The Nation's quest for net zero energy buildings:

DC DISTRIBUTION

The Power to Change Buildings

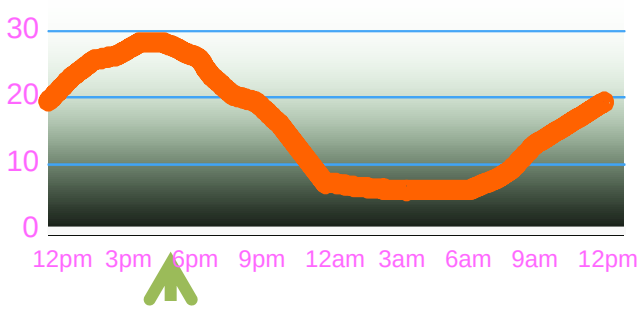
A presentation of the EMerge Alliance

Brian Patterson
Chairman, EMerge Alliance
Dennis Symanski
EPRI – Chairman, EMerge Standards Committee

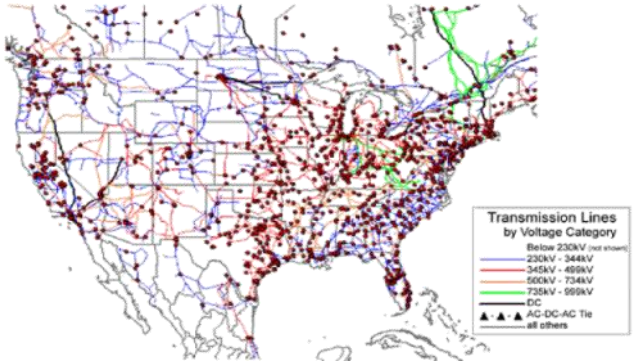
Challenges of the New Energy Economy

Catching Up on 100 yrs of Little Progress

- **The Smart-Grid**
  - Automating the Grid
  - Return on Asset (ROA)
  - Dynamic Pricing



- **Dealing with Disruptive Change**
  - >30% Renewables, Distributed
    - Photovoltaic, Solar/Thermal, Wind, Biofuels, Fuel Cells
    - Climate Modeling & Prediction
    - Distribution becomes Transmission
  - Electric Vehicles nearly doubles demand
  - Transmission Capacity and Location Difficulties



- **Revolutionary Change**
  - Cyber-Security
  - Low-Cost Energy Storage
  - User-Centered Energy System

- **Emerging New Markets**
  - New Technologies Seeking Critical Mass
  - Open Systems & Standards
  - Code & Regulatory challenges

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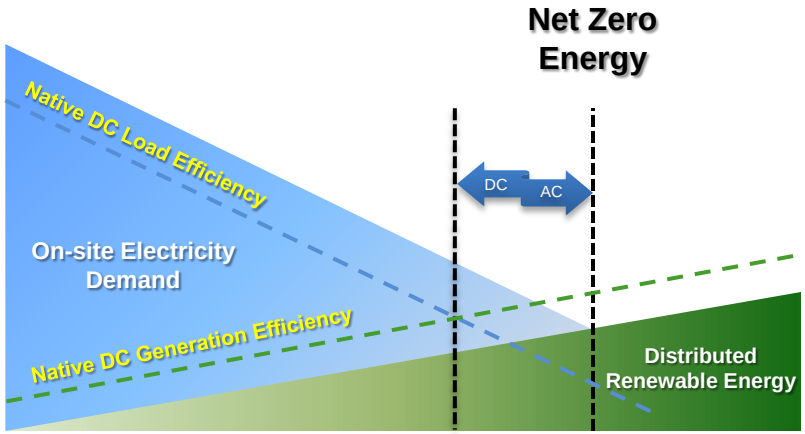
Zero Energy Building Model

Buildings that produce as much energy as they consume

1. **Integrated design** and operations planning
2. **Site renewable** strategies get optimized using dc
3. **Energy Storage** in dc allow Grid independence
4. **System Intelligence** control, monitor, verify

U.S. DEPARTMENT OF ENERGY

ZERO ENERGY COMMERCIAL BUILDINGS CONSORTIUM



"DC power would fundamentally change the way power is distributed in commercial buildings…"

2012: **Begin DC Microgrid Demonstrations**

2030: **All new commercial buildings**

2040: **50% of commercial building stock**

2050: **All commercial buildings**

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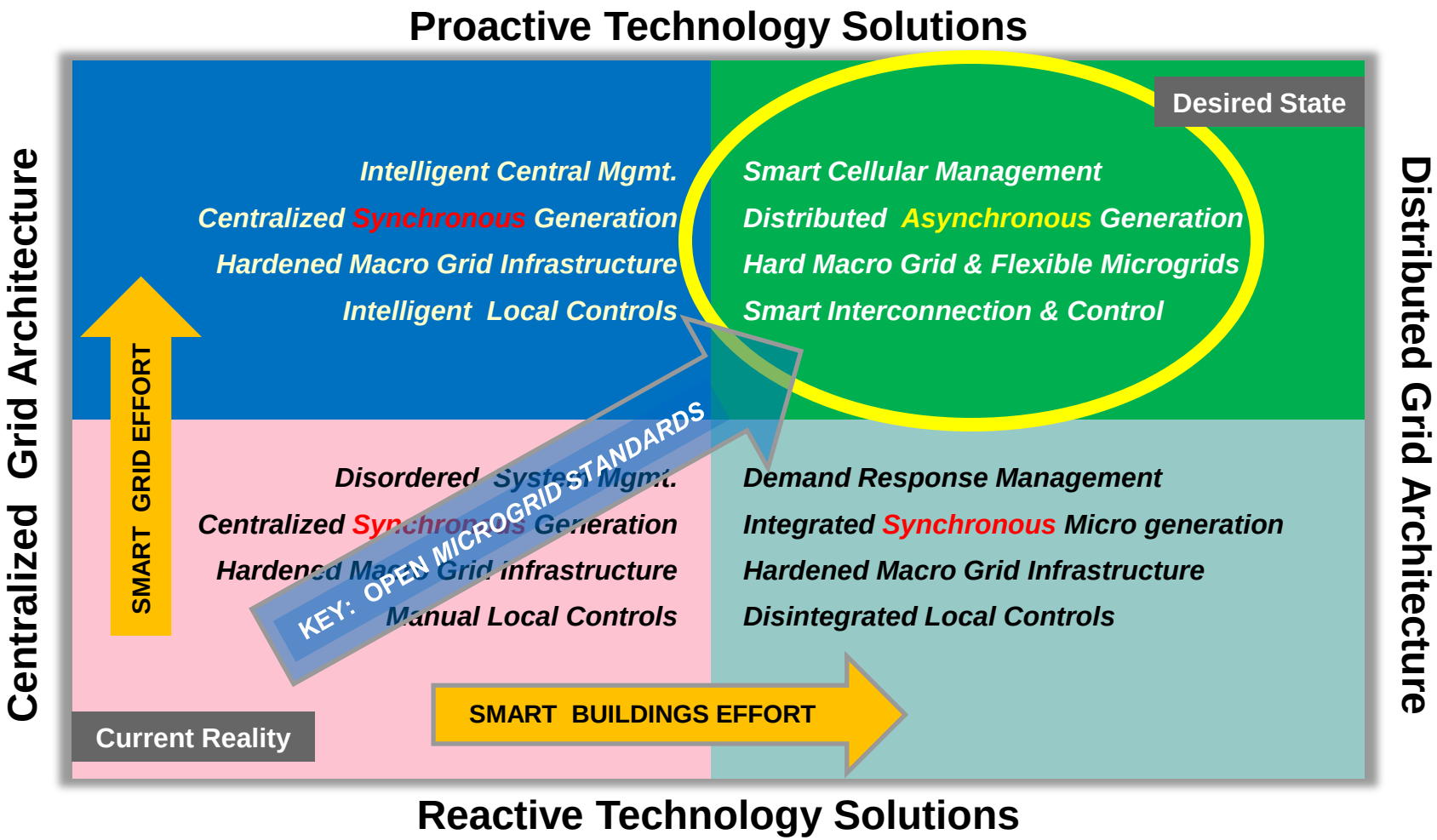
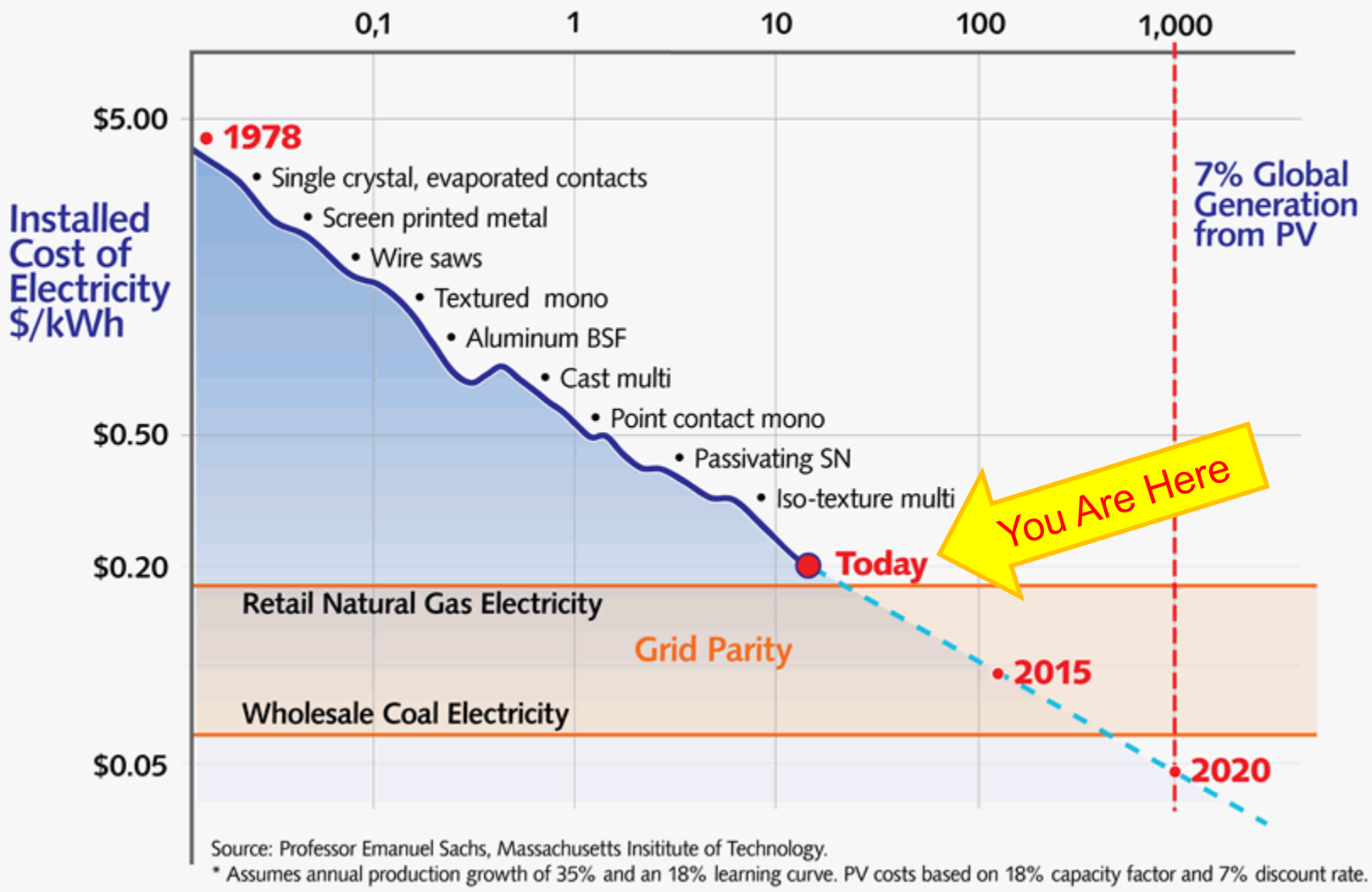
Power Technology and Architectures

Toward A More Integrated Energy Network



Moving to an Alternative Energy Economy

Cumulative PV Production GigaWp



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Too Much of a Good Thing?

