Life-cycle assessment: Tracking CO2 Emissions caused by transportation of items purchased by Non-Share@work app users

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Introduction

A sharing community

Sharing goods and services benefits the participants (app users) in various ways. It allows a borrower, a person whose is seeking an item or service, to try out a product or amenity before making their initial purchase. Also, it deviates from purchasing an item to use for one project with no justification to utilize it again, at least not for a long period of time. Sharing items creates an opportunity to socialize with those that live in the community by bringing people together that would not normally cross paths. Furthermore, it validates ideas about other possible items to be shared by looking at what other lenders, people sharing items or services, may post. In the case of higher education, Share@work allows staff and faculty at the University of California, Merced (UCM) to benefit from a cost-effective solution and possible lesser detrimental environmental impact by using and actively participating on the app.

Share@work

Tribes Field Study has created a mobile sharing app that promotes sustainable consumption within faculty and staff at UC Merced. There are two apps, Share@home and Share@work, which provide a platform for users to share and borrow goods and services. The objective as a Carbon Neutral Initiative (CNI) fellows, was to conduct a Life Cycle Analysis (LCA) to capture the environmental impact of greenhouse gases (GHG) by focusing solely on the Share@work app that was relaunched on November 4th, 2019 and closed on April 17th of 2020. [1]

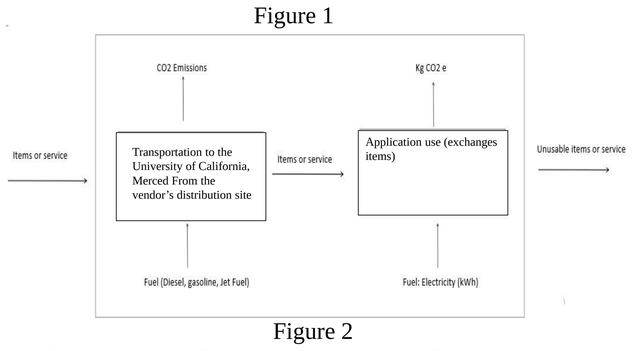
Participants of Share@work listed had listed 29 different goods and services which are separated and placed into 7 different categories. The categories include: Academic, Computer Accessory, Electronic, Laboratory, Literature, Personal Use and School Supplies. Each category varies with the number of items; therefore, it will be evaluated as a whole to simplify the LCA.

Further information about a Life Cycle Assessment

The environmental impact of products, processes and services are assessed by a systematic cradle-to-grave process. This full version of the Life Cycle Assessment tracks the impacts from raw materials extraction and refined to its final stages where the product is disposed and/or recycled. Considering each stage a product endures such as raw material extraction, process/manufacturing, transportation/distribution, use and end of life determined the total environmental impact that examines both the energy it used and the pollution it created. [22] Interpretation the data from each process should be evaluated to seek ways to reduce the environmental burden. [23] This may be extraction of raw materials from the soil due to the use of heavy machinery or the transportation between each processing step are some examples that expel an abundance of CO_2 emissions. The LCA determines which processing phase accumulates the most GHG emissions, which will be a great start to find alternative and sustainable solutions to replace current methods. A condensed version of the LCA may take place by evaluating from cradle-to-gate, gate-to-grave or gate-to-gate. **Figure 1** shows the system diagram of the gate-to-gate analysis originally planned to complete. It would have analyzed both users and non-app users to make a comparative analysis. This would have determine whether a sharing community emits fewer GHG emissions compared to making a new purchases. Purchases of new items and transactions between app users would be products or services to be undeniably placed in the 7 categories create for the LCA. There were few issues that required to alter the methodology to conduct the LCA for the fellowship.* As a result, **Figure 2** is even more condensed, evaluated one process phase rather than two. This LCA focused on the transportation from the vendor's distribution center that traveled to the University of California, Merced, to represent new purchases made off the app. This is used to demonstrate the environmental impact of GHG's of purchased items rather than sharing.

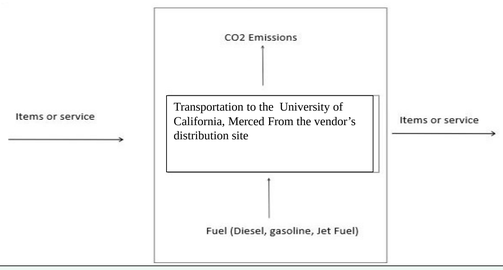
Overview of the LCA's System Boundary

Figure 1



Note. This is a gate-to-gate system diagram for the items traveling to campus from the vendor's distribution cite. Categories above the arrows represent the items and services that are on the app.

