LED Lighting Evaluation with Commercial Poultry Production

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Lighting continues to be a significant energy cost for poultry producers with solid side wall or dark out curtain tunnel houses. After the 4 house Applied Broiler Research Farm was retrofitted to solid side walls and tunnel ventilation in 2006, electrical usage for lighting was measured for 4 flocks and found to be an increased operating cost (Table 1.) It was determined the biggest and quickest opportunity for energy and economic savings involved replacing existing 75 and 60 watt incandescent lamps (75 and 90/house, respectively)[1] used for brooding and growing broilers with more energy efficient technologies such as dimmable compact fluorescent lamps (DCFL) or cold cathode fluorescent lamps (CCFL). Electrical usage associated with lighting was reduced as much as 66% when the lamps were replaced with 23 w compact fluorescents for brooding and 16 watt CCFL for growing, saving an estimated $80/house/flock. However, time determined that CCFL or DCFL bulbs were not durable under poultry house conditions and producers which switched to these technologies were complaining of frequent lamp failure and loss of light due to dirt accumulation on the spiral DCFL. Challenges which have been identified with using these bulbs include bulb failures when bulbs are dimmed below 10% and failures due to incompatibility between the lamps and the metal used in the light sockets.

Now, light emitting diodes or LEDs are emerging as a lighting source for the poultry industry. LED lamps are more efficient, durable, versatile and longer lasting than incandescent or fluorescent lighting. Light is produced by the movement of electrons in a semiconductor material resulting in the illumination of the tiny light sources called LED’s whereas incandescent bulbs operate by passing an electric current through a metal filament until it becomes so hot it glows producing both light and heat. LED lamps release only a small amount of heat into a heat sink above the diodes. To dissipate this heat, LED lamps often have metal fins or an enclosed area above the diodes.

In January 2009, NextGen Illumination (Fayetteville, AR) provided prototype LED lamps designed specifically for broiler production meaning the lamps were well sealed to prevent dust or moisture accessing the internal components. A 10 watt, 400 lumen, 3500 Kelvin lamp was installed in the brood and grow light sockets. Energy savings were significant for the LED house when compared to the 60 watt incandescent lamp houses (352 versus 1991 kWH electrical usage; $21.12 versus $119.46 lighting electrical cost based on $0.09/KWH). Since that time, six more LED manufacturers have provided lamps for evaluation at the ABRF unit. These include Luma Vue which provided a 6.7 watt, 600 lumen, 6,000 Kelvin bulb, Power Secure which provided a 10 watt, 400 lumen, 6,000 Kelvin bulb, Once Innovation which provided a 12.5 watt, 900 lumen lamp and Selco which provided a 7.2 watts, 525 lumens, 5,000 kelvin bulb in 2011. In addition, Crownmate Technologies and Verbatim provided lamps in 2012. The Verbatim lamp is an A19 design which is 8 watt, 480 lumen bulb with a 3000 Kelvin. The Crownmate

Technology lamp is also an A19 design and has 11 watt with 5000 Kelvins and 720 lumens. The A19 looks more like an incandescent bulb in design.

Table 1. Lamps Evaluated

Manufacturer	Lamp	Wattage	lumens	Kelvin
NextGen	AgLED a. Original version b. Updated version	10	400	3500
LumaVue	PAR38 Flood	6.7	600	6000
Power Secure		10	400	6000
Once Innovation	Agrishift	12.5	900 at 5000K	6400 to bluish hue
Selco	LL30 LED Grow Light	7.2	525	5000
Crownmate Technologies	PS250	11	720	5000
Verbatim	A19-type LED bulb	8	480	3000

For each of the four barns, feed usage along with water, electricity and propane are monitored daily. Each house is equipped with three electrical meters; one each for lighting usage, fans and motor usage and total usage. Each house is equipped with bird scales and average bird weights are recorded daily. When birds are marketed, average bird weights by house are estimated by monitoring number of trucks loaded per house and trucks are then weighed on certified scales at the processing plant. When trucks were split loaded between two houses, coops filled from each house were determined. Then the total load weight divided by the number of birds from each house placed on the split load truck. As of the July 2012 flock, loads are kept completely separate by house. In the following table, “plant” weight is an average bird weight using the total estimated pounds produced by each house divided by the bird numbers determined by the plant. “Ours” is the weight estimate divided by bird numbers determined from mortality records for each house. Utilizing the flock information, a Performance Index (PI) was calculated for each lighting technology. The PI formula is as follows:

$$PI=\left[\left(\frac{\text{Average Weight x Livability}}{\text{Age of flock x FCR}}\right) \Big/ \text{Lighting Electrical Usage}\right] \text{x } 100$$

