Broiler Lighting Overview: The Technologies

E.R. Benson, R.L. Alphin, and D.P. Hougentogler
• Lighting and electrical basics
• Common Types of Lamps
  – Incandescent
  – Compact Fluorescent Lamp (CFL)
  – Cold Cathode Fluorescent Lamp (CCFL)
  – LED (and now OLED)
• Dimmer Response
• Environmental concerns
Background
• Luminaire is the complete lighting unit, includes:
  – Light source
  – Lamp or lamps
  – Reflectors and/or lenses
  – Power supply and/or ballast
  – Support structure

Image: Superbrightled.com
• Lamp is the consumable portion of the luminaire that converts electrical energy to light
• Commonly called the bulb or tube
• Can become more complex with LED lamps that are incorporated into luminaire
• Lumens measure the amount of light produced or at a surface

• Lumens are calculated, not measured directly
  – Method to compare light output from different lamps

<table>
<thead>
<tr>
<th>Type</th>
<th>Power (W)</th>
<th>Initial Light Output (Lumens)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incandescent</td>
<td>60</td>
<td>610</td>
</tr>
<tr>
<td>Halogen</td>
<td>60</td>
<td>960</td>
</tr>
<tr>
<td>CFL</td>
<td>11</td>
<td>660</td>
</tr>
<tr>
<td>CCFL</td>
<td>11</td>
<td>540</td>
</tr>
<tr>
<td>LED</td>
<td>6.1</td>
<td>615</td>
</tr>
</tbody>
</table>
• “We will make electricity so cheap that only the rich will burn candles.”
  – Thomas Edison
• Electrical power generally rated as Watts
  – Maximum design power at rated voltage
  – Kilowatt is 1000 W

• Power consumption provided as power x time or kW-h.
Disposal:

Science and Theory

Spectral Intensity

• Color based on light output from lamp

• Significant differences in output from different lamp technologies

• Light spectrum rarely flat or single peaked

• Lamp output needs to be matched to end use

– Human vs Bird

Image: ni.com

Spectral Intensity
• Detailed spectral analysis more in depth than often required
• Simplification to represent lamps as color in Kelvins (K)
• Compresses spectrum to one number
  – But spectrum is rarely one color

Color (Kelvin – K)
• Electrical devices and lamps can be rated many ways
• Underwriters Laboratory
  – Voluntary review
  – Safety oriented
• Energy Star
  – Indicates energy efficiency, not safety
• DLC (Design Light Consortium)
  – Designed for LED lighting
Lamps
• “I did not fail. I found 2,000 ways not to make a light bulb.”
  – Thomas Edison
• Incandescent bulbs use a thin piece of wire (filament) to create light
  – Household voltage used directly
• Current flow causes tungsten or carbon filament give off light
  – Filament is a thin wire
  – Wire degrades with time (~1,500 hr)
  – Large portion of electrical energy converted to heat
  – Heat causes radiation of energy, but 95% of lamp output not usable
• Commodity item
- Gas discharge light
- Electrons emitted from cathodes
- Electrodes bounced off inside of glass, hitting phosphor coating
- Phosphor gives off light

Fluorescent Lamp
• Typically 2 ½ times more efficient than incandescent lighting
  – Last 10,000 – 20,000 hrs
  – May require being left on to achieve life
  – Flicker a concern for poultry
• Exposed design not ideal for agriculture
• Commodity item
• Optimal light levels only reached after a few minutes
  – Minute or two
  – May produce < 25% at start
• Typically do not work well at colder temperatures (<50 F)
  – Base up vs Base down
• Largely has not met performance goals for poultry
  – Exposed tubes, dust, flicker all concerns
Disposal:

Science and Theory

CFL and CCFL Lamps

120 V

500 V

Lim et al. (2011)

CFL and CCFL Lamps
• CCFL is similar to CFL in concept
  – Execution different
• Tube elements tend to be covered
  – More suitable for dusty poultry environments
• Electrically efficient
  – Not as efficient at production of meat
Disposal:

Science and Theory

CCFL

• In terms of body weight (and breast weight), CCFL lags other technologies.

• Why?

• More recent evidence supports difference in gene expression between technologies.

– CCFL enhances a growth inhibitor.
• Semiconductor based lights
  – Originally low power and selected colors
  – Efficiency improving 35% annually
  – Projected to save $250 billion across 20 years

• Directed light, which is different from all other lighting sources

Luma Vue
• Significant lamp to lamp variations in design
• Cannot meet high lumen requirements
• Use about 40% less energy than CFL’s
• Rugged, no moving parts
• Heat dissipation an issue
• Long lifespan — 25,000 - 50,000 hrs
• Form factor not same as conventional lamp
LED Lamps

120 $V_{AC}$

3.3 $V_{DC}$ or 5 $V_{DC}$

Lim et al. (2011)
Disposal:
Science and Theory

In small flock trials, LED performed similarly to other technologies.

In large flock trials, incandescent resulted in greater weight moved—CCFL greater than LED for the specific lamps tested.

Lost Income

![Bar chart comparing CCFL, Incandescent, and LED with Lost Income text overlay.]

- CCFL
- Incandescent
- LED

LED
• Semiconductors that use organic materials in construction
• Can be made into sheets
  – Flexible
  – TV’s, monitors, cell phones initial market
  – Animal agriculture not a target market
• Advantage will come when form factor differences can be utilized
• Potential to completely change lighting
  – Integrated into walls, ceilings
  – Unlimited sizes
  – Can be printed using inkjet technology

• Being used in technology today
  – $1 billion USD in 2011

Image: charterworld.com
Dimmers
• **Dimmers fall into two categories**
  – Resistance: Alters voltage
  – Electronic (Triac): Alters current wave

• **Altering voltage**
  – Incandescent output proportional to voltage
  – Decrease voltage, decrease light
  – Decreased voltage, increased life
  – Incandescent lamps dim to ~0%
Disposal:

Science and Theory

Once Lighting

LED Dimming
• What about CCFL, CFL, and LED?
  – Do not work well with varied voltage
  – Some lamps are designed for use with dimmers
  – Requires revised ballast design to reduce power to bulb
  – New specific dimmer designs available

• Not all lamps turn on or turn off at the same dimmer setting
  – CCFL and CFL: 10 – 30%
  – LED: 5 - 15%, but variable between lamps
How does the efficiency compare in the field?

- Most CCFL, CFL, and LED lamps are rated for lower wattage than incandescent.
- CCFL and LED lamps are between 80% and 90% more efficient than incandescent.
Mercury is a concern for CFL and CCFL lamps. It is highly toxic and toxins are released at the breakage site. Greater levels of mercury are released through the combustion of coal. Solid state components also contribute to mercury emissions.
• What does this mean for growers?
• Incandescent lamps will be going away
• CCFL and CFL lamps more expensive, higher durability (?), and more efficient
  – Neither ideal
• LED lamps more efficient and durable
  – Results more lamp specific
• Any Questions?

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Additional Slides
• LM-79
  – Power, efficiency, color information

• LM-80
  – Measures lumen maintenance rather than durability
  – All lights degrade with time; most technologies eventually fail catastrophically (i.e. burn out)
  – LED typically do not fail, but rather eventually produce less light than desired
  – Test run for 6,000 or more hours, no guess for final lifespan
Incandescent Bulb

- **Glass bulb**
- **Vacuum or inert gas**
- **Filament**
- **Filament supports**
- **Screw base**
Variety of Configurations
LED Dimmer Response