Hyperion Research

HPC Sustainability

Sponsored by: Dell Technologies, Intel and NVIDIA

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www.HyperionResearch.com
www.hpcuserforum.com

Contents

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Study Background and Highlights

How We Do Our Research

100% focused on HPC/AI/Quantum and the results from using HPC

- **Worldwide coverage**
  - Strong focus on international sites
- **Data is collected via direct interviews and surveys**
  - Multiple survey methods
    - In-depth interviews (many on-site in person, also via phone)
    - On-line with mix of multiple choice and open-end questions
    - Video survey process – NEW!
  - Research includes all types of R&D, technology, business, and market activities
- **Establish, maintain, and grow strong relationships**
  - Global HPC suppliers, including Chinese vendors
  - Most of the larger HPC sites around the world
  - Many individual HPC and China experts

Goals

Gain insight into sustainability efforts in HPC

- **Determine HPC users' awareness of and sentiment towards environmental sustainability**
- **Understanding users' prioritization of sustainability and energy efficiency in procurement decisions**
- **Willingness to direct budget towards related features and initiatives**
- **What initiatives are being considered?**
- **Top motivations driving the increased priority of sustainability**
- **Energy budget/consumption and ability to increase**
- **Outline sustainability and net zero strategies currently employed**

Demographics

- **Visibility into the operations of their organization's HPC computing environment**
- **Regions**
  - APJ (16%)
  - EMEA (25%)
  - North America (59%)
- **Sector**
  - Academia (10%)
  - Government (12%)
  - Industry (78%)
- **Roles**
  - HPC data center manager, director, or lead (42%)
  - CSP data center manager, director, or lead (12%)
  - HPC data center operations professional (14%)
  - Researcher, scientist, or engineer (32%)

Motivations for Sustainability

- **The top motivations by region:**
  - APJ: ESG Goals
  - EMEA: Prohibitive Energy Costs
  - North America: Wanting to do more with less
- **Sustainability goals will impact HPC budgets**
  - Region
    - APJ (80%)
    - EMEA (78%)
    - North America (47%)
  - Sector
    - Academia (78%)
    - Government (55%)
    - Industry (59%)
- **48% of respondents cited ESG goals as a sustainability motivator**

Impact of Energy Costs

Impacts are being felt in APJ and EMEA to a greater extent

- **Of the respondents that indicated energy costs will impact operations (58% of total)**
  - 60% will defer the purchase of new systems
  - 43% will limit the capabilities of current systems
  - 34% will reduce operational hours
- **Regional breakout**

Impacts	APJ	EMEA	North America
Operations at their data centers	60%	61%	47%
Level of investment into new HPC systems (55% of total)	73%	65%	55%

Moving to Cloud

A popular option for outsourcing the issue of sustainability

- **The option to outsource energy costs to a cloud service provider (CSP) is expected to gain popularity**
- **76% of respondents said energy costs influence their adoption of public cloud resources (to a great extent for 33% of respondents)**
- **New government regulations surrounding sustainability, sites are looking to CSPs to meet new energy efficiency requirements. This survey adds quantitative evidence of these cloud trends.**
- **62% said government regulation influences their adoption of public cloud resources**

Strategy

Smart power management/telemetry and renewable energy sourcing are expected to increase

Impacts to Future Procurements

Most sites consider procurement necessary for sustainability plans

- **87% of respondents said new equipment procurement will play a role in their sustainability plans**
  - 48% of those sites expect procuring this equipment will be a part of regularly scheduled procurement plans
  - 20% will expedite procurement plans for new sustainable equipment
  - 18% will delay procurement plans for sustainable solutions
- **37% of industry sites indicate that environmental sustainability/energy efficiency is the second most important factor in on-premises procurements (35% of total sites)**

