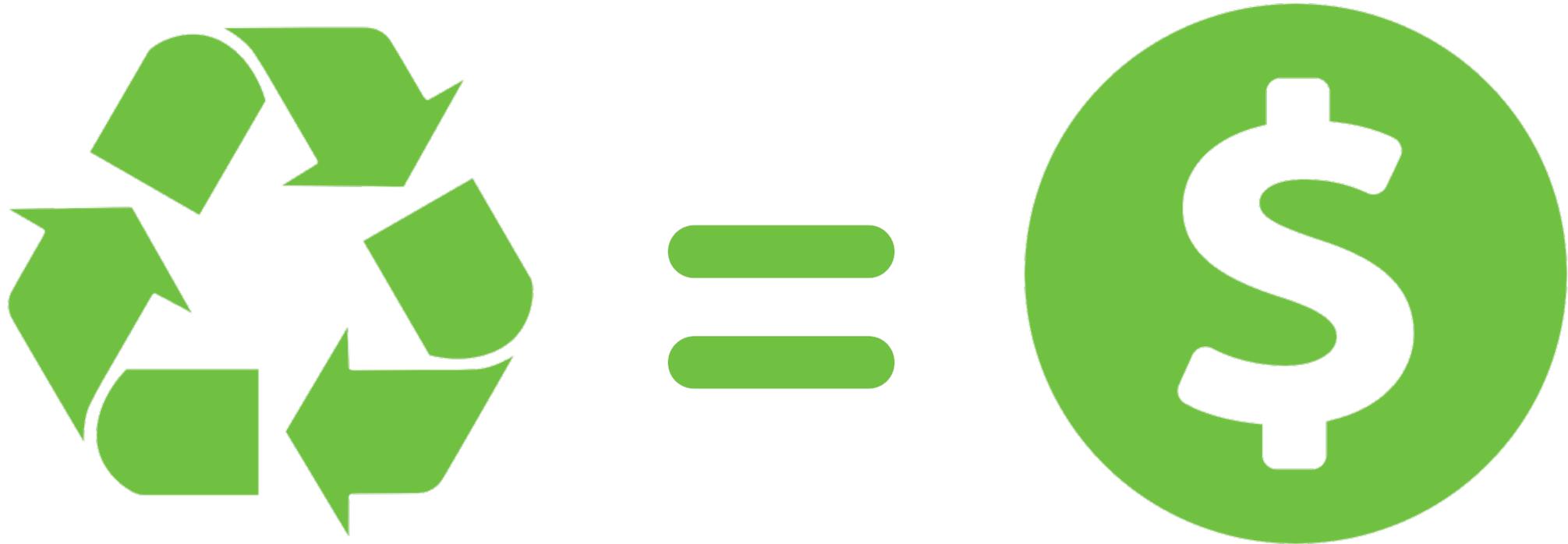


Sustainability for Competitive Advantage

US DOE SSL R+D WORKSHOP 2021





Does “deep green” sustainability lead to radically reduced costs?

6 years ago...

2014 US DOE Solid State Lighting R+D Workshop

The Evolution of Adoption

2014 US DOE Solid State Lighting R+D Workshop

Philips Lighting Research



Does "deep-green" sustainability lead to radical cost reductions?

Customers will hold the lighting industry accountable for lifecycle costs. (OMG!)

PERFORMANCE ECONOMY

- Contracts for holistic lifecycle costs
- Planned performance upgrades
- System leasing plans
- "Pay-per-lux" billing
- "Take back" programs

PERFORMANCE ECONOMY CIRCULAR ECONOMY

Externalities... internalized?

"The transition from a linear to a circular economy is a necessary boundary condition. A circular economy requires innovation in the areas of material, component and product reuse, as well as related business models."

...economic growth will eventually be decoupled from the use of natural resources and ecosystems. In such we economy, the better use of raw materials allows us to create more value."

-Frans van Houten, CEO Royal Philips

Design
Specification
Procurement
Installation
Commissioning
Operation
Maintenance
Disassembly
Reclamation/Reuse

Peak Design Performance Economy

Drive adoption by lowering the upfront price?

Leasing?
Residual value of the fixtures?

Energy services?
Shared value?

Pay-per-use?
Pricing for light-as-a-service?

Residual Value? Place your bets: Asset or Liability?

The Fashion Cycle?

What is the residual value of the fixtures?

Extracting value at "end of life"

- Reuse -> Used Lighting Market?
- Rebuild -> Maintenance? Upgrade?
- Reclaim -> Separation/OEM Parts?
- Recycle -> Biological? Technical?

Extracting Value?

Zhaga

- 200 lm/w L70 - 50,000 hrs
- 140 lm/w L70 - 50,000 hrs
- 100 lm/w L70 - 50,000 hrs
- 70 lm/w L70 - 50,000 hrs

Where could the DOE invest?

Reduce the junk: system consolidation

Shrink the fixture: treat light as a material

Go "deep green": eco-materials + lifecycle

Reduce the junk: system consolidation

Reduce the junk: Simply, simply

Reduce the junk: miniaturization of "smart" drivers

Reduce the junk: integrate drivers?

Shrink the fixture: treat light as a material

Why are our lighting systems constrained to "fixtures"?

We're selling gashlight era fixture formats instead of architectural lighting systems.

Shows which fixture paradigms you start with.

Seagram Building
NYC Energy Audit
Built: 1928 out of 100
Modern: 68 out of 100
Seagram: 1 out of 100

Architects want to treat light as a material

Can we treat lighting just like gypsum board?

On highly complex, customized projects, how can we efficiently produce, ship and install sheets of light?

Lock-Bonding MIT Media Lab

LuxExcel
200lm/w @ 100hrs

Coolidge Lighting

Secondary benefits of package-integration R+D?

Lighting as a Service?

Cut it?
Bend it?
Mold it?
Stamp it?
Glue it?

Alain Kopylov offers us an idea for the future of lighting.

Go "deep green": eco-materials, lifecycle, material bank

Why do our lighting products use such energy intensive materials?

Do we really need steel, aluminum and plastic in our lighting products?

How can we use renewable, natural materials?

Molded bamboo-fiber pulp

How can we use reclaimed, recycled material streams?

Examples: Recycled plastic lumber products

SUSTAINABLE MATERIALS STRATEGY

What Goes In

What Comes Out

Bio-derived or bio-degradable parts?

Disposing electronics?

Do the current safety codes allow for eco-friendly material use?

Where could the DOE invest?

Reduce the junk: "system on a chip"

Shrink the fixture: electrical topology of resistors, novel LED packaging + bonding-to-substrates, mass-customized fabrication techniques

Go "deep green": eco-materials, consistency of EOL, material reclamation, advancement of safety codes

Another L-Prize?

Circular Economy Prize

Featherweight Prize

What sorts of future are we specifying today for tomorrow's world?

THANK YOU!

Brad Koerner
Director of Experience Design
Philips Lighting

www.lucept.com
brad.koerner@philips.com

<https://lucept.com/2014/02/10/us-doe-ssl-rd-workshop/>

Performance Economy <> Circular Economy:

Where could the US DOE invest?

Reduce the junk:

➔ **system consolidation**

Shrink the fixture:

➔ **treat lighting as an arch. material**

Go "deep green":

➔ **eco-materials + lifecycle**

Our industry progress the past 6 years?

12-PACK FOR \$74.10?

\$6.18 RETAIL????

WHERE DOES THIS END?

The screenshot shows an Amazon product page for a 4-inch LED disk light. The page includes a navigation bar with the Amazon logo, delivery location (Amsterdam 1059), and various menu options. The main content area features a product image of a white LED disk light, a specifications table, and a list of features and benefits.

4" LED Disk Light
PRODUCT SPECIFICATIONS

10WATT	650 LUMENS	120VAC
65WATT REPLACEMENT	3000K SOFT WHITE	110° BEAM ANGLE
DAMP LOCATION RATED	CRI >90	DIMMABLE

(12 Pack) 4 inch Dimmable LED Disk Light Flush Mount Recessed Retrofit Ceiling Lights, 10W (60W Replacement), 650lm, Installs into Junction Box, ENERGY STAR & ETL-Listed, 3000K (Soft White)