Figure 2



Note. This is a condensed version of the original system diagram. It reduced from a gate-to-gate to just gate evaluating a single phase for this Life Cycle Assessment. The transportation process of the purchased items starts from the vendors distribution cite to reach its destination; UCM.

Note:* The methodology was structured to gather and analyze the data during the time of the relaunch. There were two unfortunate inevitable events that occurred which required to change the methodology last minute. First, Share@work was barely used by the staff and faculty, resulting in only 3 exchanges. The outbreak of COVID-19 could contribute to the low number of exchanges. Due to the pandemic, the University of California, Merced officially started remote learning on March 17th, 2020 where only a few staff and faculty stayed behind, hindered transaction even more. Secondly, the request of similar items on the app but purchased through UCM's Procurement department was denied. Request of their records would have helped construct a more solidified comparative analysis of non-app users versus using the items on the application. It would have helped determine how often similar items on the app were purchased personally or through school rather than making a trade during the time of the relaunch Ultimately, it would have supported the method to determine the overall miles traveled for transportation to estimate how much greenhouse gas was emitted for multiple purchases and create a cost analysis to determined which is the cheaper solution; to use the app or not. Due to the issues that occurred, the Fellow was not able compile a database of the items facilitated by the Share@work app and their associated GHG emission per exchange. This further explains why the final LCA overview of a product was condensed seen in **Figure 2.

Methods

The breakdown of each category

The items were separated into the following technically 7 categories seen in **table 1.** the Laboratory (lab) category was separated into two different scenario, which will be explained later. For the two items(tutoring in building/posting and excel) listed under the Academic category, reflect a performable service the app users were able to provide. If the individual provided the service and the recipient were both on campus, then there was no need to account for any use of transportation. Items listed under the Computer Accessories category are essentials that assist operation or enhance the performance of a computer. Since most of the items within this category are easily accessible via the internet, especially by using Amazon as a platform to search for these goods. Amazon is listed as the vendor. The Electronic category listed items that need power in order to operate such as an iPad Mini. In addition, the University of California, Merced book store partnered with Apple to provide students, staff and faculty the best quality computers, iPods, and accessories. With that being said, Apple is the vendor for the Electronics category. [13] For clarification there are other items located within the categories that do not come from the same vendor. The Electronic category provides the best example that may use other vendors in order to obtain a product. The fan listed could have been bought off of Amazon. The original analysis would have focused on each item's vendors to see how an individual product contributed to the GHG emissions based on its transportation route and vehicle used.

The Laboratory category listed items typically used in a lab setting, such as a kilowatt meter for educational and research purposes. Scientific Block is listed at the vendor since they are contracted with University of California as well as other higher education schools across the country. [10] Since it was difficult to determine the vendor, analysis done for Lab 1 and Lab 2 are scenarios to see whether FedEx freight planes or UPS freight planes emit more GHGs**.** Items listed in the Literature category are reference guides and books that are inspiration, fictional and self-improvement based. Listed on the app is the Leadership in Environment Engineering Design (LEED) reference manual which can be found on campus. As a result, this doesn't contribute to GHG emissions. However, a more personal set of books listed, such as Clockwork Angels by Cassandra Clare can be found at Barnes and Noble, therefore, it is the vendor selected for this category. [8] The Personal Use category listed a yoga ball and a desk lamp bought for personal reasons. Amazon is listed as the vendor for this category due to the simple search for these items. Lastly, lenders have listed a binder, a hole puncher, and a pen. Items like these are placed in the School Supplies category that can be assumed to be bought through Amazon to cover the bulk orders purchased by the school's Book Store, procurement, or any other department that handles purchases for their office/department.

Table 1

List of the Categories

Category	Vendors	Headquarters	Distribution Sites
Academic	Participate users	UC Merced	n/a
computer accessory	Apple	Cupertino, Ca	Elk Grove, California
Electronic	Apple	Cupertino, Ca	Elk Grove, California
lab (1)	Block Scientific	Bellport, Ny	Bellport, Ny
lab(2)	Block Scientific	Bellport, Ny	Bellport, Ny
Literature	Barnes and Noble	New York, New Jersey and Nevada	Reno, Nevada
Personal Use	Amazon	Seattle, WA	Tracy, Ca
School Supplies	Amazon	Seattle, WA	Tracy, Ca

Note. Listing the categories and the possible vendors that may be used based on the items listed in the categories. To see the items in each category, please refer to table 1A located in the appendix.

