Understanding Data Centre IT Efficiency – The Hidden Power Source

Rich Kenny

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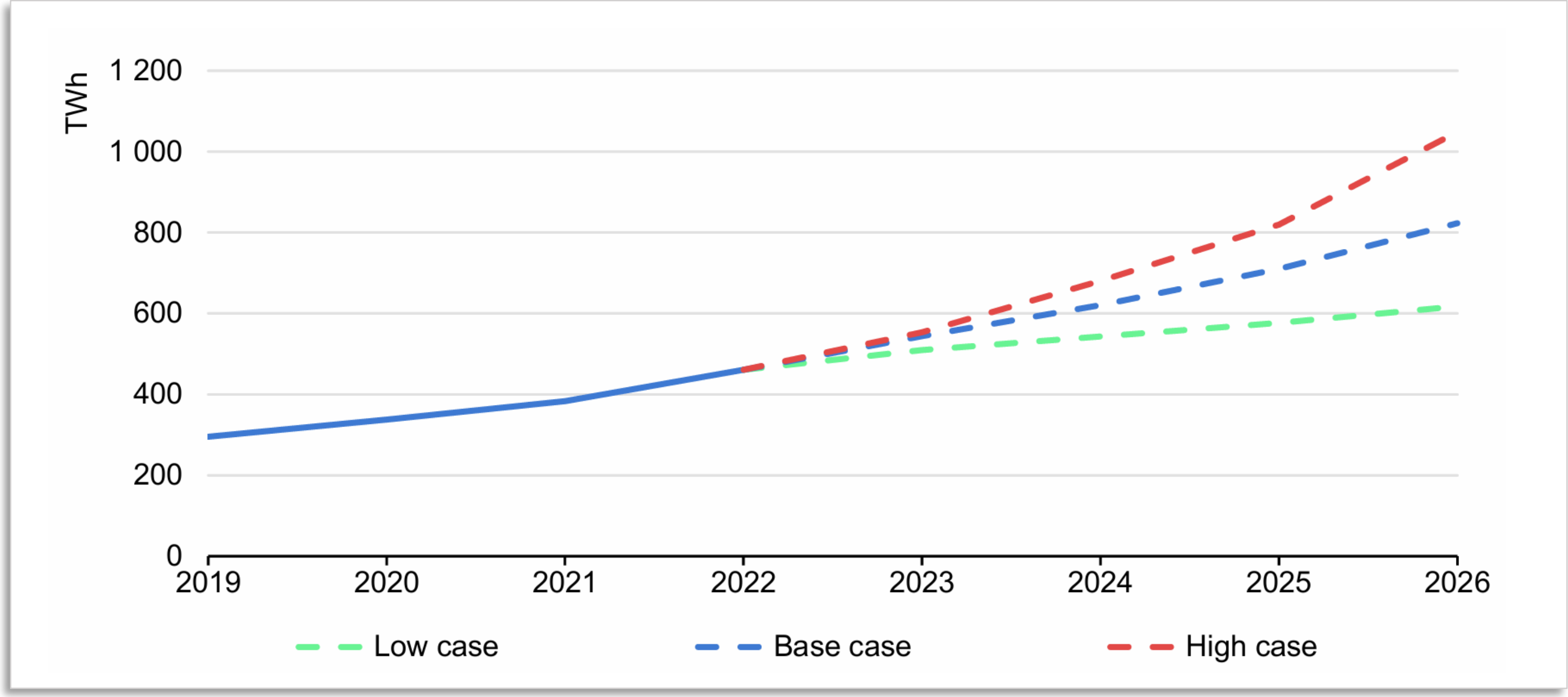
Energy Demand

International Energy Agency

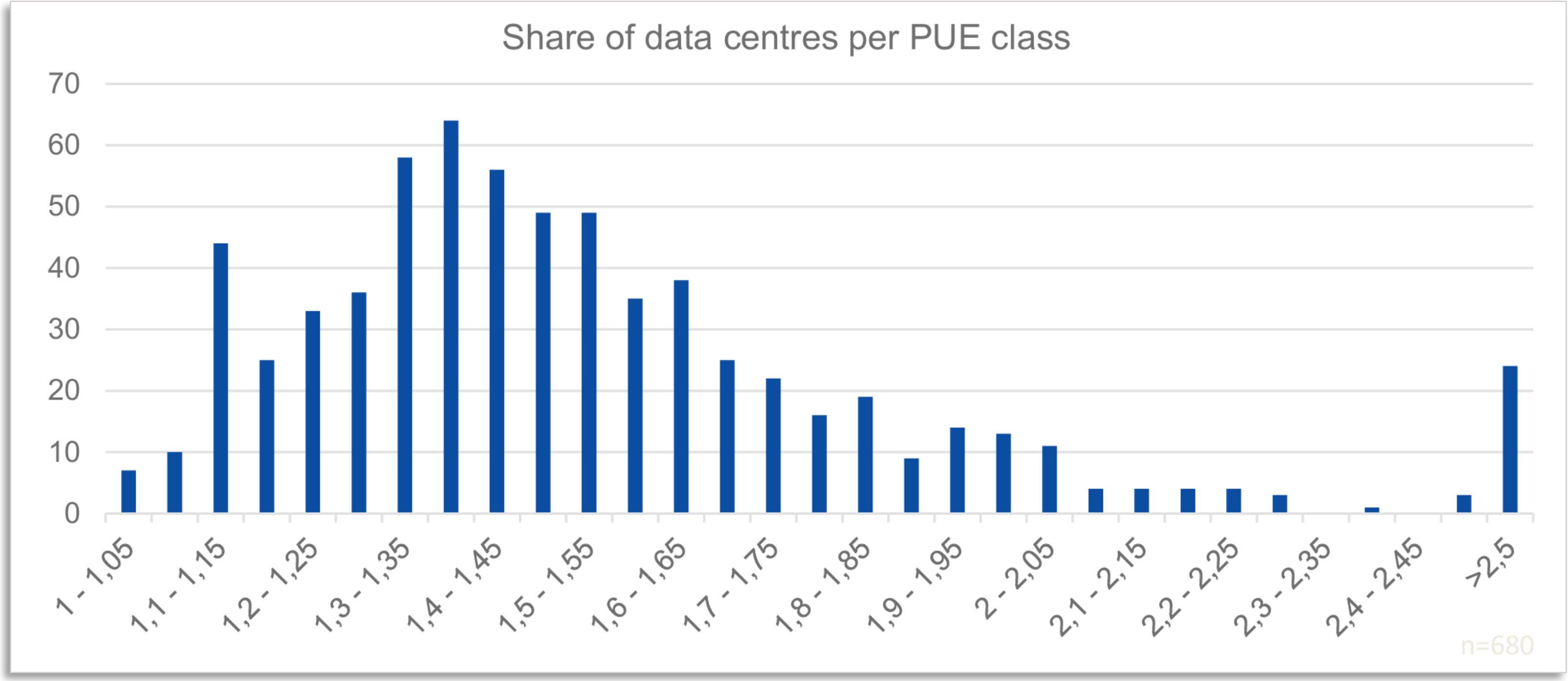
Datacenters are globally consuming an estimated 460 terawatt-hours (TWh) in 2022.

Datacenters total electricity consumption could reach more than 1.000 TWh in 2026.