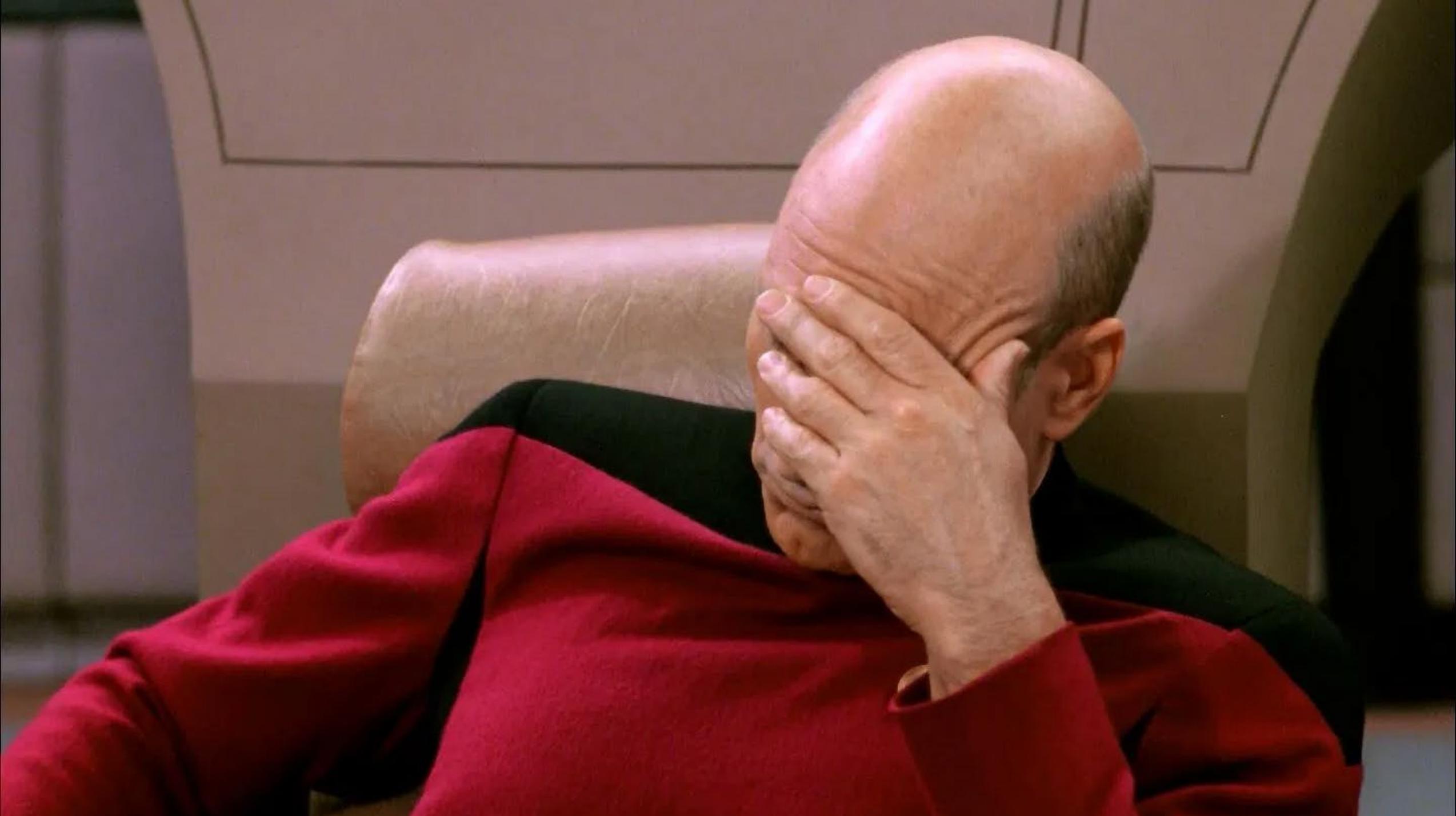
Price: **\$74.10** (\$6.18 / Count)

Total cost: **\$127.18** including Shipping & Estimated Import Fees Deposit to Netherlands Details

Returnable until Jan 31, 2021

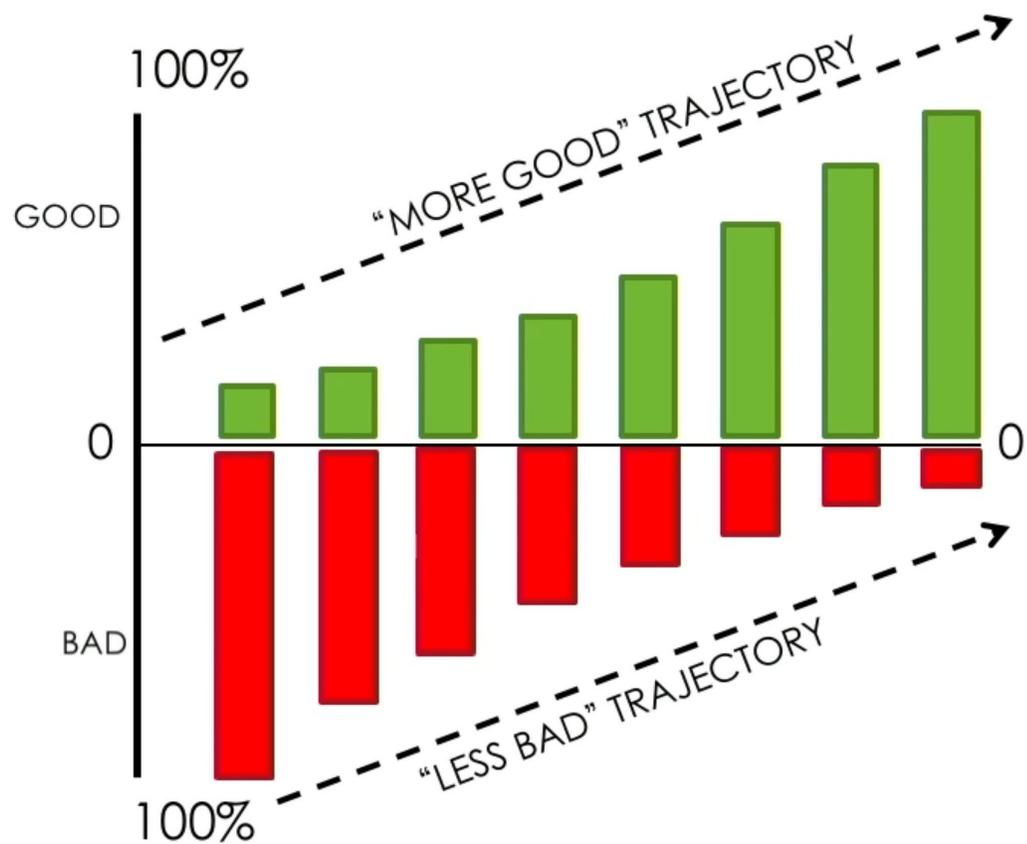
Color: **3000K (Soft White)**

- SAVE 84% IMMEDIATELY. Save 84% on your energy bill by replacing 60W with 10W LED. 50,000+ hours of life.
- EASY INSTALLATION: Can be installed into any 2.75", 3.5", or 4" Junction Box. Optimal for new construction and retrofit applications. All accessories included. Installation manual can be found in photo options.
- QUALITY AND SAFETY ASSURED: Our Energy Star certified lights are Title-24 JAB certified, ETL-Listed, Damp-Location Rated and FCC compliant, meaning they are both energy efficient and reliable. The Parmida Promise guarantees 50,000+ hours of use, and we have a 5 Year Warranty and dedicated Customer Support to give you peace of mind.
- DIMMABLE. Customizable brightness comes courtesy of its dimmable capability so you can set the preferred mood lighting. Compatible with most LED compatible dimmers and Caseta Wireless Dimming Systems.
- MODERN SLEEK THIN DESIGN. 0.03" thickness allows for an ideal flush mount look, similar to that of a standard modern downlight.



Deep green?





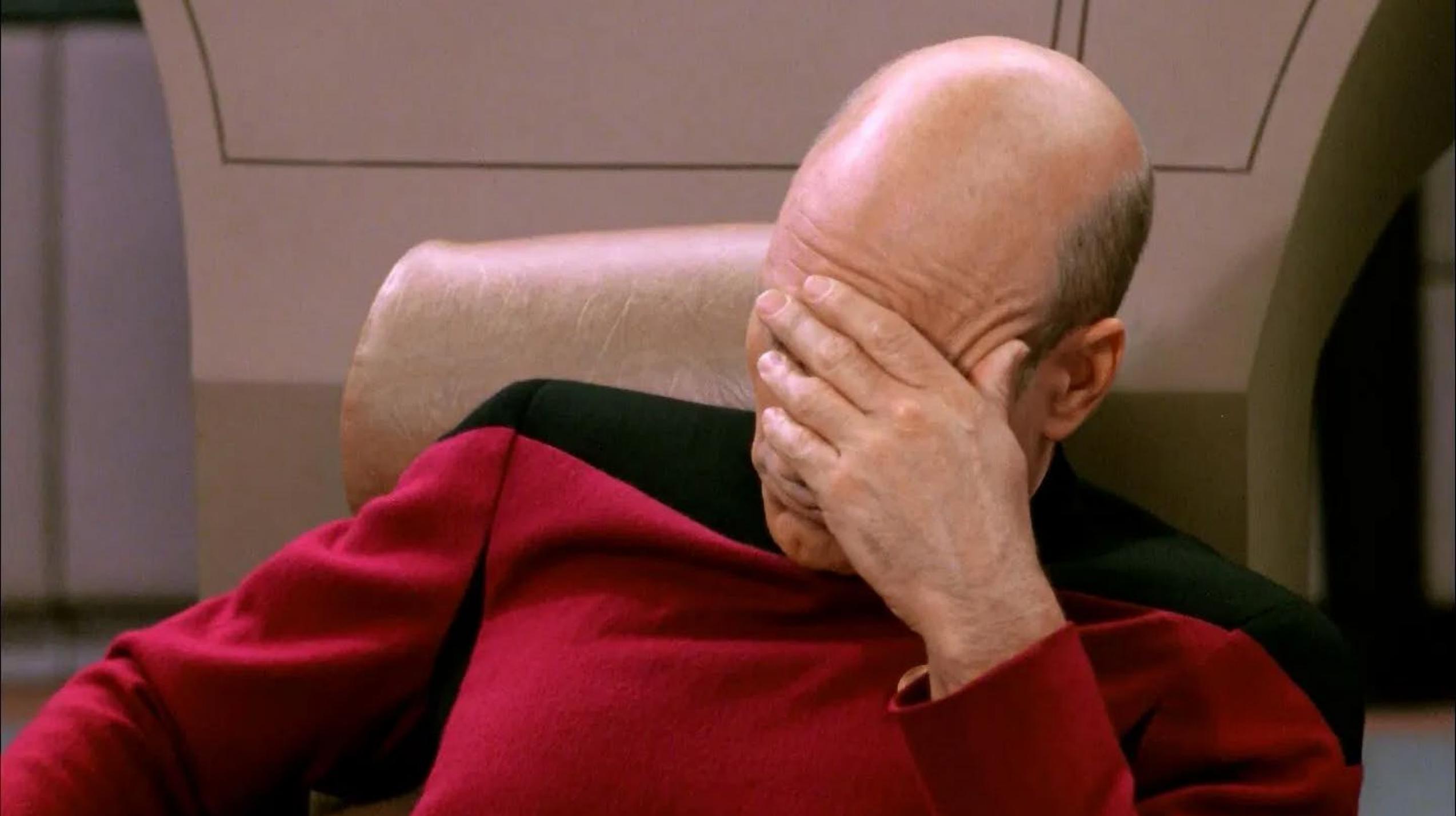
“Being less bad is not also being good.”

