PikeResearch
Cleantech Market Intelligence

Research Report

Materials Footprint Reduction of Televisions and Computer Monitors: 2004-2010

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Section 1

EXECUTIVE SUMMARY

1.1 Trends in the TV and Monitor Segments within the Electronics Industry

TV and monitor equipment changed dramatically from 2004 to 2010. Most significant has been the transition from cathode ray tubes (CRT) to flat panel technology. Heavy, bulky CRT-based technology requires the use of leaded glass and is limited by physical size and power constraints to a screen size of mid-30 inches. Flat-panel technologies, in contrast, use liquid crystal displays (LCDs), with or without light emitting diode (LED) backlighting and plasma to produce higher resolutions, and can reach screen sizes twice those of the largest CRTs. A comparison of CRTs and flat panels (in the same size range) shows that the flat panel's weight has been reduced by 82% and volume by 75%.

Equipment modifications have been driven, in part, by a mandated change to digital broadcasting and increasing customer demand for a movie "theater-like" viewing experience. Moreover, such demand is currently being influenced further by the introduction of real-time viewer interaction with content and access to the Internet.

1.2 Summary of Study

Pike Research used an Economic Input-Output (EIO) model to provide a high-level estimate of the energy required and water consumed to manufacture the TVs and monitors in this study. Since a baseline level of economic activity must be selected to use an EIO model, Pike Research used $1 million. The model predicts that for each million dollars of product produced, an LCD TV will require 8.4 TJ (10^12 joules) of energy and consume 10.5 million gallons of water in the supply chain from raw materials extraction to end-of-life. These figures are 26% and 21% less, respectively, than those for an equivalent CRT TV.

The weight and volume impacts of transporting TVs and monitors are directly linked to the percentage differences between CRT and LCD technologies noted above. To ensure the finished product reaches the marketplace without handling and environmental damage during transit, individual units are packaged and palletized for shipment. On average, packaging adds 78% more volume and 33% more weight to each unit shipped.

All electronic equipment reaches end-of-life status for multiple reasons (broken/no longer repairable, replaced by newer technology, etc.) and each *unit* produced will need to be recycled or properly disposed of at that time. As the gross number of units produced increases, the number of units that must be processed at end-of-life will also increase. However, as technology changes (CRT to flat panel) and functionality increases (cell phone to smartphone or desktop to laptop to iPad), the *volume* of electronic equipment requiring end-of-life management will decrease until all of the older equipment with more volume is processed.

1.3 Screen Size, Unit Weight and Volume, Materials Used

1.3.1 Televisions and Monitors

Table 1.1 shows a 75% reduction in enclosure volume when comparing an average CRT TV with a flat-panel equivalent. In addition, weight has been reduced by 82% when comparing CRT TVs to flat-panel equivalents. Also note that flat-panel TVs with screen sizes of between 40 and 70 inches are 34% lighter than CRT TVs between 13 and 36 inches.

Table 1.1 Average Volume and Weight Comparison: CRT TVs vs. Flat Panels

Average Volume	CRT	Flat Panel	Reduced by
Cubic Feet	6.4	1.6	-75%

Average Weight	CRT	Flat Panel	Reduced by	Flat Panel	Delta %
Pounds	80.9	14.8	-82%	53.5	-34%
Data Points	36	24		73	
Screen Size Range	13”-36”	16”-37”		40”-70”	

(Source: Pike Research)

A Tier One TV manufacturer and CEA member has made significant and continuous reductions in the weight of plasma TVs over the last seven years. As shown in Table 1.2, the manufacturer’s data indicates that an average plasma TV, based on a significant number of units manufactured, is currently less than half the weight of a similar unit in 2004. (The size range of the screens was not disclosed.)

Table 1.2 Average Weight per Unit: 2004-2010

	2004	2005	2006	2007	2008	2009	2010
Plasma TV (lbs)	125	117	110	98	95	79	59
TV Units (000s)	64	130	456	229	849	964	1,646

(Source: Pike Research)

The most significant change in TV and monitor equipment over the last ten to 15 years has been the transition from classic CRT technology to multiple flat-panel options, including LCDs and plasma display panels (PDPs).

The first transition products for both TVs and monitors had smaller diagonal sizes of between 15 and 19 inches. As manufacturing processes and the underlying technology have advanced, the screen sizes have increased. Today, a common “theater-like” LCD TV size can reach 55 inches, with 65 inches and above possible. The practical limit for a desktop LCD monitor is around 30 inches. As with all new technology introductions, the early adopters – those customers that must have the newest and most advanced products – fuel the volume production that results in price reductions.

