



# SUST-201-1: Sustainability, Session 1 of 3 8:30 AM – 9:35 AM

Organizer + Moderator:

Wayne M. Adams

SNIA Green Storage Initiative

SNIA ,Chairman Emeritus

# FMS Sustainability Tracks 1,2,3

- 201-1, 8:30-9:35, Ballroom A
  - Maximizing Energy Efficiency for High Fidelity Storage Platforms
  - Low-Voltage PLP IC for Enterprise SSDs for Reliability and Cost Savings
  - SNIA Specifications for Energy Efficiency Measurement
- 202-1, 9:45-10:50, Ballroom A
  - Building Sustainable Data Centers with Innovative Technology
  - Beyond Carbon Footprints: The Holistic View of Sustainability in ICT
  - Methods to improve system lifecycles to improve Sustainability
  - Environmentally-Friendly Storage Architectures
- 203-1, 3:30-4:35, Ballroom F
  - The Industry and Sustainability Opportunity in Circular Storage
  - From Cradle to Cradle: A Journey Towards a Circular Economy for Data Storage
  - Profiting While Doing Good: How to Harness Circular Storage

## Maximizing Energy Efficiency for High Fidelity Storage Platforms

Mike Bennet, Solution Architect

Ampere Computing

## Low-Voltage PLP IC for Enterprise SSDs for Reliability and Cost Savings

Junguei Park, Principal Analog Design Engineer

FADU

## SNIA Specifications for Energy Efficiency Measurement

Wayne Adams, SNIA Chairman Emeritus

SNIA

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# SNIA Specifications for Energy Efficiency Measurement

Wayne M. Adams  
Chairman Emeritus  
Co-chair Green Storage Initiative  
SNIA  
[www.snia.org](http://www.snia.org)



# Brief Agenda of Topics

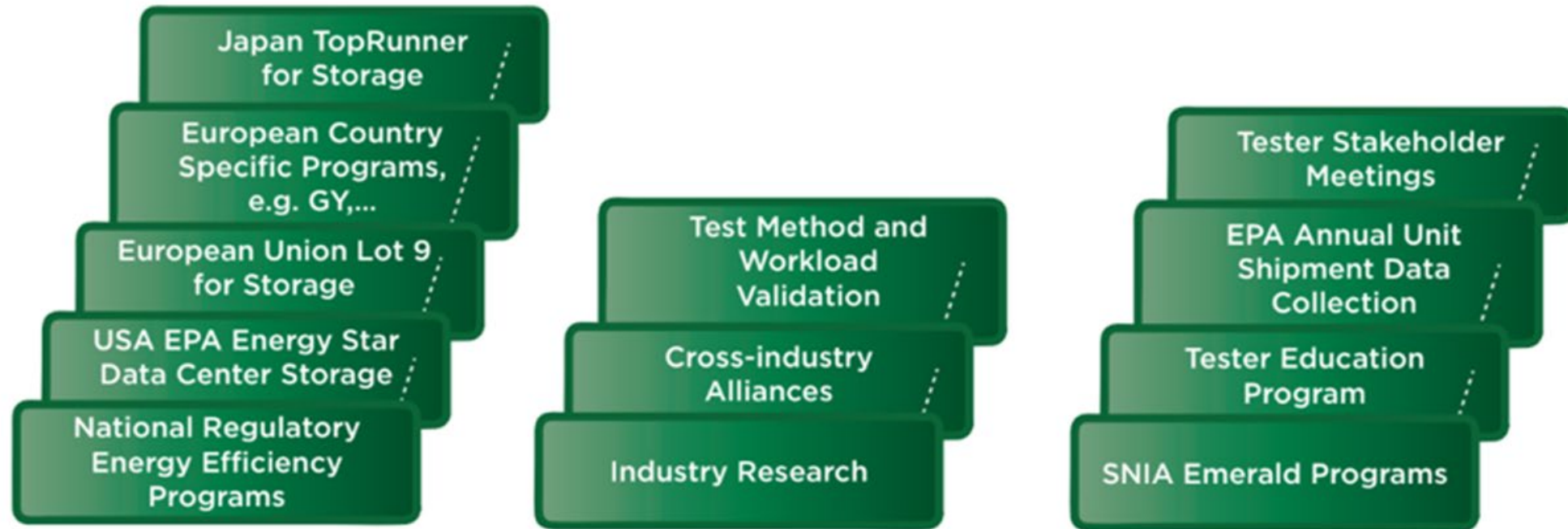
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- Storage system power efficiency characterization with SNIA Emerald
  - Industry data with EPA Energy Star Data Center Storage Program
  - Workloads and workload generator evolution
- Storage device characterization with Calypso Test Suite
  - Workload capture programs and test methods
- Opportunity, challenges, and planning points for IT
- Additional Resources

