Life Cycle Assessment

Materials Acquisition

Disposal

Materials Processing

Product Use
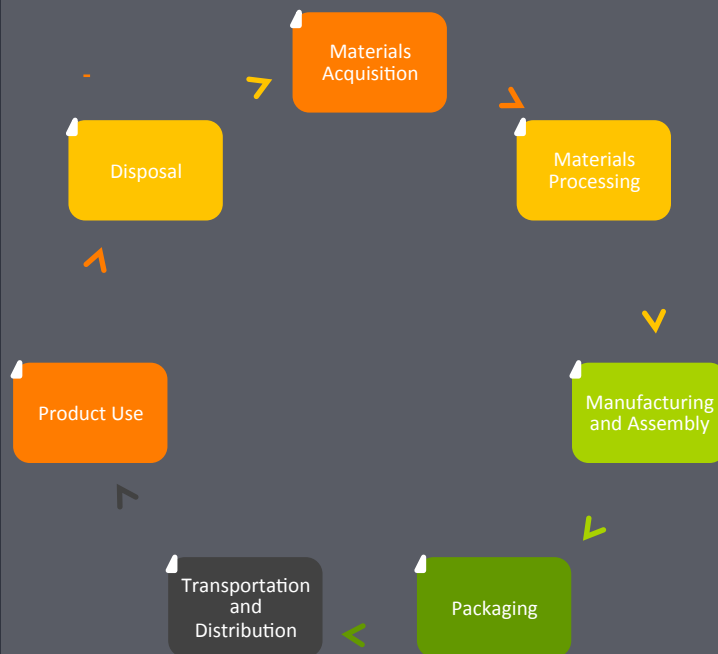
Manufacturing and Assembly

Transportation and Distribution

Packaging

Key Findings

- It is much more beneficial to use computers to their end-of-life due to the environmental impacts and energy required during raw material extraction, processing, and manufacturing of new computers.
- Reusing and recycling computers can lessen the environmental impacts of computers. Reuse means reselling or donating in order to ensure a 2nd lifespan of computers is realized before final disposal.
- Recycling computers at the end-of-life is crucial to salvage materials necessary for the production of new computers.

Computers: Use or Replace?

By Shannon Thomas

Introduction

While the efficiency of computers is increasing, there is often times pressure on consumers to replace their outdated devices with new, more efficient models. However, disposing of devices before their end-life often causes unforeseen and unintentional environmental impacts that are explicated below. Therefore, the real question involves balancing difficult tradeoffs: energy inefficiency leading to increased emissions or life cycle costs which involves the extraction of raw materials, processing, manufacturing, use, and disposal processes.

Replace or Use?

It is much better to use computers to their end of life due to the substantial environmental impacts caused during the raw material extraction, processing, and manufacturing process. For example, in general reselling or upgrading just 10% of end-of-life computers reduces life cycle energy significantly compared to recycling (Table 1). In fact, reselling and upgrading can be 20 and 12 times more efficient at reducing life cycle energy compared to recycling (Table 2) (Williams 2003). The production of computers contains a greater energy demand than actual use, meaning there should be a greater emphasis on proper management and life spans of computers. Even if computers are recycled, the retrieval of raw materials does not undo the environmental burden associated with processing and manufacturing. Therefore, it is more beneficial to use computers to their end-of-life.

Table 1: Results from reselling, upgrading, or recycling 10% of end-of-life computers (Williams 2003)

End of Life	Life Cycle Energy Reduction
Reselling	8.6%
Upgrading	5.2%
Recycling	.43%

Table 2: Energy Values for Desktop Computers (Williams 2003)

Life Cycle Stage	Energy Value
Production	1556 kilowatt hours
Use (2 year 1st lifespan)	253 kilowatt hours
Use (3 year 1st lifespan)	378 kilowatt hours
2nd lifespan	1-2 years
Upgrade (energy for parts)	486 kilowatt hours
Recycle	-77 kilowatt hours (theoretical limit) -378 kilowatt hours

More specifically, in order to produce a desktop computer with a 17-inch display screen, it takes about 1800 kilowatt-hours and 260 kilograms of fossil fuels. The ratio of fossil fuel use and the weight of the computers is 11 to one, representing a very energy intensive process. This large energy use coupled with a high turnover rate results in substantial energy consumption. Additionally, computers are unique to other appliances in that their energy use is caused primarily from production (81%) rather than operation (19%) (Williams 2004).

