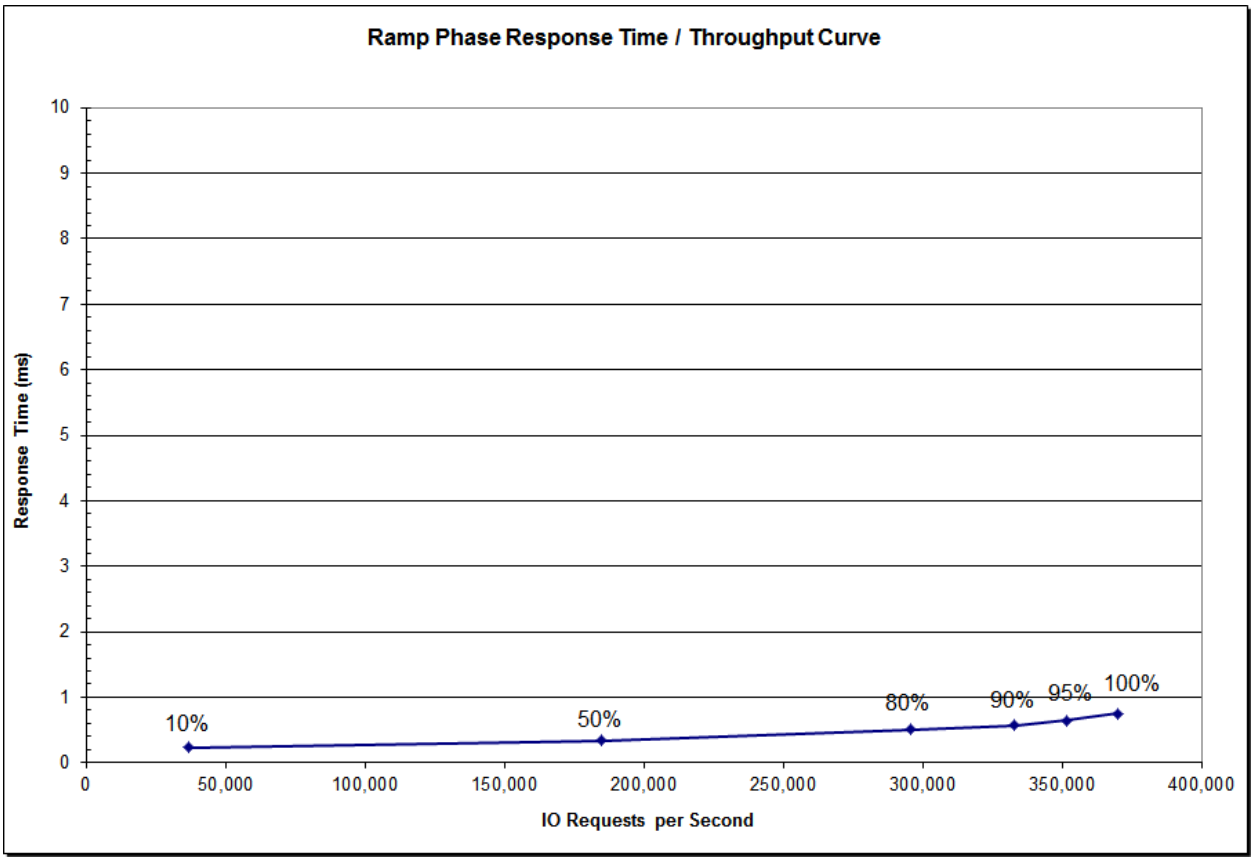
Unused Storage Ratio: Total Unused Capacity *(20,027.003 GB)* divided by Physical Storage Capacity *(25,769.804 GB)* and may not exceed 45%.

Detailed information for the various storage capacities and utilizations is available on pages 30-31 in the Full Disclosure Report.

Response Time – Throughput Curve

The Response Time-Throughput Curve illustrates the Average Response Time (milliseconds) and I/O Request Throughput at 100%, 95%, 90%, 80%, 50%, and 10% of the workload level used to generate the SPC-1 IOPS™ metric.

The Average Response Time measured at the any of the above load points cannot exceed 30 milliseconds or the benchmark measurement is invalid.



