RATIONALE

Earth Capital has signed up to the Net Zero Asset Managers Initiative, committing to support the goal of net zero greenhouse gas emissions by 2050 or sooner, in line with global efforts to limit warming to 1.5 degrees Celsius. As part of this commitment, we have conducted net zero assessments on all of our assets under management. This process included extensive carbon accounting, comparisons to industry standards and a prediction of each assets’ net zero trajectory. In the following report, we present many of the findings from SoftIron’s net zero assessment in a format which allows prospective customers to understand:

a) The carbon footprint of a single SoftIron node;

b) how SoftIron are improving their carbon footprint and;

c) how SoftIron products can be used to help customers attain their own sustainability goals.

What is the carbon footprint of a SoftIron node?

Our carbon footprint assessment reveals the full life cycle emissions of a single SoftIron node equates to 2,898 ± 290 kg CO₂e. Of these emissions, ~77% (2227 ± 223 kg CO₂e) pertain to the use of the product while ~23% (671 ± 40 kg CO₂e) pertain to the collective contributions of raw materials, manufacturing, transportation, and installation (fig.1). These findings highlight that electricity during product operation is a significant carbon source for SoftIron. However, carbon

![Diagram showing the breakdown of emissions for a SoftIron node compared to an industry standard node.](image)
emission pertaining to energy usage in industry standard servers is ~11,135 kg CO$_2$e (i.e. up to 5 times larger than that of SoftIron), thereby demonstrating how SoftIron has confronted the most carbon-intensive aspect of data storage appliances.

To help stakeholders contextualise the product carbon footprint values, we provide approximate equivalencies:

The average carbon required to build and transport a SoftIron node to the customer:

- Is equivalent to the carbon produced by driving 1,644 miles in a passenger car (US EPA, 2021).
- Is equivalent to what 0.8 acres of US forest can absorb in a year (US EPA, 2021).

N.B. These equivalences are based on SoftIron’s 2022 carbon footprint data. As SoftIron introduce “Edge Manufacturing” (see below), the carbon pertaining to manufacturing and transportation will dramatically reduce.

**Main assumptions made in calculating product carbon footprint (for full calculations see appendix A):**

<table>
<thead>
<tr>
<th>Subject</th>
<th>Value used</th>
<th>Reasoning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product lifetime</td>
<td>5 years</td>
<td>SoftIron has only been shipping their current products for ~2 years so lack data on the products’ serviceable lifetime. Typical data centre servers have a lifespan of 3-5 years. As SoftIron products use less power and therefore generate less heat during operation, they place less stress on the server (and hard drives) than that of an industry-standard appliance, reducing the likelihood of system failure. Additionally, SoftIron’s optimised design uses fewer components (and no cable assemblies) which again decreases the likelihood of a system fault. Therefore, it is reasonable to assume that SoftIron’s products have a minimum lifespan of 5 years.</td>
</tr>
<tr>
<td>Power consumption during operation</td>
<td>220 W</td>
<td>SoftIron sells multiple different products (i.e. HyperDrive, HyperCast, HyperSwitch), each with differing energy demand. A given SoftIron product’s energy consumption will also vary depending on its workload (typically ranging from &lt;60W to &gt;200 W). An investigation into the power consumption of a SoftIron hard disk drive-based system found it to be working at 220W. However, 220W is almost certainly an overestimate for the average power consumption of a SoftIron node as every deployment contains a multi-node “cluster” which will always contain some low-power nodes.</td>
</tr>
<tr>
<td>Assembly Location</td>
<td>California</td>
<td>SoftIron has facilities in California where the product is typically built (i.e. product assembly in a facility in San Francisco; software configuration in the Newark lab). Although SoftIron is starting to manufacture in other locations (e.g. Australia), the vast majority of manufacturing still occurs in California. Hence, California is used as the assembly location in the carbon footprint assessment.</td>
</tr>
<tr>
<td>Use location</td>
<td>UK</td>
<td>SoftIron products are sold and shipped worldwide. However, to conduct the carbon footprint assessment, UK carbon conversion factors have been adopted wherever product use is concerned. For alternative countries’ carbon conversion factors, see link.</td>
</tr>
</tbody>
</table>
What is SoftIron doing to improve its products’ carbon footprint?

