Defining the Needs for Energy Storage and its Control for Zero-Net-Energy Buildings

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Chairman
EMerge Alliance

Presentation Content

1. About the EMerge Alliance
2. About Hybrid AC/DC Microgrids
3. About Key Enabling Technologies
4. About the Application's maturity
5. About their Performance Impact and Benefits
6. About the Deployment Vision
7. About the Market for DC Storage Applications
8. Q&A

About the EMerge Alliance

A 501c Part 6 Non-Profit Member Funded Corporation

Vision → Standards → Eco-system → Transformation

THE ENERNET: Doing for power what the Internet did for information networking

Using an open industry association to develop and promote standards that can lead to the rapid adoption of AC/DC power microgrid distribution in buildings

EMerge® ALLIANCE

About the EMerge Alliance

100+ Organizations - 1200+ Registered Engineers & Business Professionals

About the EMerge Alliance

Advancing DC Technology Use via International Collaboration & Harmonization

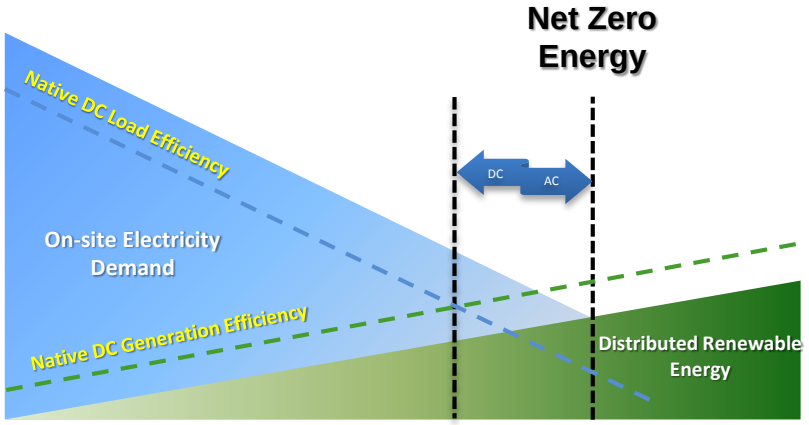
- 7x24 Exchange
- American Institute of Architects
- ASHRAE
- BACnet Association
- California Lighting Technology Center
- Clemson University
- Continental Automated Buildings Association
- Electric Power Research Institute
- EnOcean Alliance
- European Telecommunications Standards Institute
- Galvin Electricity Initiative
- IEEE Institute of Electrical and Electronics Engineers
- International Electrotechnical Commission
- International Telecommunication Union
- Lawrence Berkeley National Laboratory
- National Electronics Manufacturers Association
- National Fire Protection Association - NEC
- National Renewable Energy Laboratory
- Next Energy Center
- N. C. State Univ. – Freedm Systems Center
- Penn State University
- Power Sources Manufacturers Association
- Princeton University
- Smart Grid Interoperability Panel
- The Green Grid Alliance
- Underwriters Labs
- USB-IF Universal Serial Bus – Implementers Forum
- US Department of Energy
- US Green Building Council
- Univ. of California - California Institute for Energy and Environment
- Univ. of Pittsburgh
- Univ. of Texas – Dept. of Electrical & Computer Engineering
- Univ. of Toledo
- Virginia Tech – Center for Power Electronic Systems
- Yale University - Renewable Energy and. International Law. Renewable Energy and Energy. Efficiency Partnership
- ZigBee Alliance

About the EMerge Alliance

The Vision: Net Zero Attainment

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

US Department of Energy Report:
Zero Energy Commercial Buildings Consortium



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

2013: Begin DC Microgrid Demonstrations

2030: All new commercial buildings

2040: 50% of commercial building stock

2050: All commercial buildings

About Hybrid AC/DC Microgrids

Some History…

Electric Vehicles (Bi-Directional)

Zero Energy Buildings

Site Based Renewable Energy – Distributed Generation

Centralized Generation (Power Plants)