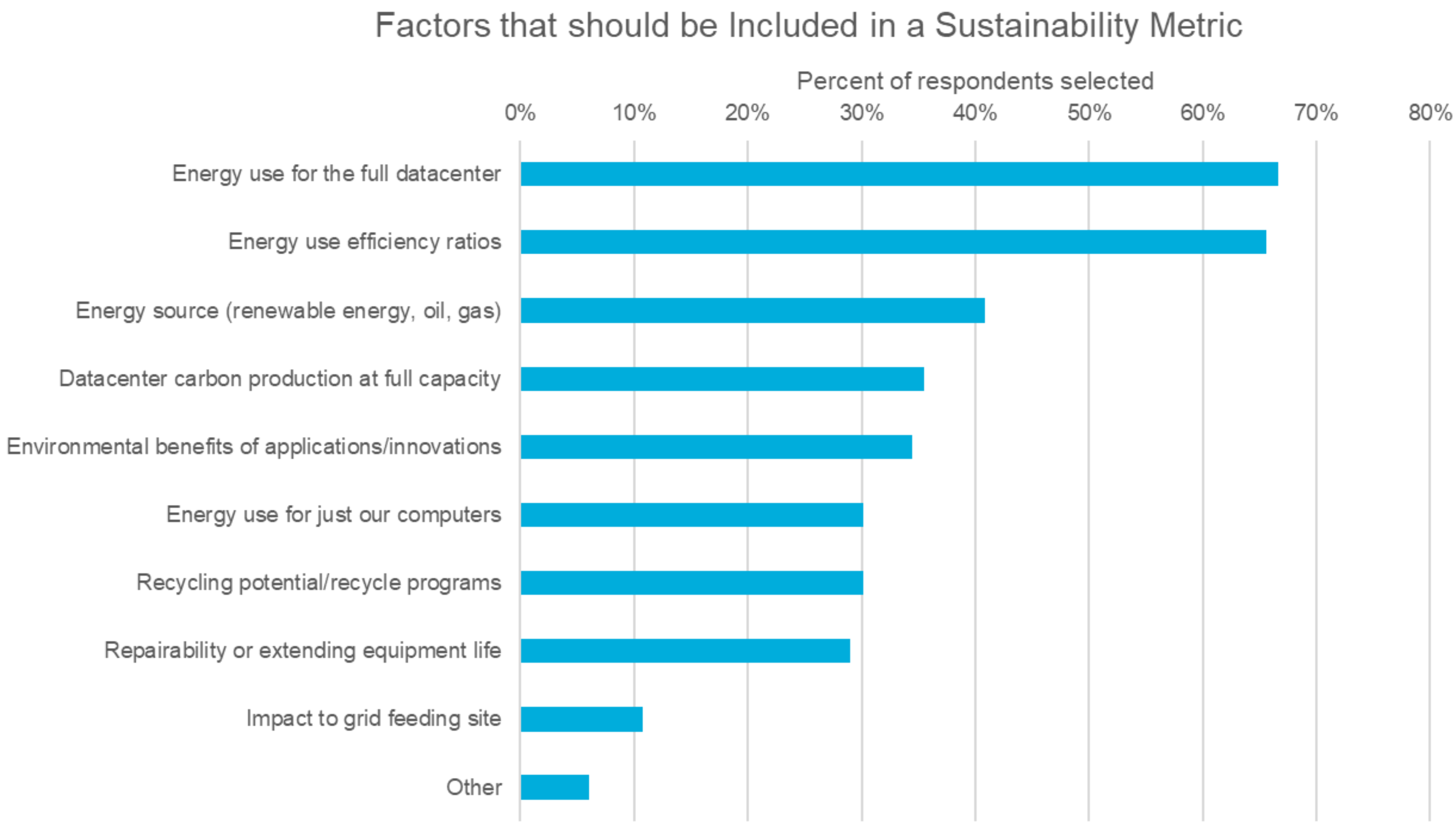
Sustainability Tracking

Telemetry is on the rise

- **Nearly half (49%) of data centers in this survey said they are currently able to measure their carbon footprint, energy use or environmental impact**
- **Smart power management/telemetry usage is expected to rise over time: 13% more sites aim to implement telemetry in the next 18 months**

A Future Metric for Sustainability

72% of respondents want 3 or more factors considered in a metric



Future Outlook

- **Users should continue to demand sustainability in their HPC systems**
- **Vendors should include telemetry products in their offerings to HPC sites**
- **Many HPC site managers are in a position of power to choose their energy sources (46%)**
  - 16% have off-grid/private energy supply
  - 30% on local grid, but with a say in energy source prioritization
- **Repeat this study in the next few years to watch as this sustainability in HPC progresses**

Detailed Study Results
(Excel sheet available with all data)

Survey Demographics

S2: 100% of respondents were required to have insight into organizations HPC environment

S1: Where is your company located?	
North America	59%
EMEA	25%
APJ	16%
Other	0%

n=93

Q1: In what sector is your organization (please select both the main sector and any applicable sub-sector)?	
Government	12%
Academia	10%
Industry	78%
None of the above	0%

n=93

S3: Please pick the one that most identifies you:	
High performance computing (HPC) data center manager or director or lead	42%
Cloud service provider (CSP) data center manager or director or lead	12%
High performance computing (HPC) data center operations professional	14%
Researcher, scientist, or engineer	32%
Sales, or marketing of vendor of a Cloud Service Provider (CSP)	0%
Employee of an Independent Software Vendor (ISV) (e.g. Ansys, Altair, etc.)	0%
None of the above	0%

n=93

Survey Demographics (continued)

Q2: Which of the following best describes the area of government you work for?	
Government lab or center (e.g., DOE, NASA, etc.)	45%
Defense, homeland security, military, etc.	0%
Private organization working at a government site or working for a government agency	36%
Other type of government organization, e.g., state & local	18%

n=11

Q3: Which of the following best describes the area of academia you work for?	
Nationally funded university	44%
Local or state university	44%
Other	11%

n=9

Q4: Which of the following best describes the industry you work for?	
Bio & Life sciences, pharmaceutical, biological, life sciences, healthcare, drug discovery, bioinformatics, genomics, et	18%
CAE, manufacturing, e.g., aerospace, automotive, consumer products, etc.	3%
Chemical engineering, chemical design, development, and production	1%
Mechanical design, e.g., CAD	0%
DCC, entertainment, digital content creation, 3D animation, advanced graphics, gaming, visualization, etc.	0%
Financial or economic modeling, pricing, risk management, modeling, business intelligence, etc.	14%
EDA, electronic design and analysis	3%
IT, computers, HPC systems, IT services, ISV, cloud provider, etc.	44%
Geosciences, energy, petroleum, oil and gas, seismic, reservoir simulation, alternative energy, power distribution, etc.	1%
Weather/climate	0%
Transportation and logistics, traffic management, pattern recognition, linear programming, etc.	4%
Retail, marketing, and related BI	7%
Telecommunications	0%
Other: (please specify:)	5%

n=73

Other responses: AdTech, Human Resources, Commercial Real Estate, Wholesale Trade

Survey Demographics (continued)

