The Economics of Cycling Personal Computers

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Introduction

Because of the increasing saturation and unit energy consumption of personal computers (PCs), some institutions are considering programs to induce office workers to shut off (cycle) their PCs when these devices are not in use for short periods. For example, in 1991, IBM Svenska, in Kista, Sweden, encouraged employees to switch off their computers when not in use, and to switch off their screens during short periods of inactivity. The company then measured the savings, and found that they achieved reductions of 40% over pre-program levels.

Analyses of such programs have, in the past, focused on potential energy savings and on possible hardware damage due to frequent cycling of the computer, but these analyses have not in general considered the cost of worker salaries. This paper uses rough calculations to assess the effect of the cost of labor on the cost-effectiveness of cycling personal computers.

Discussion

Modern personal computers are extremely reliable devices. Under normal usage, economic obsolescence (which typically occurs in about five years) is more dangerous to a PC than user-induced wear and tear. We adopt the assumption that cycling the computer several times a day will not have a significant effect on the useful lifetime of the device or on the maintenance cost associated with the device.

The technological reasons for avoiding cycling of PCs probably no longer apply. However, there may still be an economic reason for avoiding such cycling if it uses another more costly resource (people's time) to save a comparatively small amount of electricity. The time needed to reach for the shut off switch, to log in or out of external network connections, or to restart computer programs to begin work, may only be fifteen or thirty seconds, yet such time may be sufficient to render the costs higher than the value of the energy savings to the consumer.

Labor and Energy Cost Related to Computer Cycling

We focus only on changes in the cost of labor (C_{labor}) and the cost of energy (C_{energy}) specifically related to computer cycling to determine the tradeoff between these two costs. Equation 2 shows the components of C_{labor}, and Equation 3 shows the components of C_{energy}.

$$C_{labor}\left(\frac{\$}{yr}\right) = \frac{Cycles}{yr} * \frac{Hours}{Cycle} * Wage\left(\frac{\$}{hour}\right) \tag{1}$$

$$C_{energy}\left(\frac{\$}{yr}\right) = PC\ load\ (kW) * \frac{Operating\ hours}{yr} * Electricity\ price\left(\frac{\$}{kWh}\right) \tag{2}$$

These two equations and the data in Tables 1 and 2 are used to create Figure 1.

Examples

Table 1 shows typical power use by PCs. Most PCs use about 125 watts of measured power, and use roughly a penny's worth of electricity per hour (at 1989 national average commercial sector electricity prices of 7.6¢/kWh in 1990 $). Table 2 shows representative salaries per hour including overhead. These salaries are three to four orders of magnitude higher per hour than the electricity costs of the PCs.

Figure 1 shows tradeoff curves summarizing the relationship between salaries, the time needed to cycle the computer, and the time that the computer will be off, for 125 W computers. To read Figure 1, first choose the time it takes to cycle the computer. Then follow the vertical line corresponding to that time period up until it intersects the curved line corresponding to the number of hours that the PC will be off. Read the maximum wage (including overhead) off the vertical axis, and compare it to the

Table 1. Typical Electric Power Use by Computer Type

CPU Type	Measured Total Average Power Watts	Electricity Cost to Operate Computer $/hr
Desktop Models		
Apple: Macintosh SE, FD, 20 MB HD	40	0.003
Apple: Mac II, FD, 40 MB HD	130	0.010
IBM: PS-2/30, FD, 20 MB HD	76	0.006
IBM: PS-2/50, FD, 20 MB HD, SB	109	0.008
IBM: PS-2/70, FD, 70 MB HD, SB	172	0.013
IBM: PS-2/80, FD, 70 MB HD, SB	209	0.016
IBM: AT, 2 FD, 30 MB HD, 3 SB	165	0.013
IBM: XT, FD, 30 MB HD, 3 SB	115	0.009
Laptop Models		
Zenith: 181, 2 FD	11.6	0.001
Data General: 1,2 FD	6.2	0.000
Sharp: 7000	29.4	0.002
Toshiba: 1100-plus	10.8	0.001
Generic 125 W	125	0.0095

1) source of wattage estimates: Harris et al. 1988
2) FD = floppy disk drive, MB = megabyte, HD = hard disk, SP = special boards for expanded memory, graphics, expanded calculation, printer port, or modem
3) cost to operate computer assumes that electricity costs 7.6¢/kWh

Table 2. Typical Salaries for Office Workers

Type of Worker	Direct Salary k $/year	Direct Salary $/hour	Salary w/Overhead $/hour
Clerical			
Low	20	8	16
High	45	18	36
Lawyers			
Low	45	18	36
High	150	60	120
Executives			
Low	40	16	32
High	250	100	200

1) Salaries are approximate. Overhead assumed to be 100% over base salary.
2) Note that salary costs are 3 to 4 orders of magnitude greater than the cost of electricity for computers per hour (Table 1).