Long Distance Transmission

DC Power Use

1860's 1950's 1960's 1970's 1980's 1990's 2000's

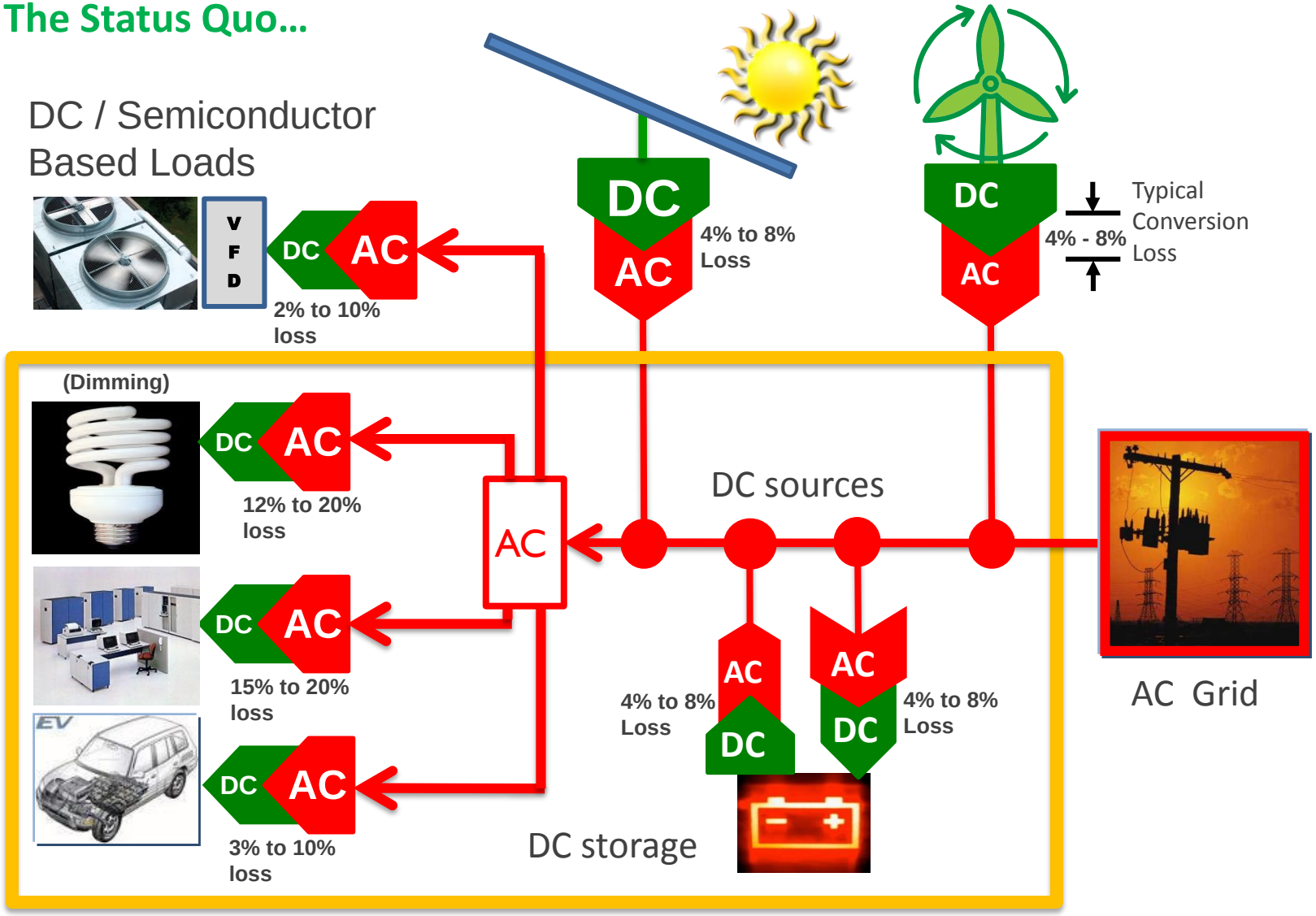
Electrical Loads: Simple Motors & Lighting

