Super-efficient Equipment and Appliance Deployment (SEAD) Initiative:

Lessons from the Technical Analysis of PC Monitors

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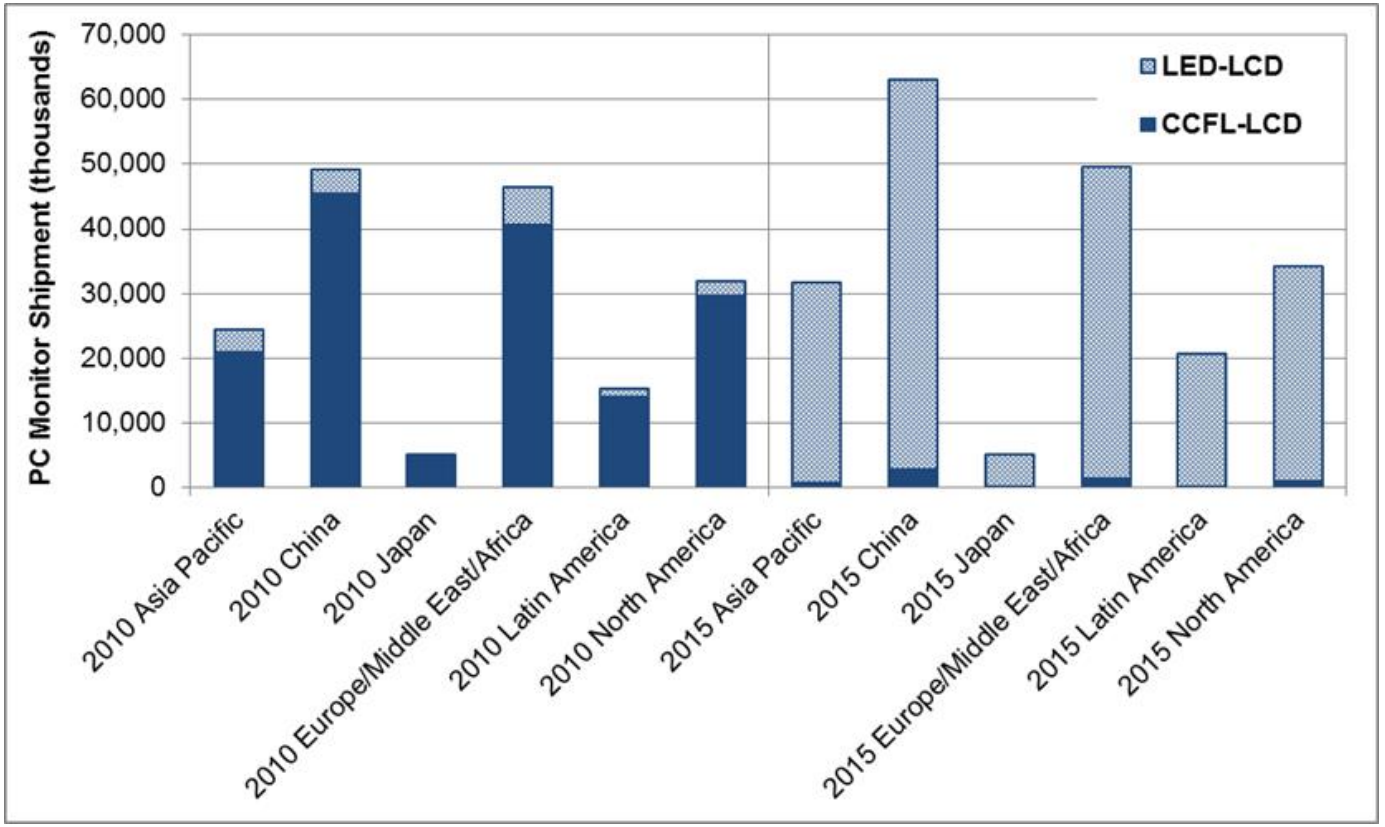
Global Market Transition: the large scale transition from CCFL to LED backlights is likely to bring substantial improvement in efficiency.



Actual (2010) and Forecasted (2015) shipments showing market transition by region and screen technology

Source: DisplaySearch 2011

LCD Monitor Efficiency Improvement Options

Components		Improvement options	Notes
Backlight unit	Backlight source	CCFL to LED transition	Cost increase
			Adopted by manufacturers due to improved product quality
			Expected to be accelerated by economies of scale and technological learning (BAU[b])
		High LED efficacy	Cost reduction in the long term (BAU)
			Technical barrier in thermal management and short term cost increase from adoption of much higher efficiency LEDs (i.e., high power LEDs) than BAU
	Optical films	Optimized combination of films	Trade-offs in material cost, ease of manufacture, and efficiency (BAU)
		Reflective polarizer (DBEF[a])	Cost increase, proprietary technology
LCD panel		Improvement in panel transmittance by optimizing pixel design, functional layers, e.g., polarizer, color filter, and data line	Proprietary technology
			R&D investment required but driven by cost reduction (BAU)
Power management		Brightness control based on computer usage patterns	Efficiency improvement varies with settings and usage patterns (BAU)
		Brightness control based on ambient light condition	Efficiency improvement varies with settings and ambient light condition
		Brightness control (local dimming) based on image signals	Efficiency improvement varies with manufactures' design scheme. The use of local dimming in PC monitors is more limited than in TVs
Other		Low voltage DC powered monitors (e.g., USB-powered monitors)	High-efficiency LCD panel required
			Cost increase for the LCD panel but likely cost neutral for the monitor set

