SPC Benchmark 1C/Energy™ *(SPC-1C/E™)*

Storage Component Benchmark with Energy Use Extension

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SPC Benchmark 1C/Energy ™

- SPC Benchmark 1C/Energy™ *(SPC-1C/E™)* is an extension to the first storage component benchmark, SPC Benchmark 1C™ *(SPC-1C™)*.
- SPC-1C/E was publicly announced on June 3, 2009. IBM and Seagate were the first SPC member companies to submit results at that time.
- SPC-1C/E consists of the complete set of SPC-1C performance measurements and reporting, combined with the measurement and reporting of energy use.

SPC Benchmark 1C *(SPC-1C)*

- SPC-1C is based on the SPC-1 specification and utilizes the SPC-1 workload.
- SPC-1C reporting requirements are similar to SPC-1.
- Storage component vendors comprise the primary producer audience for SPC-1C.
- Storage solution providers *(vendors, resellers, etc.)*, as well as end users, are the primary consumer audiences for SPC-1C.

SPC-1C Configurations

- SPC-1C configurations consist of the following two components:
  - One or more HBAs/Controllers (single/dual/quad…).
  - One of the following storage device configurations:
    - One, two, or four storage devices in a “standalone” configuration.
      - » An external enclosure may be used but only to provide power and/or connectivity for the storage devices.
    - A Small Storage Subsystem may include a maximum of forty-eight (48) storage devices in no larger than a 4U enclosure profile *(1 – 4U, 2 – 2U, 4 – 1U, etc.)*

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- SPC Benchmark 1C/Energy *(SPC-1C/E)* is the first SPC benchmark to include measurement and reporting of energy use in addition to storage performance.
- The SPC-1C/E is only applicable to Small Storage Subsystem configurations as previously described on page 4.

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- In addition to the “core” SPC-1C performance measurement and reporting requirements, SPC-1C/E defines:
  - Configuration and instrumentation requirements for energy usage measurement
  - Execution requirements for application idle state measurements and the transition into active *(performance)* state measurements
  - Data collection requirements for energy use measurements
  - Expanded disclosure and audit requirements

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- The storage configuration's energy use is measured and reported.
  - Measurements are taken during both application idle and active states of the benchmark execution.
  - Multiple application idle phases are allowed.
  - The active *(performance)* state consists of performance Test Runs, identical to SPC-1C.
- SPC-1C/E energy use results cannot be reported without the corresponding SPC-1C/E performance results.

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- SPC-1C/E execution profile:
  - A 10 minute “precondition” phase at 100% of the specified performance offered load.
  - An application idle phase lasting at least 30 minutes with one or more distinct phases.
  - Each application idle phase may be preceded by an optional transition period not to exceed 3 minutes.
  - A second 10 minute “precondition” phase at 10% of the specified performance offered load.
  - Execution of the current SPC-1C Tests: Metrics *(Sustainability, IOPS, Response Time Ramp),* Repeatability, and Persistence *(energy use measurements are not taken during the Persistence Test)*

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- SPC-1C/E application idle phases:
  - More than one idle phase is allowed as long as transitions between idle phases do not require manual intervention.
    Idle Phase 0, Idle Phase 1…Idle Phase L-1, Idle Phase L
  - Idle Phase 0 thru Idle Phase L-1 must have the same duration, selected by the Test Sponsor, up to a maximum of 10 minutes.
  - Idle Phase L (“deepest” idle state) duration is selected by the Test Sponsor with a minimum of 30 minutes.
  - The simplest Idle Test consists of a single idle phase with a duration of 30 minutes.

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- SPC-1C/E Reported Data includes multiple energy use metrics:
  - Across several selected environments
  - Taking into account hourly variations in I/O load
- This reported data will allow an estimate of average annual energy use.
- The SPC-1C/E required table and graph lists and illustrates storage performance and energy use for each performance test.

