U.S. Department of Energy SOLID-STATE LIGHTING WORKSHOP

Cosponsored by the Illuminating Engineering Society



Mark Lien LC, HBDP, CLMC, CLEP, LEED AP Illuminating Engineering Society mlien@ies.org

The Future of Lighting is About the Convergence of Technologies & Services

Amara's law: "We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run" – Roy Amara 1925

New market leaders, rapid innovation through fusion, unexpected convergent consequences

Convergent Technologies Experiencing Exponential Growth

Computing (Quantum)	IoT / Smart & Connected (includes networking & sensors)	Artificial Intelligence / Machine Learning	3D Printing
Robotics/Drones	XR (Augmented, Virtual, Mixed, Parallel Realities)	Materials Science	Synthetic Biology (design/discovery of new materials through fusion)

• The 6 D's Hallmarks of Exponential Growth

- Digitalization
- Deception/Hype Cycle
- Disruption
- Demonetization
- Dematerialization
- **Democratizatio**n







Industry Shifts

Lighting Industry Changes -Globalization

Industry organizations are working on the globalization of standards

Luminaire manufacturers remain primarily regional

Components are more internationally marketed but safety and other regional requirements may necessitate regional modifications

Information is digital and available internationally with simple online translation if the site does not offer it as an option In addition, the United Nations identified three mega-trends related to globalization: **shifts in production and labor markets, rapid advances in technology, and climate change**. Aug 11, 2021 <u>https://publications.jrc.ec.europa.e</u> <u>u/repository/bitstream/JRC122760</u> /status of led lighting world mar ket 2020 final rev 2.pdf

Luminaire Manufacturers Are Regional





Members

LightingEurope is the trade association that represents the lighting industry in Europe. We are the voice of more than 1,000 lighting companies that employ more than 100,000 people across Europe.

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https://www.lightingeurope.org/aboutus/members-and-partners

II. Top 10 Lighting Companies and Manufacturers in China

To help you choose the most appropriate lighting solution, here we offer you a clear list of top 10 lighting manufacturers in China.

Rank	Lighting Manufacturer	Headquarters
1	Osram Lighting China	China
2	Philips Lighting China	Shenzhen & Nanjing
3	George Buildings	Foshan
4	Foshan Lighting	Foshan
5	Opple Lighting	Shanghai
6	Huayi Lighting	Zhongshan
7	NVC Lighting	Huizhou
8	TCL Lighting	Huizhou
9	Guangdong PAK Corporation Co.,Ltd.	Guangzhou
10	Zhejiang Yankon Lighting	Zhejiang

https://georgebuildings.com/top-10-lightingcompanies-in-china/

Local exhibitors such as Abensal, Cinmar, Creation Gulf, Elettrico Lighting, Ledvance, Lumentek, and Zeta Lumen, are rubbing shoulders with top international brands including ACB Iluminacion, Centrsvet, Korner, Ledvance, Perdix, Luz Negra, and Intiled, with all eager to re-establish business links in a Middle East lighting fixtures market estimated to be worth US\$5.1 billion in 2022.

Lighting Industry Changes – Carbon Metrics

Operational Carbon

 28% of global carbon emissions are from building operations (Lighting and HVAC are included)

Embodied Carbon

Embodied carbon is the carbon dioxide (CO₂) emissions from materials and construction processes through the whole lifecycle of a building or other infrastructure.

The total of all greenhouse gas (GHG) emissions from mining, harvesting, processing, manufacturing, transportation and installation of building materials

Post construction updates to building efficiency do not reduce embodied carbon

ASHRAE Building Decarbonization Task Force

- Formed last spring with 15 people, now over 120
- Nine working groups including one writing their position document

India accounts for 8% of carbon emissions but estimates suggest it will be 15-20% soon

Bitcoin's Energy Usage, Explained



John Schmidt Editor

Updated: Jun 7, 2021, 10:29am

When the enigmatic, possibly nonexistent Satoshi Nakamoto minted the world's first cryptocurrency in 2009, the plan was to create a decentralized payments platform that would revolutionize the way we buy and sell everything.

If Bitcoin were a country, it would rank in the top 30 worldwide for energy use. That's roughly enough electricity to power countries with populations in the tens of millions, with an environmental burden of an estimated 34 megatons of carbon emissions or more, according to Digiconomist's Bitcoin Energy Consumption Index.

