OLED TRACK 2: PRODUCT DESIGN AND INTEGRATION: OLED Light Engines

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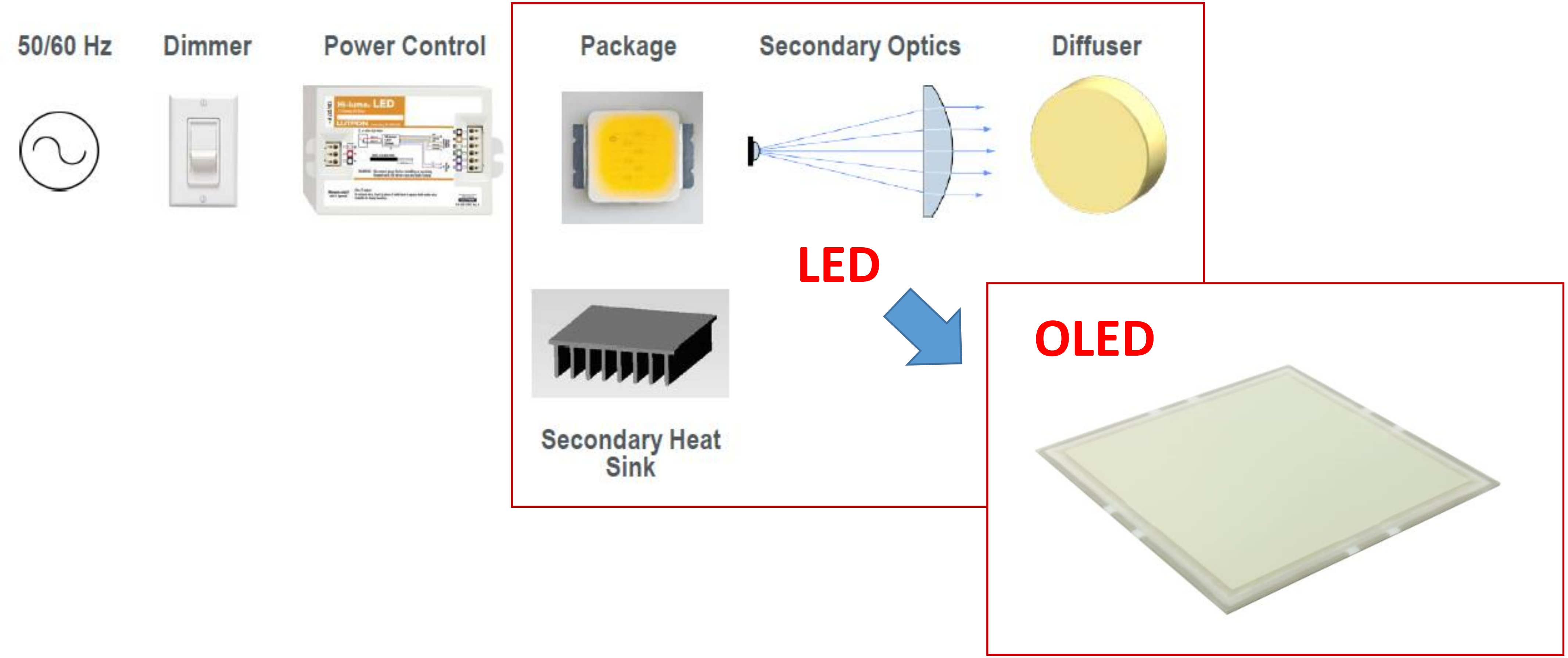
DOE SSL R&D Workshop - Long Beach, CA - February 1st, 2017