Vendors

Reasons for purchases are not described in its entirety and is not the focus of this LCA. In other words, the psychology of purchased goods depending on its performance, price, advertising and consumer habits will not be considered. Only consider personally purchased items (not done through procurement) or the items bought through procurement shall assume that the University is used as the shipping address. Taking the 29 items listed on the app, 7 different categories helped generalize the typical vendors for a category, depended on which common vendor would be used for the items listed. Vendors offer something for sale, the items list on the app may come straight from the company that produces the product such as Block Scientific which produces lab equipment; Apple which produces iPads; Barnes and Noble which handles books, or the use of a platform to find and discover anything online such as Amazon. [4] Once the vendors were determined, their headquarters**,** distribution site, and mailing service were found, **Table 2**.[1,2,7,9,25,27] The mail carrier contracted with Scientific Block was difficult to find. Therefore, two different analyses were conducted to evaluate which freight planes from FedEx and UPS may emit more CO_2. Furthermore, Amazon uses a variety of different transportation modes, ranging from their own Amazon trucks and planes to other carriers such as UPS, U.S. Postal Service and FedEx.**[1]** Final selection for UPS mode of Transportation was chosen. The other carriers were not evaluated due to the limited amount of time to conduct the LCA.

Table 2

Transportation used by mailing services, traveling from the Vendor's distribution site to campus

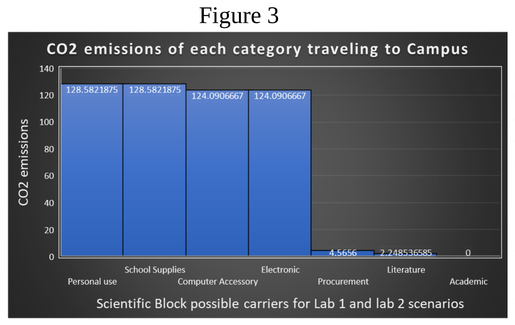
Category	Mailing service used	Transportation vehicle to campus	Did it go UC MERCED warehouse?	Transportation used to warehouse	Miles to campus
Academic	n/a	n/a	no	n/a	0
Computer Accessory	FedEx	Freightliner MT55 P1200 Step-van (gas)	no	n/a	106
Electronic	FedEx	Freightliner MT55 P1200 Step-van (gas)	no	n/a	106
Lab (1)	FedEx	Boeing 777F	no	n/a	3043
Lab(2)	UPS	Boeing 747-400F	no	n/a	3043
Literature	Drove themselves to a nearby store	Toyota Camry	no	n/a	8.4
Personal Use	UPS	heavy duty tractor-trailer 3-axle truck	yes	Chevrolet 2-axile gas cargo van	80.6
School Supplies	UPS	heavy duty tractor-trailer 3-axle truck	yes	Chevrolet 2-axile gas cargo van	80.6
Total					6467.6

Transportation

Transportation of goods to the consumer takes a toll on the environment. To figure out the GHG emissions due to transportation, a baseline is established as the app users. If items and services are already located as well as exchanged on campus, then there's zero GHG emitted due to transportation. Effects of non-application users whom purchased items have different repercussions. The Computer and Electronic category both list Apple as their vendor. Due to the close proximity of the distribution site and electronic ware, assumedly will directly go to campus in a Freightliner MT55 P1200 Step-van (gasoline). It is the largest van to carry cargo and has the lowest fuel economy.[20,21] Since it was difficult to find the carrier provider for Scientific Block, FedEx and UPS freight planes were accounted for to see the possible CO2 emissions. To find the maximum CO_2 emitted, planes with highest pay loads were used. It can carry the largest amount of equipment from location to location. Lab (1) scenario used FedEx as their carrier for their products. Six different aircraft were listed (Boeing 757F, Boeing 767F, Boeing 767F, MD-10-30F MD-11F, and Airbus A300-600F). [16] The top 2 candidates were the Boeing 77F and MD-11F where the pay loads were 230,000lbs and 180,000lbs, respectively. [17,18]Lab (2) scenario used UPS as their carrier for their products. Six different aircrafts were listed (757-200F, 767-300F, A300-600F, MD-11F, 747-400F, and 747-8F). [32] The top 2 candidates were Boeing's 747-400F and 747-8F, which were the aircraft with the highest payloads. The Literature category is a non-app user that drove him/herself to the closest Barnes and Noble—8.4 miles away—in the most commonly driven car in California; a Toyota Camry**.** [26] The Personal use and School supplies category used the same vendor. Orders for personal use may have had a vast number of individual purchases. For the School supplies category covers bulk orders needed for the staff and faculty to up hold a modern day work place with the certain amenities to use during board meetings, specials events, research and celebrations. These two scenarios have a cause for a 3-axle heavy duty truck to transport the items. Also, it will maximize CO2 emissions by selecting this mode of transportation.