"In the case of Bitcoin, this is done by having many different competitors all conduct a race to see how quickly they can package the transactions and solve a small mathematical problem," says Paul Brody, Global Blockchain Leader at EY. The fastest computer not only certifies the transaction, but it also gets a small reward for its trouble in the form of a Bitcoin payment.



Energy usage trend over past few months is insane cbeci.org

(annualised)

40	Estimated consumption: 148.77 Lower bound consumption: 46.56	4
80	Upper bound consumption: 511.75	1
120	Monday May 10 2021	
160		
200		
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520		

5:54 AM · May 13, 2021

https://www.forbes.com/advisor/investing/bitcoins-energy-usage-explained/

Lighting Industry Changes -Renewables

President Biden promised to...

- Double offshore wind, increase research and innovation, and invest 400 billion dollars on clean energy by 2030
- reduce carbon footprint of U.S. Building Stock by 50% by 2035
- Net-Zero U.S. emissions and 100% clean energy economy by 2050

One cent per KWH projected by Ray Kurzweil for 2024 from solar & wind generation

ASHRAE, IEEE, IECC have renewable workgroups

Renewables will change the energy sector.

Electrification will gain momentum as a renewable grid emerges.



2020 2019 2018 2017 2016 2015 2014 2013 2012 2011 2010 2009 2008 2007 2006 2005 2004 2003 2002 2001 2000 1999 1998 1997 1996 1995 1994 1993 1992 19

Reasons for Acceptance

- 1. Combination of features (15)
- 2. Color tunable (9)
- 3. Highest output (9)
- 4. Highest efficacy (8)
- 5. Smallest (6)

PROGRESS R e p o r t



Welcome to Progress!

New Submitters

- Healthcare
- Instituto
- Kyocera
- LightStanza
- NAILD
- nanolambert
- NULITE
- Scout
- University of Oxford
- UPSPRINGPR
- VISO

PROGRESS R e p o r t



New Members of the Lighting Community





Telecom / Lighting Companies

Lighting Solutions: Shine Brighter with Trane®



Integrating lighting and HVAC for greater efficiency

Lighting has changed. Dramatically, and quickly. Today's broad spectrum of LED lighting has opened a new area of lighting science: the study and application of light's influence on people; how it affects our physical and mental health and our perceived productivity. Knowledge and technology are driving innovation.

Today, there are some 70,000 lighting companies around the world. Many are solely focused on changing light fixtures to improve quick energy ROI. But when energy is the only objective, building owners miss out on a big opportunity to improve the indoor atmosphere with lighting that supports human well-being-and to simplify IEQ management with integrated lighting and HVAC control systems where more than half of a building's energy can be controlled from a single platform, from virtually anywhere in the world.

17VNE











The Power of Integration

Lighting has become the infrastructure of smart buildings, smart campuses, and smart otles. Integrated systems offer increased energy avings, comfort, and flexibility. You can manage your integrated lighting and controls simply, from a single platform.

our internal subject matter experts can help you achieve quality lighting design to help increase your energy savings and cost-effective providing quality products. We make your life easier by helping to negotiate priong and turnkey proposals to best set you up for success



As we look to reopen our buildings and ensure the safety of our could be to help track occupants within a space and identify people who have come into contact with a potentially infected person

Additionally, asset tracking has never been easier and you can spend time tracking down wheelchairs or important equipment and spend more time actually doing your job.



Environmental Quality (IEQ)

mes above to deliver on multiple critical facts mosphere that balances human wellness, energy efficiency, and stainability to provide holistic solutions for addressing occupants health and wellness.

The artition design of indicor spaces can affect peopled productive comfort, mood, safety, health & evelibeing, and even the circadian mythms of their bodies.

al UV lighting solutions in a space can improve air and

Trane & Honeywell – HVAC /Lighting Companies

Q

Sharp & LG– Electronics/Lighting Companies

GLG Barness



LED LIGHTING

AN EXCEPTIONAL VISUAL EXPERIENCE.

SHARP LED LUMINAIRES DELIVER LIGHTING QUALITY THAT IS SECOND TO NONE.