Response Time – Throughput Data

	10% Load	50% Load	80% Load	90% Load	95% Load	100% Load
I/O Request Throughput	37,011.27	184,985.30	295,977.82	332,996.17	351,497.45	369,994.84
Average Response Time (ms):						
All ASUs	0.23	0.34	0.50	0.57	0.65	0.75
ASU-1	0.24	0.37	0.56	0.63	0.72	0.82
ASU-2	0.24	0.38	0.56	0.64	0.71	0.81
ASU-3	0.21	0.26	0.37	0.41	0.47	0.55
Reads	0.28	0.50	0.78	0.88	1.00	1.13
Writes	0.20	0.23	0.33	0.37	0.42	0.50

SPC-1/E Reported Data

The initial SPC-1/E energy extension temperature, recorded during the first one minute of the Idle Test was 72F. The final SPC-1/E energy extension temperature, recorded during the last one minute of the Primary Metrics Test was 71F.

Power Environment

Average RMS Voltage:	**201.70**	**Average Power Factor:**	**0.982**

Usage Profile

	Hours of Use per Day			Nominal	Nominal	Nominal	Nominal
	Heavy	Moderate	Idle	Power, W	Traffic, IOPS	IOPS/W	Heat, BTU/hr
Low Daily Usage:	0	8	16	**756.14**	**61661.77**	**81.55**	**2,580.04**
Medium Daily Usage:	4	14	6	**785.18**	**157237.73**	**200.26**	**2,679.12**
High Daily Usage:	18	6	0	**825.79**	**268229.69**	**324.82**	**2,817.66**
			Composite Metrics:	**789.04**	**162,376.40**	**205.79**	

Annual Energy Use, kWh:	**6,911.97**		
Energy Cost, $/kWh:	$ 0.12	**Annual Energy Cost, $:**	**$ 829.44**

The above usage profile describes conditions in environments that respectively impose light ("low"), moderate ("medium"), and extensive ("high") demands on the Tested Storage Configuration (TSC).

HEAVY SPC-1 Workload: 837.78W at 80% of maximum reported performance *(295,977.82 SPC-1 IOPS)*.

MODERATE SPC-1 Workload: 789.82W at 50% of maximum reported performance *(184,985.30 SPC-1 IOPS)*.

IDLE SPC-1 Workload: 739.31W at 0% of maximum reported performance *(0.00 SPC-1 IOPS)*.

AVERAGE RMS VOLTAGE: The average supply voltage applied to the Tested Storage Product (TSP) as measured during the Measurement Intervals of the SPC-1/E Tests.

AVERAGE POWER FACTOR: The ratio of average real power, in watts, to the average apparent power, in volt-amps flowing into the Tested Storage Product (TSP) during the Measurement Intervals of the SPC-1/E Tests.

NOMINAL POWER, W: The average power consumption over the course of a day *(24 hours)*, taking into account hourly load variations.

NOMINAL TRAFFIC, IOPS: The average level of I/O requests over the course of a day *(24 hours)*, taking into account hourly load variations.

NOMINAL IOPS/W: The overall efficiency with which I/O requests can be supported, reflected by the ratio of **NOMINAL TRAFFIC** versus the **NOMINAL POWER**.

NOMINAL HEAT, BTU/HR: The average amount of heat required to be dissipated over the course of a day *(24 hours)*, taking into account hourly load variations. *(1 watt = 3.412 BTU/hr)*

COMPOSITE METRICS: The aggregated **NOMINAL POWER**, **NOMINAL TRAFFIC**, and **NOMINAL IOPS/W** for all three environments: **LOW**, **MEDIUM**, and **HIGH DAILY USAGE**.

ANNUAL ENERGY USE, KWH: An estimate of the average energy use across the three environments over the course of a year and computed as (**NOMINAL POWER** * 24 *0.365).

ENERGY COST, $/KWH: A standardized energy cost per kilowatt hour.

ANNUAL ENERGY COST: An estimate of the annual energy use across the three environments over the course of a year and computed as (**ANNUAL ENERGY USE * ENERGY COST**).