Q5: Which of the following best describes the category of your job title?	
HPC/data center service manager/director/lead	28%
HPC user/applications support staff	5%
HPC system manager	9%
Other HPC data center staff	1%
End user or researcher	9%
Manager/Senior manager of users/research teams	13%
Senior IT staff (e.g. CIO, managing director, VP, etc.)	34%
Procurement/contracts specialist	0%
Other IT staff	0%
Other	1%

n=93

Q6: Does your organization have a C-Level or SVP-level sustainability officer?	
Yes	61%
No	37%
Don't know	2%

n=93

HPC Systems

Q7: How many HPC server systems of all types (number of clusters, SMP systems, etc. (treat a cluster as one system) does your organization have?	
1	4%
2 to 5	33%
6 to 10	22%
11 to 15	5%
More than 15	35%

n=93

Q9: Based on overall runtime, approximately what percent of all your HPC workloads are run on external clouds TODAY?	
None	9%
>0% to 25%	27%
>25% to 50%	31%
>50% to 75%	20%
>75% to <100%	6%
100%	6%

n=93

Q8: What was the price of your single largest HPC/AI/HPDA system?	
Under $100,000	10%
$100,000 to less than $250,000	15%
$250,000 to less than $500,000	14%
$500,000 to less than $1 million	9%
$1 million to less than $5 million	15%
$5 million to less than $10 million	15%
$10 million to less than $20 million	2%
$20 million to less than $50 million	6%
$50 million to less than $100 million	8%
$100 million to less than $500 million	4%
More than $500 million	2%

n=93

Q10: In 2-3 sentences, please describe what sustainability in HPCs mean to you?

- **Highlights**
  - “Broadly, being able to provide a service over a long term period. Operationally operating a service that balances the needs of the users with constraints such as power, cooling, and other things that impact the university such as the environment”
  - “The energy used by HPC is sourced from green energy sources”
  - “Energy consumption, longevity of the cluster and ability to expand it over time with modular hardware”
  - “Reduce carbon footprint, redirect generated heat to other purposes, increase energy efficiency”
- **See appendix Q10 for all responses**

Power Consumption

Q11: What is the power capacity of your current data center?	
1 MW or less	9%
More than 1 MW to 5 MW	16%
More than 5 MW to 10 MW	12%
More than 10 MW to 25 MW	13%
More than 25 MW to 50 MW	9%
More than 50 MW to 100 MW	4%
More than 100 MW to 200 MW	9%
More than 200 MW to 300 MW	4%
More than 300 MW to 500 MW	4%
More than 500 MW	8%
Don't know /not sure	13%

n=93

Q12: What is your current utilization of available power in your current data center?	
5% or less	2%
More than 5% to 10%	4%
More than 10% to 25%	8%
More than 25 % to 50%	24%
More than 50% to 75%	37%
More than 75% to 90%	17%
More than 90% to 100%	2%
Don't know / not sure	6%

n=93

On-prem Procurement Priorities

Q13: Please select your top two most important priorities for your next HPC on-premises procurement	Most Important	Second Most Important
Performance	60%	18%
Price	16%	29%
Environmental sustainability	3%	10%
Energy efficiency	11%	25%
Positive brand reputation	2%	8%
Architecture (e.g., Accelerated compute, CPU type)	8%	11%
Other: Please specify	0%	0%

n=93

Reasons for Prioritizing Sustainability

Q14. Regardless of your current priorities for your next HPC on-premise procurement, please select your top two reasons for prioritizing sustainability in your HPC systems.	
Environmental, Social and Governance (ESG) goals	48%
Government policies/regulations	26%
Prohibitive power/energy costs	33%
Lack of access to more power	8%
Wanting to do more with less: Expand computing capabilities with lower power requirements	57%
Environmentally responsible brand reputation	20%
Other: Please specify	1%

n=93

Other Responses: N/A

Impacts of Energy Costs

Q15: Are rising energy costs impacting the level of investment (funding) available to you for your new HPC systems?	
No	45%
Yes	55%

n=93

Q17. How has the increased energy costs impacted operations within your HPC data center? Please select all that apply.	
Energy costs have not impacted my HPC data center	42%
Limited the capabilities of system	27%
Reduced operational hours	22%
Limited users' access to systems	14%
Deferred purchase of new systems	38%
Other (please specify)	2%

n=93

Other Responses: Tighter specification when it comes to computing power vs. energy use, In the US the increase energy cost has minimal impact to HPC

Q16: You indicated that rising costs are impacting the level of investment (funding) available for your new HPC systems. What has been the percent change in the investment (funding) level?	
5%	14%
8%	4%
10%	12%
12%	4%
14%	2%
15%	12%
16%	2%
20%	22%
25%	10%
30%	10%
32%	2%
40%	2%
47%	2%
50%	2%
100%	2%

n=51

Budget for Sustainability Goals

Q18: What percentage of your current site budget is a result of addressing sustainability goals and energy efficiency? (e.g., liquid cooling, more efficient componentry) (Please select the percent range that best fits)	
5% or less	19%
More than 5% to 10%	32%
More than 10% to 25%	29%
More than 25 % to 50%	12%
More than 50%	2%
Don't know / not sure	5%

n=93

Q19: How will your on-premises HPC budget be impacted by your sustainability initiatives? Please select only one.	
Sustainability goals will not impact my on-premises HPC budget.	40%
I will reduce my next on-premises purchase and use the saved money toward my sustainability initiatives.	31%
I will increase my next on-premises purchase budget and use the increased budget towards sustainability initiatives.	29%
Other (please specify)	0%