INFORMATION COMPUTERS INVAC LIGHTING SELAR PROJECTORS SUPPOR

LED History—our expertise for 45 years Sharp has decades of experience in LED technology, ranging from component development to complete luminaires

Sharp benefits from a wealth of experience at each stage along the whole LED value chain, ranging from individual components to entire luminaires. As a pioneer of LED technology, Sharp innovated a number of industry firsts since beginning large-scale production in 1972. 20

https://www.sharp-cee.com/cps/rde/xchg/scee/hs.xsl/-/html/led-lighting.htm



156 Trillion KRW = 132+ Billion USD





If Samsung is This Ambitious, What Will They Do With Lighting?

INNOVATION

200+ Billion USD Annual Sales

Samsung Wants to 'Copy and Paste' the Brain Into a Chip

With the help of Harvard researchers, Samsung thinks it can reverse engineer the brain.







Google, Amazon & Apple Internet /Lighting Companies

SMART HOME TECH

Project CHIP will finally ship later this year

The long-awaited smart home partnership should show some fruits by the holiday season By Dan Seifert | @dcseifert | Apr 16, 2021, 9:05am EDT

Project Connected Home over IP (CHIP), the awkwardly-named-butinteresting smart home partnership between Apple, Amazon, Google, and over 170 other companies that's supposed to make everything more compatible should finally start showing some results later this year.

https://www.theverge.com/2021/4/16/22387252/project-chip-will-finally-ship-later-this-year



SIDEWALK LABS	Products 🕶 I	Alp	bhabet
We build products a places to radically improve o of life in c	and quality ities	Googleplex, ho	ome to Alphabet Inc., in Mountain View, California
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ittps://www.sidewai	klabs.com	ISIN	US02079K3059 US02079K1079
		Industry	Conglomerate
Finishing and Block Plancks and Farmers Franchs and for	Patrotologia	Founded	October 2, 2015; 5 years ago
G Google St	ore	Founders	Larry Page Sergey Brin
		Headquarters	Googleplex, Mountain View, California, U.S.
9 M		Area served	Worldwide
O LITY Branceled LITX Color Nanoteal Shapes - Hesagons Smarter RI	senged Sengled Smart Wi-R Light But, No Hub Required	Key people	John L. Hennessy (Chairman) Sundar Pichai (CEO) Ruth Porat (CFO)
Shep now > Shep now >	Ship new >	Revenue	US\$182.53 billion (2020)
		Operating income	▲ US\$41.22 billion (2020)
		Net income	🔺 US\$40.27 billion (2020)
		Total assets	▲ US\$319.62 billion (2020)
		Total equity	US \$222.54 billion (2020)
		Owners	Larry Page Sergey Brin
		Number of employees	▲ 135,301 (Q4 2020)
		Subsidiaries	Calico · CapitalG · DeepMind · Google · Google Fiber · GV · Sidewalk Labs · Verily · Waymo

Wina · X

abc.xyz 🗗

Website

Recent Lighting Reports





About	Career	Architect Resources	Community	Advocacy	Equity, Diversity & Inclusio
Natio Architectr a steady t Graphs repres	onal ure firm billin trajectory in (sent data from Octo	gs remain on October ber 2020-October 2021.		Abo	We 50 Below 50
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55 50 46.0		4.9	57.9	54.6	54.3
45 40 Oct-20	Nov-20 Dec-20	Jan-21 Feb-21 Screen	nshot May-21	Jun-21 Jul-21	Aug-21 Sep-21 Oct-21

Architecture Billings Index (ABI)

The Architecture Billings Index is an economic indicator for nonresidential construction activity, with a lead time of approximately 9–12 months.

Investment groups like Wells Fargo, media outlets, firms of all sizes, and business leaders rely on this leading monthly economic indicator to assess business conditions and predict and track the market.

2018 Lighting = 5.6% of Total Energy / 15% of Total Electricity Consumed (2020 DOE Report)

3. Results

In 2018, the total energy consumption in the U.S. was 100.1 quads of primary energy, according to the U.S. Energy Information Administration's (EIA's) Annual Energy Outlook (AEO) 2019. Roughly 38 quads, or 38%, of this energy was consumed for electricity use. DOE estimated that in 2018, there were 7.7 billion lighting systems¹³ installed in the U.S. and that they consumed approximately 5.6 quads of energy annually. Thus, according to the lighting estimates determined in this analysis, lighting accounted for 5.6% of the total energy and 15% of the total electricity consumed in the U.S. in 2018.¹⁴

Light Source Efficacy

From 2000 to 2030



LiFi / Optical Wireless Communication Report

Global Li-Fi and Optical Camera Communications Growth Opportunities

Accelerated Growth of IIoT and Building IoT Applications Powers Future Growth Potential

Global Energy & Environment Research Team at Frost & Sullivan

- "large-scale implementations are anticipated over the next 2-3 years"
- "more strategic partnerships among LiFi providers, IoT network and communication providers, and LED providers are expected in the next 2-3 years"
- "Li-Fi is expected to appropriately complement existing Wi-Fi, 6 and 5G communication networks for both indoor and outdoor applications"



PBE9-19 August 2021

Industry News





IEEE Future Directions



Lighting is a significant new IEEE initiative.