Renewables Just Over 10% Destabilizing the Grid

"The head of the German energy agency DENA has warned that a surge in **solar power is overwhelming Germany's grid***."*

"With 15 GW+ installed by the end of the year, **this requires more than a few peaking gas turbines on standby***; it needs large-scale power plants capable of both economical base load and peaking power."*

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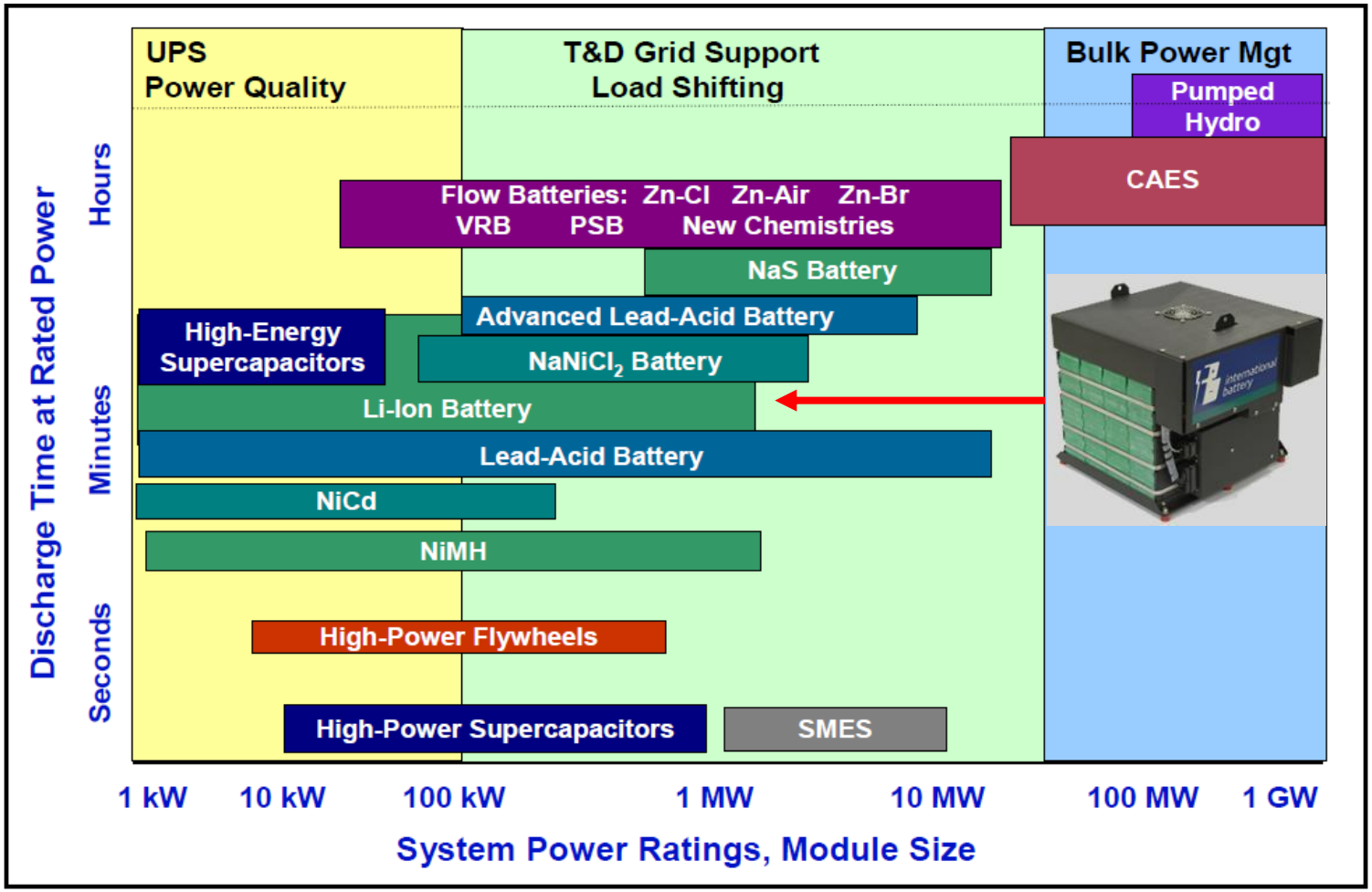
Growing Array of Stored Energy Options

Accelerating Double-digit Growth



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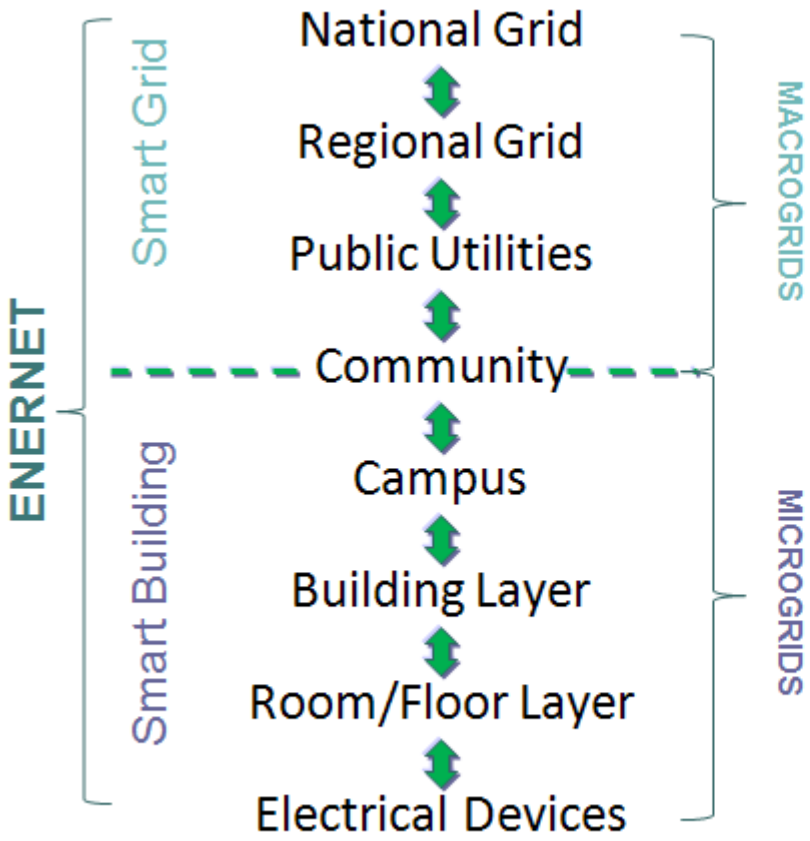
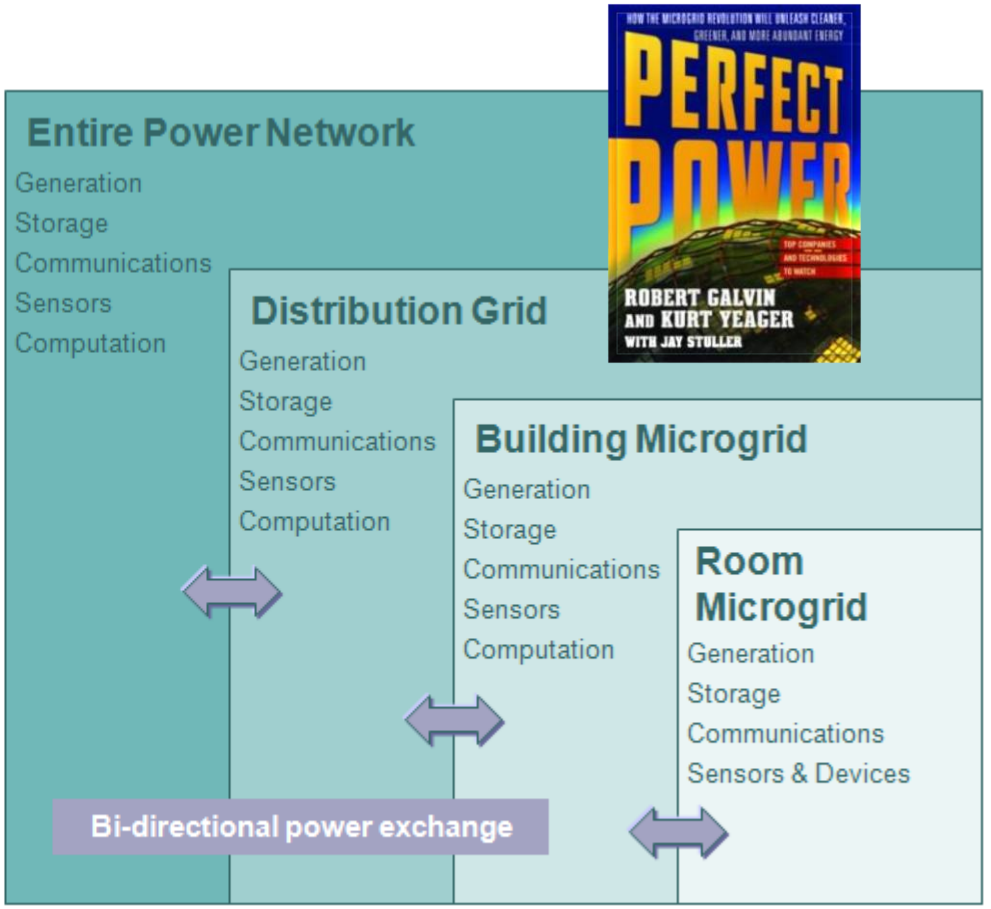
Smart Grid to Smart Buildings:

Layered DC Microgrids at the Core of the New Energy Network





En•er•net: noun \en-ər-net\ : the Internet of powered things Bob Metcalfe

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From Smart Grid to Microgrids

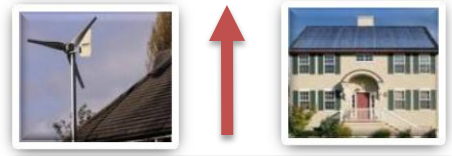
Balancing the Renewable Power Equation

Generation → Transmission → Distribution → Smart Meters

Smart Buildings

Smart Homes

Local Energy Storage



Local Generation

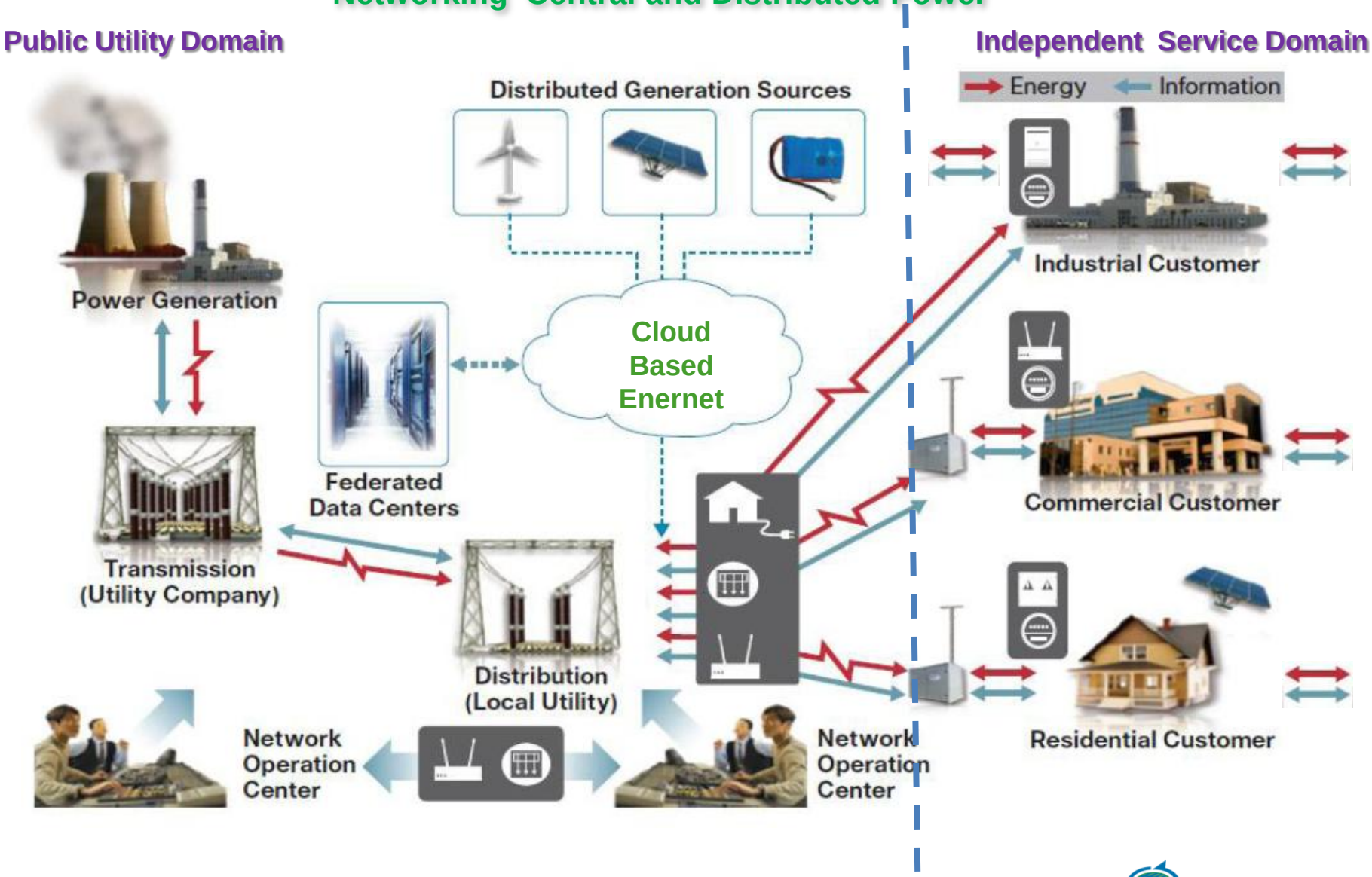
Closing the Loop with Microgrids

- **Why Microgrid Energy?**
  - Increase renewable energy availability
  - Improve, reliability & independence / security
  - Improve availability in underserved markets
  - Create open environment for energy innovation

