Hidden Cost Savings of Flat Panel Displays

Joe Miseli
Sun Microsystems, Palo Alto, California

Abstract
1998 marked the beginning of full-performance LCD flat panel monitors capable of competing directly with CRT monitors for primary computer displays. Decisions to use flat panels in place of a CRT often weigh heavily on cost. Although LCD's and other flat panel monitors cost more than CRT's today, they have a number of physical and technological advantages. When properly analyzed, these can translate into cost savings, and if time is factored into the analysis, there can eventually be enough savings to offset the additional cost .... and more.

Shown are a number of obvious and not-so-obvious hidden-cost savings that can help defray the initial cost premium. There are also several worked-out examples of LCD flat panel monitor savings for different scenarios.

Introduction
Costs of LCD monitors are dropping rapidly. As in Figure 1, the initial cost difference between LCD's and CRT's may one day disappear. For now, the understanding of how LCD savings can be obtained can be achieved only through detailed analyses.

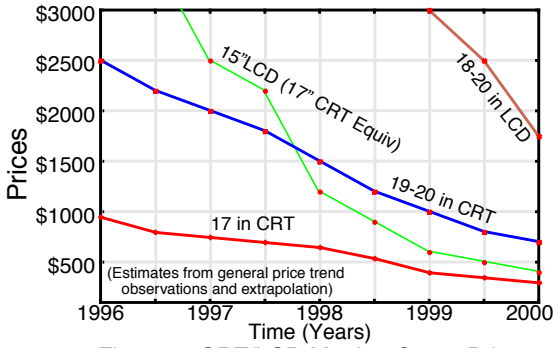

Figure 1: CRT/LCD Monitor Street Prices

For all cases, assumptions have to be made. The assumptions will vary for each case in which CRT monitors are used. Readers are encouraged to use the guidelines provided, and to alter any conditions dependent upon their specific situations. Many of the examples given will provide more cost advantages for multiple units for an organization, but there is much that is useful also for the individual monitor case.

Fundamental Assumptions
Suppose we are comparing a high-grade CRT monitor with a comparable LCD monitor, and we make the following assumptions.

Common CRT-LCD Assumptions		
Characteristic	**CRT**	**LCD**
Initial Cost	$1000	$2000
Power Consumption	90W	30W
Operation Time*	50%	50%
Weight	75lbs	20lbs
Number of Units	100	100

*Due to a power management or energy savings mode assumed to be in use.

Cost of some items may be better understood when amortized over a number of units.

We can then begin a cost analysis such as the following.

1) Power Consumption Cost

Direct power savings due to the lower power consumption of the LCD over the CRT may be the most fundamental cost savings item for analysis.

Power Consumption Cost Analysis Assumptions		
Characteristic	**CRT**	**LCD**
Power Consumption	90W(0.09kW)	30W(0.03kW)
Power Cost	10¢/kW-hr	

- *For 1 year = 8765.8 hours = 365.24 days*
- *50% of this time = 4382.9 hrs.*

Power Consumption Cost Analysis
CRT power cost for 1 year (P1) = $0.10 x 0.09kW x 100 x 4382.9 hr = $3,944.61
LCD power cost for 1 year = $0.10 x 0.03kW x 100 x 4382.9 hr = $1,314.87
CRT Cost = $3,944.61/year ($39.45 per unit) *LCD Cost = $1,314.87/year ($13.15 per unit)*
LCD power cost savings = $2629.74 / year *= $26.30 / unit / year*

2) Air Conditioning Power Consumption Cost

Power consumption for monitors produces heat. In many environments, air conditioning units are required, and they work harder to overcome the extra heat of the CRT monitors. They also cost more to install, since increased cooling needs require extra capacity of the installed unit.

The reduction of heating due to the monitor BTU generation can be considered to be much less than the cooling required and will be disregarded in this analysis, since heating is rarely used in many places. Those in colder climates may wish to consider factoring heat reduction into the analysis.