IEEE Smart Lighting



- Description: This project consists on the seeding of a 'Smart Lighting Initiative (SLI)' that will be carried during the 3 to 5 next years
- Vision: Smart Lighting fits perfectly with the IEEE mission for Advancing Technology for Humanity because artificial light generation is an inherent need of human beings and society. It consumes huge amounts of energy and resources, it impacts our performance, security, well-being and health, but also our environment and ecosystem.

MIT Technology Review

Opinion

Why Facebook is using Ray-Ban to stake a claim on our faces

To build the metaverse, Facebook needs us to get used to smart glasses.

by **S.A. Applin**

September 15, 2021

Smart glasses will control lighting apps by voice and thought activation.

Facebook released its new \$299 "<u>Ray-Ban Stories</u>" glasses. <u>Wearers</u> <u>can</u> use them to record and share images and short videos, listen to music, and take calls. The people who buy these glasses will soon be out in public and private spaces, photographing and recording the rest of us, and using Facebook's new "View" app to sort and upload that content.



3D Printing Disrupts 10T Industry



- 3D printed light sources
- 3D printed components
- Printed & Flexible Electronic Systems



Dubai opens world's first 3D-printed office

It only took 17 days to print the basic form of the 2,690-sf office, which was made of a layered cement mixture. Additional internal and external finishing time was required. Gizmag reports that the printing was most likely done in sections and assembled on site.



Company Says World's First 3D Printed School Is Now Open

If you were under the impression that 3D printing technology was only meant to be used for printing outer space BioPods or reusable rockets, we wouldn't judge you. High costs of 3D printing have long meant that the technology is only used for high-end jobs. But the UK-based CDC Group wants to change that notion and recently 3D printed a school in Malawi in just 18 hours. Students are already



3D printed house of the future to have AI meals and robots doing washing by 2035

Families could eat meals designed by artificial intelligence and employ robots to do their washing and tidying around their 3D printed homes - in just 15 years, a new report claims. The Future Smart Energy Consumer study looks at how technology and our quest to be more sustainable will ebaptic our home lives in 2025.



Selected By Virtual Peter



Russia's Yandex To Launch Delivery Robots In US

Russian tech giant Yandex said Tuesday it planned to launch selfdriving delivery robots on US college campuses later this year, the company's latest push into foreign markets. In a statement, the Russian group said it would partner with US delivery giant Grubhub to deploy the self-driving rovers at 250 college campuses across the United States.

Transportation



Moving autonomous vehicles from R&D to mass production is closer than you think

The vision of safe, reliable autonomous vehicle transportation at scale is closer than ever to being realized, says James Peng, CEO at Pony.ai. Since the company's founding in Fremont, California in late 2016, the company's been making strides in autonomous mobility deployment in both the U.S. and China. The company was the first to launch and offer a public-facing Robotaxi service in both countries.

Transportation

FedEx, Nuro Partner on Autonomous Delivery

FedEx and Nuro have teamed up through a multi-year, multi-phase agreement to test delivery via autonomous vehicles. Through the collaboration, Nuro's autonomous delivery vehicle will be tested within FedEx operations, according to a news release, with use cases that include multi-stop and appointment-based deliveries. The companies began a pilot program across the Houston area in April, giving FedEx the opportunity to explore various use cases for on-road autonomous vehicle logistics.

Selected By Virtual Peter



Ford and Argo AI will deliver your Walmart order in an autonomous car

<u>Citizens of Austin</u>, Miami and Washington, DC, may receive their next Walmart order from an autonomous car. On Wednesday, Ford and its self-driving technology partner Argo AI announced a new last-mile delivery service with Walmart. The three companies will launch the service in the three cities as a pilot program as each looks to expand their footprint with these sorts of emerging operations.