SSL System Design

M. Poplawski, 2010 DOE SSL Market Intro Workshop

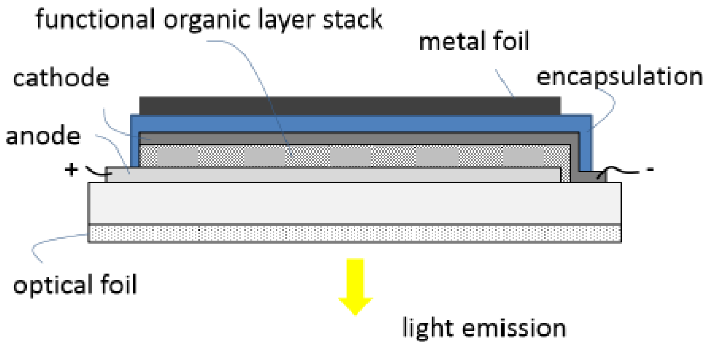


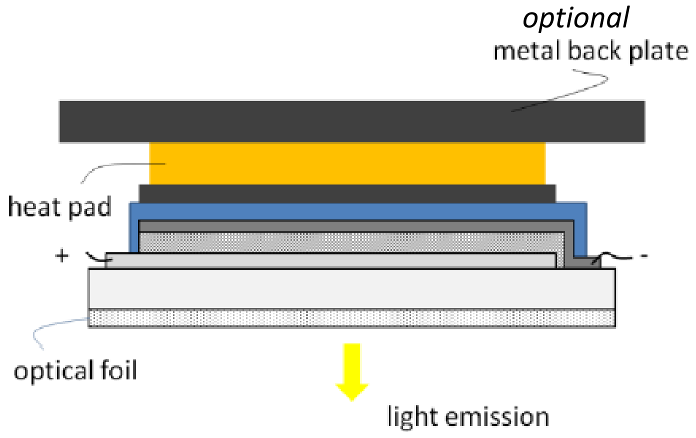
Luminaire system design should be simpler with OLEDs!