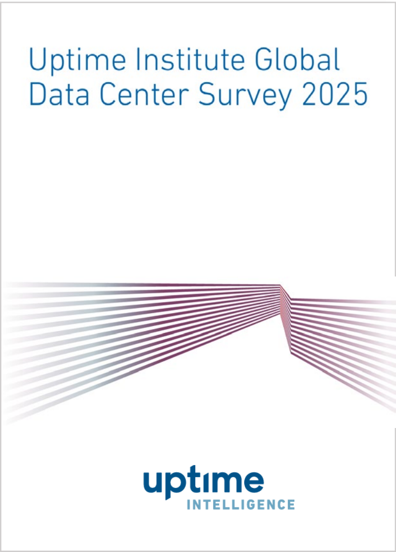


PUE - Efficiency in Data Centres

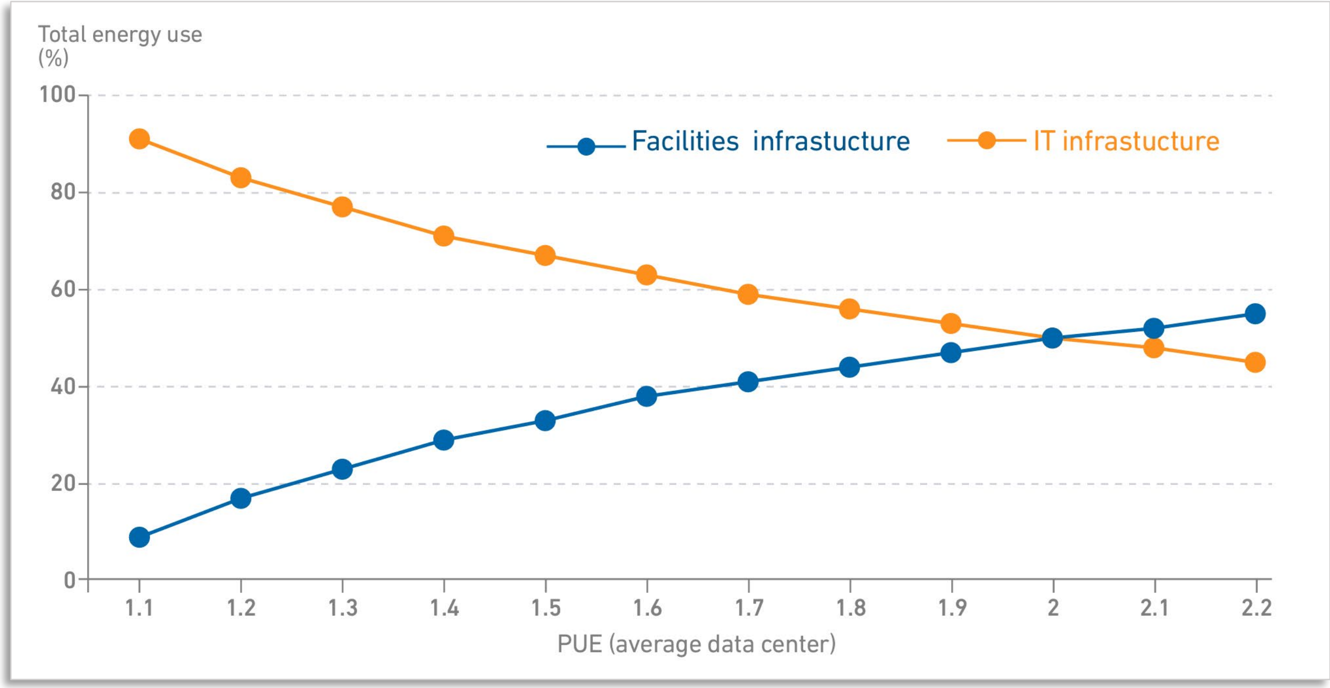
Power usage effectiveness (PUE) is the most used KPI for data centres. But it shouldn't be!



IT Power use in Data Centres



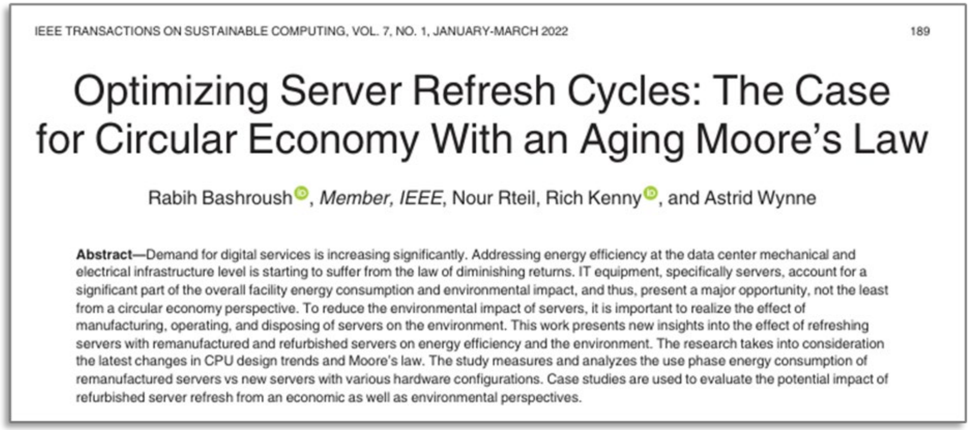
PUE is defined as the ratio of the overall annual energy consumption of the data centre facility, to the annual IT equipment energy consumption.



At a PUE of 1.1, IT is responsible for 90% of total Energy consumption of a Data Centre.

IT Efficiency in Data Centres

Interact studies IT hardware in data centres. Our research has been funded by the UK Research Institute and Innovate UK and published in academic journals.

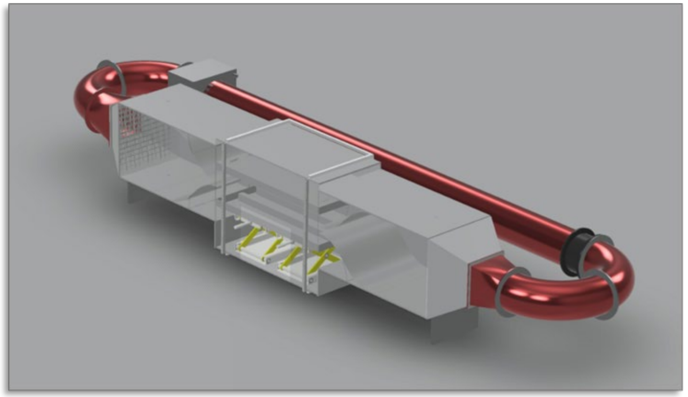


IEEE TRANSACTIONS ON SUSTAINABLE COMPUTING, VOL. 7, NO. 1, JANUARY-MARCH 2022 189

Optimizing Server Refresh Cycles: The Case for Circular Economy With an Aging Moore's Law

Rabih Bashroush, *Member, IEEE*, Nour Rteil, Rich Kenny, and Astrid Wynne

Abstract—Demand for digital services is increasing significantly. Addressing energy efficiency at the data center mechanical and electrical infrastructure level is starting to suffer from the law of diminishing returns. IT equipment, specifically servers, account for a significant part of the overall facility energy consumption and environmental impact, and thus, present a major opportunity, not the least from a circular economy perspective. To reduce the environmental impact of servers, it is important to realize the effect of manufacturing, operating, and disposing of servers on the environment. This work presents new insights into the effect of refreshing servers with remanufactured and refurbished servers on energy efficiency and the environment. The research takes into consideration the latest changes in CPU design trends and Moore's law. The study measures and analyzes the use phase energy consumption of remanufactured servers vs new servers with various hardware configurations. Case studies are used to evaluate the potential impact of refurbished server refresh from an economic as well as environmental perspectives.