Air Conditioner Cost Analysis Assumptions		
Characteristic	**CRT**	**LCD**
Air conditioner usage	30%	
Cooling unit efficiency	1.0	
Cooling-power conversion	1 ton of cooling ≅ 1kW	
Heat to AC tonnage conv.	12,000Btu require 1 ton	
AC cost + installation	$2,500 per ton	
Power cost	10¢ per kW-hr	

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A. Air Conditioner Power Consumption Cost

Problem: Find the cost for Air Conditioner extra power consumption due to heating (in Btu's) of the monitor.

Cost Analysis for Air Conditioner Operating Expense Due to Monitor Btu Output
Btu's generated from a 90W CRT monitor = Btu/kW-hr = 0.09W x 3412 = 307.08 Btu/hr Cooling required for CRT (90W) monitor (tons) = $\frac{307.08\ \text{Btu/hr}}{12{,}000\ \text{Btu/ton}} = 0.0256\ \text{tons/mon}$ Since 1kW ≅ 1 ton of cooling, 0.0256 tons needed per CRT mon ≅ 0.0256 kW = 0.0256 kW x $0.1kW-hr = $0.00256 / unit/hr = $0.00256/unit/hr x 12 hr/day x 365.25 day/yr x 0.3 (AC % usage) x 100 units = *CRT Cost = $336.61 per year ($3.37/unit/year)*
LCD monitor AC Power Cost = 1/3 of CRT Cost = 30W/90W x $336.61 per year = *LCD Cost = $112.20 per year ($1.12/unit/year)*
LCD Air Conditioning power cost savings = $224.41 / year ($2.24 / unit / year)

B. Air Conditioner Installation Tonnage Cost

Problem: Find the cost for Air Conditioner extra tonnage required due to monitor heating.

Assumptions (As per section A.)

- Btu's from CRT monitor = 307.08
- A/C tonnage for CRT monitor = 0.0256 tons/mon

Cost Analysis for A/C extra tonnage due to monitor heating in Btu's
CRT Monitors, 0.0256 tons/mon x $2,500/ton x 100 monitors = $6,400.00 ($64.00/unit)
LCD Monitors, 0.00853 tons/mon x $2,500/ton x 100 monitors = $2,132.50 ($21.33/unit)
LCD Air Conditioning tonnage cost savings = $4,267.50 ($42.67 / unit)

3) Magnetic Interference Expenses

Magnetic Field Interference (EMF) for CRT monitors can be a very serious problem. A small amount of magnetic force can significantly disrupt the picture on a CRT display. There are many case histories which show a great deal of time and expense to solve CRT-related magnetic interference problems.

The magnetic fields can be either AC, such as from power lines, or DC, such as the Earth's magnetic fields. Custom solutions to solve EMF problems might include relocation, shielding, or special construction.

LCD monitors do not have magnetic field susceptibility.

It is beyond the scope of this paper to do an in-depth analysis of this topic, as it could easily take a very long paper on its own, so only several basic EMF-related issues will be addressed here.

A. Isolation

This is the case in which EMF sources have to be isolated to avoid interference with CRT monitors.

B. Individual System Shielding

Often, individual system shielding is required to block the effect of EMF on a CRT display. Suitable CRT monitor shields can run from about $500 to nearly $1000.

C. Special Construction

This often concerns such items buried electrical conduits or electrical distribution sites. Sometime expensive construction is require to minimize interference from these.

D. Earth Magnetic Fields (Hemispheric Sensitivity)

The sensitivity of monitors to magnetic interference is great enough that even the Earth's magnetic forces will affect its performance. CRT monitors must be built or aligned for the Northern and Southern Hemispheres. Manufacturers must build and align them accordingly, and there are handling issues. These all incur extra expense.

Cost Analysis Assumptions (extremely abbreviated):

- 3% premium for a Southern Hemisphere CRT Monitor
- 10% of CRT monitors purchased are Southern Hemisphere Monitors
- The cost premium is amortized over Southern and Northern Hemisphere monitors.

E. Simplified EMF-related Cost Analysis

(Details omitted due to space constraints.)

There are many ways to analyze EMI cost issues for monitors, and the following estimate is quite conservative for many real life situations.

- Shielding: $2,000
- Construction/Labor: $2,500
- Other: $500

LCD EMF-Related Cost Savings: $5,000.00

4) Shipping Expenses

Shipping of the displays involves costs, which are greater for the greater bulk of the CRT's. For many situations, such as for monitor OEM's, shipping one or several times will occur.

