Virtual Tape CO2e Report

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Intent of this document

- While all data is provided in good faith and using scientific reference, to be as accurate as represented, this document is not intended to be a legally binding representation of any of the data provided. All calculations are based on publicly available data.
- This document is intended to breakdown the CO2e and other sustainability impacts of the IBM TS7770 virtual tape product.
- The sustainability impacts are measured as a result of the lifecycle of the product at the time of the document publication.
- Not all measurements are exact and may include estimations of usage during the lifecycle that do not exactly match the duty cycle of a particular use case or customer
- Where available, referenced third party data is utilized in formulating the outcomes. The intent of this methodology is to provide a proof of work with as unbiased information as may be available at the time of the data collection.
- Where an IBM corporate standard exists, the standard has been referenced for guidance.
- This report is not intended to give total values for any complete solution architecture or customer delivery. This is due to the variability and scale of solutions.

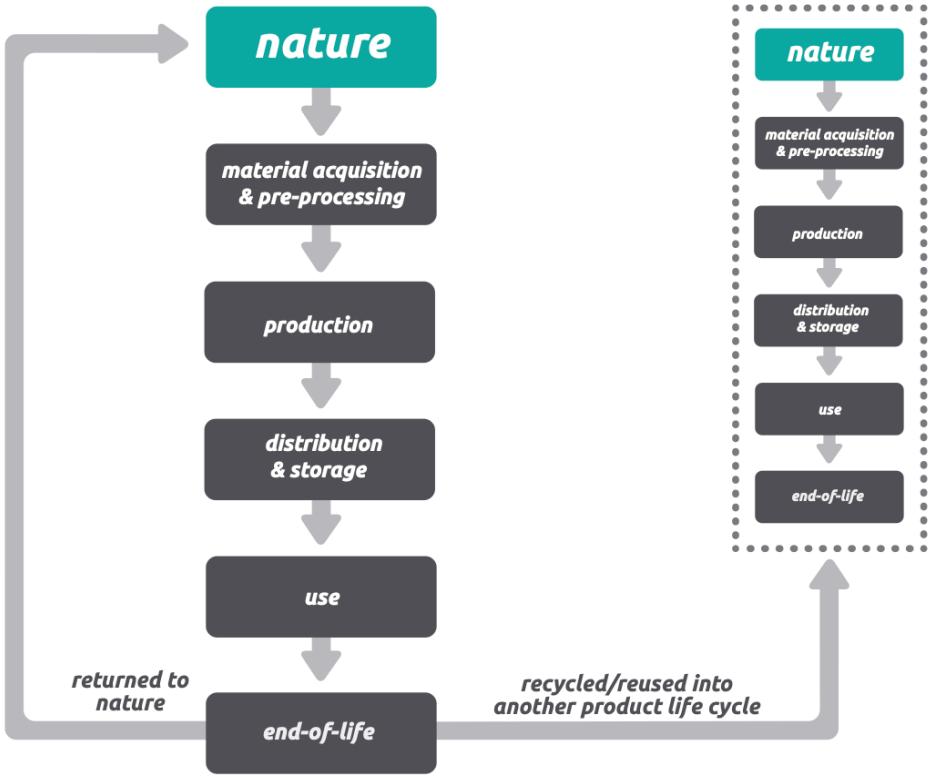
Guidelines to Measurement and Reporting

- GHG protocol methodologies as referenced in the GHG Product Life Cycle Accounting and Reporting Standard.
- Shipping calculations are based on true reporting standards for greenhouse gas calculations from Environmental Defense Fund + Business green Freight Handbook.
- In some instances, measurement of CO_2e may not be measurable within reasonable reporting levels, an uplift to the tape product is applied. In each case, an additional 5% of the total calculated attribution by product is added
- Where a measurement of distance is referenced, the applied distance is an average of distance travelled and not to a specific destination. This variability has been measured at an average of +/- 8.7%.
  - This was deemed reasonable as destinations number in the hundreds for Air shipping locations and thousands for client use destinations.
- Where applicable a recycle contribution has been applied to hardware and shipping materials. This is reported as a carbon offset weight. This offset has not been applied to the data as displayed as could it be considered standard in reducing carbon impact statements
- The Lowest level component recognized is at the silicon-based card level.
  - Water consumption, rare earth metals usage and waste produced during sob-component manufacturing are included in the totals.
  - Breakdown of these components are the full responsibility of the subcomponent manufacturer.
  - Semiconductor productions represent the largest water consumer in the world at 2,200 gallons of ultra pure water (UPW) per 30cm wafer.
- Energy calculations based on natural gas produced electricity are calculated at 40.6% efficiency.
- Materials are assumed new with no attribution for recycled materials usage in the production process (metals and Plastics)
  - This is not a statement of the lack of usage of recycled materials. The attribution of recycled materials varies based on availability. Shortages of recycle supply at any time will not impact the data as currently derived in this report
- All end measurements are reported in tons.