n=93

Budget for Sustainability Goals

Q19 Responses: I will reduce my next on-premises purchase and use the saved money toward my sustainability initiatives. **Q20: Approximately how much budget will be shifted from the on-premises to the cloud HPC budget?**	
Less than $100,000 USD	34%
100,000 USD to 250,000 USD	17%
250,000 USD to 500,000 USD	31%
500,000 USD to 1,000,000 USD	10%
1,000,000 USD to 2,000,000 USD	7%
More than 2,000,000 USD	0%

n=29

Q19 Responses: I will increase my next on-premises purchase budget and use the increased budget towards sustainability initiatives. **Q21: Approximately how much budget will be shifted from the on-premises to the cloud HPC budget?**	
Less than $100,000 USD	7%
100,000 USD to 250,000 USD	30%
250,000 USD to 500,000 USD	26%
500,000 USD to 1,000,000 USD	22%
1,000,000 USD to 2,000,000 USD	15%
More than 2,000,000 USD	0%

n=27

Energy Cost and Gov't Regulation

Q22: To what extent are rising energy costs influencing the following	Great Extent	Limited Extent	No extent	Unsure
Adoption of public cloud resources	33%	43%	18%	5%
Data center operations	23%	59%	15%	3%
Data center architecture	35%	39%	23%	3%

n=93

Q23: To what extent is government regulation influencing the following	Great Extent	Limited Extent	No extent	Unsure
Adoption of public cloud resources	29%	33%	32%	5%
Data center operations	23%	40%	35%	2%
Data center architecture	13%	44%	38%	5%

n=93

Priorities for Sustainability Goals

	Q24: Which of these do you consider to be the most important priorities in your sustainability goal? Please select up to two priorities.	Q25: Which of these priorities are you implementing today to reach your sustainability goals? Please select all that apply.	Q26: Which of these priorities are you planning on implementing in the next 18 months to reach your sustainability goals? Please select all that apply.
Efficient hardware configuration (Higher performance per watt)	56%	59%	49%
Optimized cooling and power distribution	42%	47%	39%
Smart power management (telemetry)	16%	27%	40%
Optimized workloads (identifying efficient workloads on-premises and in the cloud)	34%	47%	45%
Effective equipment retirement (e.g., take back, recycling, proper disposal)	14%	24%	27%
Extending equipment life	5%	26%	29%
Renewable energy sourcing	22%	20%	26%
Efficient code (e.g., language, compilers, tools, libraries)	6%	32%	30%
Other: Please specify	0%	0%	1%

n=93

Impacts to Procurement Timelines

Q27: Does sustainability affect the timeline of your future equipment procurement plans? Please select ONE response.	
Yes, a more sustainable solution is expediting our next procurement plan(s)	20%
Yes, a more sustainable solution procurement is delaying the timeline for our next procurement	18%
No, a more sustainable solution will happen as a part of our regularly scheduled procurement plan	48%
No, our sustainability goals do not involve new equipment procurement(s)	9%
No plans to pursue greater sustainability at our site	4%

n=93

New Sustainability Metric

Q28. If you were to create a sustainability metric, to compare site to site, data center to data center, what factors would a part of the algorithm? Please select all that apply.	
Energy use for just our computers	30%
Energy use for the full datacenter	67%
Energy use Other (please specify)	3%
Energy use efficiency ratios	66%
Energy source (renewable energy, oil, gas)	41%
Recycling potential/recycle programs	30%
Repairability or extending equipment life	29%
Impact to grid feeding site	11%
Environmental benefits of applications/innovations	34%
Datacenter carbon production at full capacity	35%
Other (please specify)	3%

n=93

Open-ended responses in Appendices Q29 and Q30

- **Q29: Any specific metric/unit for energy use?**
- **Q30: Which energy-to-efficiency ratios?**

Insight into Energy Source(s)

Q31: Do you have insight into your site's energy source(s)?	
No, our site is off grid/private energy supply	15%
Yes, dependent on local grid, but we have a say in energy source prioritization	30%
Yes, dependent on local area energy sources	34%
Don't know / unsure	18%
Other (please specify)	2%

n=93

Other Responses: Hydro, on major airport grid

Current Data Center Measurements

Q32: Do you measure the carbon footprint/ energy use/ environmental impact of your data center?	
No	51%
Yes	49%

n=93

Open-ended responses in Appendices Q33 and Q34

- **Q33: Please list the metrics that you use to measure the carbon footprint/ energy use/ environmental impact of your data center**
- **Q34: Please describe your insight/tracking tools and methodology you use to measure the carbon footprint/ energy use/ environmental impact of your data center**

Current Cloud Measurements

Q35: Do you measure the carbon footprint/ energy use/ environmental impact of your cloud?	
No, I do not use cloud	8%
No, I do not measure my cloud impact	43%
No, I would like to, but my CSP does not provide visibility for my usage.	37%
Yes	13%

n=93

Open-ended responses in Appendices Q36 and Q37

- **Q36: Please list the metrics you use to measure the carbon footprint/ energy use/ environmental impact of your cloud**
- **Q37: Please describe your tracking tools and methodology you use to measure the carbon footprint/ energy use/ environmental impact of your cloud**

Impact to Recruiting

Q38: Will sustainability practices impact your ability to recruit employees?	
No	75%
Yes	25%

n=93

Open-ended responses in Appendix Q39

- **Q39: Please describe how sustainability practices will impact your ability to recruit employees**

HYPERION RESEARCH

QUESTIONS?

Questions or comments are welcome.

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Appendices

Appendix Q10: In 2-3 sentences, please describe what sustainability in HPCs mean to you.