SPC-1/E Power/Performance Profile

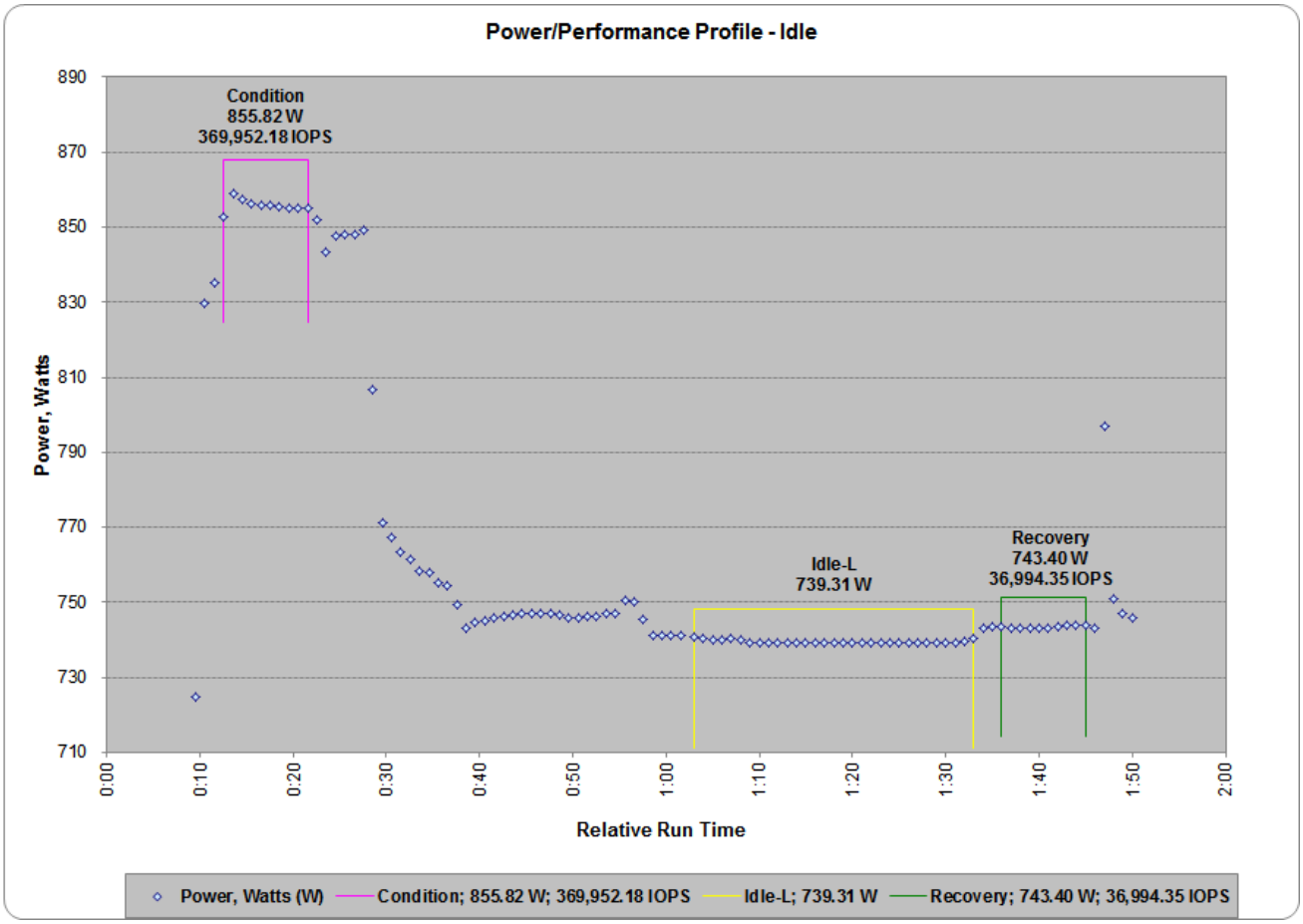
The following four SPC-1/E Power/Performance Profile charts provide a complete "at a glance" illustration and report for each SPC-1/E execution component. The power consumption at each step is reported and, where appropriate the measured SPC-1 performance *(SPC-1 IOPS™)* is also reported.

The **Load Level** value in the table represents the percentage of the maximum, specified offered load that was used for a specific execution component. Each **Execution Component** entry includes the acronym, in parenthesis, which is used in the corresponding chart to identify the execution component.

