Towards a Circular Economy: Recommendations for Circularity at UBC IT

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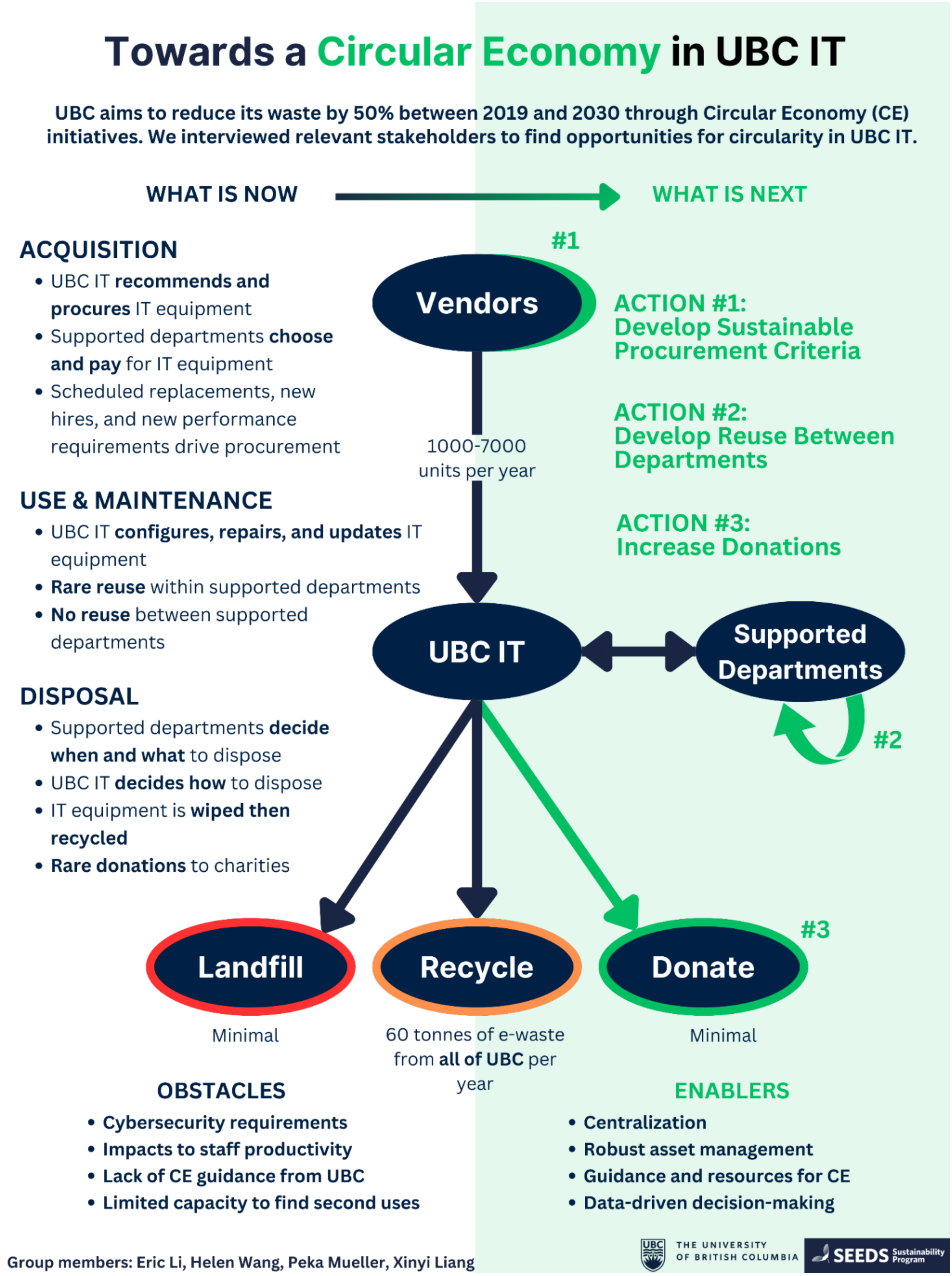
Practitioners’ Summary



Executive Summary

In its 2030 Zero Waste Action Plan, the University of British Columbia (UBC) committed to reducing waste disposal by 50% between 2019 and 2030, with a focus on Circular Economy (CE) initiatives. CE initiatives keep items out of the landfill for as long as possible through processes like reuse, refurbishment, composting, donation, and recycling.

Assets differ in their baseline material flows and opportunities for circularity. This project was focused on IT equipment managed by UBC IT due to its rapid turnover and large financial and environmental impacts. UBC IT manages about 60% of the IT equipment at UBC. Using a semi-structured interview approach, this project characterised the decision-makers, processes, and procedures shaping IT equipment flows through UBC IT. The sizes of the flows were quantified where data were available. Data collection across the IT equipment lifecycle varied in units and granularity, partly due to the decentralised structure of UBC IT. There were no data available to quantify internal reuse or external donations.

Stakeholders from UBC IT and UBC Finance were also asked to identify opportunities to implement circularity (i.e., to reduce waste) in IT equipment flows. First, they proposed the development of actionable sustainable procurement criteria, which would help to align IT procurement decisions with UBC's CE goals. Second, they suggested that supported departments could offer their used IT equipment to other departments before disposing of it. They noted that there is currently no interdepartmental reuse of IT equipment, even though supported departments have different needs, budgets, and replacement schedules. Third, they suggested that UBC IT could prioritise donations over recycling. While UBC IT has clear processes to prevent old IT equipment from entering the landfill, stakeholders acknowledged that some of what they recycle still has useful life left and could be donated instead.

The three key actions identified by UBC IT stakeholders are supported by the successful implementation of a circular IT asset management program at McGill University. In 2020, McGill's CE program facilitated the reuse of 186 servers, 43 desktops, and 7 displays. They also built a relationship with a non-profit organisation that accepted donations of used IT equipment, and they developed sustainable procurement criteria that will become increasingly stringent over time.

The UBC interviewees also identified obstacles and enablers to more circular IT equipment flows in UBC IT. The enablers, which support the three interventions identified above, included centralisation, robust asset management, data-driven decision-making, and CE guidance from UBC. The obstacles, which must be addressed to implement circularity, included cybersecurity requirements, potential impacts to staff productivity, and the lack of CE guidance from UBC. Stakeholders also highlighted that finding second uses for used IT equipment takes time and resources that UBC IT does not currently have.

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List of Abbreviations

AxM - Asset Exchange Manager
CAP - UBC's Climate Action Plan 2030
CE - Circular Economy
CRP - Critical Response Plan
DAE - Department of Alumni Engagement
DL - Distributed Ledger
EEE - Electrical and Electronic Equipment
EOL - End-of-Life
EPR - Extended Producer Responsibility
ERA - Electronics Recycling Association
EU - European Union
HWM - Hazardous Waste Management
MFA - Material Flow Analysis
MOL - Middle-of-Life
MSR - Minimum Standard Requirements
REC - Reuse Eligibility Criteria
SEEDS - Social Ecological Economic Development Studies
UBC - University of British Columbia (Vancouver Campus)
UBCO - University of British Columbia (Okanagan Campus)
UEMS - University Endpoint Management System
WEEE - Waste Electrical and Electronic Equipment
ZWAP – UBC's Zero Waste Action Plan: Towards a Circular Economy 2030

Introduction

1.1 Social Ecological Economic Development Studies (SEEDS) Sustainability Program

An initiative of the University of British Columbia (UBC), the Social Ecological Economic Development Studies (SEEDS) Sustainability Program connects students with faculty and staff to transform their motivation for sustainability into actionable research (UBC Sustainability, n.d.a). SEEDS utilises a "Campus as a Living Laboratory" approach to inform plans, practices, and policies that can progress UBC towards its sustainability targets. The creation of circular economies is one of SEEDS's five research priorities (UBC Sustainability, n.d.a). It aligns with UBC's environmental goals and the United Nations Sustainable Development Goals by advancing climate action, responsible consumption and production, and UBC's Zero Waste Action Plan: Towards a Circular Economy 2030.

1.2 UBC Action Plans and the Circular Economy

UBC Vancouver's 2030 Zero Waste Action Plan: Towards a Circular Economy (ZWAP) aims to achieve a 50% reduction in diversion to landfill for food scraps, recycling, garbage, and other materials by 2030 relative to 2019 (UBC, 2023; https://planning.ubc.ca/zero-waste-action-plan). The 21- page plan mentions the "circular economy" 25 times, demonstrating UBC's recognition of circularity as a means to achieve its social, economic, and environmental goals.

UBC's Climate Action Plan 2030 (CAP) aims for net-zero operational greenhouse gas emissions by 2035 (UBC, 2021; https://planning.ubc.ca/cap2030). The CAP also aims to reduce non-operational emissions from "commuting, food, business air travel, embodied carbon, waste and materials, and paper" by 45% by 2030 (UBC, 2021, p. 2). Importantly, by recognising the indirect and embodied carbon emissions associated with waste and materials, the CAP explicitly links UBC's zero-waste goals with its climate commitments.

While UBC Vancouver achieved a 29% reduction in its greenhouse gas emissions between 2007 and 2020, it did not meet the waste diversion targets set out by its first Zero Waste Action Plan, which launched in 2014 (UBC Sustainability, n.d.b; UBC, 2023). It attributed this failure in part to a "lack of data on types and quantities of waste disposed" and insufficient "human and financial resources needed to execute some high impact actions, such as enhanced data collection" (UBC, 2023, p. 4). Our project was a step towards overcoming these data and resource gaps in terms of IT equipment to begin the waste reductions envisioned by UBC's 2030 ZWAP.

1.3 Defining and Motivating the Circular Economy

The circular economy (CE) decouples resource extraction from economic growth (Ellen MacArthur Foundation, n.d.). The traditional linear economy operates under a "take-make-waste system" in which finite resources are continually extracted to make new materials, leading to waste, resource depletion, and high greenhouse gas emissions (Pan, Wong, & Li, 2022). To mitigate these effects, materials must be used more efficiently: they must be kept in circulation for as long as possible. Processes like reuse, intensified use, refurbishment, and recycling can accomplish this by creating circular flows around the linear economy (see Figure 1).

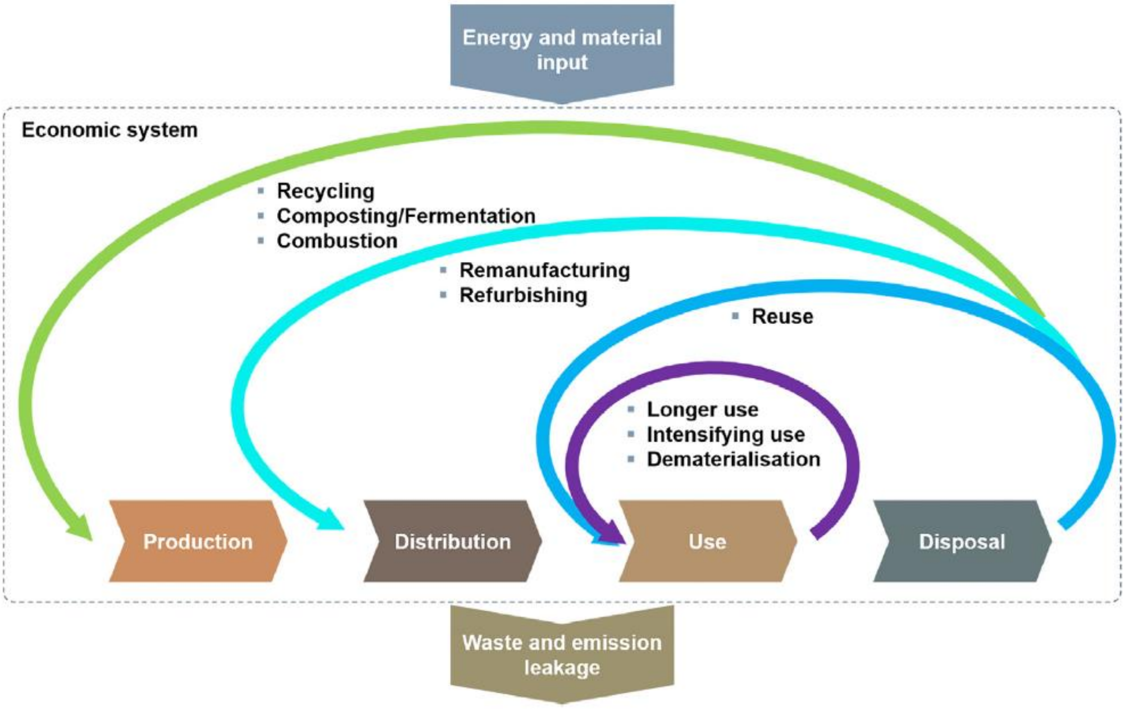

Figure 1. Circular flows are indicated by the curved arrows connecting the steps of the traditional linear economy. For example, recycling links disposal and production. From Geissdoerfer et al., 2020.

The CE concept is gaining traction as the problems caused by overconsumption and waste, including resource depletion and climate change, become increasingly urgent (Ellen MacArthur Foundation, n.d.; Gao, Song, & Fang, 2020; Leclerc & Badami, 2022). Moreover, by establishing markets for recycled materials, fostering innovation, and decreasing reliance on scarce resources, a CE can offer economic benefits, such as cost and energy savings (Murthy & Ramakrishna, 2022). The concept is therefore increasingly incorporated into institutional strategies and action plans for sustainability, including UBC's Zero Waste Action Plan (Wong, et al., 2021).

While organizational definitions of—and thus goals for—circularity vary, its general attraction is its balancing of environmental responsibility with economic growth and social wellbeing (Pan et al., 2022). In its 2030 Zero Waste Action Plan, UBC positions the CE as a way to reduce the amount of waste sent to the landfill. This project report thus understands "CE implementation" or a "successful shift to CE" as the lengthening of material life spans through processes like reuse, longer or intensified use, and refurbishment, with the primary aim of reducing waste.

1.4 Circular Economies and IT Equipment

There is agreement in the action-research literature that a successful shift to a CE will occur as a build-up of small-scale initiatives (Cramer, 2020; Leclerc & Badami, 2022; Wong et al., 2021). This is because different assets have unique barriers and opportunities for circularity. Our project was focused on IT equipment, which is an asset category characterised by its high costs, rapid turnover, large carbon footprint, and detrimental impacts on the environment (Islam et al., 2021; Leclerc & Badami, 2022). UBC's 2030 ZWAP does not mention specific plans for IT equipment.