- Broadly, being able to provide a service over a long-term period. Operationally operating a service that balances the needs of the users with constraints such as power, cooling, and other things that impact the university such as the environment.
- Being able to continue to serve our customers, provide compute and memory to them so that they can run their jobs, do their experiments and lead the organization in generating revenue.
- Reduce energy consumption without sacrificing performance. Optimize code to reduce computations. Design the applications efficiently.
- The energy used by HPC is sourced from green energy sources.
- Make sure we meet the computational needs at the minimal environmental impact. Use the best energy-efficent hardware and optimise our software.
- Energy efficiency. Power consumption reduction. Environmental cost.
- reasonable total cost of ownership Cloud bursting net zero
- To me, sustainability in high-performance computing (HPC) means using computing resources and technologies in a way that meets the needs of the present without compromising the ability of future generations to meet their own needs.
- PUE with carbon footprint metrics.
- The computing infrastructure can support the increasing computational load economically, organically and smoothly.
- Smart power, CPU, and processing management, if not used then my cluster should not utilize these resources always all the time.

Appendix Q10 (Continued)

- The ability to best utilize compute resources in a manner that maximizes productivity (measured by some concrete metric directly related to results) and minimizes cost and environmental footprint (i.e., simulation time and dollar amount spent on compute)
- The consumption of computing resources in way that it has zero impact on environment. Broad concept that includes energy, ecosystem , pollution etc.
- HPC is energy intensive and supporting HPC systems by means of energy efficient, renewable energies with reduced carbon footprint is a sustainable solution for me.
- Lower carbon emission. Use of resources efficiently Proper planning of infrastructures to meet the growing demand while keeping cost efficient.
- Operating HPCs in an energy and power-efficient manner. Particularly, only operating them when being used and needed. Offsetting the carbon footprint for the energy consumed.
- Green energy. initiatives that improve the community and people's lives.
- In manufacturing, HPC and AI are being used for predictive and prescriptive maintenance, automation of product lifecycle management, and short design cycles.
- Energy consumption, longevity of the cluster and ability to expand it over time with modular hardware.
- Having the energy for the hpc systems coming from confirmed green energy sources, rather than buying carbon credits. Having high usage of our hpc stacks, so that the highest utilisation is achieved, this includes developing our works loads to be most energy efficient.

Appendix Q10 (Continued)

- The HPC system should have a decent power consumption efficiency. The infrastructure makes use of natural sources (water/air cooling).
- Reduce carbon footprint, redirect generated heat to other purposes, increase energy efficiency.
- Sustainability usually meant sustained output in terms of the number of floating point operations per second. However, sustainability in the context of HPC would mean efficient utilization of resources optimizing cost as well as impact on environment i.e., power.
- Energy efficiency, reusable waste heat generated by the data center, Lesser power consumption of the cloud data center.
- Sustainability in HPC means designing, implementing, and managing computing resources in a way that minimizes environmental impact, reduces energy consumption and promotes long-term viability. It typically is the trade-off between high computational demand.
- Create a system where power/performance is the key factor for decision.
- Energy efficiency. Cooling without harmful chemicals.
- Efficient and better utilization of HPC resources along with use for empowering sustainability projects using the same.
- Creating an optimized framework to reduce or conserve energy consumption for research experiments.
- Energy/space/cost/compute efficiently... Outcome benefit over resource consumption... Continued workforce preparation & readiness...
- Sustainability has traditionally referred to sustained output in terms of floating-point operations per second (FLOPS), a standard measure of computing performance.

Appendix Q10 (Continued)

- Opportunity to grow future businesses   Enabling brand awareness.
- Sustainability in HPCs means using these systems in a way that is environmentally responsible, socially ethical, and economically efficient. This involves optimizing energy efficiency, reducing waste and resource consumption, promoting social responsibility.
- We don't consider it at all.
- Sustainability in HPCs means to me that the HPC systems can operate efficiently and reliably with minimal environmental impact and resource consumption. It also means that the HPC applications can deliver meaningful and beneficial outcomes for society.
- Computing resources hosted in data centers that take steps to minimize environmental impact.
- 1. Lower TCO of maintenance and upgrade for the system,   and higher resource usage rate 2. Software compatibility without changing the code or the basic software, including compilers and libraries 3. Better user experiences and more efficiency.
- While we don't pay attention to this, I guess it's about efficiency in using resources.
- Resilience and efficiency
- HPC sustainability is about ensuring our clusters run on green power, and the carbon footprint associated with their manufacturing is offset.
- Energy efficiency, cost-to-performance value.
- Zero impact on the environment.

Appendix Q10 (Continued)

- General care of the environment and ensuring that the right decisions are made for future generations.
- Ensuring, where possible, to use the most energy-efficient options available, while still getting good value for money on compute power.
- Use only what is needed and not overprovision. This will help with sustainability and cost.
- We can achieve sustainability in HPCs by optimizing or selecting energy-efficient hardware and software algorithms to consume less energy. We should also try to recycle or repurpose the heat waste that is generated by HPC systems.
- The consumption of computational resources in the way it optimizes the usage and scales to the incremental needs as needed.
- Sustainability in high-performance computing means ensuring that the computational power and resources used for HPC are utilized in a way that minimizes their environmental impact, while also maintaining long-term economic viability and social responsibility.
- Politically popular talk. Energy efficiency is important as it is directly translated into operating costs. However, we are unwilling to pay even a penny more for a greener energy source. We purchase the cheapest energy possible.
- Energy efficiency of compute nodes, storage, supporting infrastructure (networking, facilities, cooling)
- Primarily a selling point, not a decision point. Not a real consideration compared to the ability to delivery, labor savings, etc.
- Using current and planned resources to support current and future HPC expansion to support current and future initiatives and planned system growth.