# Overview of SNIA Emerald™ - Storage Systems



Flash Memory Summit

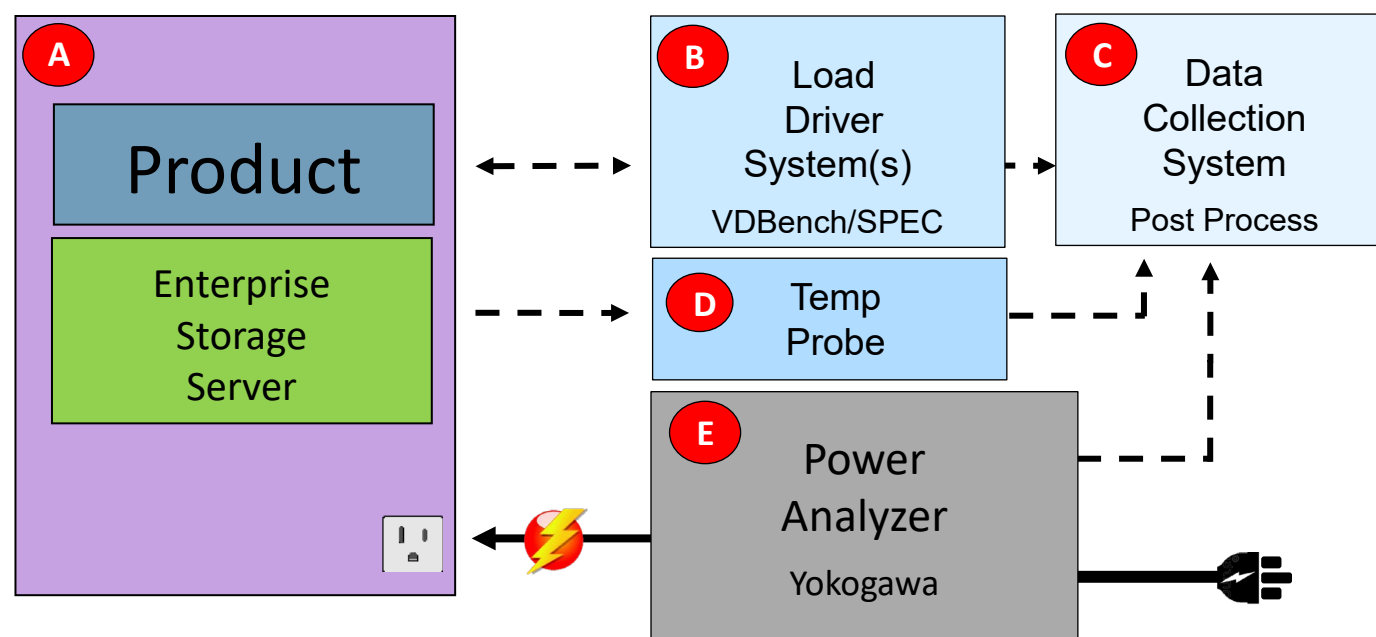


SNIA Emerald™ Power Efficiency Measurement Specification  
for Enterprise Storage Systems  
ISO/IEC 24091 – Information Technology – Power Efficiency  
Measurement Specification for Data Center Storage

# SNIA Emerald™ & IEC/ISO 24091:2019

US EPA Energy Star, EU Lot 9, and Japan TopRunner Referenced

- Standardized Methodology to Assess Power Efficiency
- Commercial Storage Products (Systems/Servers)
- Idle Power States: Idle, Active
- IO Power States: VdBench Block Synthetic Workloads (RND/SEQ 8K, 128K RW)
- IO Power States: File System SPEC SFS 2014 Real World Workloads
- Power Measured at the Product Server AC Input
- System considerations for Capacity Optimization and RAS