SPC-1/E Power/Performance Profile Data

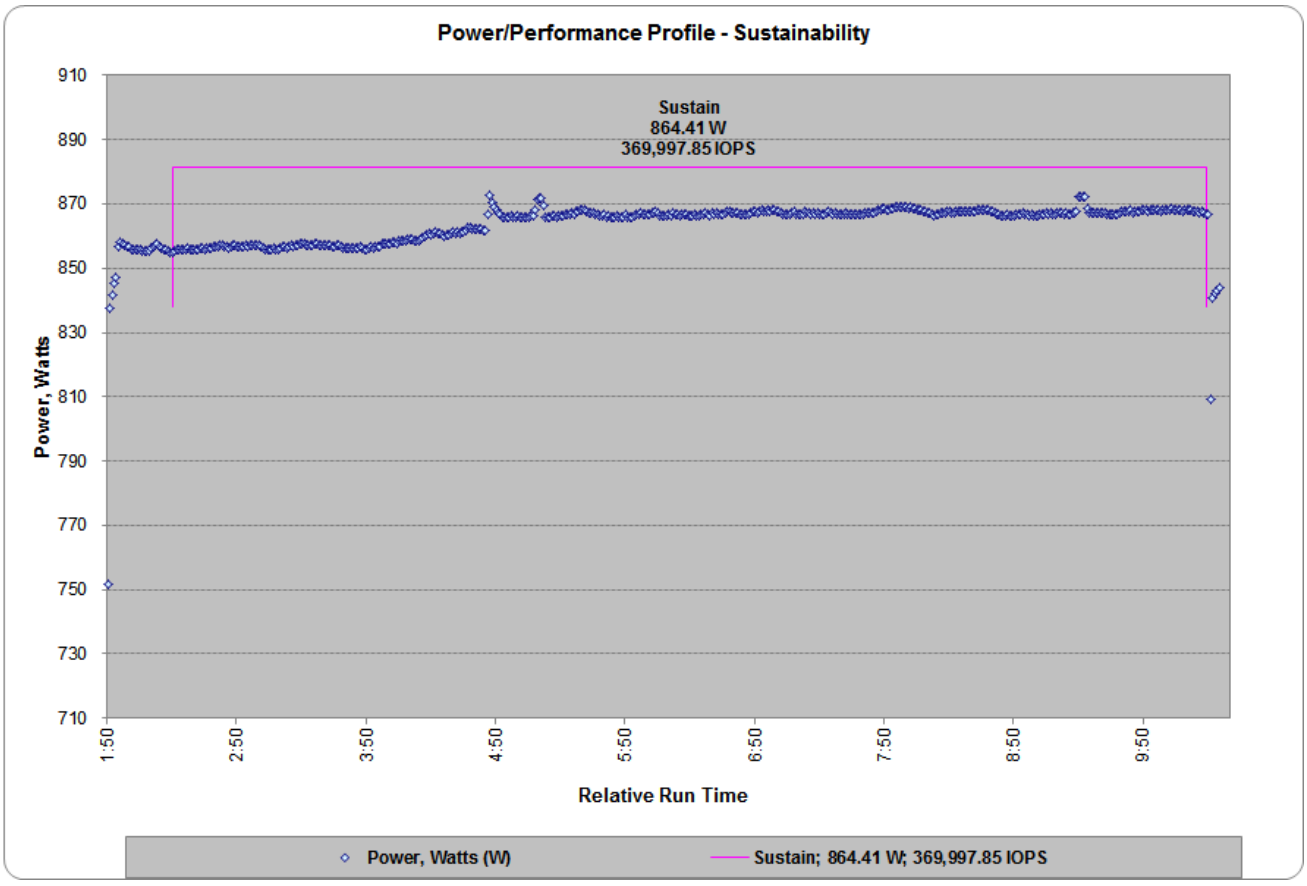
Execution Component	Load Level	SPC-1 IOPS™	Power (W)
Idle – Conditioning ***(Condition)***	100%	369,952.18	855.82
Idle ***(Idle-L)***	0%	-	739.31
Idle - Recovery ***(Recovery)***	10%	36,994.35	743.40
Sustainability ***(Sustain)***	100%	369,997.85	864.41
IOPS ***(100%)***	100%	369,994.84	862.83
Ramp95 ***(95%)***	95%	351,497.45	856.04
Ramp90 ***(90%)***	90%	332,996.17	849.64
Ramp80 ***(80%)***	80%	295,977.82	837.78
Ramp50 ***(50%)***	50%	184,985.30	789.82
Ramp10 ***(10%)***	10%	37,011.27	742.89
Repeat1 LRT ***(10%)***	10%	36,993.22	742.21
Repeat1 IOPS ***(100%)***	100%	370,018.82	860.77
Repeat2 LRT ***(10%)***	10%	37,002.47	741.74
Repeat2 IOPS ***(100%)***	100%	370,033.30	859.28

