Pulsar 2 SSD Product Life Cycle Analysis Summary

Product Description

The Pulsar 2 SSD is a solid state drive designed to deliver the price-performance benefits plus the data integrity and drive endurance demanded by performance-demanding enterprise applications – all from the world leader in enterprise storage. The Pulsar offers enterprise-class endurance, protection against unintended data change or loss, capacities up to 800GB, and a self-encrypting drive option.

Life Cycle Analysis

Functional Unit, System Boundaries and Allocation Unit:

The functional unit for this study is a single Pulsar 2 solid state drive in operation for 3 years. The base case of this study assumed product distribution and use in the United States, Europe, and Asia.

The system boundaries are inclusive of raw material extraction, material manufacturing, supplier transportation, product assembly and distribution, packaging, consumer use and assumed end of life (EOL). Burdens from the recycling of product components at EOL are included in the system boundary but avoided burdens from displaced virgin raw materials are subject to a cut-off and are not included. Systems infrastructure such as the manufacture of machinery or buildings used in product production and assembly have been excluded. All product components were considered in this study with the Bill of Materials provided by Seagate. Burdens at Seagate's assembly were allocated on a production unit volume basis.

SimaPro v7.2 software and the Ecoinvent v2.2 database were used during preparation of the LCA. The ReCiPe mid-point hierarchical method was used to determine life cycle impacts for the product. This study, commissioned by Seagate Technology, was prepared by WSP Environmental, and 3rd party critically reviewed by EarthShift.

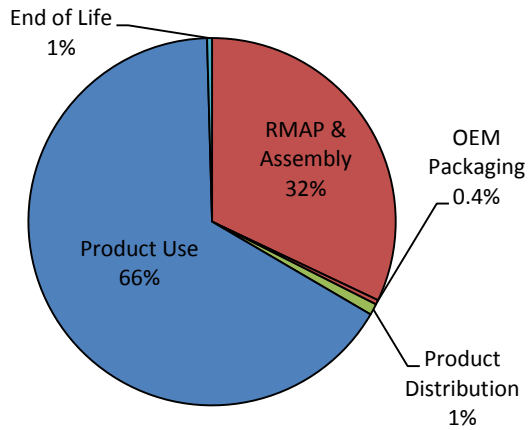
Calculated Impacts:

Mid-point Impact	Unit	Total
Climate change	kg CO2 eq	2.05E+02
Ozone depletion	kg CFC-11 eq	3.87E-06
Human toxicity	kg 1,4-DB eq	5.89E+01
Photochemical oxidant formation	kg NMVOC	7.02E-01
Particulate matter formation	kg PM10 eq	4.66E-01
Ionizing radiation	kg U235 eq	7.72E+01
Terrestrial acidification	kg SO2 eq	1.24E+00
Freshwater eutrophication	kg P eq	5.29E-02
Marine eutrophication	kg N eq	1.24E-01
Terrestrial ecotoxicity	kg 1,4-DB eq	3.59E-02
Freshwater ecotoxicity	kg 1,4-DB eq	1.01E+00
Marine ecotoxicity	kg 1,4-DB eq	1.15E00
Water depletion	m3	5.39E+01
Metal depletion	kg Fe eq	1.81E+01
Fossil depletion	kg oil eq	5.11E+01

Climate Impacts

As Climate Impacts are often a primary concern for our stakeholders, the remainder of this document will focus on carbon dioxide equivalent emissions (CO_2 eq) through the product life cycle. The total life cycle greenhouse gas (GHG) emissions of 205 kg CO2e per product are split between the various life cycle stages as presented right.

GHG Impact Distribution by Life Stage



Raw Material Acquisition and Pre-processing (RMAP)

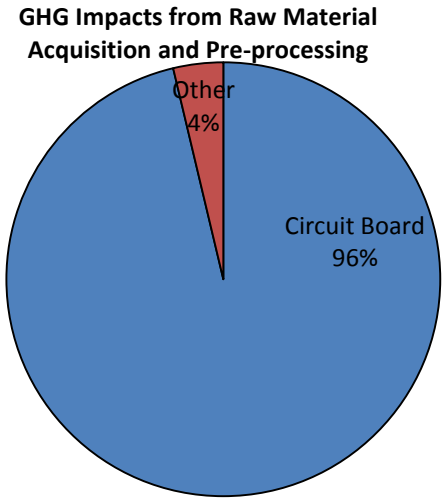
This phase captures the raw material extraction and pre-processing. Composing 32% of the total product footprint, component manufacturing is largely determined by the materials used in each component and the energy intensity of component production.

As seen in the figure on the next page, the production and mounting of printed circuit boards and associated electronic components dominates the raw material climate impacts, accounting for 96% of total raw material acquisition and pre-processing climate impacts.

Production
The product assembly environmental impacts for each Pulsar 2 drive were estimated using activity data from Seagate's GHG emission inventory. Activity data from the inventory were allocated to the product on a unit volume manufactured basis. Thus, all direct and indirect emissions from both production and facility operation (including heating and cooling, vehicle fleets, and fugitive emissions) are captured in this estimate.

Distribution
The product life cycle assumes distribution to the United States, Europe, Asia, and shipments to customers from the Seagate assembly site. The total GHG emissions from product distribution amount to 1%of the total life cycle impact.