Product Life Cycle Standard

- Process maps are not part of this report
- Generalized attributional impacts are in each phase
- Vendor reported process results may be used in any phase.
- Attributional impacts are included as estimates when:
  - A data gap exists between primary or secondary data and it cannot be collected, only estimated
  - Extrapolated data cannot be determined to fill the gap
  - The data is determined to be insignificant
  - Where applicable to “products” all scope 3 category contributions are included (https://www.nature.com/articles/s41467-021-26349-x.pdf)

Product-Life-Cycle-Accounting-Reporting-Standard_041613.pdf



Simplified for Illustrative purposes

Reporting Methodology

- Where more than 1 variation of a component or subsystem exist, the highest carbon emitting process is reported
- Weights may be reported in Metric or Standard. All calculations are completed in the correctly converted form.
- No demonstration of standardized computations are included in this document.
- Variances in integrated products vs product offerings as stand alone may have variance in the sustainability calculation. Most of these variances are related to product configurations and have been deemed acceptable for larger calculations.
- If no specific note is observed, the listed generations are within the previously stated variance.
- Due to the wide variance of individual end solutions, high case values are used for carbon impact.
- Any non-compliant chemical and materials are listed separately in the report slide.

<layout> Component Report: <Product>

Product description>

Component/Assembly 1> <QTY> …..<future: RA>

Component /Assembly +n> <QTY …..<future: RA>

Transportation Contribution

Weight

Energy usage <kWh>

Life Cycle <years average>

<Metric Outcomes>

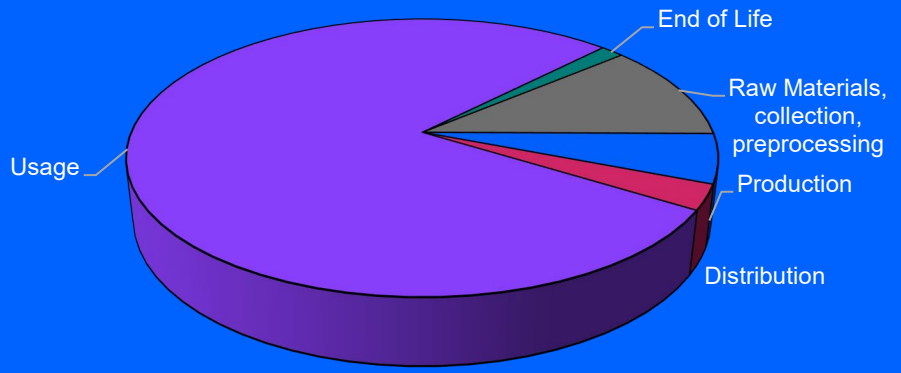
- *In all cases shipping as part of production is included in the final outcomes.*
- *Minor gaseous contributions are contained within each process measurement and not broken out.*
- *Contribution totals are based on the stated life cycle in years, not an individual usage calculation.*
- *All stated values subject to variability in sourcing, scale and delivery.*
- *End-of-Life stage assumes local recycling and e-waste disposal. Associated fees are regional and not included due to scope and variation.*
- *Final Mile distribution not included in product contribution* *(see Final mile page for uplift by product and Geo)*

High Level Inputs and Outcomes

System Boundaries

- Raw material extraction,
- Material manufacturing
- Supplier transportation
- Product assembly and distribution
- Packaging
- Data center usage
- End of life burdens
- Recycling burdens
  - Benefits from recycling virgin materials savings are not included
- Manufacturing systems infrastructure not included

Lifecycle Impact Distribution



*Average distribution model. Actuals may vary based on the system architecture

Hazardous/Restricted Materials Statements

- Contain no bromine or chlorine above 900 parts per million (ppm) or listed phthalates at the homogeneous material level.
- No JIG/IEC 62474 restricted chemicals over allowed limits
- No ozone depleting chemicals, and no REACH substances of very high concern (SVHC) over 1000 ppm at the article level.