In 2022, 62 million kilograms of e-waste were generated worldwide, with a reported collection and recycling rate of 22.3% (Baldé et al., 2024). The average annual growth in e-waste generation between 2010 and 2022 was 2.3 billion kilograms. Over the same period, the formal collection and recycling rate increased by 0.5 billion kilograms per year. E-waste generation is thus increasing almost five times faster than e-waste recycling efforts. Dumping, incinerating, and acid-leaching e-waste releases toxic fumes and contaminates soil and water with heavy metals, like lead and arsenic (Houessionon et al, 2021). Further, IT assets are carbon-intensive to produce. A 2013 study found that the greenhouse gas emissions associated with the manufacturing of IT equipment (also known as their embodied carbon emissions) were about 27 kg CO_2-eq per kg of product (Teehan & Kandlikar, 2013). Recovering metals through recycling lowers greenhouse gas emissions relative to mining (Baldé et al., 2024).

Despite the large financial, environmental, and data security concerns associated with IT equipment, there are few regulations or standard practices governing the sustainability of its life cycle (Mangold, Cristobal, Mars, & Dornfeld, 2015). The IT departments of large organisations are thus high-impact places to begin the implementation of CE principles (Boström, Gilek, Hedenström, & Jönsson, 2015; Leclerc & Badami, 2022).

Examples of Implementation

Quebec passed a law in 2011 that required publicly funded institutions to promote the longevity of their IT assets (Leclerc & Badami, 2022). McGill University responded by creating a circular IT asset management program that increased interdepartmental reuse from zero units per year in 2014 to 236 units in 2020 (Leclerc & Badami, 2022). Further, by centralising the collection of e-waste for refurbishment and recycling, they reduced environmental, reputational, and security risks: their new standard procedures ensure that all McGill devices are wiped prior to disposal and recycled by an approved Canadian recycler. There is additional information on the strategies and impact of McGill University's circular IT asset management program in the Results and Discussion sections.

The European Union (EU) has also countered its burgeoning e-waste problem with circular processes (Eurostat Statistics Explained, 2023). It implemented the Waste Electrical and Electronic Equipment (WEEE) Directive with the objective of reducing e-waste through recovery, reuse, and recycling. EU Member States are required to report annually on their compliance with WEEE targets. The volume of electronic and electrical equipment introduced to the EU market increased by 77.1% between 2012 and 2021. During that time, the amount of WEEE that was recovered increased from 2.6 to 4.4 megatonnes (+ 69.8%), while the amount of WEEE that was recycled and prepared for reuse increased from 2.4 to 4.0 megatonnes (+ 64.8%).

Apple serves as an example of internal reuse, designing devices using recycled or renewable materials to promote circularity in usage. Figures provided by Recover Approach of Apple indicate that more than 40,000 metric tons of electronic scrap was directed to recycling in 2023 (https://www.apple.com/ca/environment/#footnote-9). They claimed that each product contains materials suitable for making new products and operate a material recovery lab to reclaim more products using innovative tools (Apple, 2023). Crucial materials from iPhone devices were disassembled by robots and returned to the raw materials marketplace for recycling into next-generation products (Apple, 2023). Recovery of materials during disposal is crucial for maintaining a circular economy, and Apple exemplifies this through their old device reuse programs. Customers can trade in current devices for credit toward new ones, and the old devices can be transferred to new owners if they are in good condition (Apple, 2023). Ineligible devices can be recycled by Apple at no cost. These initiatives contributed to reducing electronic waste and promoting sustainability in the electronics industry.

Dell offers recycling or retiring services for used devices, but unlike Apple, which only recycles its own branded products, Dell accepts any brand (Dell, n.d). Dell has committed to keeping products and materials in circulation, pledging to reuse or recycle one metric ton for every metric ton of product bought by customers by 2030 (https://www.dell.com/en-ca/dt/corporate/social-impact/advancing-sustainability/accelerating-the-circular-economy.htm?hve=explore#anchor). Dell also offers refurbished products for reuse.

1.5 Research Objectives

Previous work on real-world CEs demonstrates that implementing circularity requires an understanding of baseline material flows (Leclerc & Badami, 2022; Wong et al., 2021). It also suggests that pilot projects should focus on one asset category because assets differ in their opportunities for circularity. Recognizing UBC's ever- nearing 2030 sustainability targets, and the significant environmental impacts of IT equipment, our project investigated the following questions:

1. What data are (and are not) available to characterise the procurement, use, and disposal of IT equipment under UBC IT's jurisdiction?
2. What decisionmakers, processes, and procedures govern the procurement, use, and disposal of IT equipment under UBC IT's jurisdiction?
3. What are the opportunities to implement circular economy principles in IT equipment flows at UBC IT? What could prevent or enable UBC IT from taking these opportunities?

The scope of our analysis was primarily focused on IT equipment managed by UBC IT, which accounts for around 60% of total IT equipment at UBC. We also interviewed stakeholders from the Faculty of Forestry, UBC-Okanagan, and McGill University to learn about their IT equipment management.

There are three lifecycle stages in which a university has jurisdiction: procurement, use, and disposal (Leclerc & Badami, 2022; McGill Procurement Services, 2015). For this project, procurement included purchases made by UBC IT for itself or supported departments. The use stage included IT equipment that is actively used or stored by UBC IT and/or its supported departments—i.e., all IT equipment that has been procured but not yet disposed of. Disposal included any pathway through which IT equipment controlled by UBC IT leaves the University, whether official (through UBC's designated e-waste recycler, FCM Recycling) or unofficial (donations, landfilling, or other means).

Background

2.1 Measurement: The First Step towards Circularity

UBC must understand the baseline flows of its asset categories to identify opportunities to move towards a CE (Wong et al., 2021). The first step towards changing a material flow is to measure it—but there is disagreement about what to measure (Cramer, 2020; Leclerc & Badami, 2022). Industrial ecologists, for example, tend to focus on quantifying the size of various material flows. In contrast, Leclerc and Badami (2022), the action-researchers that successfully implemented CE principles into IT asset management at McGill University, focused their baseline analysis on the management of IT equipment flows rather than the quantity. They argued that identifying key decision-makers, and the factors and processes that guide their decisions, is the first step to changing material flows.

This project primarily studied the flows of IT equipment under UBC IT's jurisdiction. According to Brett Thompson from UBC IT, this department controls the majority—about 60%—of UBC's IT equipment. According to UBC IT's procurement data, 6.4 million Canadian dollars worth of IT Assets were purchased through UBC IT between 2015 and 2019. Faculties and departments at UBC can opt in or out of support from UBC IT. There is a list of fully supported faculties and departments published on the UBC IT website (https://it.ubc.ca/about/client-service-manager-portfolios). Notably, the Faculty of Arts and the Faculty of Forestry maintain their own IT departments. Narrowing the scope to UBC IT reduced the complexity of our project, and it made sense because an effort towards institutional circularity would likely require more centralisation in IT asset management (Leclerc & Badami, 2022). In order to compare UBC IT's practices with other IT asset management systems, both circular and non-circular, we included the Faculty of Forestry, UBC-Okanagan, and McGill University in our analysis.

2.2 The Size of IT Equipment Flows at UBC IT

Procurement

We acquired UBC IT's procurement data for 2015-2023 (see Figure 2). These data record purchases from UBC IT's primary vendor, Microserve. The dataset was presented as an Excel spreadsheet, where each row logs a purchase, and the columns indicate the UBC PO number, Microserve number, purchase and invoice dates, and the make, model, quantity, and description of equipment. Unit price and extended price were also available columns from 2015-2019 but not 2020 onwards. The date, quantity, and description fields were most useful to understanding these data.

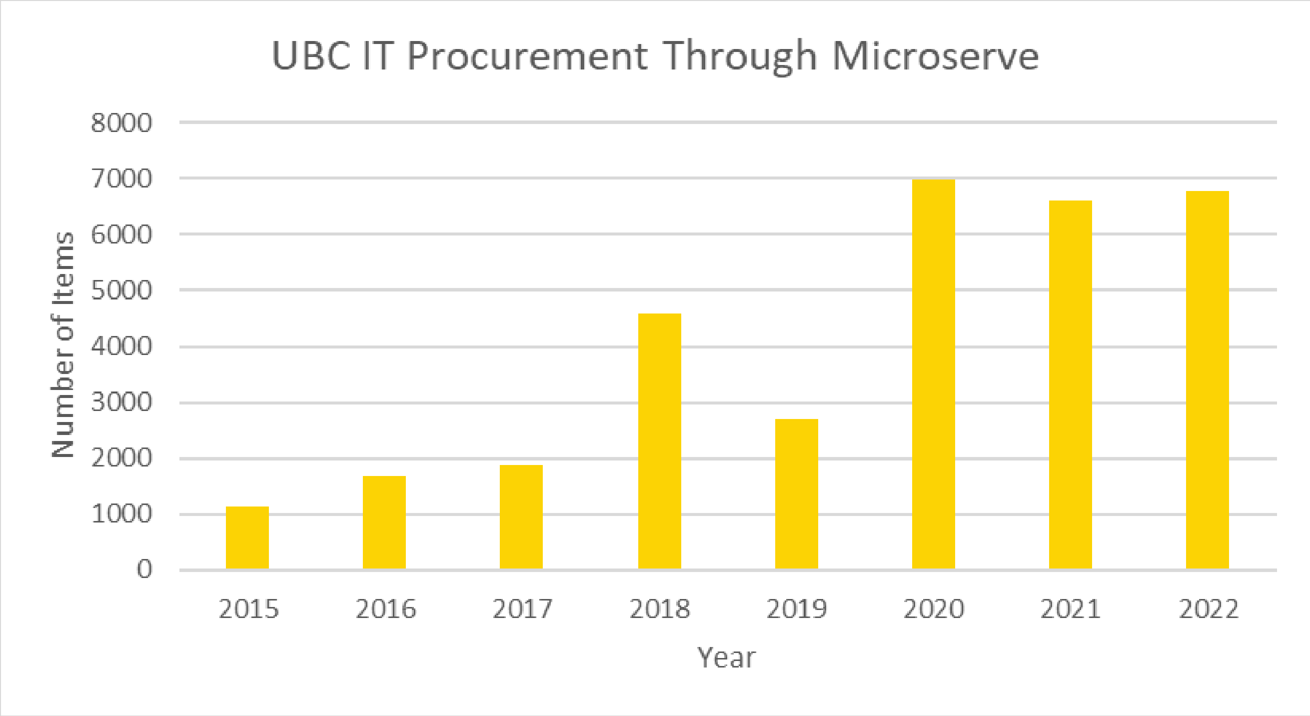

Figure 2. UBC IT procurement data from 2015-2022 from purchase record spreadsheets provided by Microserve (via UBC IT). Yellow bars show the number of units procured each year. Procured Items encompass desktop PCs, laptop PCs, all-in-one PCs, cameras, monitors, printers, projectors, tablets, headphones, docking stations, cables, and more.

The 2018 procurement data was an outlier relative to neighbouring years due to the procurement of a multitude of peripherals[1]; the exact reason for this was not known even after corresponding with an expert at UBC IT. With this outlier aside, there are between 1000 and 3000 pieces of IT equipment procured annually between 2015 and 2019. There was a marked increase in procurement beginning in 2020, which according to UBC IT experts was due at least in part to the COVID-19 pandemic. The pandemic forced UBC to rely more heavily on remote and hybrid work, which required additional and different IT equipment. UBC IT experts also indicated that updated security protocols have led to a shift to using Windows 11. Older equipment without TPM 2.0 (a hardware-based security microcontroller that only exists in newer equipment) was unable to support Windows 11 and needed to be replaced, which kept procurement relatively elevated. Overall, there are between 6500 and 7000 units of IT equipment procured annually between 2020 and 2022.

Disposal

The disposal data was much less detailed, with only a summary of tonnes of e-waste collected per year by UBC's designated e-waste recyclers, FCM Recycling[2] and the Electronics Recycling Association (ERA[3]). FCM Recycling data was separated into two categories[4]: 1) monitors and computers, and 2) peripherals and other electronics. Between 40 and 70 tonnes of e-waste are disposed of annually, with the majority recycled by FCM Recycling as opposed to the ERA (Figure 3). According to an expert from UBC IT, all of UBC's central and independent IT departments dispose of

[1] See Appendix A for a categorised analysis of 2018 procurement alongside of 2017 and 2022.
[2] FCM Recycling: https://fcmrecycling.com
[3] ERA: https://www.era.ca
[4] See Appendix B for FCM Recycling data by category.

End-of-Life[5] (EoL) IT equipment in designated bins across campus, which was collected and stored by Building Operations until there was enough for FCM Recycling to pick up. By contrast, ERA only collected smaller quantities of various sources of e-waste around campus and was not affiliated with UBC IT.

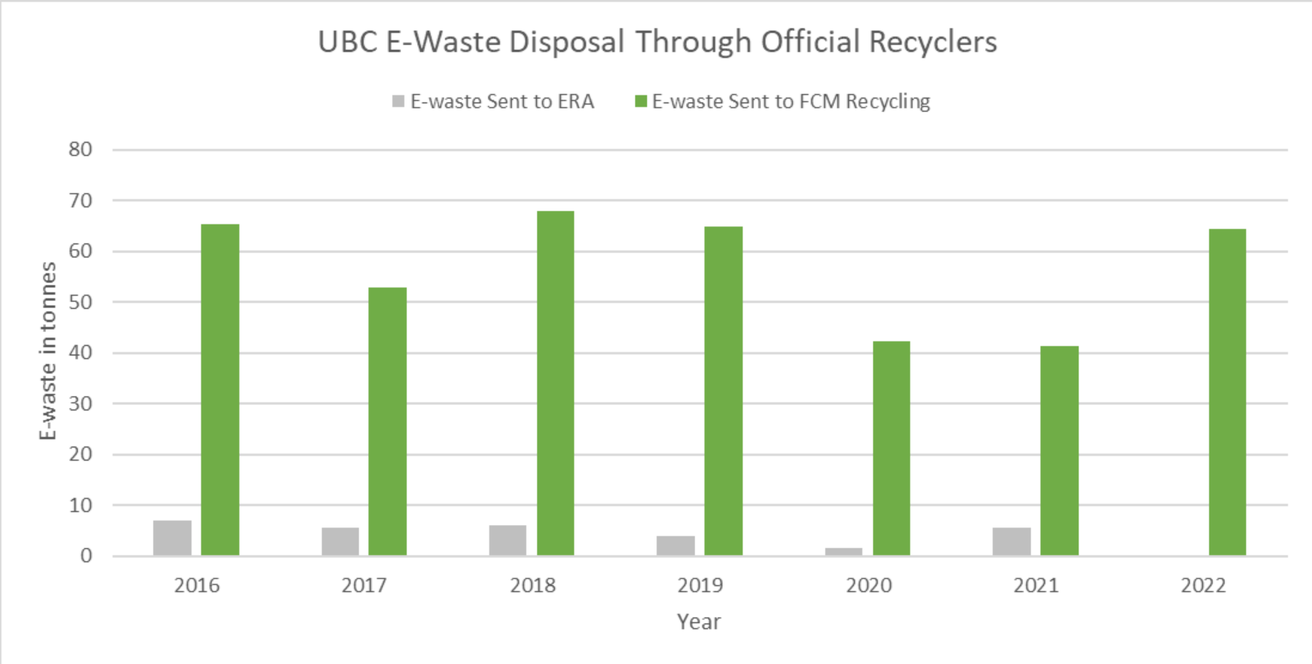

Figure 3. Total UBC e-waste collected by FCM Recycling and the Electronics Recycling Association (ERA) in tonnes from 2016-2022. The green bars represent the tonnage of e-waste sent to FCM Recycling each year, and the grey bars represent the small amount of e-waste from various other sources on campus sent to ERA. Note: ERA data from 2022 was not yet available.