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- An example of SPC-1C/E Reported Data:

Usage Profile	Hours of Use per Day			Nominal	Nominal	Nominal
	Heavy	Moderate	Idle	Power, W	Traffic, IOPS	IOPS/W
Low Daily Usage:	0	8	16	**161.50**	**7498.96**	**46.43**
Medium Daily Usage:	4	14	6	**162.64**	**19118.11**	**117.55**
High Daily Usage:	18	6	0	**164.01**	**32601.39**	**198.77**
			Composite Metrics:	**162.72**	**19,739.49**	**121.31**

Annual Energy Use, kWh:	**1,425.41**		
Energy Cost, $/kWh:	$ 0.12	**Annual Energy Cost, $:**	**$ 171.05**

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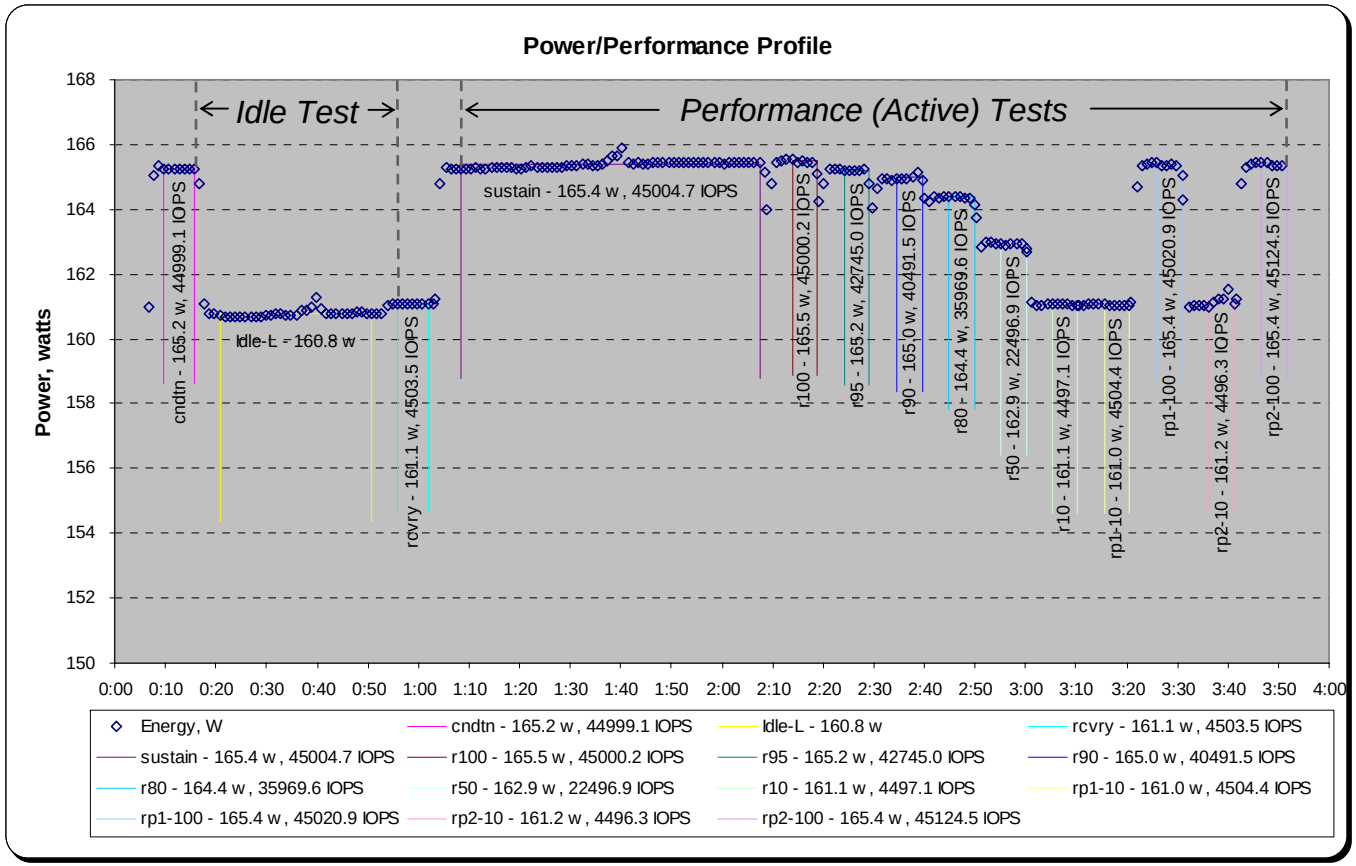
- Example of SPC-1C/E required graph *(corresponds to the earlier Reported Data example)*:



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- Example of SPC-1C/E required table *(used for the earlier SPC-1C/E required graph example)*:

