Working for the Weekend: Material Intensity in Appliances & Office Equipment

We are still looking at getting the same services from consumer goods, with lower intensity of environmental impact – and indirect energy savings. One of the big end uses is appliances and office equipment. (Technically office equipment is part of the production process; but we will treat is as a consumer good.) Now it would be beyond the scope of this book to look individually at what it takes to make a can opener, and what it takes to make a microwave oven, and a washer and dryer and printer and copier and paper shredder and every possible consumer or office appliance. So we shall simply look at two ends of the spectrum; computers and refrigerators – the newest most complex technology, and oldest most mature one.

Appliances	
Computers: the materials discarded in making the average desktop computer and monitor weigh about the same as an SUV[78].	
Chips – Water and chemical use may be reduced from 80%-95% through techniques from simple things like extending the length of soaks in cleaning baths ,to using dry processes and clean chambers to reduce the need for water and chemicals, to improved purification and recycling of used water and chemicals[75;76;77]. These constitute 86% of chip manufacturing impact - thus 75% reduction	50% energy savings
Circuit boards: silk screening substitutes for etching process[79]. The result is lead, halogen and bromide free, uses fewer harsh chemicals, produces less manufacturing waste, and contaminates less water – 75% - 80% reduction environmental impact.	50%+ energy savings
chip packaging - epoxies and films that can complete replace solders[80] - 75% reduction	50% energy savings
Monitors: LCD monitors have much lower lifetime impacts than CRTs[81] - ~73% (must incorporate technologies to reduce nitrogen and phosphorus pollution[82], and recycling and major reductions in emissions of Sulfur hexafluoride[83].)	40% energy savings
Assembly – lead free solder, less toxic plastic, easier recycling - example - Fujitsu's Scenic Green E -75% impact reduction	50% energy savings
Average life of computer 2 years[84]. Double it! Four years was average computer lifespan at the height of the internet bubble. Make computers with easier to open cases, and roomier bays. (Dell, and many other manufacturers already do.) Limit software license restrictions that forbid selling obsolete computers with old obsolete software. That will encourage "second lives" for business computers that are currently scrapped to avoid copyright liabilities.	
Manufacturer liable for recycling computer end of life (as in Europe). This will both encourage longer lifespans, and encourage manufacturers to make computers easier to recycle…	
Computer total impact savings 80%	*60% energy savings*

If computers are leading edge appliances, refrigerators are perhaps the oldest, most mature technology. Heat pump based cooling was invented and commercialized in the late 19th century, mostly to make ice for distribution. Can we lower the intensity of the manufacture of heat pump refrigeration, and improve efficiency too?

The Wuppertal institute proposed (and built an example of) an alternative[85], based on looking at refrigeration in a new light. What services exactly does it provide?

> *...produce or groceries should be kept cool and dark so that they will not spoil; the storage space should be located in immediate proximity to where food is prepared; it should be hygienic, able to accommodate the usual containers, as well as meet the reigning aesthetic standards, and it should be easily accessible....*
>
> *...why should a refrigerator not be a part of the house similar to our grandmother's root cellar or pantry? … The doors, seals, control technology, as well as the separately incorporated refrigeration unit, should be exchangeable....*

So instead of building what amounts to a cupboard, and transporting it to the home, build it in place like any other cabinet and add a high quality thermostat, heat pump, vent and insulation. In operation, it uses around 145 kWh per year - about a tenth of the average U.S. household refrigerator. (In fairness new U.S. refrigerators consume a great deal less than average U.S. consumption.) At the time the analysis was done they simply noted that they used around the same weight of material, but designed it to last the life of the house instead of the usual refrigerator lifespan. Their material substitutions, greatly reducing steel (and other metals), glass, and plastic, replacing them with wood and cork or paper will reduce material intensity even of manufacture by a factor of four or greater - before you consider the greater lifespan – four or five time the U.S. average. So you end up with a factor 16 to 20 reduction in embedded impact, a 90% or better reduction in embedded energy over the life of the refrigerator (not counting operational savings.)