Component Report: 3957-VED

Consists of Power9, I/O expansion drawers, energy and power distribution

Sheet metal assembly	3
Silicon card Assembly (Assembly, HBAs, interconnects, processors, asics)	24*
Interfaces	2
Interconnects and cables	15*
Weight	72.6kg
Recycle Offset.	5.1kg
Energy usage (average)	1.792 kWh
Environmental Conditioning	2.5 KBTU/kWh
Life Cycle	5.3 Yrs

kgCO2e contribution

FE	1611
Aluminum	1
CU	3
Plastics	4
Silicon Card	84
Silicon Processor	4
Tin	2

- Production – 724.2kg
- MFG Distribution – 453.3kg
- Operational Energy – 37127.5kg
- Cooling Energy – 27187.3kg
- End-of-Life – 144.8kg

72.4 tons CO2e

*Variable dependent on configuration. Variance is not highly impacting to the result.

Component Report: 3956-CSB

Storage Array controller with HDD storage.

Sheet metal assembly	1
Silicon card Assembly (Assembly, HBAs, interconnects)	4*
HDD Interfaces	10
10TB HDD	10
Weight	34.47kg
Energy usage (average)	1.792 kWh
Environmental Conditioning	2.5 KBTU/kWh
Life Cycle	5.3 Yrs

kgCO2e contribution

FE	720
Aluminum	0
CU	3
Plastics	2
Silicon Card	15
Silicon Processor	2
Tin	1

- Production – 3233.6kg
- MFG Distribution – 258.2kg
- Operational Energy* – 8287.3kg
- Cooling Energy – 6068.6kg
- End-of-Life – 148.5kg

19.8 tons CO2e

Note: Integration of the IBM DS5000 series may yield CO2e contributions different from the individual product assessment. Variances in HDD, and configurations contribute to those variations.

Component Report: 3956-XSB

Storage expansion drawer with HDD storage.

Sheet metal assembly	1
Silicon card Assembly (Assembly, HBAs, interconnects)	2*
HDD Interfaces	10
10TB HDD	10
Weight	33.1kg
Energy usage (average)	1.792 kWh
Environmental Conditioning	2.5 KBTU/kWh
Life Cycle	5.3 Yrs

kgCO2e contribution

FE	700
Aluminum	0
CU	2
Plastics	2
Silicon Card	11
Silicon Processor	2
Tin	1

- Production – 3209.1kg
- MFG Distribution – 248.0kg
- Operational Energy* – 6215.5kg
- Cooling Energy – 4551.4kg
- End-of-Life – 143.6kg

15.8 tons CO2e

Note: Integration of the IBM DS5000 series may yield CO2e contributions different from the individual product assessment. Variances in HDD, and configurations contribute to those variations.

Component Report: 3956-CFC

Storage Array controller with SSD storage.

Sheet metal assembly	1
Silicon card Assembly (Assembly, HBAs, interconnects)	4*
SSD Interfaces	24
3.84TB SSD	24
Weight	31.63kg
Energy usage (average)	1.792 kWh
Environmental Conditioning	2.5 KBTU/kWh
Life Cycle	5.3 Yrs

kgCO2e contribution

FE	720
Aluminum	.40
CU	2.5
Plastics	2
Silicon Card	15
Silicon Processor	2
Tin	1

- Production – 3233.6kg
- MFG Distribution – 258.2kg
- Operational Energy* – 8287.3kg
- Cooling Energy – 6068.6kg
- End-of-Life – 148.5kg

19.9 tons CO2e

Note: Integration of the IBM DS5000 series may yield CO2e contributions different from the individual product assessment. Variances in HDD, and configurations contribute to those variations.

Component Report: 3956-XFC

Storage expansion drawer with SSD storage.

Sheet metal assembly	1
Silicon card Assembly (Assembly, HBAs, interconnects)	2*
SSD Interfaces	24
3.84TB SSD	24
Weight	30.27kg
Energy usage (average)	1.792 kWh
Environmental Conditioning	2.5 KBTU/kWh
Life Cycle	5.3 Yrs

kgCO2e contribution

FE	700
Aluminum	.4
CU	2
Plastics	1.5
Silicon Card	11
Silicon Processor	2
Tin	1

- Production – 3209.1kg
- MFG Distribution – 248.0kg
- Operational Energy* – 6215.5kg
- Cooling Energy – 4551.4kg
- End-of-Life – 143.6kg

15.8 tons CO2e

Note: Integration of the IBM DS5000 series may yield CO2e contributions different from the individual product assessment. Variances in SSD, and configurations contribute to those variations.