-William McDonough





Pure greenwashing!!!!!!





What does the US lighting industry need?

A genuine R&D challenge

(not just an easy layup for more product-marketing **greenwashing)**

Sustainability
= Local Advantage

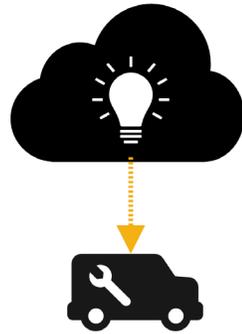


SUSTAINABILITY = LOCAL ADVANTAGE



**REPAIRABLE
FIXTURES**

LOCAL SERVICE REVENUE STREAMS



**SMART
MAINTENANCE**



**BEAUTIFUL
FACTORIES**

LOCALIZED SUPPLY CHAIN



**BIO-FRIENDLY
MATERIALS**

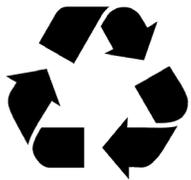
Sustainable design rating?

For competitive local advantage?



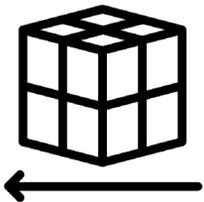
Sustainable materials and components:

Locally Sourced X **Bioderived** X **Biodegradeable** X **Distance Traveled**



Efficient recycling

Low-Labor Disassembly X **Distance Traveled**



Reduction in transport waste:

Mass X **Volume** X **Distance Traveled**



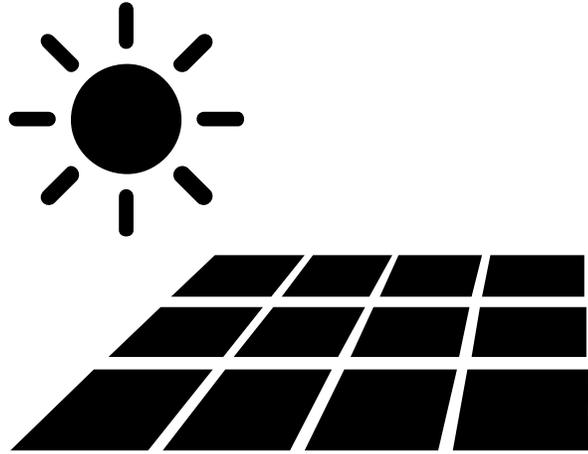
The fusion of lighting and architecture?