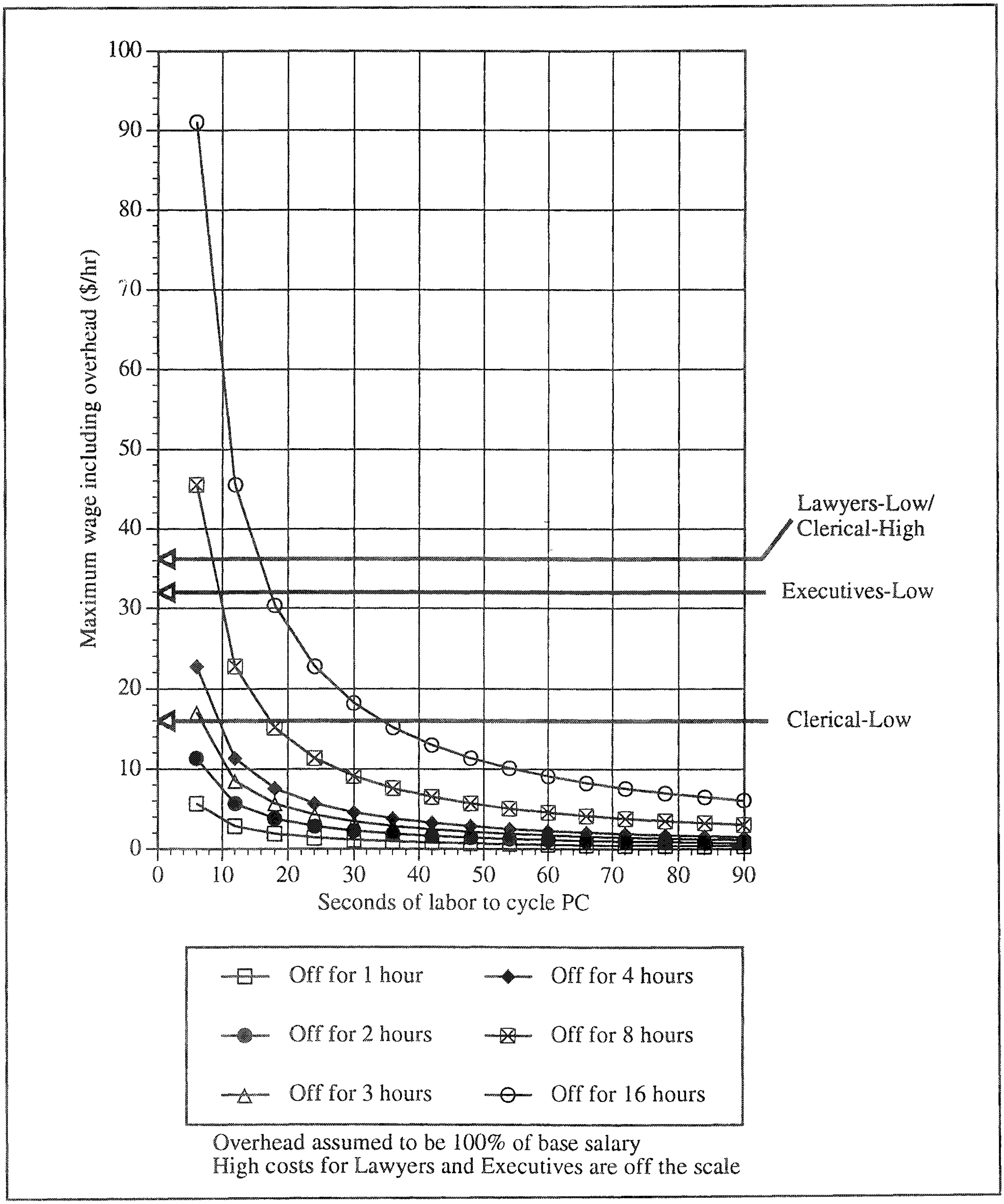

Figure 1. Maximum Wage to Justify Turning Off a 125 Watt Personal Computer (PC) as a Function of the Number of Hours of PC Off-Time and the Number of Seconds of Labor to Cycle the PC

wages of typical office workers (dark arrows). If the maximum cost-effective wage for a given shut off time and labor time is less than the wage of an office worker, it is not cost-effective for the worker to shut off the computer for that period.

An unsystematic survey of half a dozen PC and Macintosh users found that fifteen to twenty seconds of labor are typically required to cycle a PC (including logging into and out of network connections). This 15 to 20 second interval includes only the time when the operator must be paying attention to the computer to log into network connections and restart programs. Many users perform other tasks during the considerably longer period in which the computer "boots up."

These calculations show that salaries swamp the savings from turning the computer off for an hour or two. For the typical 125 W PC and one to two-hour off-times, the avoided electricity costs are always lower than the labor costs for even the lowest paid office workers (Clerical--low). For cycling labor times of 15 to 20 seconds, it is not economical for any worker to cycle the PC for an hour or two.

Using simple calculations, we have shown the importance of labor costs to assessments of the cost-effectiveness of cycling personal computers. Specifically, we have shown that shutting off PCs for one or two hours is not a cost-effective use of people's time if it takes them 15 to 20 seconds to cycle the computer, log into network connections, and restart programs. Simply shutting off the monitor and leaving the CPU on is sensible from this standpoint, since this action takes little time and can save a substantial fraction of the PC's energy use. Shutting the entire PC off for nights and weekends can be justified in many cases by the direct value of energy savings, but also by the extension of useful lifetime this action affords, and by the additional internal diagnostic tests it allows.

Assessments of commercial sector efficiency programs must account for the cost of labor accurately, because it can affect the results of cost effectiveness calculations significantly. The total cost of energy in commercial buildings is typically 100 to 200 times smaller on a per square foot basis than people's salaries, and therefore the cost effectiveness of efficiency programs can be jeopardized by reductions in worker productivity of less than one percent (Koomey 1990, Lovins and Sardinsky 1988, Rosenfeld 1989, Smith 1989). On the other hand, efficiency technologies that also improve worker productivity should be allocated that benefit in cost-effectiveness calculations.

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