**E** Yokogawa WT 210 Power Analyzer



# Detailed Taxonomy



Attribute	Set					
	Disk		RVML		NVSS	
	Category					
	Online	Near-Online	Removable Media Library	Virtual Media Library	Disk Access	Memory Access
Access Pattern	Random/ Sequential	Random/ Sequential	Sequential	Sequential	Random/ Sequential	Random
MaxTTFD	≤ 80 ms	> 80 ms	≤ 5 min	≤ 80 ms	≤ 80 ms	≤ 80 ms
Media Type	Magnetic disk	Magnetic disk	Magnetic tape, optical disk	Magnetic disk, Solid State Storage	Solid State Storage + optional magnetic disk <sup>a</sup>	Solid State Storage
Access Paradigm	Block, File, Object	Block, File, Object	Block	Block	Block, File, Object	Memory
<sup>a</sup> Allows a purely Solid State Storage system or a hybrid Solid State Storage and magnetic disk system.						

Attribute	Category: Disk Set Online						
	Classification: Online						
	1 <sup>a</sup>	1.5	2	3	4	5	6
Multi-host Shareability	Not Specified	Ability to share with 1 or more hosts	Ability to share with 2 or more hosts	Ability to share with 2 or more hosts	Ability to share with 2 or more hosts	Ability to share with 2 or more hosts	Ability to share with 2 or more hosts
Consumer/Component	Yes	No	No	No	No	No	No
Storage Controller	Optional	Optional	Required	Required	Required	Required	Required
Storage Protection	Optional	No	Required	Required	Required	Required	Required
No SPOF	Optional	Optional	Optional	Optional	Required	Required	Required
Non-Disruptive Serviceability	Optional	Optional	Optional	Optional	Optional	Required	Required
FBA/CKD Support	Optional	No	Optional	Optional	Optional	Optional	Required
System Capacity (number of drives) <sup>b</sup>	≥ 1	≥ 4	≥ 4	≥ 12	> 100	> 400	> 400

# EPA Energy Star Testing – since July 2021

## DCS V2.0 – Threshold for Block; not File yet

<https://www.energystar.gov/productfinder/product/certified-data-center-storage/results>

<b>Storage Controller Configuration</b> <input type="checkbox"/> Scale-Out Storage (17) <input type="checkbox"/> Scale-Up Storage (46)	<b>D</b> <input type="checkbox"/> DELL (18) <input type="checkbox"/> DELL EMC (5) <input type="checkbox"/> Dell EMC Unity XT380 (1) <input type="checkbox"/> Dell EMC Unity XT380F (1) <input type="checkbox"/> Dell EMC Unity XT480 (1) <input type="checkbox"/> Dell EMC Unity XT480F (1)	<b>I</b> <input type="checkbox"/> IBM (4)	<b>P</b> <input type="checkbox"/> Pure Storage (2)
<b>Workload Optimization Type</b> <input type="checkbox"/> Composite (14) <input type="checkbox"/> Streaming (19) <input type="checkbox"/> Transaction (30)	<b>L</b> <input type="checkbox"/> Lenovo (1) <input type="checkbox"/> Lenovo (United States) Inc. (2)	<b>S</b> <input type="checkbox"/> Seagate (4)	
<b>Storage Model Connectivity</b> <input type="checkbox"/> Block I/O (47) <input type="checkbox"/> File I/O (16)	<b>H</b> <input type="checkbox"/> Hewlett Packard Enterprise (3) <input type="checkbox"/> Hitachi Vantara (3) <input type="checkbox"/> HPE (5) <input type="checkbox"/> HPE Primera (3)	<b>N</b> <input type="checkbox"/> NetApp (5) <input type="checkbox"/> NetApp, Inc. (3)	<b>V</b> <input type="checkbox"/> Viking Enterprise Solutions

Vendors test in-house or contract with independent test lab, e.g. MET Labs ; EPA Certified Body reviews/submits results

Comprehensive Data Analysis in Joint Whitepaper from SNIA/TGG:  
ENERGY EFFICIENT DATA CENTER STORAGE: AN ASSESSMENT OF STORAGE PRODUCT POWER EFFICIENCY