We have tested servers in our lab for 8 years and created the world's largest database on server performance.

IT Efficiency in Data Centres

As servers are the highest energy users in the IT stack, there are two important server metrics to consider:

ITEEsv - IT Equipment Energy Efficiency for Servers

ITEEsv quantifies the energy efficiency of servers. A higher ITEEsv score indicates greater processing capacity per unit of electric power, meaning the servers operate more efficiently.

ITEUsv - IT Equipment Utilization for Servers

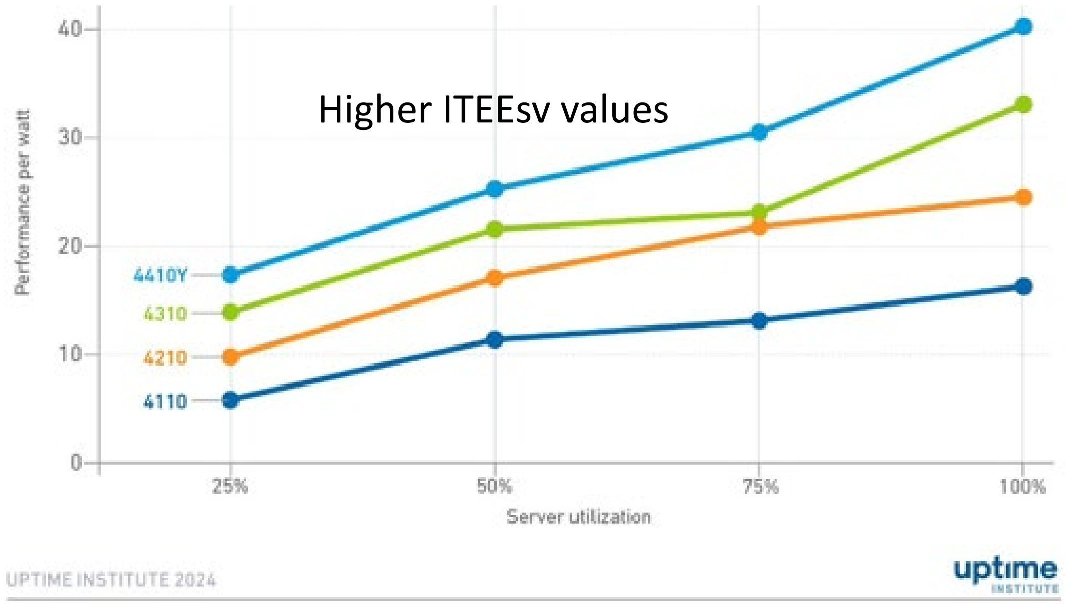
ITEUsv specifies the average CPU utilisation of servers in a data centre. Higher utilization means the servers perform more work, improving overall productivity.

IT Efficiency – CPU over time

- ITEEsv (ISO/IEC 30134-4) sets the grade
  - SSJ_ops per watt (SERT® Worklet)
  - A more efficient server has a higher ITEEsv value

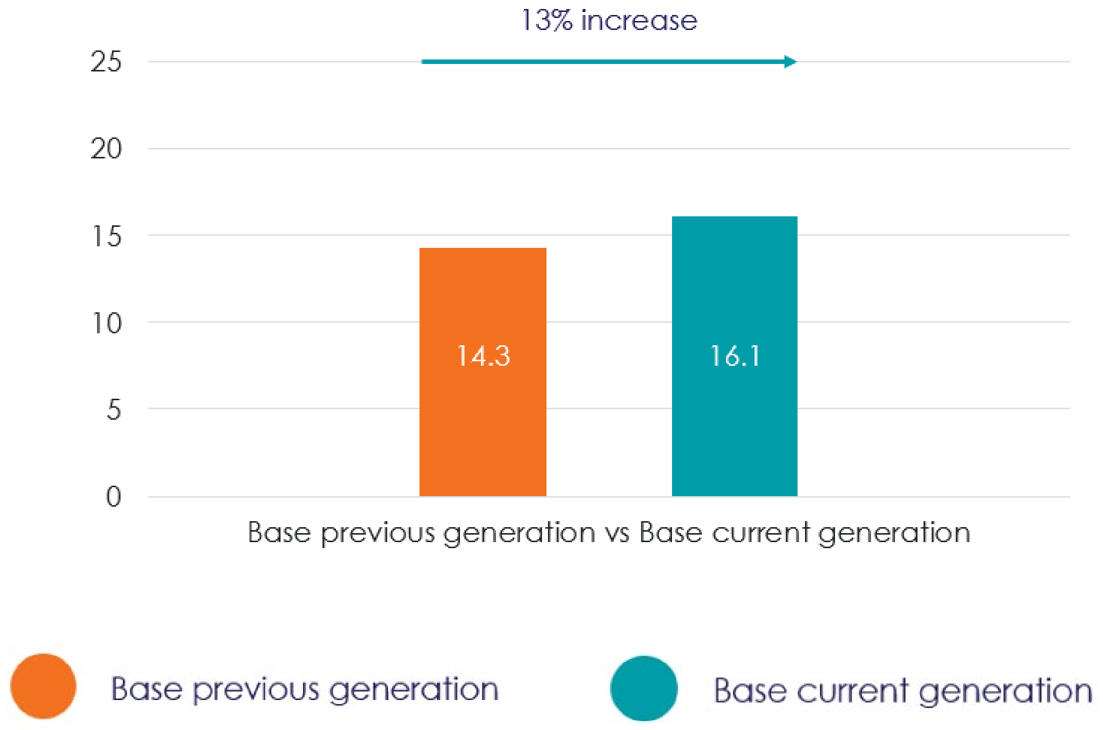
- Every refresh or decommissioning should consolidate equipment
  - Replacement server should have a higher ITEEsv than the original server
  - Quantity of IT equipment should be reduced