2.3 Material Flow Analysis and Circular Economy

There is disagreement in the literature about what needs to be measured to understand baseline material flows and move towards a CE. The Material Flow Analysis (MFA) method characterises the size and direction of a material's flow into, within, and out of a clearly defined system, and can be visualised with a flow chart or a Sankey diagram (Gao et al., 2020). Some previous studies assessed circularity through an MFA (Agamuthu, Kasapo, & Mohd Nordin, 2015; Islam et al., 2021; Lombardi, Amicarelli, Bux, & Varese, 2023; McMahon, Uchendu, & Fitzpatrick, 2023). This method establishes a system's boundaries and identifies its flows and stocks, then attempts to quantify the size of the flows and stocks using consistent units. This information allows investigations into past trends, potential impacts of waste reduction strategies, and opportunities for performance monitoring and evaluation. For example, Agamuthu et al., (2015) used an MFA to study IT asset management at seven universities across Malaysia and found that only around 60 percent of used IT assets were recycled while around 37 percent were improperly disposed of. They used their quantitative data to conclude that institutional policy on e-waste management was needed to keep IT assets out of the landfill.

[5] Andersen and Jæger (2021) defined EoL products as products that are recycled, disposed, or deemed unable to be repaired or refurbished. This is slightly different from "used" equipment that could still be reused, repaired, or refurbished.

Material Flow Analysis at UBC IT

We initially set out to do an MFA that tracked and quantified the flows of IT equipment controlled by UBC IT. However, our literature review and experience with the data collected by UBC revealed that this approach, while possible, would be time-consuming and assumption-laden. For example, the mismatch between the procurement and disposal data would require broad assumptions, limiting the potential to draw conclusions from the findings. FCM Recycling measures the mass of e-waste collected, while UBC IT's vendor records the number and type of IT equipment procured. Material flow analysis requires standardisation to the same units to compare the quantities of inputs and outputs (Lombardi et al., 2023; Aguilar-Hernandez et al., 2019). The conversion of procurement data into tonnes can only be estimated and may lead to inaccuracies (see appendix A for our attempt at a rough conversion). Further, the data from FCM Recycling do not differentiate between the source of the IT equipment, and UBC's e-waste has more sources than UBC IT. Any staff or student who follows UBC's e-waste guidelines (https://buildingoperations.ubc.ca/accountability/sustainability/zero-waste/e-waste/) will have their old IT equipment included in the annual tonnage reported by FCM Recycling and the ERA.

Ultimately, IT stakeholders at UBC have differed in their goals, and in their documentation of progress towards those goals (Wong et al., 2021). Collecting and collating data across a large, decentralised university is a challenging and time-consuming task. For example, we heard from an expert at UBC IT that old IT equipment is occasionally donated, but never tracked: quantifying that flow would require parsing through many years of emails. Even if a piecemeal dataset is acquired, standardising its units, time period, and other details would require many assumptions and estimations.

As we began exploring other methods of analysing baseline material flows in the literature, it became clear that an MFA is not necessarily the most useful first step towards a CE. An MFA is certainly useful as a subset of information, but it is painstaking to construct in the context of a large and decentralised university—it requires robust and consistent asset tracking across units and years, and is thus more likely an outcome of, rather than a necessary precursor to, CE implementation. Even McGill University, which began implementing its CE program in 2014, still lacks the data to complete a full MFA (Leclerc & Badami, 2022). McGill relies on different indicators for each of its flows to measure progress towards circularity, including the percent of IT purchases that meet their sustainable procurement criteria (procurement stage), the number of units internally reused (use and maintenance stage), and the tons of e-waste sent to their external recycler (disposal stage).

2.4 Qualitative Investigation Supports Circularity

An MFA quantifies "what is". The precision and transparency of this approach is appealing, particularly in a setting where progress towards a CE must be continuously justified, measured, and evaluated. However, an MFA is not designed to identify the details that are crucial to real-world CE implementation, such as key decision-makers and the forces or processes that guide their decision-making (Leclerc & Badami, 2022; Wong et al., 2021). An MFA does not study the factors shaping the sizes of the flows and stocks, and thus fails to indicate the easiest or most impactful opportunities to intervene. For example, an MFA might reveal that most IT equipment is recycled rather than landfilled—but it does not explain why that is, nor generate ideas for solutions.

The few examples of real-world CE implementations documented in the literature suggested that qualitative data about the decision-makers and processes shaping material flows is more actionable than quantitative data on the size of those flows (Cramer, 2020; Leclerc & Badami, 2022; Wong et al., 2021). For example, McGill University held 20 semi-structured interviews with IT stakeholders and determined that there was an appetite for internal reuse: some IT units were interested in acquiring the items disposed of by other units. That information justified the development of a CE program that reused 186 servers, 43 desktops, and 7 displays in 2020. Similarly, a successful CE program developed by the Amsterdam Economic Board (which works with industry, academics, and municipalities in the Amsterdam Metropolitan Area) conducted 98 interviews to develop objectives, roles and responsibilities, and new ideas for circularity initiatives (Cramer, 2020). The outcomes of these interviews included a commitment signed by 31 municipalities and two provinces to achieve 50 percent circular procurement by 2025, as well as investments in circular initiatives in IT business equipment, office furniture, and three other product groups.

Given that UBC has limited time and resources to transition to a CE, it must select the most efficient approach to understanding baseline material flows. An MFA provides useful information but is time-consuming in a large, decentralised university context—it is perhaps better viewed as an outcome, rather than an enabler, of a well-tracked CE (Wong et al., 2021). Imperfect metrics and indicators can be iteratively improved as the organisation learns how to implement and measure CE (Leclerc & Badami, 2022). Semi-structured interviews are an efficient means to understanding decision-makers and their decision-making processes. Further, by capturing the obstacles, enablers, and internal motivations for a CE, semi-structured interviews form a bridge between "what is" and "what ought to be"; they make it easier to identify next steps (Leclerc & Badami, 2022). The rest of this report details the outcome of this approach for IT asset management at UBC IT.

Research Methodology and Methods

3.1 Primary Data Collection: Semi-Structured Interviews

Semi-structured interviews are commonly used to qualitatively assess baseline material flows (Agamuthu et al., 2015; Boström, Gilek, Hedenström, & Jönsson, 2015; Cramer, 2020; Leclerc & Badami, 2022). They can be structured with closed- and open-ended questions, as well as follow-up questions, allowing interviewers and interviewees to introduce new ideas or unforeseen issues (Adams, 2015). Adams (2015) notes that semi-structured interviews are useful when “examining uncharted territory with unknown but potentially momentous issues [in which] your interviewers need maximum latitude to spot useful leads and pursue them” (p. 494). Real-world CE implementation is largely “uncharted territory”, and semi-structured interviews have allowed researchers to study circularity in large, decentralised systems while also building rapport with decision-makers (Cramer, 2020; Leclerc & Badami, 2022). Further, semi-structured interviews can both complement quantitative data and fill gaps where no quantitative data exists (Castleberry & Nolen, 2018). For example, semi-structured interviews could be used to explain the large variation in UBC IT’s annual purchases, and to find out whether internal reuse and donation, which are untracked, are occurring within UBC IT.

Leclerc and Badami (2022) developed interview questions for their baseline and benchmark analysis of IT asset flows at McGill University (see Table 1). The baseline analysis documented IT flows and their determinants within McGill University, while the benchmark analysis enabled a comparison with other large Quebec universities. Leclerc and Badami’s (2022) questions prompted participants to describe the policies and procedures guiding IT asset management from procurement to disposal. They also asked for suggestions on how to make IT equipment flows more sustainable, or circular (“Visioning Questions” in Table 1). The questions are thorough but generic enough for use at other institutions.

Table 1. Questions for semi-structured interviews with IT stakeholders at UBC, adapted from Leclerc and Bada mi (2022).

Life Cycle Stage	**Material Flow Questions** *(What is?)*	**Visioning Questions** *(What ought to be?)*
Procurement	• What drives acquisitions (budget availability, scheduled replacements)? • Who decides what is purchased, based on what criteria? • How are acquisitions made, and through what purchasing mechanism? • Who decides on equipment allocation, and based on what criteria? • Do you keep an inventory? Who feeds the info into the inventory? • Can you reuse existing IT equipment instead of acquiring new equipment?	In an ideal world, how would IT acquisitions work at the University? What should be changed, in support of improved, more sustainable, material flows?
Use and Maintenance	• Who maintains the IT equipment in your unit? • Is equipment shared? • Who decides if the equipment gets upgraded, and how? • If you have an inventory, is it updated to reflect equipment condition? • Is equipment use monitored to optimise allocation?	How could the use and maintenance of university IT equipment be improved? What changes or improvements would you like to see?
Disposal	• Who decides if an equipment is no longer needed, based on what criteria? • How does used equipment get wiped, and by whom? • Where does used or End-of-Life equipment go, and who decides this? • If you have an inventory, does it get updated to reflect equipment decommissioning and removal? • Is used equipment offered for reuse, and if so to whom, and how? • Does parts harvesting happen, and if so, who allows this?	How could the management of used and End-of-Life IT equipment be improved?

Following Leclerc and Badami (2022), we conducted a baseline analysis of IT equipment flows by holding 45-minute interviews with five stakeholders from UBC IT and UBC Finance. Interviewees were sent the list of questions ahead of time (Table 1). They were asked all of the same questions, including the visioning questions. We also asked interviewees for datasets that could bolster our quantitative understanding of material flows, but none provided any relevant data. The interview consent form provided to interviewees can be found in Appendix C.

The visioning questions were designed to illuminate the ideas of the employees managing the material flows being studied—which, in this case, are only the employees of UBC IT and UBC Finance (Leclerc & Badami, 2022). Research shows that employee motivations and interests matter to the success of an organisation's sustainability initiatives (Boström et al., 2015; Cramer, 2020; Leclerc & Badami, 2022). Further, the coordinator of a successful reuse program at UBC (https://reuseit.ubc.ca/) emphasized that sustainable solutions appeal to UBC stakeholders for different reasons, and that understanding the broad appeal of sustainability, including CE initiatives, may lead to its broader uptake. For example, some reuse items to reduce their costs, while others do it to lessen their environmental impact. Given that employees managing UBC IT's IT assets may be given new roles and responsibilities in the shift towards CE, it is important to investigate their visions and motivations for sustainability (Leclerc & Badami, 2022).

The stakeholders from UBC IT were recommended by Brett Thompson (Desktop Services Team Lead, UBC IT) based on their knowledge of IT asset management. A procurement officer was identified from the UBC Finance website (https://finance.ubc.ca/procure-pay/need-assistance/contact-your-procurement-officer) because they specifically support procurement for UBC IT. Another procurement officer at UBC Finance, who wishes to remain anonymous, was also interviewed. The following four UBC stakeholders consented to being acknowledged by name as a source of information for this report:

- Edith Domingue, Client Services Manager - Engagement Services, UBC IT
- Robert Stout, Desktop Services Team Lead, UBC IT
- Brett Thompson, Desktop Services Team Lead, UBC IT
- Tassadite Delepine, Senior Procurement Officer, UBC Finance

Those that consented to being directly quoted are anonymised in the Results section.

For our benchmark analysis, we held three interviews with stakeholders from McGill University, UBC Forestry IT, and the UBC Okanagan IT department. They were identified from our literature review or recommended by Brett Thompson. All of these interviewees consented to being acknowledged by name as sources of information:

- Stéphanie Leclerc, Program Manager, Sustainable Procurement and Asset Management, McGill University
- Carl Johansson, Director, UBC Forestry IT
- Stacey Broderick, Buyer, UBCO Finance

They all consented to being directly quoted in the report. These interviewees also received the questions before the interview (Table 1). They were not asked the visioning questions.

3.2 Data Analysis

Interviews were recorded and transcribed using Zoom closed captioning. Once the audio transcripts were converted from a VTT to a .docx format, they were checked and edited for accuracy by watching the video recording. This took time but helped us familiarise ourselves by reading and re-reading the interview data, which aids the analysis process (Castleberry & Nolen, 2018).

The material flow questions (Table 1) were fact based rather than opinion based and did not require thematic coding. Following Leclerc & Badami (2022), the information presented in these interviews was summarised with a focus on decision-makers, processes, and procedures guiding IT equipment flows at each lifecycle stage. The interview questions were designed to get these details from interviewees (Leclerc & Badami, 2022). For example, at the disposal stage, we asked:

- Who decides if an equipment is no longer needed [decision-maker], based on what criteria [procedure]?

- Where does used or End-of-Life equipment go [process], and who decides this [decision-maker]?

Note that a process refers to a set of tasks while a procedure specifies the steps of a single task (Babb, 2024). The benchmark analysis included one stakeholder per organisation, while the baseline analysis synthesized interviews with five stakeholders. For the baseline analysis, we created a document that organised all of the relevant answers—not all stakeholders could provide relevant answers to all questions—question by question (Vaughn & Turner, 2015). This made it easier to identify new or repeated ideas, and thus to create one summary out of several interviews.