OLED Panel Integration

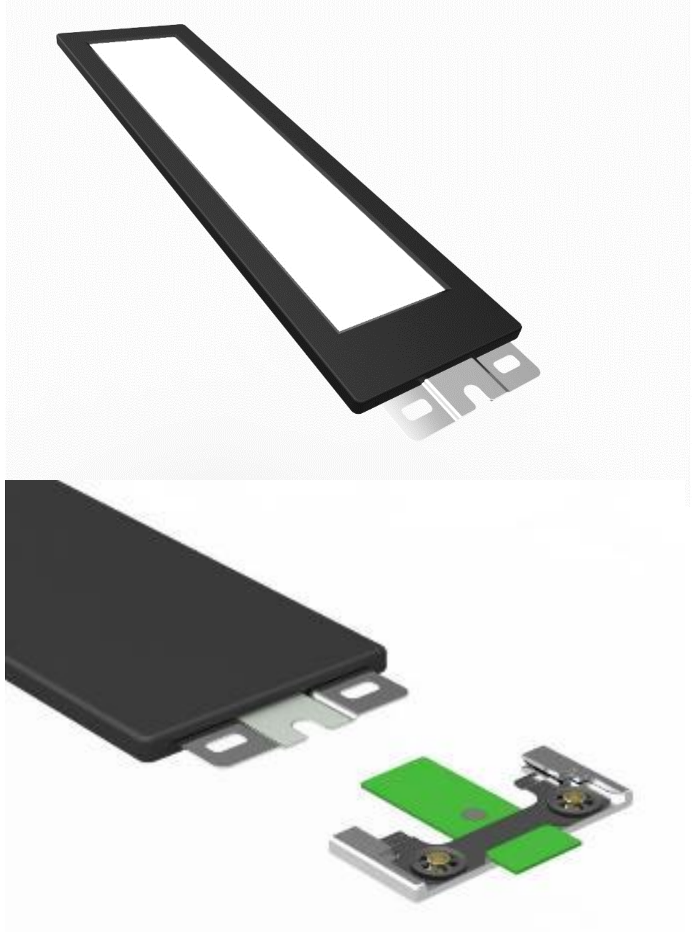
Bare OLED Panel

OLED Panel + Back Plate + Connector





OLED Panel + Driver + Housing

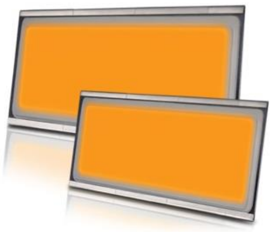


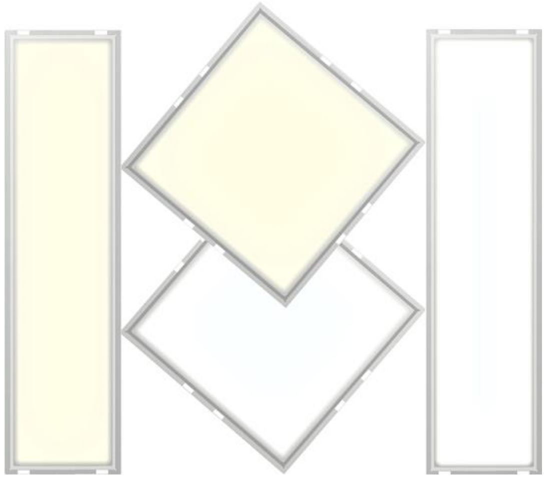
OLEDWorks Keuka OLED Module

From an OLED panel manufacturer’s perspective

Near term, OLED panels should offer:

- Excellent color quality: CRI > 90, R9 > 50
- Variety of CCTs (3000K, 3500K, 4000K…) and colors
- High efficacy (60-80+ lm/W)
- High brightness to enable more applications
- Wide variety of shapes and sizes
- Simple integration with connectors, drivers, luminaires
- Good reliability
- Reasonable price





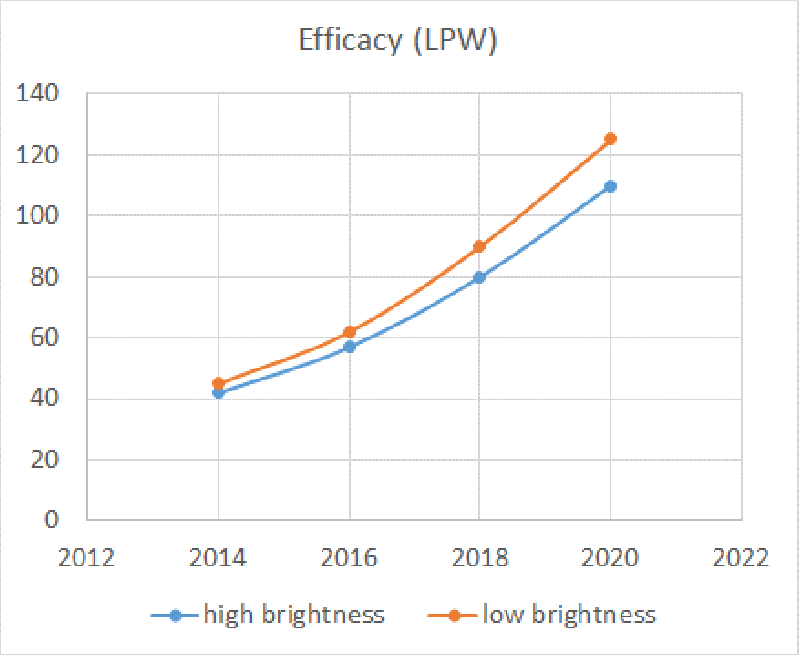
Future:

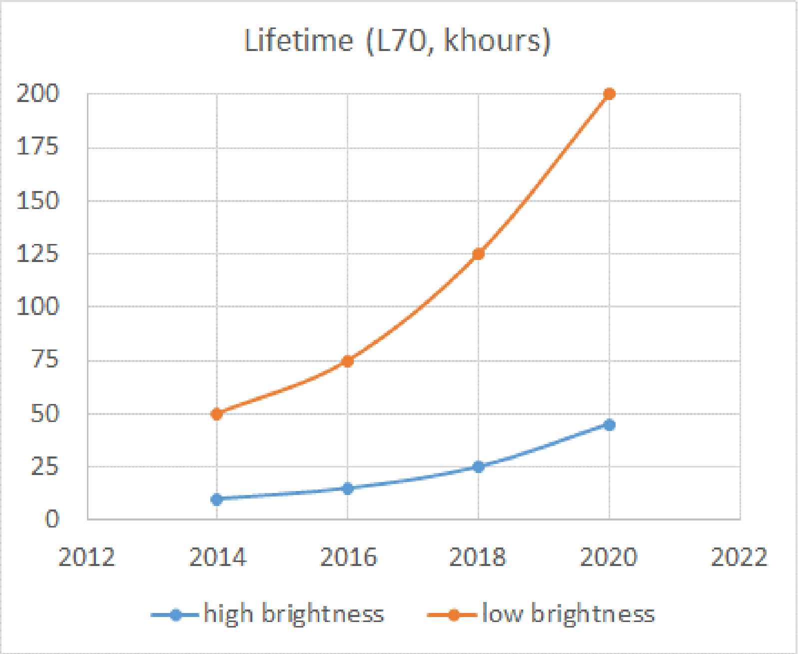
- Flexible/Bendable
- White tunable, color tunable
- **100+ lm/W**
- **Low price**