Shipping Cost Analysis Assumptions		
Characteristic	**CRT**	**LCD**
Packaged Weight	80 lbs	25 lbs
Packaged Size (in.)	25×25×25	20×20×12
# of Times Shipped	2.5	2.5
Shipping Price (UPS)*	$30.01	$6.87
Shipping Price (Bulk)	$10.00	$2.29
No of Shipping Cycles**	2.5	2.5

*Basis: UPS shipping cost from San Diego to Mountain View, California.

Based on UPS shipping cost, the LCD ship price is 0.229 of CRT price ∴ LCD bulk ship price =0.229 of $10.00 =$2.29.

- Shipping = 2 single trips, from supplier to OEM to customer. Additional 0.5 for returns, repairs, etc. during display life.

Shipping Cost Analysis
For CRT shipping of $10.00/unit. LCD Shipping = 0.229 of $10.00 = $2.29/unit
CRT mon shipping expense = $10.00 x 100 units x 2.5 cycles = 2,500.00
LCD mon shipping expense = $2.29 x 100 units x 2.5 cycles = $572.30
LCD Cost Savings: $1,927.70 ($19.28/unit)

5) Life

True life of a CRT or LCD is defined for the case when it runs continually at full intensity. End of life is usually defined as the point in which the luminance output has degraded to 50% of the original level.

A CRT has a true life of about 1.25 years, When it reaches end of life, it is difficult and expensive to replace. Often CRT monitors are discarded, and new ones are acquired. Today, LCD monitors have a true life of about 2.9 years or more. When they reach end of life, only, the fluorescent backlight lamps or assembly can be replaced at a relatively low cost, then the life cycle begins anew. The LCD itself may have a life of many years.

For simplicity, let us assume for this analysis that a 2:1 life cycle difference between the LCD and CRT, and that the CRT is replaced.

Life Analysis CRT-LCD Assumptions		
Characteristic	**CRT**	**LCD**
Cost	$1000	$2000
Expected life (normal use)*	2.5 years	5.8 years
Analysis interval	5 years	
Replacement cycles	1	0

*The life can be extended perhaps 2 times or more by restricted usage, such as by a power saver or a reduction mode, the type of video being displayed (CRT's), and the user's tolerance for time-induced degraded performance.

Life Cost Analysis
CRT monitor extra life expense = $1000 cost x 100 units x 1 life cyc = $100,000.00
LCD mon extra life expense = $2000 cost x 100 units x 0 life cyc = $0.00.
LCD Cost Savings: $100,000.00 ($1000/unit)

6) Disposal

Proper disposal of CRT monitor costs money to the CRT owners. Often, contractors are involved to disassemble the monitor, salvage some components, and metals to recycle what they can. Then they send hazardous materials like lead to proper disposal sites, and grind up or crush the rest and dispose of it as nonhazardous waste. Although some money is recovered, there is often still an aggregate expense. For situations requiring disposal expenses, they may be factored into the total analysis as follows

Disposal Cost Analysis Assumptions		
Characteristic	**CRT**	**LCD**
Weight	75lbs	20lbs
Shipping Charge	None: part of disposal cost	
Aggregate Cost	$0.40 / lb	$0.20/ lb
Life Cycles*	2	1

*See section on Life

Due to the lower toxic material content of LCD's.

Disposal Cost Analysis
CRT disposal cost = $0.40 x 75lbs x 100 x 2 cyc = $6,000.00 (= $30/unit x 2, or an aggregate of $60.00/unit)
LCD disposal cost = $0.20/lb x 20lbs x 100 x 1 cyc = $400.00 ($4/unit)
LCD disposal cost savings = $6,000.00 - $400.00 = $5,600.00 ($56.00 / unit)

7) System Mechanical/Material Design

There are system mechanical design considerations due to the extra weight and bulk of a CRT monitor. Computer system components which will support the weight of CRT's require extra material to give them the needed strength. Both engineering design time and extra materials are required, and would not be needed if an LCD monitor were used. One rough estimate of the material is $6.00 per unit. It is difficult to quantify the extra design time expense, since the one time effort is dispersed among many systems. It will be disregarded for this calculation.