The visioning questions, which were speculative and opinion-based, were thematically analysed. Thematic analysis is commonly used in qualitative research to identify and analyse themes, and to report emerging conclusions from text data like interview transcripts (Castleberry & Nolen, 2018; Braun & Clarke, 2008). Coding is “the process by which raw data (e.g., transcripts from interviews and focus groups or field notes from observations) are gradually converted into usable data through the identification of themes, concepts, or ideas that have some connection with each other” (Austin & Sutton, 2014, p. 439). The answers to the three visioning questions (one per lifecycle stage) were collated into a single document and organised question by question (Castleberry & Nolen, 2018; Vaughn & Turner, 2015). Following Wong et al. (2021), the review and coding of the visioning questions was performed as a group to promote inter-coder reliability. Ideas that were repeated within and between interviews constituted a “code” (Gibbs, 2007). We used an inductive approach, often called open coding, which is common in qualitative research: the codes emerged from the data rather than being constructed before or separately from them (Gibbs, 2007; Kuper, Reeves, & Levinson, 2008). This approach accepts that it is impossible to avoid bias during data interpretation, but it still requires researchers to try, as much as possible, to avoid imposing their preliminary ideas and presuppositions on the data (Gibbs, 2007).

We read each transcript individually, then held a group discussion about the new or repeated ideas that we observed. We coded the transcripts by labelling the sections of text (on paper) that expressed the same idea (Gibbs, 2007). Each passage of text labelled with a particular code was thus an example of the same idea, or code, which enabled a structured organisation and examination of the data. Codes were refined and defined iteratively as the transcripts were read and discussed. We saw relationships within the final list of codes, so we grouped similar codes into “themes” (Gibbs, 2007). The themes, codes, and examples are presented in the Results section.

Results

4.1 Baseline Analysis - UBC IT

According to an expert from UBC IT, UBC IT maintains about 60% of the IT equipment at UBC, including devices in computer labs, libraries, and administrative units. Here is what we found about the current processes at UBC IT:

Procurement

Factors driving the acquisition of new equipment varies between units. It is often life-cycle based; in many units, there are scheduled replacements based on equipment age. For example, Desktop Services (which provides IT support to its own department, UBC IT) replaces units once they are four years old, which is one year out of warranty. New equipment is also procured for new hires and to replace equipment that no longer meets performance requirements, particularly those related to cybersecurity. For example, laptops that cannot install newer versions of Windows are not secure and must be replaced, and “the push to Zoom and the push to Teams…really sort of drove a requirement for memory usage” (UBC Expert #1).

Supported units—i.e., units that do their IT procurement and maintenance through UBC IT—ultimately decide what equipment to purchase. They may choose standard equipment that has been vetted and recommended by UBC IT, or they may request something else. UBC IT will research the alternative equipment to ensure that it is supportable. UBC IT provides standards and advice, but individual units ultimately determine their purchases based on their unique needs and budgets.

Purchases over $75,000 must go through a bidding process facilitated by UBC Procurement. For purchases above and below $75,000, procurement criteria include performance and pricing: the responsible spending of public funds is the first priority. UBC Procurement stated that while there is an effort towards sustainability, the existing sustainability criteria are too general to be actionable, and contribute about 5 of the 100 possible points used to judge vendors. Procuring a large number of units at once yields a significant discount. For this reason, UBC IT strives to reduce the overall order volume by grouping orders into larger cross unit purchases. One-offs are procured throughout the year as needed.

When a unit wants to purchase equipment, it submits a request to UBC IT. Their order is placed through Workday, which is connected to the primary vendor used by UBC IT, Microserve. UBC IT configures the new equipment by installing Windows and other supported software, then hands it off to the staff.

Use and Maintenance

UBC IT maintains its clients’ IT equipment. They manage software updates, facilitate warranty repairs, and ensure that active devices meet security requirements.

UBC IT manages a “considerable amount” of shared IT equipment, such as computers in labs and libraries (UBC Expert #1). IT equipment is generally not shared between staff members—allocation tends to be one personal computer per staff member—with the exception of some place-based roles, like receptionists. The growing trend towards hybrid work and hotelling stations leads to some sharing of IT equipment (mouse, docking station, monitor) but having a home- and office-setup may increase IT equipment use overall: “is it shared or is it duplicated” (UBC Expert #2)? Further, “laptops provide a lot of functionality but they’re more impactful on the environment than desktops ever were” (UBC Expert #1).

UBC IT can see when equipment connects to the UBC network, making it possible to see which devices are still in use. When equipment is configured, the information captured includes warranty dates. It is thus possible to see when active equipment was procured, and to make recommendations that it should be replaced. The last active time of shared devices in labs and libraries is checked to determine whether they are used regularly enough to eventually warrant replacement.

In some cases, existing equipment may be reused instead of replaced. However, “there’s a line between productivity and cost thriftiness” (UBC Expert #1). In other words, extended equipment lifespans may generate cost-savings, but they also risk decreasing staff performance: new equipment performs better than old equipment. Understanding this trade-off is a crucial precursor to extending equipment lifespans. Equipment is typically warrantied for 3-4 years, after which the cost of keeping that device in use increases. Lastly, reuse can only occur up to a certain point. Some devices are too old to support required updates, like Windows 11. Performance, warranty, and cybersecurity are thus important obstacles to reuse.

Disposal

It is seen as an industry best practice to replace IT equipment after 3 to 5 years. One stakeholder suggested that this is an informal deadline for UBC IT, but it is not “something currently seen as a written UBC practice” (UBC Expert #1). This is largely for security reasons but also reflects the fact that older equipment becomes more onerous in terms of repairs and buying additional warranty. Few, if any, units replace their IT equipment on a 3-year schedule: “as a general rule people tend to extend for as long as they can…in a sense having a budget keeps us doing the right thing and not replacing so often” (UBC Expert #2). UBC Expert #1 also noted that individuals are often reluctant to replace their old IT equipment because it takes time to set up and get accustomed to a new device: “there’s a certain level of avoidance there…more avoidance than I would expect.”

UBC IT can make soft recommendations to replace equipment. These recommendations are typically based on 1) age, 2) inability to meet cybersecurity standards, 3) personal willingness, and 4) declining equipment performance. Age is the most important factor, as many departments have scheduled replacements based on a 3- to 5-year lifecycle. Units tell UBC IT which computers they would like to have disposed, and their criteria for this decision is generally age. Occasionally there are other factors, such as cybersecurity requirements. For example, UBC Expert #2 is currently going to various units that they support to say, “hey, you’ve been using this laptop now for 7 years, or 8 years, and we can no longer install Windows…you will need to replace this because this is too old, and we cannot secure this equipment any longer.”

Ultimately, the decision of whether or not to replace IT equipment rests with the client. While meeting cybersecurity standards is a requirement, individual units can speed up or slow down the replacement process based on their needs and budget. For example, the Department of Alumni Engagement (DAE) has the budget to maintain a 4-year lifecycle for their IT equipment. Desktop

Services also aims to replace IT equipment after 4 years (one year after the warranty expires). Other units with lower budgets are willing to risk keeping equipment for longer after the warranty expires.

Once units decide to dispose of IT equipment, they hand it off to UBC IT. All equipment is wiped by UBC IT prior to disposal. The disk is either physically destroyed or wiped using security-approved software solutions (like DBAN). Encrypted drives do not need to be physically destroyed—just wiped. Machines are generally recycled, but occasionally donated. The interviewees characterised the landfilling of IT equipment as very rare.

Recycling is the "fastest option" for disposal, but old IT equipment is donated when possible and efficient. There is no mandate for the disposal method, other than the fact that removal must adhere to security standards—i.e., ensure that the hard disks are wiped. When "equipment hits that 4-year mark, it is pretty much typically recycled. That being said, nobody likes to do it… [an employee at Desktop Services] makes sure he has 20 laptops at all times at his desk because we get asked for charity donations…so, we do that because there's life in the equipment" (UBC Expert #1). There are lots of special events that benefit from a free laptop pool. One stakeholder mentioned that the DAE recently disposed of 40 desktop computers, which UBC IT intends to donate, rather than recycle, once they are wiped.

The number of laptops that leave the University via external reuse is not tracked, but probably occurs two to three times a year. Typically, charities are not interested in one-offs; it is only worth it to come to UBC for larger bundles of devices (for example, if all the computers in a lab are replaced). There may be some reuse within departments but not between them.

Parts harvesting is very rare, largely due to the fact that it is now common for everything to be soldered onto a single board, especially in laptops and compact desktop PCs. It is more cost-effective to go through warranty replacement channels, and to recycle old equipment, than to maintain a team that is qualified to harvest and replace parts. There are very rare instances where parts from an old machine are repurposed, but that happens unofficially: it is a gray area because the donation of parts between departments technically has a financial impact. Students have been observed harvesting parts from the recycling bins, but there are security concerns that need to be dealt with before making used equipment widely available to students.

The key issue limiting the external reuse of equipment is time. "If we want to make it ready for second use by someone, it's a lot more work…most teams don't have the time or the capacity to do that sort of task" (UBC Expert #2). Time spent sourcing options for external reuse takes away time from procurement and supporting users with their current equipment. "…recycling is the fast option…no one is resourced in a way to be able to spend the time and effort to find a second use for those computers" (UBC Expert #2).

The issue with making used equipment available to staff and students for external reuse is the risk of that equipment coming back into use at UBC. This equipment has been deemed unfit for UBC usage, so any solution involving re-selling or donating to students or staff must have a way to keep that equipment out of UBC.

Asset Tracking

There is no full inventory of all equipment procured and supported by UBC IT. UBC IT manages inventory information (who has what, how many computers, how old, warranty expiration) for some clients, but others manage their own. Desktop Services, for example, maintains “a very meticulous spreadsheet of exactly who has what and for how long they’ve had it” (UBC Expert #1). Athletics has a “fantastic” asset management system that they manage themselves.

The inventory data provided by UBC IT to a few of its clients is all entered manually. However, they are working with Service Now to create a more automated system for asset management. The goal is to automatically import vendor data to the inventory, which would still require manual entry to track some details, like the equipment user. Disposal can also be tracked within Service Now—there is a place to record the method of disposal (recycling, donation).

The University Endpoint Management System (UEMS) is a bit like an inventory: it is a database of active computers used to push out updates, among other things. Devices that log on to the network are added to the UEMS automatically. It also updates automatically: inactive devices are removed completely after 90 days.

Overall, “there is no fiscal requirement from the university…to actually track any of this hardware at any given time. However, functionally…our clients really need to maintain some level of visibility on who has what. And typically, that’s generated through [Desktop Services]” (UBC Expert #1).

For the most part, equipment decommissioning and removal are untracked. There is no mandate to track these things. Inactive devices disappear from the UEMS (the active directory) after 90 days, so that is automatically updated to reflect disposal. There is no record in the UEMS indicating that the disposed IT equipment ever existed. However, the new ServiceNow system, which is being tested in a few small units, does track this. There is a record of the device—of its specific serial number—being decommissioned, and a section to record the disposal method, as well. “…from my practical operations side, there’s no difference between me putting it physically into a recycling bin to sending it to, you know, some researcher out there in the world” (UBC Expert #1). An inventory might capture that a device has been removed, but it probably will not distinguish between donation and recycling because there is no mandate to do so.

Visions for Circularity

Stakeholders from UBC IT and UBC Finance were asked three visioning questions:

1. In an ideal world, how would IT acquisitions work at the University? What should be changed, in support of improved, more sustainable, material flows?
2. How could the use and maintenance of university IT equipment be improved? What changes or improvements would you like to see?
3. How could the management of used and End-of-Life IT equipment be improved?

Codes were developed for each new or repeated idea that we encountered in the interview transcripts. Codes were sufficiently generalised to capture several passages of text. Three themes emerged from the relationships that we observed within the final list of codes and are defined as follows:

1. **Actions:** Steps that directly improve circularity
2. **Obstacles:** Concerns that must be addressed or overcome to improve circularity
3. **Enablers:** Steps that indirectly improve circularity by driving **Actions**

After developing the themes and codes, one team member reread the transcripts for the material flow questions and found that many of the actions, obstacles, and enablers were also mentioned there. The list of codes developed for the visioning questions was therefore applied to the material flow questions using deductive coding. Deductive coding “refers to a coding process aimed to test whether data are consistent with prior assumptions, theories, or hypotheses” (Chandra & Shang, 2019, p. 92).

By applying our initial set of codes to the material flow question data, we found additional support for the codes and themes that we developed from the visioning questions. It also helped us to expand and refine our codes. For example, cybersecurity and declining staff productivity were frequently mentioned in the material flow questions as disincentives for extending equipment lifespans. These are thus clearly obstacles to developing interdepartmental reuse, even if they were not mentioned explicitly within the answers to the visioning questions.

Table 2 contains themes, codes, and examples of direct quotes from both the visioning (V) and material flow (MF) questions: it is increasingly specific from left to right. Note that several relevant examples were excluded because not all interviewees consented to being directly quoted.

Table 2. Themes, codes, and examples derived through thematic analysis of visioning questions asked to stakeholders from UBC IT and UBC Finance.

Themes	Codes	Examples
Actions	Develop sustainable procurement criteria	“What’s the potential impact of switching an entire fleet of devices from 13 inch to 14 inch displays? Is there a responsibility for us to sort of make certain decisions based on that?” (MF)
	Develop reuse between departments	“Because there might be departments out there with very little funding, who would be able to benefit from onesies-twosies[6] that still have some life but might not have warranty” (V) “I think as a general rule people try to extend for as long as they can. Primarily because there are costs involved, right?” (MF)
	Increase external donation	“I think in general we use the equipment to a point where, I guess it could be donated, but probably outside the UBC community” (V) “If it still has some life, we try, we do our best, to be able to donate and keep it going somehow. But there is a lot that goes into the e-waste bin, especially hard drives” (MF)
Enablers	Centralisation	“If there was a centralised place to donate all of these things…if e-waste was managed on a larger scale, there could be some sort of determination at that level as to whether or not something could be used” (V)
	Data-driven decisions	“What’s the practical cost of keeping that equipment in the field from 4 to 5 years?” (V)

[6] Onesies-twosies: One or two used devices (as opposed to large batches of used devices).