Slide Courtesy of Intel Research Labs

Smart Grid + Microgrids = EnerNet

Networking Central and Distributed Power



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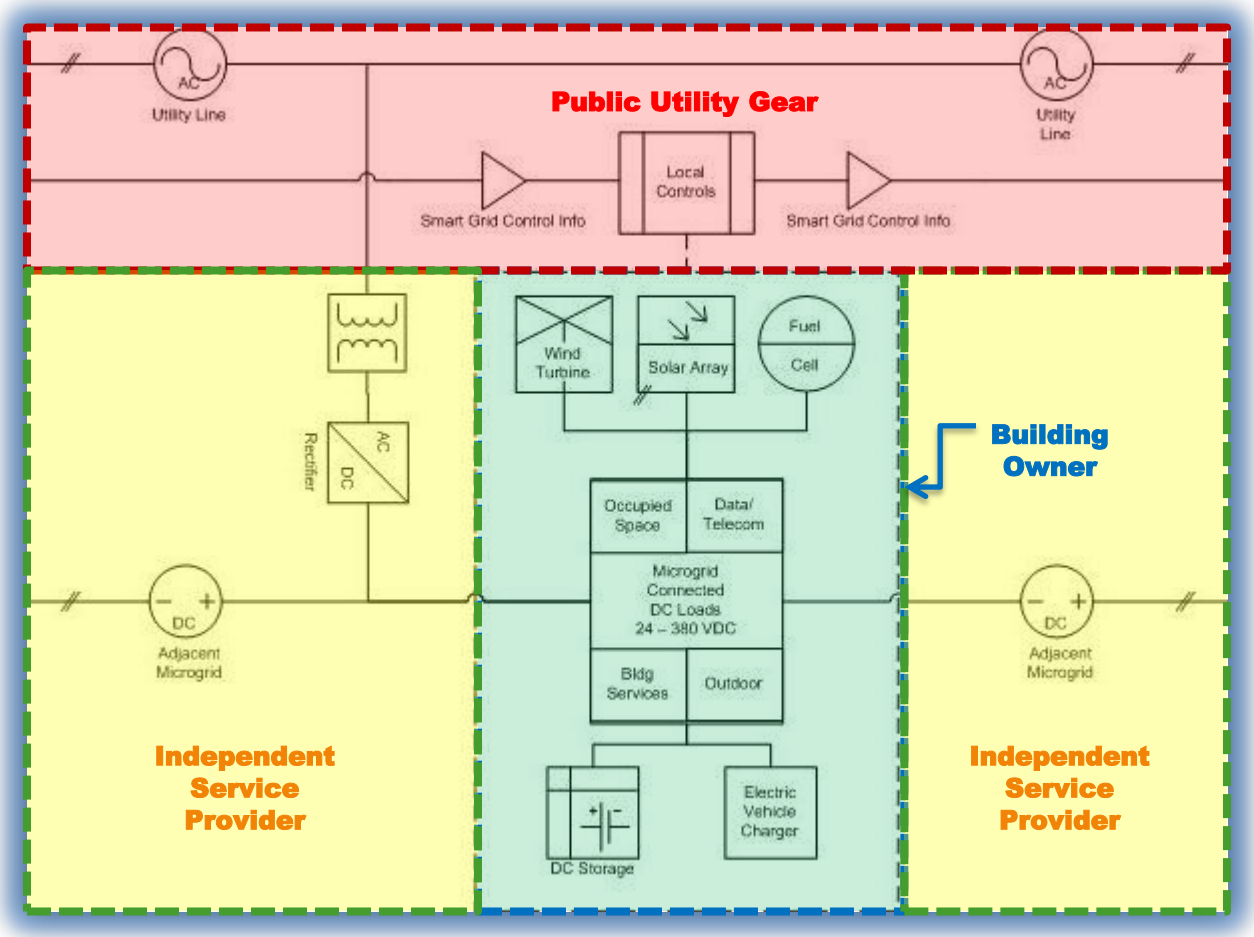
Zero Energy Buildings (ZEB)

A Microgrid network will look much like the Internet

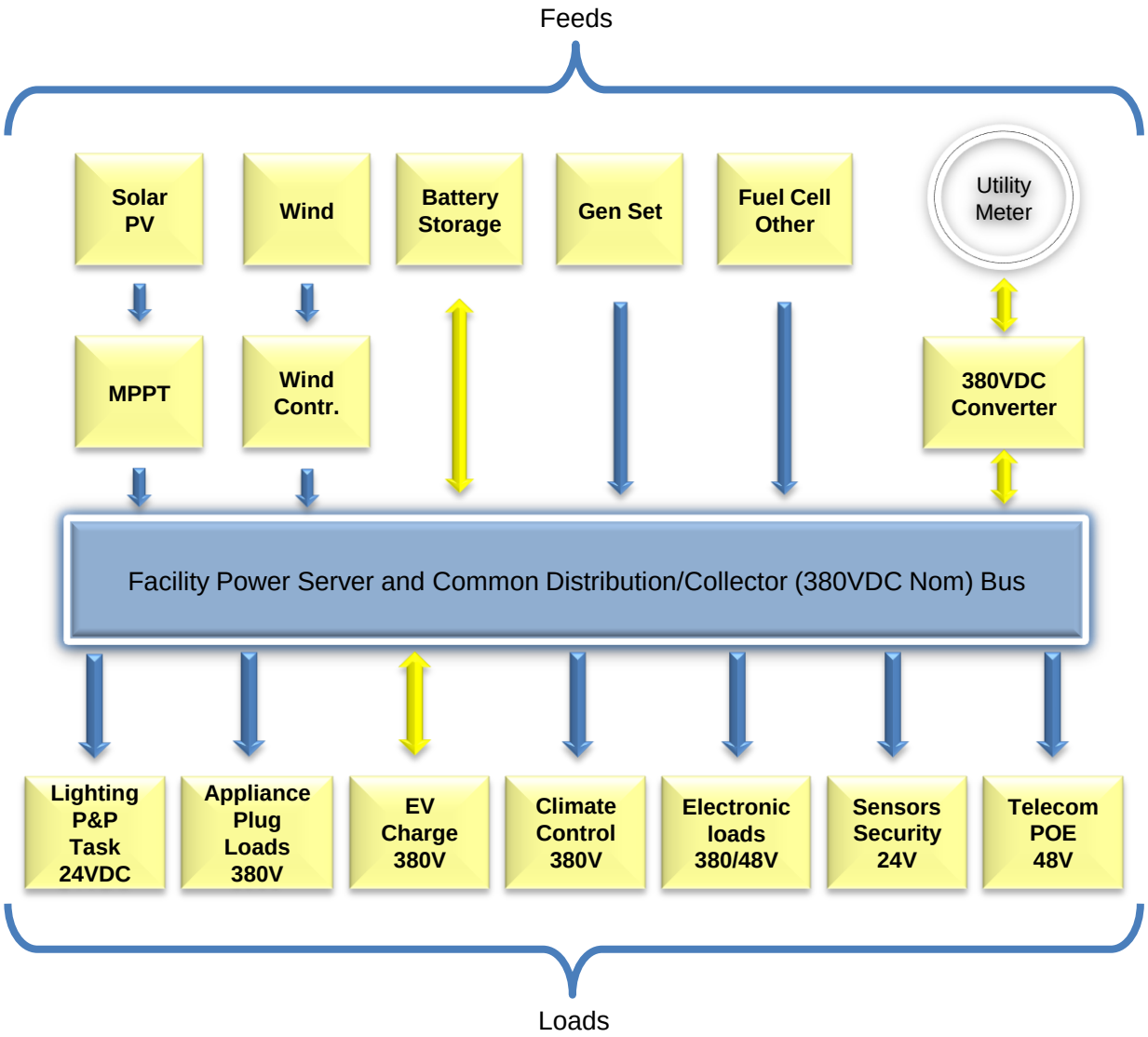
DC MICROGRID MODEL



Zero Net Energy Buildings (ZEB)

DC Microgrid with Renewable & Alternate Distributed Generation

Slide Courtesy of EMERSON Network Power



DC Microgrid may include :

- Various AC and DC loads: fixed & plug and play loads
- Dispatchable generation: fuel cell or bio-fuel turbine.
- Non-dispatchable sources: solar PV and wind turbines.
- Energy storage, such as ultra-capacitors or batteries.
- Common Distribution – Collector Bus
- Management & Demand Response (DR) capability
- Ride-thru & Off-grid operation capability (islandable)

