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My ICT GHG Footprint

In this paper, I will attempt to estimate my GHG footprint for a week of ICT usage and compare it to that of driving a gasoline powered car. I have divided my ICT usage into two categories; personal laptop and phone. Both my personal laptop and phone are Apple devices, so I was able to use their ScreenTime feature to track my total usage time (refer to 1.1 – 1.4 in the **Glossary** section to view breakdowns). From here, I calculated the energy usage of the device(s) using:

$$E_D = E_E + E_C + E_A + E_P$$

In the equation above, E_D represents the total energy consumed by the device and it is the sum of E_E, the embodied energy of the device, E_C, the charging energy of the device, E_A, the energy used by the applications in the device, and E_P, the energy consumed by any peripherals used with the device. E_A is applicable towards applications which are communicating with different remote servers and networks and therefore have an external power consumption which needs to be accounted for. In order to calculate the energy use of these applications, I looked at my total internet data usage; which was revealed to be ~70 gigabytes of data in that week. The paper '*The Megawatts behind Your Megabytes*' estimates 5.12 kWh per GB of data accounting for the additional switches, routers, signal repeaters, servers, and data centers outside of the local access point. Furthermore, according to the *Canada Energy Regulator*, Quebec consumed 1770 petajoules of electricity releasing 77.9 megatons of carbon dioxide equivalent (CO2e). This equates to about $4.4 * 10^{-5}$ grams of CO2e per joule of electricity consumed. Using these data points, and information collected from other sources regarding energy required for charging, peripherals and embodied energy, I calculated my CO2e for one week (refer to 2.1 – 2.2 in the **Glossary** section). The *EPA* estimates tailpipe carbon dioxide (CO2) emitted from driving one mile to be 404g, which would mean my ICT usage is equivalent to driving ~134 miles or ~216 kilometers in one week.

There are several limitations of this calculation. Most importantly, the biggest limitation is the assumption that the 5.12 kWh per GB of data can be applied uniformly across all the applications. The paper uses metrics for a single tab playing a song from a streaming music service and separately for a single tab showing a television show from a streaming video service. However, the operations beyond the local access point for

these actions can vary from application to application. For example, I often utilize a service known as Google Colab for developing machine learning applications. Although this would have similar energy usage as the applications used in the paper when transferring the data, the computational complexity on the server side is exponentially greater. The servers have to set up multiple CPUs or GPUs and process millions of computations from a standard machine learning application alone. Although this is less applicable, as more and more machine learning applications get deployed for regular services, the inferencing complexity in these servers will be far greater than that of streaming a song or a video. Secondly, it was assumed that maximum power was drawn during the charging of all the devices and the peripherals, which is hardly ever the case. Nevertheless, this component was only 1.6% and 5.7% of the total energy usage of the laptop and iPhone respectively, and therefore is a very small portion of the CO2e calculation. Thirdly, capacitance loss of the batteries were not taken into account. Again, since charging is such a small portion of the energy usage this can be considered as insignificant.

Glossary
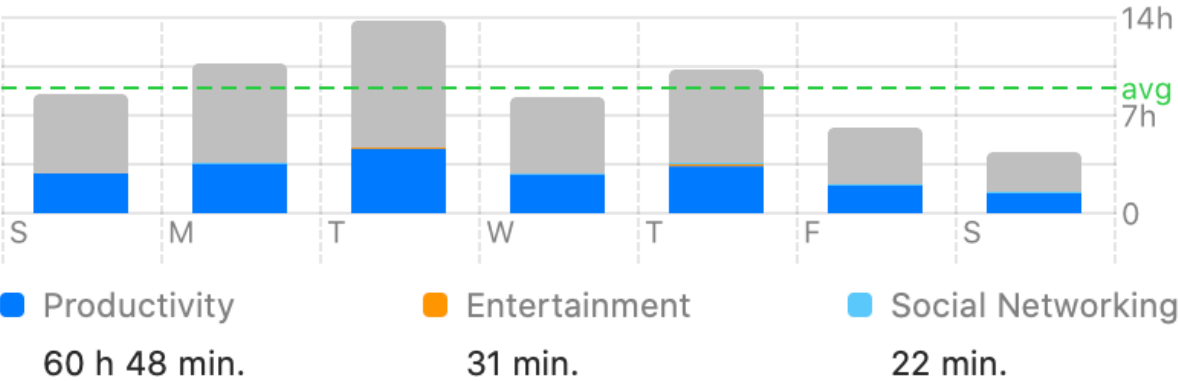
1.1 MacBook Pro Usage over 1 week

GitHub Desktop		60 h 45 min.
Microsoft Outlook		57 h 14 min.
Slack		57 h 4 min.
Visual Studio Code		51 h 21 min.
Microsoft Word		12 h 23 min.
Evernote		11 h 18 min.

