Promoting the Use of Green IT by Reducing Energy and Real Estate

A presentation of the EMerge Alliance

Tim Martinson – *Moderator*
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Universal Electric Corporation

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EPRI (Electric Power Research Institute

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Duke Energy

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Starline DC Solutions

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NM Energy & Sustainability Research Center
Intel Labs

EMerge® ALLIANCE

DC-The Power to Change Buildings

What is the EMerge Alliance?

- Not-for-profit 501c Part 6
- Open application standards - DC platform
- Developing family of inter-related standards
- Eco-system development and promotion
- 80+ Member organizations and growing!

Who is the EMerge Alliance?

- Manufacturers
- Building Owners
- Service Providers
- Technology Leaders
- Contractors/Builders/ Integrators
- Architects, Engineers
- National & Independent Labs
- Codes & Standards Groups

What is an EMerge Standard?

- Commercial Applications Standard
- Subordinate to safety, equipment standards
- Physical, electrical, operational interfaces
- Application definition - listing requirements of other standards

Members as of 9/15/2011

The EMerge Alliance

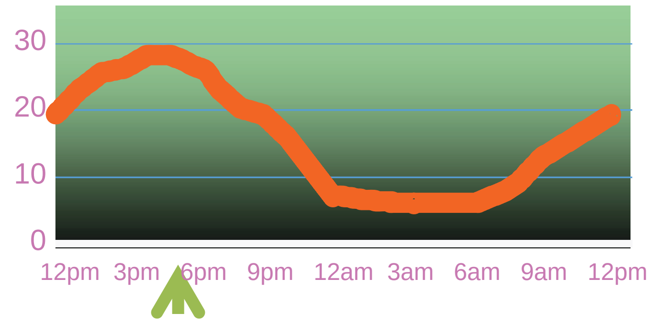
Created to Organize the Effort

- **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)

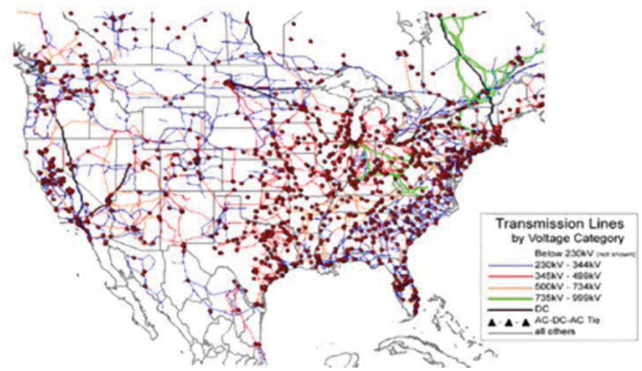
Trends in the New Energy Economy

Catching Up on 100 yrs of Little Progress

- **The Smart-Grid Drivers**
  - Automating the Grid
  - Distributed Generation Integration
  - Dynamic Pricing/Demand Response



- **Convergence Drivers for 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



- **Additional Drivers**
  - Cyber-Security
  - Low-Cost Energy Storage
  - User-Centered Energy Systems
- **Emerging New Markets**
  - New Power Electronics (Solid State DC)
  - Open Systems & Standards
  - Code & Regulatory challenges

Zero Energy Building Model

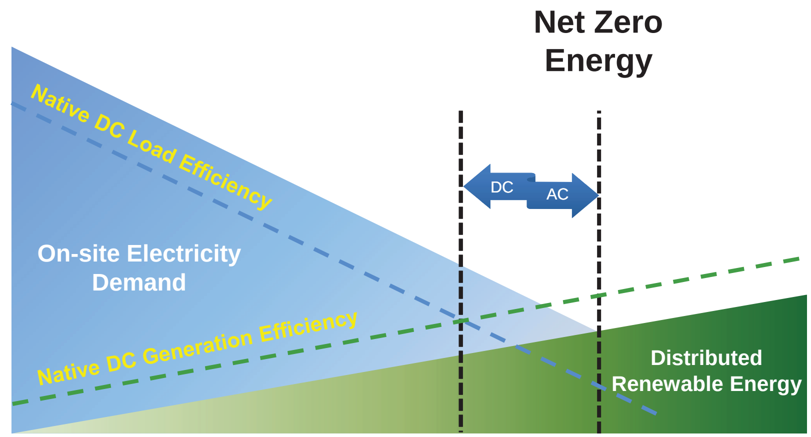
Buildings that produce as much energy as they consume

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

2012: **Begin DC Microgrid Demonstrations**
2030: **All new commercial buildings**
2040: **50% of commercial building stock**
2050: **All commercial buildings**

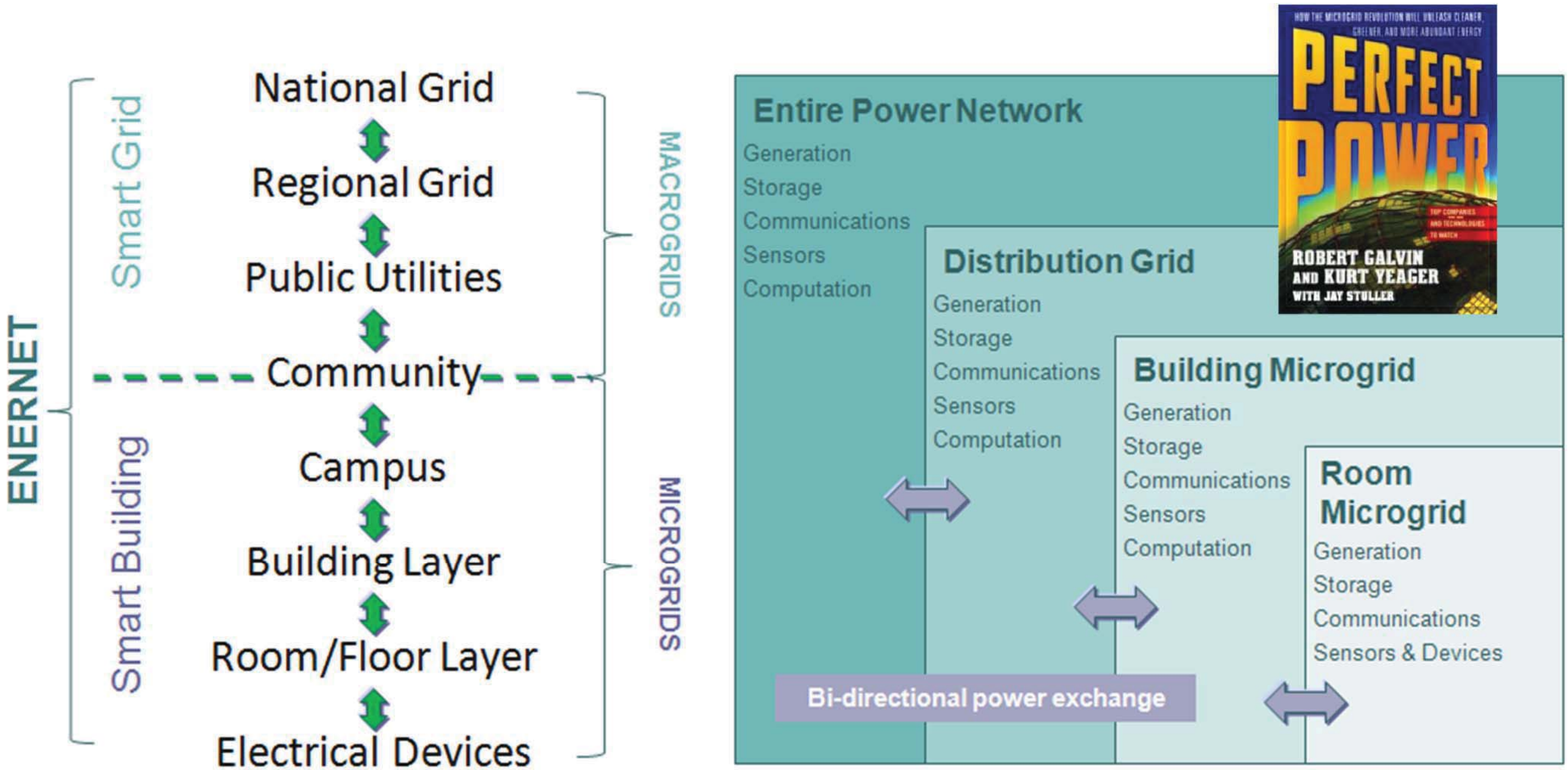


"DC power would fundamentally change the way power is distributed in commercial buildings…"


Greater Philadelphia Innovation Center Energy Hub

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 - co-invented of Ethernet, founder of 3Com and formulated Metcalfe's Law

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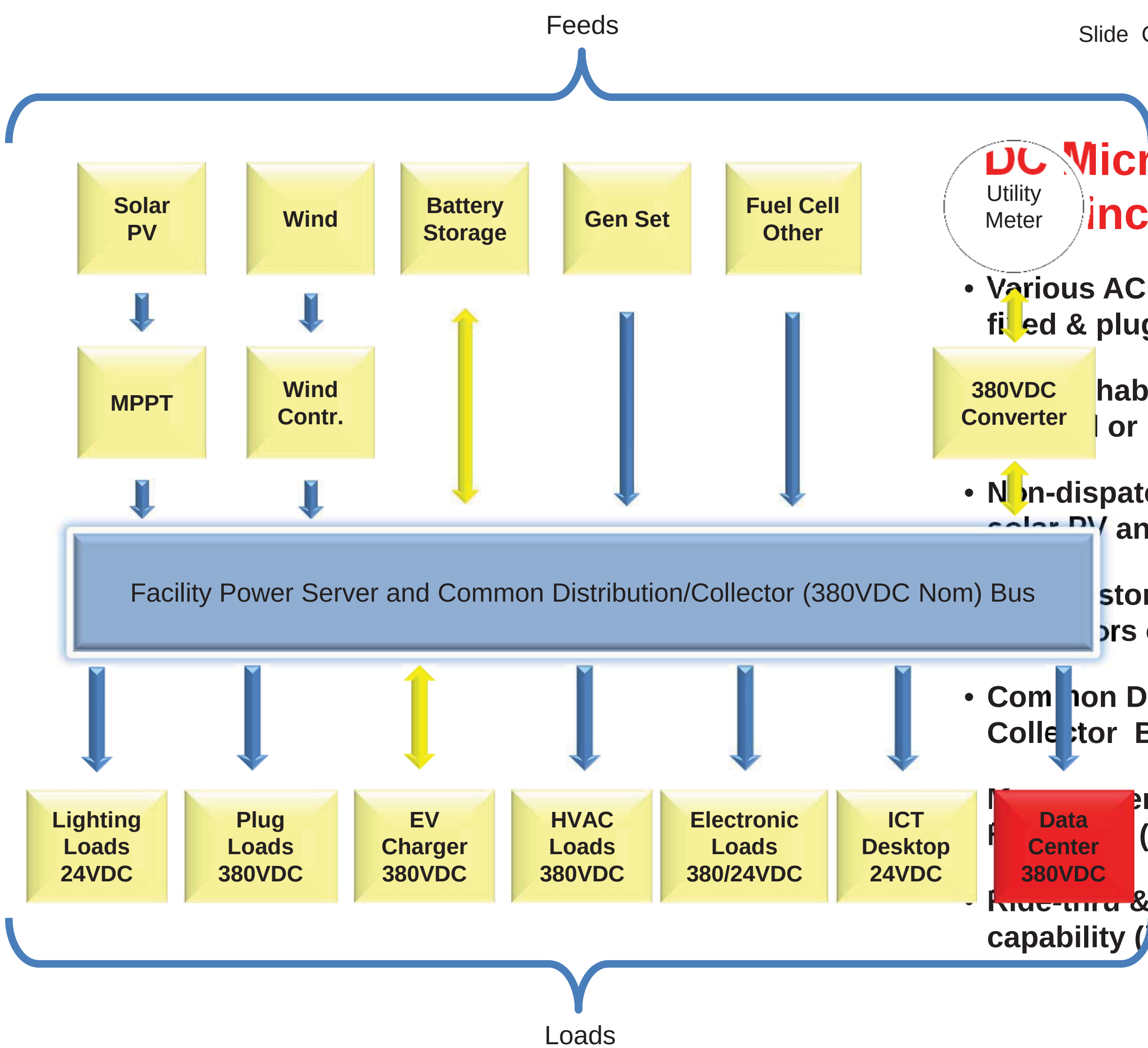
Zero Net Energy Buildings (ZEB)

