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MEMORANDUM

TO: BRAD MEISTER

FROM: PETER MAY-OSTENDORP

SUBJECT: TV POWER CONSUMPTION SENSITIVITY ANALYSIS MEMO

DATE: 10/10/2007

CC: MELANIE GILETTE, CHRIS CALWELL

Television efficiency research conducted by Ecos on behalf of Natural Resources Defense Council in 2004 and 2005 demonstrated that significant energy savings could be realized by improving the efficiency of today's televisions. The data gathered for the report indicated that one of the primary mechanisms for obtaining these savings was to encourage more energy efficient TV screen settings. Consultation with Imaging Science Foundation further revealed that the suggested improvements in TV screen settings could also significantly improve the overall picture quality of the set. This memo expands on this theme by examining the results of a study recently conducted for PIER that explores the relationship between the picture settings for a given TV and its power consumption in the active mode of operation.

Introduction to TV Screen Settings

Any TV purchased by a consumer today contains within its settings menu a variety of options for adjusting the characteristics of the picture produced by the set. Some of these options include brightness, contrast, color saturation, sharpness, tint, and even color temperature.[1] Many sets also contain a variety of factory preset picture modes, each of which comprises a particular set of stored settings labeled for use with specific types of TV content (e.g. sport, dynamic, movie, etc.).

Of all the user-adjustable settings mentioned above, two have a significant impact on energy consumption: contrast and brightness. Contrast tells the TV how bright the brightest white pixel in the display should look (it is also called white level). Brightness — counter-intuitively — tells the TV how bright the darkest black pixel in the display should look (it is also called black level). These two settings combined generally regulate how much light the TV produces. Unlike a light bulb, a TV is an information display device; more light from the screen is not necessarily better for the user. Overly bright displays may incorrectly represent the original broadcast or movie content that the user was intended to see. Under certain conditions (e.g. a dark room), overly bright picture settings can also cause eye

[1] There are dozens more options for adjusting the geometry of the screen and other variables that can and should only be accessed and adjusted by a trained technician, such as an Imaging Science Foundation certified calibrator.

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strain and fatigue.[2] These brighter settings will also result in higher power consumption in many of today's TVs.

TVs are typically shipped from the factory to a retailer with very high brightness TV settings. After years of market research, TV manufacturers determined that brighter TVs tend to stand out in a retail showroom and will subsequently garner more attention from the consumer (and higher sales). In essence, TV manufacturers compete on the retail floor for who can produce the brightest display to grab the consumer, but this competition also unintentionally drives up the energy consumption of the TVs because they need to produce more light. When the consumer brings a newly purchased TV set home, most will never bother to adjust its factory default settings, and so the energy-intensive factory settings remain intact.[3]

Measuring the Impact of TV Screen Settings on Power Consumption

Ecos and Imaging Science Foundation (ISF) set out to quantify the impact that TV screen settings have on TV on mode power consumption through a sensitivity analysis. Imaging Science Foundation testers used a series of standard Institute of Radio Engineers (IRE) test patterns to assess the power consumption of the displays across a range of content with varying signal brightness.[4] Each set was measured across a range of six test patterns and at three different picture settings: 1) the factory default picture settings, 2) the factory picture setting preset yielding the lowest power consumption, and 3) after an official ISF picture quality calibration.[5]

The testers used a Sencore VP403 digital test pattern generator to feed precisely controlled static images into the TVs. They then measured the resulting power consumption of the sets using a Brand Electronics One Meter, a highly accurate plug load power meter. Finally the testers measured the luminance of the displays with a Konica-Minolta 200 laboratory grade colorimeter to provide a measure of how the set's light output changed across different screen settings. In total, ISF measured 8 plasma TVs, 4 LCD TVS, and 2 DLP rear projection TVs.[6]

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[2] Personal communication. Joel Silver, Imaging Science Foundation. August 24, 2007.

[3] Jon Fairhurst and International Electrotechnical Commission (IEC) Technical Committee 100, *Measuring TV Power Consumption: Television Picture Settings*. Preliminary draft. September 26, 2007.