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The Current Reality…

PROBLEM: MISMATCHED AC & DC POWER REQUIREMENTS

ENERGY SOURCES – MIXED AC & DC

AC/DC Site Generation

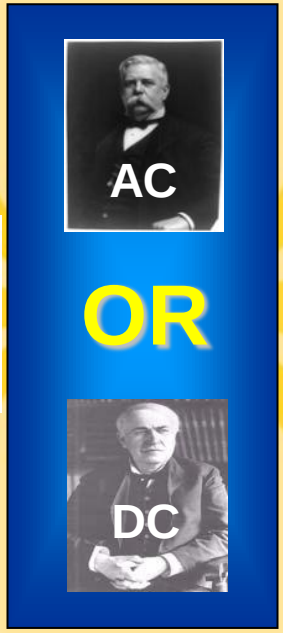
DC Fuel Cells

DC Power Storage

DC Photovoltaic

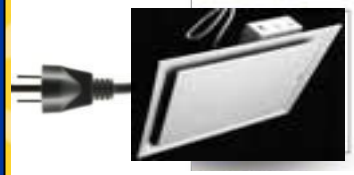
DC Wind Power

AC Line Power



ELECTRIC DEVICES – TYPICALLY DC

Electronic Lighting



Sensors & Actuators

Plug-in Vehicles

AV/IT Devices

Data & Telecom Centers

Security & Safety

RESULT: LOST OPPORTUNITY TO REDUCE ENERGY UP TO 30%

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The Logical Path Forward…

Solution: A simplified AC/DC hybrid coupled power network

ENERGY SOURCES – MIXED AC & DC

AC/DC Site Generation

DC Photovoltaic

DC Campus Fuel Cells

DC Wind Power

DC Power Storage

AC Line Power

Coupled AC/DC Power Sources

▲

DC Power Distribution Management

▼

Wireless Controls BACnet TCP/IP

ELECTRIC DEVICES – TYPICALLY DC

Electronic Lighting

AV/IT Devices

Sensors & Actuators

Data & Telecom Centers

Plug-in Vehicles

Security & Safety

Opportunity: Up to 30% less energy, 15% less capital, 200% plus more reliable

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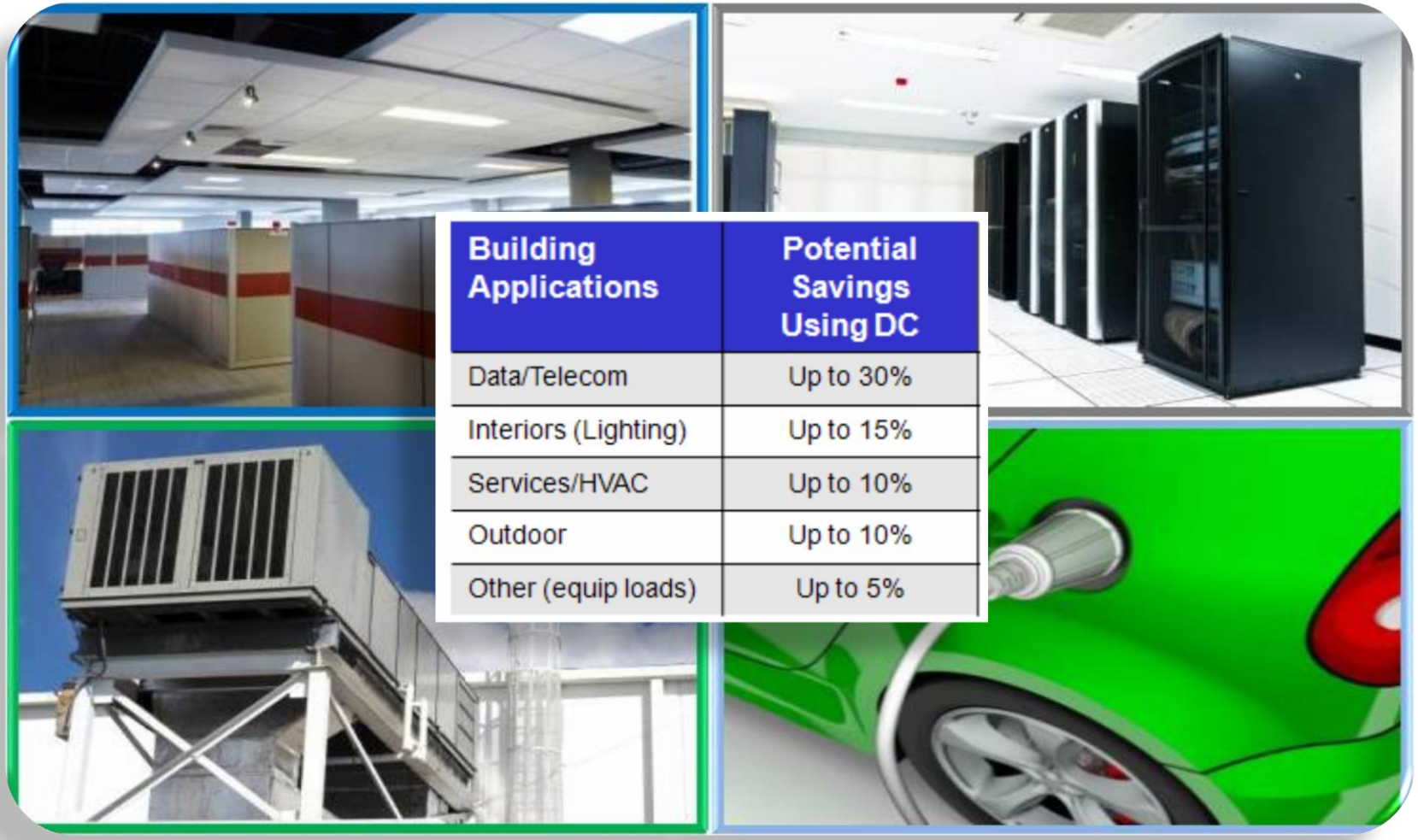
ZEB – Microgrid Building Blocks

A Microgrid network can deliver energy savings in all key areas



Building Applications	Potential Savings Using DC
Data/Telecom	Up to 30%
Interiors (Lighting)	Up to 15%
Services/HVAC	Up to 10%
Outdoor	Up to 10%
Other (equip loads)	Up to 5%

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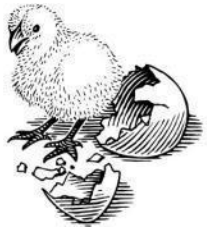
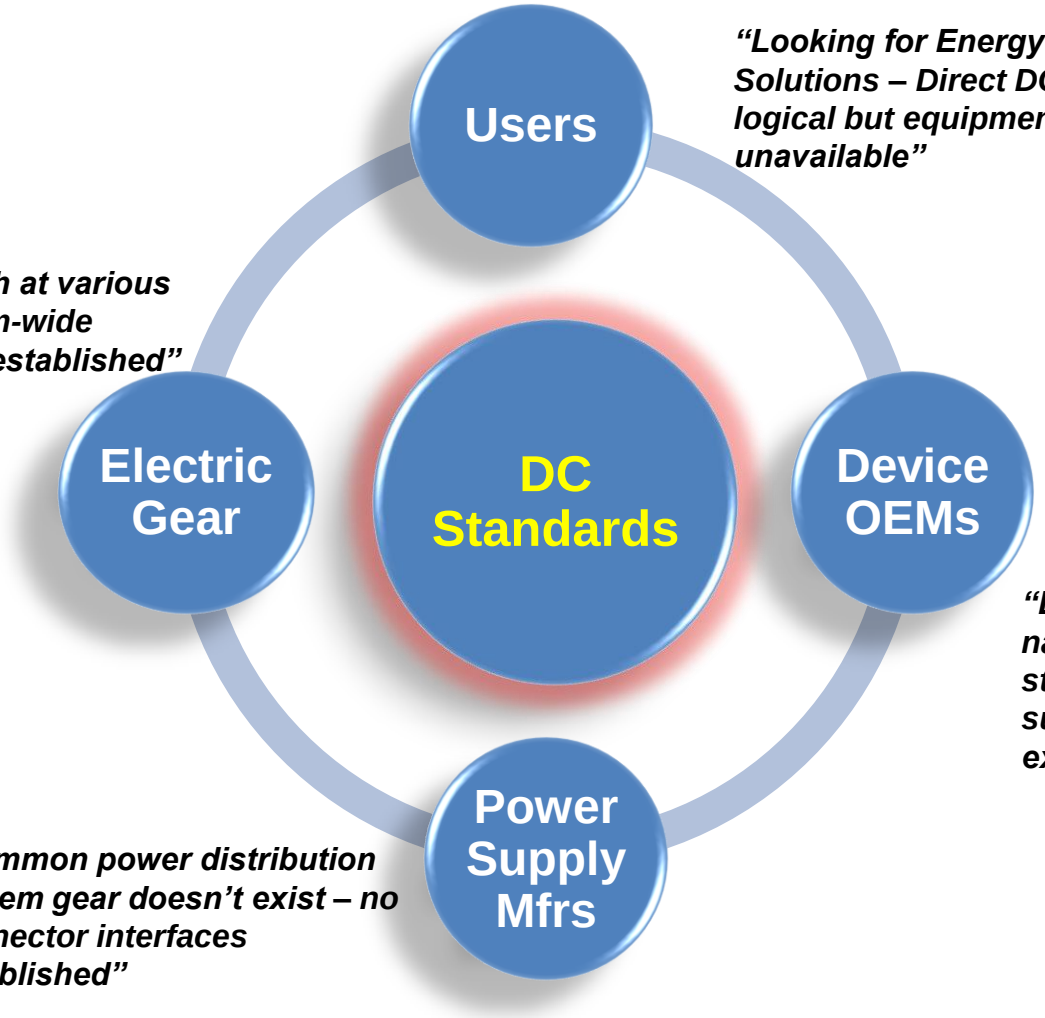


So, Why Not DC Microgrids?

Chicken-Egg Deadlock in the market



"Looking for Energy Solutions – Direct DC seems logical but equipment is unavailable"

"DC is being dealt with at various points – but no system-wide standards have been established"

"DC devices are native, but no standard power supply standards exist "

"Common power distribution system gear doesn't exist – no connector interfaces established"

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It Takes an Industry to Build a Building

Generating the Power to Change Buildings

The EMerge Alliance Approach

- Not-for-profit 501c part 6
- Open standards platform
- Industry leaders developing a family of inter-related standards
- Collaborations for integrated design
- 75+ Member organizations and growing!

An open industry association

leading the rapid adoption of safe DC power distribution in commercial buildings through the development of EMerge Alliance standards.

The EMerge Alliance

Created to Organize the Effort

- **Open Standards for DC Microgrids in Buildings**
  - Hybrid platform of AC and DC power distribution
  - Reduce or eliminate wasteful AC-DC conversions
- **Creating More Flexible & Sustainable Buildings**
  - Plug and play reconfigurability
  - Simplified electronics – improved reliability
- **Energy Savings Potential in Buildings from**:
  - More efficient use of DC-based loads
    (i.e. LED lighting, controls, data and telecom centers, EV chargers, variable speed drives, etc.)
  - Direct integration of DC energy sources
    (i.e. on-site solar, wind, fuel cells, dc storage)

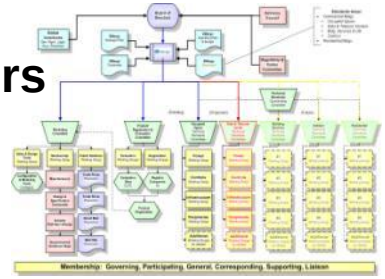
Our Tactics Are Simple

Use Well Known Technologies and Methods

1. **Create global standards for hybrid AC/DC microgrids in buildings**
   - Open specifications for infrastructure, power, control and devices
   - Interoperable platforms that drive energy savings potential

2. **Create eco-system of organizations to adopt, implement & support standards**
   - Fee Based Membership - governance, committee & member services
   - Registration & Evaluation of member products

EMerge Organization



3. **Promote use of standards by owners/specifiers/contractors**
   - Education : Technical papers, magazine articles
   - Promotion: PR & tradeshows, directories, product listings, design aids

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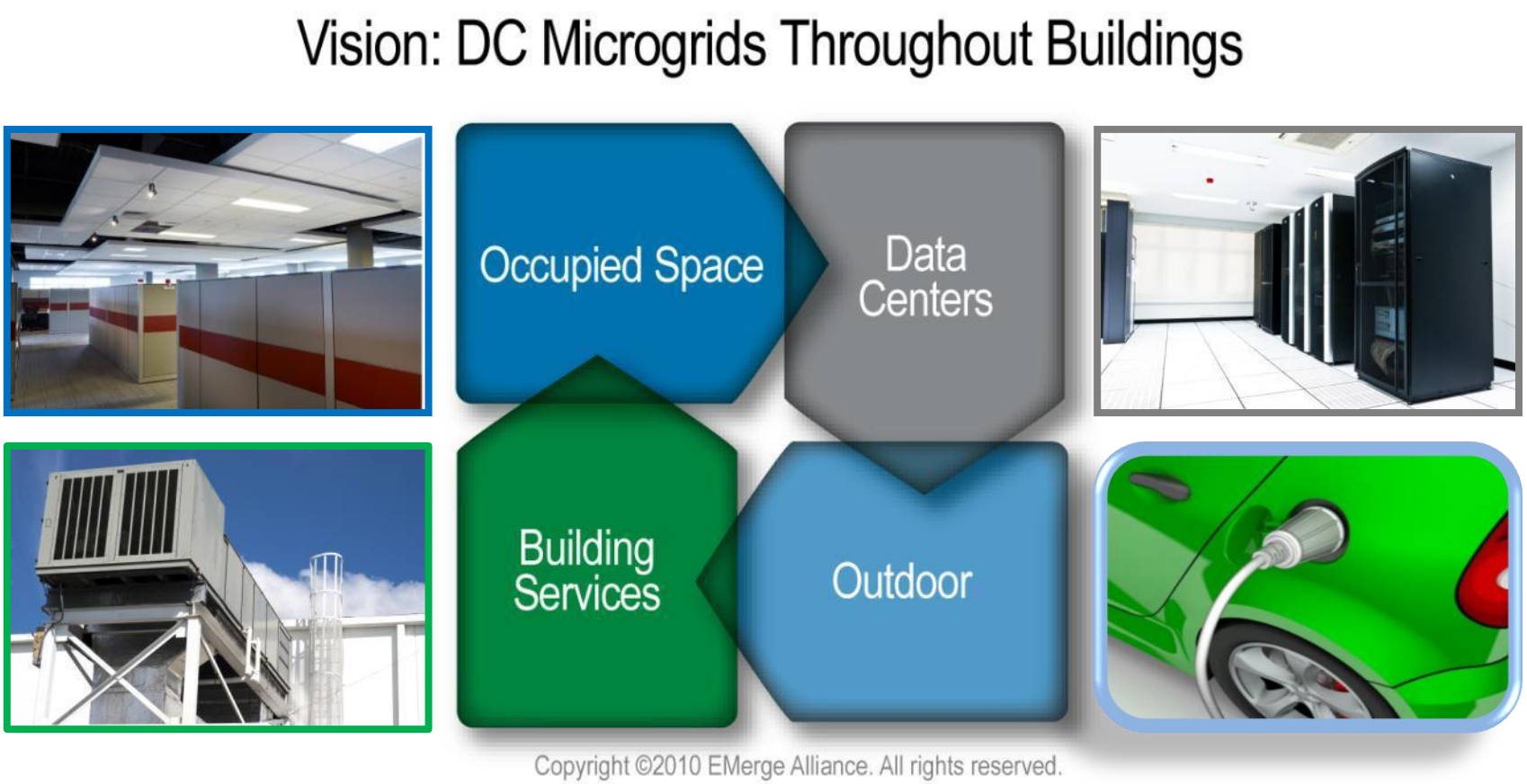
A Family of Open Power Standards for Hybrid DC Microgrids