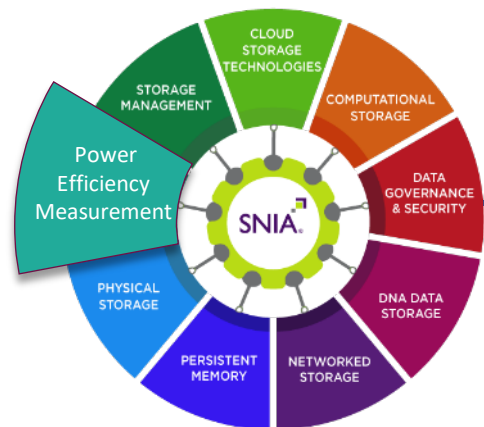
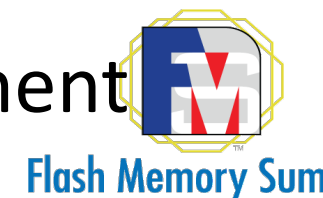
# Directions for SNIA Emerald 5.0 – Release 2024

## Evolve the Test Tools

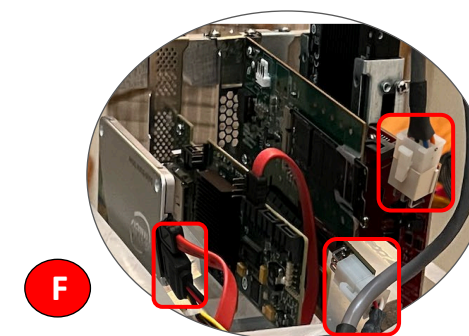
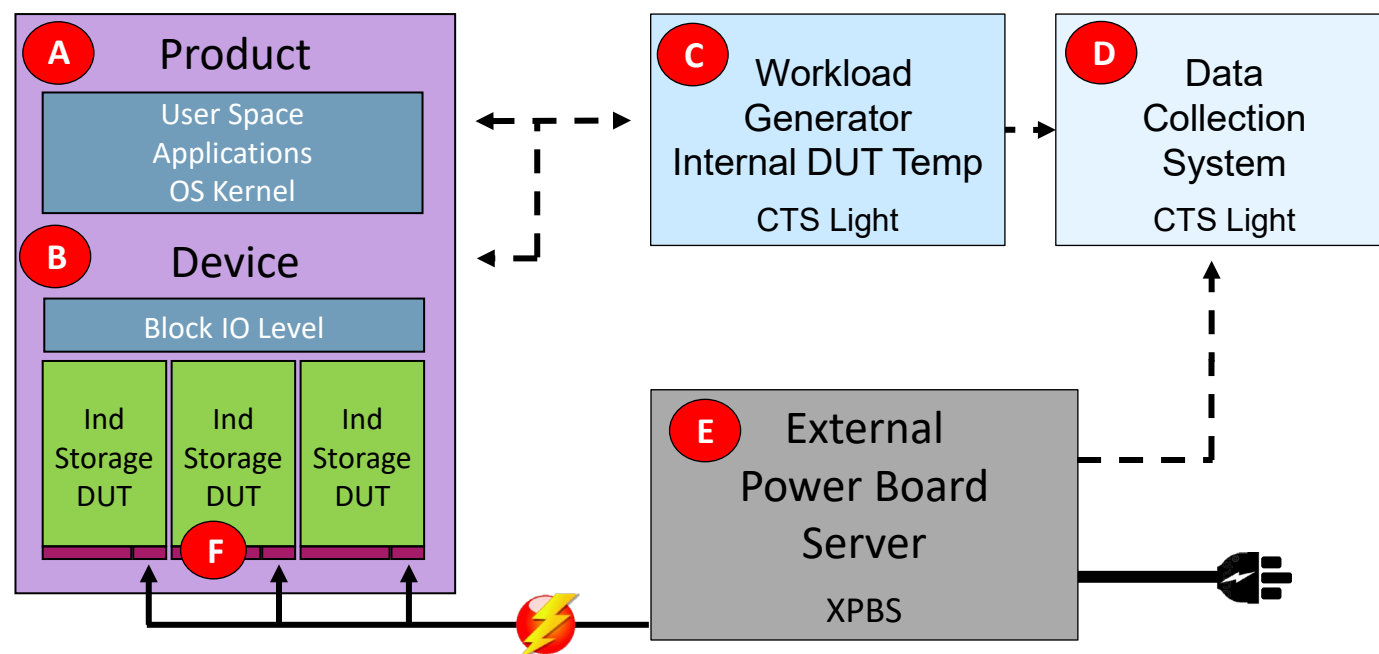
- SPEC SFS 2014 → SPECstorage Solution 2020 (available for use)
  - New workloads for 2020
  - Retain 2 of the 4 2014 workloads
- VdBench → Calypso Test Suite Light (**ready to test with NOW**)
  - Run the same VdBench scripts for the 4 corner tests (RR/W, Seq R/W, HotBand)
  - Have validated CTS Light for past 12 months various system configurations
- Work with EPA (for DCS v2.x /3.0)
  - assess whether Block IO thresholds need adjusted to correlate the old workload generators and the new generators
  - assess if enough industry data for File IO to establish thresholds