[4] Static IRE test patterns were used rather than the recently updated IEC 62087 moving test clip because, at the time that measurements began in early 2007, IEC had not yet finalized its video test clip. The static test patterns are still valid for demonstrating the *relative* difference in power consumption using different screen settings.

[5] ISF is a national leader in television picture display calibration. They have certified more than 3,800 professional TV calibrators and have worked with TV manufacturers to ensure that TVs have the best picture quality possible before leaving the factory. The ultimate goal of television calibration is to ensure that a TV's picture geometry, color rendering, and brightness levels result in an accurate picture that is as close as possible to the original image intended by the broadcaster, cinematographer, etc. These calibrations usually result in lower light output creating cinema-like quality and more natural colors. Furthermore, TVs are generally biased towards the warmer, bluer end of the spectrum; calibration balances this unevenness producing warmer colors.

[6] CRT TVs were not considered as this technology is rapidly being replaced by more popular high definition flat panel designs, such as plasma and LCD.

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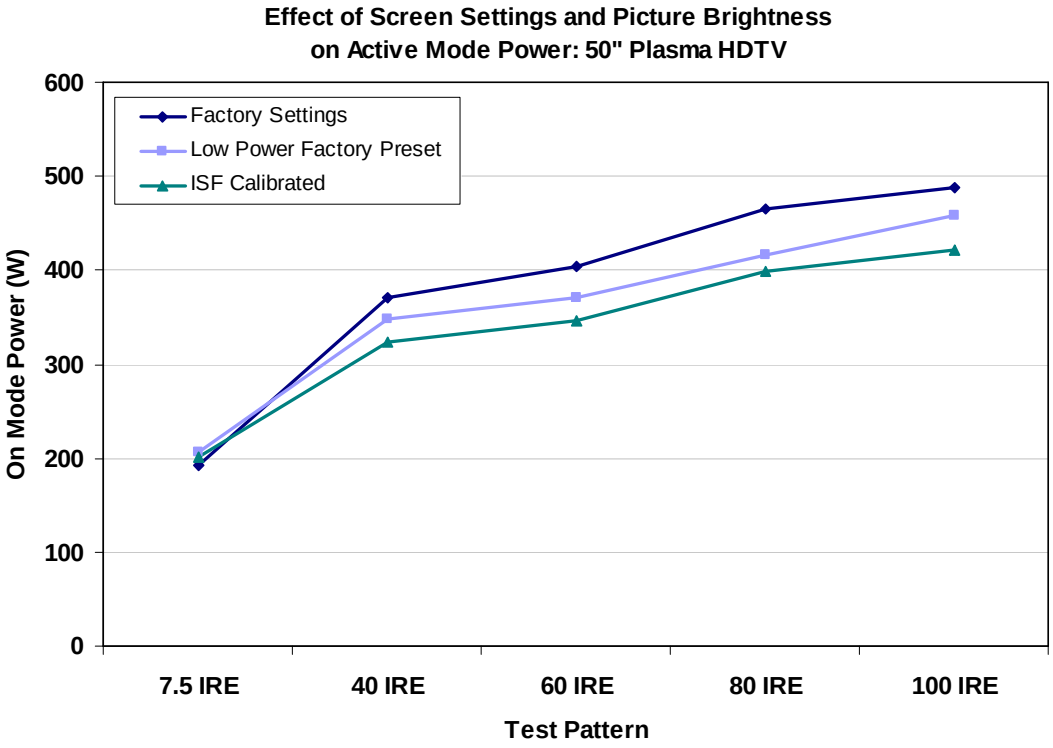

Figure 1

Figure 1 illustrates the basic phenomena observed in most measurements: a consistent drop in on mode power consumption due to changes in TV screen settings. Here we have used a sample of measurements made on an individual TV (a 50" plasma TV) to illustrate the effect. Each curve in the chart represents a series of power measurements using various IRE test patterns at a given screen setting. The test pattern used is shown on the x axis and the corresponding power consumption of the screen on the y axis. The signal brightness or average picture level of the test pattern increases from 7.5% at far left (effectively a black screen) to 100% at far right (a completely white screen). Note for each set of measurements that as the signal brightness of the test clip increases, so does the power consumption of the TV.