Key Sponsors of Open LVDC Power Standards

It Takes Industry Giants to Rock the Foundation

Key Strategies of the Alliance

1, 3 & 5 Year Planning Horizons

1. **Focus on early standards → widen scope over time**
   - North America first→ then rest of world
   - Interiors first → data centers, service & utility, outdoor
   - Ceilings first → walls, floors, furniture
   - Lighting first → A/V, HVAC, IT, Security, occupant info
   - Room level first → building level and Smart Grid

Ceilings
↓
Walls
↓
Furniture
↓
Floors

2. **Associate Alliance with national/global needs, concerns**
   - LEED – Sustainability movement– CO_2 Reduction
   - Electrical Efficiency – renewable DG & storage, reduced conversions
   - Energy Efficiency/Reliability - Net Zero Energy Buildings , islandable microgrids

Zero Net Energy Buildings Goals

2030: All new commercial buildings

2040: 50% of commercial building stock

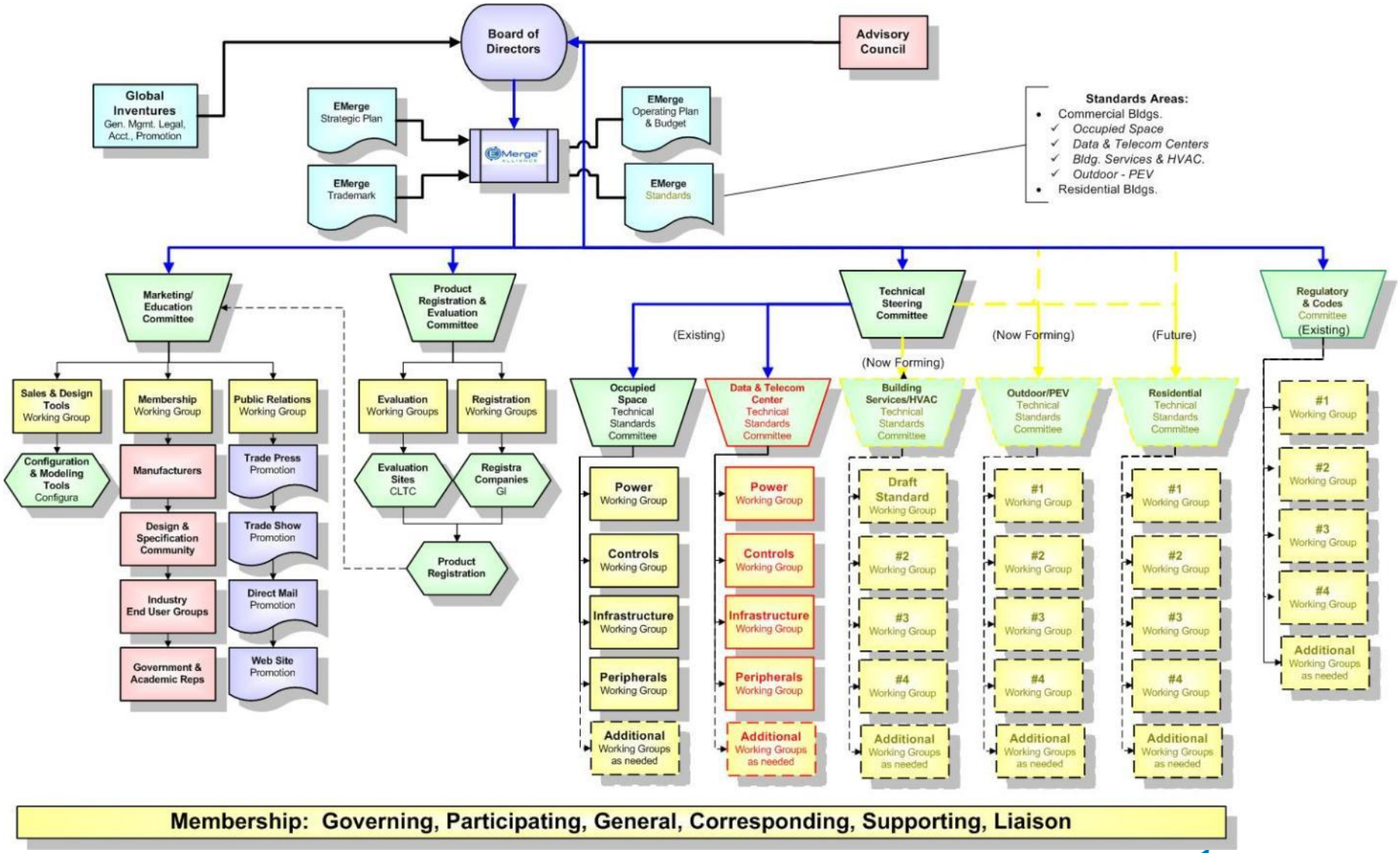
2050: All commercial buildings

3. **Connect existing codes, standards, technologies in new ways**
   - Establish liaison with traditional & contemporary organizations
   - Recruit mix of established and new tech OEM's
   - Keep standards at highest practical (application) level

4. **Brand product registration for specification ease by customers**

EMerge Alliance Organization

Managed and Operated Professionally



Who is EMerge?

Key Stakeholders

- Manufacturers
- Building Owners
- Technology Leaders
- Contractors/Builders
- Architects
- Engineers
- National Labs
- Codes & Standards Groups

We are EMerge!

Governing

Armstrong® CEILING SYSTEMS

Johnson Controls

NEXTEK Power Systems

OSRAM SYLVANIA

WAVE WORTHINGTON ARMSTRONG VENTURE

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We are EMerge!

Participating

We are EMerge!

General

SunEdison
simplifying solar

ECA
ELECTRO-CABLE ASSEMBLIES

kan·ə·pe

NORTHWIRE INC
TECHNICAL CABLE

EVERLAST LIGHTING

LEDing EDGE
efficient lighting solutions

Universal Lighting Technologies

verve
living systems

SAMSUNG

SAMSUNG LED

FOCAL POINT

KONARKA

power-one

Corresponding

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DIRECT POWER TECHNOLOGIES, INC.
"Chip 2 Grid"™ Data Center Solutions

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Alok Singh
Southern California Edison

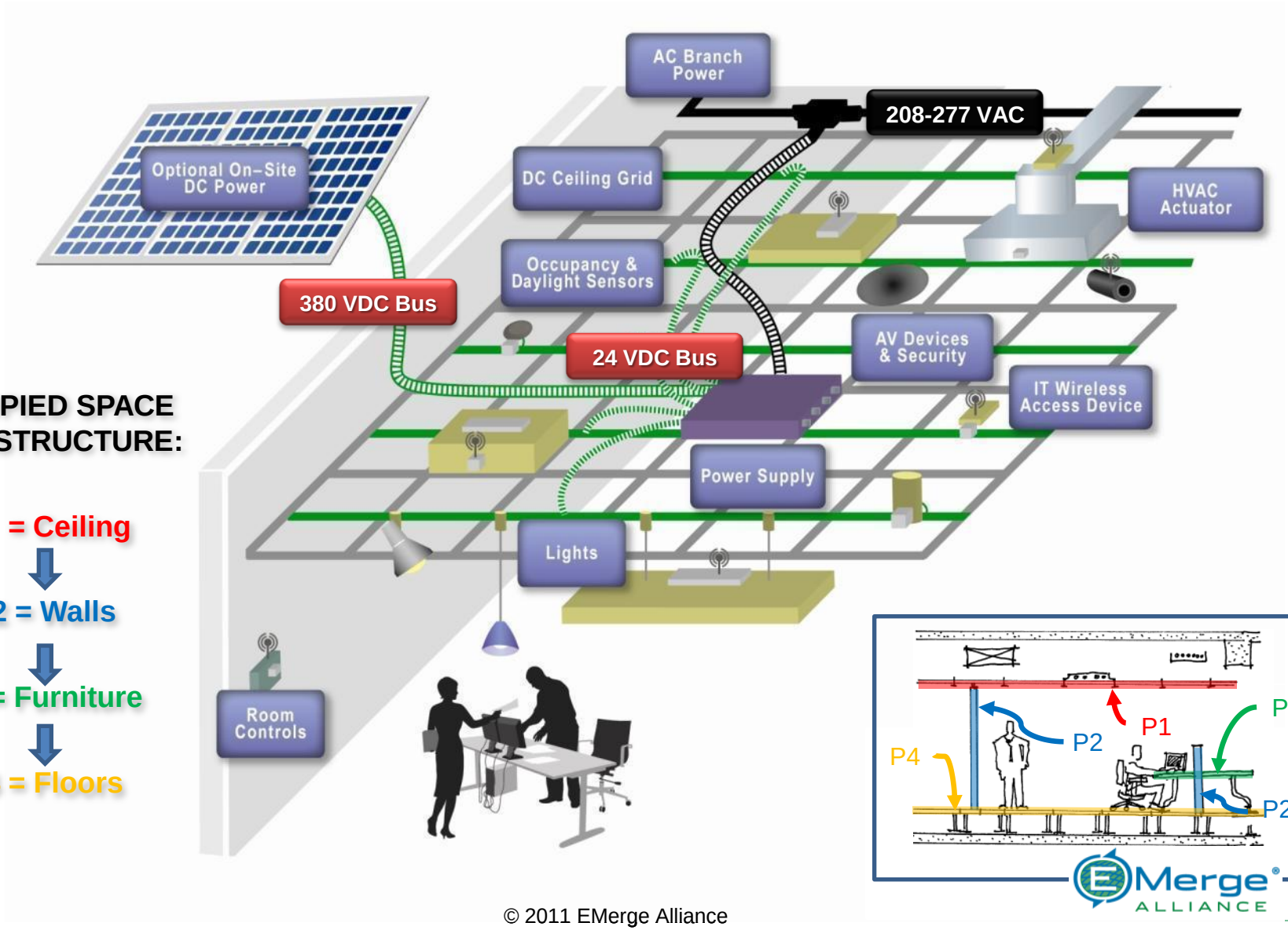
Bill Tschudi
Lawrence Berkeley National Laboratories

Nana Wilberforce
The PNC Financial Services Group, Inc.

Kurt Yeager
Galvin Electricity Initiative

Occupied Space Standard

Working from the Top Down



OCCUPIED SPACE INFRASTRUCTURE:

P1 = Ceiling

P2 = Walls

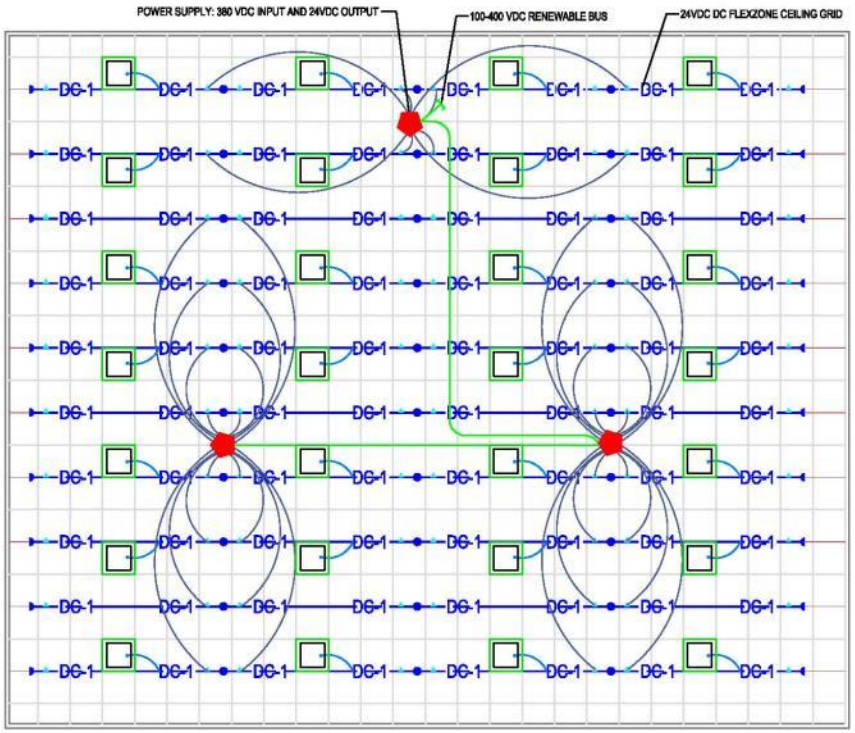
P3 = Furniture

P4 = Floors

Occupied Space Standard

Example 1: Building AC Feed

208-277VAC/24 VDC-DC Hub and Spoke Connected Distribution Bus Grid



These drawings show typical conditions in which the Armstrong product depicted is installed. They are not a substitute for an architect's or engineer's plan and do not reflect the unique requirements of local building codes, laws, statutes, ordinances, rules and regulations (Legal Requirements) that may be applicable for a particular installation.