The DC Power Revolution

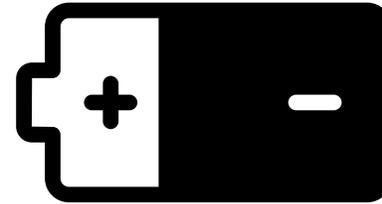




**WHAT WILL BE THE IMPACT OF
NET-ZERO BUILDINGS?**



**SOLAR PARITY
WITH GRID**



**PLUNGING
STORAGE COST**



LIGHTING



SENSORS



DEVICES



EV CHARGING



**DATA
CENTERS**

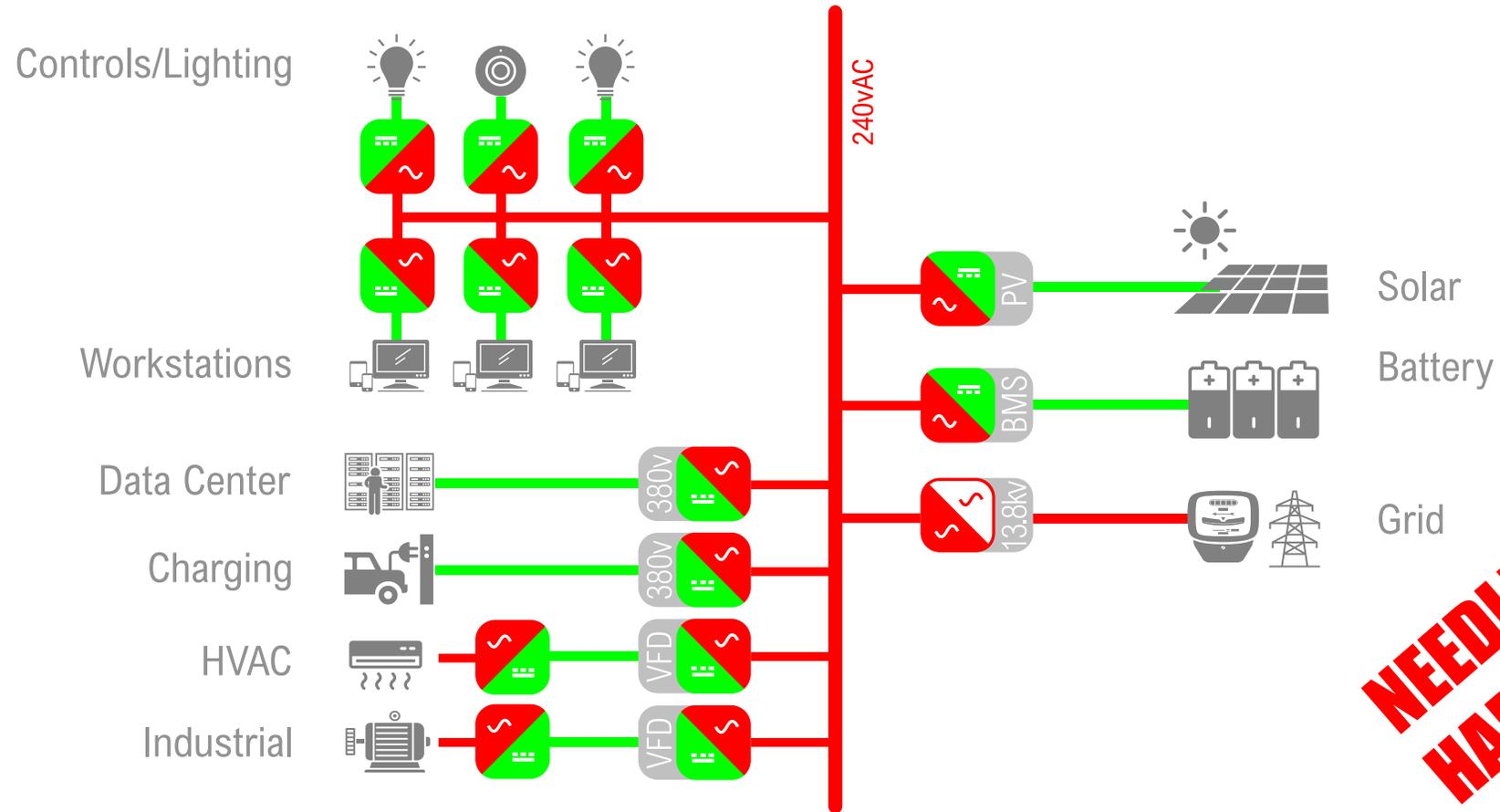


MECHANICAL

**EVERYTHING IS
DC POWER**

SO WASTEFUL, SO DUMB

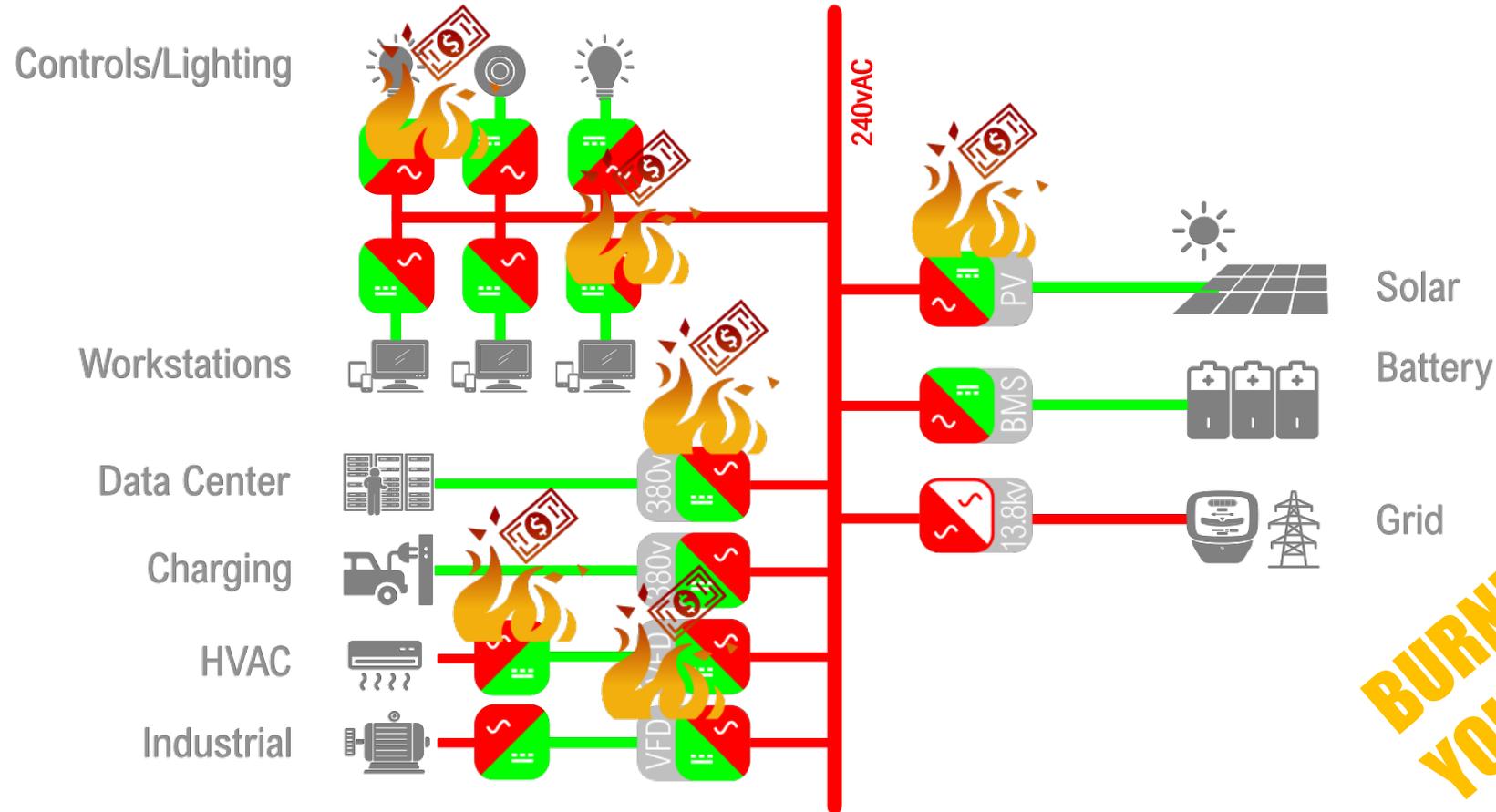
NEEDLESS DC-AC-DC CONVERSIONS ADD **UNNEEDED HARDWARE** THROUGHOUT A BUILDING



**NEEDLESS
HARDWARE!**

SO WASTEFUL, SO DUMB

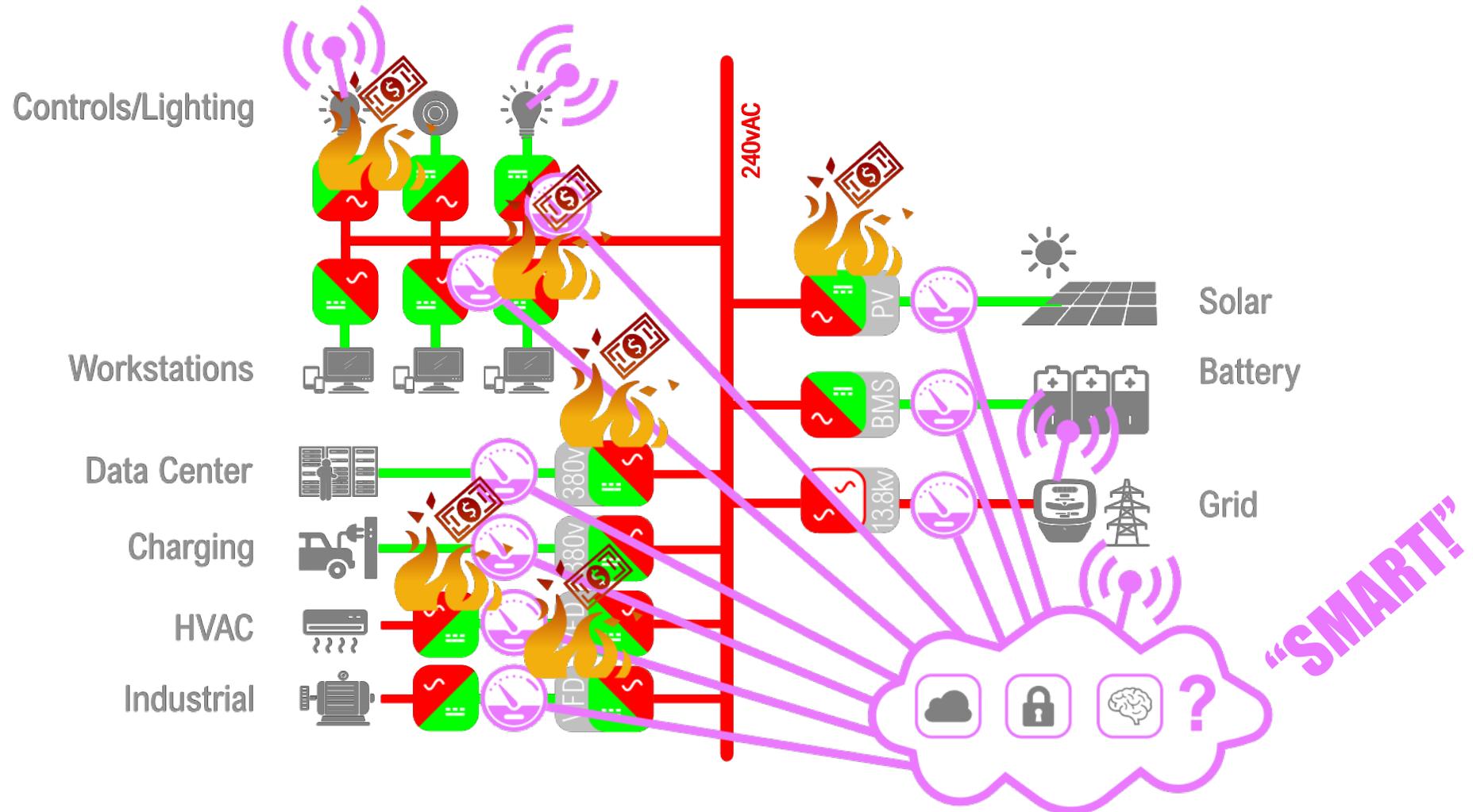
NEEDLESS DC-AC-DC CONVERSIONS WASTE 15% OF THE TOTAL POWER OF A NET-ZERO-ENERGY BUILDING



**BURNIN' UP
YOUR DOLLARS!**

SO WASTEFUL, SO DUMB

COMPANIES ARE SLATHERING ON **COMPLICATED DIGITAL/DC CONTROLS** ON TOP OF OUTDATED AC GRID



So. Much. Junk.

DC microgrids eliminate thousands of wasteful converters from commercial buildings