Relative Time	Time	Run Name	Energy, W	Voltage, V	Current, A
0:06:44	16:46:44	Conditioning	160.97	202.52	0.9057
0:07:44	16:47:44	Conditioning	165.02	202.51	0.9246
0:08:44	16:48:44	Conditioning	165.33	202.67	0.9255
0:09:44	16:49:44	Conditioning	165.25	202.67	0.9251
0:10:44	16:50:44	Conditioning	165.23	202.58	0.9253
0:11:44	16:51:44	Conditioning	165.25	202.57	0.9255
0:12:44	16:52:44	Conditioning	165.26	202.63	0.9254
0:13:44	16:53:44	Conditioning	165.26	202.60	0.9254
0:14:44	16:54:44	Conditioning	165.24	202.62	0.9252
0:15:44	16:55:44	Conditioning	165.23	202.65	0.9251
0:16:44	16:56:44	Startup Idle-L	164.77	202.72	0.9228
0:17:44	16:57:44	Startup Idle-L	161.06	202.77	0.9056
0:18:44	16:58:44	Startup Idle-L	160.76	202.65	0.9046
0:19:44	16:59:44	Startup Idle-L	160.77	202.43	0.9052
0:20:51	17:00:51	Idle-L	160.72	203.50	0.9016
0:21:51	17:01:51	Idle-L	160.67	203.84	0.9002
0:22:51	17:02:51	Idle-L	160.69	203.81	0.9003
0:23:51	17:03:51	Idle-L	160.68	203.74	0.9005
0:24:51	17:04:51	Idle-L	160.69	203.70	0.9006
0:25:51	17:05:51	Idle-L	160.70	203.64	0.9007
0:26:51	17:06:51	Idle-L	160.67	203.59	0.9006
0:27:51	17:07:51	Idle-L	160.70	203.60	0.9007
0:28:51	17:08:51	Idle-L	160.70	203.66	0.9005
0:29:51	17:09:51	Idle-L	160.72	203.77	0.9003
0:30:51	17:10:51	Idle-L	160.73	203.76	0.9005
0:31:51	17:11:51	Idle-L	160.76	203.68	0.9008
0:32:51	17:12:51	Idle-L	160.76	203.68	0.9008
0:33:51	17:13:51	Idle-L	160.75	203.63	0.9009
0:34:51	17:14:51	Idle-L	160.72	203.66	0.9007
0:35:51	17:15:51	Idle-L	160.75	203.69	0.9008
0:36:51	17:16:51	Idle-L	160.86	203.66	0.9013
0:37:51	17:17:51	Idle-L	160.89	203.65	0.9015
0:38:51	17:18:51	Idle-L	161.00	203.72	0.9020
0:39:51	17:19:51	Idle-L	161.28	203.78	0.9031
0:40:51	17:20:51	Idle-L	160.92	203.70	0.9017
0:41:51	17:21:51	Idle-L	160.76	203.64	0.9011
0:42:51	17:22:51	Idle-L	160.77	203.60	0.9012
0:43:51	17:23:51	Idle-L	160.78	203.55	0.9013
0:44:51	17:24:51	Idle-L	160.80	203.56	0.9015
0:45:51	17:25:51	Idle-L	160.79	203.63	0.9015
0:46:51	17:26:51	Idle-L	160.79	203.58	0.9015
0:47:51	17:27:51	Idle-L	160.82	203.55	0.9018
0:48:51	17:28:51	Idle-L	160.82	203.52	0.9019
0:49:51	17:29:51	Idle-L	160.78	203.44	0.9019
0:52:51	17:32:51	Recovery	160.80	203.46	0.9019
0:53:51	17:33:51	Recovery	161.04	203.39	0.9033
0:54:51	17:34:51	Recovery	161.09	203.36	0.9036
0:55:51	17:35:51	Recovery	161.11	203.34	0.9036
0:56:51	17:36:51	Recovery	161.09	203.35	0.9036
0:57:51	17:37:51	Recovery	161.09	203.38	0.9036
0:58:51	17:38:51	Recovery	161.08	203.37	0.9035
0:59:51	17:39:51	Recovery	161.06	203.33	0.9035
1:00:51	17:40:51	Recovery	161.08	203.26	0.9038
1:01:51	17:41:51	Recovery	161.08	203.17	0.9041
1:02:51	17:42:51	RunOut	161.06	203.12	0.9041
1:03:24	17:43:24	Startup Sustainabiltiy	161.24	203.12	0.9049
1:04:24	17:44:24	Startup Sustainabiltiy	164.80	203.18	0.9213
1:05:24	17:45:24	Startup Sustainabiltiy	165.29	203.27	0.9234
1:06:24	17:46:24	Startup Sustainabiltiy	165.26	203.22	0.9233
1:07:24	17:47:24	Startup Sustainabiltiy	165.26	203.13	0.9235
1:08:24	17:48:24	Sustainability	165.26	203.19	0.9233
1:09:24	17:49:24	Sustainability	165.25	203.27	0.9232
1:10:24	17:50:24	Sustainability	165.23	203.31	0.9230
1:11:24	17:51:24	Sustainability	165.28	203.27	0.9233
1:12:24	17:52:24	Sustainability	165.25	203.28	0.9232
1:13:24	17:53:24	Sustainability	165.26	203.30	0.9233
1:14:24	17:54:24	Sustainability	165.29	203.24	0.9236
1:15:24	17:55:24	Sustainability	165.30	203.20	0.9237
1:16:24	17:56:24	Sustainability	165.29	203.17	0.9237
1:17:24	17:57:24	Sustainability	165.28	203.17	0.9236
1:18:24	17:58:24	Sustainability	165.31	203.11	0.9238
1:19:24	17:59:24	Sustainability	165.26	203.10	0.9235
1:20:24	18:00:24	Sustainability	165.26	203.25	0.9232
1:21:24	18:01:24	Sustainability	165.29	203.45	0.9229
1:22:24	18:02:24	Sustainability	165.32	203.42	0.9232
1:23:24	18:03:24	Sustainability	165.31	203.43	0.9232
1:24:24	18:04:24	Sustainability	165.29	203.47	0.9230
1:25:24	18:05:24	Sustainability	165.29	203.48	0.9229
1:26:24	18:06:24	Sustainability	165.29	203.47	0.9229
1:27:24	18:07:24	Sustainability	165.31	203.54	0.9228
1:28:24	18:08:24	Sustainability	165.31	203.56	0.9228
1:29:24	18:09:24	Sustainability	165.33	203.51	0.9230
1:30:24	18:10:24	Sustainability	165.33	203.52	0.9230
1:31:24	18:11:24	Sustainability	165.35	203.48	0.9232
1:32:24	18:12:24	Sustainability	165.38	203.48	0.9234
1:33:24	18:13:24	Sustainability	165.38	203.52	0.9233
1:34:24	18:14:24	Sustainability	165.35	203.53	0.9230
1:35:24	18:15:24	Sustainability	165.36	203.53	0.9230
1:36:24	18:16:24	Sustainability	165.39	203.59	0.9231