The power consumption (and luminance) of the TV also drops significantly with each screen setting modification. For the set shown, the low power factory preset yielded an average 9% savings over factory defaults; the ISF calibrated settings yielded a 16% savings. In the case of the ISF calibration, this also resulted in a 17% reduction in the luminance of the set,

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meaning that the TV was 17% darker after a proper calibration than when left at its default settings.[7]

The effects naturally vary from model to model and from one TV technology to another. The power savings, for example, are more pronounced in plasma TVs than in LCDs. Figure 2 provides a summary of measurements made on 15 different TVs representing 3 technologies. Each bar represents the average on mode power consumption at a given screen setting using the 100 IRE 18% window test pattern. The black dots indicate how large of a power savings, if any, was generated by modifying the screen settings. We observed power savings as high as 25% in plasma TVs and as high as 12% in LCDs. Although not expected to be common, one DLP measured was able to cut over 20% of its on mode power use by under-volting its high pressure projection lamp.

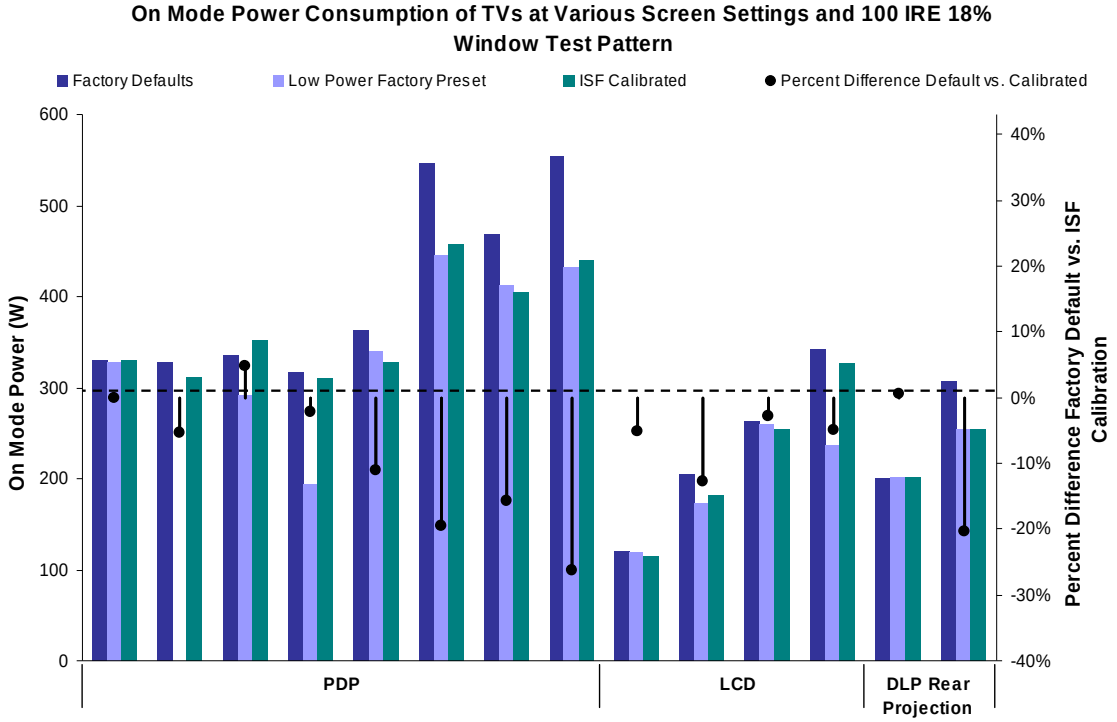

Figure 2

Table 2 summarizes the how the modified picture settings generally lowered the average power consumption of TVs by technology type. Plasma TVs have the greatest potential for reducing power consumption through lower power screen settings. On average, plasmas will

[7] A 17% drop in the luminance of the screen may sound large, but keep in my that TVs are shipped with a screen luminance that is exaggerated and overly bright to capture consumers' attention in a well-lit showroom. The brightness required for proper viewing in a more dimly lit home theater or living room will be significantly less — so too the power consumption.