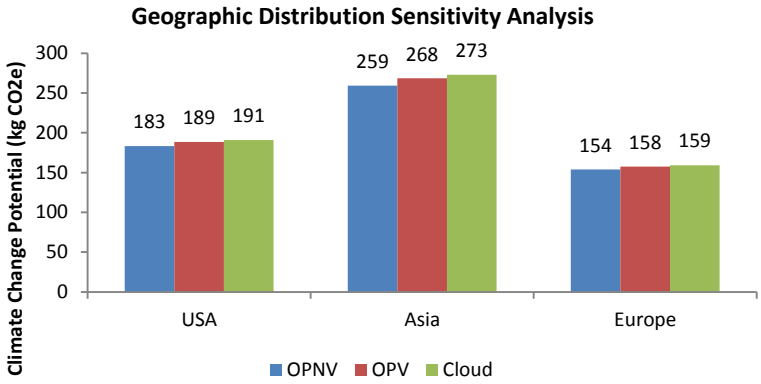
Use Phase
The Pulsar 2 drives are assumed to spend approximately 7,000 to 8,000 hours per year in idle mode. Variations in the product's use profile have a very low impact on lifecycle GHG emissions because the SSD idle mode power draw is similar to drive power draw during active use, and any variation in the server utilization will not significantly affect drive power draw. The estimated lifetime electricity consumption for the drive is 118 kWh, equivalent to the amount of energy needed to power a 100 Watt light bulb for 1.6 months.



Sensitivity analysis was conducted to evaluate how the product's climate impacts would change for distribution and use in different geographies. The product is also distributed and used within Europe and Asia, and representative distribution models for each are available from Seagate. For each geographic region, the product use phase and end of life phase will also be slightly different. The use phase sensitivity was modeled by changing the source of grid electricity from US average to Europe average and to China average for Asia.

The sensitivity analysis also evaluates different server operating scenarios to determine the impact of utilization on the drive cycle. These scenarios represent low, mid, and high use intensity, as described below and illustrated in the chart below and to the right.

- On Premise Non Virtualized (OPNV) – Individual private servers running single applications hosted on-site, without virtualization, average CPU utilization of 10%
- On Premise Virtualized (OPV) – Individual private servers running single applications hosted on-site, with virtualization ratio of 5 to 1, average CPU utilization of 30%
- Public Cloud (Cloud) – A large-scale cloud service providing computing services to high numbers of customers; virtualization ratio of 8 to 1, average CPU utilization of 40%



End of Life (EOL) & Recycling
Although the LCA data for electronic products' EOL/recycling phase has not been well established, and primary data are not available for this product, reasonable estimates of industry practices were made in this analysis based primarily on Ecoinvent unit processes. These processes represent the manual dismantling and depollution, and the mechanical treatment (shredding) of WEEE devices in various fractions based on common transfer coefficients for this type of treatment in Switzerland. These processes have been considered as representative for the global situation, and applied to the Pulsar 2 drive, although it is recognized that this will produce an optimistic result for EOL impacts. Recycling of packaging waste was derived from the Environmental Protection Agency data on Municipal Solid Waste Generation, Recycling, and Disposal in the United States.

Pulsar 2 Enterprise SSD Bill of Substances

The table and chart below illustrate the 33 largest substances by weight in the Pulsar 2 SSD drive comprising a cumulative concentration of nearly 99%. Each remaining chemical substance comprises less than 0.1% by weight of the product. Seagate Pulsar 2 SSD drives contain no bromine or chlorine above 900 parts per million (ppm) or listed phthalates at the homogeneous material level. Also, there are 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, as of the date of this writing.

Substance	CAS Number	Cumulative Concentration of Substances (%)
AL	7429-90-5	30.27
FE	7439-89-6	45.28
FUSED SILICA	60676-86-0	54.28
EPOXY RESIN	29690-82-2	60.39
AL2O3	1344-28-1	65.18
COPPER (METALLIC)	7440-50-8	69.95
TALC	14807-96-6	73.20
SI	7440-21-3	76.35
TANTALUM	7440-25-7	79.03
LCP POLYMER	147310-94-9	80.92
DIOXYGEN	7782-44-7	82.73
SN	7440-31-5	84.50
VINYL SILICONE OIL	68083-19-2	86.19
FIBROUS-GLASS-WOOL	65997-17-3	87.63
C.I. PIGMENT BLACK 28	68186-91-4	88.98
C	7440-44-0	90.20
PROPRIETARY		91.12
AG	7440-22-4	92.03
HVA-2 (PDM)	3006-93-7	92.89
CALCIUM MONOXIDE	1305-78-8	93.72
NICKEL	7440-02-0	94.52
BENZENEDICARBOXYLIC ACID POLYMER	60088-52-0	95.21
DISODIUM-OXIDE	1313-59-3	95.81
EPOXY RESIN	223766-10-6	96.28
PEGOTERATE- (INN)	25038-59-9	96.65
PHENOL POLYMER	26834-02-6	97.01
ZINC	7440-66-6	97.34
MAGNESIUM (METAL)	7439-95-4	97.67
AROMATIC POLYIMIDE POLYMER	26298-81-7	97.98
CHROMIUM	7440-47-3	98.27
BARIUM TITANATE(IV)	12047-27-7	98.52
DIIRON-TRIOXIDE	1309-37-1	98.70
FLOWERS OF ZINC	1314-13-2	98.86