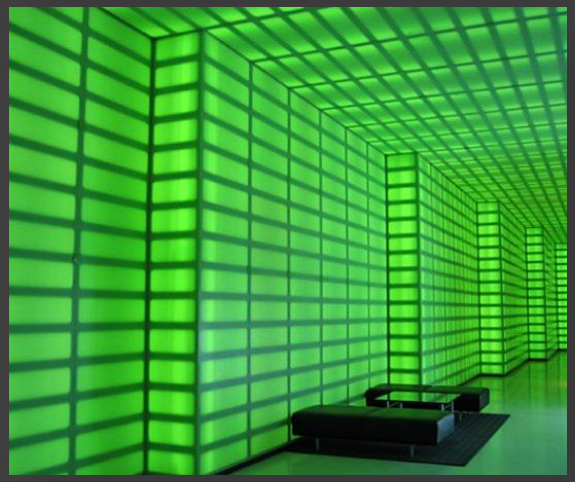
Renewable Energy from the Outside In:

Creating DC Micro-grids in Buildings



Greenbuild 2009
Thursday, November 12: 4:00pm – 5:30pm

**The future is already here;
it is just not evenly distributed.**

— William Gibson, *author, Neuromancer*

panelists

Sue Rhoades | Armstrong

Joel Zwier, AIA | Steelcase, Inc.

Paul Savage | Nextek Power Systems

Bruce Graham | Johnson Controls, Inc.

learning objectives

Understand how:

1. Digital, DC-powered devices dominate our interiors
2. On-site renewable energy gets delivered into buildings
3. DC micro-grids distribute DC power within buildings
4. You can further reduce energy use and improve flexibility

agenda

1 interior trends

2 power trends

3 what building's need

4 what's new

5 examples and applications

interior trends

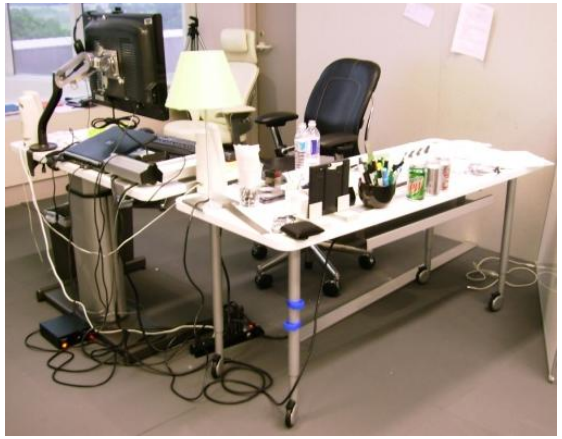
Joel Zwier | AIA - Steelcase, Inc.

When will DC power devices (fans, lights, appliances, computers, fire suppression, and projectors) surpass the use of AC power devices in a building?

Prius

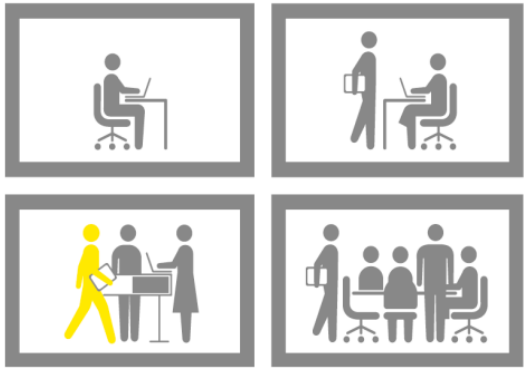
interior trends

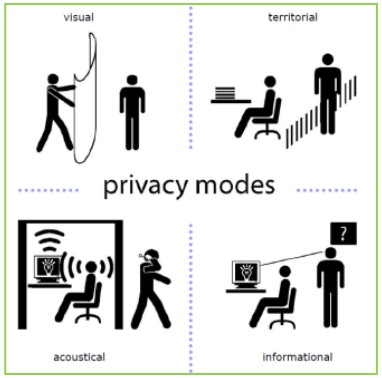
- the way we work is moving
- technology trade up – everyone's a geek
- desktop carries the load
- lighting is in flux


technology trends in the workplace

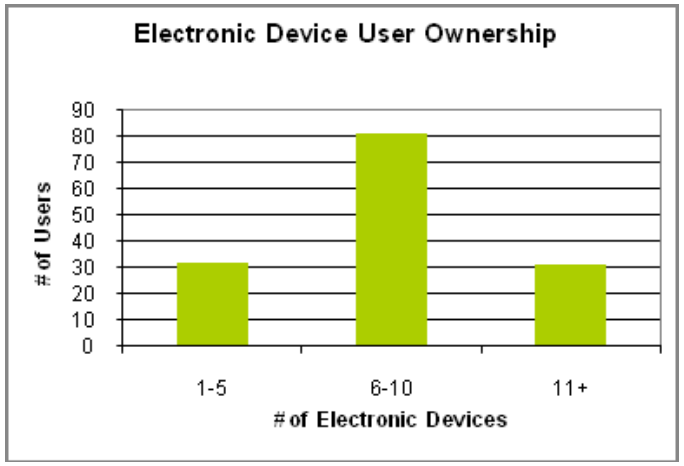
- ubiquitous access
- growth in active collaboration
- persistent large screen display and projection
- more movable architecture furniture and technology
- proliferation of mobile technology





desktop power usage is changing

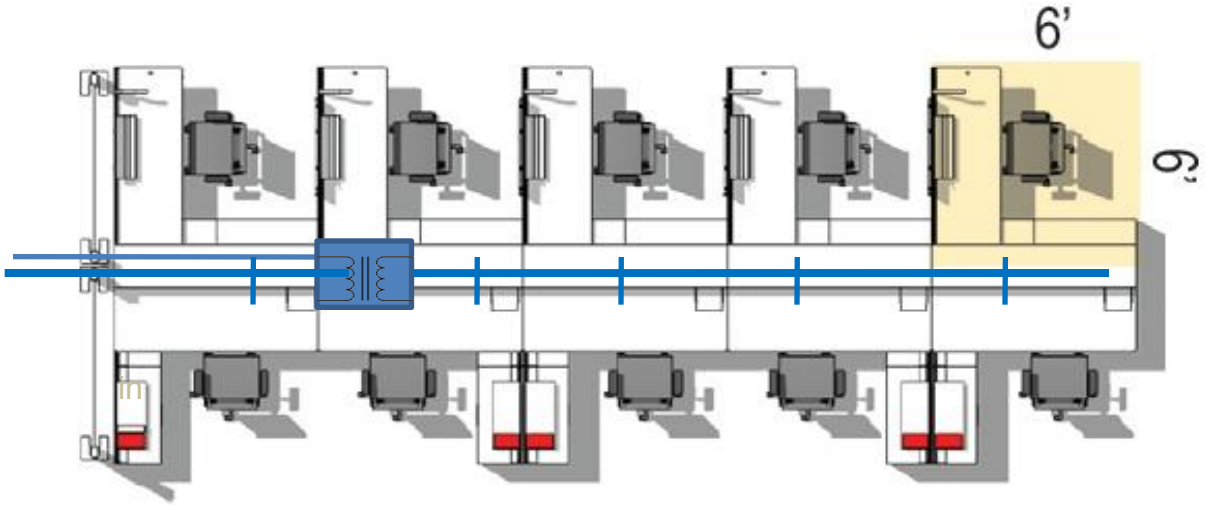
- workstations are spec-ed with 1 or 2 duplexes (2 – 4 outlets)
- desktop survey indicates employees are using 6 – 10 electronic devices
- employees frustrated by transformer blocks covering outlets
- cord spaghetti is becoming a problem