DC Microgrid with Renewable & Alternate Distributed Generation

Slide Courtesy of EMERSON Network Power

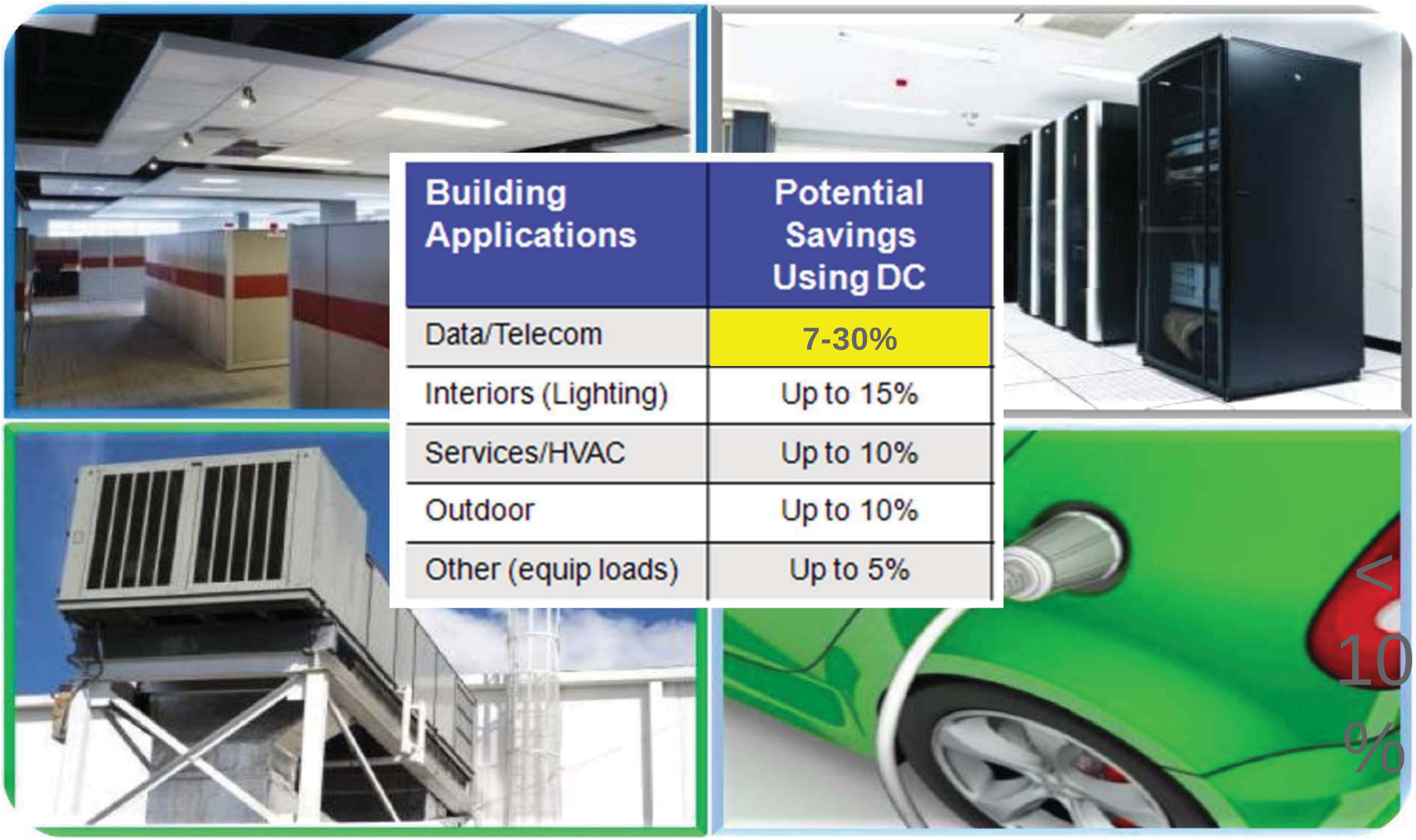


DC Microgrid may include :

- Various AC and DC loads: fixed & plug and play loads
- …hable generation: … or bio-fuel turbine.
- Non-dispatchable sources: solar PV and wind turbines.
- … storage, such as ultra-…ors or batteries.
- Common Distribution – Collector Bus
- M…ent & Demand R… (DR) capability
- Ride-thru & Off-grid operation capability (Islandable)

ZEB – Microgrid Building Blocks

A Microgrid network can deliver energy savings in all key areas



Building Applications	Potential Savings Using DC
Data/Telecom	**7-30%**
Interiors (Lighting)	Up to 15%
Services/HVAC	Up to 10%
Outdoor	Up to 10%
Other (equip loads)	Up to 5%

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Key Sponsors of Open LVDC Power Standards

It Takes Industry Giants to Rock the Foundation

Armstrong
PHILIPS
TE connectivity
intel
STARLINE DC SOLUTIONS
EMERSON Network Power
SOUTHERN CALIFORNIA EDISON An EDISON INTERNATIONAL Company
OSRAM SYLVANIA
AcuityBrands
COOPER
SAMSUNG

JUNIPER NETWORKS
APP Anderson Power Products
HUBBELL
legrand
BOSCH
Johnson Controls
ABB
EPRI ELECTRIC POWER RESEARCH INSTITUTE
GE imagination at work
CVTA CONNECTED VEHICLE TRADE ASSOCIATION

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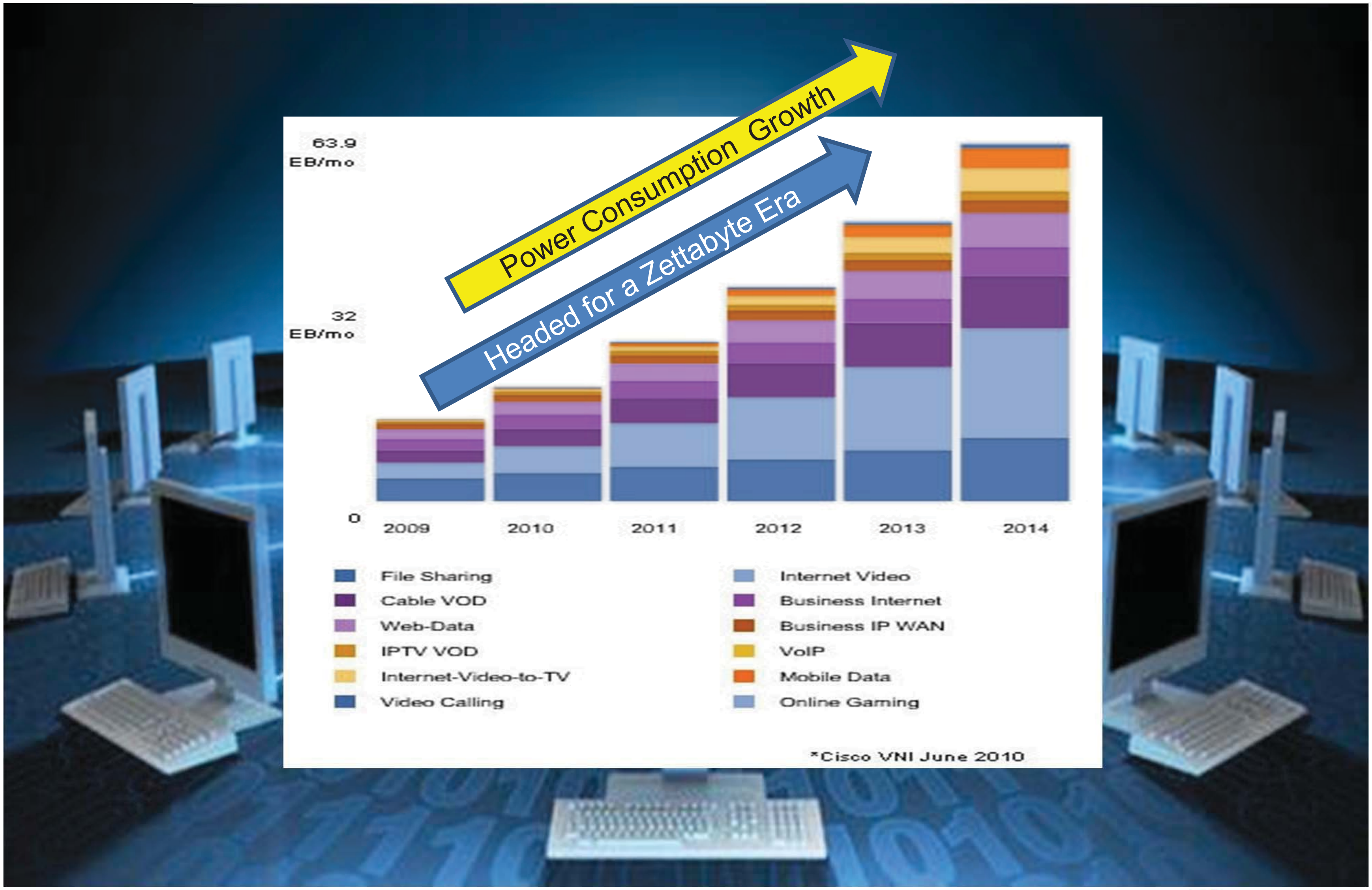
Data Centers in Multi-Decade Growth Spurt

Electrical Demand follows Internet Traffic Growth Closely



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

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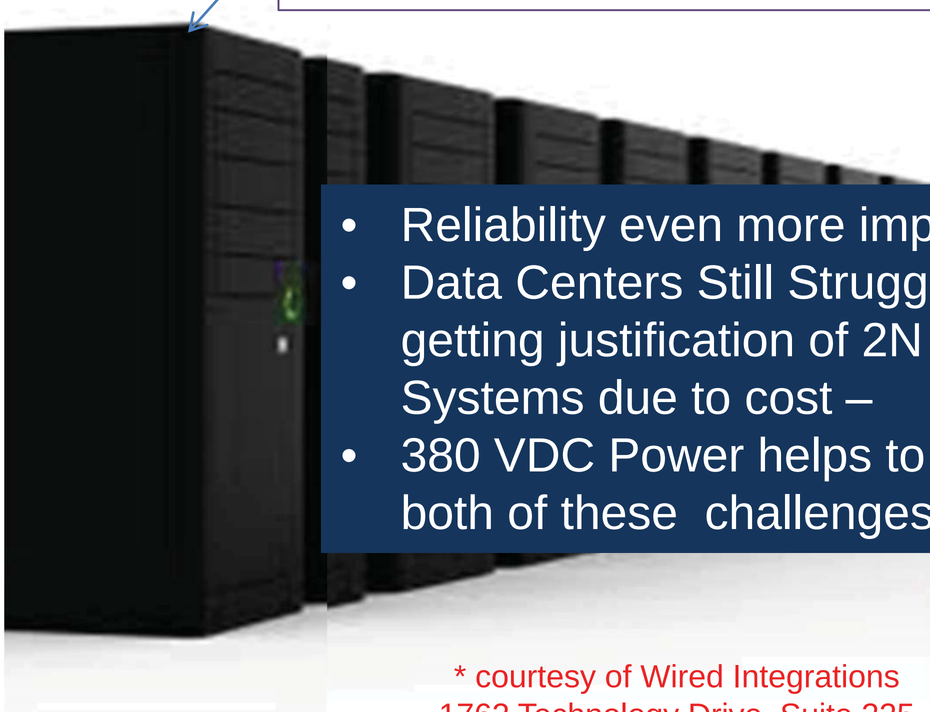
Virtualization…is driving density

$XXX,XXX Annual Application Value



- Reliability even more important
- Data Centers Still Struggle getting justification of 2N Systems due to cost –
- 380 VDC Power helps to solve both of these challenges

*Average consolidation is 8:1
Average Maintenance Agreement for 1U Server is $500
Average Maintenance Agreement for 2U Server is $750
8:1 Consolidation yields $3250 of savings per year

*Power Consumption
Average current 1U power supply is 675W
Average current 2U power supply also 675W
8:1 Consolidation yields a savings of 4725 Watts
4 tons of CO2 are eliminated for every server virtualized, the equivalent to taking 1.5 cars off the highway.