Power/Performance Profile – Idle Test



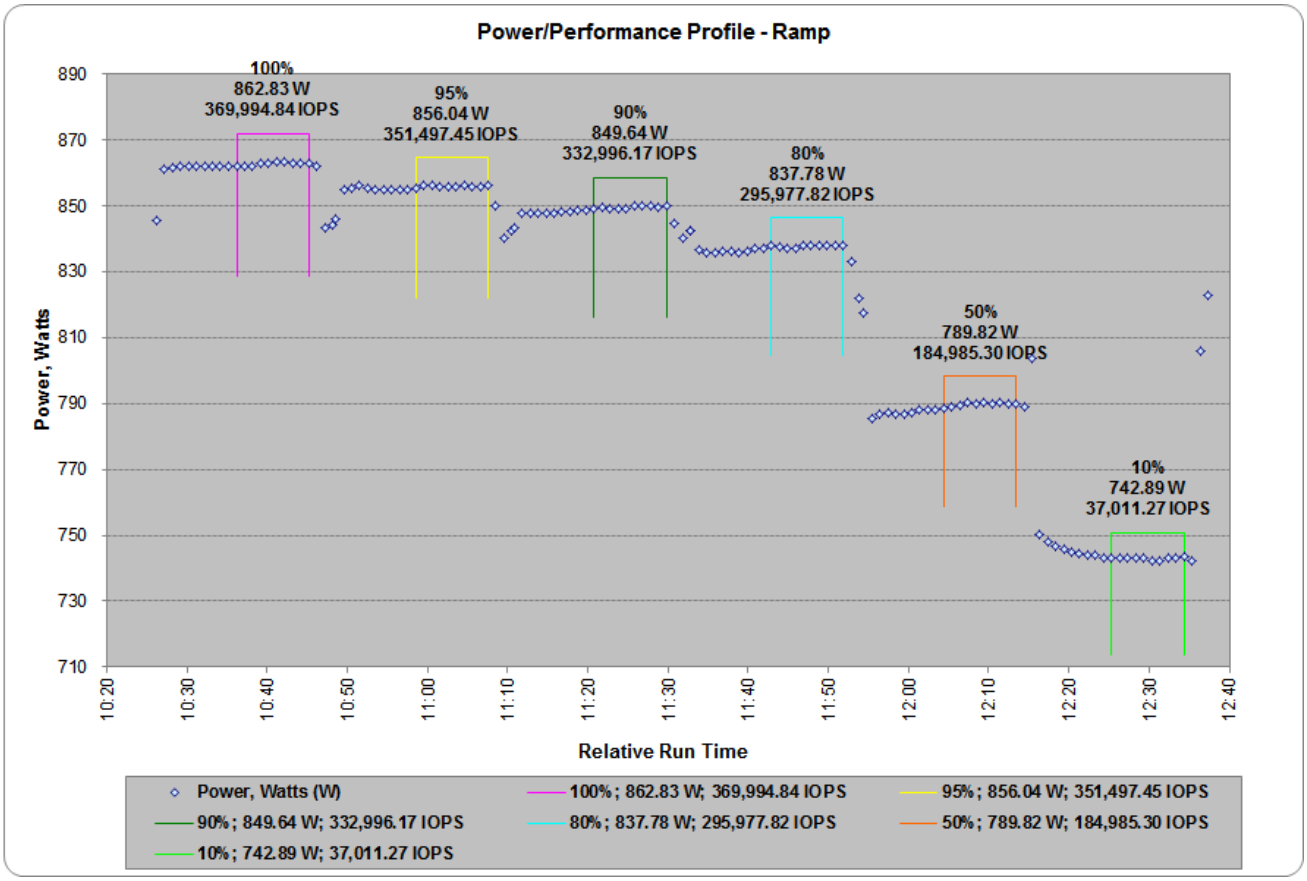
Execution Component	Load Level	SPC-1 IOPS™	Power (W)
Idle – Conditioning ***(Condition)***	100%	369,952.18	855.82
Idle ***(Idle-L)***	0%	-	739.31
Idle - Recovery ***(Recovery)***	10%	36,994.35	743.40

