LED BULB COMPARISON 2022

by

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Incandescent light bulbs have been the gold standard for those of us who are sensitive to dirty electricity (noise on household wiring) and to a 120 Hz fluctuation in light intensity like that produced by fluorescent bulbs. But they are short lived, energy inefficient, and are being phased out by government edict. The mainstream replacement is the Light Emitting Diode (LED) bulb. These produce up to ten times as much light for the same electric power as a 60 W incandescent bulb and last perhaps ten times as long. Starting in early 2018 I have been buying a fraction of the LED bulbs available at Home Depot, ACE, Walmart, and Kroger for testing. As of February 2022, I have tested 27 different bulbs from 10 different companies. These are listed in Table 1.

I hope to build a true off grid cabin, solar panels charging a nominal 128 VDC lithium ion battery, no inverter, so the lights need to work on DC voltages in the range of 110 VDC to 130 VDC. An interesting result is that all the LED bulbs tested (all rated for 120 VAC) also work when DC is applied. Some work all the way down to 90 VDC, others only above 130 VDC.

Availability of a given bulb in the marketplace changes rapidly. One bad example is the bulb designated as GV1 in the following tables. It is a Great Value bulb purchased at Walmart, 4 bulbs for $7.97 in 2020. The model number was A191011, printed on the bulb but not on the 4 pack box. On 12/20/21 I went to Walmart to buy some replacement bulbs, and very carefully looked for the same bulb. I found a box that was identical to the box I had bought in 2020, same price, same SKU. When I opened the box when I got home, it had model number A191017 bulbs in it, which do not work on 110 VDC. That bulb appears as GV4 in the following tables. I fear this will be a common occurrence, where bulbs that meet the needs of sensitives will be phased out in favor of bulbs that do not meet our needs.

On 2/9/22 I went to Kroger's and bought two different brands, a Philips (four for $11.89), and an Everyday Living (four for $14.99), which appear as PH6 and EL1 in the following tables. The Philips bulb had a model number 9290023117, similar to the model numbers of PH1 through PH5. Upon close inspection, the Everyday Living bulb was identical to the Philips bulb, even the same model number. Test results were the same. The only difference was the word 'PHILIPS', printed on the Philips bulb but not on the Everyday Living bulb! The one Everyday Living bulb I tested had a worse ripple in the light intensity than the Philips bulb, so one possibility is that the Everyday Living bulbs are Philips rejects. My guess, however, is that the manufacturing facility in China that contracted to build Philips bulbs was not running at full capacity, and just removed the Philips name to sell to a "non brand" company, and make extra money.

The claimed Color Temperature of each bulb is listed under the column heading 'Temp'.

The sun is fairly close to being a black body radiator with a temperature in the neighborhood of 6000K. The incandescent bulb with a tungsten filament is also fairly close to being a black body radiator, but operates at temperatures in the range of 2400K to 2700K. At these lower temperatures, the light output contains more red and less blue. It also contains a larger fraction of infrared, light frequencies that cannot be seen directly by the eyes but are sensed by our skin as warmth. Hence, light at these color temperatures is considered to be *warm* white (as opposed to the *cool* white or *pure* white of bulbs operating at 5000K).

All bulbs were tested on 60 Hz AC voltages from 100 to 140 VAC, and on DC voltages from 130 to 160 VDC. Bulbs that worked well at 130 VDC were tested at voltages down to as low as 90 VDC. (Note that incandescent bulbs start to explode at about 130 VAC and operate at about half intensity at 100 VAC).

Volts, amps, and power were measured with an Extech 380801. I cannot afford the tens of thousands of dollars required to measure the absolute lumen output of these bulbs, but I believe I was able to measure relative lumen production to within perhaps a 5% error with an inexpensive setup. Each bulb was mounted base down in a simple fixture sitting toward one end and on the bottom of a 48 quart Styrofoam cooler, serving as an 'integrating sphere'. The light sensor was a Pyle PLMT16 Light Meter mounted on the side of the cooler and facing the 'empty' end of the cooler, thus less likely to be unduly influenced by a stray ray from a anisotropic bulb.