Voltage Requirements	Common office tools
Very low (5V)	Cell phone PDA iPod Digital camera
Low (20V)	Laptop computer Some task lights
AC or DC devices	Light Monitor Printer Scanner Calculator Computer speakers Space heater Radio

energy reduction

- ways to demonstrate commitment to sustainability
- concern over large screen energy use
- questions about automated ways to turn off devices



11+ devices

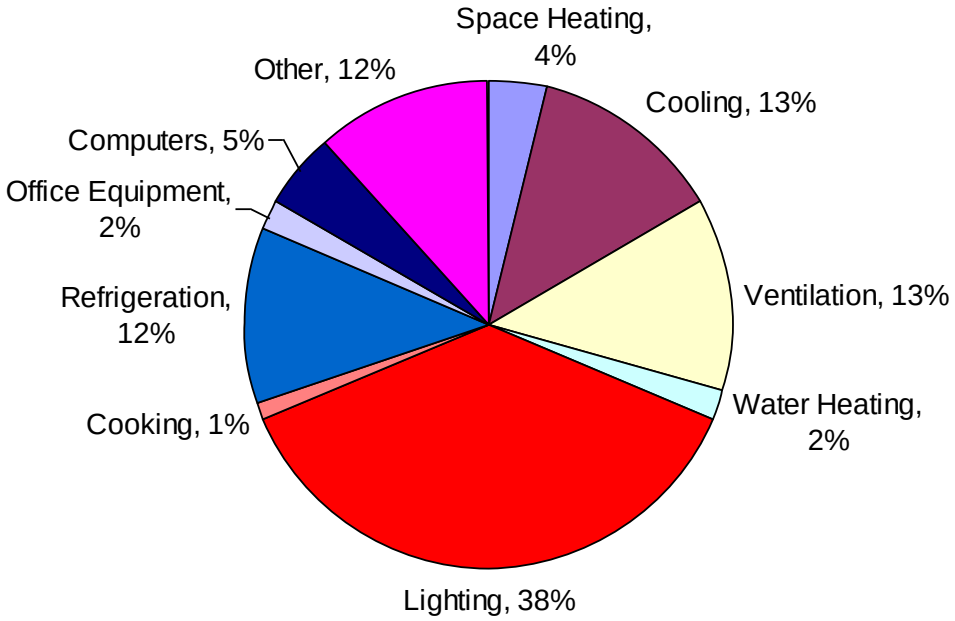
9 Receptacles
5 USB

task lighting – observations

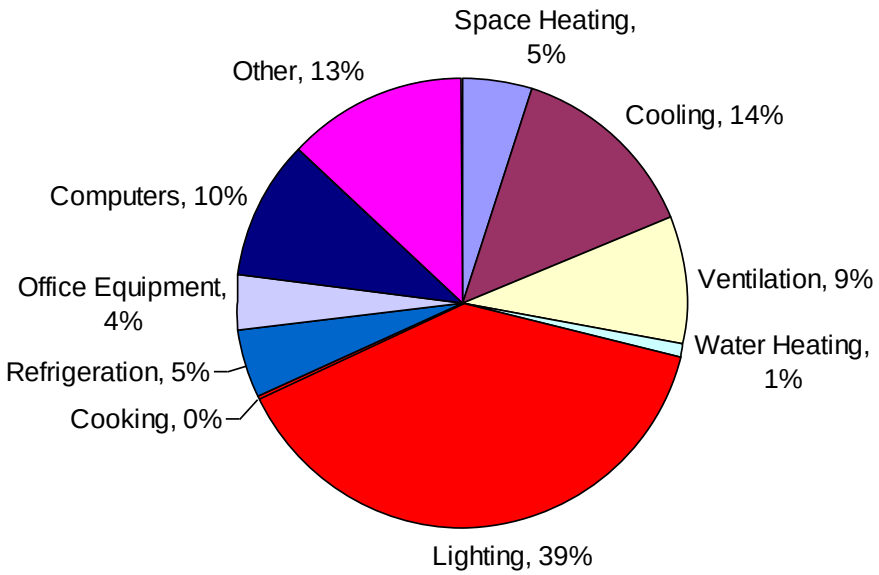
- reduction in lumen levels from architectural lighting
- automated task lighting control
- aging workforce needs task specific supplemental lighting
- furniture mounted neighborhood lighting and control

the role of lighting in energy consumption

U.S. Total Commercial Building Energy Use



U.S. Office Building Energy Use



lighting is the largest single opportunity for saving energy

Source: US Energy Information Administration – Table E5 – 2003 Data

energy efficiency in lighting – changes in meaning

Pre-1970
- more light for the same (or more) power

1973
- less light for less power

1980s
- same light for the same power

1990s
- same light for less power

2000s
- more light for less power – higher efficacy lighting
- less light for less power – dimming
- more and less light for less power – add control

lighting trends… according to US lighting specifiers

- shift from functional light to personal light
- lighting used for visualization
- shift from lamp to application and system integration driven by:
  - energy reduction approaches
  - technology development
- continued interest in sustainability and protecting the environment
- interest in lighting that improves personal health and well-being




Source: Siemens Pictures of Lighting Future Interviews

market drivers defining these trends

Product Legislation and Advocacy

- pressure to improve lamp and system efficacy
- solid state lighting will be the next high efficacy solution
- legislation will pair energy and environment

Building Design and Codes

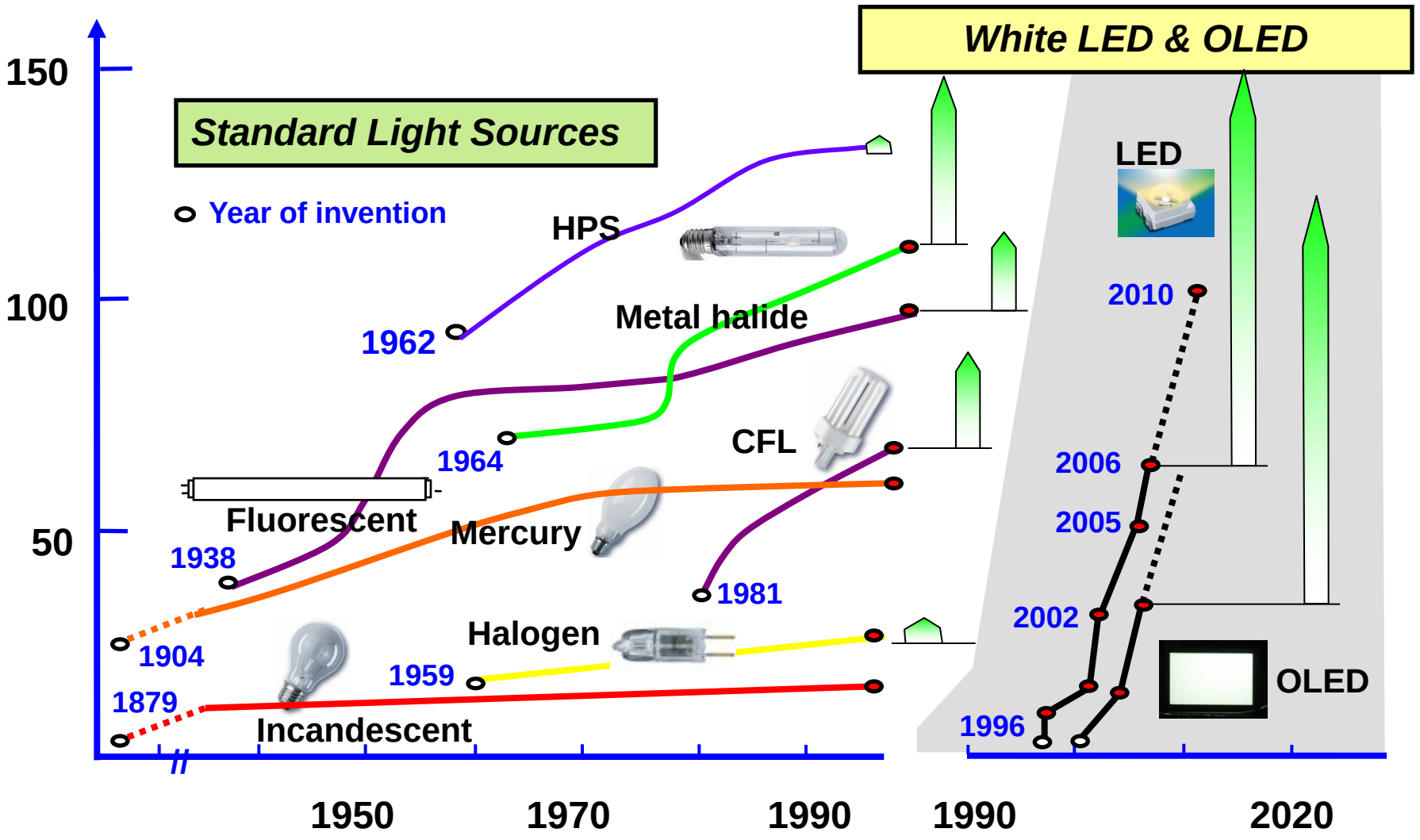
- rediscovery of daylighting benefits
- government regulating commercial buildings for efficiency and environmental impact
- trend toward kWh/sf rather than W/sf in energy codes
- mandatory controls provisions