ITEEsv improves with increased utilization and higher CPU tech generation

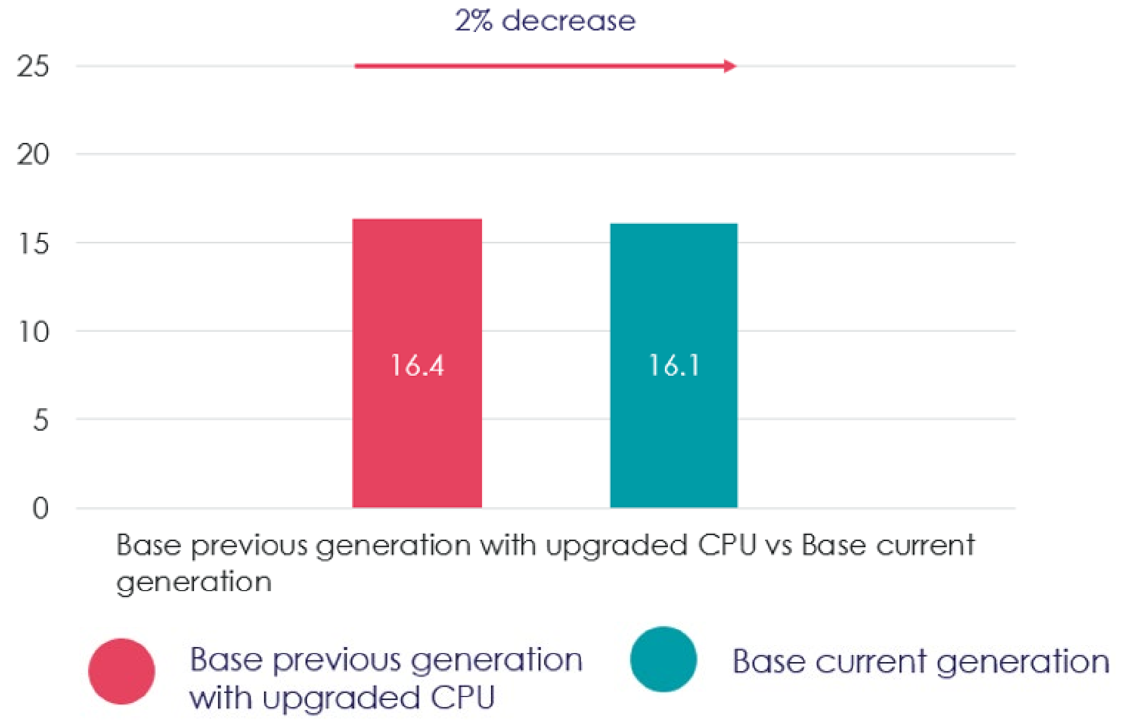


Energy Efficiency – Configuration is King

Age is less important than configuration
Latest generation server configuration – 13% more efficient.
Energy Efficiency Core-for-Core isn't transformational – Correct configuration is!



Upgrade N-1 CPU: Now current generation is less energy efficient



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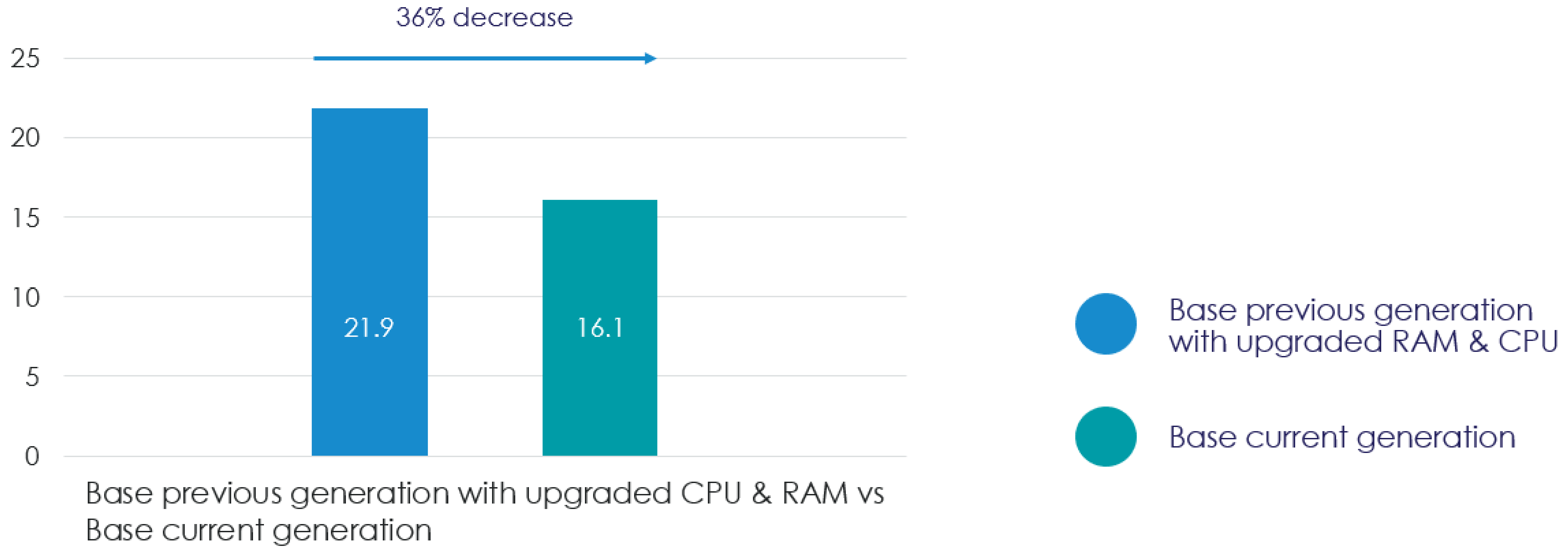
Energy Efficiency – Configuration is King

Upgrade N-1 CPU + RAM – Now Current Gen is considerably less energy efficient



ITEEsv

Research by Interact examines ITEEsv down to server configuration level.

It allowes us to grade each unique server, and identify:

- Best & underperforming servers
- Candidates for upgrade
- High energy users
- Suboptimal configurations

ITEEsv Score

SSJ ops per watt

A+	14.000
A	12.000
B	9.000
C	7.200
D	6.000
E	4.700
F	3.000

Performance Strategies

Understanding the energy effectiveness and max capacity of servers enables specific strategies for server estates:

Grade A Servers

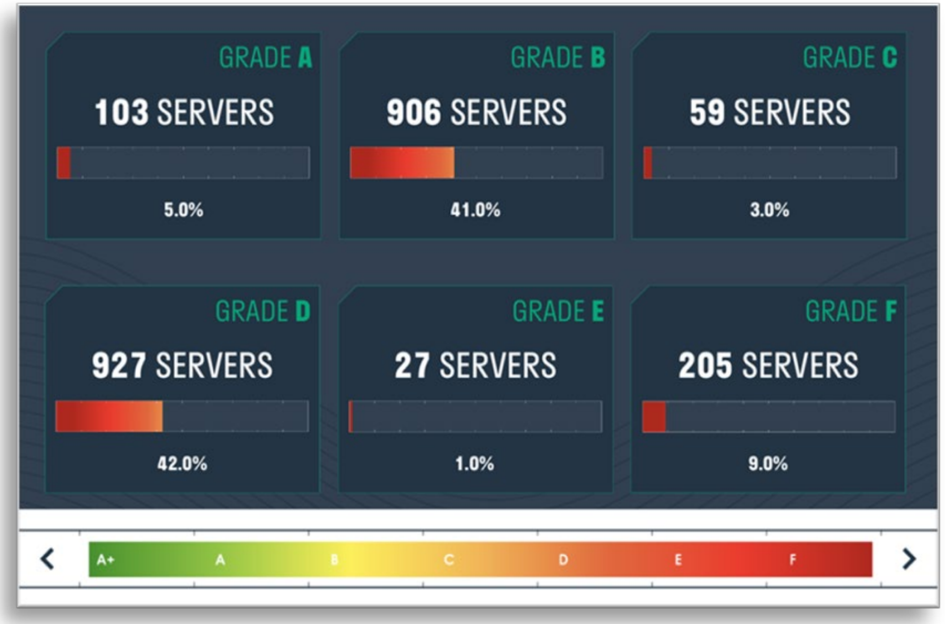
Increase utilization and explore longer product life