Solar inverters



Battery inverters

Variable frequency
drive inverters



LED drivers



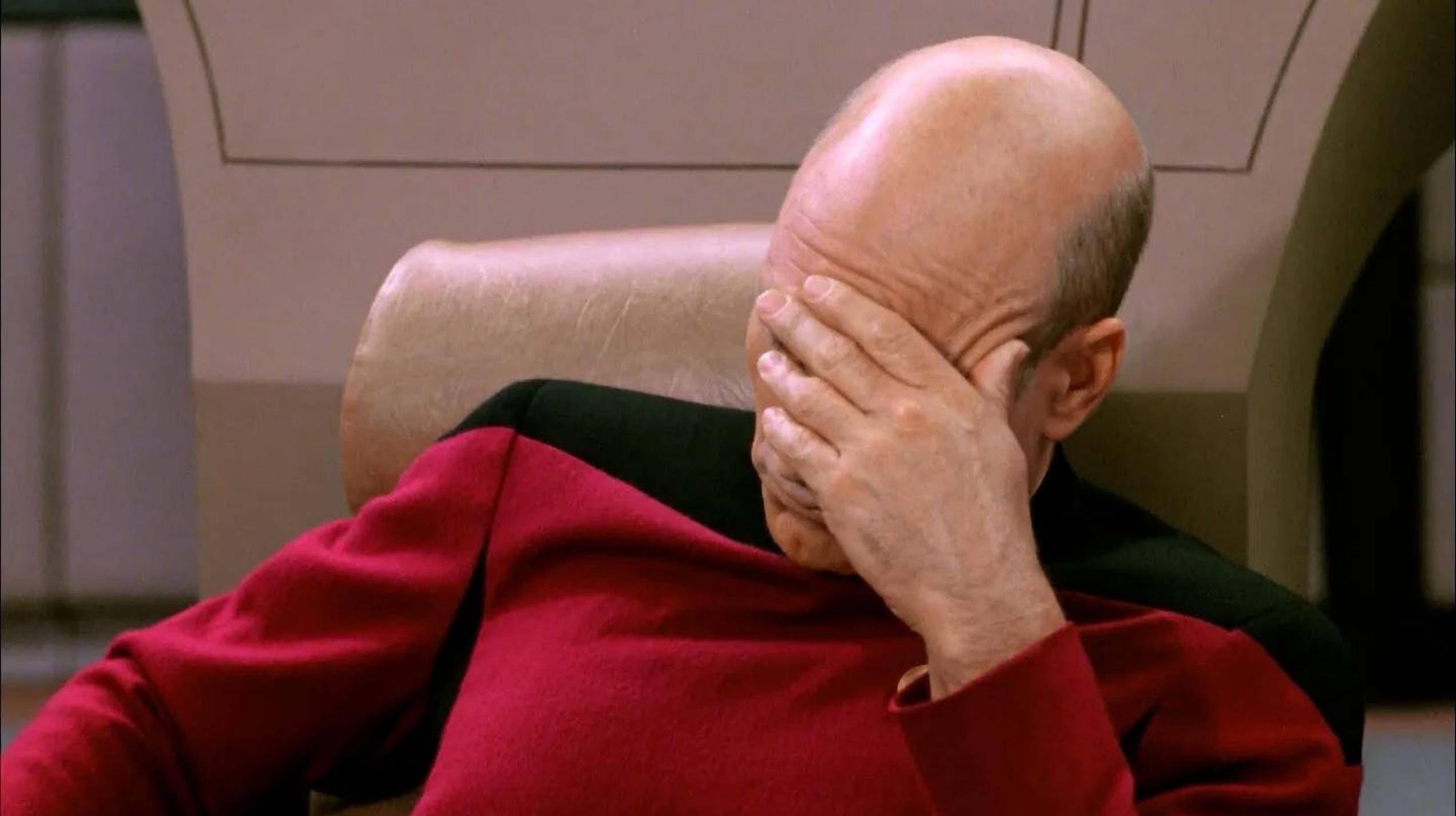
AC meters, breakers



Data center PSUs

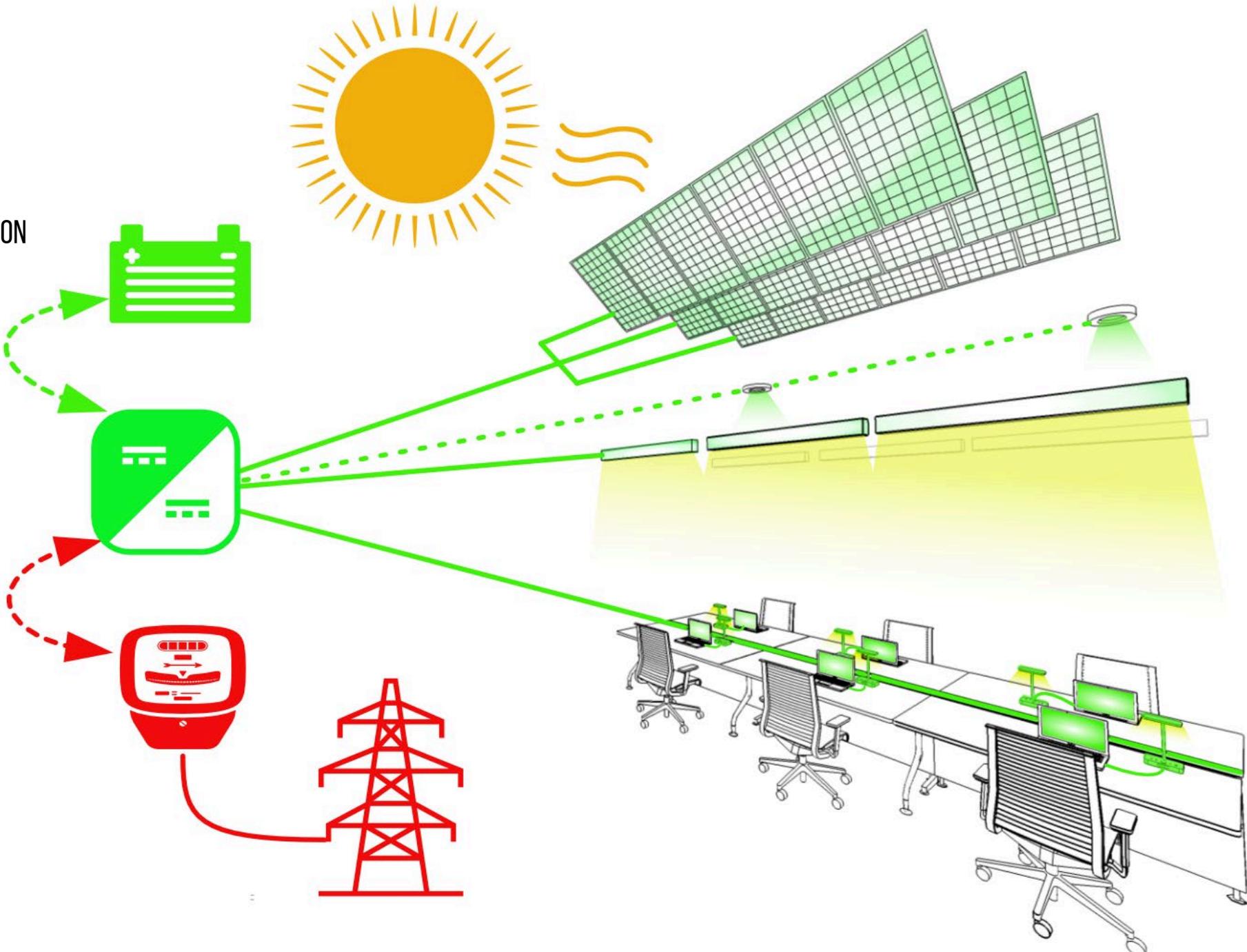
Chargers





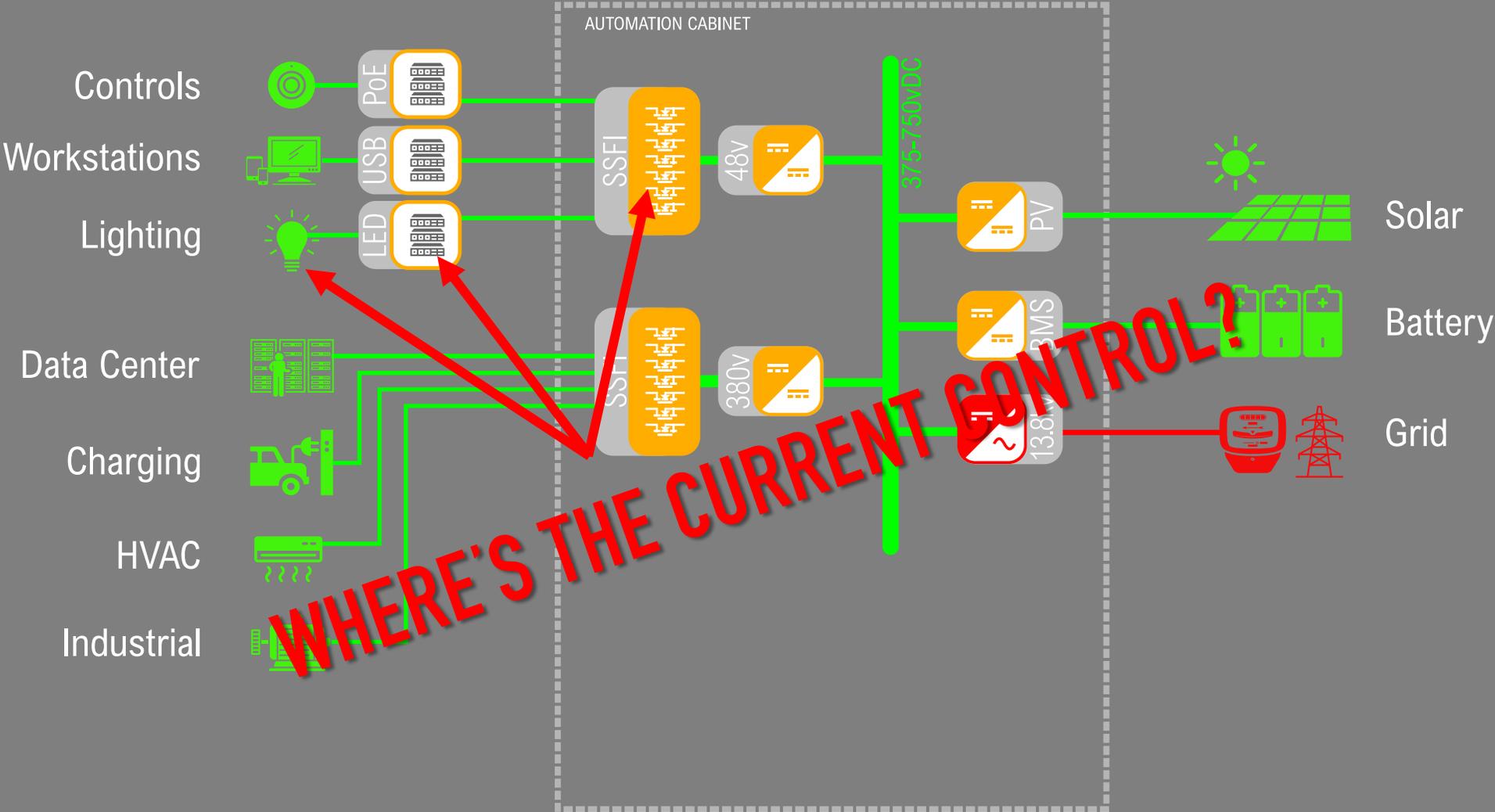
NET-ZERO ENERGY BUILDINGS

ARE LEADING US TO A DC POWER REVOLUTION



SIMPLIFYING LIGHTING SYSTEMS

DC-BUS WITH DIGITAL SOLID-STATE SWITCHING, FAULT INTERRUPTION AND CONVERSION



SMALL SAVINGS ARE A
BIG DEAL



Sustainable Luminaire Innovation



BAMBOO PENDANT

ENVISIONING A CLEAN, GREEN FUTURE FOR LIGHTING
AND ELECTRIC INFRASTRUCTURE



WINNER OF THE 2019 MANUFACTURING INNOVATOR CHALLENGE:
SUSTAINABLE MANUFACTURING OF LUMINAIRES



A CLASSIC FORMAT, MADE SUSTAINABLE

Simple design, natural materials

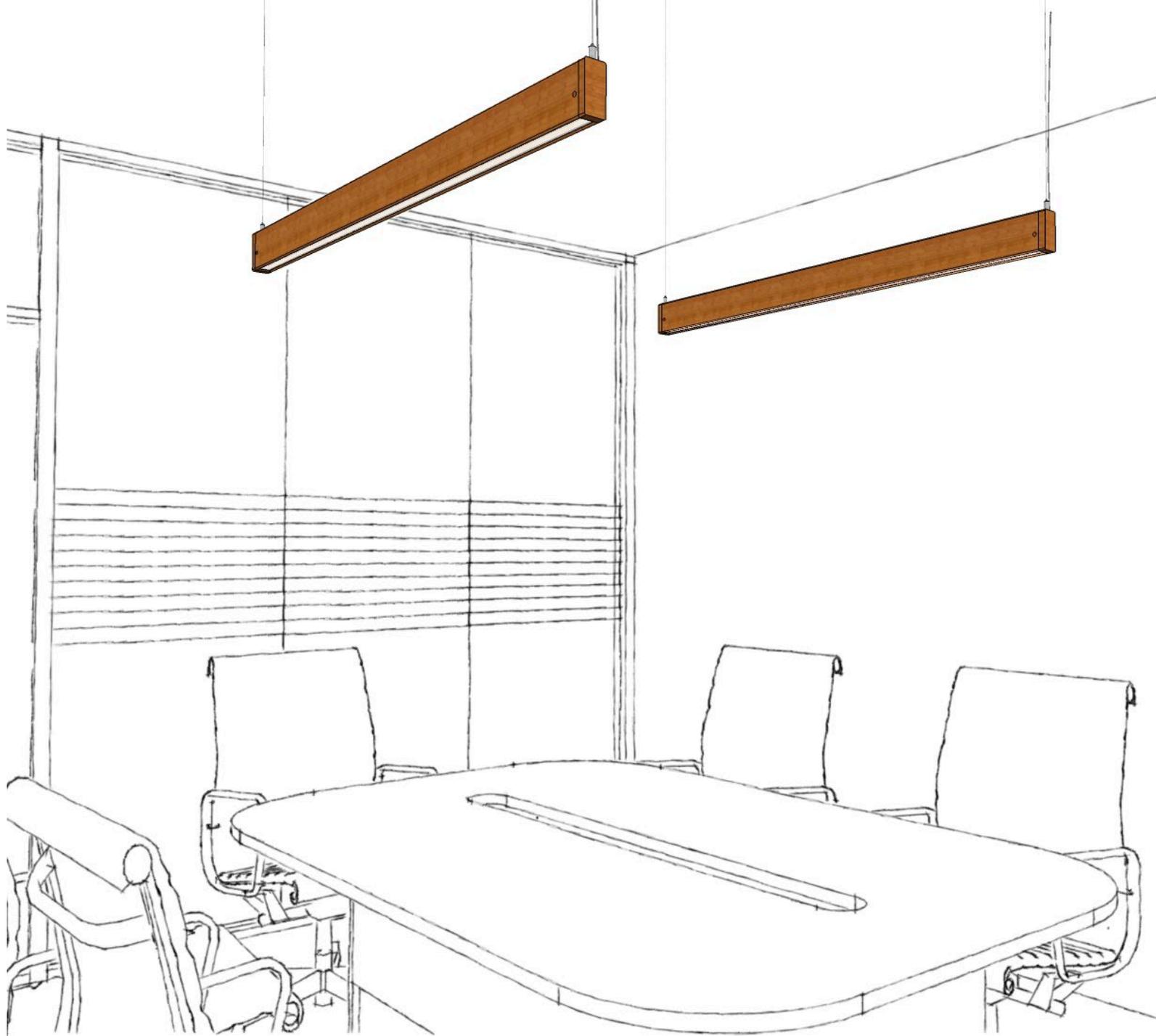
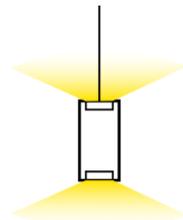
- A radically simplified design in support of the circular economy
- Low embodied-energy using bio-derived and biodegradable, low-toxicity, sustainable materials
- Simple construction, fast disassembly, radically reduced toxicity = dramatically reduced lifecycle costs & liabilities

Anticipating centralized DC power

- Net-zero-energy buildings with onsite solar PV and battery storage can save 15% overall system efficiency by skipping DC-AC-DC conversions
- Centralized DC/DC conversion with solid-state switching, solid-state fault interruptions and Class 2 topologies allow us to create SELV-compliant fixtures

The target specs