Appendix Q10 (Continued)

- **To have the necessary service running in the best way, while the pollution generated by them is compensated by certified actions.**
- **HPC can highly help to reduce carbon footprint and help the environment to keep it green.**
- **Balancing energy consumption and computational power.**
- **Leaving a carbon neutral footprint at data centers and using renewable energy.**
- **Overall effective power utilization, proper airflow management, using hydrogen fuel cell vs diesel generators for backup power, and renewable energy are examples of sustainability within High Performance Computing datacenter physical footprint...**
- **Allowing optimal scheduling of computing jobs minimizing time and utility burden. Minimizing stress on the environment.**
- **Optimizing for the architectural choices to consume the least energy/cooling costs in the data center. Sustainable energy sources and proximity to renewable sources while making a selection of the data center.**
- **Looking at the resources to make the compute nodes and external parts in terms of co2 and resources. To running the HPC in the most efficient way, particularly cooling. Operation looks at the use of efficient codes, using the HPC in offset to single compute.**
- **Sustainability in High-Performance Computing (HPC) refers to the practice of designing, building, and operating these powerful systems in a way that minimizes their environmental impact and energy consumption.**
- **Sustainability in HPC means finding the most common methods to measure the power efficiency of say, a data storage centre through its power utilisation efficiency (PUE) metric. Any PUE in excess of two, means that the HPC infra consumes twice as much power.**

Appendix Q10 (Continued)

- Floating-point operations per second (FLOPS) and efficient utilization of resources carbon footprint.
- Lowering carbon output to 0
- It means long-term, stable growth of HPC systems without limited by factors such as data center space, power and cooling constraints, system complexity and man power.
- Efficient utilisation of resources. Energy sustainability for an Organization. Increasing reusability
- Maximising power used by HPCs and offsetting carbon emissions.
- Energy efficient HPC systems.
- Reasonable attempts are made to minimize the environmental footprint generated by computing.
- Sustainability in HPC means: Long-lasting science discoveries and engineering innovation (e.g., fusion energy breakthrough in December 2023) via long-lasting scientific software.
- Efficiency factors. Renewable energy. Disposal procedure.
- Carbon offsets, using solar energy to power server farms.
- Heat, cooling, power efficiency.
- Taking into consideration the power and cooling requirements required by these systems.
- Extending the lifetime of old equipment and smart manufacturing methods.

Appendix Q10 (Continued)

- **Offsetting the carbon footprint of HPC computing which is very resource intensive. This could be done in a number of ways. For instance, it could be with green energy to power the HPC to planting trees to offset emissions.**
- **Meeting the needs of current generations without compromising the needs of future generations, while ensuring a balance between economic growth, care for the environment and social welfare.**
- **The ability to monitor and limit the amount of electricity, A/C, heat mgmt., and floor space required to host a server/cluster.**
- **Sustainability means developing a system that can continue to remain efficient as the demand scales.**
- **The priority today is on reducing power consumption (aka megawatts) and securing environmentally friendly power and hardware.**
- **Reduced carbon footprint that is achieved by leveraging energy-efficient cooling.**
- **The HPC center should have lower power budgets, increased reliability, future upgradeability, and resiliency towards failures. Improving on these factors reduces costs and decreases downtime and increases operational period.**
- **The ability to use alternative compute types that use less energy and therefore are more sustainable.**
- **Utilisation of latest technology such as liquid immersion to achieve higher performance with a PUE approaching 1.1.**
- **The goal is to improve the power utilization efficiency of clusters and overall datacenters. There are different methods of removing hot air or even reusing hot air.**
- **Minimising the environmental impact of our computing operations while striving to maximize efficiency and minimize waste.**

Appendix Q10 (Continued)

- Optimization of resources minimizing environmental impact as well as reducing energy costs. Efficient operations by optimizing queries.
- Being able to run workloads today and have software. And hardware currency in the future.
- Sustainability to me, means the efficient use of resources to organizationally meet the demands necessary for growth, in the context of environmental sustainability.
- Sustainable HPC computing concerns the consumption of computing resources in a way that means it has a net zero impact on the environment, a broad concept that includes energy, ecosystems, pollution and natural resources.
- Compute hardware, software, and facilities.
- Usage of computing resources in a way that means it has a net zero impact on the environment. Sustainability strategies in computing tend to focus on energy and the transition to clean energy.
- A power usage efficiency ratio near to 1, where the energy is produced by renewable sources.

Appendix Q29: Any specific metric/unit for energy use?

- BTU
- Carbon dioxide generation
- Carbon savings
- Comes down to price
- Compute/watt
- Cost per computing hour per cluster
- Cost per cpu/gpu
- Current meter
- Custom metric
- Energy cost per genome analyzed
- Estimated energy cost per hour
- Floating point operations per watt of energy (FLOPS/W)
- FLOPS
- FLOPS/MW
- FLOPS/watt
- Gigawhat hour
- Heat loss, heat of cpu
- Impact on local electrical infrastructure
- IO
- J
- Joule
- Kilo Watt Hour
- Kilowatt hours
- KVA
- KW
- KW
- KW/rack
- Kwh
- Kwh
- Kwh
- Kwh per simulation or study
- MG
- moderate at the moment
- MW
- MW
- MW
- MWh
- Number of compute cycles per watt
- Power load
- Power usage effectiveness (PUE)
- PUE
- PUE
- PUE or DCiE
- PUE/CUE
- Revenue per watt

Appendix Q29 (Continued)

- SDG7
- Sustainability index
- Transactions per carbon unit
- W/CPU
- Watts/Flops
- Watt per core hour
- Wattage per Terabyte
- Watts per byte transferred across a node in the HPC interconnect
- We do not use a specific metric.