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consume almost 11% less power when ISF-calibrated, 21% less power when set to a low power factory preset like "movie" or "pro." The data on LCD TVs indicate power consumption could be reduced by an average of 7% after ISF calibration and 16% through the low power factory preset.

Table 2 –Power Consumption of TVs at Different Screen Settings Displaying 100 IRE 18% Window Test Pattern

TV Technology	Average On Mode Power at Factory Default Settings (W)	Average On Mode Power at Low Power Factory Preset (W)	Power Savings Factory Default vs. Low Power Factory Preset	Average On Mode Power at ISF Calibrated Settings (W)	Power Savings Factory Default vs. ISF Calibrated Settings
LCD	93	77.8	-16%	87	-6%
Plasma	325	258	-21%	294	-10%

Also note that the power savings achieved by enabling a lower power factory preset are more than two times the savings gotten through a complete calibration. Although ISF calibration provides many other picture quality benefits to the user, this at least demonstrates that many consumers *today* could shave 16% to 21% of the power consumption off of their existing LCD and plasma TV sets simply by enabling a lower power factory preset on their TV's menu. The labels associated with these lower power settings will vary by TV manufacturer. Some may describe the setting as an "eco mode," whereas terms such as cinema, movie, pro, or dark may be more commonly used.

Energy Savings Potential from Improved TV Screen Settings

In previous research conducted for the Natural Resources Defense Council, Ecos calculated the estimated annual energy use of the United States television stock. This estimate involved finding the average energy consumption of individual technologies, multiplying this energy consumption by estimates of the number TVs for each technology,[8] and finally summing the energy consumption for all TV types (table 3). The U.S. is estimated to consume about 54 billion kWh of electricity in 2007 to power its TVs, enough electricity to power every home in the state of Delaware. By 2010 annual TV energy consumption is expected to increase to 76 billion kWh, a 41% increase from 2007.

[8] These numbers were found by using power consumption data gathered by Ecos and AGO, duty cycle data gathered by TIAX and sales figures gathered by iSuppli.

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Table 3- Estimated energy consumption for TVs in the U.S. market in 2007

TV Technology	Total Stock of U.S. TVs, 2007 (millions)	Unit Annual Energy Consumption (kWh)	Total U.S. TV Stock Energy Use (Billions kWh)
LCD	24.8	194	5
Plasma	8.8	626	5
CRT	218	184	40
Projection	11.5	349	4
		Total	54

In order to demonstrate the potential energy savings from improved, low-power TV screen settings, applied the percent power savings observed in this study to TVs expected to ship in the U.S. between 2008 and 2014. Because our study focused on plasma and LCD TVs, we only count energy savings from those two technologies even though CRT and rear projection TVs would continue to sell during this time period. Figure 2 shows the difference in energy consumption between typical and "calibrated" TVs based on the sales volume expected between 2008 and 2014. The TVs sold in 2008 at the normal factory default settings would consume about 9.4 billion kWh, whereas calibrated TVs would consume about 8.9 billion kWh, resulting in an annual savings of 0.5 billion kWh. By the year 2014, the savings would amount to 4.2 billion kWh per year.