Another quantity of interest is the variation of light intensity with time. A fluorescent bulb, for example, will always produce light that pulses 120 times per second (on a 60 Hz power grid), and some electrical sensitives find that to be a problem. LEDs are inherently high speed devices, so if current is supplied by pulses at say 30 kHz frequency, the light output will also vary at 30 kHz. I made a high speed photodetector from a small photovoltaic panel liberated from a Living Accents Solar LED Mini Pathway Light bought at ACE Hardware, rated at $V_{oc} = 2.66$V and $I_{sc} = 22$mA. A 200Ω resistor was enough load to cause the voltage to follow the bulb photon production without saturation. Waveform across the resistor was examined with a HP 54645A 100 MHz scope. The scope calculated the peak-to-peak voltage V_{pp} and the average voltage V_{ave} of this photodetector output. I call the ratio of the two voltages the Ripple.

$$\text{Ripple} = \frac{V_{pp}}{V_{ave}} \tag{1}$$

Let us start with the light intensity variation of the two incandescent bulbs, Table 5. It may come as a surprise to see that even the 'gold standard' bulbs have a 120 Hz fluctuation. The 60 watt bulb has a Ripple double that of the 100 watt bulb, suggesting lower thermal mass. I think I have heard of people who do not do well with electric lighting, even incandescent. In addition to sensitivity to electric fields and magnetic fields, they might be sensitive to variations in the light itself.

About a quarter of the bulbs have a Ripple between 37 kHz and 58 kHz, rather than 120

Hz. Except for bulb GV1, the Ripple is relatively small, less than 15% at 120 VAC. Those who are sensitive to dirty electricity, fields between 60 Hz and perhaps 200 kHz, should avoid these bulbs.

About a third of the bulbs have a Ripple that disappears as the voltage is increased, starting at 115 VAC for ACE1 and SA1. That is, the light intensity is constant throughout the 60 Hz cycle, above some minimum voltage. If you think you are sensitive to fluorescent bulbs with their strong 120 Hz Ripple, and your household voltage is 120 VAC or slightly more, I would buy the bulbs with zero Ripple at 120 VAC and above.

The light intensity of the incandescent bulbs ACE60 and ACE100 increases about 35% as the voltage increases from 110 to 120 VAC. The intensity continues to increase with voltage until failure somewhere around 130 VAC. On the other hand all the LED bulbs operate nicely up to at least 140 VAC. The light intensity is more constant than the incandescent bulbs from 110 to 120 VAC except for PH1 and PH3. The CREE1, a dimmable bulb, has light intensity constant to within about 1% over the voltage range 100 to 140 VAC. Three other dimmable bulbs, PH2, PH4, and SYL1 are almost that constant over that voltage range. Bulb GE1 produces constant lumen output for the voltage range 110 to 140, while bulb GV4 has constant output for 120 to 140 VAC. The light intensity actually decreases with increasing voltage from 120 to 140 VAC for about half of the bulbs.

Efficiency is an important reason people are replacing incandescent bulbs with LEDs. The incandescent bulb ACE60 produces 258 lux/watt in my experimental setup, while ACE100 produces 374 lux/watt, at 120 VAC. The ratio is 1.45. That is, the 100 W bulb is 45% more efficient than the 60 W bulb in producing light. Unfortunately, the 100 W bulbs are difficult to find at the big box stores, so we will just compare LED efficiencies to the 60 W bulb. The lux/watt figure varies from 1500 for PH2, a ratio of 5.81, to 2744 for PH5, a ratio of 10.64. The electric cost for lighting can be reduced by a factor of five to ten, by switching from incandescent 60 W bulbs to LED!