*Application Value Density –
8 racks into 1 = 8 Racks of Value in 1

* courtesy of Wired Integrations
1762 Technology Drive, Suite 225
San Jose, Ca. 95110
O: 408.441.8100   www.wiredint.com

ITS ALREADY A DC WORLD

"Semi-conductors began to evolve in the 1940s and 1950s and have become the predominant means of using power, and about 80 percent of power used in commercial buildings must go through some form of power electronics so it can be converted to DC," quote from studies conducted by the Center of Power Electronics Systems at Virginia Tech.

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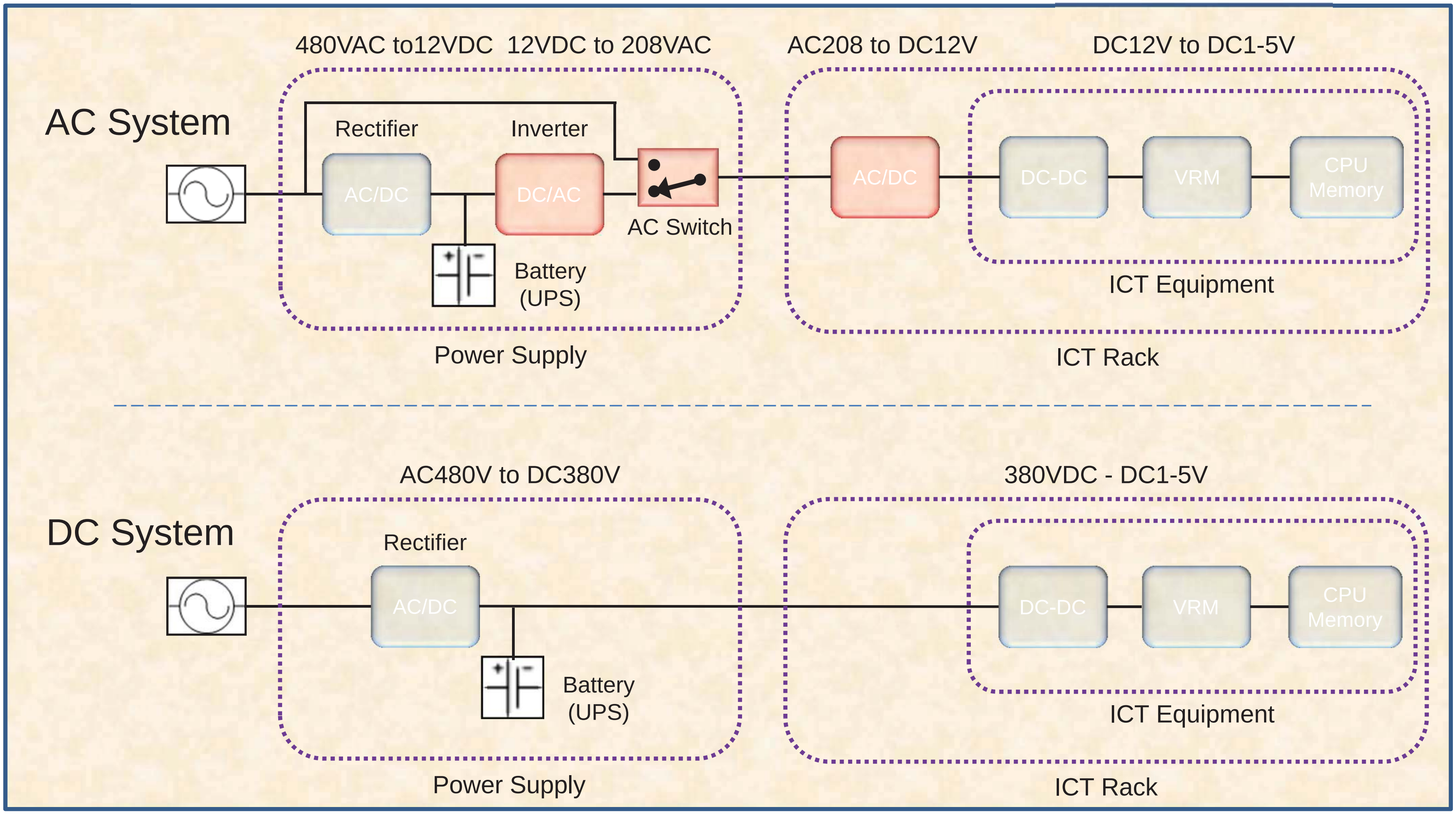
AC vs DC Power Systems for Data Centers

Reduce Loss, Footprint; Improve Reliability, Power Quality



Occupied Space Standard

Working from the Top Down

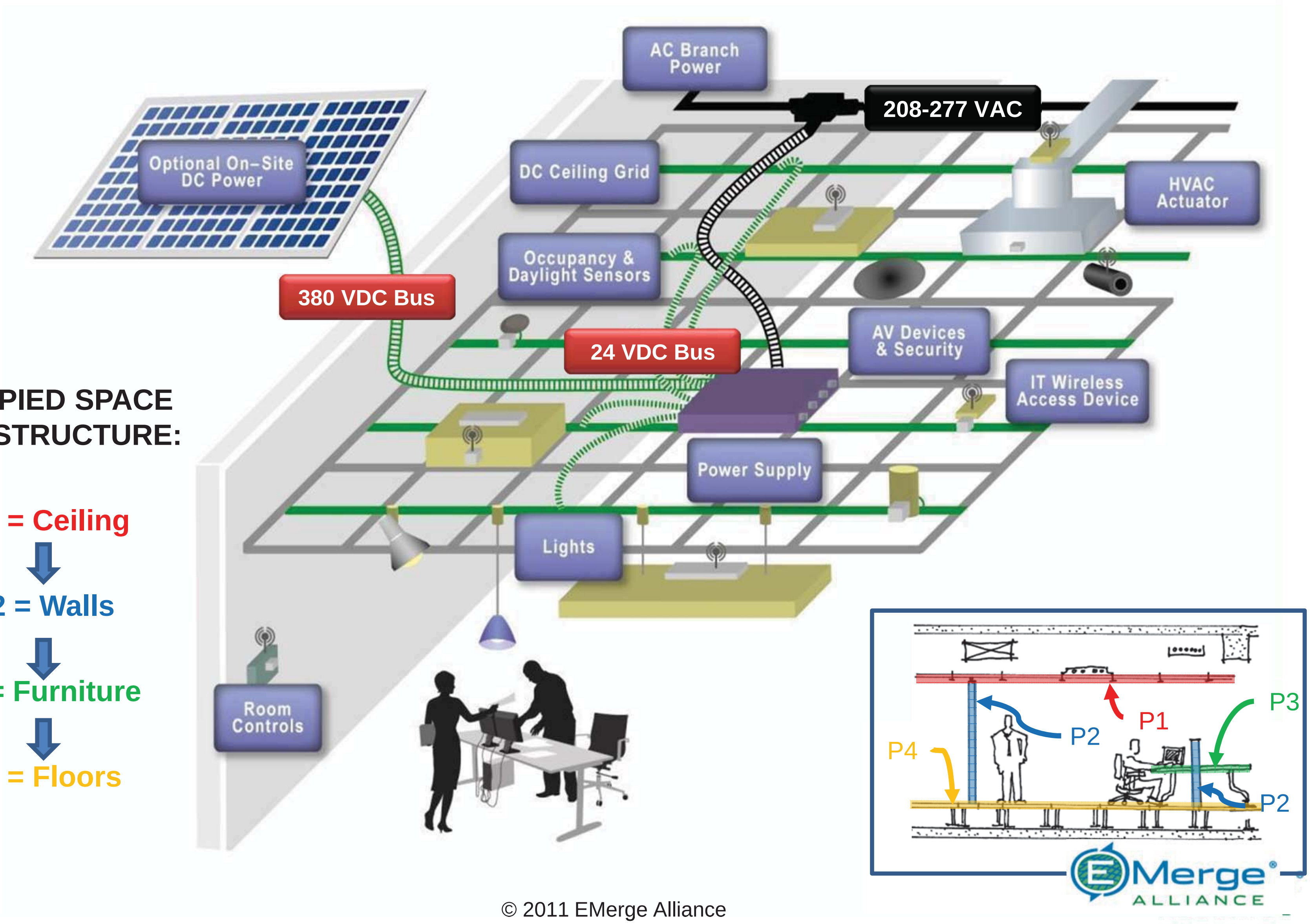
OCCUPIED SPACE INFRASTRUCTURE:

P1 = Ceiling

P2 = Walls

P3 = Furniture

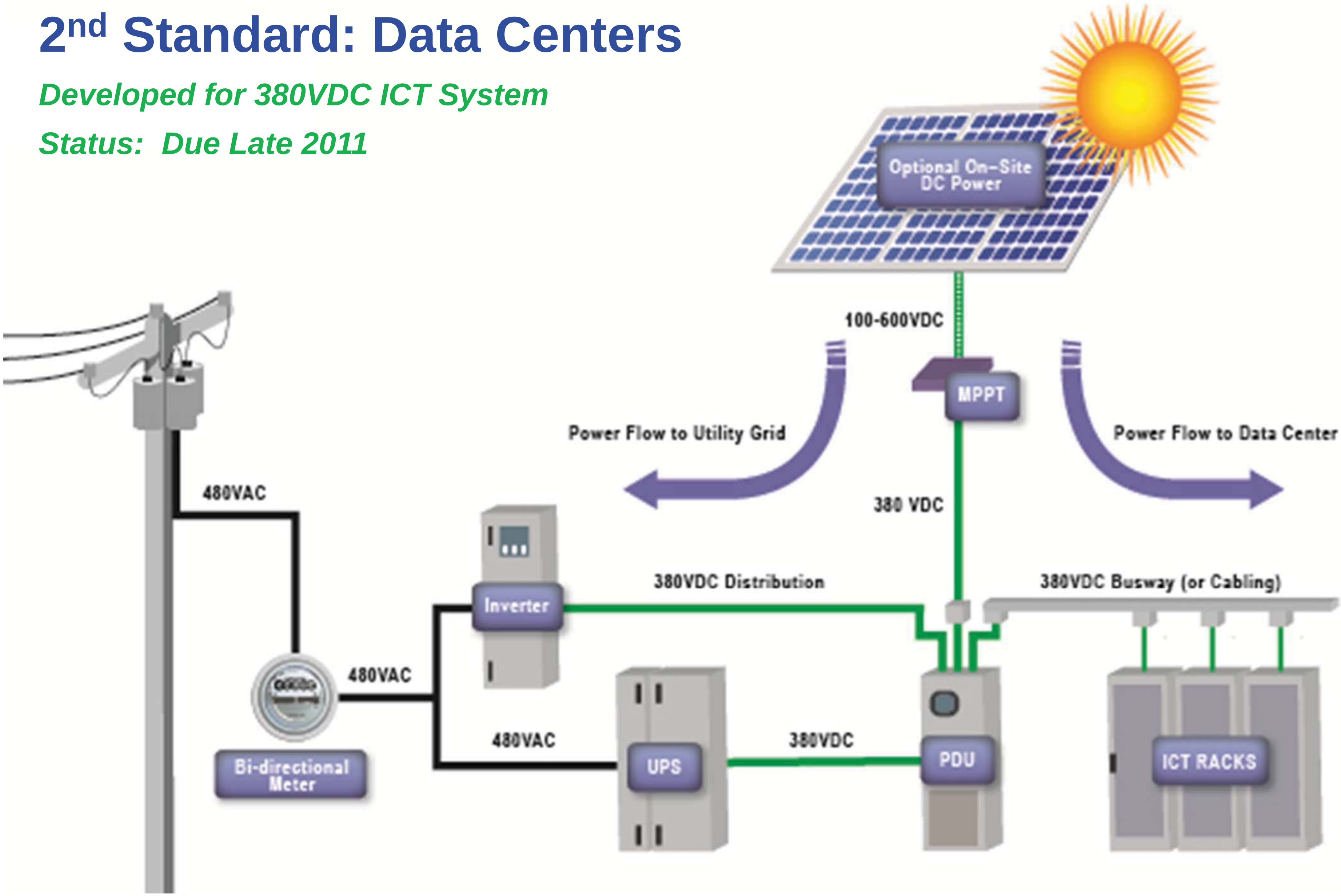
P4 = Floors



2^{nd} Standard: Data Centers

Developed for 380VDC ICT System

Status: Due Late 2011



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DC Power Offers a Safe Solution

Separating Fact from Fiction

- 30 volts is the threshold value for dangerous voltage. AC or DC above 30 volts can be potentially dangerous. Electric currents above 30 volts can cause dangerous involuntary muscle action.
- Low-frequency (50- to 60-Hz) AC used in households is 3 to 5 times more dangerous than DC of the same voltage and amperage. Low-frequency AC produces extended muscle contraction (tetany), which may freeze the hand to the current's source, prolonging exposure. DC is most likely to cause a single convulsive contraction, which often forces the victim away from the current's source.
- AC can throw the heart into fibrillation, whereas DC tends to just make the heart stand still. Once the current is removed a still heart has a better chance of regaining a normal beat than a fibrillating heart. This is why "defibrillating" equipment used by emergency medics is DC.
- Some "shocking potential" equivalents:

Voltage/Type	Peak	Equivalent VDC
24VDC (NG)	26.5V	26.5VDC
380VDC (CG)	190V	190VDC
120VAC (1Φ)	180V	720VDC
208VAC (3Φ)	294V	1175VDC
220VAC (3Φ)	311V	1245VDC
240VAC (1Φ)	339V	1355VDC
277VAC (1Φ)	392V	1570VDC
480VAC (3Φ)	679V	2715VDC

- Read more:
  - AC Vs. DC Safety | eHow.com http://www.ehow.com/facts_6300004_ac-vs_-dc-safety.html#ixzz1VniwqKfE;
  - http://www.allaboutcircuits.com/vol_1/chpt_3/1.html

EPRI Energy Efficiency Technology Pipeline

Accelerating Readiness of Emerging Efficient Technologies

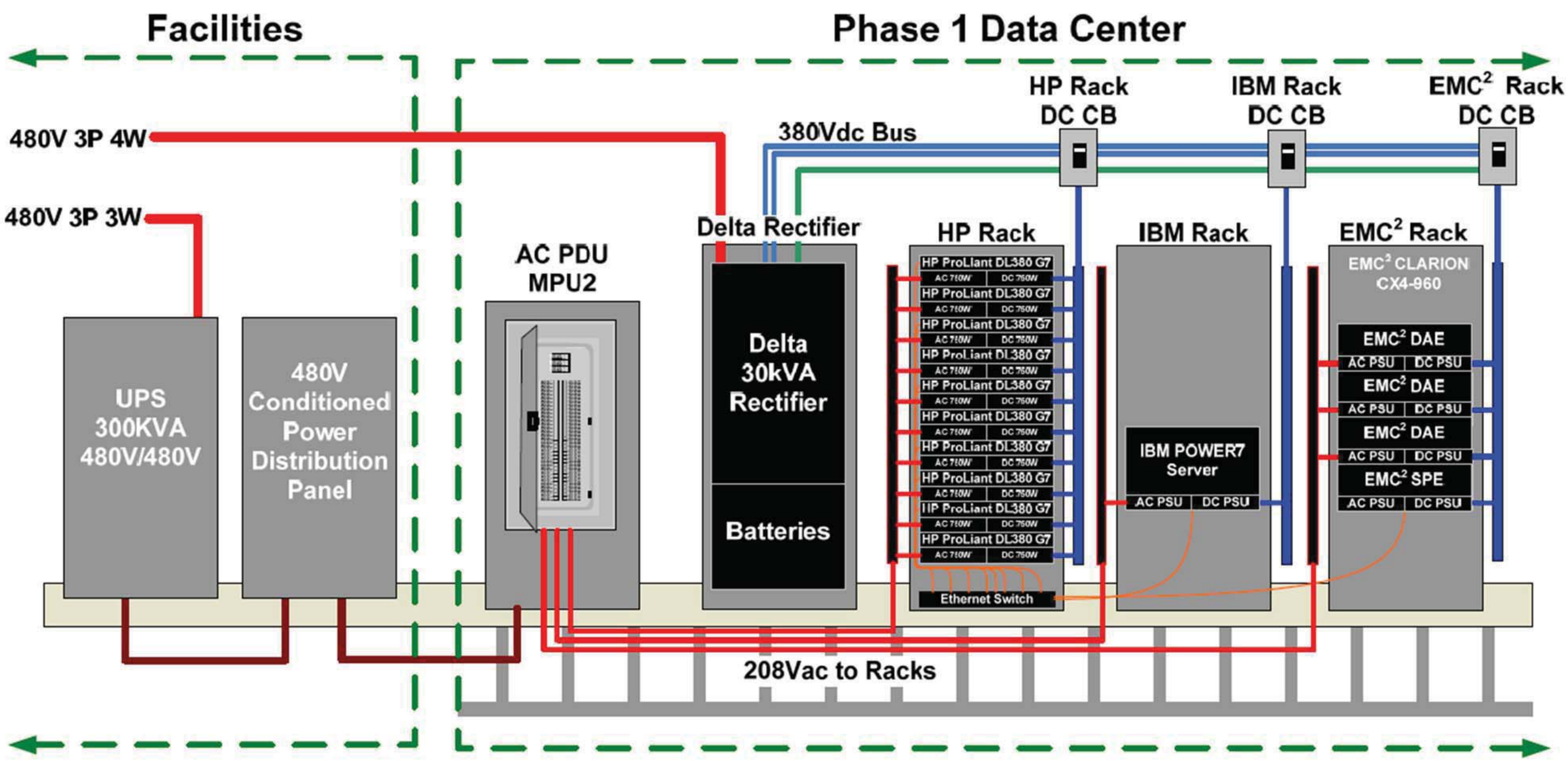
Technology Scouting	Assessment and Lab Testing	R&D Field Tests/ Demos	Early Deployments	Full Program Rollout
EPRI Technology Innovation	EPRI EE Base Program	EPRI EE Demonstration Project	EPRI Coordinated Early Deployment Initiative	Utility EE Programs
Scouting horizon for promising technologies	• Technology assessment and validation • Supporting analytics: EE potential, load shape, and environ-mental impact	• Instrument extensively • Evaluate: estimated deemed savings,	• Performance results to refine *deemed savings* • Consumer behavior • Develop supply infrastructure	• Full adoption • Conduct M&V

EPRI ELECTRIC POWER RESEARCH INSTITUTE

EMerge Alliance Data/Telecom Beta

Duke Energy Beta Site Configuration Yielded 15% Improvement

Duke Energy



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

Slide Courtesy of EPRI ELECTRIC POWER RESEARCH INSTITUTE

MEASUREMENT & VERIFICATION PLAN

Duke Energy
Data Center Demonstration Project

DC and AC Power Network Efficiency Comparison
Measurement and Verification Plan
Draft

EPRI
Chuck Thomas

July 20, 2010

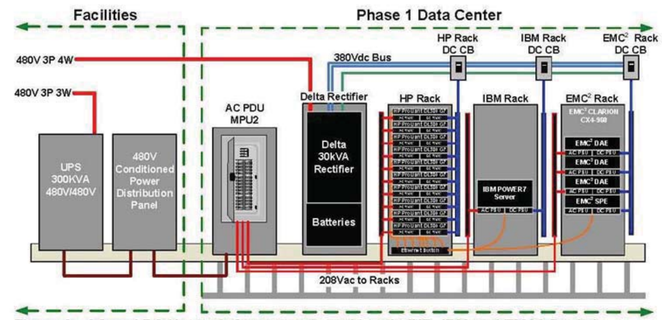


Figure 2 - AC and DC Network Components and Loads (HP, IBM and EMC2 Racks)

Lists of all test components are included in Table 1.