Grade B-C Servers

Identify upgrade options and reduce operational costs

Grade D-E-F Servers

Plan optimal consolidation and decommissioning strategies



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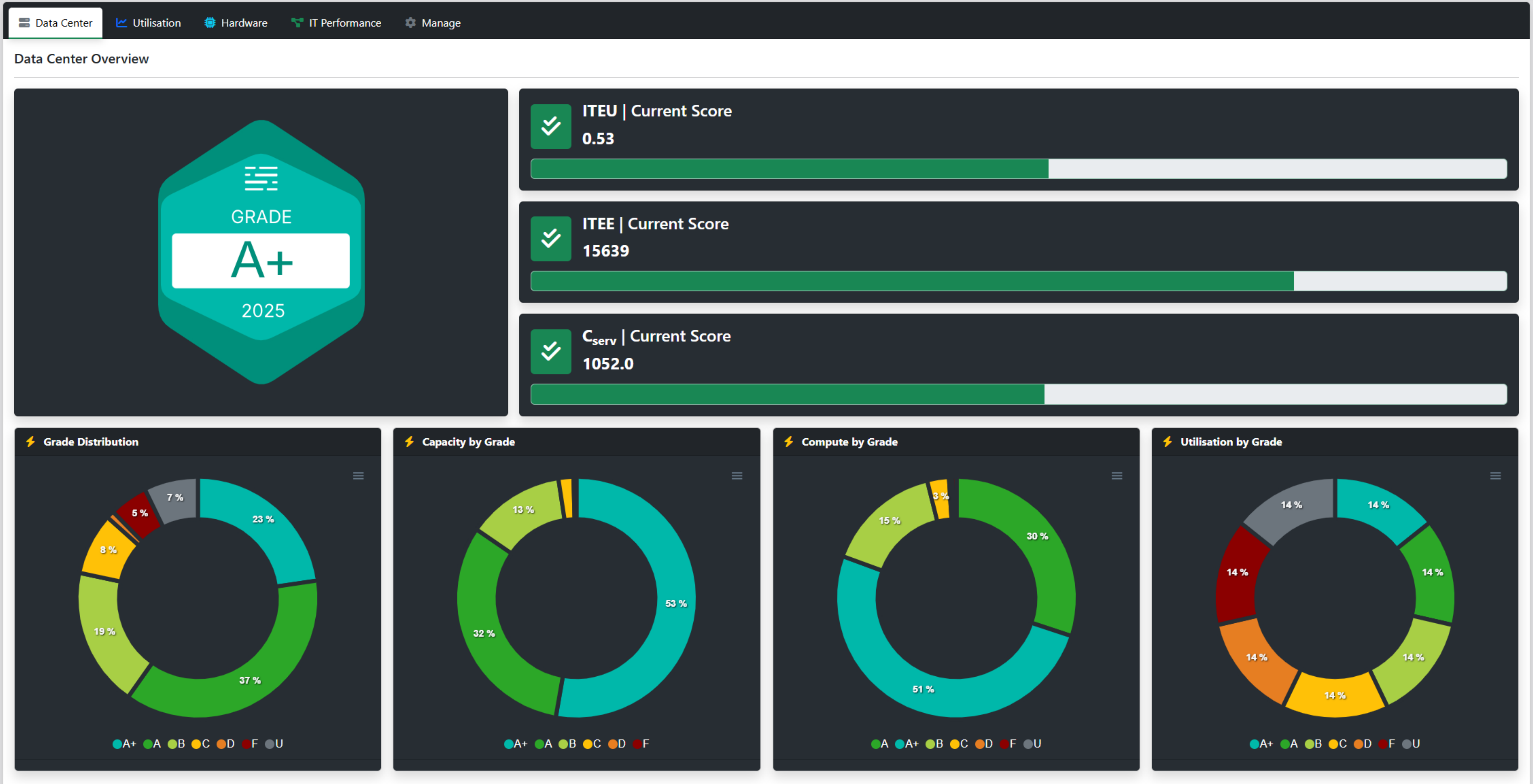
Displaying Performance - Tools



Data Center
Utilisation
Hardware
IT Performance
Manage
Data Center Overview
GRADE
A+
2025
ITEU | Current Score
0.53
ITEE | Current Score
15639
C_{serv} | Current Score
1052.0
Grade Distribution
23 %
37 %
19 %
8 %
5 %
7 %
A+ A B C D F U
Capacity by Grade
53 %
32 %
13 %
A+ A B C D F
Compute by Grade
30 %
51 %
15 %
3 %
A A+ B C D F U
Utilisation by Grade
14 %
14 %
14 %
14 %
14 %
14 %
14 %
A+ A B C D F U

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IT Performance Overview

ITEE | Current
15639

C_{serv} | Current
1052.0

Configurations
22

Efficiency

Highest Specification	Count
Chassis: HPE ProLiant DL360 Gen 10 **CPU:** 2 x Intel Xeon processor Platinum 8276L **Memory:** 1024	6

Lowest Specification	Count
Chassis: Hewlett Packard Enterprise ProLiant DL380 G5 **CPU:** Intel Xeon E5430 CPU @ 2.66GHz **Memory:** 8	2

Performance

Highest Specification	Count
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Lowest Specification	Count
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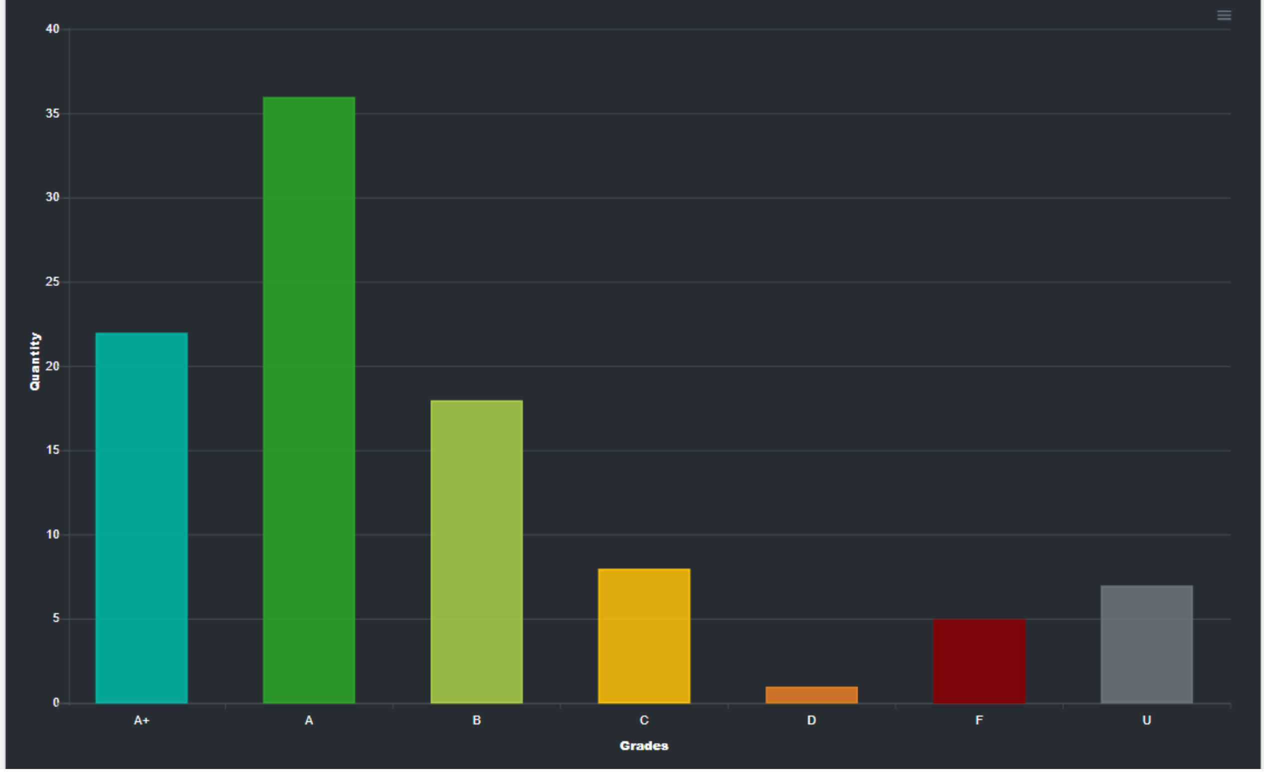
ITEEsv History