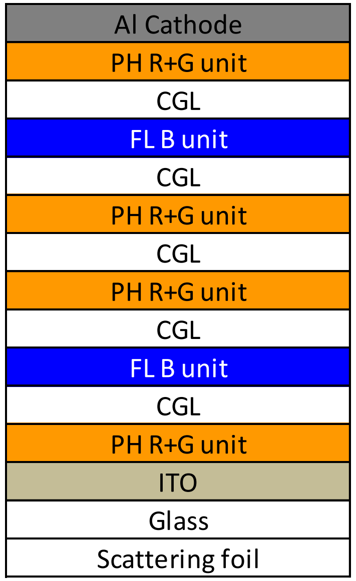
OLED Panel Performance

INNOSYS inc.

OLEDWorks Naturally Illuminating



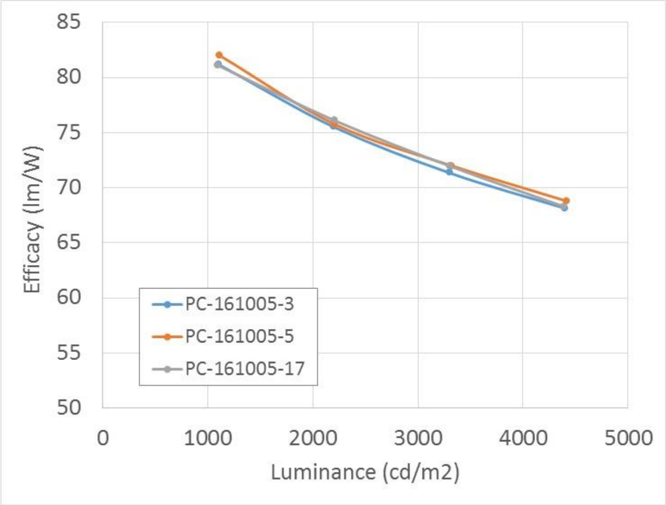


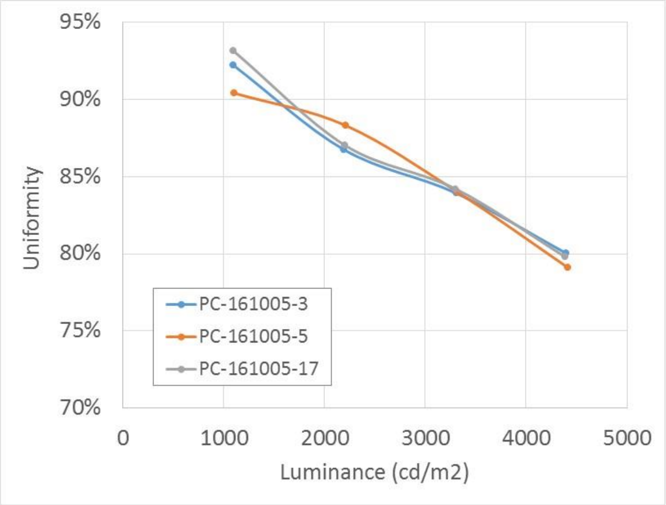


6-stack white OLED Panel (105 cm²)
High brightness = 8300 cd/m² = 300 lm
Low brightness = 3000 cd/m² = 100 lm

<u>High Performance OLED Panel and Luminaire project funded by DOE (DE-EE0006701):</u>

- OLEDWorks (prime), Acuity Brands (sub)
- Demonstrated panel efficacy of 75-80 LPW
- Uniformity > 85%, no metal grids
- 3-stack white OLED