Table 1 – AC/DC Demonstration System Components (font BOLD signifies existing systems, all other devices are new to the facility and this project)

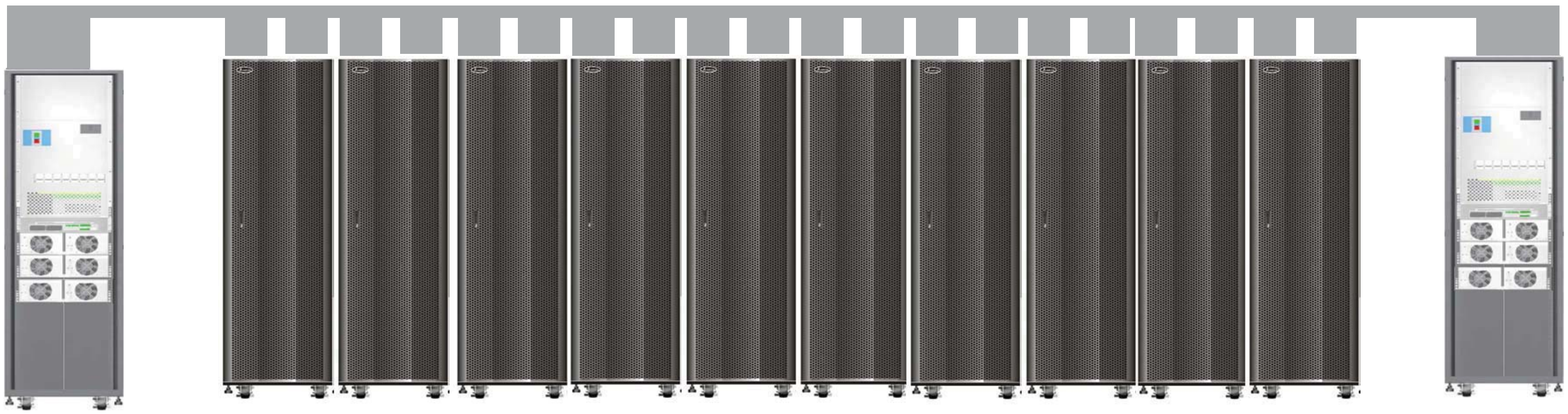
Manufacturer	Description	Applicable Power System	Quantity	Model	Power Rating
Delta Corp.	30kW 480VAC to 380VDC Rectifier	DC	1	30KW HVDC UPS	30kW
Liebert	**300kW UPS 480VAC to 480VAC Three-phase**	**AC**	**1**	**Series 610 UPS**	**300kW**
Liebert	**125kVA Data Center Power Distribution Unit**	**AC**	**1**	**PPA125C**	**125kW**
Hewlett Packard (HP)	ProLiant DL380 G7 Servers	Both	10	DL380G7	
Hewlett Packard (HP)	ProLiant DL380 G7 AC/DC Power Supply Unit (PSU)	AC	10	506821-001	750W
Hewlett Packard (HP)	ProLiant DL380 G7 DC/DC Power Supply Unit (PSU)	DC	10	506821-001	750W
IBM	POWER7 Server	Both	1	p7-FHB	
IBM	POWER7 AC/DC Power Supply Unit (Dual)	AC	8	BPR-ED	
IBM	POWER7 DC/DC Power Supply Unit (Dual)	DC	(same as above)	BPR-ED	
EMC^2	EMC^2 CLARION CX4-960 Networked Storage System	Both	1	CX4-960	
EMC^2	EMC^2 CLARION CX4-960 SPE Unit	AC	1	SPE AC PSU	1570W

The Intel White Paper – Validated almost

- 200% Reliability improvement (still theoretical, but this always is)
  - 15% Component volume reduction in every server power supply (PFC)
  - 2x lower probability of failure in 5 years
  - 1000% reliability improvement if direct connect to batteries
- 33% Space Savings
  - No PDUs, RPPS - simplified switchgear
- 15% Electrical facility capital cost savings – CAPEX Reduction
- Electrical is ~40% of total facility cost, i.e. saves 15% of 40% ~ 6% of total
- 7-8% Facility energy savings, incl. when compared to best-in-class AC system
  - (~15% over resent best in class – when HVAC benefits not included)

- Contributes to corporate sustainability goals-using fewer of the earth's resources

Modularity – The hidden benefit

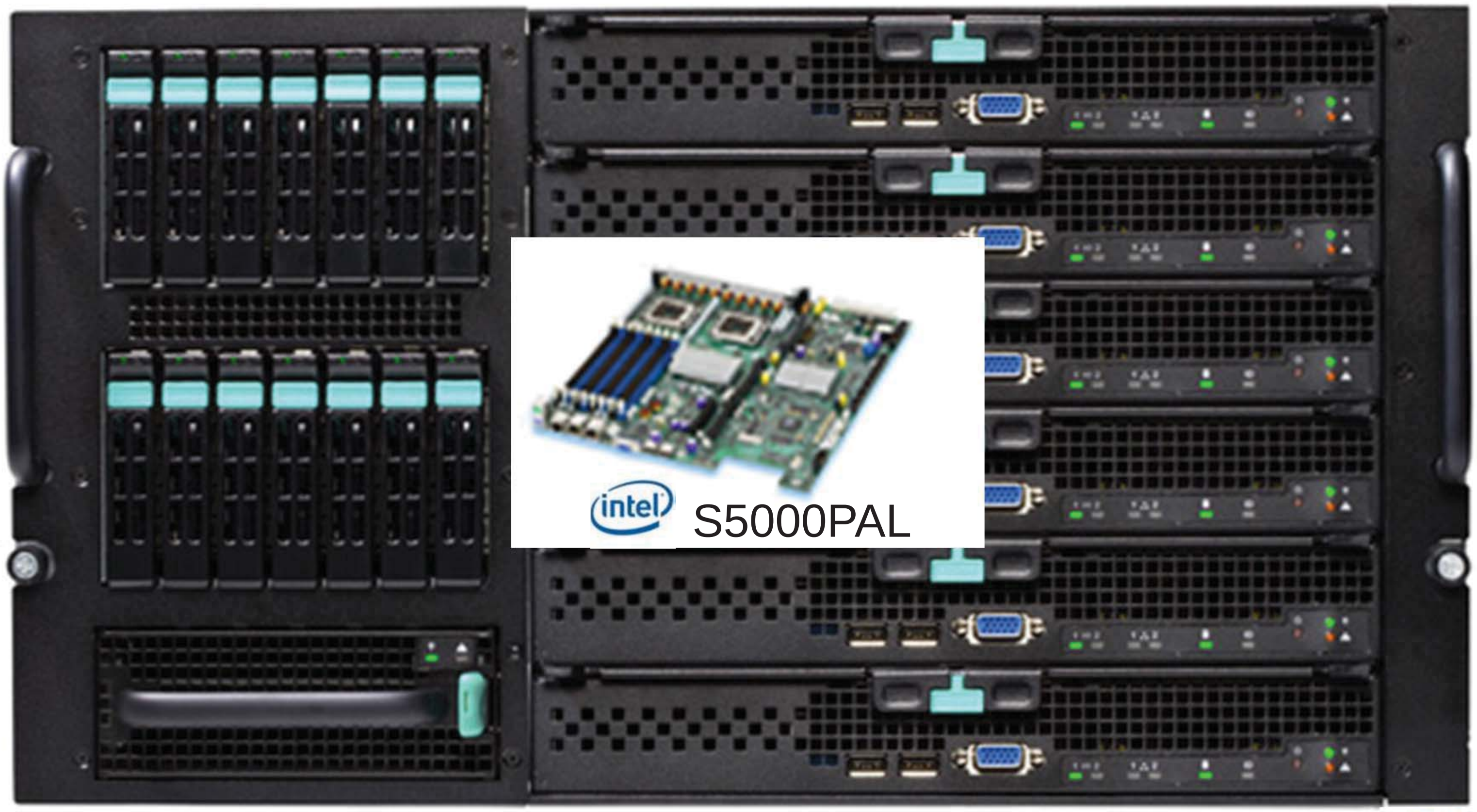


100KW – N+1 to 2N
10 KW / Rack nominal
40 KW added per quarter
2N added at 200 KW
when IT value highest
80KW Spare Space

- Optimize capital by added as needed
- Optimize efficiency by selecting point on the curve which is ultimate Compare AC vs. DC UPS
- Add redundancy when the utilization warrants
- Ideal for migrating from less efficient servers to a virtualized environment
- Available in up to 240KW starting at 40KW

Data and Telecom Standard

Example Savings at the Server Level



Results courtesy of intel

11% Power Savings just at the rack.
For a Medium sized Data Center that represents
Saving over $1.2M and 6,574 Metric Tons of CO_2 / year

Juniper Networks – 380VDC Commitment

Juniper Sustainability Mission	• Green IT • Product Innovation
Membership Commitments	• Climate Savers • Emerge Alliance
Technology Relationships	• Delta, Emerson • GE/Lineage, LiteOn
Product Implementation	• T, EX, QFX, PTX - Demonstration • Supporting Customer Interests

Data Center DC Product Examples

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

Slide Courtesy of STARLINE DC SOLUTIONS ALLIANCE

IEC Pin and Sleeve Devices Rated for Direct Current

HUBBELL®

Ideal for Data Centers and High Tech Server Industries

In today's environmentally conscious world, energy savings is a pinnacle part of going green. DC (Direct Current) is being used to reduce power consumption and decrease the amount of infrastructure needed to energize specific types of data center equipment. Electrical devices provide a means for connecting to DC power.

Hubbell is the first manufacturer to introduce a series of IEC pin and sleeve devices configured for the UL1686 eight o'clock ground position for DC voltage (Disconnecting use only). Hubbell's IEC DC rated pin and sleeve line has been qualified by UL to the requirements of DC voltage. The thermoset polyester contact carrier provides high resistance to electrical tracking, it withstands higher temperatures for this type of demanding application. The solid, one-piece pins are machined from solid brass for longer life and reliable electrical contact. In addition, the heavy duty external cord grips provide maximum cord retention to maintain secure terminations. Finally, the super tough color coded, non-conductive housing is heavy duty for protecting the internal components.

With Hubbell products you can expect high quality on the forefront of technology. We are proud to provide another industry first.

Ordering Information

Amps	Poles & Wires	Configuration Connector	Configuration Plug	DC Voltage	Plug			
30	2P 3W			550V	HBL33			
60	2P 3W			550V	HBL36			
100	2P 3W			550V	HBL3100P8V0DC	HBL3100C8V0DC	HBL3100R8WDC	1.065" - 1.94"
100	4P 5W			400V	HBL5100P8V0DC	HBL5100C8V0DC	HBL5100R8WDC	1.065" - 1.94"

www.hubbell-wiring.com

IEC Pin and Sleeve Devices Rated for Direct Current

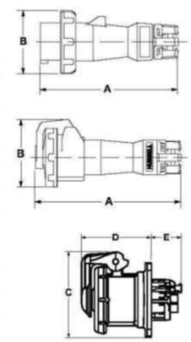
HUBBELL®

Dimensions In. (mm)

Plugs	A	B	Cord Grip Range
HBL330P	8.05" (204.5)	3.74" (95.0)	.375"-1.250" (9.5-31.8)
HBL360P	10.15" (257.8)	4.49" (114.0)	.500"-1.450" (12.7-36.8)
HBL3100P HBL5100P	12.63" (320.8)	4.92" (125.0)	1.065"-1.940" (27.1-49.3)

Connectors	A	B	Cord Grip Range
HBL330C	9.05" (229.9)	4.27" (108.5)	.375"-1.250" (9.5-31.8)
HBL360C	11.15" (283.2)	5.10" (129.5)	.500"-1.450" (12.7-36.8)
HBL3100C HBL5100C	13.57" (344.7)	5.71" (145)	1.065"-1.940" (27.1-49.3)

Receptacles	A	B	C	D	E	F
HBL330R	4.27" (108.5)	3.09" (78.5)	1.16" (29.5)	2.72" (69.0)	3.75" (95.3)	3.13" (79.5)
HBL360R	5.10" (129.5)	4.07" (103.4)	1.69" (43.0)	3.46" (88.0)	4.50" (114.3)	3.88" (98.6)
HBL3100R	5.71" (145)	4.23" (107.4)	2.46" (62.5)	3.95" (100.3)	5.50" (139.7)	4.88" (123.9)



of rated current.

nsurate with the device rating as defined in UL Standard 62.
can and IEC conventions.
e device housing.