SPC Benchmark 1C/Energy™

- SPC-1C/E future investigations and development activity under consideration:
  - Energy use extension for SPC-2C
  - Extending energy use measurement and reporting to SPC-1/SPC-2 *(larger configurations)*
  - An end-user tool to ‘customize/localize’ SPC-1C/E Reported Data to specific end user environments

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- SPC-1C/E future investigations/development:
  - Energy use extension for SPC-2C
    - Will begin testing in 3-4 weeks to determine which of the three SPC-2C workloads (Large File Processing, Large Database Query, and Video on Demand) would be appropriate for inclusion in an energy use extension.
  - Extending energy use measurement and reporting to SPC-1/SPC-2 *(larger configurations)*
    - Initial direction under discussion: SPC-1 configurations that can be measured with a single power meter, which may include multiple power inputs.

SPC-1C/E End-User Tool

- An SPC-1C/E end-user tool is under investigation, which would allow "customization/localization" of SPC-1C/E Reported Data by:
  - Allowing the end-user to change values in the "Hours of Use per Day" matrix to reflect actual or projected values..
  - Use local energy cost for calculating "Annual Energy Use *(kWh)*.

SPC-1C/E End-User Tool

- The end-user may only change the values highlighted in **red**, which will reflect actual or projected usage values. All other values are either calculated by the tool or extracted by the tool from the SPC-1C/E Result of interest.

Usage Profile

	Hours of Use per Day			Nominal	Nominal	Nominal
	Heavy	Moderate	Idle	Power, W	Traffic, IOPS	IOPS/W
Low Daily Usage:	0	8	16	161.50	7498.96	46.43
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			Composite Metrics:	162.72	19,739.49	121.31

Annual Energy Use, kWh:	1,425.41
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