Appendix Q30: Which energy-to-efficiency ratios

- A SEER of at least 13 and an EER of no less than 11.
- AC
- Algorithm
- Both renewable and nonrenewable energy to efficiency ratios.
- British Thermal Units
- BTU
- Btu per hr
- Compute
- Compute Energy/Total Energy (which might include cooling power, etc.)
- Compute per watt and cooling efficiency
- Cooling/consumed efficiency
- CPU
- Data analyzed
- EER 1.2
- EER not less than 11
- Electricity
- Energy efficiency
- Energy used in Data Centre
- FLOPS/MW
- Flops/w
- FLOPS/Watt
- Fossil vs solar
- Ful l
- It’s the ratio, or percentage, of useful output energy that you get from the input energy

Appendix Q30 (Continued)

- let's disclose in a call
- NA – Cloud-based
- Power usage effectiveness PUE
- PUE
- PUE
- PUE
- PUE
- PUE less than 1.2
- system output in BTU/hr
- TFLOPS/w
- TFLOPS/W
- Total energy to performance
- Total usage of HPC compared to workload consumption
- Under current discussions
- Usage ratio of computing resources and the energy cost
- WATT
- Watt to single HPC task
- Watt/production
- Watts used my supercomputing platform as a whole TO cumulative application node-hours

- 0.75
- 0.7
- 0.85
- 1
- 1.2
- 10
- 13
- 2.0
- 25
- 50
- 50 to 1

Appendix Q33: Please list eh metrics that you use to measure the carbon footprint/ energy use/ environmental impact of your data center

- ASHRAE Standard 90.1-2007
- Average power consumption per operating hour per equipment
- Carbon Dioxide Equivalent
- Carbon emission percentage
- Carbon usage effectiveness - Water usage effectiveness - Data center infrastructure efficiency - Green energy Coefficient - Energy reuse factor - Grid utilization factor
- Cost and energy efficiency usage
- CUE
- CUE and PUE
- Daily and monthly energy consumption. This is further broken down into cooling & rack use.
- Dividing the sum of all owned constituent greenhouse gas emissions by the total value invested in the index in millions of U.S. dollars.
- Electric efficiency cooling efficiency renewable usage recyclability of equipment
- Energy use index
- FLOPS
- For total CO2 emissions total energy usage: how much time system was in ideal state bs performance vs bandwidth
- Heat metering, power metering
- I am not sure of the exact formula (software does it for us) but it is something like amount of power usage per sq foot per data center

Appendix Q33 (Continued)

- I/O
- Key metrics: - total MW used per year for the data center. - watt per flop - watt per clock cycle   - watt per byte transferred within each node (e.g., from CPU to GPU)   The green500 HPC benchmarks are the vehicle to measure energy impact for a pa
- kgCO2e
- KVA consumed in total per DC
- Kw/hours, Tons of CO2, water consumption, ratio of sustainable electrical power
- Let's disclose in a call
- Multiplying unit of business operation with operation-specific emission factor
- N/A
- N/A
- Not sure
- Nothing to report
- Power Usage Effectiveness (PUE): A widely used metric that compares the total power consumption of a data center to the power consumption of its IT equipment. Lower PUE values indicate greater energy efficiency. Renewable Energy Usage: The percentage of
- Power Usage Effectiveness. Carbon Usage Effectiveness.
- Share of renewables (REF/ OEF)   Power Usage Effectiveness (PUE) / Total Energy Usage Effectiveness (TUE)
- Source of power, lil, natural gas, oil; dollars per megawatt, solar utilization for power, percentage of each.
- Sum up the total energy used by DC. Subtract REC. calculate CO2 emissions. See if any carbon offsets need to be deducted
- The metric is calculated by dividing carbon emission (CO2eq) by total energy use in kilowatt-hours (kWh).
- This is classified.

Appendix Q33 (Continued)

- Tons of CO_2 generated
- Total carbon footprint as Scope 1 and 3
- Total carbon production
- Unsure
- Upgrading to new equipment, reusing existing equipment that is energy efficient, and renewable energy are metrics we use…
- Water usage Energy usage   Usage efficiency as resource utilization Waste in Kg
- Watt consumption
- We do analyze the power usage and generation from the local utility for corporate reporting standards. Contraction or equipment acquisition costs are not factored in
- We look into carbon usage effectiveness.
- We measure carbon emissions in megatons
- We utilize SAP SE for these measurements.
- Weighted Average Carbon Intensity, Total Carbon Emissions, Carbon Footprint

Appendix Q34: Pleas describe your insight/tracking tools and methodology you use to measure the carbon footprint/ energy use/ environmental impact of your data center

- A tool called Aquicore
- Audits Power source
- Based on reports from energy producers and purchase tracking
- Classified
- CO2e
- Cost analyzer, compute optimizer
- Dashboards
- Energy Management Systems (EMS): These systems monitor, control, and optimize the energy consumption of a data center. EMS can track energy usage patterns, identify inefficiencies, and provide real-time data on power consumption and PUE. Building Managem
- Equipment age and energy rating we pay close attention to, for example, we have reduced our physical footprint by nearly 50% just by refreshing aging equipment while exponentially increasing our compute and storage capacity resulting in lower power con
- FLOPS
- From consulting of BCG, SAP, Schneider Electric,
- Grid and primary director of data synapse