When comparing desktop computers with laptops, laptops show a significant decrease in power usage. A study conducted by the University of Pennsylvania showed that nine out of their ten desktop computers showed a higher watt usage under moderate use compared to their eight laptop computers (Table 3 and 5) (Penn Computing 2013). Rather than using desktops, perhaps businesses should require laptops to be used in the workplace in order to save energy. Tables 4 and 6 provide costs associated with each model; however, due to the rapid turnover rate, many of these models have been discontinued and cannot be purchased by the supplier/manufacturer.

Conclusion

In the office, computers have the second highest energy consumption (Bray 2006). Additionally, about half of computers remain left on overnight and during weekends, which accounts of 75% of the week (Bray 2006). By using power management strategies such as turning off computers when not in use and ensuring computers go into power down mode when idle, firms may reduce energy use by up to 50 percent (Bray 2006).

If a newer computer is required for whatever reason, then the older model should be reused whether that means reselling, donating, etc. Upgrading current computers with new software/parts can also fit in this category. Using the computer as long as possible will minimize the environmental impacts associated with disposal of the current computer and production of the newer one. In fact, most computers that are disposed of are still functional, creating an area of opportunity to minimize some of the environmental impacts (Williams 2003). In 2009, only 38% of computers were recycled that had reached their end-of-life (EPA 2012).

Table 3: Desktop Power Usage in Watts

Approximate Desktop Power Usage In Watts					
Make & Model	**Off** (plugged in)	**Boot** (peak)	**Moderate Use** (range)	**Quiescent** (5 minutes of no activity)	**Sleep**
Apple iMac/Intel 21.5-inch (purchased late 2012)	1	60	52 - 56	44 (18 w/LCD in sleep)	1
Apple iMac/Intel 21.5-inch (purchased late 2011)	1	105	92 - 96	88 (38 w/LCD in sleep)	1
Apple iMac/Intel 27-inch (purchased late 2009)	1	177	141 - 147	130 (73 w/LCD in sleep)	1
Apple iMac/Intel 24-inch (purchased early 2009)	1	141	146 - 154	88 (42 w/LCD in sleep)	1
Dell OptiPlex 9010 All-In-One 23-inch (purchased late 2012)	1	61	43-45	43-44	1
Dell OptiPlex 9010 w/Dell LCD (purchased mid 2012)	1	48	66	20-22	1
Dell OptiPlex 990 w/Dell LCD (purchased mid 2011)	1	86	33-37	28	1
Dell OptiPlex 980 w/Dell LCD (purchased mid 2010)	1	66	64-71	46-61	1
Dell OptiPlex 760 w/19-inch Dell LCD (purchased late 2008)	1	116	95 - 111	81 - 83 (50 - 52 w/LCD off)	1
Lenovo ThinkCentre M91 w/Lenovo LCD (purchased early 2012)	1	88	50 - 68	40	1

Source: Penn Computing 2013.