1.2 Cloud Applications on MacBook Pro
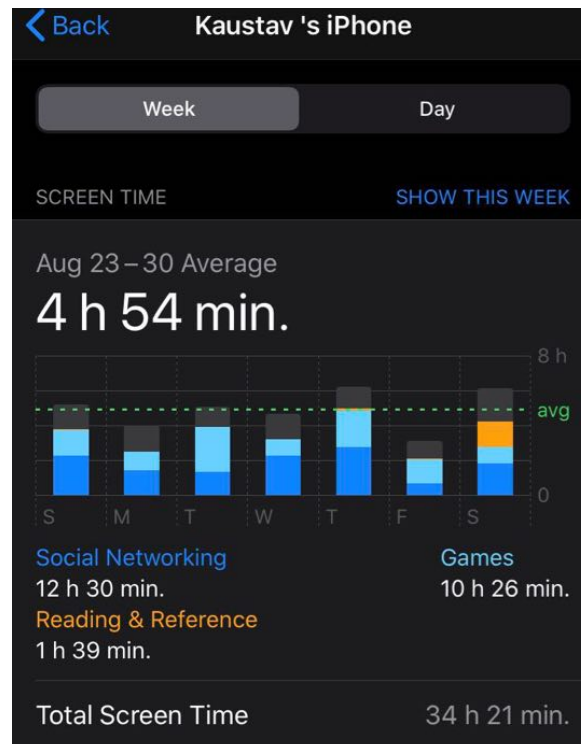
1.3 iPhone Usage over 1 week

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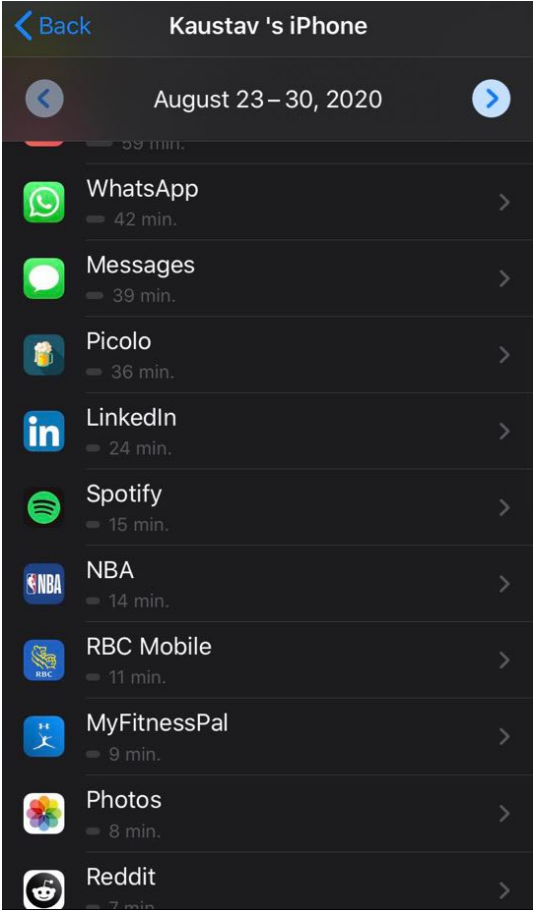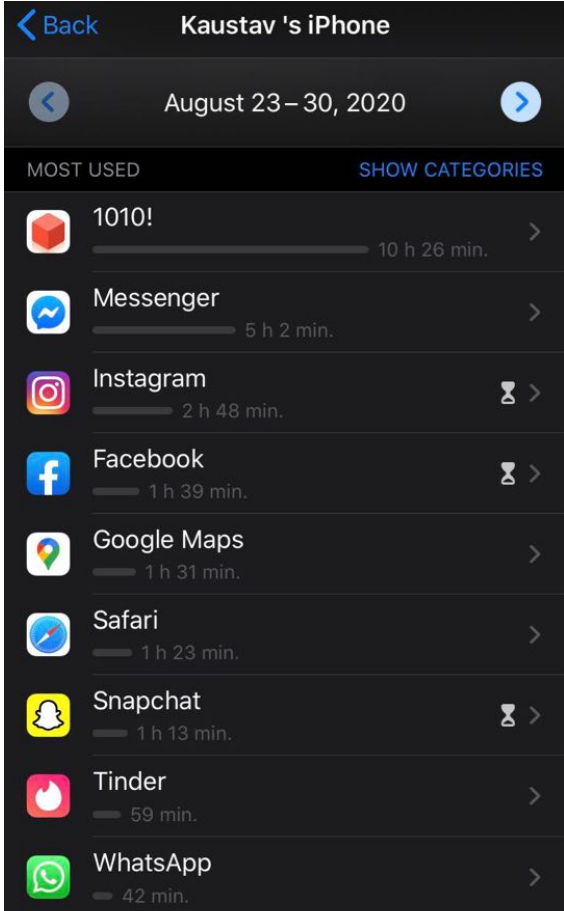
1.4 Application Usage on iPhone

Laptop		
Category		CO2e (g)
Peripherals		
	ASUS Monitor	253
	Apple Keyboard	5
	Apple Mouse	2
Embodied		
	MacBook Pro	6923
Charging		
	MagSafe 2	599
Applications		
	Software + Browsing	43794

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2.1 Laptop CO2e

Phone		
Category		**CO2e (g)**
Peripherals		
	Headphones	10
Embodied		
	iPhone 6	913
Charging		
	Lightning Cable	133
Applications		
	iPhone Apps	1622

2.2 Phone CO2e

Information Sources

- https://www.aceee.org/files/proceedings/2012/data/papers/0193-000409.pdf
- https://www.researchgate.net/publication/269101251_Wake-on-a-Schedule_Energy-aware_Communication_in_Wi-Fi_Networks
- https://www.cer-rec.gc.ca/nrg/ntgrtd/mrkt/nrgsstmprfls/qc-eng.html?=undefined&wbdisable=true#s3
- https://www.asus.com/us/Monitors/VG245H/specifications/
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- https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle
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