Appendix Q34 (Continued)

- Handmade ui built on a bespoke set of BI tables
- How many tons of carbon dioxide are emitted per year
- https://www.energystar.gov/buildings/tools-and-resources/energy-tracking-tool
- Hybrid methodology including activity-based and spend-based
- I do not have this information
- I don't know.
- In-house energy grid and cooling monitoring system. Provides granular usage per rack, HPC vs non-hpc. Cooling consumption, etc.
- I/O
- KVA used per Data center
- Let's disclose in a call
- Monitoring software and manual data entry
- N/A
- Power monitoring and usage
- Power consumed by the HPC center is used to measure the environmental impact.
- Power consumption per data analyzed
- PowerBI, ECMS, BMS
- Rack PDUs, floor PDUs, branch circuits, and uninterruptible power supplies
- Raise temperature and humidity.   Green Globes LEED BREEAM
- Ratings on equipment
- SAP SE
- Thermal modeling of data center floor, continuous monitoring and control

Appendix Q34 (Continued)

- Through the US Department of Energy’s Exascale Computing Project, there are two pertinent tools being developed: one is a tool called Variorium and the other is called Lightweight Data Monitoring System. Lightweight Data monitoring System provides re
- Tools provider by data center hoster monitoring cooling, electrical consumption for each rack, temperature of each room, ratio CPU usage vs electric consumption, age of physical assets.
- Updapt, Sphera Scope 3
- Utility report
- We have a custom program that we wrote that computes this.
- We look into metrics generated from power management telemetry and intelligent rack PDU systems, as well as data from building management systems. Lastly, we collect data from compute virtualization, network, and database management layer.
- We meter and monitor the usage of the datacenter consumption
- We use a vendor tool by SE
- We use carbon footprint software to help gather data and calculate our carbon footprint to report to stakeholders. Our goal is to reduce our company's carbon emissions and move toward a net zero/carbon-neutral target.
- We use Inhabbit software
- We use Sunbird DCIM to monitor energy usage of our infra. We prefer using the activity-based approach when it comes to measure carbon footprint.
- We use the hypercloud providers tools, but are moving towards 3rd party finops tools and defining our own metric for carbon production/savings to align with a government driven sustainability objective.
- We use various tools software’s to measure carbon emissions and footprint

Appendix Q36: Please list the metrics you use to measure the carbon footprint/ energy use/ environmental impact of your cloud.

- Carbon Dioxide Equivalent
- Carbon per hour of server runtime
- Cost breakdown by cost allocation tag
- Electricity consumed per month
- Energy efficiency
- Estimated energy use based on CPU cycles, time & space complexity of algorithms, number of concurrent users, incoming requests, etc.
- PUE and CUE utilizing advanced ECMS monitoring
- Ratio between reserved infrastructure resources and real usage. Electrical consumption of each node, each AZ, and each region.
- Total carbon footprint (Scope 3)
- Total carbon production
- total energy usage, cost, performance
- usage data and watt-hours

Appendix Q37: Please describe your tracking tools and methodology you use to measure the carbon footprint/ energy use/ environmental impact of your cloud

- Cloud Carbon Footprint
- cost breakdown provided by cloud service provider
- Datasynapse
- ECMS
- Homemade tooling based on monitoring logs, and inventory.
- Log data from cloud provider
- Microsoft Azure platform
- Nagios, Grafana
- Report from energy producer and invoice tracker
- SAP
- Updapt, Sphera Scope 3
- Use hypercloud provided tools, but are moving towards using 3rd party finops tools to surface impact and allow comparison between hypercloud providers

Appendix Q39: Please describe how sustainability practices will impact your ability to recruit employees

- Awareness and ability to contribute
- Brand recognition
- Depending on set policies recruitment activities and agencies engaged will change.
- Employees are attracted to companies that focus on sustainability as part of their business strategy because it gives meaning to the work they do.
- Employees want to be a part of organizations with sustainably and responsible practices
- FinOps, frugal architecture, devsecops
- Getting the right skill sets to maintain and extend current hardware
- Green HR encompasses HR policies that help protect and preserve natural resources. Examples of these policies include preserving knowledge assets, minimizing paperwork, and creating awareness of eco-friendly practices. These things help organizations oper
- Hard to find people who appreciate sustainability practices.
- It impacts budget
- it will be a positive story we can tell
- lack of knowledge and awareness.
- let's disclose this in a call
- MORE HPC Engineers will be hired
- Most businesses today care about sustainability because of its relevance to costs and competition. A non-sustainable company will not be able to compete with a comparable sustainable business.
- shortage of resources with awareness, lack of awareness, knowledge base

Appendix Q39 (Continued)

- Simply put: Many people are naturally drawn to energy efficiency because it implies responsible technology development. This creates a positive impression and branding of our organization, including the trust that we will be responsible in other ways as well.
- The location of workforce restricts recruitment
- the technical skills like programming language, compiler, and library affected by the architecture of the HPC are the key point when interviewing the candidates.
- They need to appreciate and be aware of our vision and goals
- This guides the core mission of our organization and the communities where we operate. It directly aligns with interests of our prospective employees living in the same communities.
- Those who have similar experience
- We prefer to recruit employees with sustainability mindset and skills. Their habits like shutdown unused servers, using new tech to save power, etc, can actually save cost for company.