One concern with LED bulbs is the possibility of dirty electricity produced by the internal electronics. The typical way of quantifying dirty electricity is to use a Stetzer meter, a device that plugs into a wall outlet and displays a three or four digit number in Stetzer units. These are not well defined electrical engineering quantities, but still give a rough measure of how bad things are. It is not uncommon to see a suggestion that 50 units or less will be acceptable to most electrical sensitives. Depending on what the neighbors are doing, the readings in my shop are mostly in the range of 40 to 60. I plugged the Stetzer meter into the same outlet as the light bulb and watched for a change as the light bulb made contact. Except for two of the LED bulbs, there was a very minimal change. These two were the FEIT1 with a Stetzer reading of about 200, and PH2 with a reading of about 140.

DC Operation of LED Bulbs

I am intolerant to 60 Hz magnetic fields, and probably to 60 Hz electric fields and to dirty electricity, yet I really enjoy the benefits of electrification (lighting, cooking, Internet, etc.). Is there any way of having my cake and eating it too? I think for a large majority of we sensitives that the solution is to go totally off-grid. The standard off-grid home today generates and stores electrical energy as DC, but then immediately connects the battery to an inverter, making the electromagnetic environment of the home the same as if it were on-grid. I advocate the omission of the inverter, and instead distributing electricity around the house as just the DC battery voltage. We still have electric and magnetic fields in the house, just like the natural DC fields mankind has experienced since the beginning, but no 60 Hz fields. We must use circuit breakers and light switches rated for 125 VDC, of course.

I applied a DC voltage (obtained from a variac, a full wave rectifier, and a 1400 μF capacitor) to each of the tested bulbs and recorded the DC current and the relative lux output, as shown in Tables 6 and 7. ECO3, FEIT1, FEIT2, GV1, PH5, and PH6 all worked quite nicely over the voltage range of 110 to 160 VDC. EL1, FEIT3, and PH4 worked over an even wider range of 100 to 160 VDC. ECO1, GE1, GV2, GV5, PH2, PH7, and SYL1 worked down to 90 VDC. The remainder required voltages above 120 VDC for operation.

Five bulbs had a ripple in the light intensity in the 20 kHz to 50 kHz range. The five bulbs and the Ripple (at 120 VDC) are: ECO1 7%, FEIT2 6.1%, GV1 54.2%, GV3 21%, and PH5 13.5%. The others had little or no ripple, either 120 Hz ripple or kHz ripple. Consider the Sylvania bulb SYL1. It has a 120 Hz ripple of $1.125/1.333 = 0.837$ or 83.7% at 120 VAC, over ten times as bad as the 100 W ACE incandescent $0.12/1.87 = 0.064$ or 6.4%, but no ripple at all operating on 120 VDC. I would not want to use it in my on grid house, but it would be a first choice in bulbs to operate on DC.

Other bulbs in the first choice category for DC operation (zero ripple, good lux/watt) are PH4, GE1, GV5, and FEIT3. EL1, PH6, and PH7 would be second choice, (similar lux/watt but with a ripple similar to the 60 watt incandescent bulb). ECO1, GV2, and PH2 would be third choice, because of a lower lux/watt.

Code	Company	Watts	Temp	Dim	Lumens	Model
ACE1	ACE	60	2700K	N	800	A80082710KLED4/ACE
ACE2*	ACE	100	2700K	N	1500	A160082710KLED2/ACE
ACE3*	ACE	100	5000K	N	1500	A160085010KLED2/ACE
CREE1	CREE	60	2700K	Y	815	08027MDFH25-12DE26-1
ECO1	Ecosmart	60	2700K	N	800	A7A19A60WES01
ECO2	Ecosmart	100	2700K	Y	1600	A7A19A100WESD04
ECO3	Ecosmart	100	2700K	N	1500	A6A19A100WUL01
EL1	Everyday Living	100	2700K	N	1500	9290023117
FEIT1	FEIT	60	3000K	N	800	BPAGOM800/LED
FEIT2	FEIT	100	3000K	N	1500	A1600/830/10KLED/6
FEIT3**	FEIT	100	2700K	N	1600	A100/827/FIL/2
GE1**	GE	100	2700K	Y	1600	LED15DA19/827
GV1	Great Value	100	2700K	N	1500	A191011
GV2	Great Value	100	2700K	N	1600	A19046
GV3	Great Value	100	2700K	N	1500	A191002
GV4*	Great Value	100	2700K	N	1500	A191017
GV5**	Great Value	100	2700K	Y	1600	E328217
GL1	Green Light	60	3000K	N	800	E344320
PH1	Philips	60	2700K	N	800	9290013154
PH2	Philips	60	2700K	Y	800	92900111840
PH3	Philips	60	5000K		800	9290013155
PH4**	Philips	100	2700K	Y	1600	9290022855
PH5	Philips	100	5000K	N	1500	9290011351A
PH6	Philips	100	2700K	N	1500	9290023117
PH7	Philips	100	2700K	N	1500	9290011349A
SA1	Satco	60	5000K	N	800	S9597
SYL1**	Sylvania	100	2700K	Y	1500	E327386
ACE60	ACE	60		Y	840	
ACE100	ACE	100		Y	1690	