Grade Counts



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Opportunities for Circularity

IT Performance over time

- Identical Performance in refurbished and new IT equipment – Multiple IEEE journals and 100's of real-life case studies
- RIC backed up that mechanical and electrical parts don't wear the same
- The latest generation is not optimum in all use phases - Overprovisioning
- Cost and energy analysis proves this over time
- Huge environmental benefits of refurbishment and 2nd life

Extend product life where appropriate - What is Circularity?

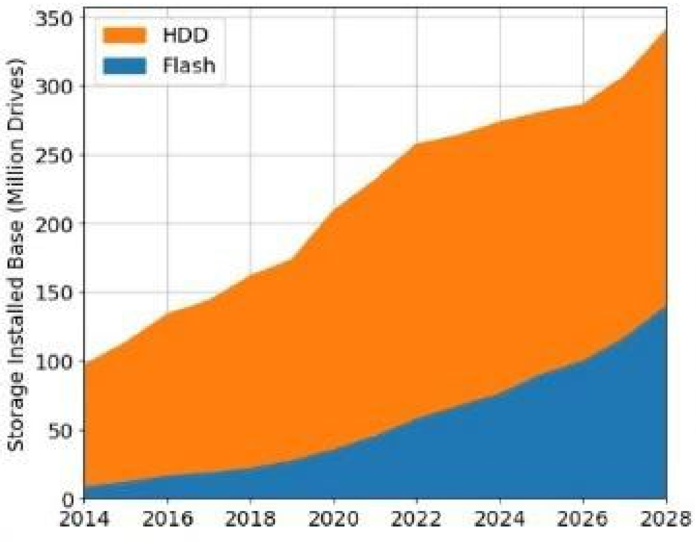
Understanding Product Lifecycle Management

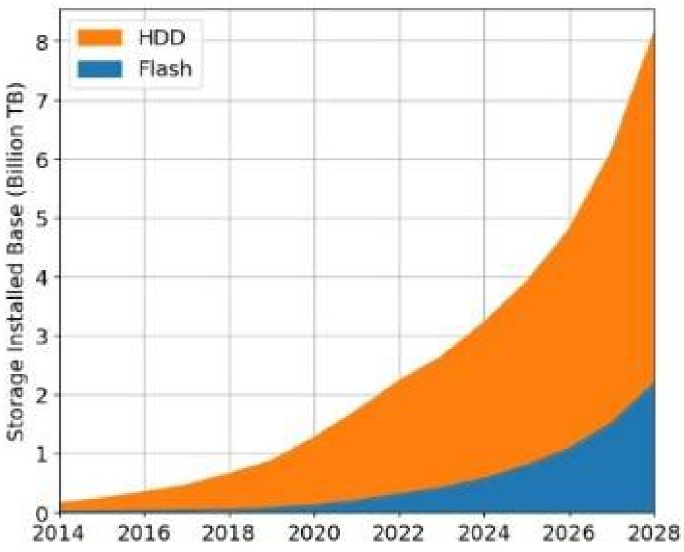
Re-use is the second-best path of return. Second only to absolute reductions.

Recycling and Recovery of materials is very important but a lower value proposition that the above

Disposal – Waste as energy and landfill

The Opportunity in storage – The demand gap



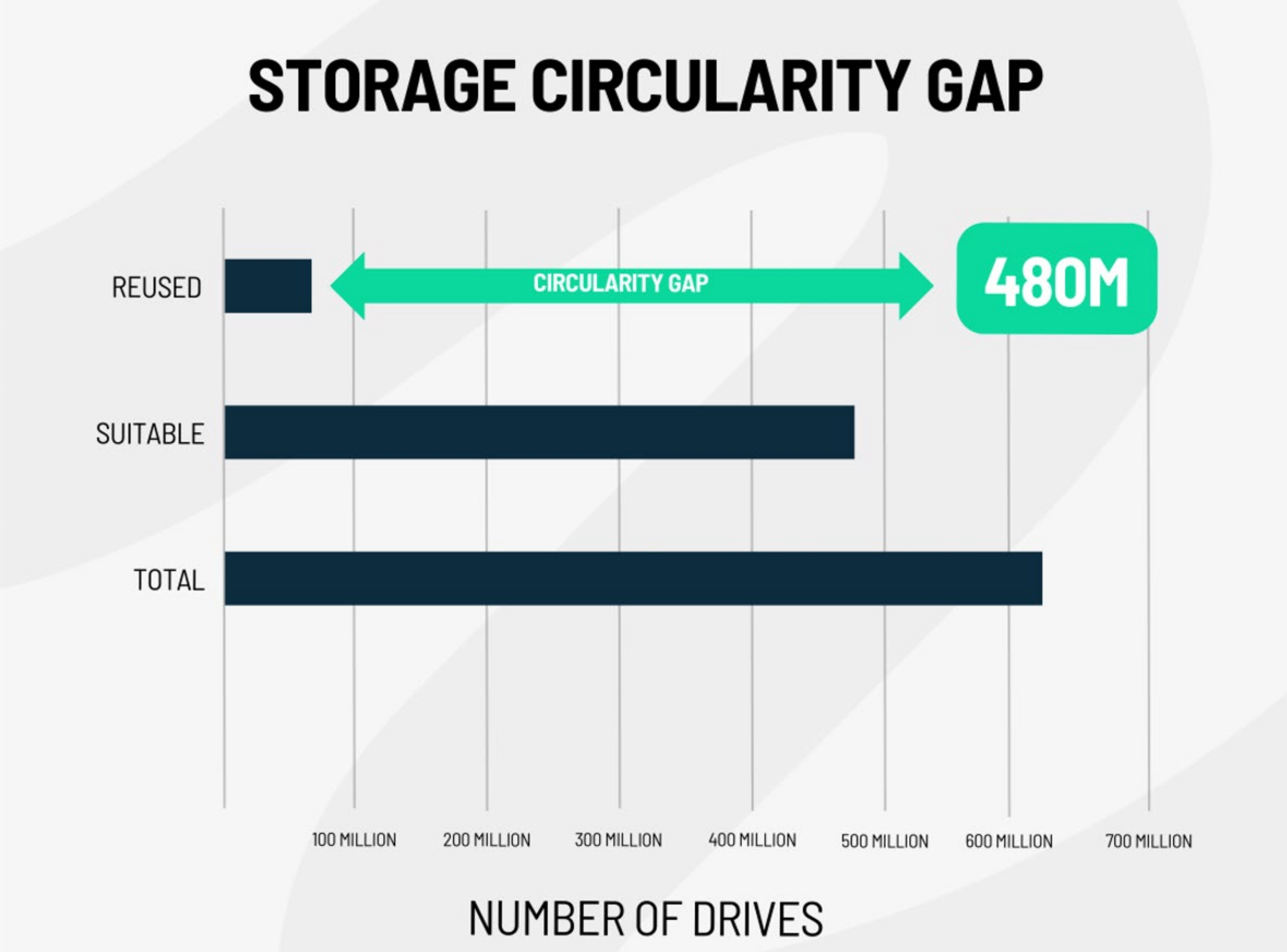


Enterprise storage projected to >40ZB by 2035

Installed base of storage devices in drive units (left) and TB capacity (right) in USA data centres

from the 2024 United States Data Center Energy Usage Report

The Opportunity – Storage 2020-2027 Part 1



Over 600 million drives produced in 2020.

