LCD Power Efficiency Technology

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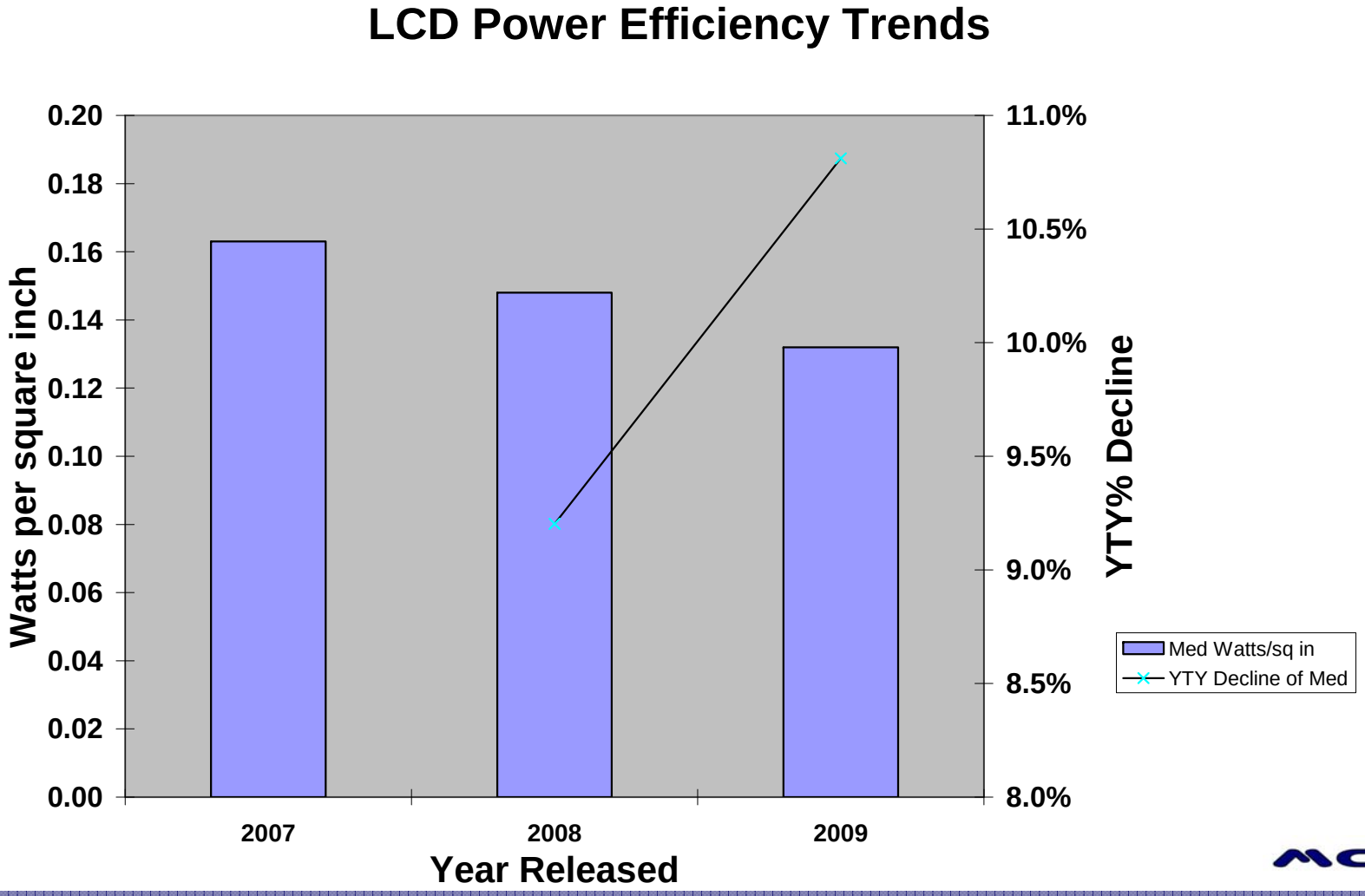
Cost of Efficiency – LCD Television

- LCD can be made more efficient
- Net additional manufacturing costs, if any, are small
  - Light management film costs offset by savings on lamps, inverters, and smaller power supply
- LED backlights offer additional efficiency, with cost adder
  - LED cost adders decreasing as volumes grow
- Net savings from lower operating cost not visible to consumers

LCD TV Power Efficiency 2007-2009



Technology / Market Forecasts

- McLaughlin Consulting Group has long history of display industry strategy and market research

- "Prism Film (BEF), Reverse Prism Film, Polarization Recycling Film (DBEF) and Brightness Enhancement Diffusers"
  http://www.mcgweb.com/reports/bef2007.htm
- "The Fast Track for LEDs into Large-Area LCD's"
  http://www.mcgweb.com/reports/led07.htm

- Both studies use proprietary cost/performance database to calculate low cost configurations
- LED model also has preference/value function to predict incremental selling prices for features

Light Management Films

- Polarization recycling – 3M or wire-grid films improve usable light output by ~ 55%
  ➔ 35% reduction in light/power input
- Prism films focus light to viewer in front
- Combine with polarization recycling – together improve light output ~ 110%
  ➔ 47% reduction in power input
- Light management films (mostly) pay for themselves in lamp, inverter and power supply savings

Light Management in Backlights

Example for 46" LCD-TV

	Differences — 46" LCD-TV, 2009			
	Street price	Electricity saving/ year	Power (W)	
A	$6	$0	0	
B	$7	$3	-13	
C	**$4**	**$16**	**-64**	**Most common 2009**
D	$0	$33	-127	**Most common 2010**

46" Power Trend	Watts	YTY %
2007	266	-
2008	230	13.5%
2009	172	25.2%

Source: McLaughlin Consulting Group LCD Brightness Enhancement film study
McLaughlin Consulting Group: "The Fast Track for LEDs into Large Area LCD's" LED Adoption
http://www.mcgweb.com/reports/bef2007.htm
http://www.mcgweb.com/reports/led07.htm

TV use 5 hours/day, power cost = $0.14/ kWh

A: No BEF or DBEF, 3 gain diffusers (25 CCFLs)
B: BEF (Cavity, Area Diffuser) (24 CCFLs)
C: DBEF(Cavity, Area Diffuser) (20 CCFLs)
D: BEF+DBEF (Cavity, Area Diffuser) (15 CCFLs)

LED Backlight for LCD-TV

- LEDs now more efficient than CCFLs:
  - ***Avg. Power (2009) for 46-in. LED TV =122W, for CCFL TV =172W, LED saves 50W or 29%.***
- Performance gap growing with LED efficiency innovation
- Cost premium shrinking, but still high
- But, additional performance features possible with LED backlight
  - High speed refresh works better
  - Local dimming ➔ higher contrast, more power conservation
  - Slim form factor
  - Elimination of CFL lamp mercury

Additional LCD-TV Efficiencies

- Dynamic backlight, local dimming
- Improved LCD array aperture
- Increased color filter transmission

Future

- It may be possible to eliminate color filters completely

Summary on LCD Efficiency

- Technology exists, **now**, to improve LCD power consumption
- Most film power reductions pay for themselves
- Power efficiency can be accelerated with incentives and/or more consumer information
- Life cycle reductions in power usage yield net savings in almost all cases except LED backlights

- LED backlight cost gap narrowing
- Added features with LED backlights can generate higher market price