The fundamental sub-assemblies and components required for a TV (reception – antenna, cable, or satellite – control electronics, audio and video capability, and enclosure) and a monitor (computer interface, control electronics, video capability, and enclosure) have not changed dramatically over the last ten years. However, the alterations in the materials used in their manufacturing have been significant. The I/O, reception, control electronics, and audio sections have benefitted from continuous improvements in basic electronic components (lighter, faster, and less expensive). Meanwhile, enclosures have migrated from wood and metal to plastic.

TV equipment changes have been driven, in part, by a mandated change to digital TV broadcasting. The use of CRTs is declining because of size, power, and weight constraints that do not meet customer expectations for a “theater-like” viewing experience. These events have accelerated the transition to the flat-panel technology of today, which began with digital watches and handheld calculator displays more than ten years ago.

Another key change for TVs and monitors has been in the video area. Because of the leaded glass needed to contain X-ray emissions from the electron gun, along with substantial power consumption per diagonal inch, the CRT has inherent weight and volume/size issues. Thus, it has been primarily replaced with LCD technology in the market place, which is considerably lighter and can be significantly larger while using less power per diagonal inch.

1.3.2 Sustainability

1.3.2.1 High-Level Life Cycle Analysis: Manufacture and Transport of Electronic Products

Pike Research developed a high-level estimate of the energy and water consumed in manufacturing generic electronic products, including TVs and monitors, using an Economic Input-Output (EIO)-based model. This model was chosen in lieu of a process-based lifecycle assessment method due to the lack of pertinent information in the public domain on specific electronic manufacturing processes.

Note that these estimates are very high level, "generic" and should only be used for comparisons between equipment types using the 'delta %' values because the model elements available *do not* exactly match the products in this study. Assumptions have been made that the model outputs for "electron tube manufacturing" are equivalent to manufacturing a CRT TV. In addition, the model outputs for "computer terminals and other computer peripheral equipment manufacturing" are equivalent to manufacturing a computer monitor. Finally, the model outputs for "audio and video equipment manufacturing" are equivalent to manufacturing an LCD/LED/Plasma TV because the elements in the model are nearly the same as the electron tube *minus* the electron tube manufacturing contribution. The model evaluates contributions from the entire supply chain, i.e. raw materials extraction through end-of-life.

An economic model requires the specification of a level of economic activity to estimate the energy and water consumption. In this analysis, Pike Research selected $1 million.

It is possible to estimate the impact of manufacturing these types of products, including the entire TV/monitor sector, by multiplying the values in Table 1.4 by the number of million dollar increments produced by all companies in the sector. The unknown accuracy of the results using this approach should be noted, if used.

Note that this type of a generic model does not allow for comparison by screen size or other equipment attributes

Table 1.3 Estimated Energy and Water Used in Manufacturing

EIO-LCA Model	Total Energy, TJ	Energy: Delta % to CRT	Water Use, kGal	Water: Delta % to CRT
CRT TV	11.3		10,500	
LCD TV	8.4	-26%	8,280	-21%
Monitor	5.4	-52%	5,140	-51%

TJ = Tera Joules = 10^12 Joules

k = 1,000 gallons

(Source: Pike Research)

1.3.2.2 Relative Weights and Volumes to Transport Products

Estimates of the energy needed to transport TVs and monitors, in terms of the volume and weight data for just the flat panel in Table 1.1 above, shows that for units with equivalent screen sizes, four flat-panel TVs can be shipped at the same volume of an average CRT TV. In addition, 5.5 flat-panel TVs can be shipped using the average weights for same size CRT TVs. For larger screen sizes (40-70 inches), an average of 1.5 flat-panel TVs can be shipped at the average weight of a CRT TV between 13 and 36 inches.

1.3.2.3 Packaging

Packaging has a significant impact on the cost of transportation throughout the supply chain. On average, for all data points available, packaging adds 78% more volume and 33% more weight. The primary function of packaging is to protect the product from the manufacturing site through distribution to the customer's installation point.

Table 1.5 shows the additional contribution of packaging in terms of volume and weight for different screen size ranges by equipment type. Note that the volume for small flat-panel TVs and monitors is virtually the same. The total number of data points used to generate the table (i.e., 36 for LCD/LED TVs) is shown to the right of the table header.

Pike Research estimated the data for CRT packaging based on the percentage differences in weight and volume from Table 1.1 above. Since CRT TV screens are constrained/capped at 36 inches, only one comparative value is shown.