Research published in European Journal of Engineering and Computer Science (EJECE 2024) by Interact, Cedar and Circular Drive Initiative.

Year-long drive erasure and diagnostics research carried out of over 117,000 individual drives in 2023/24.

87% of drives (HDD, SSD and NVMe) suitable for reuse based on health and reliability measures.

Re-use rate for storage circa 10%

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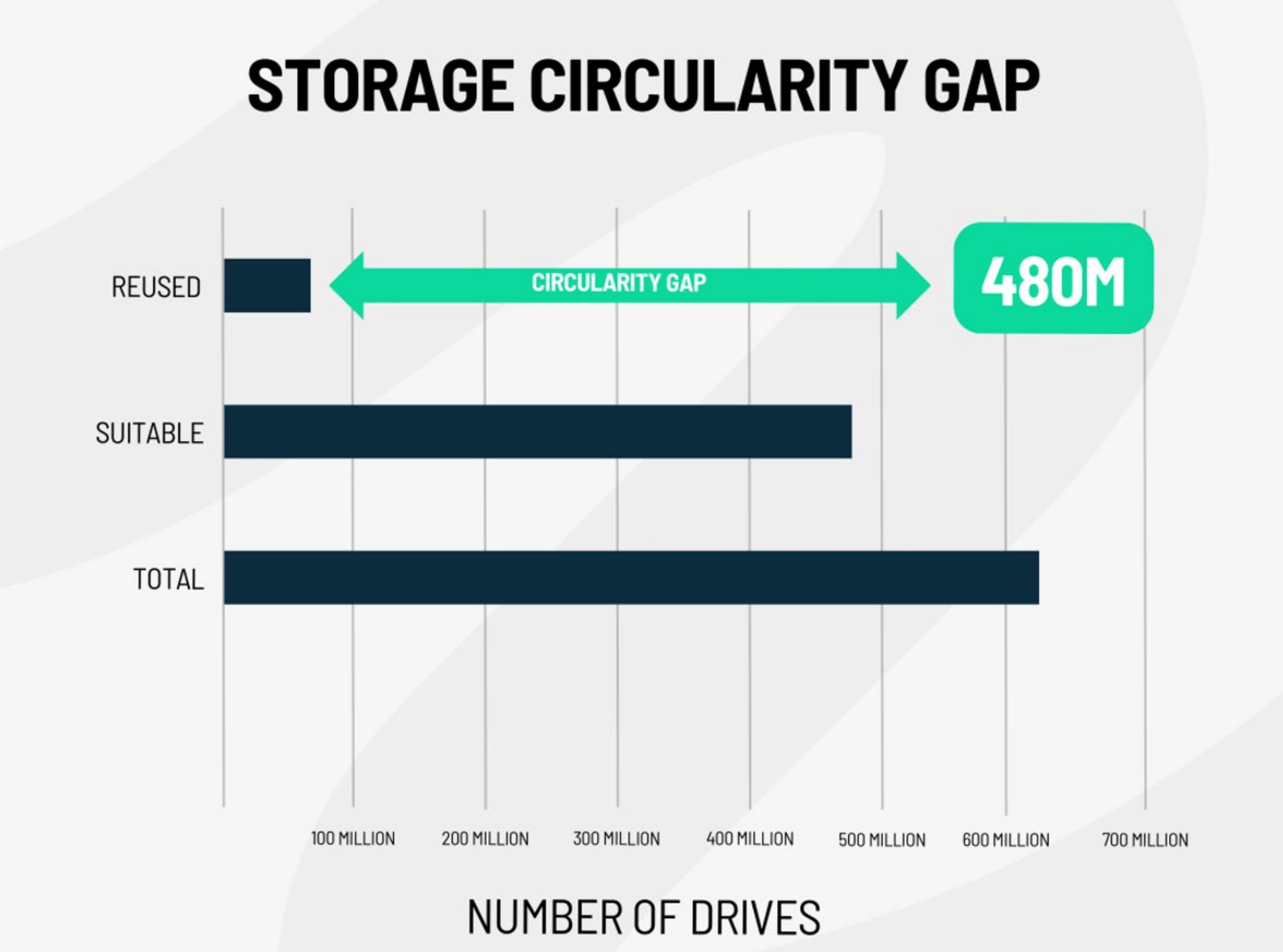
The Opportunity – Storage 2020-2027 Part 2



Value of the secondary storage market for 2020 drives in 2025:

$14 Billion resale value to ITADs / Reseller

Value to customers versus buying new:

$10 Billion in savings for enterprise versus buying the same capacity new

In carbon alone 29,425,600 Tonnes of embodied C02e wasted.

That's the carbon footprint of every home in London, Dublin and Berlin combined for a year!

Environmental Impact – Typical server

Resources & Waste

Water **2448 ltr** (equivalent to avg. adults water intake for 2 years)

Energy **2500 kWh** (equivalent to avg. UK household's electricity consumption for 278 days)

Waste, non-hazardous **38027 g**

Waste, hazardous **2218 g**

Air Emissions

Greenhouse Gases **508 kg CO_2 eq** (equivalent to avg. car CO_2 emissions over 38 days)

Acidification, emissions **3901 g SO_2 eq**

Volatile Organic Compounds **22g**

Persistent Organic Pollutants **487 ng i-Teq**

Heavy Metals **1540 mg Ni eq.**

Particulate Matter **2538 g**

Water Emissions

Heavy Metals **748 mg Hg/20**

Eutrophication **13 g PO_4**

Environmental Impact – British Geological Survey

Rare earth elements	REE	9.5	China	China
Antimony	Sb	9.0	China	China
Bismuth	Bi	8.8	China	China
Germanium	Ge	8.6	China	
Vanadium	V	8.6	China	China
Gallium	Ga	8.6	China	
Strontium	Sr	8.3	China	China
Tungsten	W	8.1	China	China
Molybdenum	Mo	8.1	China	China
Cobolt	Co	8.1	DRC	DRC
Indium	In	8.1	China	
Arsenic	As	7.9	China	
Magnesium	Mg	7.6	China	Russia
Platinum group elements	PGE	7.6	South Africa	South Africa
Lithium	Li	7.6	Australia	Chile
Barium	Ba	7.6	China	China
Carbon (Graphite)	C	7.4	China	China
Beryllium	Be	7.1	USA	
Silver	Ag	7.1	Mexico	Peru
Cadmium	Cd	7.1	China	
Tantalum	Ta	7.1	Rwanda	Australia