Since the initial product launch, efforts have been made by SoftIron to reduce their carbon footprint in the following ways:

- **Standardising the product design**: The SoftIron product works on a modular design where multiple component sub-assemblies come together to form a single functioning appliance. The design of every product conforms to the same “1U” form factor which allows most of the metalwork to be standardised thus limiting excessive use of metal materials.

- **Reusing/ recycling at manufacturing facilities**: Where possible, the steel and aluminium raw materials are sought from recycled sources; any by-products from the manufacturing processes are reduced/ actively recycled as much as possible. In 2021, SoftIron initiated a component recycling programme which involves take back and reuse of certain chips and power control parts from faulty PCBs.

- **Reducing software configuration time**: SoftIron engineers have recently been working on building deployment tools that automate much of the basic testing and configuration. The expectation is that (by Q4 of 2022) SoftIron will be able to ship more “unconfigured appliances” and then perform the custom configuration (using the newly developed deployment tools) at the customer site. Making this change will reduce the amount of time each node spends powered up in the Newark lab (from on average 1 week to as little as 15 minutes) thus reducing energy consumption and avoiding carbon emissions.

- **Installation of a Hot Aisle Containment (HAC) system**: In 2021, SoftIron installed a HAC system (i.e. an efficient airflow system) in the server room of the Newark (product configuration) facility. This installation reduced the facility’s energy consumption by 50%. HAC systems are now being implemented in all SoftIron’s manufacturing facilities.

- **“Edge Manufacturing”**: SoftIron is moving towards a model of operation (known as “Edge Manufacturing”) which involves locating manufacturing sites closer to the customer, thereby enabling greater use of local supply chains and reducing emissions pertaining to transportation.

- **Reducing plastic packaging**: SoftIron are in the process of changing their packaging such that they will no longer use foamed plastics and will instead use transparent plastic sleeves and corrugated cardboard to protect their product during shipment.

- **Clean supply chain pledge**: SoftIron is planning to sign up to a clean supply chain group. Such a commitment will require SoftIron to be purchasing materials/components from suppliers who are sustainable and circular in their practices.
How can SoftIron help reduce their customers’ carbon footprint?

In comparison to similar data storage and processing appliances available on the market, SoftIron’s product has a greatly reduced carbon footprint mainly on account of the comparably low energy usage during operation. In fact, for every 10 PB of data storage shipped by SoftIron, an estimated 292 tonnes of CO₂e are saved by reduced energy consumption alone. In addition, the SoftIron appliances produce up to 80% less heat than the standard, thereby radically reducing emissions pertaining to cooling of data centres.

Energy consumption: SoftIron versus the industry standard

Making a direct energy consumption comparison between SoftIron and industry-standard appliances is a challenging task. Many of the industry-standard products adopt a generic model, capable of numerous functions while SoftIron

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1 Assuming industry standard data storage appliances use 4.08 GWh per PB (averaged from: Supermicro, 2022; DELL EMC, 2019 & HPE, 2018) and SoftIron data storage uses 1.2 GWh per PB (Huntridge, 2020). Calculation uses UK electricity carbon conversion factor. This figure has been updated from the SoftIron Carbon Footprint Report issued in March 2022. The error was brought to our attention by SoftIron. We thank them for pointing this out and apologise for any inconvenience caused.
appliances are fully integrated and task-specific such that each appliance only contains the components necessary for its specified function. Although in theory, generic models have greater functionality, in practice the surplus componentry leads to excess energy consumption, excess heat production and a greater likelihood of system faults. The potential variability in system function makes node-to-node comparisons somewhat inappropriate. Additionally, the energy consumption (and heat generation) of any given node will vary depending on the applied workload. This nuanced situation means that it is not possible to perform a comprehensive energy consumption comparison between SoftIron and other industry-standard appliances. Instead, for customer guidance only, a sample comparison has been conducted (fig.2). This assessment uses publicly available data to compare the power required to store 1 TB of data using a SoftIron appliance to the power required using alternative Ceph reference architectures.

These energy consumption comparisons do not account for additional carbon savings stemming from reduced heat generation. The heat-related carbon savings will vary from data centre to data centre depending on location-specific variables including climate, server room layout, ventilation etc. However, it should be noted that leading-edge cooling technologies (e.g. liquid immersion cooling systems) are not required for the running of SoftIron appliances – this will result in substantial energy (and financial) savings for data centres who choose SoftIron.