Assumptions

- *Design cost: not quantified*
- *Material cost estimate: $6.00/unit*

Calculations

CRT additional material cost requirement = $6.00/unit x 100 units = $600.00.

Notes:

- This is a 1 time charge.
- This may apply to OEM's/Manufacturers only.

8) Personnel / Labor Cost

Due to the bulk of CRT's, when servicing is needed, it may involve extra servicing requirements. Two people may be needed, or else carts may have to be used, requiring extra time, use of elevators, etc. Either case produces extra effort, which translates to extra expense. This could also involve extra work to deliver units, which is disregarded at this time. One way to assess this would be to

assume that for 100 units, 25% will have to be serviced once within a year. From that we can proceed as follows.

Personnel/Labor Cost CRT-LCD Assumptions		
Characteristic	**CRT**	**LCD**
Labor expense estimate	$15/hr	
Analysis interval	4 years	
Total Service cycles	0.25/units/year	
2nd person required	50%	0%
Cart or other apparatus	50%	0%
Extra time for cart, etc.	10 min	0 min
Total Service time/cycle	30min	20min

Personnel/Labor Cost Analysis
CRT monitor extra labor expense = $15/hr ÷ 1/2 hr x 0.25 units/yr x 100 x 4 yrs = $750 + (0.5 x $750) ⇐ Extra person, 50% of time + ($15/hr x 0.167 hr x 0.25 x 100 x 4) *(Service person's extra time due to use of cart)* = $750 + $375 +$250.50 = 1,375.50
LCD monitor extra labor expense = $15/hr ÷ 1/3 hr x 0.25 units/yr x 100 x 4 yrs = $500 + (0) ⇐ Extra person, extra time, use of carts
LCD service savings: $1,375.50 - 500.00 *= $875.50 ($8.76/unit)*

Summary

While prices for flat panel monitors will drop as their usage becomes greater, cost savings for many technological advantages of flat panel displays over CRT displays exist today, and should continue to do so as the technology improves. The work of the Flat Panel industry, however is just beginning. The industry must strive to make continued improvements, such as in lower power consumption, increased life, and lower mass, and the savings will only get better.

There are many variables and assumptions in this presentation which may be used at one's discretion. There are also many additional cost analysis factors which were not addressed here. No matter how one chooses to analyze them for his/her specific situation, it should be clear even to the pessimist that there is substantial costs savings for monitors over LCD monitors after the initial purchase.

Everything included, the total cost of ownership for an organization (TCOO) is less even now for LCD's when the hidden costs are considered.

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References

- United Parcel Service (UPS) web page
- Magnetic Shield Corp. CRT Shield Enclosures product brochure, price list

Cost Summary: Savings of LCD Monitor over CRT Monitor

A) Baseline Cost Structure (100 seats)

Cost category	CRT Mon (tot)	FP Mon (tot)	Savings (tot)	Savings(unit)
Initial Purchase Price	$100,000.--	$200,000.--	-$100,000.--	-$1,000.--

B) LCD Secondary Costs Savings Analysis Summary for a 5-year timeframe (100 seats)

Cost category	CRT Mon (tot)	FP Mon (tot)	Savings (tot)	Savings (unit)
Power Consumption	$19,723.05	$6,574.35	$13,148.70	$131.50
Air Conditioner Power Usage	$1,683.05	$561.02	$1,122.03	$11.22
Air Conditioner Extra Tonnage	$6,400.00	$2,132.50	$4,267.50	$42.68
Magnetic Susceptibility	$5,000.00	$ -0-	$5,000.00	$50.00
Shipping (2:1 life cycle not counted)	$2,500.00	$572.30	$1,927.70	$19.28
Life	$100,000.00	$ -0-	$100,000.00	$1,000.00
Disposal	$6,000.00	$400.00	$5,600.00	$56.00
System Mechanical/Material Design	$600.00	$ -0-	$600.00	$6.00
Personnel/Labor Servicing	$1,375.00	$500.00	$875.50	$8.76
Total (Amortized over 2 life cycles)	**$143,281.10**	**$10,740.17**	**$132,541.43**	**$1,325.41**