light levels in transition

- Pre 1973 – recommended light levels very high
- 1973 – energy crises focuses conservation efforts
- 1987 – light level recommendations were given as ranges
- 2000-present – energy code requirements drive greater efficiency
  - lamp\ballast\fixture combinations
  - task/ambient approach
  - daylighting -occupancy sensors- controls

*Building Area Method**	*Lighting Power Densities*		
Year	**1989**	**1999**	**2004**
Office	1.26	1.3	1
Retail	2.25	1.9	1.5
Hospital	1.44	1.6	1.2
School/University	1.29	1.5	1.1
Manufacturing Facility	0.96	2.2	1.3
Warehouse	1.03	1.2	0.8

light sources in transition – lumens per watt



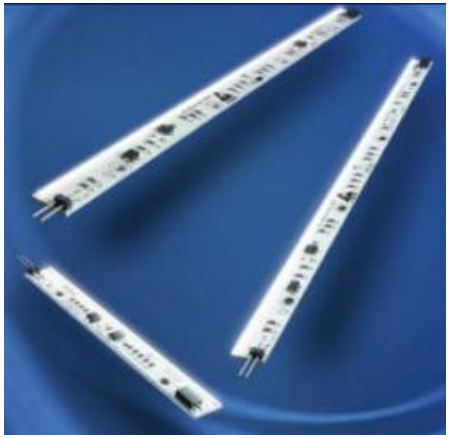
Solid State Lighting

- today's top applications for white LEDs
  - signage
  - dynamic color
  - exterior façade/security
  - street
  - refrigeration
  - accent
    - Halogen/incandescent replacements
    - Compact fluorescent replacements
  - recent introductions – *down lighting - indirect lighting - 2x2 troffers*

Lithonia Lighting

LED's use DC power

- higher efficacy
  - power supply efficiency depends upon maximum loading
  - AC-DC conversion results in 10-15% losses on loaded power supplies
- direct DC integration eliminates 120Vac to 24Vdc power conversion
  - no need for power supplies and enclosures if remote mounting
  - higher reliability
- lighter weight
  - smaller/lower profile fixtures



OSRAM Sylvania

device trends in power

- mostly digital devices in use today
- digital is ‘code’ for DC power
  - electronic & dimmable ballasts
  - LED lighting
  - AV and IT equipment
  - HVAC actuators
  - digital controls

…most use DC powered electronics

Sensors & Controls

HVAC Actuators

Security & Safety

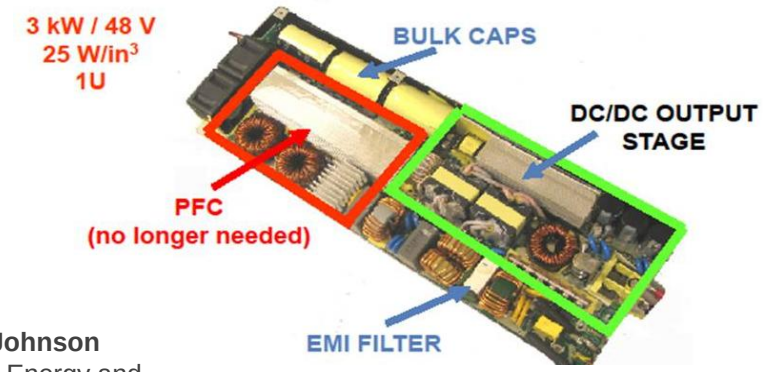
AV/IT Devices

Electronic Lighting

power trends that impact devices

- buildings distribute only AC power today
- DC devices must convert AC power to DC
  - converter & power conditioning required
  - side effects:
    - higher component count/bulk
    - higher cost
    - lower reliability

…typically consume 10 – 20% of the power in conversion process



Source: Karl Johnson
CA Institute for Energy and the Environment / PIER

recap need

- AC power is not going away – infrastructure
- need transition that is scalable
- solution needs to be hybrid – switch AC/DC
- solution needs to create greater efficiencies