- Direct/indirect Lambertian distribution
- 6.5 watt/linear foot (split 50/50 up/down)
- 150 lm/w (minimum fixture efficacy)
- Designed to meet 0.6 w/sqft for LEED applications
- Various CCT/CRI combinations available
- Full range dimming & digital control integral to centralized DC/DC system
- Additional optical distributions in the future





LOW EMBODIED ENERGY, LOW TOXICITY

Laminated bamboo body

- Bamboo is one of the fastest growing, most renewable resources on the planet
- Fully biodegradable and non-toxic adhesives and finishes
- Dimensionally stable, non-sagging across lengths up to 12'-0"
- Standard 2"x4" profile easily channeled to precise profiles on 5-axis moulder
- Elements supplied by Lamboo Technologies

Flax-based printed circuit board

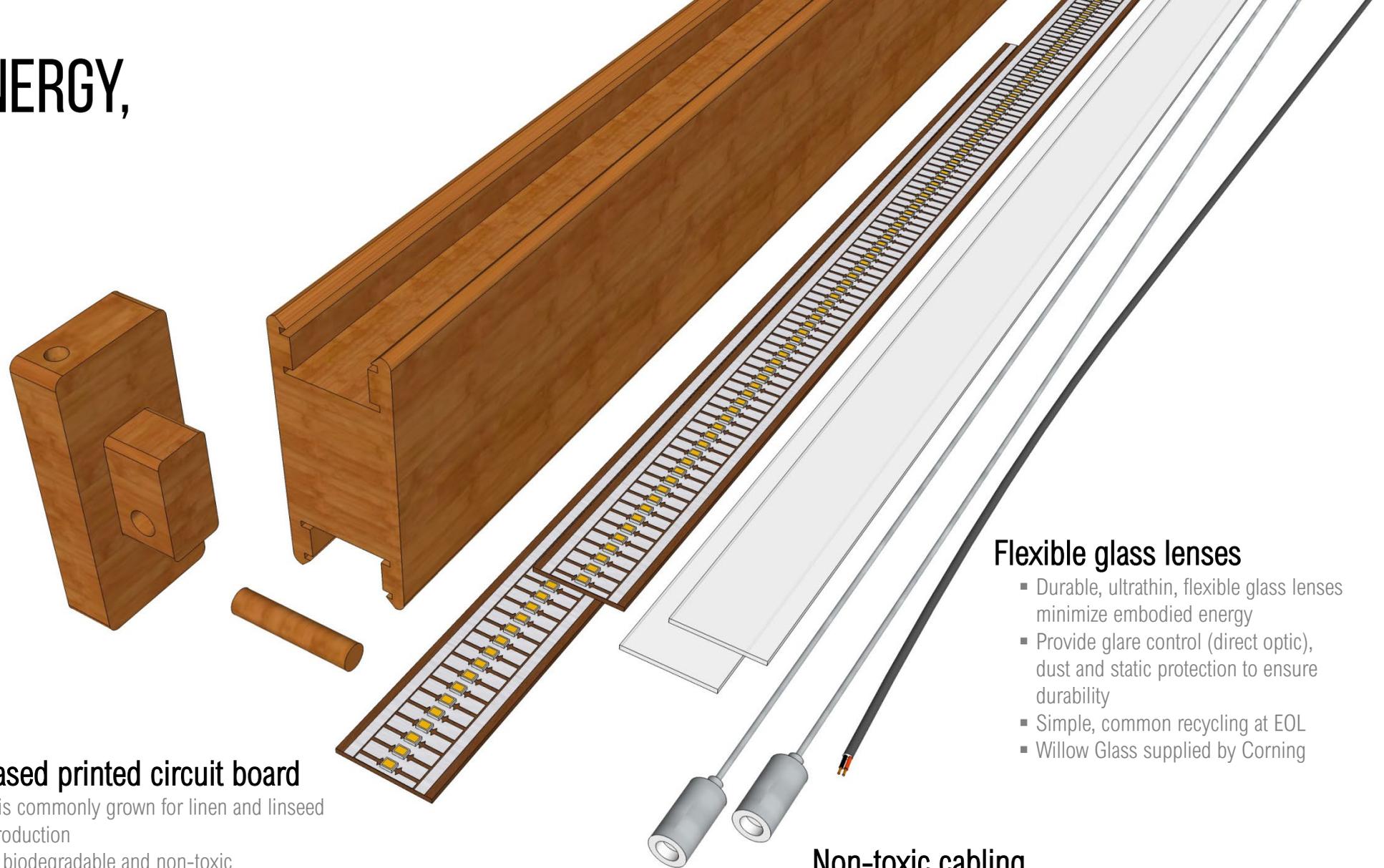
- Flax is commonly grown for linen and linseed oil production
- Fully biodegradable and non-toxic
- At end of life, traces and electronic components dissolve away from substrate
- Substrate is compostable
- Soluboard supplied by Jiva Materials

Flexible glass lenses

- Durable, ultrathin, flexible glass lenses minimize embodied energy
- Provide glare control (direct optic), dust and static protection to ensure durability
- Simple, common recycling at EOL
- Willow Glass supplied by Corning

Non-toxic cabling

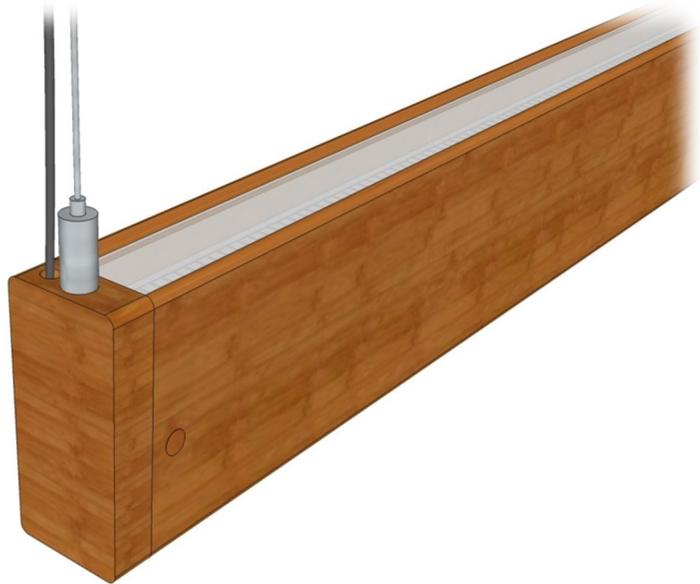
- Small gauge low-voltage DC wire minimizes copper consumption
- Free of halogen, chlorine, bromine, fluorine
- EcoAcePlus supplied by Furukawa Electric