OLED Luminaire Performance

INNOSYS inc. | OLEDWorks Naturally Illuminating | AcuityBrands

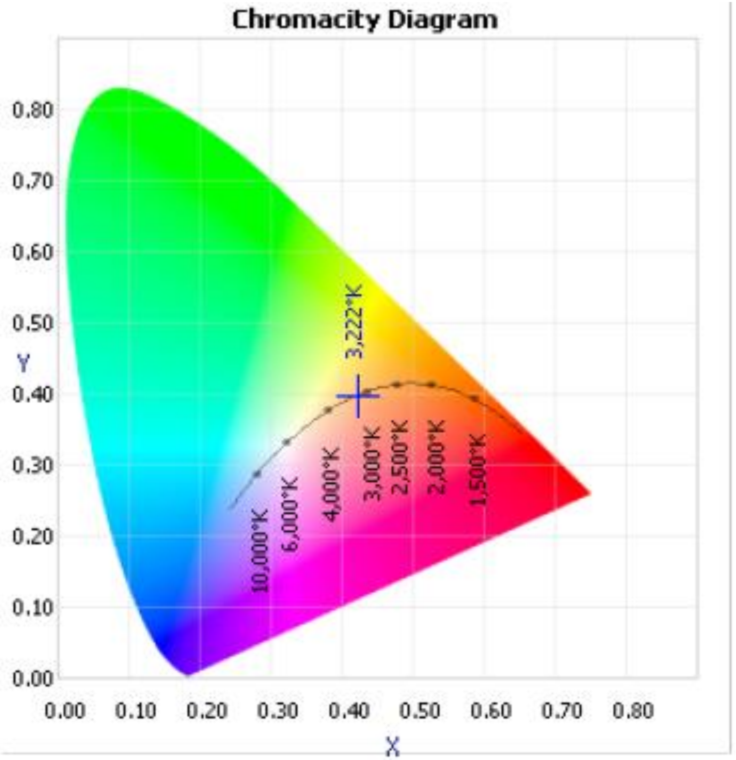
<u>High Performance OLED Panel and Luminaire project (DE-EE0006701)</u>

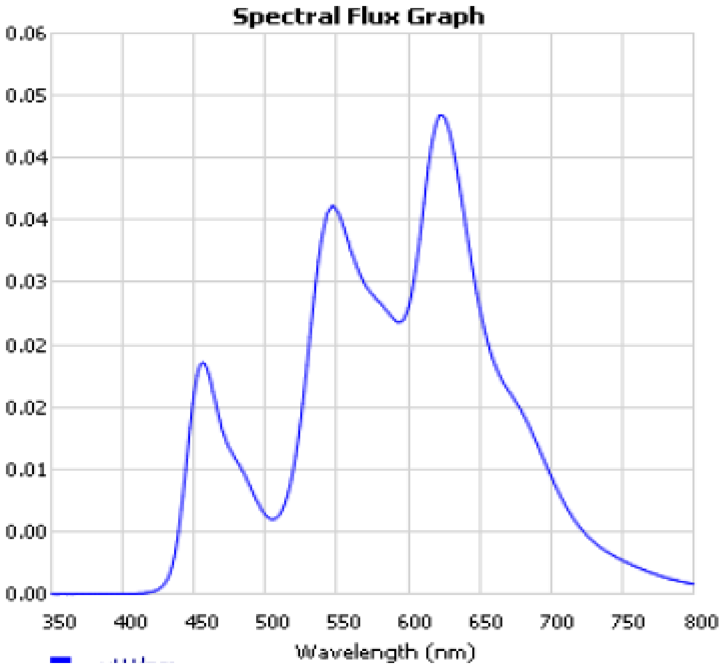
- Demonstrated 24-panel Trilia luminaire producing over 2200 lumens with efficacy nearly 60 LPW
- CRI Ra = 88, R9 = 76, CCT = 3222K, Duv = 0.0018

LM-79-08 TEST REPORT: ISF 33431S
CATALOG: TRILIA OW PANELS

PHOTOMETRIC DATA	
LUMINOUS FLUX(LU):	2237
SP RATIO:	1.38
CCT:	3222
CRI:	87.68
CHROMA X:	0.4241
CHROMA Y:	0.4035
CHROMA U:	0
CHROMA V:	0
CHROMA U':	0.2425
CHROMA V':	0.5193
DUV VALUE:	0.0018
ELECTRICAL	
INPUT POWER(WATTS):	38.05
INPUT VOLTS(VOLTS AC):	120
INPUT CURRENT(AMPS):	0.43
FREQUENCY(HERTZ):	60
POWER FACTOR:	0.74
CALCULATED	
EFFICACY(LU/WATTS):	58.79