# SNIA Device Level Power Efficiency Measurement

Under Development by SNIA Solid State & Green Storage TWGs



- Standardized Device Level Power Efficiency Measurement
- Commercial Storage Devices (SSD/HDD) ; SSD Taxonomy
- Idle Power States: Cold, Warm, Active and Cool Down
- IO Power States: Synthetic & Real-World Workloads
- File System and Block level
- Power Measurement at the Individual Storage Device
- **CTS Light - Workload Generator and IO/Energy Capture (Available Now)**



**E** 3<sup>rd</sup> Party External Power Board Server

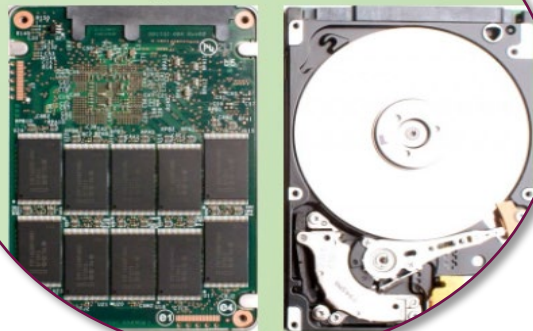
# Storage Device Level Power Efficiency is Highly Dependent on:

1

SSD vs HDD

Temp, Power  
IO Stream Dependent

Perf, Temp, Power  
Idle v Active Dependent



1. Type of Storage: SSD and HDD
2. Type of Workload: Real World and Synthetic
3. Power Efficiency Measurement: IOPS/W
4. RAS: Features & Settings  
(Reliability, Availability, Serviceability), 5 9s Quality of Service

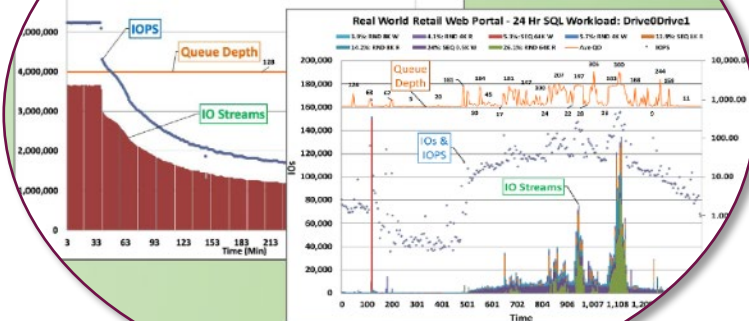
2

Synthetic - RND 4K W

RND 4K W Benchmark: IOPS IO's v Time - Fixed QD (128)