Autonomous Vehicles Now

Existing Lighting Requirements Must Be Reevaluated

In 'AI 2041' Kai-Fu Lee projects augmented roads with integrated sensors for drifting, danger ahead, car with blown tire tells others to stay away, and a car can offer financial incentive for other cars to get out of the way, Cities may have two layers with one for pedestrians, 6G with AI will be effective by 2030, human driving will be outlawed and people who love driving will do what horse lovers do toda?

Robots, Drones & Lighting



Selected By Virtual Peter



Israel Just Used Fully AI Controlled Drone Swarms in a World First

Last month, we had reported that Israel deployed a semiautonomous robot during the recent Gaza conflict. Carrying a machine gun, this robot named Jaguar, was capable of driving to a designated location, returning fire, and even self-destructing when compromised. However, the robot needed a human operator to initiate the firing from the machine gun.





This Robot May Just Be What Retailers Need in Their Warehouses

There are technological advancements taking place in the field of robotics almost every single day. The latest is a robot by RightHand Robotics for companies to sort products and get orders out. And while it may take humans some time to not just identify but also distinguish a product from another, machine intelligence and a bit of robotic manipulation is all it needs to equip a robot to perform the same.



Researchers develop a new robot that can efficiently navigate sidewalks in urban environments

To operate efficiently in urban environments, mobile robots and other autonomous systems should be able to move safely on sidewalks and avoid collisions with pedestrians or other obstacles. This is particularly true for delivery ...

ROBOTICS

feature () 1 HOUR AGO 🕞 0 🚰 28

How do we light for robots?

Streetlighting poles are now digital hubs charging vehicles and drones, powering sensors, wi-fi, audio, video, etc.

Will Flying Cars Change Lighting Requirements?

Flying car completes test flight between airports

By Zoe Kleinman Technology reporter

🕓 30 June 🛛 **戸 Comments**



A prototype flying car has completed a 35-minute flight between international airports in Nitra and Bratislava, Slovakia.

The hybrid car-aircraft, AirCar, is equipped with a BMW engine and runs on regular petrol-pump fuel.

Its creator, Prof Stefan Klein, said it could fly about 1,000km (600 miles), at a height of 8,200ft (2,500m), and had clocked up 40 hours in the air so far. It takes two minutes and 15 seconds to transform from car into aircraft.

https://www.bbc.com/news/technology-57651843



Flying cars WILL be a reality: Hyundai bosses say they are 'part of our future' and will help to reduce congestion on roads

- Hyundai bosses explained how flying taxis were 'part of our future' during an automotive summit in London
- Michael Cole, president and chief executive of Hyundai Motor Europe, pointed to the Korean brand's investment in a flying taxis project with Uber
- It is also in partnership with Urban Air Port for pop-up airports for electric taxis and drones to use in cities
- Plans for first 'Air One' mobile airport revealed for Coventry in January and could be installed by November

By RAY MASSEY and ROB HULL FOR THISISMONEY.CO.UK Y PUBLISHED: 07:30 EDT, 29 June 2021 | UPDATED: 03:39 EDT, 30 June 202

https://www.thisismoney.co.uk/money/cars/article-9736893/Hyundai-boss-says-flying-cars-future.html

Transportation

All roads lead to flying cars by 2030

<u>Cars could be</u> taking to the air towards the end of this decade, according to Michael Cole, chief executive for European operations at world-leading South Korean automaker Hyundai. Addressing a conference organised by the Society of Motor Manufacturers and Traders, a trade association for the UK motor industry, Cole said that Hyundai has made some "very significant investments" in urban air mobility.

Questions:

- How many, how soon (niche or like cars?)
- Autonomous or human pilots?
 - FAA helipad lighting requirements for buildings?

Coming Soon

Nanobionics

Living Lasers

Reconfigurable Intelligent Sources

Plant Nanobionics – Emerging Field

Glow-in-the-dark plants could act as passive lighting for public spaces

"A decent chunk of energy usage goes towards lighting, so scientists at MIT are developing a new kind of passive lighting – glow-in-the-dark plants. In the latest experiment, the team has made them glow much brighter than the first generation plants, without harming their health."



2/3 A diagram showing where the nanoparticles accumulate inside the plants MIT

September 19, 2021

Disposable Living Lasers From Common Inkjet Printers

Scientists have created a new way to monitor subtle drug interactions between bacteria and antibiotics.