Armstrong does not warrant, and assumes no liability for the accuracy or completeness of the drawings for a particular installation or their fitness for a particular purpose. The user is advised to consult with a duly licensed architect or engineer in the particular locale of the installation to assure compliance with all Legal Requirements.

Armstrong is not licensed to provide professional architecture or engineering design services.

PROJECT NAME: AC FEED – 24VDC Distribution			
DWG. NO.	PATH:	REV: .	DATE: .
DATE: 05-16-11	SCALE:	DESC.: .	
DRAWN BY: DLH	CHK BY:	.	

TechLine Armstrong CEILING SYSTEMS * ARMSTRONG WORLD INDUSTRIES, INC. * Lancaster, PA * Phone: 877-ARMSTRONG

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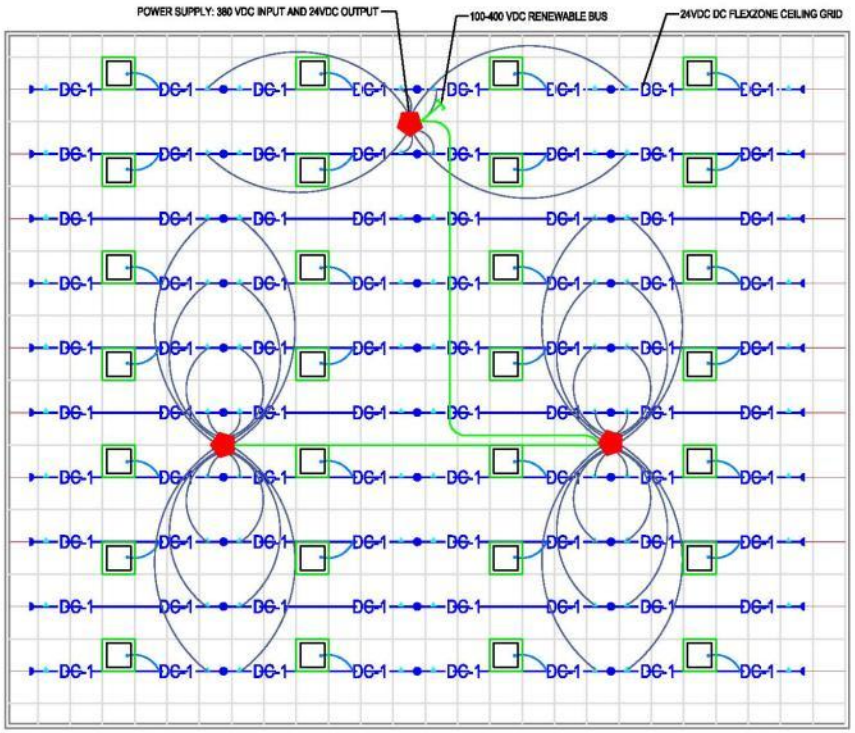
Occupied Space Standard

Example 2: DC Feed

100-400VDC/24 VDC-DC Hub and Spoke Connected Distribution Bus Grid



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PROJECT NAME: DC FEED – 24VDC Distribution			
DWG. NO.	PATH:	REV: .	DATE: .
DATE: 05-16-11	SCALE:	DESC.: .	
DRAWN BY: DLH	CHK BY:	.	

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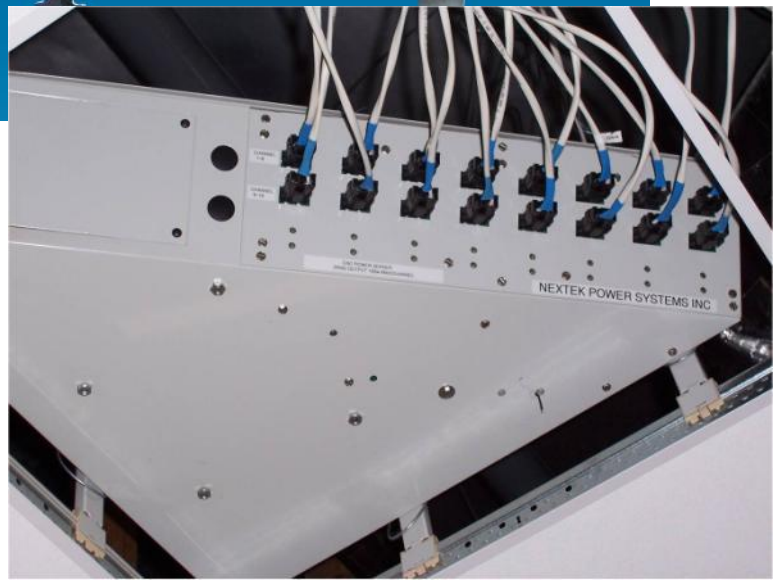
Product Example:

Multi Channel Power Distribution Hub

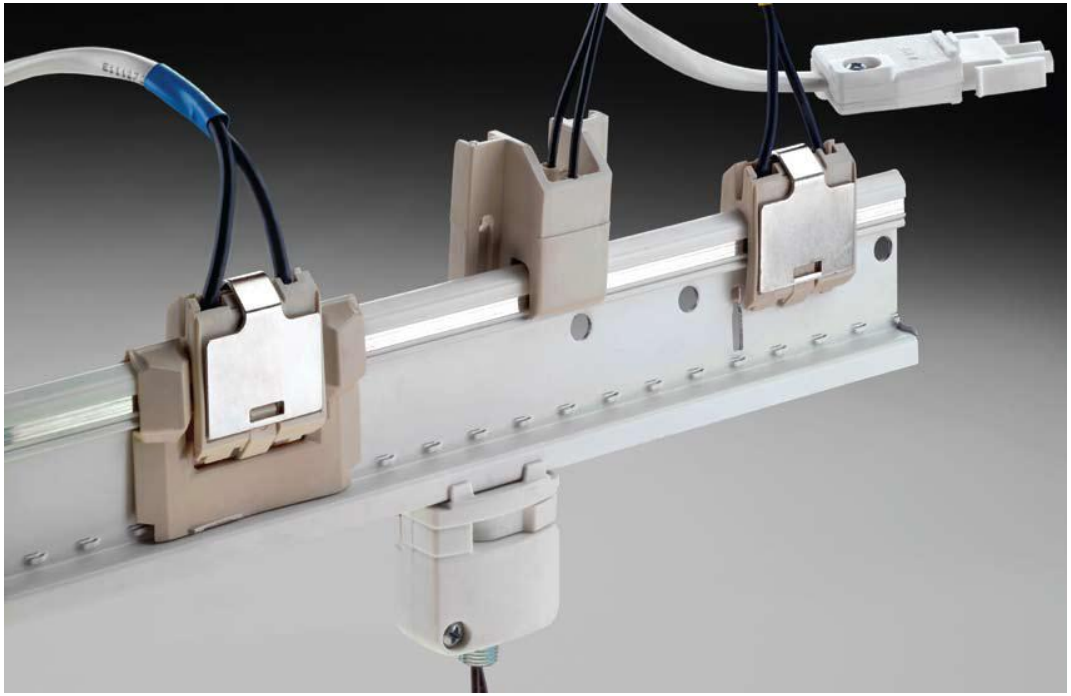


- AC-DC conversion at high efficiency
- 16 Isolated class 2 LVDC channels
- Automatic fault protection
- Automatic reset – audible and visual alarms
- Embedded RF communications
- Ceiling Grid mounted
- UL Listed

EMerge® ALLIANCE

Product Example:

Multi Channel Power Distribution Hub



- **Power-in. Power-out, Chassis mount, Power-slot**
- **Special keying to prevent over powering**
- **Compatible with all ceiling grid styles**
- **UL Listed Cable Assemblies**

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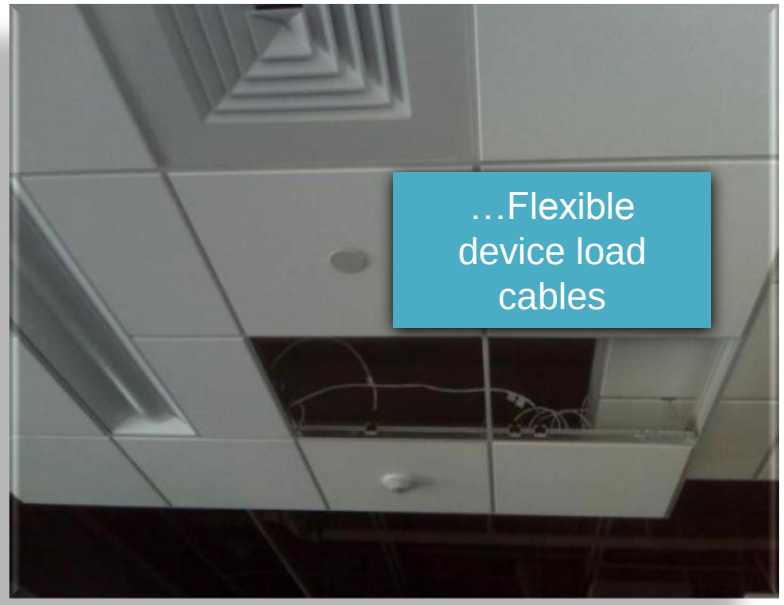
Product Example:

Fluorescent Fixtures

Current Designed & Listed Product → Change to DC Ballast → Add Device Load Connector/Cable Assembly



- **Direct DC input eliminates AC-DC conversion**
- **Can improve ballast efficiency by 10% or more**
- **Results in higher lighting system efficacy (light output per watt)**
- **Can improve ballast reliability significantly by eliminating HV inductors**

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Product Example:

LED Fixtures

Current Designed & Listed Product → **Change to Listed DC Driver** → **Add Listed Device Load Connector/Cable Assembly**

- **Direct DC input eliminates AC-DC conversion**
- **Can improve driver efficiency by 10% or more**
- **Results in higher lighting system efficacy (light output per watt)**
- **Can improve driver reliability significantly by eliminating HV inductors**

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Product Example:

Wired & Wireless Control Alternatives

Current Designed & Listed Product → **Change to Listed DC Power Input** → **Add Listed Device Load Connector/Cable Assembly**

- **Works with any 0-10V controlled device**
- **Eliminate high voltage switches, relays and wiring.**
- **Actuators for room level sensors and devices.**
- **Stand-along or can Integrate with Building Automation system**
- **Uses robust ZigBee® communication technology**

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EMerge Alliance Occupied Space Standard

Beta Site Applications in the Field

PNC Financial
Headquarters Office
Pittsburgh, PA

lauckgroup
Architectural Office
Dallas, TX

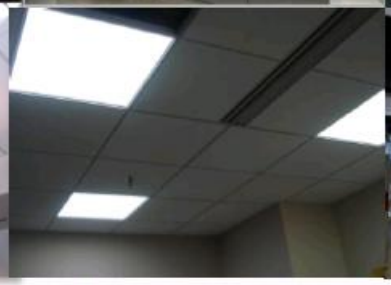
US Green Bldg Council
Conference Rooms
Washington, DC

Nextek Power
NextEnergy Center
Detroit, MI

UC San Diego
Sustainability Center
San Diego, CA

Southern Cal Edison
Utility Services Office
Irwindale, CA

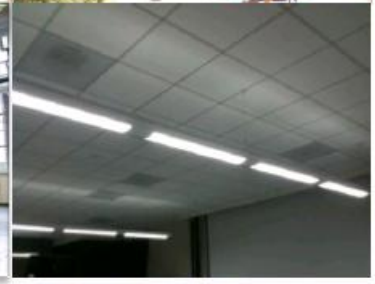
Johnson Controls
Headquarters Office
Milwaukee, WI



Optima Engineering
MEP Firm
Charlotte, NC

LA Community College
Trade Tech Campus
Los Angeles, CA

CA Lighting Tech Center
UC Davis Campus
Davis, CA



Solar to Fluorescent Lighting

LEED® GOLD CERTIFIED

Sustainability Resource Center
Equity-Environment-Economy
UC San Diego
Local Impact, National Influence, Global Reach