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request.
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Wiring Device-Kellems

Leading Through Innovation
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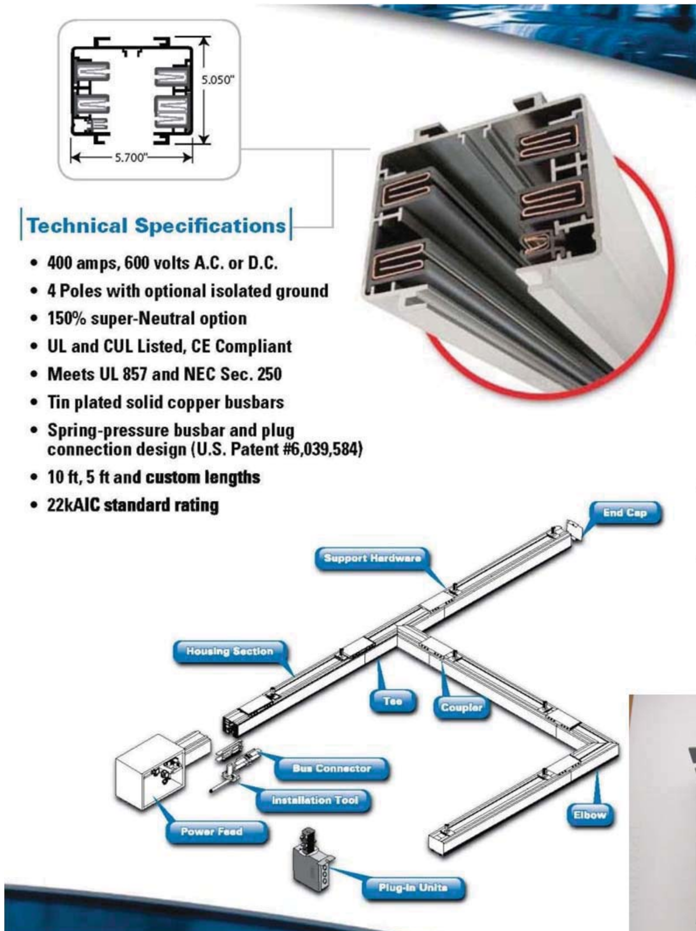
WLDSP004 6/10

STARLINE DC SOLUTIONS

380V DC SAVES!



- 400A BUSWAY DISTRIBUTION COMPARISON

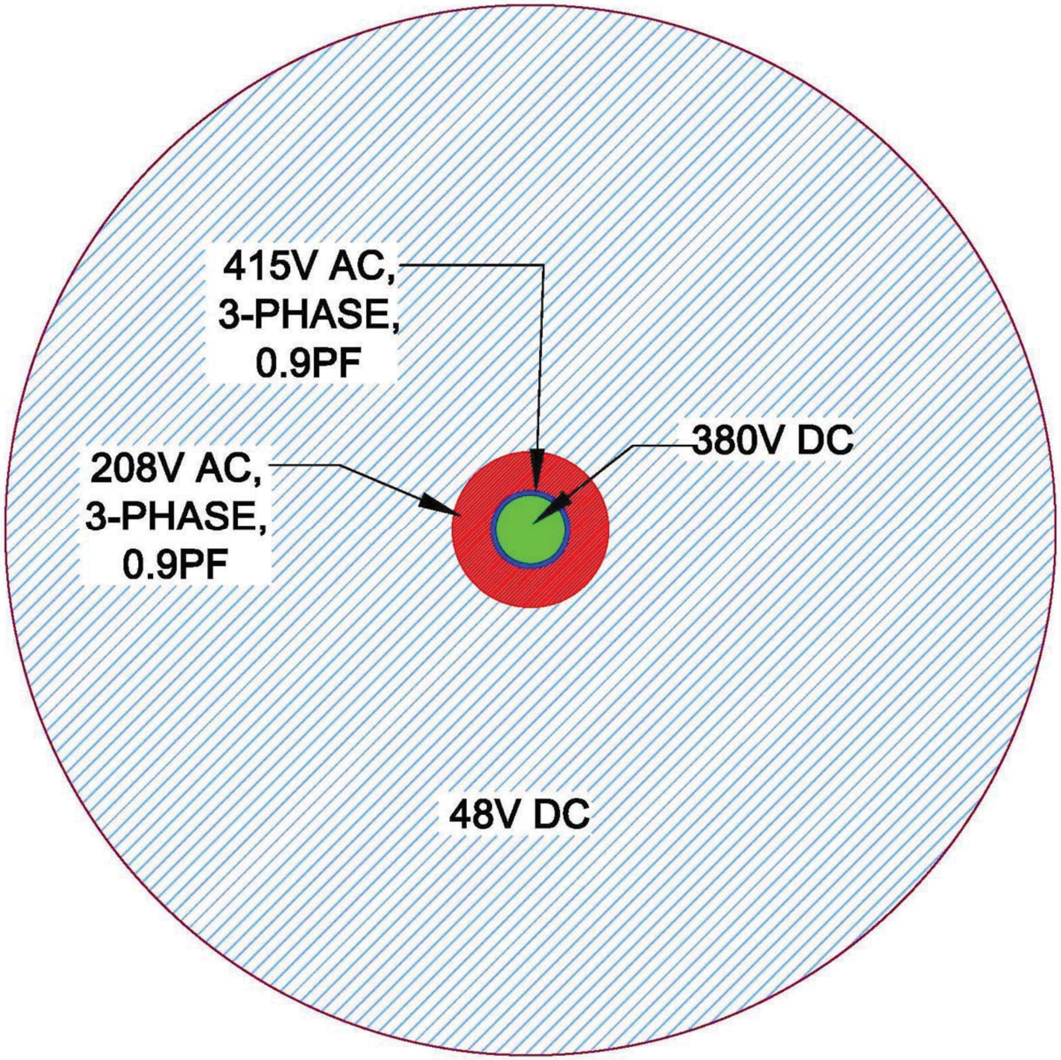
- 208V AC @ 400A = 144kVA/130kW (0.9pf)
- 415V AC @ 400A = 287kVA/258kW (0.9pf)
- 380V DC @ 400A = 152kVA X 2 = 304kVA/Kw (1.0pf)

- AN OBSERVATION:
- 380V DC ALLOWS FOR MORE POWER DELIVERY THAN AC ON THE SAME AMOUNT OF COPPER!

UNIVERSAL ELECTRIC CORPORATION

380V DC SAVES!
A COMPARISON RELATIVE COPPER WIRE SIZES

BASED ON A
260kW SYSTEM FOR
COMPARISON



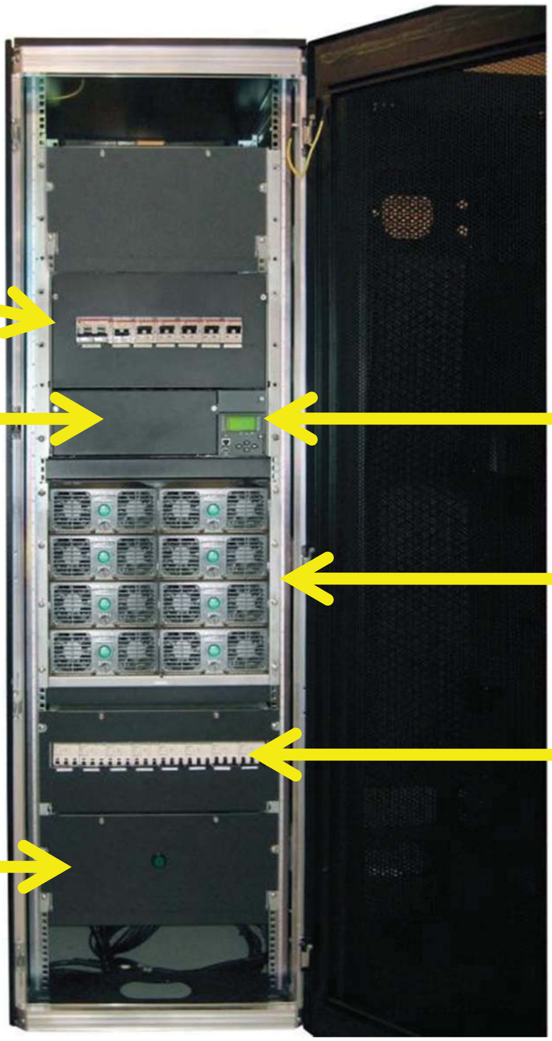
Data Center DC Product Examples

105kW (n+1) 380VDC PS Rectifier Cabinet

Output Distribution
(380VDC)- single section

Insulation Failure
Detector

Controller



Power Conversion Units (PCUs)
Subrack

Individual PCU
input breakers

AC Input
section

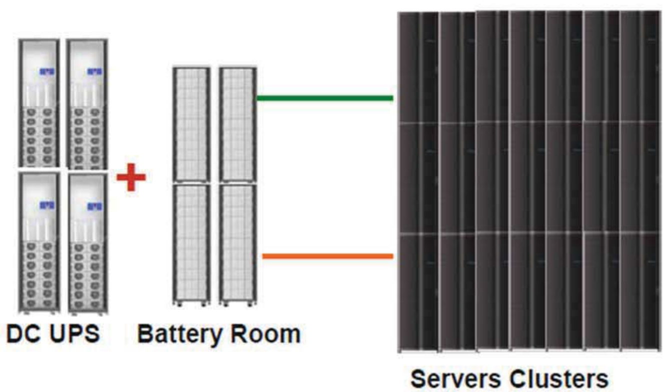
Slide Courtesy of EMERSON Network Power

Data Center DC Product Examples

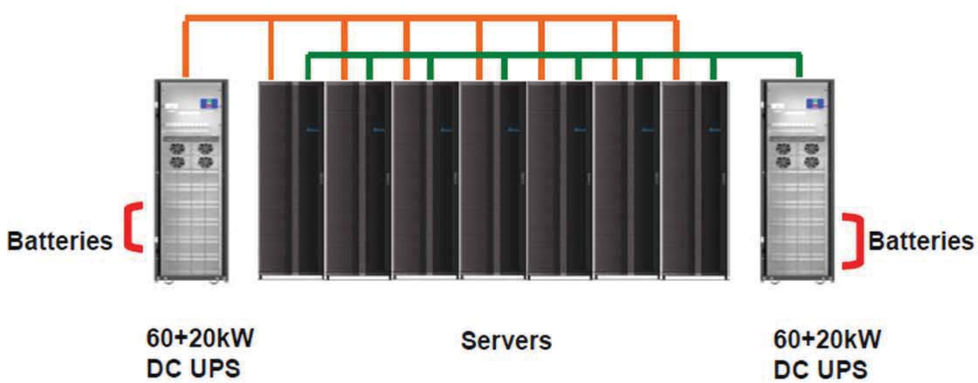
280kW (n+1) 380VDC PS

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

Facility Configuration



Row Configuration

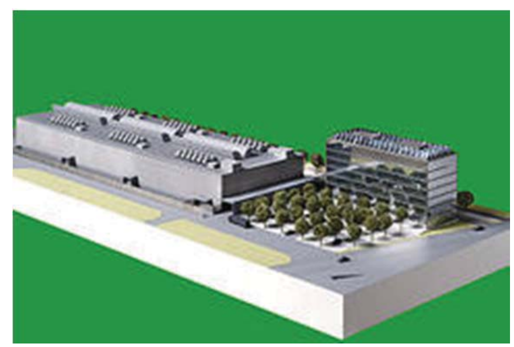


Slide Courtesy of DELTA ALLIANCE

ABB
Direct Current

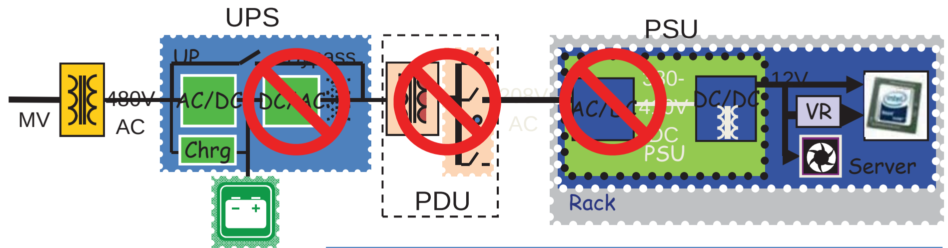
- ABB is the global leader in DC circuit protection, including the ONLY DC power breaker with an electronic trip unit
- ABB has invested in Validus, in order to provide a full DC solution for Data Centers
- ABB has made DC a priority and has won awards for our 800kV UHV DC transmission solutions
- ABB and Green CH are building a DC Data Center