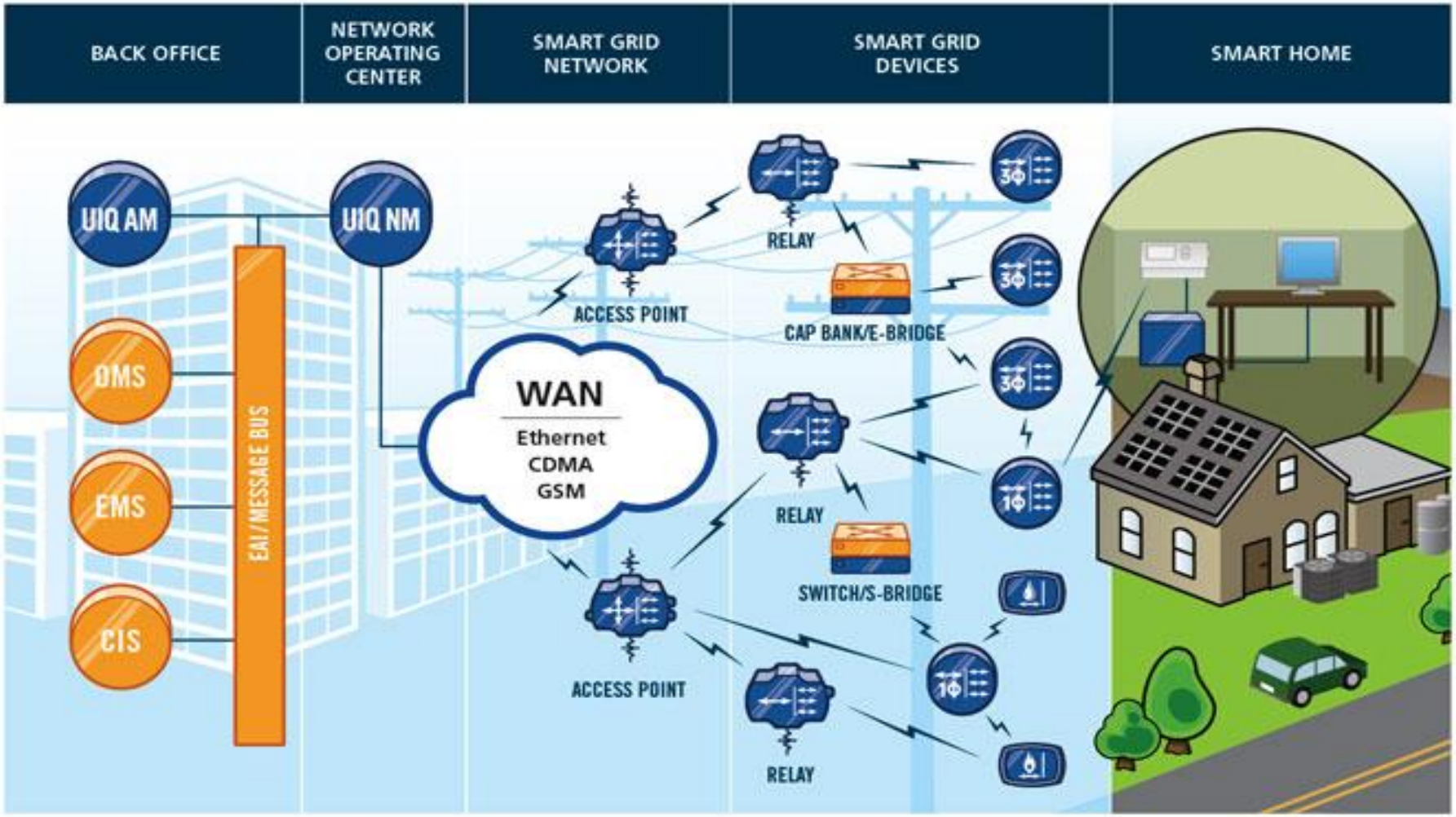
power trends

Paul Savage | Nextek Power Systems

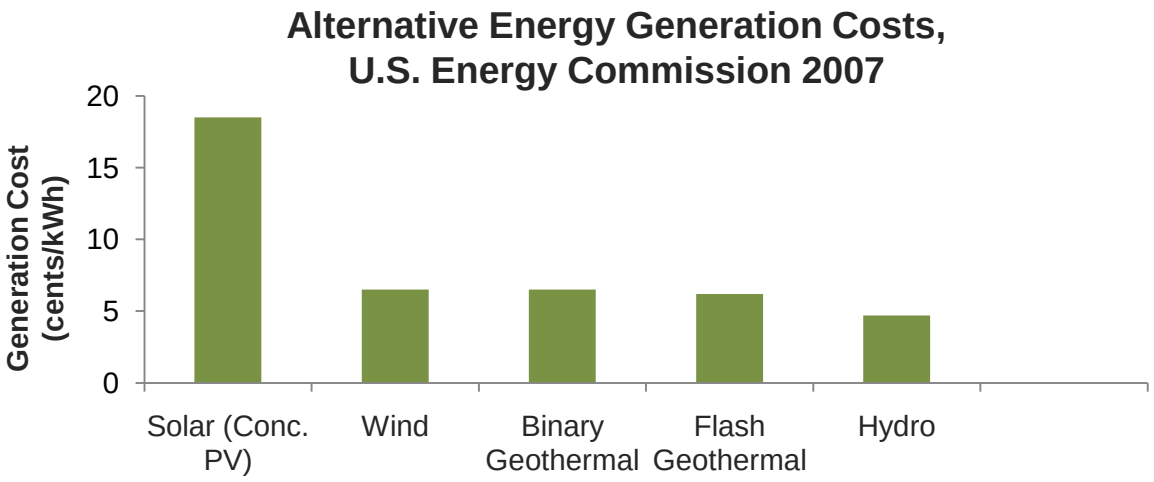
best practices in net-zero buildings

- NC's www.dsireusa.com database
- USGBC's LEED programs
- MASCO's Efficiency Guarantees
- Oak Ridge National Lab
- California Energy Commission
- Austin Energy
- BASF
- Brad Pitt, for crying out loud…

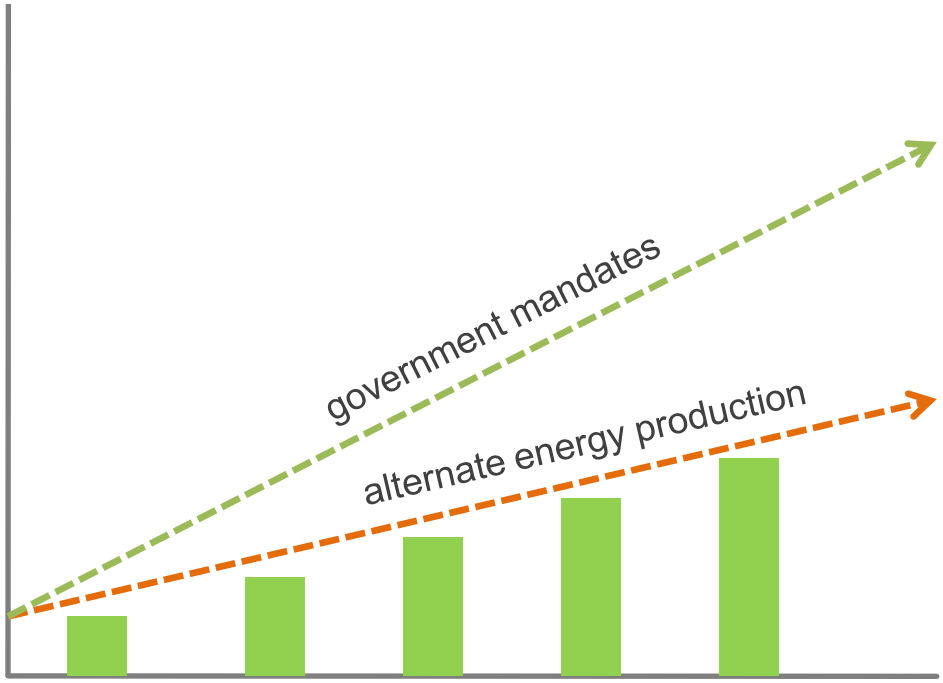
Smart Grid or “Where is my internet for power”?



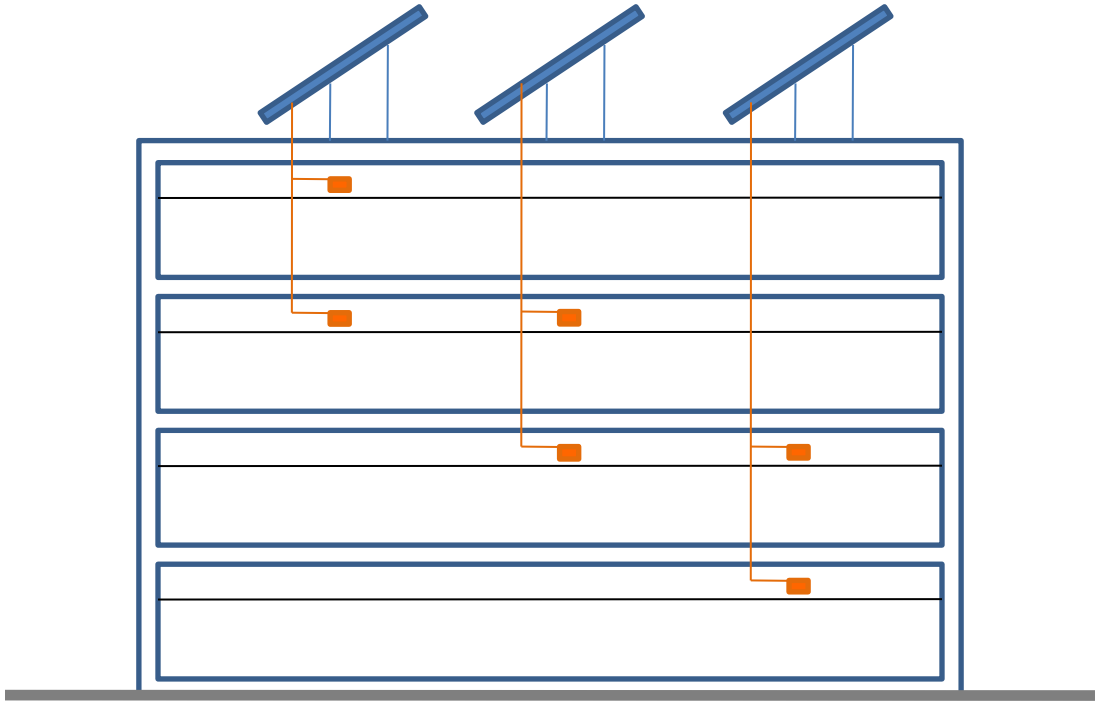
What infrastructure favors alternate energy sources?