UC San Diego
Sustainability Resource Center

EMerge® ALLIANCE

Solar to LED Lighting

Optima Engineering
Charlotte, NC

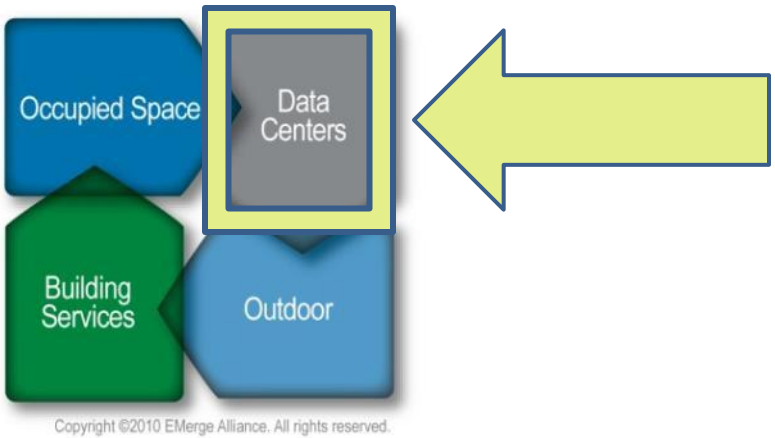
New: Solar Upgrade

LEED® GOLD CERTIFIED

USGBC Headquarters
Washington, DC

2nd Standard – Data and Telecom

Developing a 380VDC ICT Standard



Technical Committee led by

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Data Centers By the Numbers

99% of Data Centers are in 57% of Buildings

Type	Server Closet	Server Room	Localized Data Center	Mid-tier Data Center	Enterprise-Class Data Center
Scope	Secondary computer location, often outside of IT control, or may be a primary site for a small business	Secondary computer location, under IT control, or may be a primary site for a small business	Primary or secondary computer location, under IT control	Primary computing location, under IT control	Primary computing location, under IT control
Power/cooling	Standard room air-conditioning, no UPS	Upgraded room air conditioning, single UPS	Maintained at 17°C; some power and cooling redundancy	Maintained at 17°C; some power and cooling redundancy	Maintained at 17°C; at least N+1 power & cooling redundancy
Sq ft	<200sq ft	<500sq ft	<1,000sq ft	<5,000sq ft	>5,000 sq ft
US data centers (2009 est)	1,345,741 = 51.8%	1,170,399 = 45.1%	64,229 = 2.5%	9,758 = 0.4%	7,006 = 0.3%
Total Servers (2009 est)	2,135,538 = 17%	3,057,834 = 24%	2,107,592 = 16%	1,869,595 = 15%	3,604,678 = 28%
Average servers per location	2	3	32	192	515





Source Data Courtesy of EPRI ELECTRIC POWER RESEARCH INSTITUTE

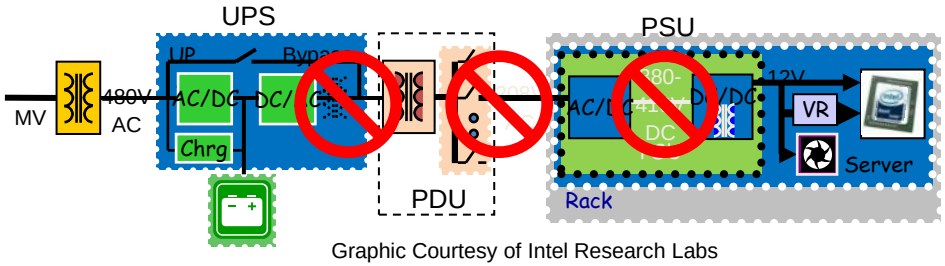
Benefits of DC in Data Centers

Eliminating Conversions Pays Big Dividends

EMerge ALLIANCE

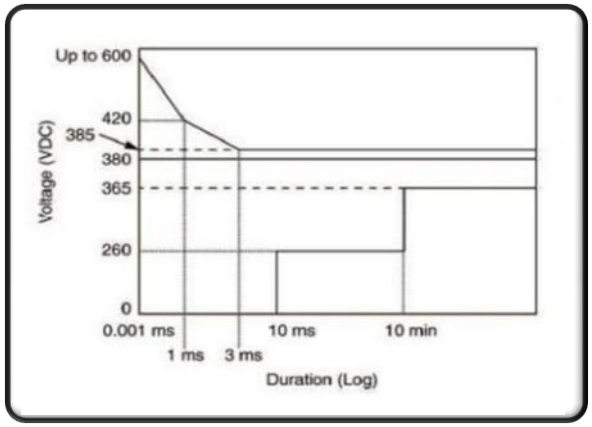
380VDC – The New Standard

The Highest Efficiency, Most Cost Effective Solution



Graphic Courtesy of Intel Research Labs

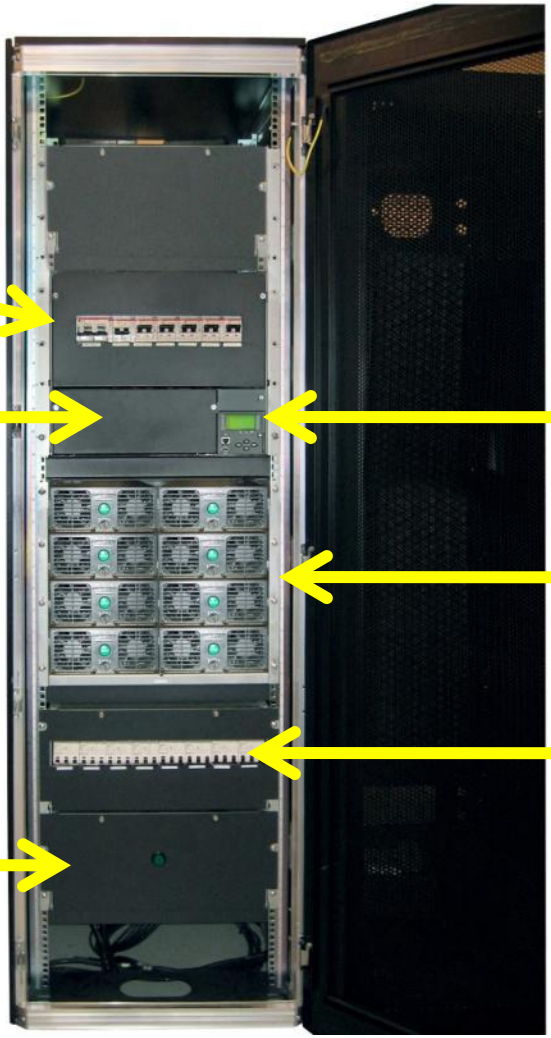
- ETSI 300132-3 (draft)
- Japan DC Power Partners
- EMerge Alliance
- IEC – LVDC WG
- Datacenter
  - ✓ 28% more efficient than 208VAC
  - ✓ 7% more efficient than 415VAC
  - ✓ Est. 15% less up-front capital cost in volume
  - ✓ 33% less floor space
  - ✓ 200%-1000% more reliable
  - ✓ No Harmonics, Safer
- Compliments Building-wide Photovoltaic, Wind, Lighting, Electric Vehicles & Charging, VFD Motors



Slide Courtesy of intel

Data Center DC Product Examples

105kW (n+1) 380VDC PS



Slide Courtesy of EMERSON Network Power

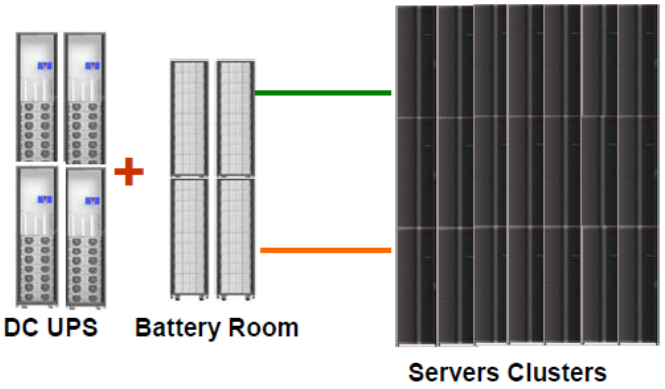
Data Center DC Product Examples

280kW (n+1) 380VDC PS

80kW 120kW 160kW ··· 280kW

- Modular design
- Hot-swappable control module
- 20kW per power module
- Redundancy Configuration

Facility Configuration



Row Configuration

Slide Courtesy of DELTA

Data Center DC Product Examples

380VDC Power Supplies, Interconnect Cables, Bus Ways, Outlet Strips, Breakers

Slide Courtesy of STARLINE DC SOLUTIONS

EMerge Alliance Data/Telecom Standard

Beta Site Applications in the Field

EPRI/LBNL - Electric Power Research Institute
Lawrence Berkeley National Lab, California

Ernest Orlando Lawrence Berkeley National Laboratory

EPRI Electric Power Research Institute

Duke Energy data center in Charlotte, North Carolina

Duke Energy

Calit2 - California Institute for Telecommunications and Information Technology , UC San Diego

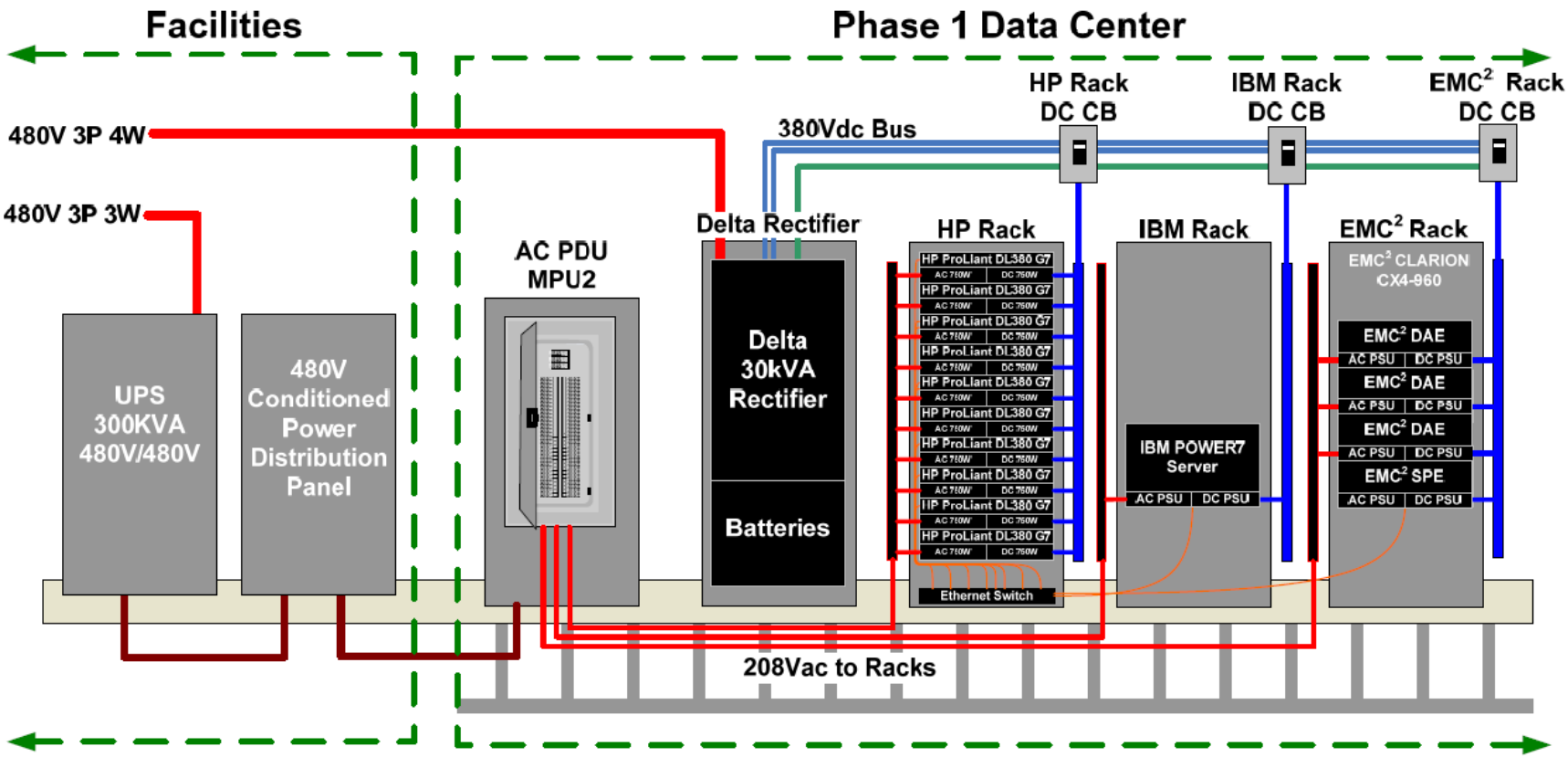
Sustainability Resource Center Equity-Environment-Economy
UC San Diego
Local Impact, National Influence, Global Reach