Power/Performance Profile – Sustainability Test Run



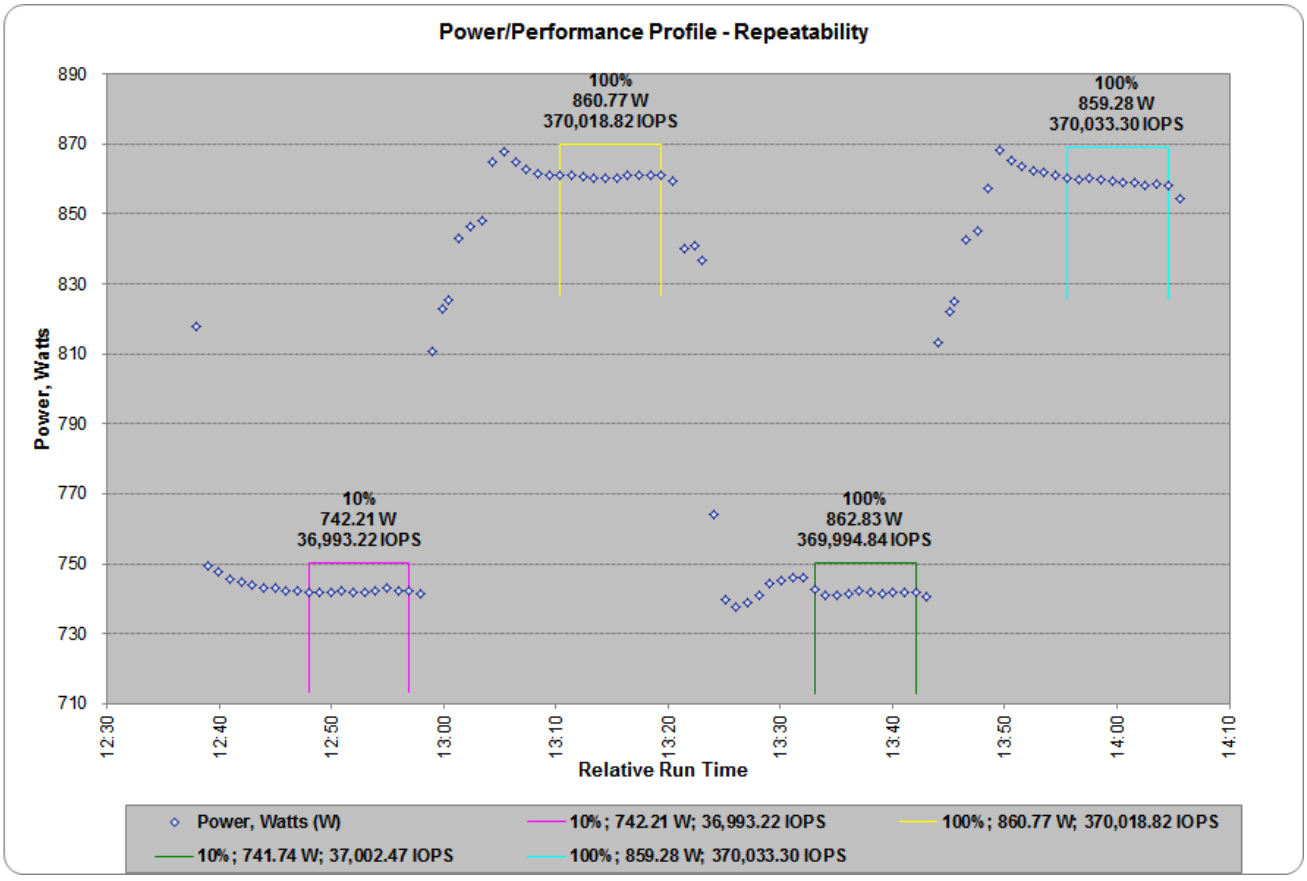
Execution Component	Load Level	SPC-1 IOPS™	Power (W)
Sustainability ***(Sustain)***	100%	369,997.85	864.41

Power/Performance Profile – IOPS and Response Time Ramp Test Runs



Execution Component	Load Level	SPC-1 IOPS™	Power (W)
IOPS *(**100%**)*	100%	369,994.84	862.83
Ramp95 *(**95%**)*	95%	351,497.45	856.04
Ramp90 *(**90%**)*	90%	332,996.17	849.64
Ramp80 *(**80%**)*	80%	295,977.82	837.78
Ramp50 *(**50%**)*	50%	184,985.30	789.82
Ramp10 *(**10%**)*	10%	37,011.27	742.89