OLD SCHOOL SIMPLICITY

Slide fit assembly/disassembly

- With such high LED efficacy and low wattage, spread linearly, we can dissipate the heat via the PCB traces without complicated PCB fastening or toxic gap-pads
- Circuit boards and lenses are loosely inserted into slots milled directly into the laminated bamboo
- At EOL disassembly processing, the board and lenses simply slide out of the fixture

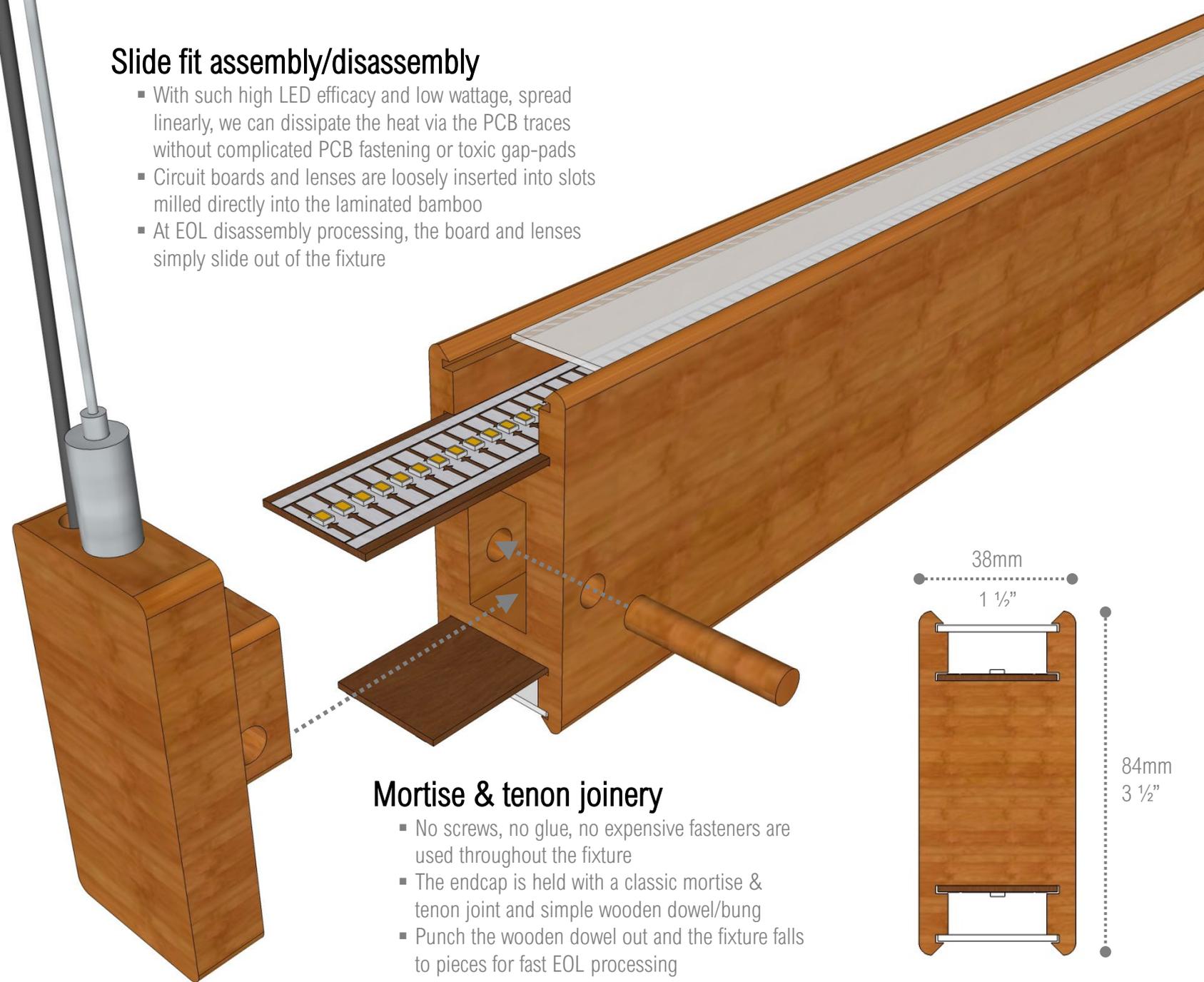
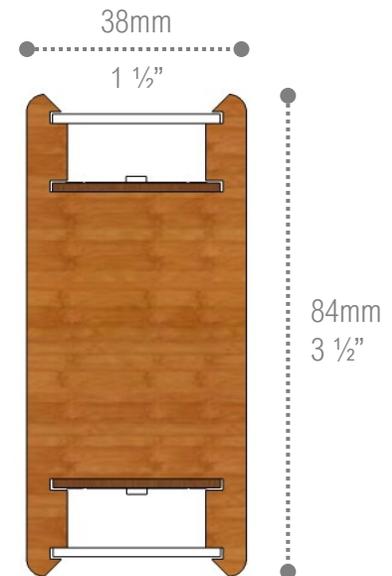


Endcap concept

- To ensure fast assembly and later disassembly for circular economy processing, the end caps hold the fixture components captive
- The aircraft cable support for the fixture and wire strain relief are simply drilled into the end cap, without requiring additional hardware

Mortise & tenon joinery

- No screws, no glue, no expensive fasteners are used throughout the fixture
- The endcap is held with a classic mortise & tenon joint and simple wooden dowel/bung
- Punch the wooden dowel out and the fixture falls to pieces for fast EOL processing



BEAUTIFUL FACTORIES

ALUMINIUM VS. BAMBOO WHICH IS "MORE SUSTAINABLE"?

Do you want to live next to any part of the supply chain?



VS



BAMBOO

Fast growing and plentiful resource

- Bamboo is one of the most rapidly renewing resources on the planet
- Laminated structural bamboo is a low-embodied energy, non-toxic, durable material

Can light fixtures make the world a better place?

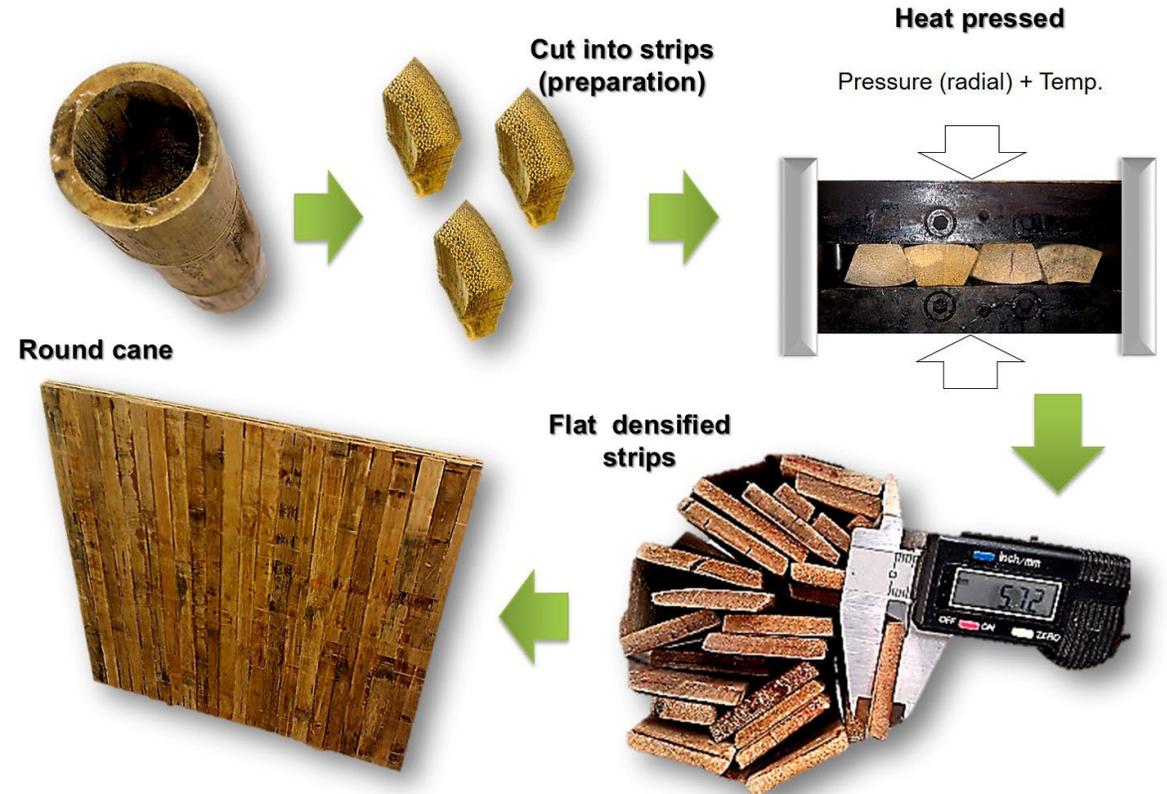
- Instead of merely “mitigating our impact” we want to help correct excess CO2 levels
- The laminated bamboo in our fixture sequesters 10.72 lbs of CO2 per 4' length (even after considering CO2 released during manufacturing processes of laminated product)

Safe

- Class B Fire Rating per ASTM E84 testing standards for standard product (not treated with flame retardants)