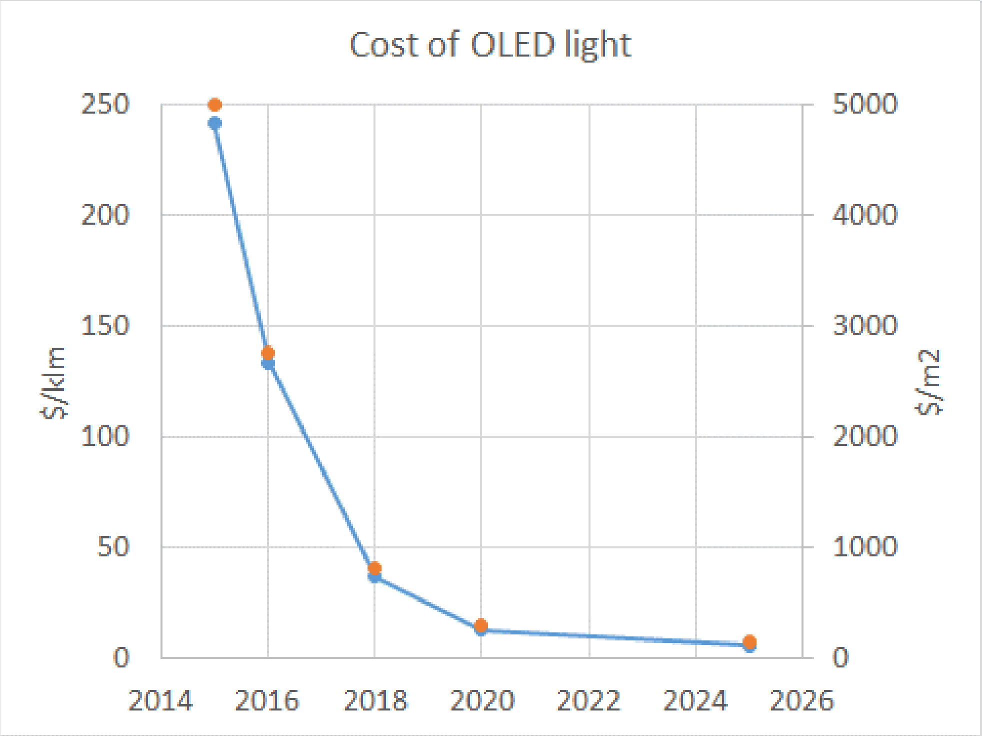
R VALUES	
RA:	87.68
R1:	91.05
R2:	90.75
R3:	78.83
R4:	86.12
R5:	84.31
R6:	80.06
R7:	97.28
R8:	93.06
R9:	75.95
R10:	66.12
R11:	74.03
R12:	49.97
R13:	90.22
R14:	85.61





Cost

* Prices have fallen below $200/klm
* Cost reductions will continue due to:
* Lower costs for organic materials, substrates, encapsulation, electrical connections
* Higher yield
* Increased capacity
  * Higher throughput
  * Larger factories



J. Hamer, DOE Stakeholder Meeting Oct. 2016
Based on DOE SSL R&D Plan 2016

Drivers

INNOSYS inc. OLEDWorks Naturally Illuminating

* You have heard and you are going to hear a lot about drivers and power supplies in general both in this OLED panel session and throughout this DOE R&D Workshop
* There are many things and attributes and requirements of drivers in general…
* The first being to put out safe power to light the SSLs, as well as:
  * High Power Factor (PF), typically greater than 0.95 on a scale of 1.00
  * Related to this, relatively low Total Harmonic Distortion (THD) of less than 20%
  * Acceptable (in the USA) FCC conducted and radiated Electromagnetic Interference (EMI) levels
  * Ideally no flicker
  * Great dimming to 1-10 %
  * Either "Triac" of Smart/Intelligent/Connected/IOT dimmable
  * And the list goes on…

What to interface to/with?