Distributed Generation
or Grid Support
or Both?



How could this gap be bridged?



distributed micro generation

power generation trends

- strain on national AC grid
- need for Smart Grid
- strong focus on alternative energy
  - photovoltaic
  - fuel cell
  - wind power
  - battery/capacitor storage

…most alternatives are native DC power generators


Photovoltaic


Microturbine


Wind


Fuel Cell

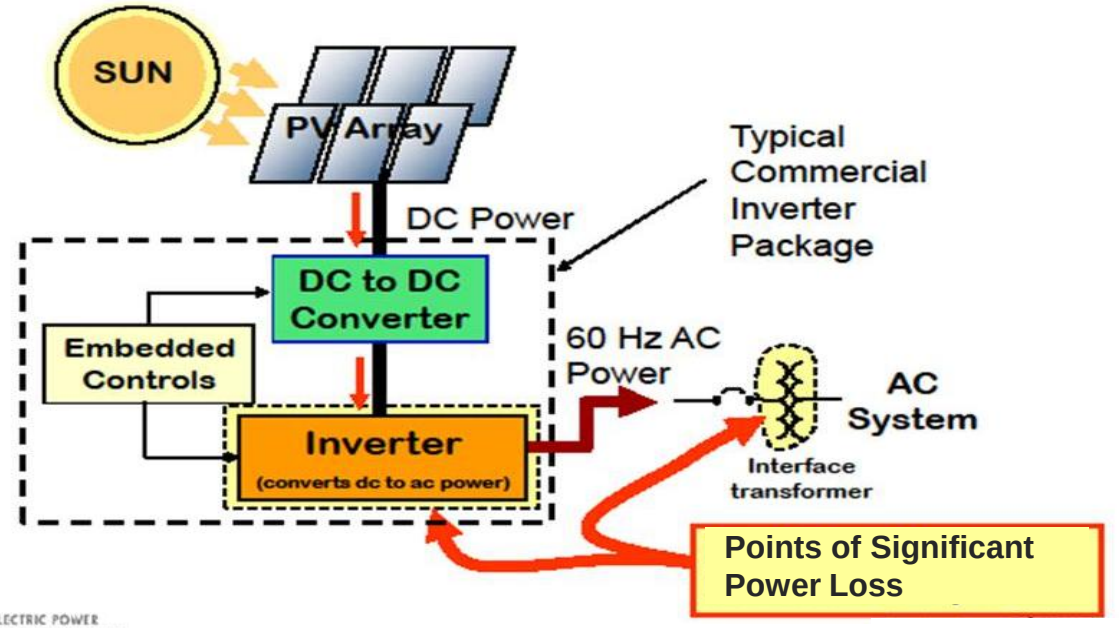

Storage (e.g. Ultra Capacitators)

Source: EPRI | ELECTRIC POWER RESEARCH INSTITUTE

power generation trends

- building power distribution is only AC today
- alternate DC power sources must be converted to AC
  - must be isolated from utility grid
  - inverter, isolation transformer and power conditioning required

…consumes 7-15% of the power generated in the conversion process



Source: EPRI ELECTRIC POWER RESEARCH INSTITUTE

CURRENT STATE: MISMATCHED AC & DC POWER REQUIREMENTS

ENERGY SOURCES – MIXED AC & DC

AC/DC Site Generation

DC Campus Fuel Cells

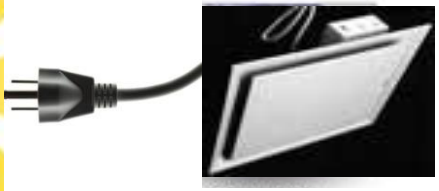
DC Photovoltaic

DC Wind Power

AC Line Power

DEVICE LOADS – TYPICALLY DC

Electronic Lighting



HVAC Actuators

Sensor & Controls

AV/IT Devices

Security & Safety

OPPORTUNITY: HYBRID AC/DC COUPLED POWER SYSTEMS

ENERGY SOURCES

AC/DC Site Generation

DC Campus Fuel Cells

DC Photovoltaic

DC Wind Power

AC Line Power

Coupled AC/DC Power Sources

▲

DC Power Distribution Management

▼

ZigBee
BACnet
TCP/IP
Wireless
Controls

DEVICE LOADS

Electronic Lighting

HVAC Actuators

Sensor & Controls

AV/IT Devices

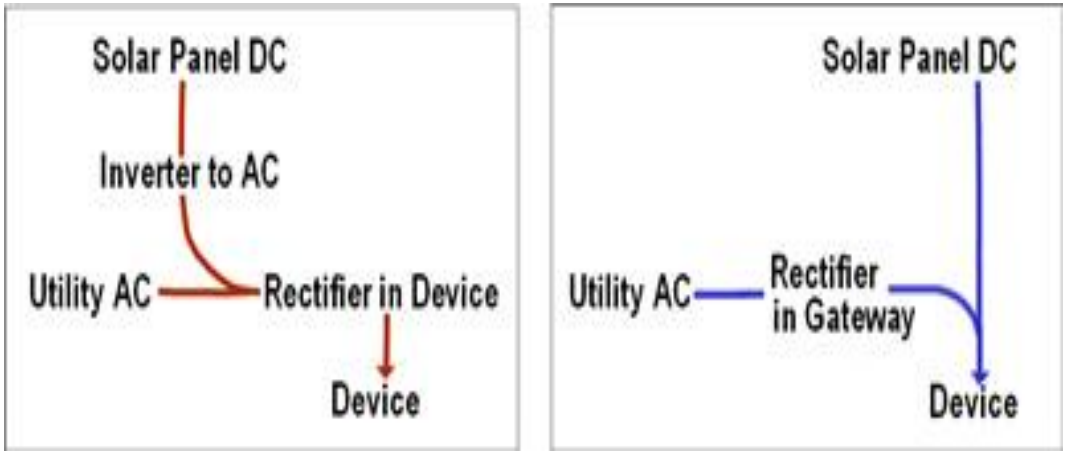
Security & Safety

28% LESS ENERGY, 15% LESS CAPITAL, 200% MORE RELIABLE

Source: Energy Systems Research intel

use less energy by going direct

- improve power utilization
- eliminate DC to AC inversion from renewable energy source
- save 7-15% without inversion
- back up with battery +/or tie back to AC grid



Graphic © Nextek Power Systems

leaders in direct dc use

» Whole Foods

A typical solar installation can:

- Produce and save more than 2.2 million kilowatt hours over 20 years
- Result in more than 1,650 tons of CO_2 emissions avoided, the equivalent of removing 440 cars from the roadways
- Reduce the impact on our country's power grids