Table 1: Tested Bulbs. * recommended for 120 VAC, ** recommended for 125 VDC.

Bulb	V_{ac}	I_{ac}	P_{ac}	Ripple	freq	lux	lux/P_{ac}
ACE1	100.5	0.069	4.2	1.32	120	9700	2310
flat	109.8	0.105	6.9	0.40	120	14220	2061
115V	120.2	0.115	8.2			14810	1806
	130.2	0.116	8.9			14660	1647
	140.0	0.118	9.7			14540	1500
ACE2	100.1	0.065	3.9	1.63	120	10290	2638
flat	110.7	0.145	10.2	0.70	120	25600	2510
120V	120.2	0.177	13.4			30500	2276
	130.1	0.180	14.6			30300	2075
	140.9	0.183	15.9			30100	1893
ACE3	100.0	0.071	4.3	1.67	120	13260	3060
flat	110.5	0.145	10.3	0.71	120	30400	2951
118V	120.0	0.176	13.4			35900	2679
	130.2	0.179	14.6			35600	2438
	140.1	0.182	15.8			35300	2283
CREE1	101.2	0.104	9.6	0.35	120	16080	1675
	109.8	0.096	9.7	0.32	120	16290	1679
	120.4	0.088	9.7	0.31	120	16250	1848
	130.4	0.083	9.6	0.26	120	16140	1681
	140.1	0.079	9.6	0.26	120	16100	1677
ECO1	100.2	0.133	9.2	0.11	51kHz	16610	1805
	110.3	0.120	8.9	0.10	51kHz	16360	1838
	119.9	0.111	8.8	0.07	51kHz	16170	1837
	130.0	0.103	8.7	0.06	51kHz	16010	1840
	140.9	0.096	8.5	0.06	51kHz	15910	1872
ECO2	100.1	0.079	4.9	0.58	120	12600	2571
	110.0	0.178	14.0	0.49	120	33800	2414
	120.7	0.186	16.5	0.42	120	36600	2218
	130.0	0.177	17.6	0.38	120	36900	2097
	140.1	0.175	19.4	0.34	120	38100	1964
ECO3	99.5	0.211	15.0	0.54	120	31700	2113
	110.0	0.197	14.7	0.41	120	31400	2136
	120.5	0.183	14.5	0.31	120	30900	2131
	130.0	0.173	14.3	0.28	120	30600	2139
	139.8	0.164	14.3	0.30	120	30400	2133
EL1	100	0.213	13.6	0.14	50kHz	32400	2382
	110	0.194	13.2	0.14	50kHz	31700	2402
	120	0.180	13.0	0.14	50kHz	31100	2392
	130	0.167	12.7	0.10	50kHz	30800	2425
	140	0.156	12.6	0.07	50kHz	30600	2429