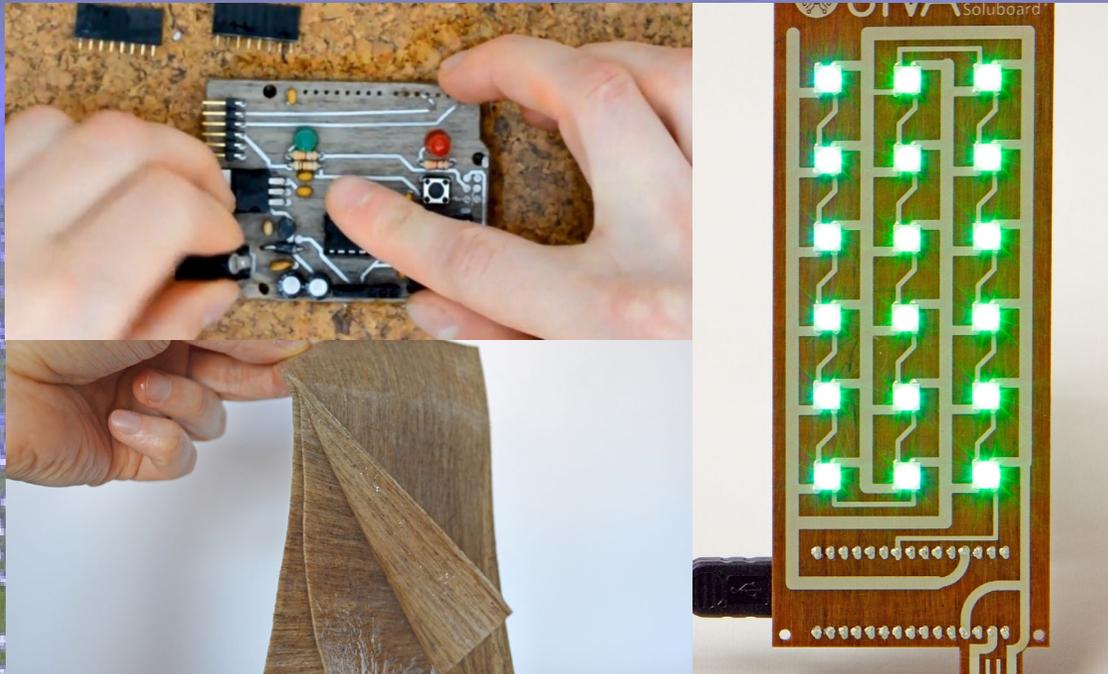
LEED v4 Credits

- Our products may offer the following LEED Credits:
 - MRc3: Sourcing of Raw Materials
 - EQc2: Low Emitting Materials (No added formaldehyde)
 - INc1: Innovation in Design (Life Cycle/Environment Impact)



BIO-BASED PRINTED CIRCUIT BOARDS

ELIMINATING THE TOXIC LEGACY OF FIBERGLASS, EPOXY RESINS
AND E-WASTE FROM THE LED REVOLUTION



Jiva Materials SOLUBOARD
Flax-based compostable circuit board



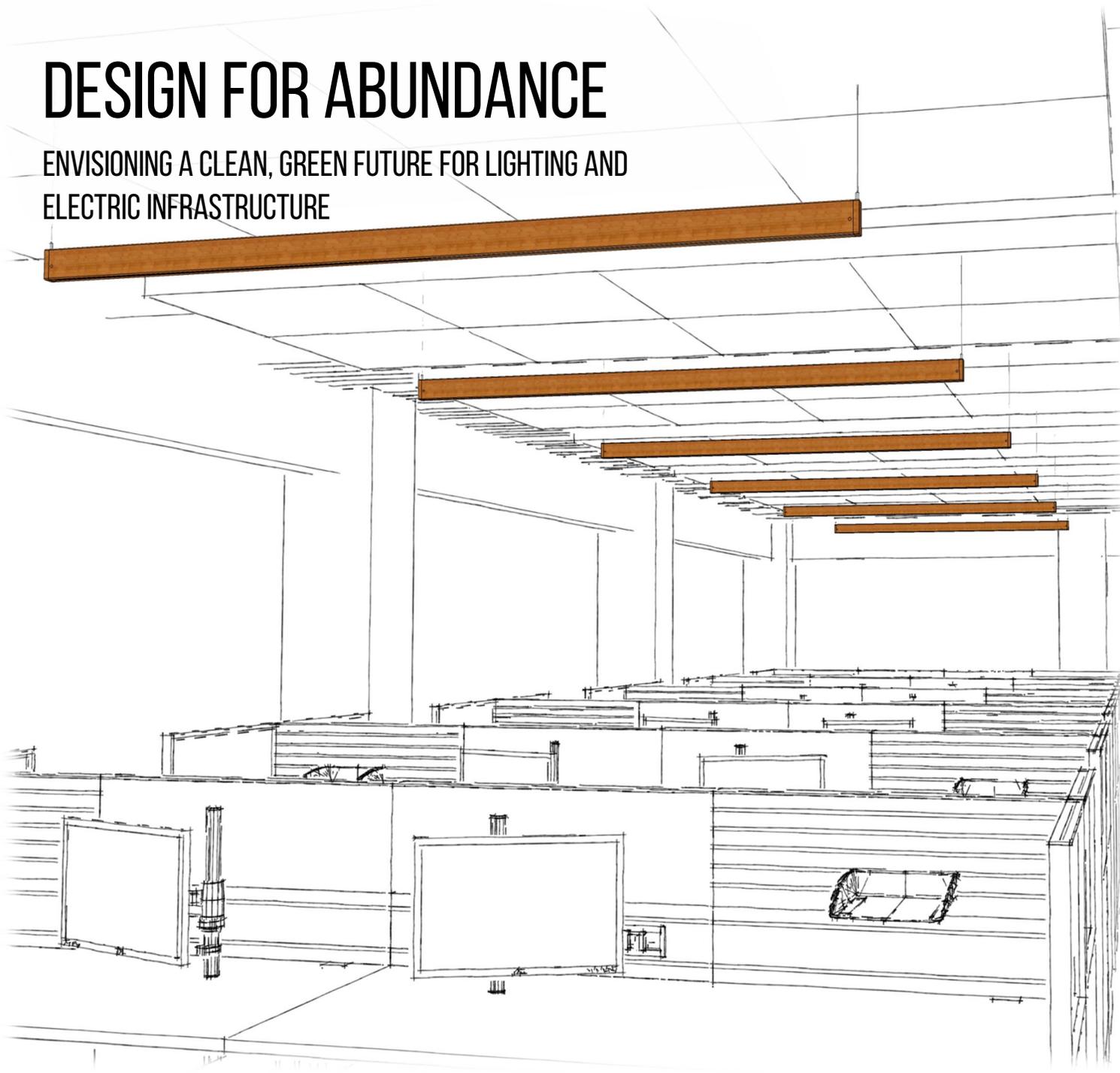
Will this be the legacy of LEDs? Poisoning children in Ghana?

OUR SUPPLY CHAIN: Flax-fields in bloom

And our circuit boards can compost back into the
fields from which they were grown

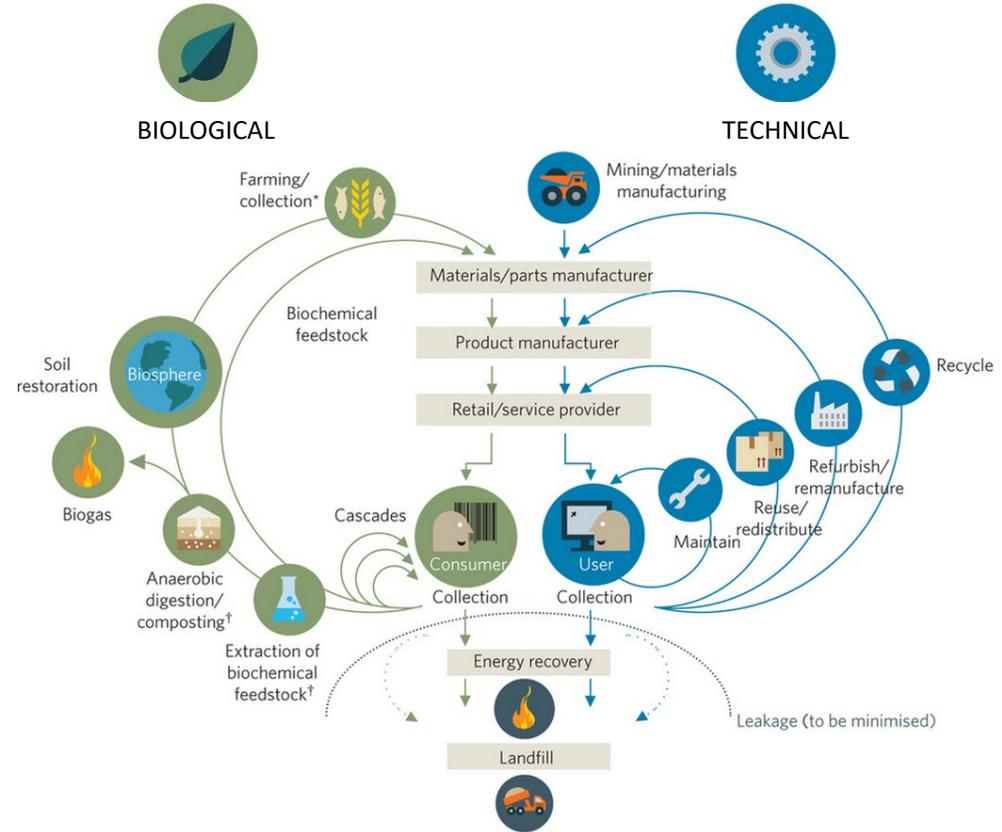
DESIGN FOR ABUNDANCE

ENVISIONING A CLEAN, GREEN FUTURE FOR LIGHTING AND ELECTRIC INFRASTRUCTURE



Design for the circular economy:

Our design aims to reduce the lighting industry's dependence on "technical" materials and increase our use of "biological" materials



Directly supporting sustainability initiatives:

Lighting hardware as a positive to be celebrated, not minimized





We are creating this future today.

What is holding the lighting industry back?



Thanks!

Brad Koerner

VP Product Development & Innovation

bkoerner@cimanetwork.com