it²

EMerge® ALLIANCE

EMerge Alliance Data/Telecom Beta

Duke Energy Beta Site Configuration Yielded 15% Improvement

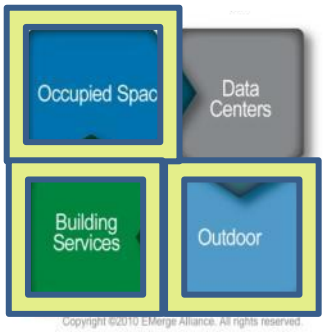


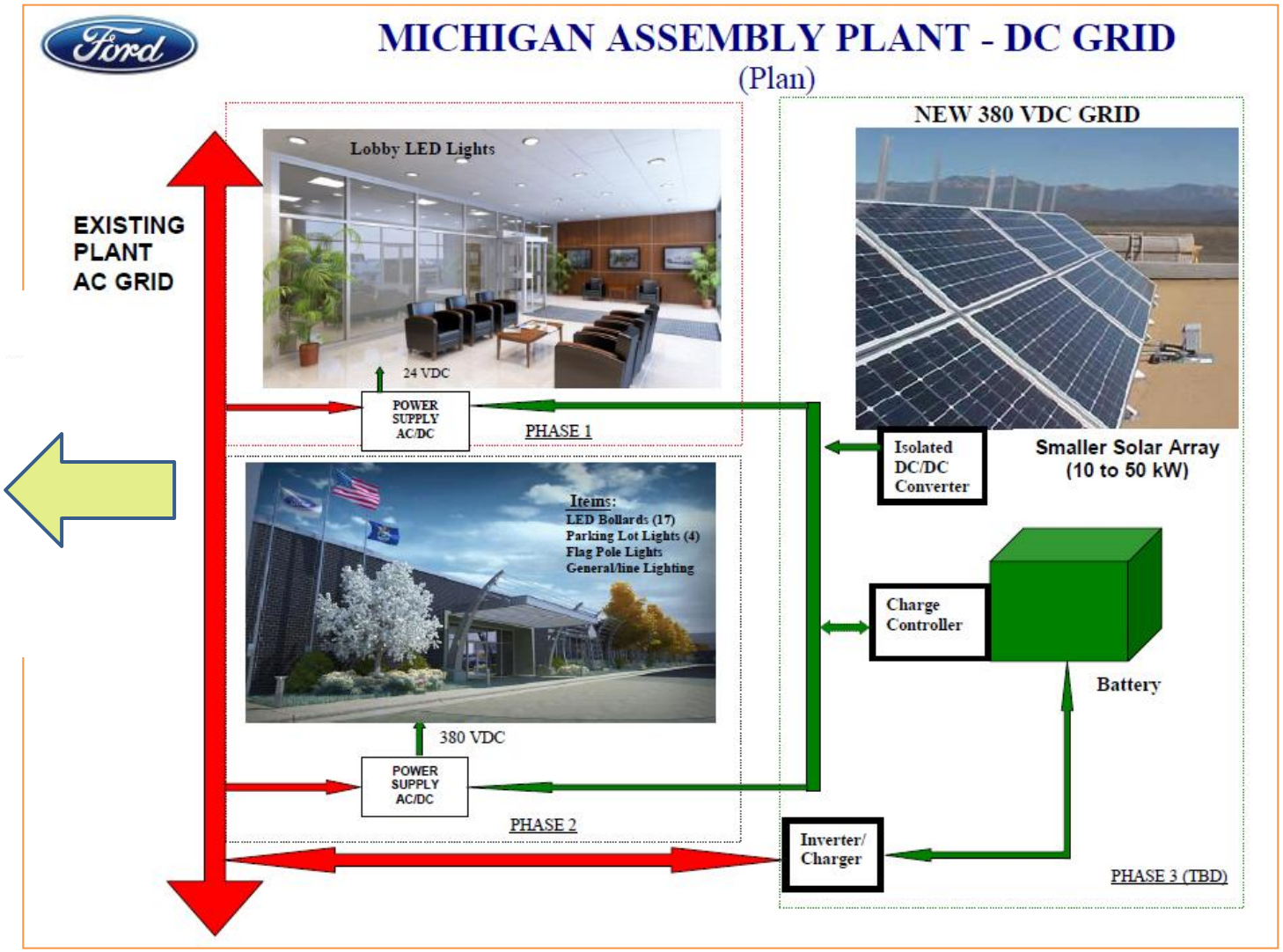
EPRI Lead Team included: HP, IBM, EMC, Delta, Starline

Slide Courtesy of EPRI ELECTRIC POWER RESEARCH INSTITUTE

Whole Building Hybrid DC Microgrid

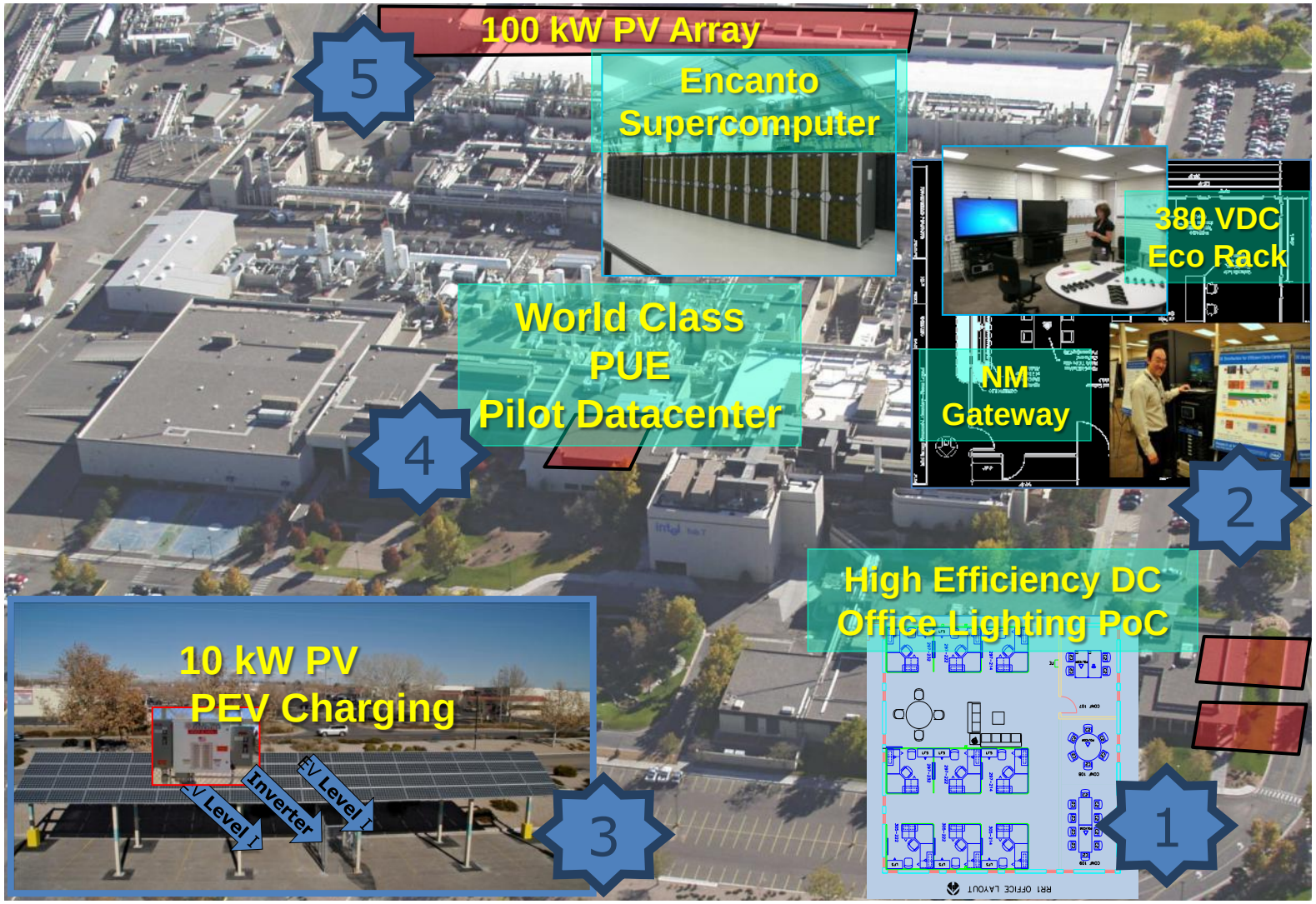
Ford's Deep Renovation Strategy Includes Multiple Stages





Standards Allow Incremental Plan/Execution

Five Discrete Projects Capture Key Elements

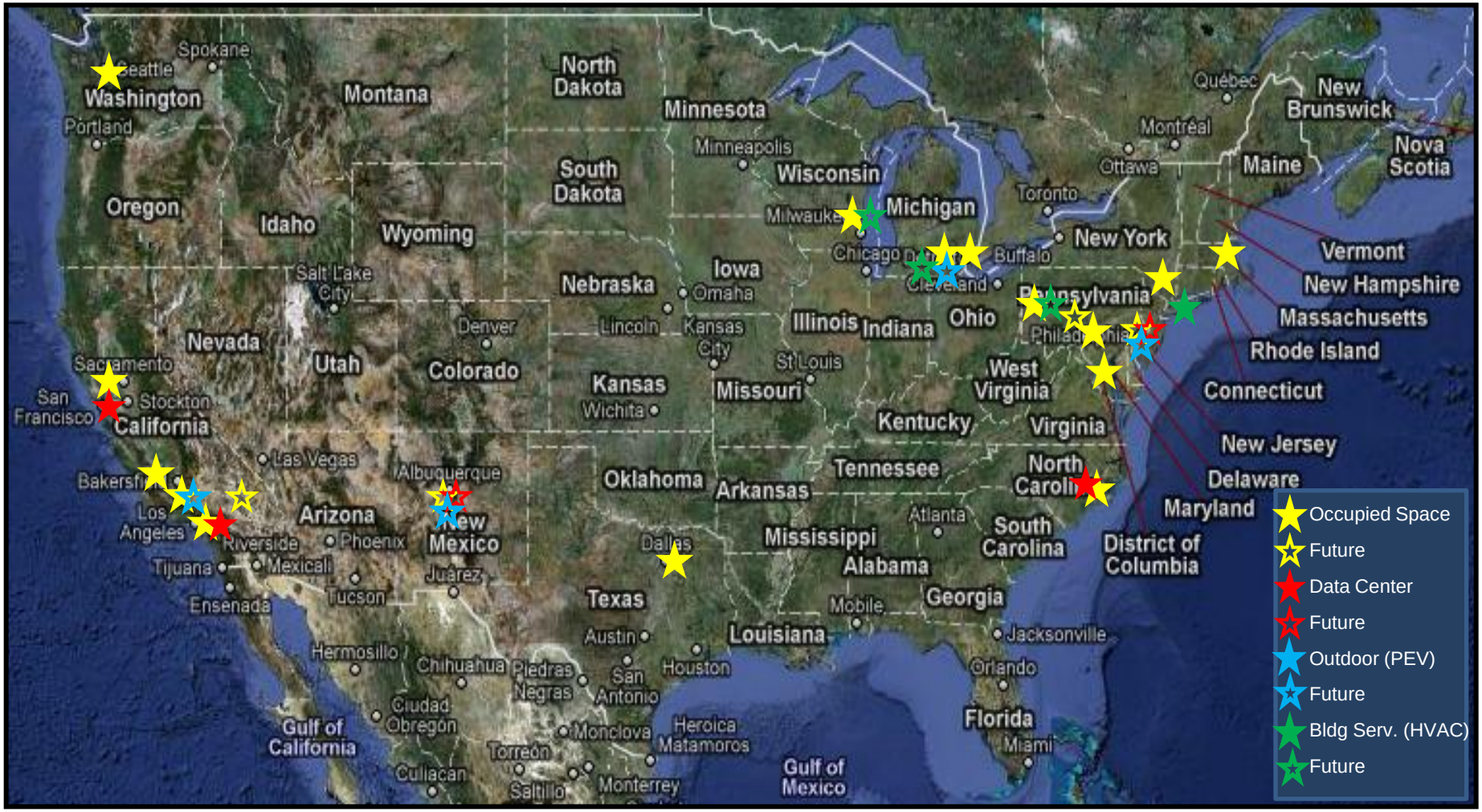


Rio Rancho Campus

Courtesy of Intel Research Labs

EMerge Alliance Beta Sites

Standards Applications in the Field



Combined Beta and Registered Sites as of February 2011

Save Energy – Connect DC-DC

Native Energy Sources to Efficient Building Loads

EMerge® ALLIANCE

Benefits of EMerge Standard Applications

Safe – Practical – Efficient - Effective

Flexibility

- Plug & play use of devices, upgradeable
- Faster, easier, cheaper for moves, adds & changes

Energy Savings

- Less conversions in DC sources & loads
- LED lighting - 5-15% more efficient, driven by DC
- Solar, wind, fuel cells - 5-10% savings if used direct

Sustainability

- Re-use of buildings and equipment
- More efficient use of clean energy & DC devices
- Smarter buildings (device level controls) for Smart Grid efforts

EMerge® ALLIANCE

www.EMergeAlliance.org

Direct Current (DC) Microgrid Power Application Standards for Buildings