Enablers (cont'd)	Robust asset management	"Capturing better data about our inventory, to allow us to make better decisions. Because I think right now it's limited." (V) "I think the robust and automated asset and inventory management system is very much called for" (V)
	CE guidance and mandates from UBC	"We are never going to get a mandate from the president's office or from the heads of the university to sort of determine that [detailed] level of procurement. But I think it would be good if there is guidance" (V) "Probably policy would go a long way. You know, if UBC were to say, 'this is how we handle equipment'" (V)
Obstacles	Desire for choice	"They would like choice about what they can get in terms of hardware…they should be able to choose how to do their roles" (V) "My support staff really aren't…set up or skilled enough to sort of determine what those [unique department] needs are. So we leave that to groups themselves…to determine what it is they want" (MF)
	Efficient spending of public funds	"It all goes back to that, well, what does it cost the university fundamentally to keep that equipment going?" (V) "At 4 years, finance has determined that the device is worth nothing. Any time now that we have a staff member work on that device, we're now at a negative device cost. Potentially budget costs for actual physical repairs" (MF)
	Impacts to staff productivity	"There's a line between productivity and cost thriftiness" (MF) "The challenge for us, though, is how do you manage that systematically while also acknowledging that there's you know, a cost potentially to staff performance, and how they do their work, to keep things alive" (MF)
	Cybersecurity	"If you can no longer install newer versions of Windows…to make sure that you keep it secure against cybersecurity attacks, then we will ask people to upgrade their machines" (MF) "So in order for us to stay up to date with cybersecurity requirements, we can't use old equipment" (MF)
	Limited capacity to find second uses	"It could be that they could be donated or resold. But right now we do not have the resources--I mean time or people--to go and look for a second life for that equipment." (V)

Thematic coding of the interview transcripts revealed a specific action and obstacles for CE in each life cycle stage. UBC stakeholders also referenced four cross-cutting enablers that could drive all three proposed actions: centralisation, data-driven decision-making, robust asset management, and guidance/mandates from UBC on CE goals. Not all stakeholders mentioned or agreed upon these enablers.

Centralisation was recommended by one UBC expert as a means to increase the efficiency of public spending while working towards common goals, including CE. Having a single, centrally-funded decision-maker, rather than many decision-makers across disparate departments, streamlines procurement. It may enable larger purchases that can better meet UBC's financial and sustainability goals. Further, a centralised inventory could facilitate internal reuse and donations by clarifying what used IT equipment is available to the departments and charities that need it. However, another UBC expert stressed that departments "would like choice about what they can get in terms of hardware" and that UBC IT's "support staff really aren't…set up or skilled enough to sort of determine what those [unique department] needs are" (UBC Expert #1). They also emphasized that researchers need maximum flexibility when choosing IT equipment.

Data-driven decision-making was another cross-cutting enabler to CE. UBC stakeholders expressed that they would be reluctant to extend the lifespan of IT assets without understanding its impacts on costs and staff productivity. For example, increased internal reuse might reduce spending on procurement by driving down demand for new devices. However, it may require buying extended warranties or allocating additional staff time to maintaining old IT equipment. UBC Expert #1 indicated that knowing "the practical cost of keeping that equipment in the field from 4 to 5 years" could facilitate decision-making around reuse. They also stated that extending IT equipment lifespans must not compromise the ability of staff to work efficiently: "There's a line between productivity and cost thriftiness. Where that line is, I would love for you to tell me" (UBC Expert #1).

UBC Expert #2 recommended "capturing better data about our inventory, to allow us to make better decisions. Because I think right now it's limited." Robust asset management could help UBC track and evaluate its CE progress over time, but it may also enable circularity. For example, UBC Expert #1 mentioned that a "considerable amount of hardware" was procured at the beginning of COVID-19, but "if we'd had an inventory system, you know, tracking these 20 systems here and tracking the 20 systems elsewhere, well, now maybe we didn't need to do that." A robust inventory may also enable more reuse within and between departments by clarifying what equipment is available. There is increasing recognition that the benefits of robust asset management extend beyond sustainability or waste reduction: "there's a very big institutional requirement now from our security apparatus to make sure that they're keeping track of these things" (UBC Expert #1). As Andersen and Jæger (2021) discussed, having oversight on the entire inventory is useful to managers because it can inform decision-making that extends a product's use and maintenance stage, which is a CE goal.

Guidance and mandates from UBC are also critical enablers to CE at UBC IT. UBC Expert #1 asked, “What’s the potential impact of switching an entire fleet of devices from 13 inch to 14 inch displays? Is there a responsibility for us to sort of make certain decisions based on that?” The first question overlaps with the enabler of data-driven decision-making (i.e., UBC Expert #1 wants to quantify the environmental impact of a decision about IT assets). The second question addresses the lack of guidance on how to include that quantified environmental impact in decision-making. Although UBC Expert #1 recognises that “we are never going to get a mandate from the president’s office or from the heads of the university to sort of determine that [detailed] level of procurement” they think that “it would be good if there is guidance.” The usefulness of guidance from UBC at the use and disposal stages was also mentioned. “Probably policy would go a long way. You know, if UBC were to say, ‘this is how we handle equipment’” (UBC Expert #2). UBC Expert #2 also wondered, “is it possible for our university to provide a place for donations or selling the equipment that they don’t need anymore?” Clarifying what data needs to be tracked to measure progress towards CE is also important. For example, there is no mandate to record whether IT equipment was recycled or donated, and “there is no fiscal requirement from the university for us to actually track any of this hardware at any given time” (UBC Expert #1).

These four enablers can drive the three actions proposed by UBC stakeholders. They address some, but not all, of the obstacles to CE envisioned by interviewees.

The action identified by UBC stakeholders in the procurement stage was the development of actionable sustainable procurement criteria for IT equipment. An envisioned obstacle to this action is the potential for sustainable procurement criteria to limit choice, particularly for researchers with specific budgets and performance requirements for their IT equipment. According to UBC Expert #1, “People doing research, and who get equipment funded through research funding—they generally have a lot more latitude in terms of choosing the type of equipment that they procure” and they “would not sit in front of a researcher and tell them what it is that they would need to run their software. So we want to leave them the option of choice.” Another obstacle to sustainable procurement is the requirement to spend public funds transparently and efficiently. Overcoming this obstacle would require guidance from UBC on how to quantify and incorporate environmental costs into decision-making.

The action identified by UBC stakeholders in the use and maintenance stage was the development of a system that allows reuse between, and not merely within, units. One UBC expert noted that there are departments with very little funding that replace their IT assets less frequently, and that they might benefit from reusing the IT equipment disposed of by departments with higher budgets. An envisioned obstacle to this action is the potential for negative impacts to productivity if staff use older, lower-performing IT equipment. “The challenge for us, though, is how do you manage that systematically while also acknowledging that there’s, you know, a cost potentially to staff performance, and how they do their work, to keep things alive [for longer]” (UBC Expert #1). The efficient spending of public funds is also a concern, as there are costs to extending the lifespans of IT assets: “At 4 years finance has determined that the device is worth nothing. Any time now that we have a staff member work on that device, we’re now at a negative device cost. Potentially budget costs for actual physical repairs” (UBC Expert #1).

The action identified by UBC stakeholders in the disposal stage was to donate, rather than recycle, IT equipment that still has useful life left. Devices may be unsuitable for internal reuse but still eligible for external reuse: “I think in general we use the equipment to where, I guess it could be donated, but probably outside the UBC community” (UBC Expert #2). Interviewees suggested that UBC IT employees are motivated to avoid recycling usable IT equipment when possible, but that they often lack the time to do so. “When this equipment hits that 4 year point, it is pretty much typically recycled. That being said, nobody likes to do it” (UBC Expert #1). “If it still has some life, we try, we do our best, to be able to donate and keep it going somehow. But there is a lot that goes into the e-waste bin, especially hard drives” (UBC Expert #1). A significant obstacle to donation is the time needed to coordinate with charities: “right now we [UBC IT] do not have the resources—I mean time or people—to go look for a second life for that equipment” (UBC Expert #2). Recycling is currently the preferred option because it is the quickest and most efficient option.

Cybersecurity is an obstacle to both internal and external reuse. It places an upper limit on IT equipment life spans within UBC: “if you can no longer install newer versions of Windows…to make sure that you keep it secure against cybersecurity attacks, then we will ask people to upgrade their machines” (UBC Expert #2). “There is some kind of an informal deadline that says between 3 and 5 years you should replace your equipment, because when it’s aging it doesn’t meet all the security requirements to be on the UBC network” (UBC Expert #2). Further, interviewees expressed that there is a risk to donating hard drives, even if they are wiped, as they may still be mineable for private information. Figure 4 visually summarises the actions, obstacles, and enablers envisioned by UBC stakeholders.

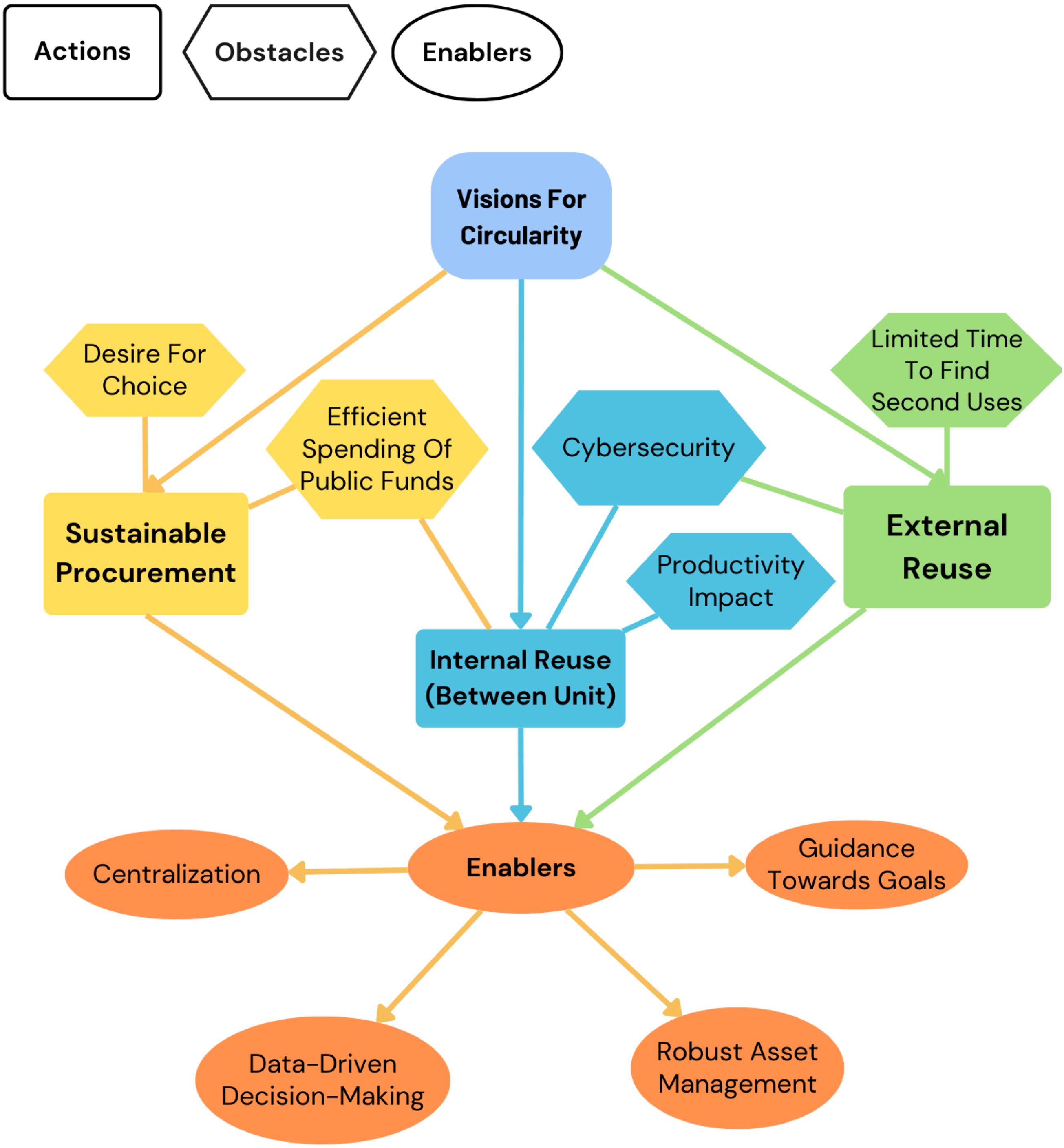

Figure 4. Thematic map representing core- and sub- key points from interviews with stakeholders from UBC IT. The colours indicate three different life stages: procurement (yellow), use and maintenance (blue), and disposal (green). The lines highlight relationships between the actions, obstacles, and enablers (orange) envisioned by UBC IT stakeholders in the context of the circular economy.

4.2 Benchmark Analysis

We interviewed stakeholders from McGill University, the Faculty of Forestry IT Department, and the UBC-Okanagan IT Department to better understand how UBC IT's IT asset management practices compare to those in other systems.

McGill University

Leclerc and Badami (2022) provide an overview of McGill's recently integrated IT asset management system (see Figure 5). A new policy specifies that McGill's Procurement services are responsible for the University's asset management, including IT equipment. McGill set up a working group with all parties involved in handling IT assets, which includes Procurement Services, IT administrators and technicians, Facilities Management, and Hazardous Waste Management (HWM). The responsibility of the working group was to incorporate innovative strategies to move McGill's IT asset management towards a more circular path. New procured units must follow the Minimum Standard Requirements (MSR) established by the working group. MSRs were established considering the technical, social, and environmental criteria; some examples include performance (hardware) criteria, and EPEAT Gold registered equipment which contain fewer toxic components and are easier to repair and recycle. IT asset stewards were responsible for ordering and allocating equipment. Most importantly, a centralised inventory was created to quantify the incoming IT equipment and to allocate responsibilities to the units purchasing equipment. Inventory information was logged during acquisition and updated through an automated script when users accessed the network. While this inventory is still a work in progress (see section 5.1), it was designed to capture data about procurement, repairs, upgrades, data-wiping, and transfers. The inventory was also made auditable for reporting purposes.

McGill's central IT department has well-defined roles and responsibilities in the use and maintenance stage (Leclerc & Badami, 2022). IT asset set-up, upgrade, maintenance, decommissioning, and data-wiping are done by IT Asset and Technical Stewards. The Central IT department incorporated the use of software to improve service management and to integrate the inventory. IT asset stewards, appointed for each supported department, were responsible for their local inventory. These duties include ordering, allocating equipment, declaring theft or damage, allowing transfers among departments, and transferring End-of-Life equipment to HWM. IT technical stewards are responsible for equipment set-up, proper equipment maintenance, and communicating the availability or need or reuse of equipment.