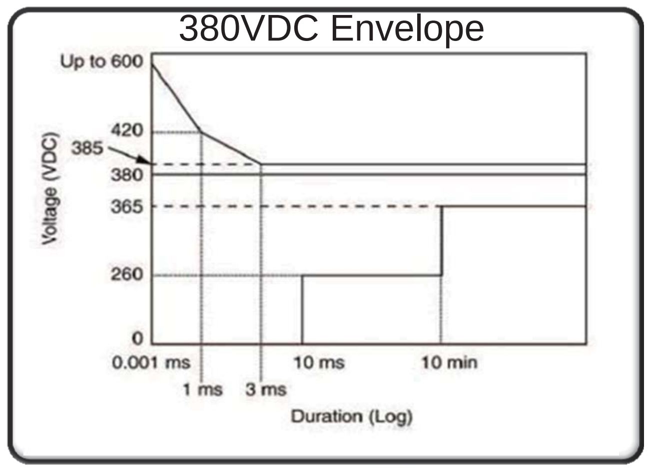
Data and Telecom Standard

Developed for 380VDC ICT Systems



- ETSI 300132-3 (draft)
- EPRI DC Power Partners
  Japan DC Power Partners
  EMerge Alliance
- Datacenter
  - 28% more efficient than 208VAC
  - 7% more efficient than 415VAC
  - 15% less up-front capital cost in vol
  - 33% less floor space
  - 200%-1000% more reliable
  - No Harmonics, Safer
  - DC is already the dominant design in containerized datacenters
- Photovoltaic, Wind, Lighting, Electric Vehicles & Charging, VFD Motors

UCSD 380VDC Datacenter



"380VDC is the highest efficiency, cost effective solution"

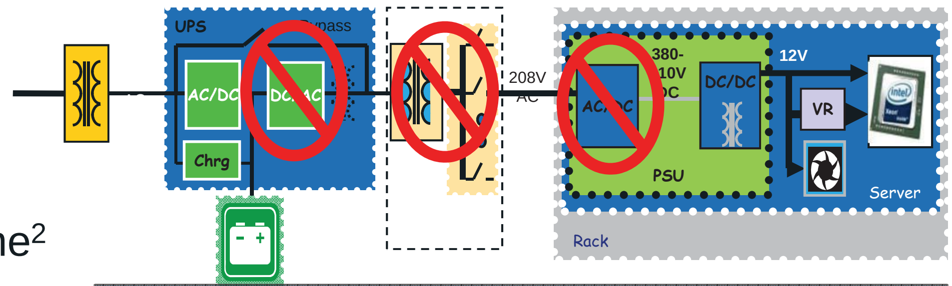
intel

Direct-Current Microgrid: 380Vdc the New Standard

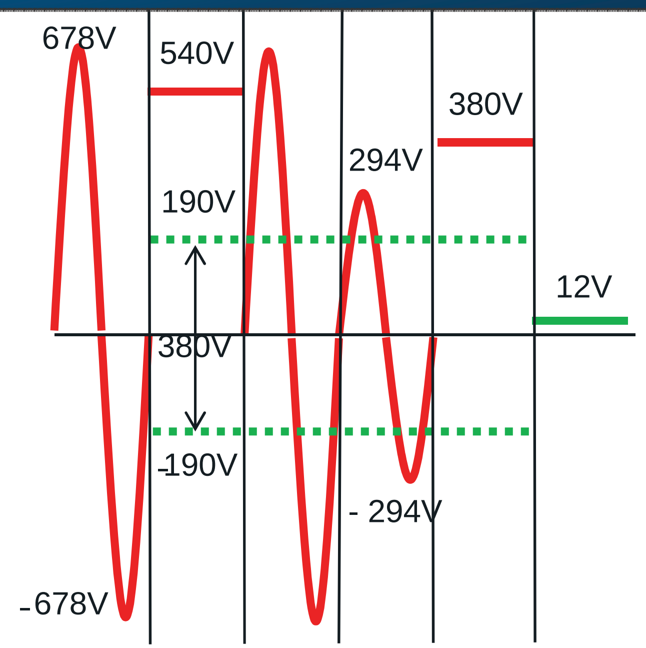
ETSI 300132-3-1 v2.1.13 (1) (2011)

EMerge Alliance ➔ NEC 2014

- 28% more efficient than 208VAC[1]
- 7% more efficient than 415VAC[2]
- 15% less up-front capital cost in volume[2]
- 33% less floor space[2]
- 36% lower lifetime cost[3]
- 200%-1000% more reliable[2]
- No Harmonics, Safer [4]



380VDC: Highest voltage with volume components, fewest conversions



Efficiency↑ ∝ Voltage↑ + C

- Volume Priced Parts (< 420V

UCSD, Duke Energy, Intel IT (2011)

Other Industries likely adopters

- PV, Wind, Lighting, EV Charging, VFD Motors

[1] Intel, Intelec Paper, 2007 [2] Intel, HP/EYP, Emerson, Whitepaper, 2009 [3] Validus/GE Study, 2010 [4] IEC 23E/WG2

Data and Telecom Standard

Cloud Data Centers as Controllable Load

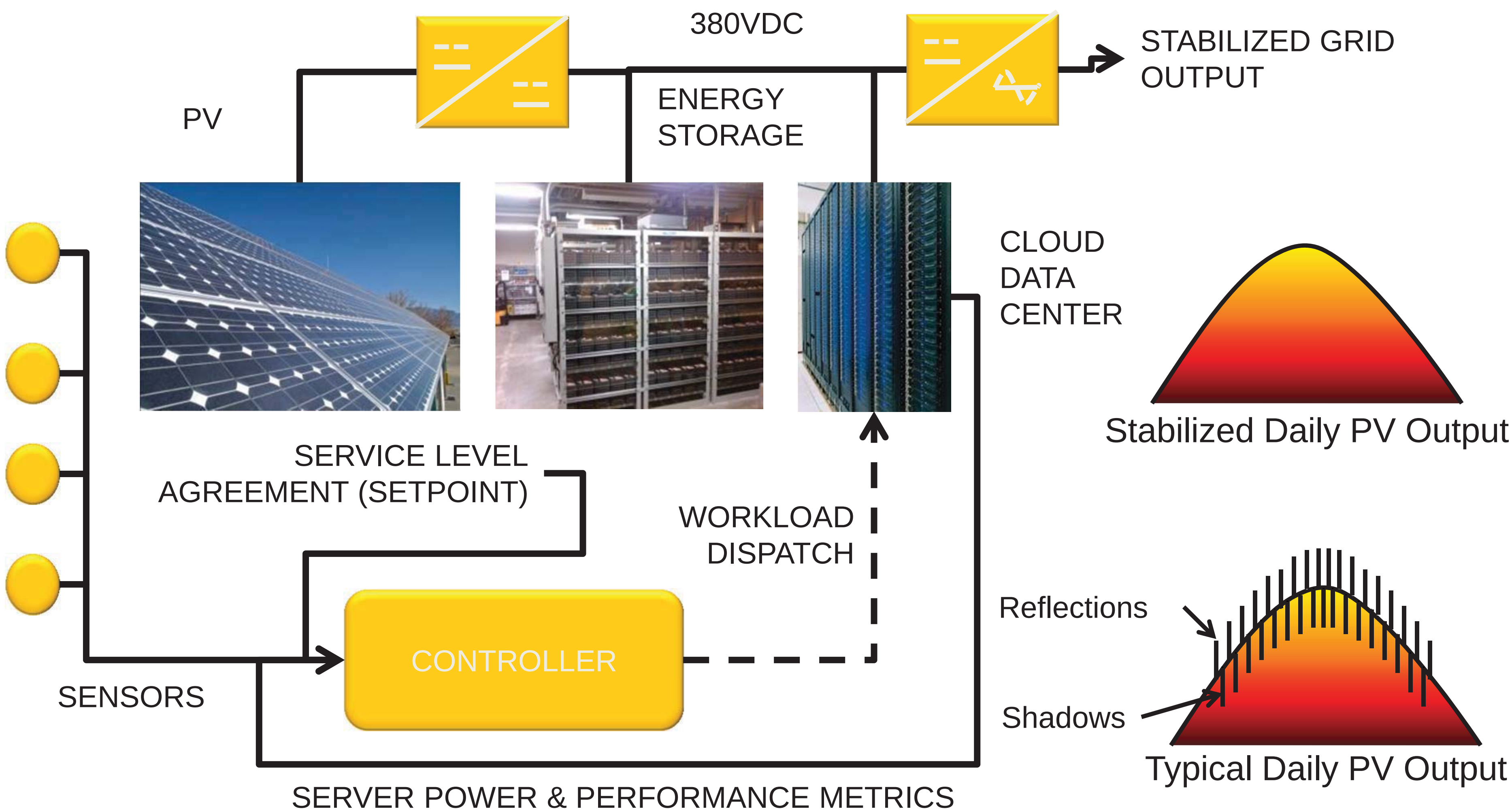
- Cloud Computing manages a suite of servers to provide computation on demand
  - Computation can be throttled to balance power use with user service level agreements on latency
- GEMS-VPM Technology
  - Controls Power used by a rack of servers
  - DCM can Cap power to a defined level
  - Can work with data center virtualization to on/offload whole servers in msecs
- Can manage a Cloud Computing Data Center as a Controllable Load (100’s of kW)
  - Predictive PV as input to workload dispatch to smooth the variability of PV arrays (1-10 sec)
  - Participate in Demand Dispatch
  - Adds a Revenue Stream to the Equation

Courtesy of intel

EMerge ALLIANCE

Data and Telecom Standard

Cloud Data Centers as Controllable Load



Courtesy of intel

EMerge Alliance Data/Telecom Standard

Beta Site Applications in the Field

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

BERKELEY LAB
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
UCSanDiego
Local Impact, National Influence, Global Reach