**Current trends in the IT industry**

Many market-leading data centre suppliers acquire commoditised, off-the-shelf hardware which use the latest iteration of central processing units (CPUs). Research indicates that each iteration of CPU requires more power than its predecessor (fig.3). Therefore, the industry standard data centre appliances are in fact becoming less energy-efficient, thereby creating more financial and environmental costs for data centres. Meanwhile, SoftIron’s task-specific and fully integrated design means that every aspect (from the hardware to the software) is optimised to make the most energy-efficient product possible. This enables SoftIron to deliver industry-leading performance while using less power-hungry CPUs.

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**Fig.3. Microprocessor trends over the past 48 years with power consumption data displayed in red.**

N.B. Y-axis is a log scale.

[Original data up to year 2010 collected and plotted by M. Horowitz, F. Labonte, O. Shacham, K. Olukotun, L. Hammond, and C. Batten. Data collected for 2010-19 by K Rupp]**
Sustainability in data centres

Global data centre electricity use in 2020 was between 200-250 TWh which equates to 1-3% of global electricity consumption (IEA, 2021). With the strong growth in the demand for data centre services around the world, the consumption of electricity by data centres is expected to increase considerably in the next decade. Therefore, the substantial energy savings offered by SoftIron give customers a unique opportunity to adopt data centre services without contributing to the escalation in data centre energy demand. Furthermore, many current customers are seeing SoftIron’s energy efficient approach as a steppingstone towards their sustainability goals. For example, a recent customer (THG) has adopted SoftIron’s solutions as part of a key corporate goal to maintain CarbonNeutral® certification as they grow their footprint of data centres.
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Appendix A – SoftIron product carbon footprint calculations

Raw materials (Scope 3)
A single node uses the following materials (incl. raw materials and materials incorporated into subassemblies & subsystems):

- Steel: ~10 kg
- Poly epoxides: ~5 kg
- Copper: ~5 kg
- Other (i.e. metal alloys): <1 kg each

- Steel production generates 2.17 kg CO₂e per kg steel (Fu, et al., 2015) thus production of 10 kg of steel generates 21.7 kg CO₂e.
- Epoxy resin generates 13.82 kg CO₂e per kg of resin (Yung, et al., 2018) thus production of 5 kg of epoxy resin generates 69.1 kg CO₂e.
- Copper production generates 4.75 kg CO₂e per kg copper (Norgate & Rankin, 2002) thus production of 5 kg of copper generates 24 kg CO₂e.
- An estimated conversion factor for other metal alloys is 2.23 kg CO₂e per kg metal (using aluminum as a proxy) (Yung, et al., 2018) thus production of an estimated 3 kg of metal alloy generates 6.7 kg CO₂e.

Emissions (per node): 121.5 kg CO₂e

Transport of raw materials, subassemblies & subsystems to manufacturing facility (Scope 3)
SoftIron’s suppliers are listed below alongside their respective modes of transportation and estimated emissions generated per node (via use of Carboncare, 2021):

Raw materials:
- Supplier A (steel): Ocean (TW) à 0.25 kg CO₂e
- Supplier B (steel): Ocean and Air freight (CN) à 0.42 kg CO₂e
- Supplier C (Polyepoxides & Copper): Air freight (CN) à 0.42 kg CO₂e
- Supplier D (Polyepoxides & Copper): Air freight (US & CA) à 9.1 kg CO₂e

Suppliers of subassemblies & subsystems (media, power supplies etc.):
- Supplier E: Ground freight (US) à 0.04 kg CO₂e
- Supplier F: Ground freight (US) à 0.12 kg CO₂e
- Supplier G: Air freight (VN/TH) à 2.9 kg CO₂e
- Supplier H: Air freight (CN) à 2.45 kg CO₂e
- Supplier I: Ocean freight (CN) à 0.05 kg CO₂e

Emissions (per node): 15.8 kg CO₂e

Configuring software (Scope 2)
Once the PCBs and subassemblies are constructed and packaged in the plastic casing, the software is custom configured for the clients’ needs and subsequently tested for functionality at the Newark lab (California). Up to four racks of 42U (known as ‘clusters’) are configured at any one time. During configuration, the smallest low-density nodes work at ~100 W while the largest, high-density nodes work at ~250 W. The configuration process can take from a few hours to a few weeks to complete. Here, we assume the average node works at 175 W for 2 weeks. Therefore, configuration uses a total of 58,800 Wh (58.8 kWh).