Table 2: AC Tests Page 1

Bulb	V_{ac}	I_{ac}	P_{ac}	Ripple	freq	lux	lux/P_{ac}
FEIT1	100.0	0.095	7.2	0.23	120	12660	1758
	110.4	0.097	8.6	0.23	120	14750	1727
	120.9	0.101	10.3	0.26	120	17250	1625
	130.0	0.105	11.8	0.26	120	19240	1630
	139.5	0.109	13.3	0.26	120	23000	1729
FEIT2	100.4	0.172	12.4	0.59	37kHz	29700	2395
	110.2	0.188	14.5	0.16	37kHz	33600	2317
	120.1	0.173	14.2	0.09	37kHz	32900	2317
	130.2	0.161	14.1	0.07	37kHz	32500	2305
	140.1	0.150	13.9	0.06	37kHz	32200	2317
FEIT3	100.6	0.091	8.7	1.0	120	24300	2793
	110.0	0.101	10.7	1.0	120	28900	2700
	120.0	0.109	12.5	1.0	120	32700	2616
	129.8	0.113	14.0	1.0	120	35600	2543
	140.0	0.116	15.6	1.0	120	38200	2449
GE1	99.8	0.130	12.5	0.33	120	31800	2451
	110.0	0.131	13.9	0.18	120	34600	2401
	119.8	0.119	13.7	0.18	120	34500	2420
	130.0	0.110	13.6	0.18	120	34200	2392
	140.2	0.102	13.5	0.18	120	34000	2378
GV1	100.6	0.218	13.8	0.57	45kHz	33300	2581
	110.2	0.202	13.5	0.60	45kHz	32700	2422
	120.6	0.189	13.3	0.54	45kHz	32300	2429
	130.0	0.179	13.2	0.54	45kHz	31900	2417
	139.5	0.171	13.1	0.52	45kHz	31700	2420
GV2	99.2	0.150	14.1	0.47	120	34000	2411
	110.3	0.149	15.5	0.45	120	36900	2381
	120.9	0.147	16.6	0.35	120	39000	2349
	130.0	0.145	17.3	0.33	120	40400	2335
	138.4	0.142	17.9	0.28	120	41000	2291
GV3	100.6	0.242	15.4	0.17	58kHz	33500	2175
	110.1	0.219	15.1	0.14	58kHz	33000	2185
	120.2	0.204	15.0	0.12	58kHz	32700	2180
	129.8	0.192	14.9	0.10	58kHz	32500	2181
	138.0	0.183	14.8	0.08	58kHz	32300	2182
GV4	100.7	0.039	2.0	1.12	120	6200	3100
flat	110.1	0.127	8.6	0.82	120	24300	2826
119V	119.9	0.177	12.9	-	-	32900	2550
	130.0	0.179	14.1	-	-	32900	2333
	140.1	0.183	15.2	-	-	32900	2164
GV5	100.0	0.098	9.3	0.22	120	26600	2860
	110.1	0.101	10.4	0.29	120	30100	2894
	120.0	0.103	11.6	0.35	120	32900	2836
	130.0	0.106	12.8	0.36	120	35800	2797
	140.0	0.108	14.0	0.42	120	38400	2743