In 2002, our Berkeley store became the nation's first major food retailer to introduce solar energy as its primary lighting power source. More of our stores followed suit; for example our Brentwood, California, store uses solar energy for 24% of its power source and our Edgewater, New Jersey, store boosts an impressive array of 14,000 square feet of solar panels providing more than 20% of the store's power needs.

leaders in direct dc use

- Frito-Lay
- Target

owner needs

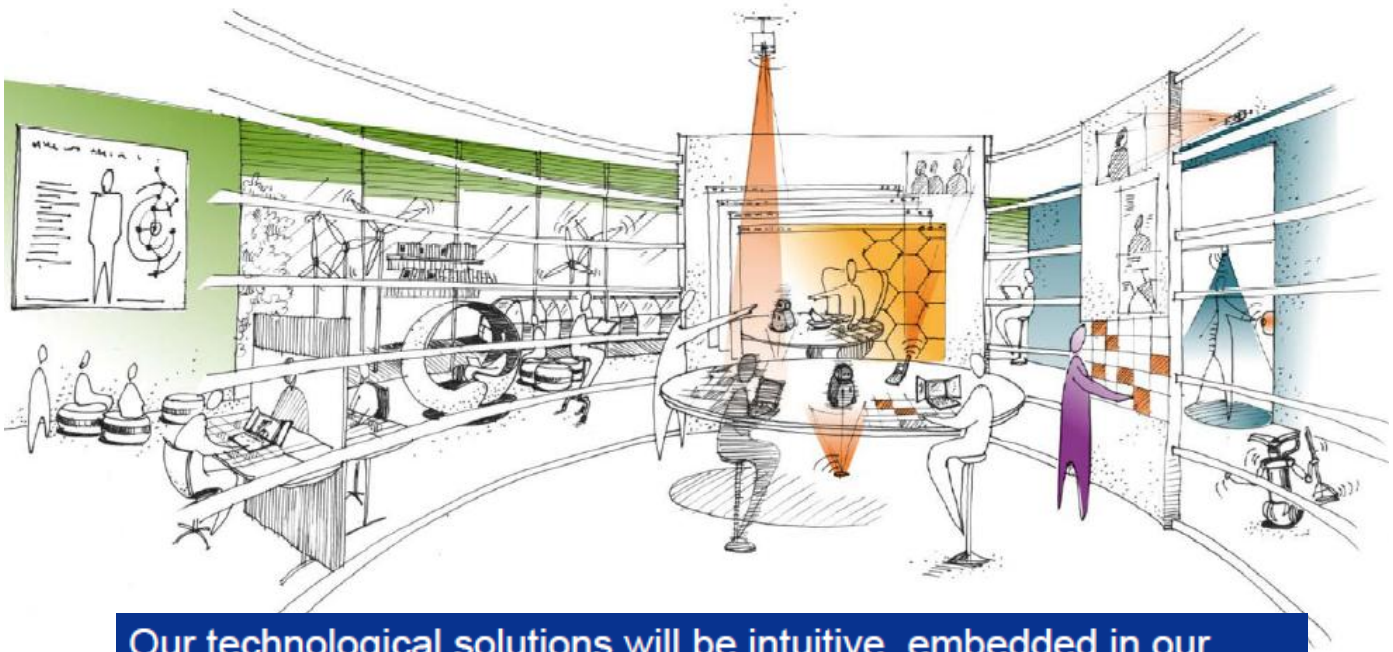
Bruce Graham | Johnson Controls

market view

- facility investments
- new construction and renovation
- integration of design and use
- more rapid re-use cycle

changing workplace

- facility management no longer reactive
- embracing complexity and unpredictability
- still driving down costs, minimizing real estate portfolios
- flexibility / adaptability of space, buildings, cities…



Our technological solutions will be intuitive, embedded in our environment and non intrusive, yet controllable by each individual

sustainable facilities

- a more powerful combination:
  - energy efficiency + on-site renewable energy

the “why” for renewables

- hedge against rising fuel costs
- reduce peak energy demand
- reduce CO_2 emissions
- demonstrate green leadership

Examples involving 5kW installations include:

Boston, MA:
- Net energy savings of up to $84,000 over 30 years
- Produce/save 5,949 kWh of electricity in the first year
- Eliminate 9,096 lbs of CO_2 emissions in the first year

Boca Raton, FL:
- Net energy savings of up to $64,000 over 30 years
- Produce/save 7,212 kWh of electricity in the first year
- Eliminate 11,546 lbs of CO_2 emissions in the first year

Kansas City, MO
- Net energy savings of up to $50,000 over 30 years
- Produce/save 7,091 kWh of electricity in the first year
- Eliminate 17,271 lbs of CO_2 emissions in the first year

Los Angeles, CA
- Net energy savings of up to $83,000 over 30 years
- Produce/save 7,648 kWh of electricity in the first year
- Eliminate 10,435 lbs of CO_2 emissions in the first year

The savings and emissions are estimates assuming a 7% inflation rate and local electric rates.

diverse segments engaged

- corporate office
- higher education
- government/military
- retail
- hospitality

firms with sustainable goals & budgets want payback < 3 years

time for system level integration

- connect facilities to energy initiatives
- smart grid needs “smarter buildings”
- open, scalable systems

life cycle thinking

Plan

- Needs
- Requirements
- Strategy
- **ENERGY MODELING**

Source

- Sourcing
- Transacting
- Property acquisition
- **MEP DESIGN AND SUSTAINABILITY IMPACT REVIEW**
- **FINANCIAL REVIEW**

Design & Construct

- Project management
- Construction management
- Workspace design
- Design integrated services
- **ADAPTABLE FOR THE FUTURE WORK FORCE**