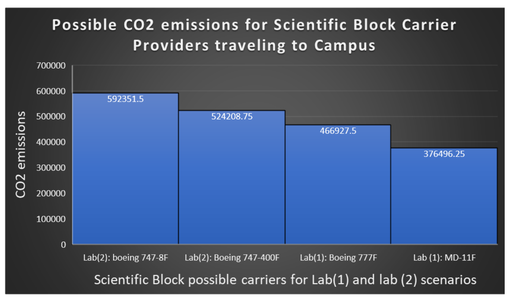
Results

Figure 3



Note. An average was taken from the fuel economy of three other freightliner step vans (model year (MY) 2009, 6.7 mpg; MY 2004, 8.4 mpg; MY 2009, 9.2 mpg) averaging to 8.2 mpg. Similar approach to find the fuel economy of a Toyota Camry (MY 2019 hybrin Le 2.5 L, 4 cylinder, 52 mpg; MY 2019 hybrid XLE/SE 2.5 L 4 cylinder , 46 mpg; 2019 2.5 L 4 cylinder , 34 mpg; MY 2019 3.5 L ,6 cylinder ,26 mpg; MY 2019 XSE 3.5 L 6 cylinder , 26 mpg) averaging 32.8 mpg . [15,36]

Figure 4



Note. The Lab category consisted of two different mail carriers, each used two different freight planes to transport items from Scientific Block's distribution center to California. Transportation from the airport to the school and/of to the warehouse was not included. Transportation from ware house to the school was, seen in Figure 3.

The results show that the category for Personal use and School supplies emitted 128.5821 CO_2e for a single travel to the campus **figure 3**, excluding the results from Lab 1 and Lab 2 shown in **figure 4.** Lab 1 and 2 used freight planes as mode of transportation. **Figure 4** shows Boeing 747-8F emitted the most greenhouse gas at 592351.5 CO_2e. This has the highest GHG emission compared to all the rest of the other categories. The Academic category resulted in the the lowest GHG emissions (zero CO_2e) for the non-app users because the services were located on campus. This shows that if borrowers used the tools listed on the app, it would eliminate a huge contribution to GHG due to transportation.

Conclusion

The idea behind Sharing Tribes Field Study is to promote sustainable consumption within faculty and staff at UC Merced by using the Share@work app. The environmental impact associated with non-app users vary due to the vendor's delivery service, mode of transportation and the distribution site. Sharing good and services eliminate harsh environmental repercussions caused by the arrival of a single item. The worst-case scenario depicted by Scientific Block, had its' distribution site located in Bellport, New York which used the only plausible mode of transportation, a freight plane. This shines light to the ugly side transportation to deliver the desired goods to the campus.