Table 3: AC Tests Page 2

Bulb	V_{ac}	I_{ac}	P_{ac}	Ripple	freq	lux	lux/P_{ac}
GL1	100.0	0.052	3.1	1.25	120	7720	3226
flat	110.0	0.093	6.3	0.79	120	13270	2106
125V	120.5	0.118	8.8	0.24	120	16110	1831
	130.0	0.128	9.7			16170	1667
	138.2	0.125	10.4			15940	1533
PH1	101.0	0.027	1.5	2.92	120	4670	3133
flat	110.1	0.056	4.0	1.42	120	10390	2597
127V	120.0	0.080	6.1	0.69	120	14430	2366
	130.1	0.088	7.3			15510	2125
	138.1	0.089	7.9			15360	1944
PH2	101.2	0.101	9.4	0.26	120	14800	1574
	110.1	0.105	10.5	0.29	120	16080	1531
	120.2	0.105	11.3	0.26	120	16950	1500
	130.0	0.104	11.9	0.25	120	17500	1471
	138.5	0.103	12.4	0.25	120	17900	1440
PH3	101.2	0.020	1.0	2.11	120	3970	3970
flat	110.0	0.050	3.5	1.42	120	10660	3046
128V	120.1	0.074	5.7	0.74	120	15360	2695
	130.0	0.084	6.9			16890	2448
	138.3	0.085	7.4			16720	2259
PH4	100.8	0.140	13.7	0.05	120	32300	2358
	110.1	0.136	14.4	0.07	120	33700	2340
	120.4	0.123	14.2	0.07	120	33300	2345
	129.8	0.114	14.1	0.07	120	33000	2340
PH5	101.2	0.209	12.8	0.15	55kHz	35300	2758
	110.0	0.194	12.7	0.12	55kHz	34800	2740
	119.8	0.179	12.5	0.10	55kHz	34300	2744
	129.8	0.166	12.4	0.08	55kHz	34000	2742
	138.3	0.158	12.4	0.08	55kHz	33700	2653
PH6	100	.197	12.9	0.60	120	30900	2395
	110	0.192	13.3	0.12	48kHz	31700	2383
	120	0.177	13.1	0.09	48kHz	31300	2389
	130	0.165	12.9	0.08	48kHz	30800	2388
	140	0.156	12.9	0.07	48kHz	30800	2388
PH7	99.7	0.219	13.8	0.16	25kHz	31100	2254
	109.6	.200	13.6	0.12	25kHz	30600	2259
	119.6	0.186	13.4	0.11	25kHz	30300	2261
	129.6	0.174	13.3	0.09	25kHz	30000	2256
	140.0	0.164	13.3	0.08	25kHz	29800	2241

Table 4: AC Tests Page 3

Bulb	V_{ac}	I_{ac}	P_{ac}	Ripple	freq	lux	lux/P_{ac}
SA1	100.9	0.082	4.9	1.08	120	11780	2404
flat	110.1	0.121	7.9	0.45	120	16570	2097
115V	120.4	0.134	9.4			17620	1874
	129.7	0.135	10.2			17380	1704
	138.4	0.137	10.9			17140	1572
SYL1	99.8	0.108	10.2	0.92	120	26000	2549
	109.9	0.100	10.2	0.92	120	26100	2559
	120.1	0.093	10.3	0.84	120	26300	2553
	129.9	0.087	10.3	0.84	120	26600	2583
	140.3	0.083	10.5	0.84	120	26900	2562
ACE60	100.5	0.460	46.2	0.14	120	8260	179
	110.6	0.484	53.5	0.14	120	11660	218
	120.2	0.507	61.0	0.14	120	15750	258
	125.3	0.519	65.0	0.15	120	18170	280
ACE100	100.3	0.758	76.6	0.12	120	18390	240
	109.9	0.797	88.4	0.10	120	28300	320
	120.5	0.839	101.7	0.07	120	38000	374
	124.9	0.855	107.6	0.07	120	42900	399