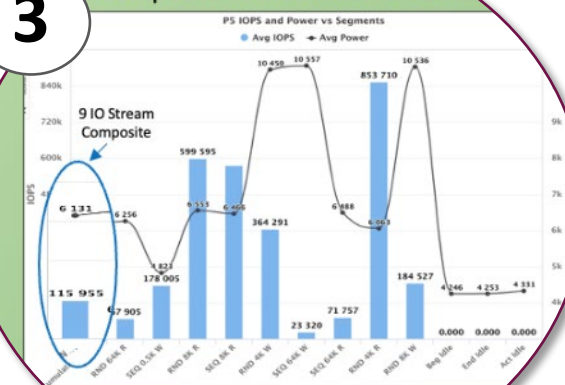
RND 4K W QD IOPS

RWW- Retail Web Portal



3

Composite vs Individual IO Stream

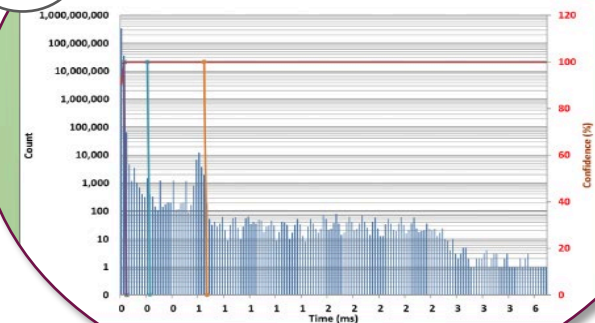


4

RAS – Response Time QoS Histogram

P15 Max Point T6/Q1 CLP. IOPS=305906, 1195 MB/s, MRT=5.77 ms

Latency % Confidence ART = 0.02 99.9% = 0.02 99.99% = 0.2 99.999% = 0.64

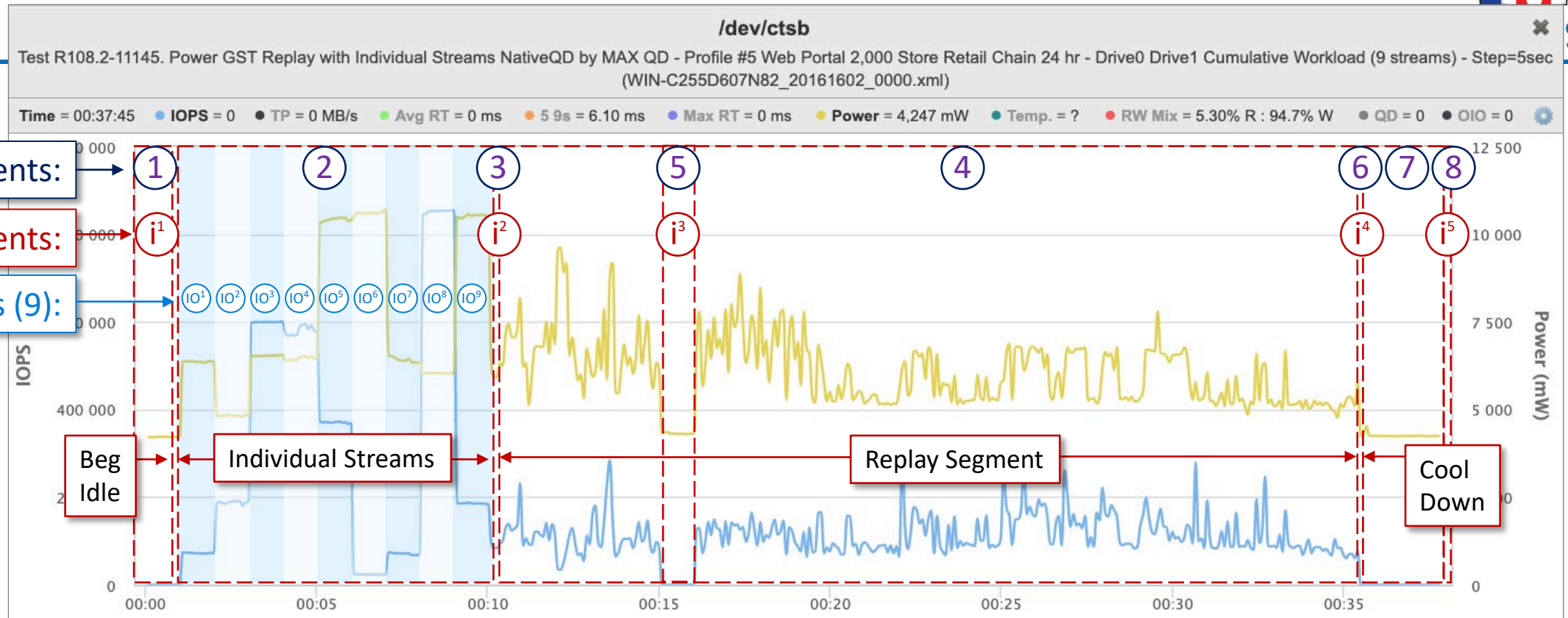




# Real World Workload Replay-Ind. Streams Test: Test Flow



Summit



## Test Flow:

1. Beg (Cold) Idle (i¹) - 60 sec Dur
2. Ind. Stream Segments - (9) Ind. IO Streams x 60 sec
3. Warm Idle (i²) - After IO Streams x 60 sec
4. Replay Segment - 9 IO Stream Sequence x 290 5 sec steps
5. Active (Hot) Idle (i³) - 60 sec idle between Steps 60 & 61
6. Begin Cool Down Idle (i⁴) - 60 sec idle after step 290
7. Cool Down - 10 min following step 290
8. End Idle (i⁵) - 60 Sec idle after 10 min cool down