Work cited

1. About Amazon Staff. How your package gets from Amazon's warehouse to your front door. (2019, July 24). Retrieved May 27, 2020, from https://www.aboutamazon.com/amazon-fulfillment/our-fulfillment-centers/how-your-package-gets-from-amazons-warehouse-to-your-front-door/
2. Amazon Fulfillment Center Tours. (n.d.). Retrieved May 23, 2020, from https://amazonfctours.com/
3. Amazon's global career site. (n.d.). Retrieved May 27, 2020, from https://www.amazon.jobs/en/working/working-amazon
4. Atlas Air. (2018) *747 -400F Specifications.* https://www.atlasair.com/wp-content/uploads/2018/01/747-400F-One-Sheet_012418.pdf
5. Automotive Fact Sheet - The UPS Value. (n.d.). Retrieved March25, 2020, from https://pressroom.ups.com/pressroom/ContentDetailsViewer.page?ConceptType=FactSheets&id=1426321752376-284
6. Bacia, J. (2010, May 24). 2009 - 2010 Boeing 777 Freighter. Retrieved May 26, 2020, from https://www.topspeed.com/aviation/aviation-reviews/boeing/2009-2010-boeing-777-freighter-ar89537.html
7. Barnes &Noble Locations. (n.d.). Retrieved May 23, 2020, from https://careers.barnesandnoble.com/locations
8. Barnes &Noble. (2020). Clockwork Angel: Cassandra. [Data set]. Barnes &Noble. April 15, 2020, Retrieved from https://help.barnesandnoble.com/app/publisher_author/list
9. Block Scientific - Clinical Laboratory Equipment Company. (n.d.). Retrieved April 23, 2020, from https://www.blockscientific.com/history/
10. Block Scientific Clients, Laboratory Equipment Clients, Lab Equipment. (2018, June 28). Retrieved March23, 2020, from https://www.blockscientific.com/our-clients/
11. Boeing 747-8 Intercontinental Airliner. (n.d.). Retrieved April 1, 2020, from https://www.aerospace-technology.com/projects/boeing-747-8/
12. Boeing 747-8. (n.d.). Retrieved May 28, 2020, from https://aviationbenefits.org/case-studies/boeing-747-8/
13. Campus Store. (n.d.). Retrieved May 23, 2020, from https://www.ucmerced.edu/campus-store
14. Clark, J. S., & Kirwan, K. D. (n.d.). 777 Freighter Greater Efficiency for Long-Haul Operators. Retrieved April 27, 2020, from https://www.boeing.com/commercial/aeromagazine/articles/qtr_02_09/article_02_1.html
15. *Express Critical Surface. (n.d.). Retrieved May 23, 2020, from* https://www.aero-ecs.com/transportation/expresscritical_surface.html
16. FedEx® Charters - Aircraft. (n.d.). Retrieved May 26, 2020, from http://www.fedex.com/us/charters/airplanes.html
17. FedEx® Charters - Cargo Planes. (n.d.). Retrieve April 1, 2020, from http://www.fedex.com/us/charters/b777f.html
18. FedEx® Charters - Cargo Planes. (n.d.). Retrieved April 1, 2020, from http://www.fedex.com/us/charters/md-11f.html
19. FedEx® Charters - Cargo Planes. (n.d.). Retrieved March27, 2020, from http://www.fedex.com/us/charters/b777f.html
20. Freightliner MT55 MPG. (n.d.). Retrieved April 23, 2020, from http://www.fuelly.com/truck/freightliner/mt55
21. Inventory. (n.d.). Retrieved May 23, 2020, from https://www.fedextrucksforsale.com/inventory/?truck_style=136
22. life Cycle Assessment (LCA) (n.d.) Retrieved May 18, 2020 from http://www.ecoil.tuc.gr/LCA-2.pdf
23. Life Cycle Assessments. (n.d.). Retrieved April 27, 2020, from https://www.nrel.gov/lci/assessments.html
24. LTL and Truckload Freight. (n.d.). Retrieved March23, 2020, from https://www.ups.com/us/en/services/shipping/freight/trucking.page
25. Lu, D., Shen, L., & Zhao, Q. (n.d.). 5. Transportation & Warehousing. Retrieved May 23, 2020, from https://u.osu.edu/iphonecommodity-hain/5-transportation-warehousing/
26. Most Common Cars in California vs. U.S. (2018, July 9). Retrieved March23, 2020, from https://www.everquote.com/california/buying-selling-autos/most-popular-cars/
27. Sharing Tribes Field Study. (n.d.). Retrieved April 11, 2020, from http://share.ucmerced.edu/
28. The Boeing Company. (1990, October) *MD-11: AIRPLANE CHARACTERISTICS FOR AIRPORT PLANNING.* http://www.boeing.com/commercial/airports/plan_manuals.page
29. The Boeing Company. (2007) *MD-11F.*http://www.boeing.com/resources/boeingdotcom/company/about_bca/startup/pdf/freighters/MD11f.pdf
30. The Climate Registry. Emission Factor. (n.d.). Retrieved May 23, 2020, from https://www.theclimateregistry.org/?s=emission+factor
31. UPS Air Cargo Aircraft. (n.d.). Retrieved May 27, 2020, from https://www.ups.com/aircargo/using/services/services/domestic/ivc-aircraft.html
32. UPS. (YEAR) UPS Boeing 747-8F. https://www.pressroom.ups.com/assets/pdf/pressroom/fact%20sheet/UPS%207475%208F%20Fact%20Sheet.pdf
33. Zorn Mallen, R. (2019, June 04). Run On Less Heavy-Duty Truck Rally Hits 10 MPG Average. Retrieved April 23, 2020, from https://www.trucks.com/2017/09/25/run-on-less-heavy-duty-truck-rally/
34. 2005 Chevrolet Express 1500/2500 2WD. (n.d.). Retrieved May 23, 2020, from https://www.fueleconomy.gov/feg/noframes/2113.shtml
35. 2019 Toyota Camry. (n.d.). Retrieved March27, 2020, from https://www.fueleconomy.gov/feg/PowerSearch.do?action=noform