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* Not too, too long ago, people were happy to just have SSL lights that lit and were more efficient than incandescent
* Then came wall dimming which had loads of challenges to deal with
* Nowadays the rage is Connected Dimming/Trimming etc.
* By and far away the two most popular wired ways to dim are “0 to 10 V” and DMX (and the nearly infinite variants). Of course both DC and AC Powerline Communications (PLC) weave their way into the system of things too.
* As for wireless dimming – there are just so, so many to choose from however Bluetooth Low Energy and Zigbee are two of the more common ones with WiFi, Thread, Zwave, Sub-GHz and too many for a such a short talk as this to list and do justice to including both the physical and firmware layers.

OLED Light Engines

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* Oh, wow, what a can of worms (or should that be wires?)
* For LEDs it is pretty easy in terms of form factors that people can agree upon
* For OLEDs, there is the good and the bad… should the driver be flat or boxy like in J-box(y)?
* The need for ‘smaller’, higher levels of intelligent integration and more adaptive form factors that also address wiring issues.
* Should it be a DC to DC converter with a wall wart doing the heavy lifting from AC to DC or should it be an AC to DC straight shot play with PF> 0.95, THD< 20%, efficiency >>95%, great dimming to sub 1% and so on.
* And then there are those darn wires…

Why make power supplies specifically for OLEDs?

* Although it may appear that LED power supplies are suitable for driving OLEDs this is not always the case
* OLEDs have their own set (or subset) of considerations when it comes to being driven and controlled. Fundamental differences.
* Interconnectivity and drive voltages and currents
* OLED wall plug efficiency and lifetime and other considerations
* Form factor is one of the considerations – Ease of user design ‘use’
* Increased driver integration & reduced OLED designer complexity
* Protection is another
* Failure mode and mitigation is yet another
* Dimming (digital vs. analog, PWM flavors, etc.)

The Case for OLED A-Lamps

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* Need to face the fact that OLEDs are going to cost more than LEDs for at least the next few years
* Yes, one could use a cheap power supply with each OLED panel and try to create the equivalent of an A-lamp bulb (maybe different form factor or shape) – however is this really where OLEDs are going to shine?
* Will the proverbial low cost LED replacement A-lamp end up being an OLED (possibly curved to form fit an incandescent lamp)? Possibly but probably not.