That defines a spectrum - but what about appliances in between? There may well be some room for material substitution and rethinking of the same type we saw in refrigerators, or drastic changes at the manufacturing level as we saw with computers, or a combination of both. Microwaves are closer to the computer end of the spectrum, dishwashers, washers and dryers closer to the refrigerator. Really small appliances, like can openers, and toasters could probably reduce impact in a third way - by a drastic increase in lifespan. A 21st century slice toaster does little a 1965 slice toaster did not do. A 21st century can opener does little a 1978 can opener did not do. There is no reason not to manufacturer such very small appliances with sufficient durability to multiply their years of service four times or more. In many cases increased durability can combine with lower impact materials.

In total we can reduce major appliance impact by 80% to 90%, minor appliance impact by 50% to 75%. A factor four to five reduction in total impact would be reasonable estimate – a 50% energy savings or a bit more.

End Notes

[78]Eric Williams, "Energy Intensity of Computer Manufacturing: Hybrid Assessment Combining Process and Economic Input-Output Methods,". *Environmental Science & Technology* 38, no. 22 15/Nov 2004, American Chemical Society, 18/Sep/2005 <http://www.it-environment.org/publications/hybrid%20PC%20LCA%20abstract.pdf or full version(paid) http://pubs.acs.org/cgi-bin/article.cgi/esthag/2004/38/i22/pdf/es035152j.pdf>.pp6166 – 6174.

[79]EECO - A Transico Company, *EECO-Greenä SILVER-THROUGH-HOLE DOUBLE-SIDED PRINTED CIRCUIT BOARDS PRODUCT OVERVIEW DESIGN CONSIDERATIONS FAQ's.* Dec 2003, EECO - A Transico Company, 22/May/2004 < http://www.eecoswitch.com/PDF%20Files/STH%20FAQs.PDF>.

[80]Sumitomo Bakelite Co. Ltd., *Products That Provide Environmental Solutions*. Jan 2004. *Sumitomo Bakelite Co. Ltd*., 4/Jun/2004 <http://www.sumibe.co.jp/english/kankyou/pdf/rc2003_E06.pdf>.

[81] Jonathan G. Overly, Lori E. Kincaid, and Jack R. Geibig, "Chapter 3: LIFE-CYCLE IMPACT ASSESSMENT," *Desktop Computer Displays: A Life-Cycle Assessment*, EPA-744-R-01-004a. Dec 2001. *Environmental Protection Agency*, 18/Mar/2005 <http://www.epa.gov/dfe/pubs/comp-dic/lca/Ch3.pdf>.pp3-30.
Table 3-10. Baseline life-cycle impact category indicators

[82]Sharp Corporation, *Sharp Environmental Report 2002*, April 2001 - March 2002. December 2002. *Sharp Corporation*, 20/Mar/2005 <http://sharp-world.com/corporate/eco/report/2002pdf/report_2002.pdf>.p9.

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[84]Keirsten Scanlon, *Poison PCs and Toxic TVs:California's Biggest Environmental Crisis That You've Never Heard of*. Jun 2001. *Silicon Valley Toxics Coalition; Californians Against Waste; Materials for the Future*, 6/Jun/2004 <http://www.cawrecycles.org/Ewaste/PPCs%20and%20TTVs/ppc-ttv.pdf>.
Citing: the Electronic Product Recovery and Recycling Baseline Report, published in May, 1999 by the US National Safety Council

[85]Friedrich Bio Schmidt-Bleek, *MIPSBOOK or The Fossil Makers -Factor 10 and More*, ed. Reuben(Trans) Deumling, 1994), ISBN 3-7643-2959-9. *Birkhäuser: Basel, Boston, Berlin*, Wuppertal Institute for Climate, Environment, Energy, 3/Aug/2004 < http://prog2000.casaccia.enea.it/nuovo/documenti/427.doc>.