Power/Performance Profile – Repeatability Test *(two phases)*



Execution Component	Load Level	SPC-1 IOPS™	Power (W)
Repeat1 LRT ***(10%)***	10%	36,993.22	742.21
Repeat1 IOPS ***(100%)***	100%	370,018.82	860.77
Repeat2 LRT ***(10%)***	10%	37,002.47	741.74
Repeat2 IOPS ***(100%)***	100%	370,033.30	859.28

Priced Storage Configuration Pricing

Component	Quantity	Unit Price	Unit Maint	List w/ Maint	% discount	Total Price
FlashSystem 840 (9840-AE1) w/12 SFPs, 1 year warranty included	1	42,000.00	6,240.00	48,240.00	39	29,426.40
eMLC (-AF11) 4 TB flash card	12	52,500.00	7,248.00	716,976.00	39	437,355.36
5m fibre channel cable (-3701)	12	75.00	0.00	900.00	30	630.00
8 Gbps dual port FC adapter (9179-5735)	6	4,583.00	0.00	27,498.00	30	19,248.60
Total Price						**486,660.36**

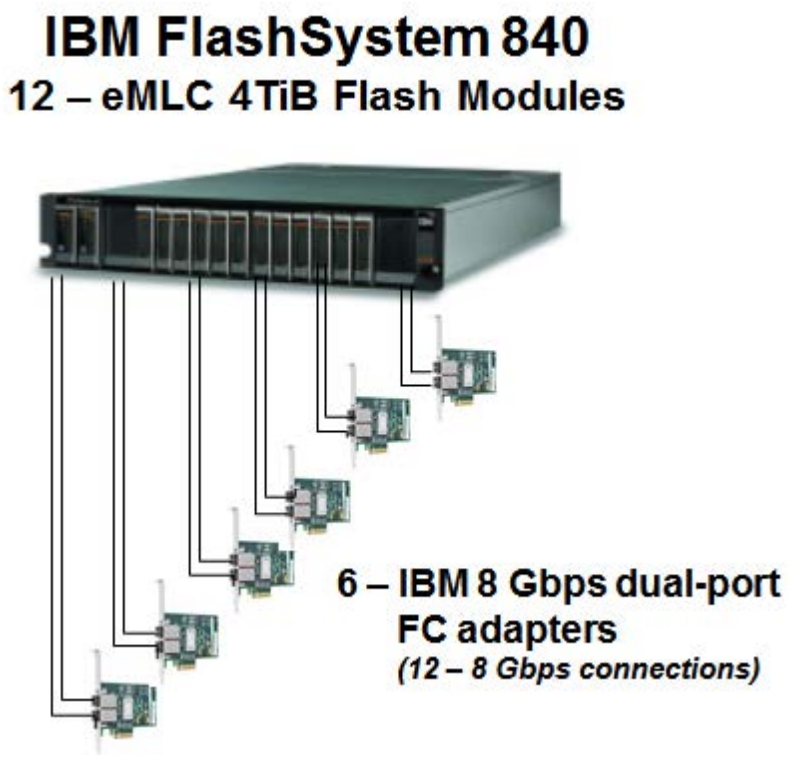
The above pricing includes hardware maintenance and software support for three years, 7 days per week, 24 hours per day. The hardware maintenance and software support provides the following:

- Acknowledgement of new and existing problems with four (4) hours.
- Onsite presence of a qualified maintenance engineer or provision of a customer replaceable part within four (4) hours of the above acknowledgement for any hardware failure that results in an inoperative Priced Storage Configuration that can be remedied by the repair or replacement of a Priced Storage Configuration component.

Differences between the Tested Storage Configuration (TSC) and Priced Storage Configuration

There were no differences between the TSC and Priced Storage Configuration.

Priced Storage Configuration Diagram



Priced Storage Configuration Components

Priced Storage Configuration
6 – IBM 8 Gbps dual-port FC adapters
IBM FlashSystem™ 840 Dual controllers 12 – 8 Gbps FC front-end connections *(w/12 SFPs)* *(12 connections used)* 40 – SAMNet backend lanes available and used *(proprietary interconnect similar to PCIe)*
12 – eMLC 4 TB Flash Modules