Table 4: Current Desktop Costs

Computer Make and Model	Cost
Apple iMac/Intel 21.5-inch	$1299-1499
Apple iMac/Intel 27-inch	$1799-1999
Apple iMac/Intel 24-inch	$1399
Dell OptiPlex 9010 All-In-One 23-inch	$899-1082.51
Dell OptiPlex 9010 w/ Dell LCD	$899-1082.51
Dell OptiPlex w/ Dell LCD 990	Discontinued
Dell OptiPlex w/ Dell LCD 980	Discontinued
Dell OptiPlex w/ Dell LCD 760	Discontinued
Lenovo ThinkCentre M91 w/ Lenovo LCD	Discontinued

Source: Apple, Dell, and Lenovo

Table 5: Notebook/Netbook Power Usage in Watts

Approximate Notebook/Netbook Power Usage In Watts					
Make & Model	**Off** (plugged in)	**Boot** (peak)	**Moderate Use** (range)	**Sleep**	**Battery Charging** (powered on)
Apple MacBook Pro 13-inch "Retina" (purchased mid 2012)	1	50	49 - 53	1	53
Apple MacBook Pro 13-inch (purchased mid 2009)	1	52	58 - 60	1	56 - 60
Dell XPS 12 12.5-inch (purchased late 2012)	1	21	38 - 40	1	66 - 71
Dell Latitude E4200 12-inch (purchased late 2008)	1	48	38 - 40	1	66 - 71
Dell Latitude XT2 XFR 12-inch (tested early 2010)	1	37	28 - 32	1 - 2	49
Dell Inspiron Mini 10 10-inch (purchased late 2009)	1	21	19 - 21	1	34 - 35
Lenovo ThinkPad X100e 11.6-inch (tested early 2010)	*1*	*21*	*19 - 21*	*1*	68 - 70
Lenovo ThinkPad T400s 14-inch (tested mid 2009)	1	*25*	*not testable*	*1*	47 - 53
Lenovo ThinkPad T410s 14-inch (tested mid 2010)	1	59	39 - 58	1	35 - 67

Source: Humbert et al 2009

Table 6: Current Notebook/Netbook Costs

Computer Make and Model	Cost
Apple MacBook Pro 13-inch "Retina"	$1499-1699
Apple MacBook Pro 13-inch	$1199-1499
Dell XPS 12 12.5-inch	$1099.99
Dell Latitude E4200 12-inch	Discontinued
Dell Latitude XT2 XFR 12-inch	Discontinued
Dell Inspiron Mini 10 10-inch	Discontinued
Lenovo ThinkPad X100e 11.6-inch	Discontinued
Lenovo ThinkPad T400s 14-inch	Discontinued
Lenovo ThinkPad T410s 14-inch	Discontinued

Source: Apple, Dell, and Lenovo

Colorado law prohibits businesses from disposing of electronic waste in landfills including computers and related devices (printers, keyboards, etc.) If your business wants to donate or recycle a computer in the office, then visit the City of Fort Collins website for more information or contact the donation sites listed below (Table 7).[1]

Table 7: Donation Sites located in Fort Collins

Donation Sites	Contact Information	Addresses
Community Computer Connection (C3)	Phone: (303) 962-2270	14500 E. 33rd Place Aurora, CO 80011
The Education and Life Training Center	Phone: (970) 482-4357	401 Linden St. Fort Collins, Co 80524
Verizon Wireless Hopeline	Phone: (970) 377-2054	4300 S. College Ave St. 101 Fort Collins, CO 80524
Computers for Learning	Phone: (866) 333-7472	Nationwide Program, visit website for details http://computersforlearning.gov/

Resources

- Provides details and locations for donation sites, take-back programs, and recycling centers - http://www.fcgov.com/recycling/computers-recycle.php
- Read about the statistic on the management of both used and end-of-life electronics - http://www.epa.gov/osw/conserve/materials/ecycling/manage.htm
- Learn about energy consumption of computers and how to reduce usage with power management strategies - http://204.13.11.223/research/computer_energy_consumption.pdf
- Review the usage of different computer types and models for comparison - http://www.upenn.edu/computing/provider/docs/hardware/powerusage.html
- Fact sheet providing information on when to turn off computers and monitors - http://www.fcgov.com/recycling/pdf/computers-monitors.pdf

Acknowledgements

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[1] Computer/Electronic Recycling page (includes donating sites): http://www.fcgov.com/recycling/computers-recycle.php.

Works Cited

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