Operate

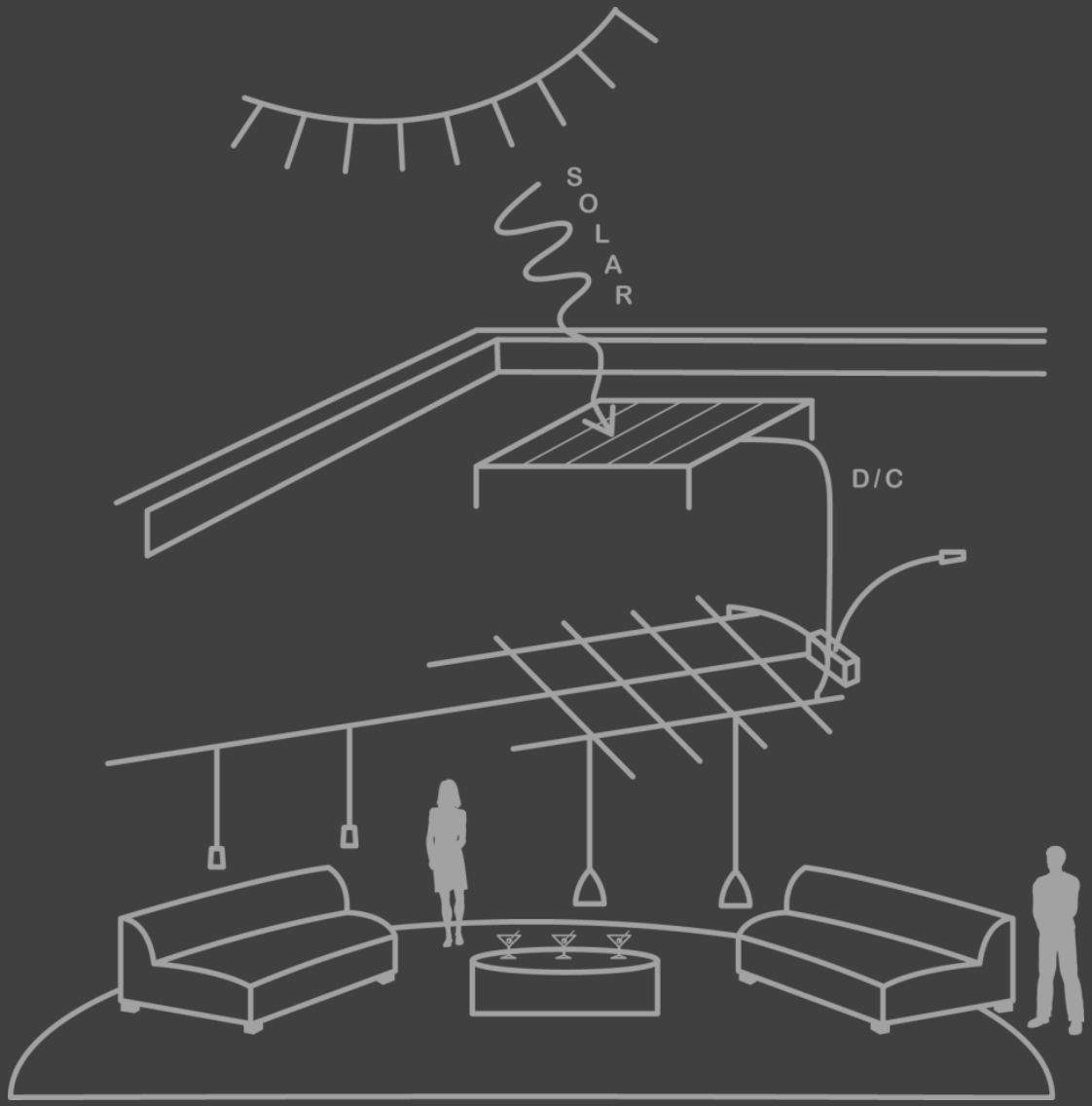
- Implement integrated service s
- Global approach, local requirements
- Sustainable occupancy
- **FLEXIBILITY OF SPACE USE**
- **SAFETY CONCERNS**

Renew

- Disposing of surplus assets
- Energy upgrades
- Management information
- **MOBILE AND REUSABLE**
- **EVOLVING APPLICATIONS**