EMerge® ALLIANCE

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

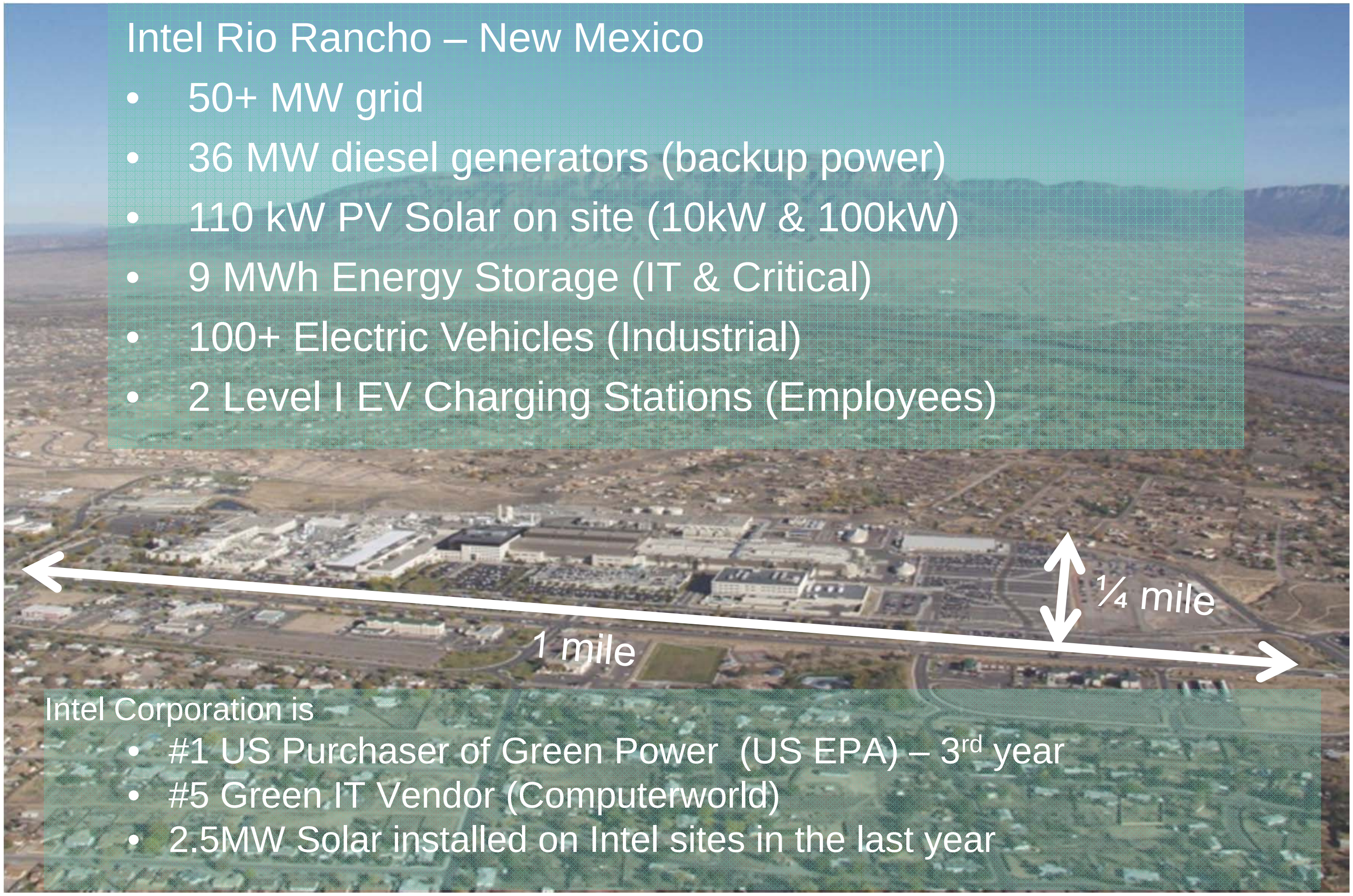
CA Lighting Tech Center
UC Davis Campus
Davis, CA

EMerge Alliance Future DC Microgrid Standards

Beta Site Applications in the Field

Intel Rio Rancho – New Mexico

- 50+ MW grid
- 36 MW diesel generators (backup power)
- 110 kW PV Solar on site (10kW & 100kW)
- 9 MWh Energy Storage (IT & Critical)
- 100+ Electric Vehicles (Industrial)
- 2 Level I EV Charging Stations (Employees)

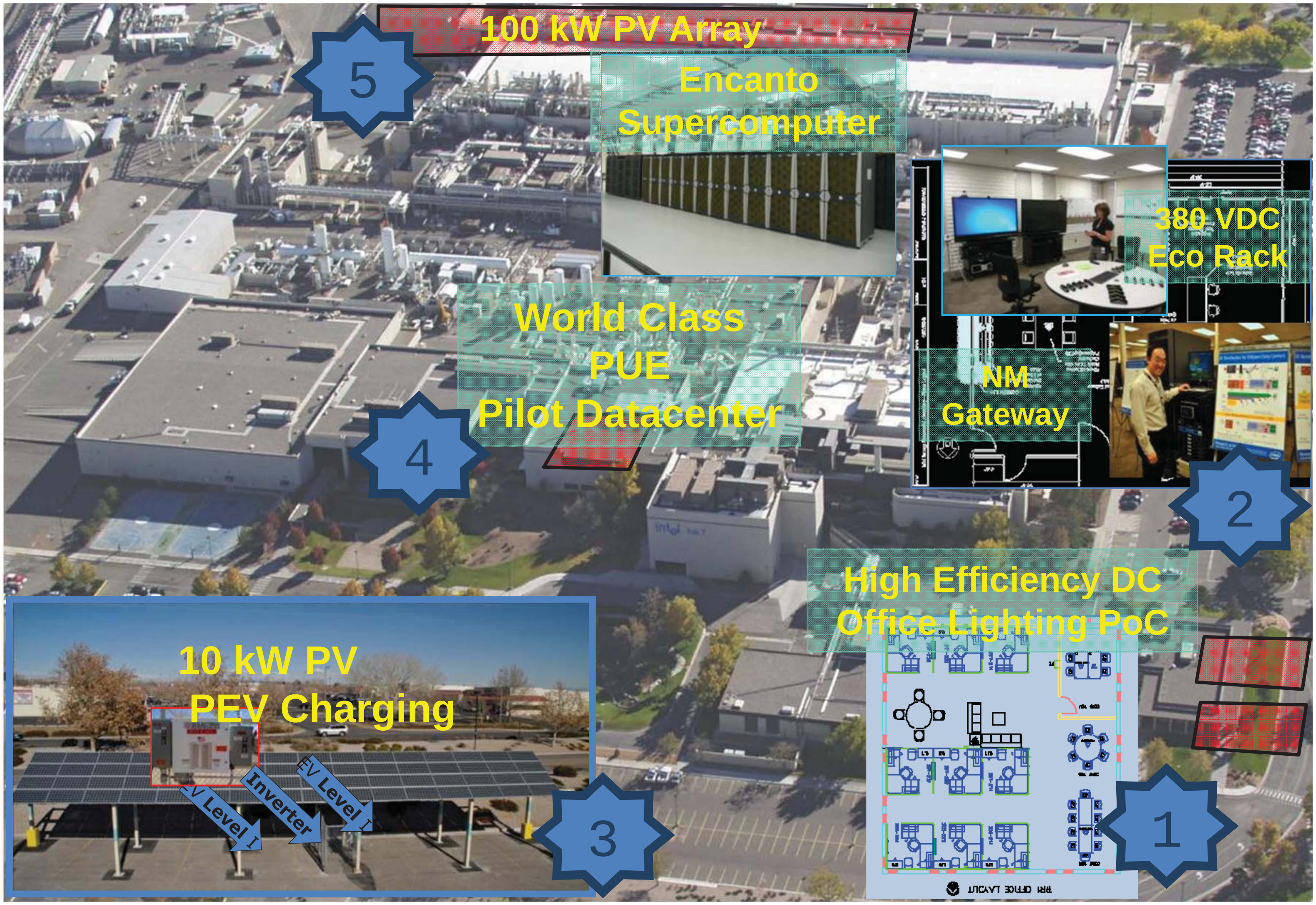


Intel Corporation is

- #1 US Purchaser of Green Power (US EPA) – 3rd year
- #5 Green IT Vendor (Computerworld)
- 2.5MW Solar installed on Intel sites in the last year

Standards Allow Incremental Plan/Execution

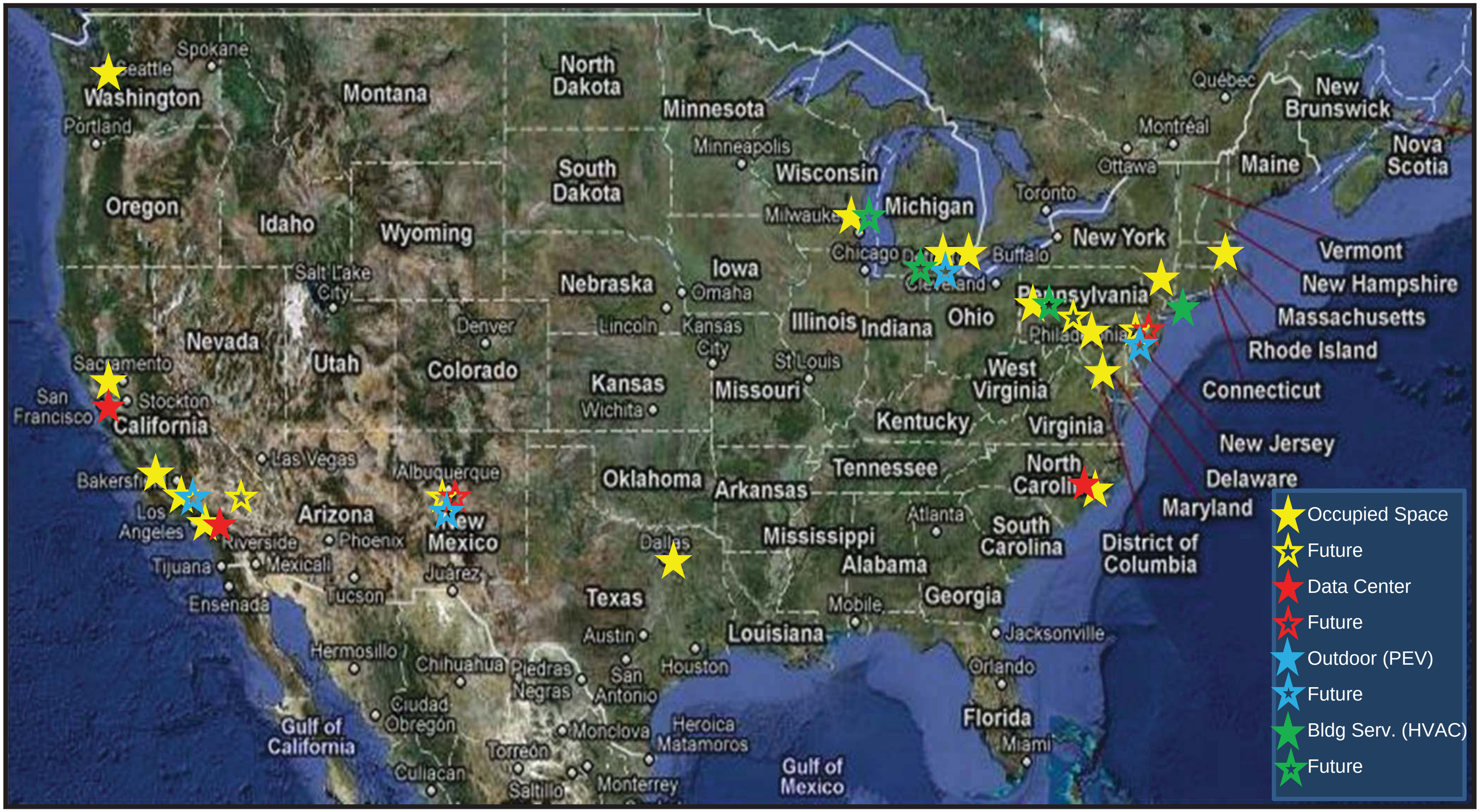
Five Discrete Projects Capture Key Elements



Rio Rancho Campus intel Courtesy of Intel Research Labs

EMerge Alliance Beta Sites

Standards Applications in the Field



Combined Beta and Registered Sites as of February 2011 www.EMergeAlliance.org

Direct Current (DC) Microgrid Power Application Standards