Component Report: Edgecore Switches (x2)

Communication distribution switches

Silicon Card	1
Sheet Metal assembly	1
Interface ports	32
LEDs Display	32
Power Supply	2
Weight	5.38kg
Energy usage	.198kWh
Life Cycle	5.3Yrs

kgCO2e contribution

FE	57
Aluminum	3
CU	2
Plastics	0
Silicon Card	15
Silicon Processor	2
Tin	0

- Production – 80.4kg
- Operational Energy – 4102.3kg
- Cooling Energy – 3003.1kg
- End-of-Life – 16.1kg

7.6 tons CO2e

Note: cabling beyond interconnections are not included in the assessment as length and total infrastructure vary widely

Component Report: PCA 10 outlet (x2)

Communication distribution switches

Sheet Metal assembly	2
‘Plastic’ as rubber and plastic	10
Weight	4.26kg
Life Cycle	5.3Yrs

kgCO2e contribution

FE	40
Aluminum	3
CU	5
Plastics	9
Silicon Card	0
Silicon Processor	0
Tin	0

- Production – 57.47kg
- MFG Distribution – 8.4kg
- End-of-Life – 11.5kg

.1 tons CO2e

Component Report:
TSSC, sPDU, Display, Keyboard

All Minor SKUs related to minimal install

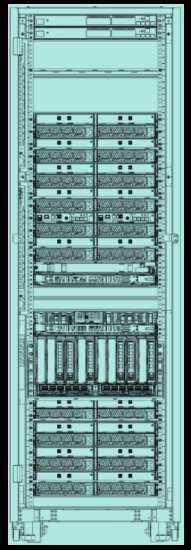
Operational component contribution to total CO2e

TSSC Intel Micro Computer

Monitor

Keyboard

Minor plastic components



- Production – 250.55kg
- Operational Energy – 764.1kg
- Cooling Energy – 910.2kg
- End-of-Life – 29.97kg

2.8
tons
CO2e

Component Report: 3952-F07 Frame

Frame only, shipped with piece products internally.

Frame	1
Doors	2
Sheet Metal assembly	3
‘Plastic’ Rollers	4
Life Cycle	7Yrs

kgCO2e contribution

FE	3076
Aluminum	0
CU	0
Plastics	19
Silicon Card	0
Silicon Processor	0
Tin	0

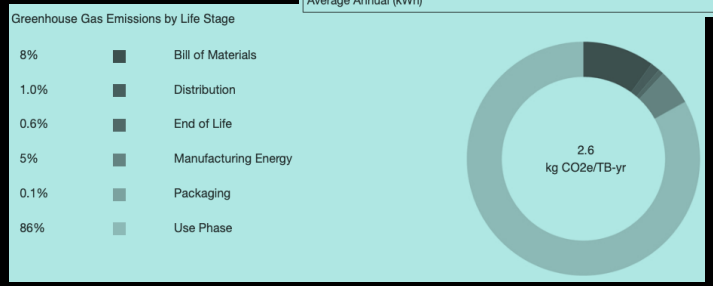
- Production – 3094.8kg
- MFG Distribution – 8.5kg
- End-of-Life – 619kg

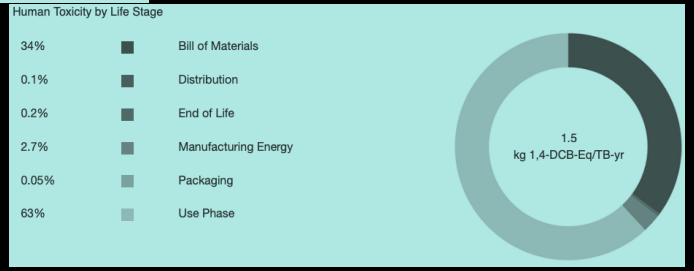
4.1
tons CO2e

Media Impact Comparison

HDD

Power Consumption	Per Unit	Per TB
Idle A (W) Average	4.5	0.45
Max Operating Power, Random Write (WCD) 4K/4Q RR50% / RW50%	8	0.8
Max Operating Power, Random Read 4K/16Q (W)	8.4	0.84
Average Annual (kWh)	31.1	3.11