Central IT Services established two sets of Reuse Eligibility Criteria (REC) for used equipment; one set for admin and research use, and one for on-campus public use (Leclerc & Badami, 2022). REC was also regularly updated based on new findings. McGill implemented a so-called "Virtual IT gate". The objective of this gate was to keep all IT equipment that meets REC in circulation within the University. Reuse was encouraged within and across various departments, and IT stewards were assigned to find on-campus reuse opportunities for used equipment that meets the REC. To aid in reuse across departments, Central IT Services set up an IT-Reuse email listserv, which is an email list that faculty and staff could sign up for to be notified about used electronics listings. HWM collected equipment that did not fit the REC, which they then distributed to carefully selected refurbishers or recyclers. Refurbishers and Recyclers must be certified and audited for health, safety, and proper handling of e-waste. All IT technicians and system administrators are responsible for data wiping before reuse or external refurbishment/recycling. Very small quantities of used electronics were set aside for students' refurbishing clubs.

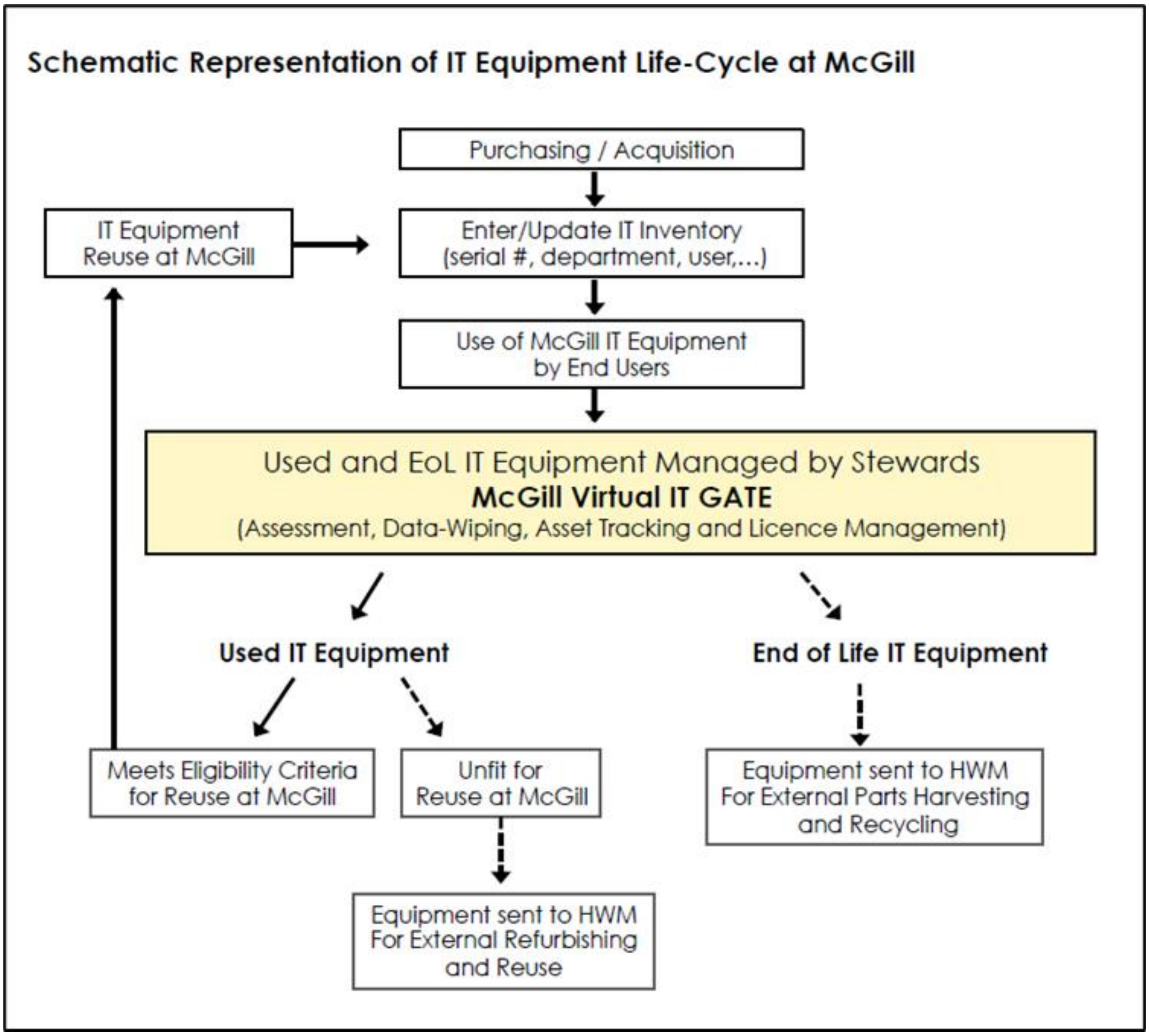

Figure 5. Flow chart characterising the flows, processes, and tracking of IT assets through McGill University. Figure from McGill Procurement Services (2015, p. 13).

UBC Forestry

We corresponded with Carl Johansson, the Director of Forestry IT. IT acquisitions in the Department of Forestry at UBC involve varied decision-making processes across different units. Specifically, the office of the Dean, staff, and undergraduate labs follow a model of “5-year leases, off-lease devices are sold to faculty members for their grads or sold to other departments on campus”, noted Carl. Carl told us this model considers the applications used for teaching and the annual budgetary process, which is reviewed and signed off by the Dean of Forestry. IT Carl plays a pivotal role in decision-making for equipment allocation in the office of the Dean, staff, and undergraduate labs, ensuring that the allocation remains fixed and constant. On the other hand, faculty research units in Forestry purchase equipment as needed, considering cost-effective technologies or older units suitable for server purposes. Carl added that ultimately, the faculty members make purchase decisions and sometimes they consult Forestry IT or UBC Finance. Forestry units and personnel have the autonomy to allocate equipment based on their specific requirements. As equipment age out, it will not be reused in research units. Carl says that many Forestry faculty members use their PCards (UBC Visa cards) for purchases and will buy once a year then recycle their previous for home use.

Carl described, “reuse is only an option for poor faculty members, the rest get a new system for their office less than years”. Carl maintains an up-to-date inventory, with information provided by the department IT team feeding into the inventory system. Carl believes that in an ideal world, centralisation and strict University policies are needed for sustainable material flows.

Forestry IT staff are responsible for maintaining the equipment. Equipment is usually not shared unless for work-learn positions, co-op students, or undergrad computing labs. On the topic of asset management at Forestry IT, Carl Johansson shared with us “the inventory just handles when it arrives, where it is and when it dies” whereas they have patching tools that handle the device health data. Carl believes a centralized set of tools can improve the use and maintenance of university IT equipment.

Forestry IT Department's disposal process was also discussed during the interview with Carl Johansson. The decision to retire equipment is determined by whether it was under lease or faculty member control. With leased equipment, the lease agreement dictates when it is no longer used, while faculty members have authority over their equipment's retirement. Carl informed us that, for used equipment, “devices sent out for recycling are wiped by ERA, and the department of forestry pays for their service to recycle and wipe the data”. Typically, the equipment sent for recycling comprises dead or unsupported hardware. To ensure accurate records, the inventory is revisited in depth once a year to reflect decommissioned or removed equipment. When offering used equipment for reuse, items under lease are first offered internally before being made available to other departments at UBC. Carl noted that parts harvesting does not occur in the leased system, but it may happen in areas under faculty member control. In such cases, some IT staff may pick usable parts as needed for part harvesting.

University of British Columbia Okanagan (UBCO)

We engaged with Stacey Broderick, an experienced procurement officer with a background at Okanagan College before joining UBCO. Her insights have significantly contributed to understanding the procurement and management processes of IT equipment. Stacey explained the driving forces behind IT acquisitions, it is evident that decisions are multifaceted, “encompassing budget allocations, renewal schedules, the necessity for new hires, repairs, and project-specific requirements.” The decision-making on what to purchase is vested in the hands of managers, direct reports, project owners, and faculty heads, who base their decisions on a combination of budgetary constraints and prioritization of needs. The procurement process is detailed by Stacey as follows: "Acquisitions are made by getting quotes from vendor reps, approval processes, and then via workday purchase, requisition into a purchase order". Stacey explained that the Allocation of equipment is determined by the respective equipment owners, taking into account the user's position within UBC and their employment status, whether full-time or part-time. UBCO maintains an up-to-date inventory system, managed by the snippet and receiving team. According to Stacey, this team is responsible for updating and recording all IT purchases, ensuring assets are monitored efficiently. The policy is to keep inventories at minimal levels to ensure current information and avoid excess. Furthermore, the reuse of existing IT equipment is encouraged to promote sustainability and cost-effectiveness. Stacey added that the criteria for reuse include compatibility with current Windows and Cisco updates, adherence to a 7-year support model, and the condition of the equipment. Functional equipment can be repurposed for short-term use or as loaners, showcasing our commitment to a circular economy in IT equipment management.

Stacey informed us that the maintenance of IT equipment at UBCO is a collaborative effort involving various specialised teams within UBC IT, including the service desk, desk-side support, research, audio-visual, and telecommunications teams. This integrated approach ensures that all IT assets are kept in optimal condition, enhancing both their functionality and longevity. Certain assets, such as department-owned devices and multi-use desktops, are designated for communal use. However, Critical Response Plan (CRP) devices are assigned specifically to positions, indicating a tailored approach to resource allocation that ensures each device is used by those most in need, according to their current role within the organization. Stacey asserted that the inventory system plays a crucial role in the management strategy, with constant updates reflecting the condition of the equipment, its compatibility with ongoing requirements, adherence to the 7-year support cycle, and compliance with Cisco and Windows security standards. This dynamic inventory management allows for an informed understanding of the available resources and their readiness to meet the university's needs. Moreover, Stacey clarified that the allocation of equipment is meticulously monitored through consultations for each position at UBCO, ensuring that the provision of IT assets aligns with the specific needs and requirements of various roles. This strategic approach to equipment use and management not only maximises the utility of the technology available but also supports the overarching goal of optimizing resource allocation across the university.

At UBCO, the decision to deem IT equipment as no longer needed rests with the IT teams, who evaluate the equipment's age, condition, and compatibility with current security standards and software updates. This careful consideration ensures that only devices capable of supporting the required programs are retained. Stacey indicated that “When equipment is identified for disposal, it "undergoes a re-imaging process conducted by various IT teams, employing in-house maintained deployment tools". This process effectively prepares the equipment for its next stage, whether it be continued use within the organization or external disposal. Used equipment is either integrated into a loaner pool—if it still meets operational requirements—or sent for recycling. The disposal and management of used equipment are primarily handled by the desk side and research teams, highlighting a structured approach to equipment lifecycle management. The Asset Management team plays a crucial role in maintaining an accurate inventory and updating the status of devices to reflect decommissioning and removal. This process helps to manage resource levels effectively, especially in aligning acquisitions with the fiscal budget and operational needs, such as provisioning for new hires. Regarding the reuse of equipment, Stacey explained that UBCO allows departments and employees to purchase used IT equipment for either academic or personal use, depending on the device's condition and suitability. This practice of equipment reuse and parts harvesting for repairs is managed by the IT teams, who ensure that valuable components are retained for future use. This approach not only extends the lifecycle of IT assets but also supports environmental sustainability by reducing waste.

Discussion

5.1 UBC IT and Circular Economy: Present Performance

Summary

The flows of IT equipment through UBC IT, as described in the results, are summarised on Figure 6.

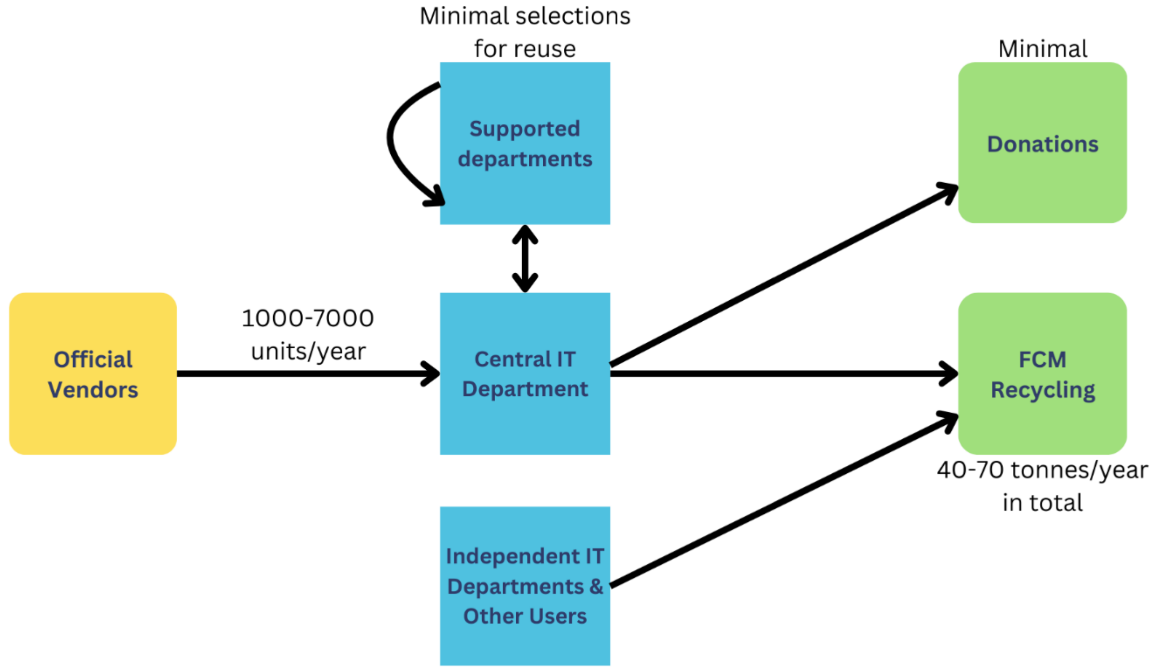

Figure 6. Map of the material flow of IT Equipment through UBC IT. Rounded boxes represent the procurement (yellow) and disposal/transfer (green) of IT equipment, rectangular boxes represent the locations or places that equipment passes through during the use phase (blue). Note: "Supported departments" include UBC IT itself, for they procure and handle their own equipment in addition to other departments. The amount of equipment flowed in and out are indicated by arrows. The procurement data has a quantifiable number of items each year. The FCM Recycling data has a known final amount, but unknown allocation from the two branches.

IT equipment procurement at UBC is driven by a combination of scheduled replacements, departmental needs, and budget constraints. Although there is a broad focus on lifecycle and security standards, the criteria and decision-making processes for procurement, allocation, and disposal vary across departments. While there is an awareness of the need for sustainable procurement criteria, the current criteria are too general and lack actionability. Equipment reuse is limited by concerns over productivity, cost, and cybersecurity standards, and although there is a protocol for wiping and disposing of used equipment, the tracking of equipment decommissioning is not thorough. There is some equipment reuse within the university and occasional donations, but recycling is the predominant disposal method due to resource constraints that limit the pursuit of second-use options. Parts harvesting is not a common practice due to the technical and cost implications. Overall, the university is working towards better asset management and sustainability, but there are still several areas that need development.