Rhenium	Re	7.1	Chile	Chile
Selenium	Se	6.9	Japan	China
Mercury	Hg	6.9	China	
Fluorine	F	6.9	China	South Africa
Niobium	Nb	6.7	Brazil	Brazil
Zirconium	Zr	6.4	Australia	Australia
Chronium	Cr	6.2	South Africa	Kazakhstan
Tin	Sn	6.0	China	China
Manganese	Mn	5.7	China	South Africa
Nickel	Ni	5.7	Indonesia	Australia
Thorium	Th	5.7		USA
Uranium	U	5.5	Kazakhstan	Australia
Lead	Pb	5.5	China	Australia
Iron	Fe	5.2	China	Australia
Carbon (Diamond)	C	5.2	Russia	Australia
Titanium	Ti	4.8	Canada	China
Copper	Cu	4.8	Chile	Chile
Zinc	Zn	4.8	China	Australia
Aluminium	Al	4.8	Australia	Guinea
Gold	Au	4.5	China	Australia

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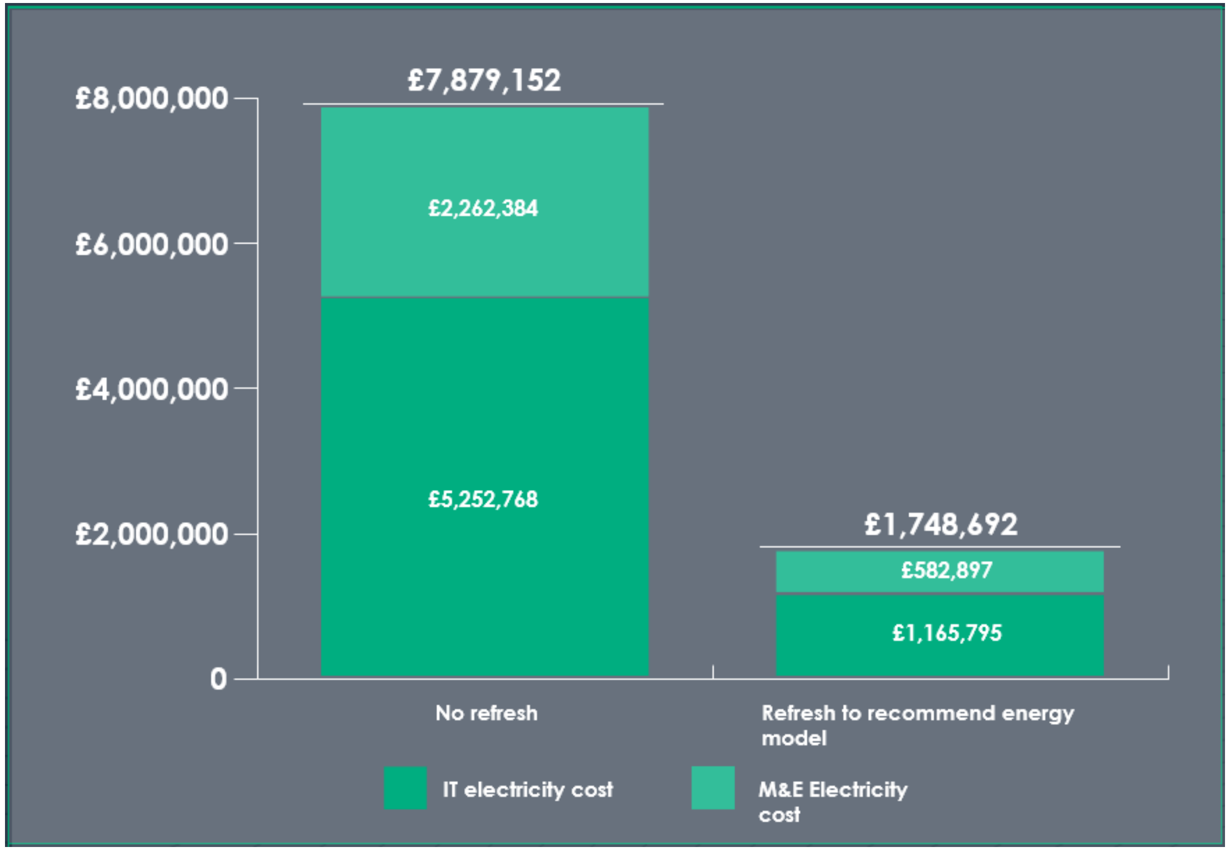
Case Studies

Energy Efficiency – Decommissioning – UK Bank



End of life decommission. The servers for analysis were due to be decommissioned and replaced over the next 12 months.

These 2217 servers could be replaced with 406 PowerEdge R7625 Servers at the same average utilisation of 40%

This lead to a **78% reduction in Energy and Carbon** or saving of over **38 million kWh and 8 thousand Metric Tonnes of Co2e** over 3 years.

Saving, at today's energy prices, **£6.1 Million pounds**.

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Energy Efficiency – Sustainability Projects – Dutch Government

SCOPE Determine energy consumption and emissions. Provide an analysis with identified projects that achieve efficiency, sustainability, and cost reduction goals.

PROJECTS

- IT efficiency improvements up to 33%
- IT energy cost savings of €100,000 p.y.
- Scope 2 & 3 emission reduction up to 260 tonnes

40% Energy Reduction	**143%** Increase in Maximum Performance	**65%** Procurement Saving

Benchmarking and Solution

SHI were looking to increase the capacity of their ITAM lab due to high use and limited available compute for growth. They needed to increase performance while reducing environmental impact.

SHI utilised Interact to establish current energy efficiency and performance benchmarks and identify solutions.

Three options were presented ranging from total replacement, partial upgrade and addition of servers and comprehensive component reconfiguration utilising refurbished components.

Each option would deliver the desired outcome with different costs and benefits.

Results

SHI went with complete reconfiguration using refurbished components to reduce impact on critical raw materials and scope 3 carbon. Once the work was completed, they monitored performance and impact.

Selecting the refurbished reconfiguration had saved over 65% in procurement costs while decreasing total energy used by 40%. Available capacity also increased 1.5x (143%).

By utilising the refurbished option, they decreased their scope 3 impact from 4,500 Kg co2e to only 40 Kg co2e for the project.

Case Study – Healthcare

Case Study – Improve Performance

Example hardware simulation

- Rightsized consolidation to 21 physical hosts from 38
- Keep architecture similar and consistent (same Manufacturer, similar Model, same CPU Manufacturer), but move forward one generation with main adjustments to the CPU and RAM balance
- Utilisation kept the same at 6% to allow no risk with peak

Results over 4-year period

- Energy: 378,092 kWh will be saved ↑
- Scope 2 emissions: 139,894 kg CO2e will be saved ↑
- Embodied emissions: 59,724kg CO2e ↓
- Cost: 58,966 EUR will be saved ↑

We do not recommend this scenario because new hardware does not make financial sense, even though the environmental benefits are substantial.

We recommend removing 2 to 4 of the lowest utilisation servers with peak loads below 50%. Migrate their workloads to other servers within the same cluster. This approach is likely to yield an annual 8–10% reduction in energy use and carbon emissions, while allowing those assets to be redeployed internally.

Thank you! Questions?