By using a common office inkjet printer, researchers from NTU Singapore and China developed a disposable living laser on chip by encapsulating living bacteria inside.

Strong laser emissions generated from bacteria inside the droplet will be dramatically enhanced during drug interactions.

This breakthrough could enable more sensitive and high-throughput testing using micro-nano laser technology in the near future. MARCH 25, 2021

A disposable living laser printed on chip for drug screening

by Nanyang Technological University



Credit: Nanyang Technological University

RIS Mitigates Line-of-Sight Blockage with LiFi

Cornell University	W the Simon
arXiv.org > cs > arXiv:2104.02390	Search Help Advanced
Computer Science > Information Theory	
[Submitted on 6 Apr 2021 (v1), last revised 21 Apr 2021 (this version, v3)] LiFi Through Reconfigurable Intelligent Surfaces: A New Frontier for 6G?	
Hanaa Abumarshoud, Lina Mohjazi, Octavia A. Dobre, Marco Di Renzo, Muhammad Ali Imran, Harald Haas	
Light fidelity (LiFi), which is based on visible light communications (VLC), is celebrated as a cutting-edge technological paradigm envisioned to be an indispensable part of 6G systems. Nonetheless, LiFi performance is subject to efficiently overcoming the line blockage, whose adverse effect on wireless reception reliability becomes even more pronounced in highly dynamic environments vehicular application scenarios. Meanwhile, reconfigurable intelligent surfaces (RIS) emerged recently as a revolutionary concept to the physical propagation environment into a fully controllable and customisable space in a low-cost low-power fashion. We antice integration of RIS in LiFi-enabled networks will not only support blockage mitigation but will also provision complex interactions network entities, and is hence manifested as a promising platform that enables a plethora of technological trends and new applic this article, for the first time in the open literature, we set the scene for a holistic overview of RIS-assisted LiFi systems. Specifica explore the underlying RIS architecture from the perspective of physics and present a forward-looking vision that outlines potent operational elements supported by RIS-enabled transceivers and RIS-enabled environments. Finally, we highlight major associate and offer a look ahead toward promising future directions.	that is -of-sight , such as hat transfers ipate that the among ations. In Ily, we ial d challenges
Subjects: Information Theory (cs.IT); Networking and Internet Architecture (cs.NI) Cite as: arXiv:2104.02390 [cs.IT]	

(or arXiv:2104.02390v3 [cs.IT] for this version)

MIT EmTech September 2021

Consider a future where we attend conferences virtually through our welldefined avatars. We move through the space and mingle having group and individual (and hopefully private) conversations (already a part of Spatial platform).

Imagine that our Artificial Intelligence (AI) defaults to ANSI Standards for lighting (with user overrides).

Robotaxis will change lighting roadway requirements and parking areas will be repurposed.

XR/Mixed realities will enable further visual enhancements including the ability to zoom in and correct vision to at least 20/20. Initially this will be with smart glasses, then contact lenses and ultimately implants. Augmented vison will enable live streams of information both passive and active overlayed on the world we are seeing around us. Breaking news, facial linkage to social media showing info on people in front of us, and whatever we program as alerts will stream into view (like CNN across the bottom of screens) as we simultaneously engage with the world around us.

Brain-computer interfaces will allow thought activated controls of the feeds as well as gaming and for controlling devices such as lighting, HVAC and more.

In the past decade systems and hardware have transformed Machine Learning. Now it is time for ML to transform systems and hardware

The 3 M's-anything that Moves, is Manufactured or needs Maintenance will be done by robots

"It is not about efficiency anymore, it is about electrification"

Our Next Lighting Decade

 \star

Complexity will force more specialization



System Integrators will be needed



Lighting designers will be learning and specifying products from nontraditional lighting manufacturers

一不

Large companies are moving into lighting by integrating it into their smart lighting control systems initially partnering with traditional lighting manufacturers



Energy efficiency workers will transition to renewable energy



Lighting will further miniaturize and integrate into the electrical infrastructure of our buildings morphing with other trades



Light's impact on life will transform our buildings and horticulture



Quantum computers will yield unprecedented acceleration of technologies.



Unexpected Convergent Consequences

"It is not the strongest of the species (companies) that survives, nor the most intelligent, but the one most responsive to change"

- Charles Darwin





U.S. Department of Energy SOLID-STATE LIGHTING WORKSHOP

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