We found that progress towards circularity can be measured without doing a full MFA. For example, McGill University uses different indicators for each flow, which skirts the issue of mismatching units (Leclerc & Badami, 2022). It also reflects the different goals and capacities of various stakeholders.

For example, McGill's vendors are more interested in tracking the proportion of procurement that meet their sustainable procurement criteria, whereas recyclers are more concerned with the tonnage of resources recovered than the number of individual units recycled. However, if it is desirable to compare the inputs and outputs with the same units, a robust inventory that is consistently updated may be required.

5.2 UBC IT and Circular Economy: Benchmark and Literature Comparisons

UBC IT in comparison with McGill IT Services

Only limited data are available to characterise the procurement, use, and disposal of IT equipment under UBC IT's jurisdiction. An expert at UBC IT envisioned that due to the lack of a robust centralised inventory, it is difficult to track the lifecycle of IT equipment after it is procured by UBC IT. By comparison, McGill University's Central IT Services implemented a centralised inventory as a part of their progress towards circularity (Leclerc & Badami, 2022). As discussed in section 4.2, this inventory was designed to capture data on IT assets' Middle-of-Life[7] (MoL) stages and to allocate responsibilities for particular pieces of equipment to IT asset managers. From our interview with Stéphanie Leclerc, we learned that so far, McGill's inventory allows for full visibility of IT asset stocks, incoming flows, internal reuse, and some external transfers, but external transfers in general are still quantified by weight rather than the number of items. The ultimate goal for McGill is to track everything as the number of items, and future development to the inventory is to make it accessible by McGill's e-waste collector HWM, who can confirm write-offs and transfers to reflect the disposal or external transfer of IT assets (Leclerc & Badami, 2022).

Because IT is a rapidly evolving field, sustainability practices and procedures need to be continuously revised to reflect technological advancements (Islam et al., 2021). McGill's Minimum Standard Requirements (MSR) for IT purchases are constantly updated to reflect the evolving technology (Leclerc & Badami, 2022). For example, in the study by Leclerc and Badami (2022), the environmental certification required at McGill was EPEAT Gold or Silver certification, but as of 2024, this has been shifted to EPEAT Gold certification only. It is not important to go into McGill's detailed MSR in this paper because they will shift with time. Instead, the importance lies in the decision-making processes around the MSR; McGill's working group was responsible for the development and Central IT Services were responsible for the reviewing and updating of MSR. The obstacle to implementing strict procurement guidelines is the shortfall of choice, as identified by UBC IT and McGill IT stakeholders; for this reason, McGill's IT allows for exceptions to the MSR to support researchers if they need higher-performance equipment.

As discussed previously, IT is a rapidly evolving field in which consistent sustainability efforts need to be maintained (Islam et al., 2021; Pérez-Belis, Bovea, & Ibáñez-Forés, 2015). From our interview with Stéphanie Leclerc, we learned that CE initiatives at McGill required constant upkeep. Leclerc identified a few obstacles in maintaining circularity practices during the interview, “New people come in, they don't know the story, or they're not super informed,” or “one team is understaffed, and things

[7] Andersen and Jæger (2021) define MoL products as after leaving the factory and before being disposed, remanufactured, or recycled. MoL processes include maintenance, reuse, repair, and refurbishment.

pile up instead of going to the refurbishing," which demonstrated both the importance of updating and enforcing guidelines at regular increments and the education and awareness of these efforts. Leclerc identified in the interview that her team is still working with McGill IT Services after the implementations discussed in Leclerc and Badami (2022), this is not only to implement further proposed changes but also for the preservation of phase one's changes. This further highlights the dynamic and iterative nature of CE implementation.

Another considerable difference between McGill and UBC's IT asset management was the opportunity for reuse and refurbishment. All the UBC IT experts we consulted wanted to see more reuse, internally or externally. However, lack of communication between supported departments about availability of, or need for, used IT equipment has been cited as a major obstacle to finding internal second use of IT assets, both in our interviews with UBC IT experts and Stéphanie Leclerc. Additionally, UBC IT and its supported departments consider computers to have zero value once they reach four years old, thus they have no monetary incentive to prolong the lifespan beyond four years. Few used items were donated in the past but the vast majority of used assets that pass through UBC IT end up in FCM Recycling. In contrast, McGill Central IT Services set up an IT-Reuse listserv to assist in communication for reuse. They established a Reuse Eligibility Criteria (REC) for used equipment and implemented a Virtual IT gate to keep all assets meeting the REC in circulation (Leclerc & Badami, 2022). Just like McGill's MSR, their REC is constantly updated based on acceptable performance and security protocols. Assessing security protocols can be tricky because older hardware does not have TPM 2.0 which is necessary for Windows 11. McGill's REC, however, does not require Windows 11. Instead, it lists operating system requirements as vendor- or community-supported with continuous critical security updates, for example, some Linux-based operating systems. McGill saw a substantial increase in IT asset reuse after implementing these measures. In fact, the increased IT asset reuse at McGill provided monetary savings of hundreds of thousands of dollars in the past few years, as identified by Stéphanie Leclerc in the interview.

In addition, IT assets at McGill that are unfit for reuse but are salvageable were sent to certified refurbishers by HWM. Refurbishing further extends the lifespan of assets and saves energy and resources that are otherwise needed for recycling and remanufacturing; in the hierarchy of R's, reuse and refurbishment are prioritised over recycling (Andersen & Jæger, 2021). After careful auditing for health, safety, and environmental practices, HWM selected a non-profit certified IT refurbishing organization for at-risk youth to work with computers, to refurbish and resell them (Leclerc & Badami, 2022). According to our interview with Stéphanie Leclerc, just like how McGill IT Services has a REC to determine what equipment is fit for reuse, this external refurbisher established refurbishment criteria and used IT equipment that did not fit their criteria were sent to recycling.

Andersen and Jaeger

Andersen and Jæger (2021) also emphasized the importance of asset tracking. One of Andersen and Jæger's main arguments is that it is crucial to have a central actor[8] that keeps control of the asset management data which other actors could access and provide updates on maintenance, repair, reuse, refurbish, recycle, etc. Constant updates to asset conditions are key in asset management

[8] The term "actor" refers to any party involved in handling electronic equipment. This can include manufacturers, suppliers, recyclers, and other stakeholders (Andersen & Jæger, 2021).

because the Middle-of-Life (MoL) stage of each asset is unique and is affected by its environment (Andersen & Jæger, 2021). Andersen and Jæger (2021) highlight that a substantial way to achieve IT circularity is by maximizing the MoL stage (maintenance, reuse, repair, and refurbishment) of IT equipment, and they found that the information flow over the lifecycle of IT equipment can act as indicators for the circularity of these assets. For example, Andersen and Jæger (2021) proposed an Edge and Distributed Ledger (Edge&DL) model as a means of asset tracking and overcoming communication obstacles between actors. In this model, the central actor would assign each product with a unique ID that can be logged into a centralised database called the Distributed Ledger (DL). Various actors will be able to access the DL through decentralised Edge portals to provide updates to the products at different stages of life. The use of a centralised IT inventory was also demonstrated by Leclerc and Badami (2022).

For Andersen and Jæger (2021), they found that the producers should bear the responsibility for the entire life cycle of their products including the End-of-Life stage. This concept is known as Extended Producer Responsibility (EPR) and its goal is to shift the waste management burden from civilians back to the producers, which in turn motivates producers to manufacture environmentally friendly products that are easily refurbished, remanufactured, or recycled. Ultimately, The EPR concept is beyond the scope of our project as we are more concerned with IT asset management on a University scale. However, Andersen and Jæger's (2021) argument is that asset tracking should be done by a central actor and commence early in the lifecycle of IT equipment and on the UBC scale, UBC IT should be the central actor which has the responsibility of keeping an asset inventory since UBC IT is the first stop at UBC for new IT assets.

Recommendations

6.1 Recommendations for Action

The baseline and benchmark analyses indicate opportunities for circularity at UBC IT. After doing the same at McGill University, Leclerc and Badami (2022) created a working group. Using the findings from their semi-structured interviews, the working group developed and tested policies, processes, and procedures for circular IT asset management. Further, they developed performance indicators to monitor and evaluate their progress towards CE. For example, McGill University tracks the fraction of IT equipment purchases that meet its sustainable procurement criteria, the number of units reused internally through the listserv, and the tons of e-waste recycled annually. Thus, our first recommendation is to:

1. **Create a UBC IT working group comprising experts from each lifecycle stage to begin CE implementation.** We recommend that this report be provided to a UBC IT working group comprising experts from each lifecycle stage, including UBC Finance, IT administrators and technicians, Building Operations, and FCM Recycling. This working group can develop policy and launch pilot projects based on the actions, obstacles, and enablers identified by UBC IT stakeholders during the visioning exercise.

CE implementation requires action at all lifecycle stages: procurement, use and maintenance, and disposal. UBC's Zero Waste Action Plan sets a goal "to achieve a 50% reduction in operational waste disposal for the Vancouver academic campus by 2030 relative to 2019" (UBC, 2023, p.1). UBC's progress towards CE will thus be measured at the disposal stage. However, UBC stakeholders and CE research suggest that actions must be taken, monitored, and evaluated at the procurement and use stages as well (Leclerc & Badami, 2022). We recommend that the following actions, which were identified by experts from UBC IT and UBC Finance, be considered by the working group:

2. **Develop sustainable procurement criteria for IT equipment.** Specific and actionable procurement criteria can help decentralised organisations work towards common goals, including CE (Leclerc & Badami, 2022). McGill University developed Minimum Standard Requirements for IT equipment purchases to ensure that they meet minimum performance standards, security features, warranty terms, and environmental certifications such as EPEAT (https://www.epeat.net/).

    a. **Barriers:** First, developing sustainable procurement criteria that are too specific or stringent may limit choice. This would be undesirable because certain roles require specialised IT equipment. Second, adhering to the sustainable procurement criteria may have a financial impact if the most cost-competitive vendor cannot meet them.

3. **Develop reuse between departments.** UBC is decentralised, so departments replace their IT equipment on different schedules. As a result, some departments may be disposing of IT assets that are newer than the IT assets used in other departments. Leclerc and Badami (2022) identified a similar dynamic at McGill University, and successfully facilitated interdepartmental reuse by creating a listserv that alerted IT administrators when used IT equipment became available. Similarly, reuse-it! UBC (https://reuseit.ubc.ca/) uses Rheaply's

Asset Exchange Manager (AxM) to facilitate the interdepartmental reuse of furniture and other items. The reuse-it! UBC coordinator has indicated interest in putting used IT equipment on the platform. Following McGill University, a set of Reuse Eligibility Criteria (REC) should be established so that UBC IT can consistently evaluate what items can be internally reused.

   a. **Barriers:** First, extending the lifespan of IT assets could decrease staff productivity if the older equipment has lower performance. IT assets must meet cybersecurity standards, and this presents an upper limit on equipment age. All devices that cannot install Windows 11 are currently being replaced for this reason. Second, a means of communication may need to be established between supported departments, unless internal reuse is facilitated by UBC IT.

4. **Increase donations.** If used IT equipment is ineligible for internal reuse, but still has useful life left, then donation options should be explored prior to recycling. For example, McGill University formed a relationship with a non-profit and donated their used IT equipment exclusively to them. Criteria were developed to consistently distinguish between what could be donated versus what needed to be recycled (i.e., what did and did not have useful life left). UBC IT occasionally donates used IT equipment because its employees are personally motivated, rather than mandated, to do so.

   a. **Barriers:** First, finding opportunities for donations, or external reuse, takes time. UBC IT does not have the time nor the resources to coordinate with charities, and there is no mandate to prioritise donations over recycling. Second, there are cybersecurity concerns associated with the external reuse of hard drives.

The actions taken at the earlier stages (procurement, use and maintenance) may be more impactful than those taken at the disposal stage. The order of the well-known “three R’s” matters: in terms of reducing resource extraction and waste, it is preferable to reduce than reuse, and it is preferable to reuse than recycle (Andersen & Jæger, 2021). Recycling is a circular process because it extends material life spans compared to landfilling. Reuse opportunities will extend the use and maintenance stage of IT assets as well as drive down the demand for new assets.

UBC stakeholders also identified changes that would enable the implementation of CE principles in IT asset management. These enablers relate to all three proposed actions and address some of the identified barriers.

1. **Guidance on goals.** It is vital that UBC IT is provided with clear mandates and sufficient resources to implement CE initiatives. For example, policies must indicate whether donations should be prioritised over recycling. Further, finding second uses for IT equipment, both internally and externally, takes time from UBC IT’s other tasks.
2. **Robust asset management.** UBC IT stakeholders noted the multiple potential benefits of a centralised inventory to CE, including avoiding over-procurement, facilitating internal reuse, and tracking internal and external transfers (donated versus recycled). Employees must be given clear responsibilities and training in updating the database.
3. **Data-driven decision-making.** Understanding the impacts of extended use of IT assets on budgets, staff productivity, and the environment can help decision-makers weigh the costs and benefits of sustainable procurement and internal reuse.

4. **Centralisation.** Some UBC IT stakeholders suggested that centralised decision-making helps organisations work towards common goals, such as CE. If decisions related to procurement, internal reuse, and donations were less decentralised (i.e., if there were fewer decision-makers involved) then actions towards CE may be more efficient and impactful.

Lastly, it is important to remember that CE transitions are iterative (Leclerc & Badami, 2022; Cramer, 2020). We recommend beginning with small-scale pilot projects and simple performance indicators, which can then be monitored, evaluated, and scaled up over time.

6.2 Recommendations for Future Research

This project was limited to UBC IT. As UBC strives to improve circularity in its IT equipment flows, it may be beneficial to conduct semi-structured interviews with IT decision-makers outside of UBC IT, such as researchers and independent IT departments. Lessons learned from small-scale pilot projects within UBC IT should be shared with independent IT departments.

Leclerc & Badami (2022) and Cramer (2020) employed an action-research approach to their research on CE implementation: in other words, they studied and sought to change material flows at the same time. This allowed them to develop, monitor, evaluate, and scale-up circularity solutions while reporting on their findings as objectively as possible. Action-research is well-suited to CE implementation, which requires an iterative, learning-by-doing approach. We suggest that future SEEDS research should leverage action-research to ensure that UBC's CE transition is rigorously studied but not delayed.