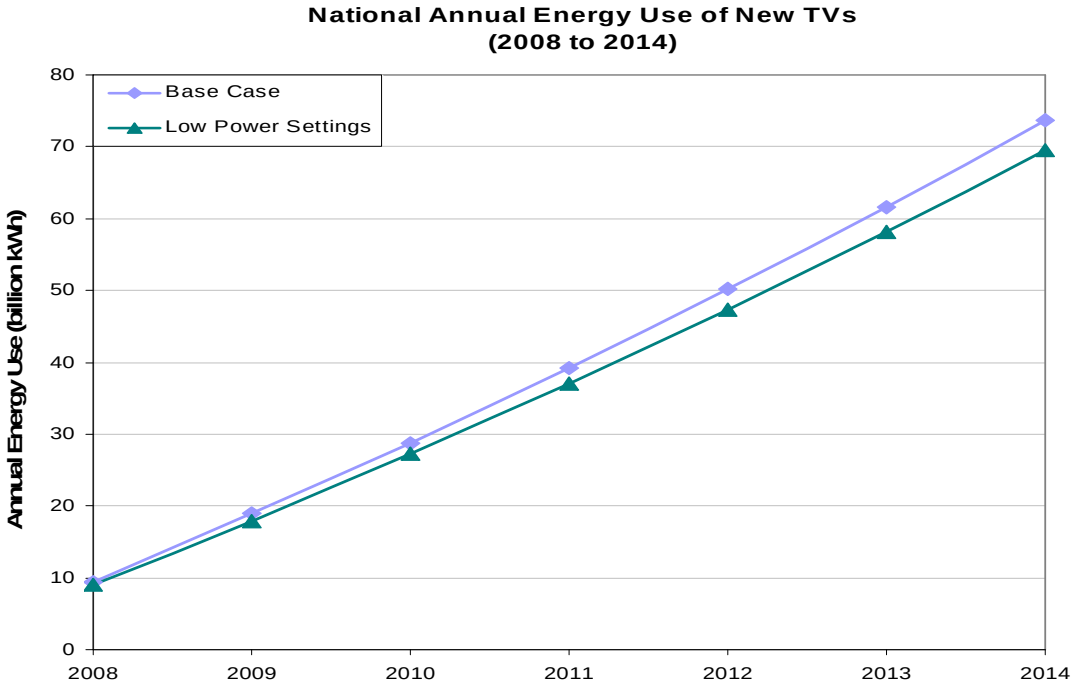

Figure 3

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Appendix A: TV Sensitivity Analysis Power Consumption and Luminance Data

Power Consumption of Televisions in Different Screen Settings (watts)

				IRE 100.0			IRE 80.0			IRE 60.0			IRE 40.0			IRE 7.5		
Technology Type	Display Type	Display Size (diagonal inches)	Resolution (pixels x pixels)	Factory Default	Low-Power Factory Preset	ISF Calibrated	Factory Default	Low-Power Factory Preset	ISF Calibrated	Factory Default	Low-Power Factory Preset	ISF Calibrated	Factory Default	Low-Power Factory Preset	ISF Calibrated	Factory Default	Low-Power Factory Preset	ISF Calibrated
PDP	Direct View	50.0	1280X768	332	328	309	322	324	310	299	292	285	198	170	199	85	81	79
PDP	Direct View	50.0	768x1024	307	n/a	295	298	n/a	284	295	n/a	279	221	n/a	213	152	n/a	148
PDP	Direct View	50.0	1366x768	333	331	307	334	301	316	324	228	328	344	163	347	195	113	191
PDP	Direct View	50.0	1366x768	488	458	422	465	416	398	404	370	347	371	348	323	192	207	201
PDP	Direct View	50.0	1920x1080	386	388	383	379	380	381	354	358	334	211	177	232	65	64	66
PDP	Direct View	60.0	1920x1080	637	630	636	663	588	591	587	519	493	439	418	404	264	259	260
PDP	Direct View	58.0	1920x1080	623	592	571	602	653	606	641	624	604	669	500	505	95	150	98
PDP	Direct View	63.0	1920x1080	635	584	565	561	573	566	578	400	408	480	340	408	110	140	110
LCD	Direct View	46.0	1366x768	265	264	257	265	262	258	264	261	257	263	261	256	261	259	255
LCD	Direct View	26.0	1366x768	127	123	117	123	121	116	123	120	116	122	119	115	52	119	115
LCD	Direct View	40.0	1920x1080	213	178	186	210	177	184	208	175	183	206	174	183	189	140	181
LCD	Direct View	65.0	1920x1080	350	299	335	347	261	333	346	239	331	344	238	331	317	244	305
DLP	Rear Projection	100.0	920x1080	311	255	255	308	255	255	308	254	255	307	255	254	307	255	255
DLP	Rear Projection	70.0	1920 X 1080	201	201	202	201	202	202	202	201	201	201	201	202	202	202	202