solutions

Sue Rhoades | Armstrong


SOLAR
D/C

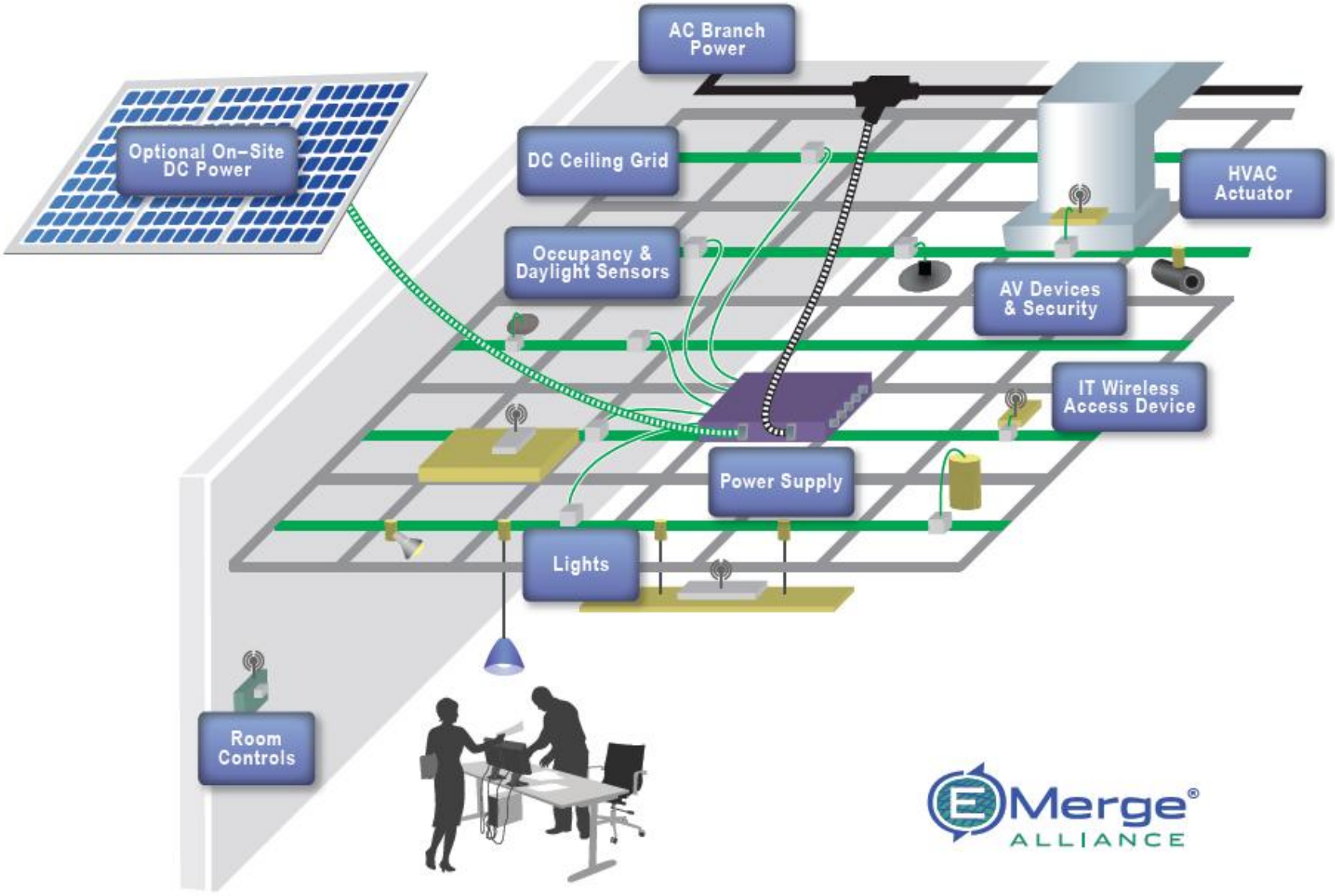
industry standards for dc micro-grids

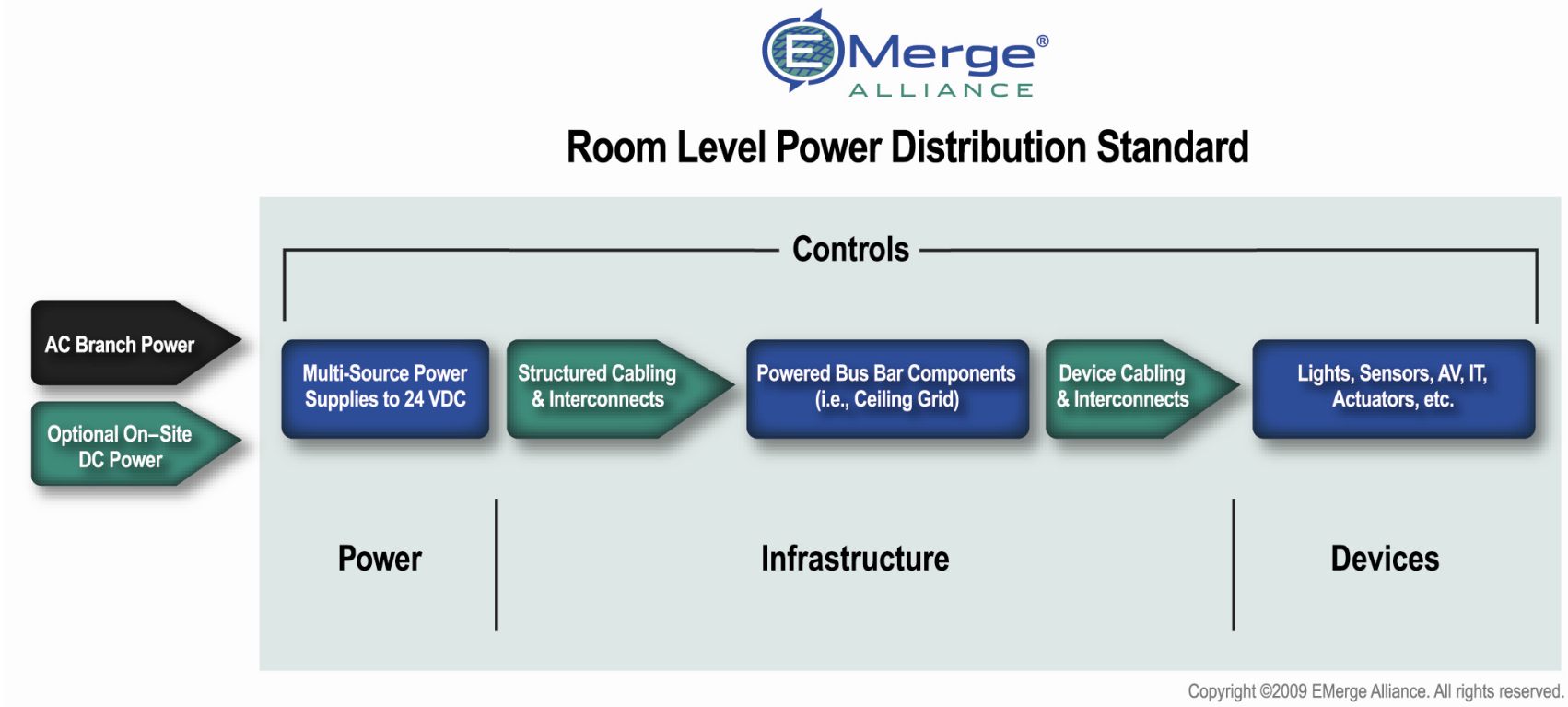
- give on-site renewable energy systems some direct dc loads
- bring together power & devices with building infrastructure and controls
- connect with other industry standards for communications, safety, lighting, etc
- move ac/dc conversion upstream to improve efficiencies
- provide flexibility for reconfigurations and future technology shifts / upgrades

open source alliances

design goals of standardization

- reduce complexity, installation time, first-cost competitive
- simple and flexible use / re-use
- NEC recognized Class 2 power levels
- reduce system energy loss
- interoperable device-level controls
- integration of solar panels, wind, fuel cell, batteries
- open platform for innovative applications




EMerge ALLIANCE
Room Level Power Distribution Standard
Controls
AC Branch Power
Optional On–Site DC Power
Multi-Source Power Supplies to 24 VDC
Structured Cabling & Interconnects
Powered Bus Bar Components (i.e., Ceiling Grid)
Device Cabling & Interconnects
Lights, Sensors, AV, IT, Actuators, etc.
Power
Infrastructure
Devices
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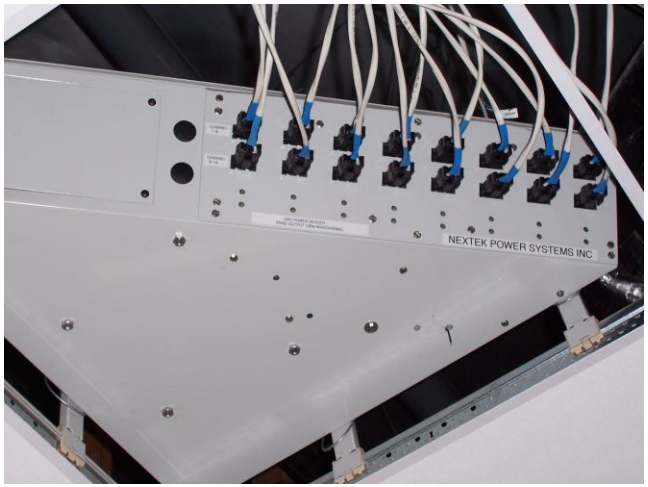
examples

Southern California Edison

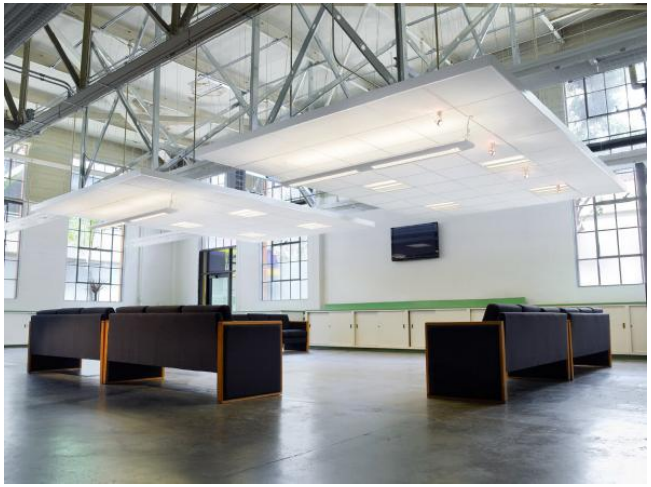
- Single story commercial office
- Promotes energy savings programs with commercial customers – studies lighting & control systems
- DC multi-channel power servers – utility AC primary
- Fluorescent lighting fixtures – with DC ballasts
- Wireless (Zigbee) controls from touch panel – IP addressable
- Daylight, occupancy and dimming functions
- Solar (PV) direct to DC loads planned in next phase



Targeted 'Net Zero Energy Ceiling '– Irwindale, CA

Los Angeles Community College District

- Trade & Technology College – home of architectural, electrical & renewable energy depts.
- Re-purposed single story hi-bay multi-use building
- Clouds of high light reflectivity acoustical ceilings
- DC multi-channel power servers – utility AC primary, solar desired for future
- Fluorescent lighting fixtures – dimmable DC ballasts
- Wired controls – touch panel interface
- Daylight, occupancy and dimming functions
- New buildings LEED certified, commitment to using renewable energy



Smart Ceiling – Los Angeles, CA

US Green Building Council Headquarters

- Continuous high light reflectivity acoustical ceilings
- DC multi-channel power servers – utility AC Primary
  - Solar supplemental planned for later
- Fluorescent light fixtures – with DC ballasts
- Wired controls, touch-panel interface
- Daylight, occupancy and dimming functions
- LEED Platinum for Commercial Interiors

Solar Ready Conference Rooms – Washington, DC

According to architect Rod Letonja of Envision Design:

“The infrastructure is in place for USGBC to add solar... Solar panels will be able power all the lights in the conference rooms with DC energy distributed directly through the ceiling grid.”

Nextek Power Systems

- One-story mixed use commercial office/lab/ factory building
- DC multi-channel power servers – utility AC with Solar planned
- Fluorescent lighting fixtures – with DC ballasts
- Wired bus/branch controls – traditional wall switch interface
- Daylight, occupancy and dimming function

DC Micro-Grid Ceiling – Detroit, MI

Armstrong World Industries

- Two-story mixed use commercial office/factory building
- Mockup of solar-driven dc micro-grids for higher education campus
- DC multi-channel power servers – solar (PV) primary power with utility AC back-up
- Fluorescent lighting fixtures – with DC ballasts
- Wired branch controls – touch panel interface
- Daylight, occupancy and dimming function

Solar Classroom – Lancaster, PA

question + answer

contacts

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