[a] DBEF (dual brightness enhancement film) produced by 3M

[b] BAU options are likely to be adopted regardless of policy intervention

Cost of Conserved Electricity (CCE): PC monitor efficiency can be further improved by at least 20% cost effectively beyond ongoing market trends.

Table 5 Cost of conserved electricity (CCE) for reflective polarizers

Screen size/resolution	Backlight	$\Delta P_{\text{on-mode}}$ [a] (W/unit)	ΔC_m [b] ($/unit)	CCE_m [c] ($/kWh)	ΔC_p [d] ($/unit)	CCE_p [e] ($/kWh)
21.5″ (1,920×1,080)	CCFL	4.7	3.4	0.079	4.7	0.109
	LED	3.6	3.2	0.097	4.4	0.134
23.0″ (1,920×1,080)	CCFL	5.0	3.8	0.081	5.2	0.111
	LED	3.8	3.7	0.104	5.4	0.152
Weighted average	CCFL	4.8	3.5	0.080	4.9	0.110
	LED	3.7	3.5	0.101	4.9	0.144

Assumptions: discount rate=5 %, economic lifetime=6 years, daily usage=5 h

[a] Average power saving per unit=(average on-mode power of 2012 standard models estimated by authors)−(estimated average on-mode power of 2012 models with reflective polarizer)

[b] Incremental manufacturing cost=(manufacturing cost for 2012 standard models predicted by DisplaySearch)−(manufacturing cost for 2012 standard models with reflective polarizers estimated by authors)

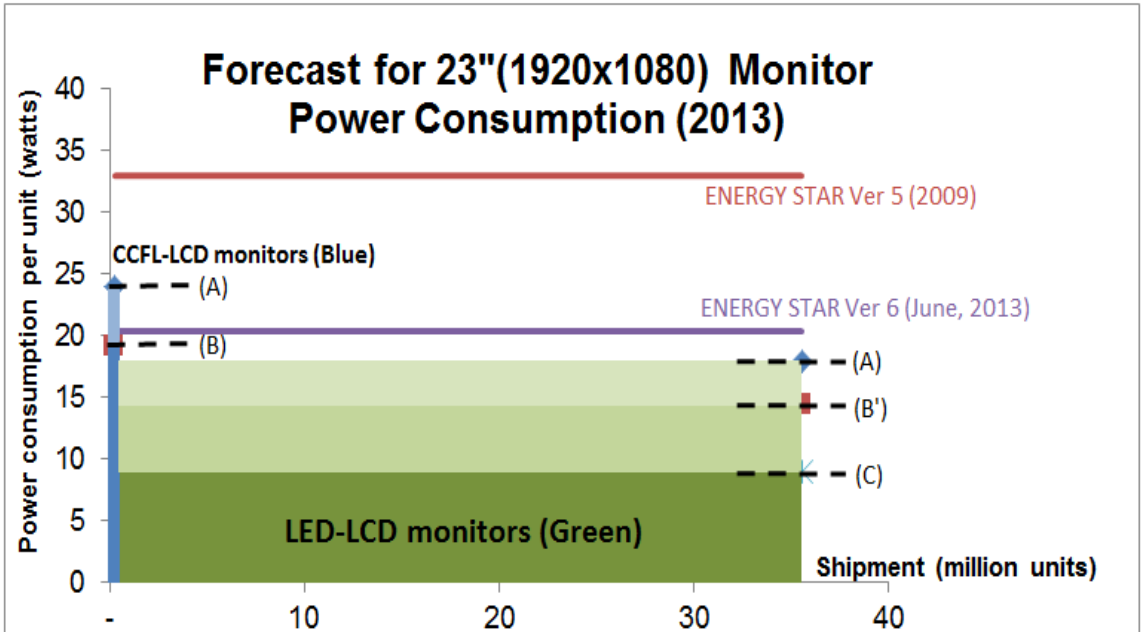
[c] Cost to the manufacturer of conserved energy which is calculated by Eqs. 1 through 3 at IC=ΔC_m

[d] Incremental price=(average market price for 2012 standard models predicted by DisplaySearch)−(price for 2012 standard models with reflective polarizer estimated by authors)

[e] Cost to the final user of conserved energy which is calculated by Eqs. 1 through 3 at IC=ΔC_p

Insights for Energy Efficiency Programs:

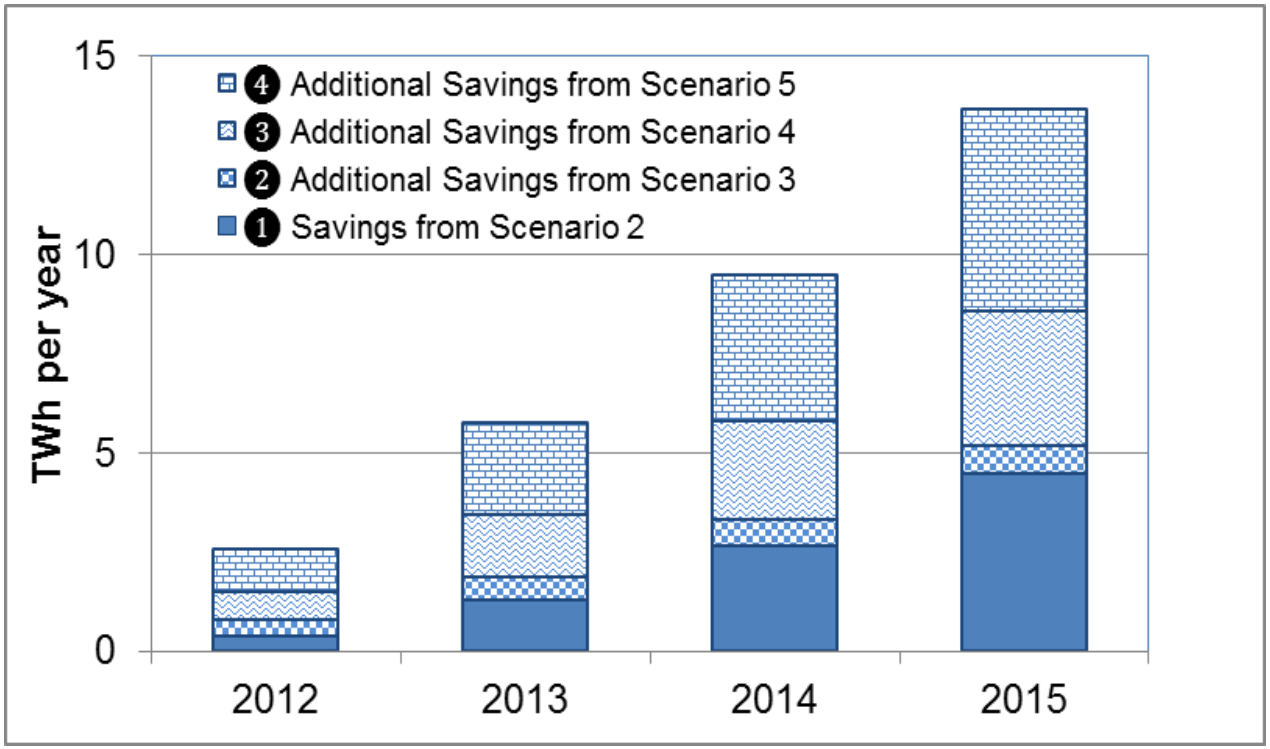
- **Standards/entry-level of labeling programs –** a level that remains technology neutral and thereby leads to additional savings.
- **Advanced levels of labeling and incentive programs –** a level that efficient units, i.e., LED-LCDs, can meet by employing cost-effective options.



(A) Estimated average power consumption in a BAU scenario
(B), (B′) Power consumption possible with reflective polarizers - (B): possible level for standards or entry level of labeling program
(C) Power consumption possible with USB-powered DC monitor with reflective polarizer (i.e., possible level for advanced levels of labeling or incentive programs)
Each shaded area represents total power consumption by global shipments in the corresponding scenario.

Global PC Monitor Savings Potential:

If in every year the efficient designs discussed in this paper reach 100% of the product groups analyzed, i.e., about 90% of the whole market, the total energy savings potential would be about 4.1 to 9.2 TWh per year in 2015.



❶: Possible savings by BAU improvement
❷: Possible savings by standards
❸+❹: Possible savings by incentives and labeling programs

Conclusions:

• A significant decrease in on-mode energy consumption (about 25% from 2011 to 2015) for newly sold PC monitors is likely because of the large-scale transition toward LED-LCD monitors and rapid efficiency improvement.

•PC monitor consumption can be cost effectively reduced further beyond these improvements. If in every year the efficient designs reach 100% of the product groups analyzed, i.e., about 90% of the whole market, the total energy savings potential would be about 4.1 to 9.2 TWh per year in 2015, and up to 55.1 TWh during their lifetime.

•Market transformation programs need to take into account these rapid developments and determine more stringent efficiency targets than are currently in place.

SEAD PC Monitor Analysis (full report)

- **Efficiency improvement opportunities in PC monitors: Implications for market transformation programs. *Energy Efficiency*. Jan 2013. Available at http://link.springer.com/article/10.1007%2Fs12053-013-9191-0**

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