# Directions for SNIA Storage Device Level Work

- **Test Specification can be of benefit for (apples to apples comparisons)**
  - System vendors supply chain in device selection and custom workloads
  - Cloud service vendors who roll their own systems with business/application specific workloads
  - Specification target completion is before year end 2022
  - CTS Light Available Now , test 4 corners and any custom workload
- **Potential Regulator interest – longer term**
  - Japan TopRunner could evolve from idle only HDD; include SSD and active workload
  - Re-validate EPA Data Center Server Spec assumptions for storage device “adders” rules of thumb (currently based on HDD from several years ago)

# Challenges and Opportunity for Operations Measurements

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- Methods described characterize a system and or device as though it is in a production environment, however pre-deployment
- Current power measurement methods in operations tend to be focused on the rack, regardless of what is in the rack – e.g. server, network, storage, not tied to any workload (CPU, network, or storage)
- Though servers and storage are instrumented with DMTF Redfish and SNIA Swordfish management interfaces (including power and IO), no universal/open DCIM platform has embraced system level energy usage reporting.
- Hyper-converge systems considered to difficult to assess with server/network/storage, and SDS mix-n-match



# A few planning points, some you may have tackled for those directly involved in IT and Business Ops

- Manage the size of your dataset(s);
- Leverage as many capacity optimization products and tools as possible;
- Matched to the requirements for data protection and response time; copies of data moved onto nearline or offline storage.
- \*\*What is your data deletion strategy/policy to curb ballooning storage requirements...while AI/ML, IoT, and other growth drivers mature ?
- Future climate and emissions reporting for public corporations will need disclosure of your outsourced services, so you will need to work with your cloud vendor(s) of choice to receive energy usage reporting along with the resource usage if they are storing data for you.

# CTS Light – Available Now

## same tool for storage system and storage device testing



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- CTS Light – software test and measurement tool
  - Storage System Testing – SNIA Emerald specification
    - IO Workload Generator for Block IO
      - Runs on Linux and Windows
      - 4 Corners and HotBand workloads – SNIA Emerald
    - Power measurement with power meter
  - Device Level Testing – Single Device Level specification
    - IO Workload Generator for Block IO and File IO
      - SSD and HDD
      - Block IO – 4 Corners
      - Custom workloads
    - Power measurement with interposer board
  - Yearly Subscription Model and Service Support Plan
    - Single seat/multi-seat plans , starting at \$7000 USD
  - Light is upgradeable to full featured CTS

# Additional Resources



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- SNIA Emerald™ Specification, Test Kit, and Training
  - [www.sniaemerald.com](http://www.sniaemerald.com) , [emerald@snia.org](mailto:emerald@snia.org)
- IEC/ISO 29041:2019
  - <https://www.iso.org/standard/77801.html>
- Joint TGG(TheGreenGrid®) / SNIA Whitepaper #86:
  - ENERGY EFFICIENT DATA CENTER STORAGE:  
AN ASSESSMENT OF STORAGE PRODUCT POWER EFFICIENCY
  - <https://www.thegreengrid.org/en/resources/library-and-tools>
- SNIA Whitepaper, estimated release - October 2022
  - Storage Device- Level Power Efficiency Measurement for  
Cloud, Datacenter, and Enterprise Storage
  - [https://www.snia.org/sites/default/files/SSSI/Introduction%20to%20RWW%20-%20A%20Primer%20v2.1.2.Final\\_.pdf](https://www.snia.org/sites/default/files/SSSI/Introduction%20to%20RWW%20-%20A%20Primer%20v2.1.2.Final_.pdf)
- SNIA CMSI White Paper: Real World Workloads – A Primer
  - <https://www.snia.org/educational-library>
- SNIA IO Traces and Workload Library
  - <http://iota.snia.org/>



# Thank You

## Time for Q&A

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