Luminance of Televisions in Different Screen Settings (ft-lambert)

				IRE 100.0			IRE 80.0			IRE 60.0			IRE 40.0			IRE 7.5		
Technology Type	Display Type	Display Size (diagonal inches)	Resolution (in pixels)	Factory Default	Low-Power Factory Preset	ISF Calibrated	Factory Default	Low-Power Factory Preset	ISF Calibrated	Factory Default	Low-Power Factory Preset	ISF Calibrated	Factory Default	Low-Power Factory Preset	ISF Calibrated	Factory Default	Low-Power Factory Preset	ISF Calibrated
PDP	Direct View	50.0	1280X768	21.0	21.3	20.3	19.9	19.6	18.4	16.8	17.0	15.6	9.7	8.0	6.9	85.0	0.3	0.2
PDP	Direct View	50.0	768x1024	21.0	n/a	18.0	19.0	n/a	17.0	16.0	n/a	15.0	7.7	n/a	7.5	152.0	n/a	0.0
PDP	Direct View	50.0	1366x768	15.0	14.0	13.0	15.0	14.0	13.0	14.0	7.6	13.0	11.0	2.5	8.3	195.0	0.2	0.3
PDP	Direct View	50.0	1366x768	27.0	26.0	23.0	22.0	22.0	19.0	18.0	18.0	14.0	14.0	15.0	13.0	192.0	0.4	0.2
PDP	Direct View	50.0	1920x1080	17.0	17.0	16.2	15.0	15.0	14.9	12.0	12.0	11.8	6.0	4.2	5.7	65.0	0.1	0.1
PDP	Direct View	60.0	1920x1080	13.0	12.0	12.3	13.0	11.0	10.2	10.0	7.6	7.2	5.0	4.3	4.1	264.0	0.1	0.1
PDP	Direct View	58.0	1920x1080	14.0	15.0	15.2	13.0	13.0	13.6	12.0	11.0	11.2	9.0	5.7	5.9	95.0	0.1	0.1
PDP	Direct View	63.0	1920x1080	11.0	14.0	13.0	10.0	12.0	12.8	10.0	7.4	8.9	6.0	4.0	8.9	110.0	0.1	0.1
LCD	Direct View	40.0	1920x1080	95.0	89.0	82.9	55.0	55.0	41.5	32.0	29.2	20.6	11.0	9.3	8.0	189.0	0.1	0.1
LCD	Direct View	65.0	1920x1080	59.0	27.0	42.5	49.0	18.0	25.0	32.0	9.5	13.7	17.0	4.7	5.9	317.0	0.1	0.0
LCD	Direct View	46.0	1366x768	202.0	161.0	41.0	125.0	86.0	27.0	69.0	43.0	13.0	25.0	19.0	5.2	261.0	0.2	0.2
LCD	Direct View	26.0	1366x768	131.0	70.0	62.0	76.0	38.0	36.0	41.0	19.0	17.0	21.0	6.5	7.4	52.0	0.1	0.3
DLP	Rear Projection	100.0	920x1080	26.0	18.0	18.0	15.0	10.0	9.4	8.0	5.6	5.6	3.7	2.7	2.7	307.0	0.1	0.1
DLP	Rear Projection	70.0	1920 X 1080	30.5	62.5	51.2	24.5	40.6	35.5	15.7	22.8	19.8	9.6	10.3	7.5	201.8	0.4	0.1