Lastly, we recommend that semi-structured interviews be used to find opportunities for circularity in other asset categories. This method allowed us to quickly gain an understanding of the opportunities, obstacles, and enablers of CE while building relationships with key decision-makers.

6.3 Recommendations for MFA

In order to do a material flow analysis on UBC IT assets, UBC will need to implement better asset-tracking strategies. The current methods UBC IT uses to keep track of incoming and outgoing flows are purchase and disposal records made by the vendor and recyclers. Due to the different goals and interests between Microserve and the recyclers, the procurement data is presented as a detailed spreadsheet based on the number of units and their description whereas the recycling data is presented in tonnes. This is not a problem in and of itself, but it poses a few problems when MFA comes into question; while weight is a good performance indicator for recyclers to calculate the percentage of materials recovered (Hlavatska, Ishchenko, Pohrebennyk, & Salamon, 2021), weight should not be used as the sole metric for measuring the circularity, for weight does not contain information on the type of equipment and quantity of units and it varies across categories and products (Mangold, Cristobal, Mars, & Dornfeld, 2015). Especially in the case of UBC, the weight received by recycling companies is quite broad as a metric because the campus e-waste sent to FCM Recycling or ERA include UBC IT, independent IT departments, and any staff or student who follows UBC's e-waste guidelines. No one is certain what proportion of this metric went through UBC IT.

It is important to recognise that good data is often a result of, rather than a precursor to, circularity (Wong et al., 2021). This means that a by-product of circularity practices, such as asset management, can lead to data with matching units (Andersen & Jæger 2021; Leclerc & Badami, 2022). Even with the shifted focus of recommendations discussed in sections 6.1 & 6.2, the by-product is that UBC could have improved data quality that is suitable for a material flow analysis. Further circularity performance indicators from an MFA that could be explored are the circularity index (CI) and the circularity gap index (CGI) (Aguilar-Hernandez et al. 2019).

$$CI = \frac{W_{rec}}{MI} \times 100 \qquad (1)$$

$$CGI = \frac{W_{gen} - W_{rec}}{W_{gen}} \times 100 \qquad (2)$$

Equations adapted from Aguilar-Hernandez et al. (2019), Where MI = material input to the system, W_{gen} = waste generated, and W_{rec} = waste recovered. FCM Recycling and ERA would have to be audited to obtain the amount of material recovered. Weight is a good metric for these calculations because materials recovered by recyclers are often reported in terms of weight (Aguilar-Hernandez et al., 2019). It is still important to note that without high quality data and matching units, these two indexes can only be very roughly estimated.

A well-rounded inventory that reflects equipment disposal can quantify the recycled assets in the number of units and help differentiate the proportion of FCM e-waste that originated from UBC IT compared to independent IT departments or other staff/students. This asset management strategy ultimately leads to clearly defined system boundaries previously lacking in the FCM Recycling data. These boundaries are also essential for a MFA should one be desired.

Conclusion

We used semi-structured to understand the processes guiding decisions about IT equipment flows in the acquisition, use and maintenance, and disposal life stages (see “Current Processes” on Figure 6). We found that most decisions, including what to procure and dispose of, ultimately rest with supported units. UBC IT has an important advisory role: it provides recommendations on what devices to purchase, and on when to replace old IT equipment. The efficient spending of public funds is a key driver throughout all life stages, and it may be an obstacle to CE initiatives unless there is a clear way to factor in the value of their environmental benefits. For example, the expiration of warranties (and the subsequent higher costs of repairs) is a driver of disposal and replacement. Further, old IT equipment is typically recycled because it is the most efficient option in terms of time.

UBC's current IT equipment management process has room for improvement in terms of circularity (see “Visions for Circularity” on Figure 4). Three key interventions were identified from interviews with UBC IT stakeholders. First, the development of actionable sustainable procurement criteria will help UBC IT to select vendors with competitive prices *and* a demonstrated or measurable commitment to the environment. Second, creating opportunities for internal reuse would maximise the lifespan of IT equipment within UBC. Third, increase the amount of external reuse through charity donations. UBC IT’s standard procedures are already keeping used IT equipment out of landfill: most of it is recycled. However, by making it standard procedure to prioritise reuse (internal, then external) over recycling, UBC would move up the R hierarchy and thus make more progress towards a CE. Indicators should be developed for each of these three initiatives to monitor and evaluate circularity.

Finally, the development of sustainable procurement criteria, robust asset tracking, and reuse programs require capacity that UBC IT does not currently have. New funding and mandates are essential to making IT equipment flows more sustainable at UBC.

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Appendices

Appendix A - Procurement Data Unit Conversions

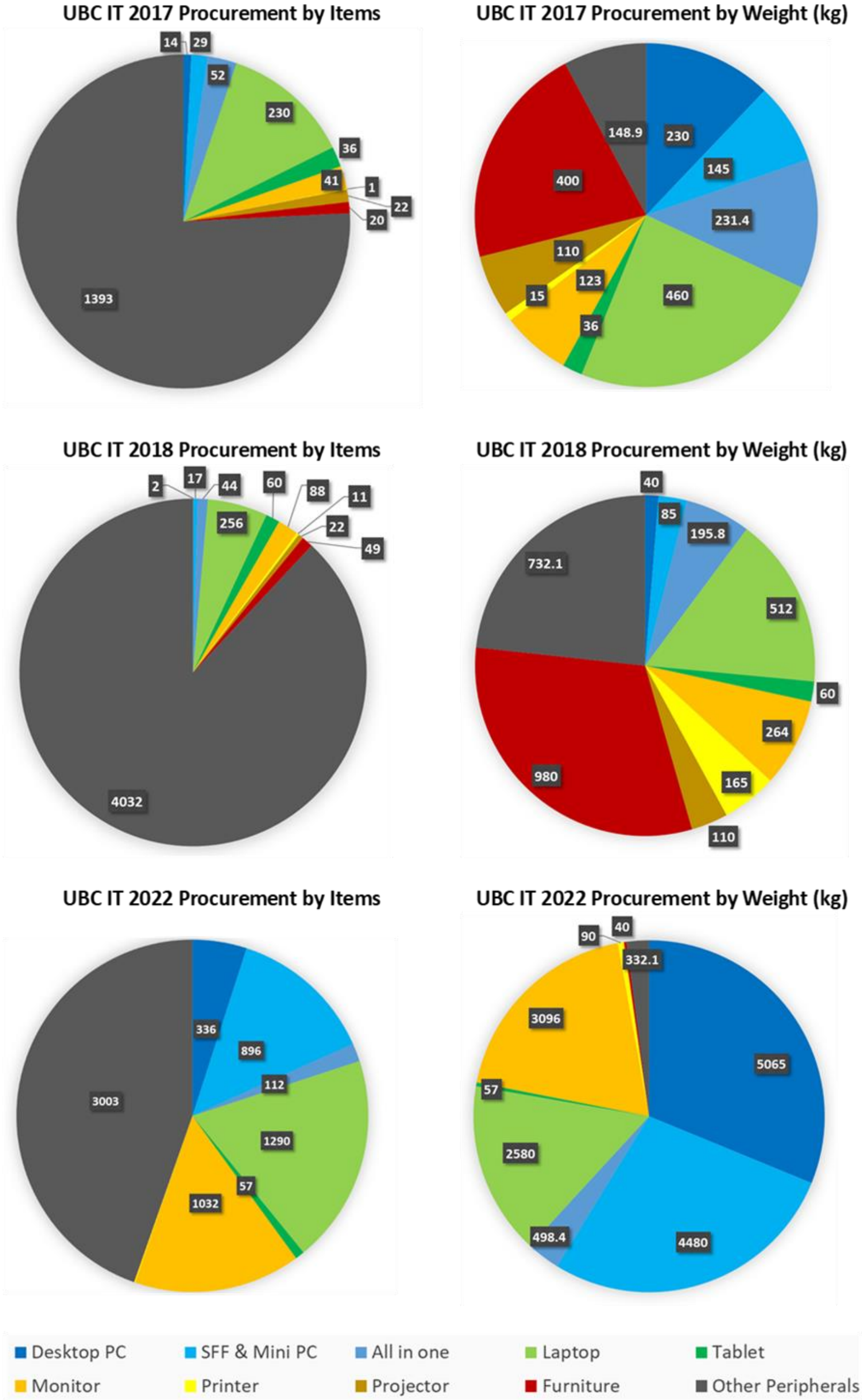

Figure 7. UBC IT procurement data: 2017, 2018, and 2022. Each entry was categorised, then sorted by number and weight.

As an initial attempt at material flow analysis, we randomly selected years 2017 and 2022 from the two sets of procurement data for asset categorization. 2017 is a fairly accurate representation of the proportions and magnitudes of yearly procured units between 2015 and 2019, and 2022 is a good representation of yearly procured units from 2020 onwards. Additionally, we chose 2018 data to show the high number of peripherals procured that year. The weight conversions were only rough estimates based on manufacturer websites for common office-grade equipment. The conversion estimates (in kg) were:

- Desktop PC: 15
- Small Form Factor (SFF) and Mini PC: 5
- All-in-one: 4.45
- Laptop: 2
- Tablet: 1
- Monitor: 3
- Printer: 15
- Projector: 5
- Furniture (desks and monitor arms): 20
- Other peripherals (cables, headphones, keyboards and mice): 0.1

As seen in Figure 7, “other peripherals” is the biggest category by number of units for all three years, but when converted to weight, this category only represents a small fraction of the total weight of procurement for 2017 and 2022. In contrast, various PC types (desktop, laptop, SFF, all-in-one) do not take up the biggest area on the number of units graph but represent a huge proportion in terms of weight. The outlier is 2018 due to the overwhelming number of peripherals procured. Although these conversions are only rough estimates, this procedure tells us that numbers and weight are very different metrics and consistency is key for a material flow analysis (Lombardi et al., 2023; Aguilar-Hernandez et al., 2019).

Appendix B - FCM Recycling Data by Category

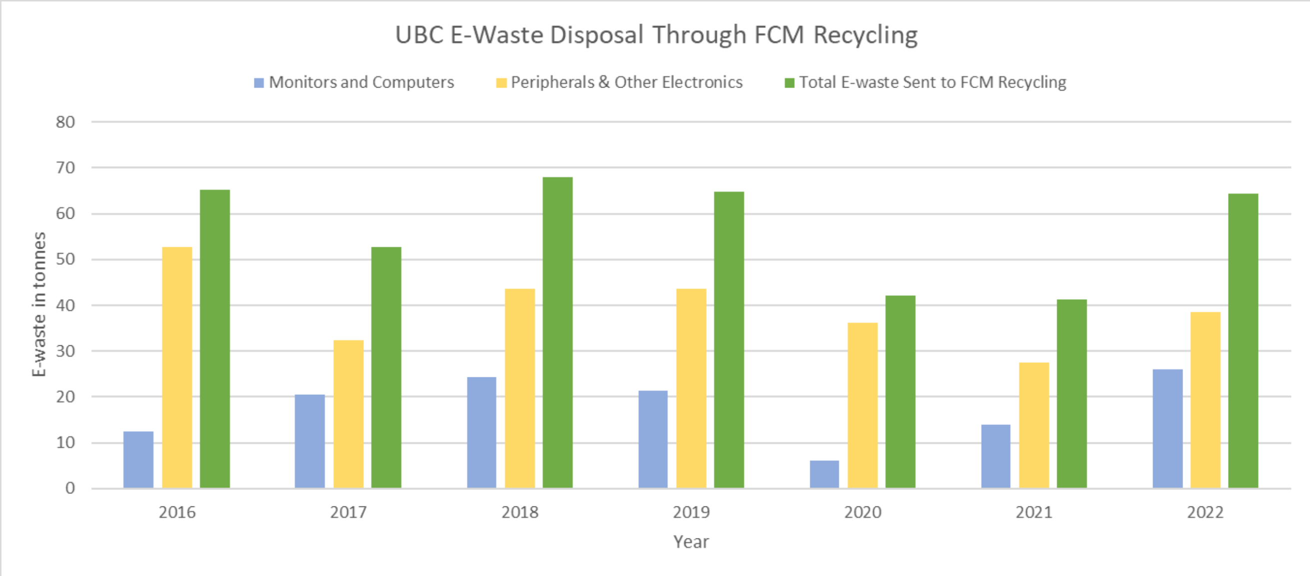

Figure 8. UBC e-waste disposal through FCM Recycling in tonnes, 2016-2022. Green bars indicate the total e-waste sent to FCM Recycling each year and corresponds to the green bars depicted in Figure 3. Blue bars indicate the total weight of monitors, laptops, desktops, SFF and Mini PC's, and all-in-ones. Yellow bars show other electronic equipment categories including printers, projectors, and other peripherals. Side-by-side weight comparisons can be done with these categories.

Appendix C - Blank Consent Form for Semi-Structured Interviews

Consent form, Expert Interviews for SEEDS Circular Economy Project

We are a team of students in ENVR 400 conducting interviews with experts regarding management of IT equipment at UBC. This project is in collaboration with UBC SEEDS (Social Ecological Economic Development Studies) and Bud Fraser, Senior Planning and Sustainability Engineer at UBC. Jenalee Kluttz is the SEEDS Project Developer, and Josh Travers is the SEEDS Circular Economies Coordinator for this project.

These interviews are to gather information about existing IT asset management processes from UBC experts. We, the team of students, will be conducting the interviews and summarizing your responses.

A primary outcome of our work will be a report that will be made available on the UBC Library's digital repository, cIRcle (https://circle.ubc.ca/). This is a publicly available repository. We are asking for your consent to (1) include information from your interview in our report, (2) quote you, with attribution, if quotes are appropriate in the report, and (3) acknowledge you by name in our report, as a source of information, in an acknowledgements section.

If we identify a direct quote that we would like to use, we will contact you with the specific quote before the report is finalized, for your review and permission.

We appreciate the time you are taking to talk with us. Thank you.

Please check any appropriate boxes and sign below
I consent to the following:

- ☐ The team may use information from my interview in their report
- ☐ The team may use direct quotes from my interview, attributing them to me by name
- ☐ The team may use direct quotes from my interview, attributing them to an anonymous source
- ☐ The team may acknowledge me by name, as a source of information, in an acknowledgements section of the report

____
Signature

____
Print name

Team members:
Student team contact: envr400circulareconomy@gmail.com

SEEDS contact: Josh Travers (josh.travers@ubc.ca)

If you have any questions or concerns about participating in this interview, please contact Sara Harris at sara.harris@ubc.ca, one of the instructors of ENVR 400.