Table 5: AC Tests Page 4

Bulb	V_{dc}	I_{dc}	lux	lux/P	Bulb	V_{dc}	I_{dc}	lux	lux/P
ACE1	130.1	0.029	8710	2309	GV1	111.6	0.112	33300	2664
	140.2	0.052	14670	2012	ripple	120.3	0.112	32600	2420
	150.2	0.052	14540	1862	= 0.53	132.2	0.102	32000	2373
	160.9	0.052	14440	1726		140.5	0.093	31800	2434
ACE2	130.7	0.016	5860	2802		150.6	0.087	31500	2406
	140.0	0.075	27000	2571		159.6	0.082	31400	2399
	150.8	0.085	30500	2379	GV2	90.0	0.136	30000	2451
	160.5	0.085	30300	2221	ripple	100.0	0.164	38300	2335
ACE3	130.4	0.017	6910	3117	= 0	110.4	0.191	46800	2219
	140.7	0.084	35700	3021		121.2	0.215	54700	2099
	151.1	0.085	35800	2787		130.5	0.205	55400	2017
	161.0	0.085	35600	2601		140.0	0.190	54700	2056
CREE1	130.5	0.072	16040	1707		150.3	0.175	54100	2057
	140.0	0.068	16000	1681		159.4	0.166	54300	2052
	150.0	0.063	15950	1688	GV3	150.7	0.043	14850	2292
	160.9	0.059	15940	1679		160.3	0.063	24300	2406
ECO1	90.8	0.103	16090	1806	GL1	130.8	0.022	7070	2457
ripple	100.4	0.090	16460	1822		140.0	0.83	14700	2100
= 0.08	110.4	0.080	16210	1835		150.0	0.91	16280	1871
	119.7	0.073	16030	1834		159.7	0.058	16030	1731
	130.4	0.068	16720	1886	PH1	131.6	0.004	1440	1736
	141.6	0.062	16510	1881		141.0	0.044	15700	2531
	150.6	0.057	16340	1903		150.0	0.044	15500	2348
	160.5	0.053	16180	1902		160.4	0.044	15330	2172
ECO2	131.3	0.026	8500	2490	PH2	90.2	0.105	14660	1548
	140.8	0.094	33100	2501	ripple	100.2	0.110	16240	1473
	150.0	0.174	58400	2238	= 0	110.4	0.114	17600	1398
	158.8	0.229	69700	1917		120.5	0.113	18390	1351
						130.5	0.108	18780	1332
						140.4	0.102	18960	1324
FEIT1	110.0	0.075	14360	1741		150.0	0.097	19000	1306
ripple	120.2	0.076	15660	1714	PH3	139.6	0.020	8810	3155
= 0	130.7	0.081	17710	1673		150.1	0.042	16960	2690
	140.0	0.088	21800	1769		159.4	0.042	16730	2499
	150.6	0.096	24400	1688	PH4	100.2	0.135	31000	2292
	161.2	0.104	26900	1605	ripple	111.7	0.131	33400	2283
FEIT2	111.4	0.061	16400	2403	= 0	120.7	0.120	33100	2285
ripple	121.4	0.094	28200	2471		130.8	0.111	33400	2300
= 0.15	131.4	0.107	33400	2376		140.6	0.103	33200	2293
	140.0	0.100	32800	2343		150.3	0.096	33000	2287
	150.0	0.092	32300	2341		165.0	0.087	32900	2292
	159.0	0.086	32000	2096					

Table 6: DC Tests Page 1

CONCLUSION

We have seen that LED bulbs have many advantages:

- Very efficient. May cut energy requirement by factors of five to ten.
- Long lived. 10,000 to 15,000 hours compared with 700 to 1500 hours for incandescents.
- Some operate over a wide voltage range, 110 to 140 VAC or 100 to 160 VDC.
- Some have constant light intensity at a given voltage. No indication of 60 Hz or some switch mode circuit operating in a few tens of kHz.
- Most do not increase the dirty electricity in the house. No change on the Stetzer meter.

I use LED bulbs in my house and lab, with no ill effects. When I build a true off-grid cabin (no inverter, DC only) lighting will be with LED bulbs. Incandescent bulbs just do not have the operating voltage range necessary to work directly on battery voltage, even if we were willing to accept the factor of five to ten on energy requirements. The alternatives are things like propane lamps or coal oil lamps. I was 12 years old before I lived in a house with electricity, so I know about coal oil lamps! Trust me, electric lights are much superior!

Even with all the advantages, I still hear people making blanket statements about LED bulbs being bad for those of us with EHS. It is certainly possible to get a bulb that increases the dirty electricity, or a bulb that has the light intensity pulse at 120 Hz like a fluorescent bulb, but that does not mean that all LED bulbs are bad. If someone reacts to one of the 'good' bulbs, the only possibility I can think of is that the light spectrum of the LED bulb is different from that of the incandescent bulb. The LEDs produce more light in the blue portion of the spectrum, which is then absorbed by various phosphors and reradiated at longer wavelengths, toward the red end of the spectrum. I would hope the fraction of us that are really affected by the difference in spectrum would be small.