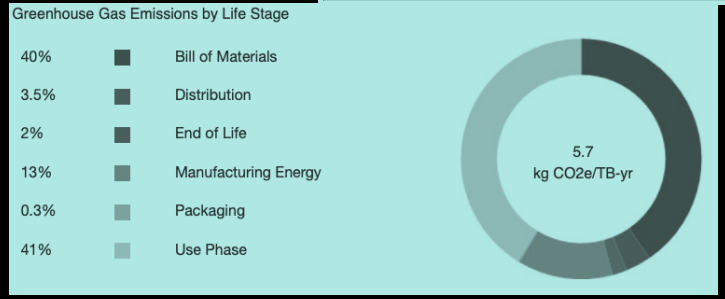


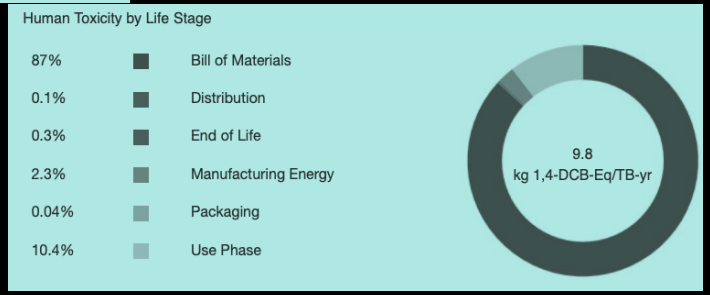


https://www.seagate.com/global-citizenship/product-sustainability/enterprise-cap-3-5-hdd-sustainability-report/

SSD

Power Consumption	Per Unit	Per TB
Operating, Average (W)	5.6	1.9
Standby/Sleep, Average (W)	0.5	0.17
Average Annual (kWh)	9.8	3.3





https://www.seagate.com/global-citizenship/product-sustainability/skyhawk-3tb-sustainability-report/

Related “Last Mile” Shipping – CO2e in tons

Component	Region									
	NA		EU		MEA		ASEAN		LA	
	Air	Ground	Air	Ground	Air	Ground	Air	Ground	Air	Ground
Base Unit	0.6	0.012	2.3	0.008	3.2	0.009	2.8	0.009	1.5	0.010
Per Additional Controller	0.1	0.001	0.2	0.001	0.3	0.001	0.2	0.001	0.1	0.001
Per Additional Expansion	0.0	0.001	0.2	0.001	0.3	0.001	0.2	0.001	0.1	0.001
Per Expansion Frame	0.3	0.007	1.3	0.005	1.8	0.005	1.6	0.005	0.8	0.005

*All configuration weights are at highest weight with packaging
*All distances used in calculations are average distances for the region.
*Specific destination will vary for air and ground distances, with little impact on the outcome of the CO2e production.

TS7770
5.3-Year Total Solution Example

- 3.6TB/HR Data Rate
- 4 external data connection
- 780 TB uncompressed capacity
- 1sq. meter
- Europe “final mile”

258.4
tons
CO2e

62.5
tons
CO2e per PB
per year

• 1 base configuration	81.8 tons CO2e
• 8 Expansion drawers	86.6 tons CO2e
• Environmental Conditioning	86.1 tons CO2e
• Last Mile Shipping	3.92 tons CO2e


IBM

Public Reference Materials

https://business.edf.org/insights/green-freight-math-how-to-calculate-emissions-for-a-truck-move/

https://ghgprotocol.org/sites/default/files/standards/Product-Life-Cycle-Accounting-Reporting-Standard_041613.pdf

https://www.ibm.com/docs/en/ts7700-virtual-tape/5.2.0?topic=requirements-ts7770-specifications

https://www.ibm.com/docs/en/ts7700-virtual-tape/5.2.0?topic=requirements-ts7770-minimum-configuration

https://www.ibm.com/docs/en/ts7700-virtual-tape/5.0?topic=details-ts7770

Silicon-chemistry carbon balance an assessment of Greenhouse Gas emissions and reduction - Bernd Brandt et al

A Review of the Carbon Footprint of Cu and Zn Production from Primary and Secondary Sources – MDPI

https://www.chinawaterrisk.org/resources/analysis-reviews/8-things-you-should-know-about-water-and-semiconductors/

https://www.epa.gov

https://www.eia.gov

https://www.energy.gov

Version 1.0

Version Log

20211117	-	Initial offering
20211129	-	CFC/XFC
20211210	-	Added references to Water and rare earth metals