The following table provides information on bird performance and lighting electrical usage when the different lighting technologies are used. Time lines for flocks are provided. The data for the incandescent and cold cathode flocks is from 2006 and 2007 when corn prices were significantly lower so performance is slightly better than flocks grown during 2010 and 2011 when corn prices forced the industry to utilize more alternative ingredients thus significantly learning their value. Therefore, it is not suggested that bird performance be compared between the 2006 and 2011 flocks. But rather the focus of this paper should be on the energy usage and the performance index. While not listed, it is important to note that flocks settling during these time lines were competitive in the tournament settlement so results for each time period are reflective of industry performance standards. The primary goal of this paper is to show that electrical usage is significantly impacted by lighting technology and LED technology did not compromise bird performance. Overall, performance for the birds grown under the LED lighting has proven to be competitive and the LED lighting technology significantly improves electrical usage as compared to incandescent bulbs and cold cathodes. One word of warning, the Power Secure bulbs experienced a significant loss in light output during the March 2011 (50% of light output was lost in the field demo during this same time period.) Light output dropped approximately 90% within 2 flocks. Bulbs were pulled after the flock was removed. This experience indicates the need to work with light suppliers who understand the challenges of the poultry production environment and address this in their bulb design. Overall, LED bulbs are proving to be an efficient and durable light source for poultry production. Of the seven LED sources that have been evaluated at the ABRF unit, four have shown durability and optimal bird performance for a year or longer. The Power Secure bulb was almost in the barn for a year when dramatic light loss (90%) forced us to pull the bulbs. Two bulbs, Verbatim and A&D Crown technology have performed well for three flocks.

Table 2. Comparison of Flocks Grown under Different Lighting Sources

# Flocks1	Flock placement months	Grow Light	Brood Light	Number of Bulbs Brood/Grow	Flock Average Lighting Electrical Usage KWH	Lighting electrical cost based on $0.09/KWH ($)	Avg. Feed to gain ratio lb:lb	Average Weight Estimate (lbs)		Avg. Livability (%)	Avg. Age in days	Average Energy Performance Index
								Plant	Our			
11	April 2006 June 2006 July 2006 Oct 2006 Dec 2006 Feb 2007 Flock 93,94,95,96, 103	60watt Incandescent	75w Incandescent	33/42	***2234.33***	***201.09***	***1.99***	***6.89***	***6.85***	***96.04***	***51.46***	***0.30***
6	April 2006 June 2006 July 2006 Oct 2006 Dec 2006 Feb 2007	60w Incandescent	75w Incandescent	40/50	***2609.00***	***209.64***	***1.98***	***6.76***	***6.77***	***95.77***	***51.10***	***0.29***
3	Dec. 2006 Feb. 2007 May 2007	2700K 16 watt Cold Cathode	23 w	40/50	***1472.67***	**132.54**	**1.99**	**6.61**	**6.72**	**95.17**	**52.3**	**0.51**

8	Nov. 2010 Jan 2011 March 2011 May 2011 July 2011 Oct 2011 Feb 2012 April 2012	Once Innovation Agrishift 12.5 watts	15w OI	33/42	***313.72***	**28.24**	**1.95**	**5.88**	**5.88**	**97.20**	**46.5**	**2.03**
9	Nov 2009 Jan 2010 March 2010 May 2010 July 2010 Sept 2010 Nov 2010 Jan 2011 Mar 2011	Power Secure 10 watts	40w CFL	33/42	***533.16***	**47.98**	**1.93**	**6.08**	**6.09**	**97.02**	**47.6**	**1.25**
13	Nov 2009 Jan 2010 March 2010 May 2010 July 2010 Sept 2010 Nov 2010 Jan 2011 Mar 2011[3] May 2011 July 2011 Nov 2011 April 2012	Luma Vue 7 watts	40w CFL	40/50	***288.75***	**25.98**	**1.90**	**6.02**	**5.96**	**96.82**	**46.6**	**2.41**
10	Jan 2009, March 2009 May 2009 July 2009 Sept 2009 Nov 2009 Jan 2010 March 2010 May 2010 July 2010 September 2010 November 2010 Jan 2011 March 2011	Original NextGen Ill. 10 watts	40w CFL	40/50	***516.13***	**46.45**	**1.96**	**5.96**	**5.96**	**96.74**	**47.3**	**1.27**
8	May 2011 July 2011 Oct 2011 Feb 2012 May 2012 July 2012 Sept 2012 Nov 2012	New NextGen Ill. 10 watts	40 w CFL	40/50	***386.88***	**34.82**	**1.87**	**5.92**	**5.94**	**97.13**	**45.5**	**2.00**
7	July 2011 Oct 2011 Feb 2012 May 2012 July 2012 Sept 2012 Nov 2012	Selco 7.2 watts	40 w CFL	40/50	***334.86***	**30.14**	**1.85**	**6.10**	**6.06**	**97.01**	**45.5**	**2.11**

3	July 2012 Sept 2012 Nov 2012	Verbatim-H2 8-watts	40 w CFL	33/42	***284.00***	**25.56**	**1.80**	**5.90**	**5.81**	**97.21**	**44.0**	**2.49**
3	July 2012 Sept 2012 Nov 2012	A & D LED/Crownmate Technology Soy Best H4 11 watts	40 w CFL	40/50	***407.00***	**36.63**	**1.80**	**5.94**	**5.93**	**97.45**	**44.0**	**1.77**

1. For all houses lighting is located over each of the two feed lines with brood lights located only in the first half of the barn. Houses 1 and 2 have grow-out lighting on 20 foot centers with brood lighting located directly in middle of every two grow bulbs and houses 3 and 4 have grow-out lighting on 16 foot centers with brood lighting located in the middle of every two grow out bulbs
2. Power Secure bulbs pulled prior to May 2011 flock placement due to significant light loss;
3. Luma Vue bulb house experienced a feed bin weigh cell failure for 24 hours which resulted in a loss of feed usage data for 24 hours, therefore data has been omitted for that flock