Newark, CA electricity uses 0.23768 kg CO₂e per kWh.

Emissions (per node): 14.0 kg CO₂e
Transport to customer (Scope 2)
Once the software is configured and tested, the product is shipped to the customer. Softiron typically transports completed products by road or sea but may also transport products by air when operating on short time frames.

Of the sales made in 2021, Softiron expects 65% US-based clients, 25% UK/Europe-based clients, 10% Asia-Pacific-based clients. Assuming one-node weighs ~25 kg, estimations have been made (using Carboncare, 2021) for the emissions generated by transporting to customers based in the different locations:

Nodes transported (by road) from San Fransico, California to Kansas: 1011 kg CO$_2$e
Nodes transported (by sea) from San Fransico, California to London: 273 kg CO$_2$e
Nodes transported (by sea) from San Fransico, California to Bangkok: 81 kg CO$_2$e

Average emissions (per node): 2.7 kg CO$_2$e

End-of-life (Scope 3)
Softiron “follow industry best practice for end-of-life recycling and seek to improve this in future product designs”. Softiron also state that the new ‘modular design’ of the product improves potential for reuse of key subassemblies. However, Softiron products have an expected lifespan of 5+ years and as Softiron has only been shipping products for around 18 months, the company has little exposure to end-of-life/disposal of the product.

At present, the annual carbon footprint for product disposal is 0 kg CO$_2$e as no sold/installed product has reached end-of-life.

Plastic packaging (Scope 3)
To protect the product during shipment, nodes are packed in plastic. The exact type of protective plastic used is unknown, but it is most likely a form of polyethylene foam sheets. A single node is estimated to use 1 kg of protective plastic. Production of polyethylene uses 1,962 kg CO$_2$e/ton (or 1.962 kg CO$_2$/kg) and conversion uses 1,088 kg CO$_2$e/ton (or 1.088 kg CO$_2$/kg) (Zheng & Suh, 2019). Therefore, a single node is estimated to generate 3.05 kg CO$_2$e.

The supplier of the protective plastic is also unknown. However, the material is thought to be made in Texas, US and so an estimated value of 0.8 kg CO$_2$e per 1 kg node has been made for the emissions resulting from the transportation from suppliers (in Texas) to the San Fransisco manufacturing facility.

Emissions (per node): 3.85 kg CO$_2$e

Electricity during product operation (Scope 3)
Softiron have multiple different products (i.e. HyperDrive, HyperCast, HyperSwitch), each with differing energy demands. A given Softiron product’s energy consumption will also vary depending on its workload (ranging from <60W to >200 W). An investigation into the power consumption of a Softiron hard disk drive-based system found it to be working at 220W. However, 220W is almost certainly an overestimate for the average power consumption of a Softiron node as every deployment contains a multi-node “cluster” which will always contain some low-power nodes.

A unit working at 220W for 5 years (43800 hrs) uses 9636 kWhs.

UK electricity uses 0.23112 kg CO$_2$e per kWh (GOV.UK, 2021). [For alternative countries’ carbon conversion factors, see link]

Emissions (per node): ~2227 kg CO$_2$e

Manufacturing the PCB (Scope 1)
To manufacture the PCB, Softiron first produces the PCB substrate using polyepoxide. Then, they conduct metalworks and surface-mount the subassemblies. The energy usage involved in producing PCBs is not recorded by Softiron but is known to be an energy-intensive process.
Yung, et al. (2018) estimate that the carbon footprint of 1 m² of PCB is ~283 kg CO₂e, 57% (161 kg) of which can be attributed to the manufacturing (rather than the production of raw materials). Therefore, assuming that a single node contains 3 m² of PCB, manufacturing the PCB produces 483 kg CO₂e per node.

**Emissions (per node):** 483 kg CO₂e

*Installation (Scope 1&2)*

For every sale, SoftIron sends out two engineers to the customer site to help assist with installation (i.e. unboxing, on-site configuration and power-up). Here, there are scope 1 emissions relating to the onsite installation and scope 2 emissions associated with travelling to the customer site.

- Estimated installation (Scope 1) emissions: 5 kg CO₂e per node
- Estimated travel (Scope 2) emissions: 25 kg CO₂e per node

**Emissions (per node):** 30 kg CO₂e per node

**Total emissions per node**

Full life cycle emissions of a single SoftIron node: **2,898 ± 290 kg CO₂e** (assuming a 20% error bar)