Finding the 'right' bulb can be a challenge. I went to Home Depot, ACE, and Walmart on 2/15/22 and looked through their entire selection, for 100 W, warm white or soft white bulbs. Selection was better at 60 W equivalent, but I like the 100 W equivalent for the efficiency (greater lux/watt). There may have been more daylight bulbs than warm white, but I prefer the warm white. I also have a little concern about the blue component of the daylight bulb spectrum affecting sensitives. I found the Feit3 at ACE, $9.99 for two, ECO3 at Home Depot, $13.87 for four, and at Walmart SYL1, $14.79 for four, and GE1, $21.96 for four.

There was an Ecosmart three bulb pack for $16.77, prominently labeled 100 W Soft White. It was the spherical bulb used around bathroom mirrors, with no markings at all on the bulb. The box was marked 1006 265 462, ECSG25100WE927FDIME26FR. After buying it, I noticed the bulb used only 7 W and put out only 680 lumens, as compared with the 12 to 16 W and 1500 or 1600 lumens in Table 1. Whatever happened to Truth in Advertising? I tested the bulb. It functioned as claimed on 110 to 130 VAC but had a really bad 120 Hz ripple. It did not work at all on DC.

So, do not trust the 100 W label. Look for a light intensity of 1500 or 1600 lumens.

Bulb	V_{dc}	I_{dc}	lux	lux/P	Bulb	V_{dc}	I_{dc}	lux	lux/P
PH5	110.5	0.118	36400	2792	SA1	130.1	0.031	9960	2470
ripple	120.7	0.105	35000	2762		140.2	0.061	17810	2081
= 0.14	130.3	0.096	34400	2750		150.4	0.060	17260	1913
	140.1	0.088	33900	2750		164.9	0.060	17060	1724
	150.0	0.082	33600	2732	FEIT3	100.6	0.081	21700	2663
	165.0	0.75	33300	2691	ripple	110.8	0.092	25800	2531
GE1	90.3	0.119	25700	2392	= 0	120.3	0.103	29700	2397
ripple	100.8	0.136	32200	2349		130.6	0.115	33400	2224
= 0	110.3	0.128	33400	2366		140.0	0.126	36400	2063
	119.7	0.117	33400	2385		149.9	0.138	39700	1919
	130.2	0.107	33300	2390	SYL1	90.0	0.109	23400	2385
	140.5	0.099	33500	2408	ripple	99.2	0.099	24100	2454
	150.0	0.094	33800	2397	= 0	110.6	0.090	24900	2502
	160.9	0.089	34100	2395		120.2	0.084	25500	2526
GV4	131.9	0.002	624	2365		130.2	0.079	26100	2537
	141.4	0.035	13720	2770		140.4	0.075	26800	2545
	151.2	0.080	32800	2712		150.1	0.072	27500	2545
GV5	90.4	0.109	27200	2760		160.7	0.070	28400	2525
ripple	100.8	0.110	30400	2741	EL1	100.8	0.104	26900	2334
= 0	110.2	0.111	33000	2698	ripple	110.0	0.131	33900	2353
	120.3	0.112	36100	2679	= 0.12	119.7	0.114	32000	2345
	130.2	0.113	39100	2658		129.7	0.101	31000	2366
	140.3	0.115	42400	2628		139.5	0.092	30300	2361
	150.3	0.116	45100	2644	ECO3	110.3	0.126	29800	2144
	160.7	0.117	50500	2686	ripple	120.1	0.116	30100	2161
PH6	100.0	0.074	18470	2496	= 0.08	130.0	0.110	31500	2203
ripple	110.5	0.129	35100	2462		140.4	0.101	31000	2186
= 0.10	120.2	0.112	33100	2459		150.4	0.093	30500	2181
	130.0	0.101	32400	2468		159.2	0.087	30100	2173
	139.7	0.093	31700	2440					
PH7	90.8	0.071	15150	2350					
ripple	99.4	0.120	27800	2330					
= 0.09	109.0	0.123	30100	2246					
	120.4	0.110	29600	2236					
	129.6	0.101	29300	2238					
	140.0	0.093	29000	2227					

Table 7: DC Tests Page 2