Table 1.4 Additional Weight and Volume from Packaging by Product Type

TVs (LCD/LED)		36
Contribution of Packaging		
Size Range	Volume	Weight
17"-31"	1.4	7.1
32"-46"	4.1	14.2
47"-65"	14.7	23.8

Monitors (LCD/LED)		20
Contribution of Packaging		
Size Range	Volume	Weight
17"-30"	1.2	5.5

TVs (CRT)		Estimated
Contribution of Packaging		
Size Range	Volume	Weight
13"-36"	5.6	39.1

(Source: Pike Research)

1.3.2.4 E-Waste Quantities Over Time

The changes in display technology have reduced the volume and weight of both TVs and monitors. While there are still millions of CRT-based displays in use worldwide (a larger percentage in developing nations), manufacturing capacity has been significantly reduced and will eventually fall to zero. Ultimately, the remaining CRTs will reach the end of their usable life and will need to be processed.

The global appetite for new and better electronic products is not expected to decline in the foreseeable future. On a unit basis, if the number of units sold increases, the number of units that must be handled at end-of-life also increases. However, as a result of changes in technology and materials modifications (e.g., CRT to flat panel) that significantly alter the volume of materials, the amount of e-waste volume that must be processed at end-of-life will eventually decline.

Table 1.5 shows a comparison of the number of average smartphones that take up the volume equivalent of an average CRT TV, LCD/LED flat-panel TV, or computer monitor. For example, the average volume of a CRT TV with a diagonal screen dimension of between 13 and 36 inches is the same as approximately 1,950 smartphones. As end-of-life management migrates from CRT TVs to flat-panel technology, the number of smartphone equivalents will decline to about 475 for a flat panel TV.

Table 1.5 E-Waste Volume Comparison: TVs and Monitors vs. Cell Phones (Cubic Feet)

CRTs		LCD/LED Flat Panel				Phones	
TVs		TVs		Monitors		Cell	Smart
13"	1.81	16" >	0.09	17" >	0.22	0.0032	0.0033
Avg 13"-36"	6.41	Avg 16"-70"	1.55	Avg 17"-30"	0.38		
36"	16.64	70" >	3.12	30" >	0.69		

Phones per CRT TV		Phones per FP TV		Phones per FP Monitor	
13"	553	16"	27	17"	67
Average	1,957	Average	473	Average	116
36"	5,080	70"	953	30"	211

(Source: Pike Research)

Section 2

REFERENCES AND NOTES

2.1 References

- *Current Status of Field Emission Displays*, S. Itoh and M. Tanaka, Proceedings of the IEEE, Volume 90, No. 4, April 2002.
- *Power Consumption Trends in Digital TVs Produced Since 2003*, Darrell J. King and Ratcharit Ponoum, February 2011.
- *Economic Input-Output Life Cycle Assessment (EIO-LCA) US 2002 (428) Model*, Carnegie Mellon University Green Design Institute, www.eiolca.net, 2011.

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SCOPE OF STUDY

The scope of this study was specified by the client and included determination of the average weight of televisions and computer monitors from 2000-2010. Additionally, it included a high level review of changes in materials used, with a focus on those that helped improve sustainability.

SOURCES AND METHODOLOGY

Pike Research's industry analysts utilize a variety of research sources in preparing Research Reports. The key component of Pike Research's analysis is primary research gained from phone and in-person interviews with industry leaders including executives, engineers, and marketing professionals. Analysts are diligent in ensuring that they speak with representatives from every part of the value chain, including but not limited to technology companies, utilities and other service providers, industry associations, government agencies, and the investment community.

Additional analysis includes secondary research conducted by Pike Research's analysts and the firm's staff of research assistants. Where applicable, all secondary research sources are appropriately cited within this report.

These primary and secondary research sources, combined with the analyst's industry expertise, are synthesized into the qualitative and quantitative analysis presented in Pike Research's reports. Great care is taken in making sure that all analysis is well-supported by facts, but where the facts are unknown and assumptions must be made, analysts document their assumptions and are prepared to explain their methodology, both within the body of a report and in direct conversations with clients.

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NOTES

CAGR refers to compound average annual growth rate, using the formula:

$$\text{CAGR} = (\text{End Year Value} \div \text{Start Year Value})^{(1/\text{steps})} - 1.$$

CAGRs presented in the tables are for the entire timeframe in the title. Where data for fewer years are given, the CAGR is for the range presented. Where relevant, CAGRs for shorter timeframes may be given as well.

Figures are based on the best estimates available at the time of calculation. Annual revenues, shipments, and sales are based on end-of-year figures unless otherwise noted. All values are expressed in year 2011 U.S. dollars unless otherwise noted. Percentages may not add up to 100 due to rounding.

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