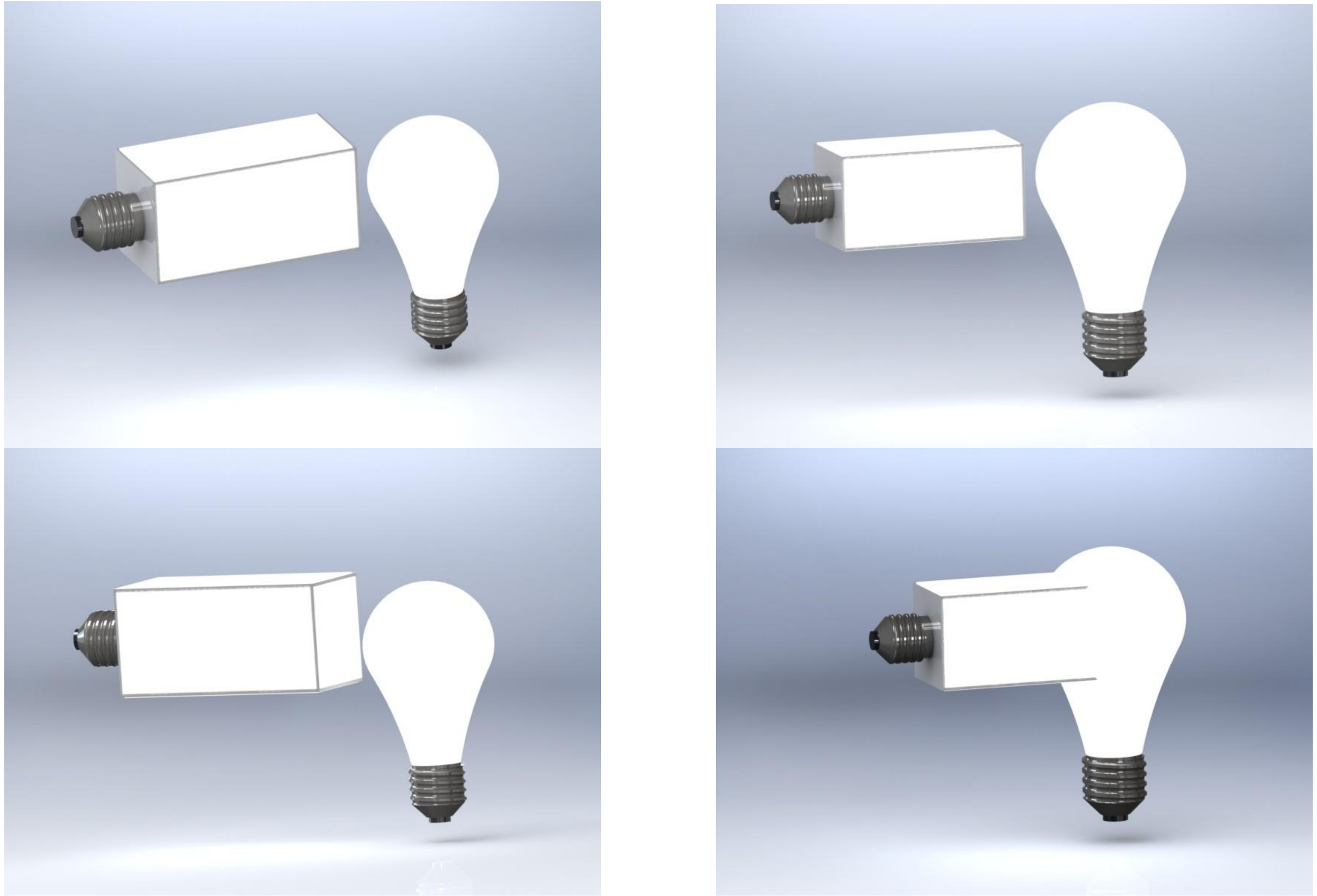
What's wrong with this picture?

Conventional A-lamp

OLED A-Lamp

In many ways, the same applies to power supplies and drivers for OLEDs.

Do we just need to look at it from a different perspective/viewpoint/angle? (answer: yes and no)



Examples of Past InnoSys Power Supplies for OLEDs (All with Very High PF)

1. A universal (80 to 305 VAC and up to 500 V DC) isolated power supply for a ~6 W (6.3 V, 1 amp) OLED panel.
2. A universal (80 to 305 VAC and up to 500 V DC) non-isolated power supply for a ~6 W (6.3 V, 1 amp) OLED panel.
3. A 10 to 60 V AC and up to 85 VDC input power supply for a ~6 W (6.3 V, 1 amp) OLED panel.
4. A 6 W to 150 W single to multiple OLED power supply with wireless control and monitoring.
5. A ~ 6W desk lamp that uses a single 6.3 V 960 mA OLED panel that is locally and remotely dimmable.

Some of the above was supported by DOE SBIR Grant DE-SC0010184

A Path to Generalized and Common OLED Light Engines

* Collaborate and interact with architects and lighting designers as well as OLED luminaire manufacturers.
* Provide ultra-efficient design and product solutions for solid state lighting including and especially OLEDs.
* Provide solutions to challenging lighting problems and situations in terms of power supplies, drivers, control and monitor electronics.
* Help to develop, foster and be a part of complete supply chains for OLED-based lighting and luminaires.
* Provide value-added, cost-efficient and cost-effective lighting and related applications including and especially for OLED lighting.
* Provide innovative solutions.
* Provide enabling solutions.

How can DOE help?

* Fund projects that encourage collaboration between makers of OLED panels, drivers, light engines, luminaires…
* Fund projects that can deliver real technical progress toward higher performance, lower cost, and wider variety of panels, drivers and light engines
* Continue education efforts: SSL = LED + OLED
* Highlight benefits of OLED SSL, Roadmaps, Gateways, Workshops…
* Help develop standards for OLED lighting

How can we all help?

* Collaborate
* Deliver higher performance (100+ lm/W) and lower cost ($10/klm)
* Focus on strengths of OLEDs, where complementary to LEDs
* Standardize where necessary