DC Semiconductors Power Electronics Invented

80% of devices convert AC to DC with Power Electronics

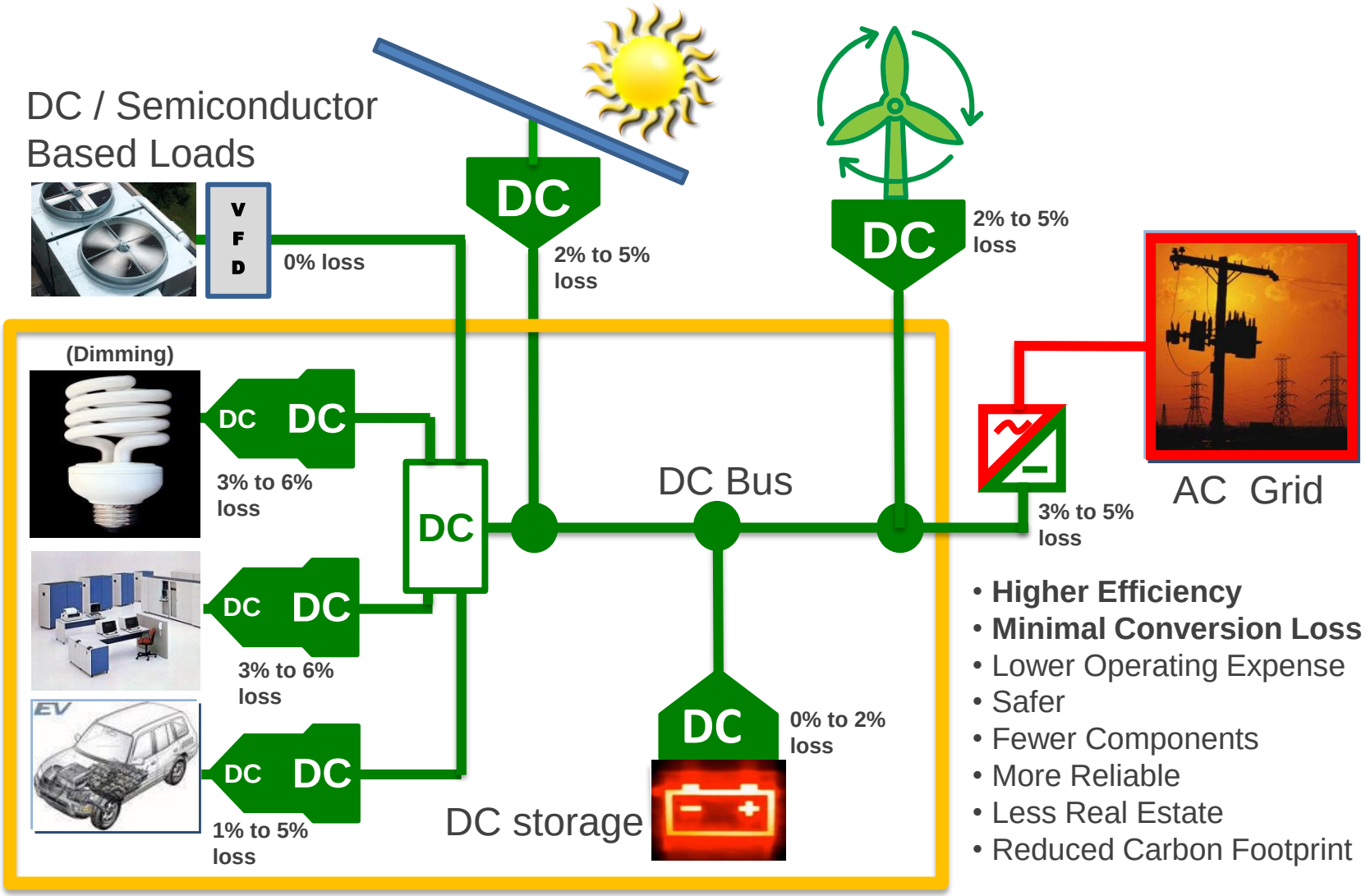
About Hybrid AC/DC Microgrids

The Status Quo…



About Hybrid AC/DC Microgrids

The Ideal End State…

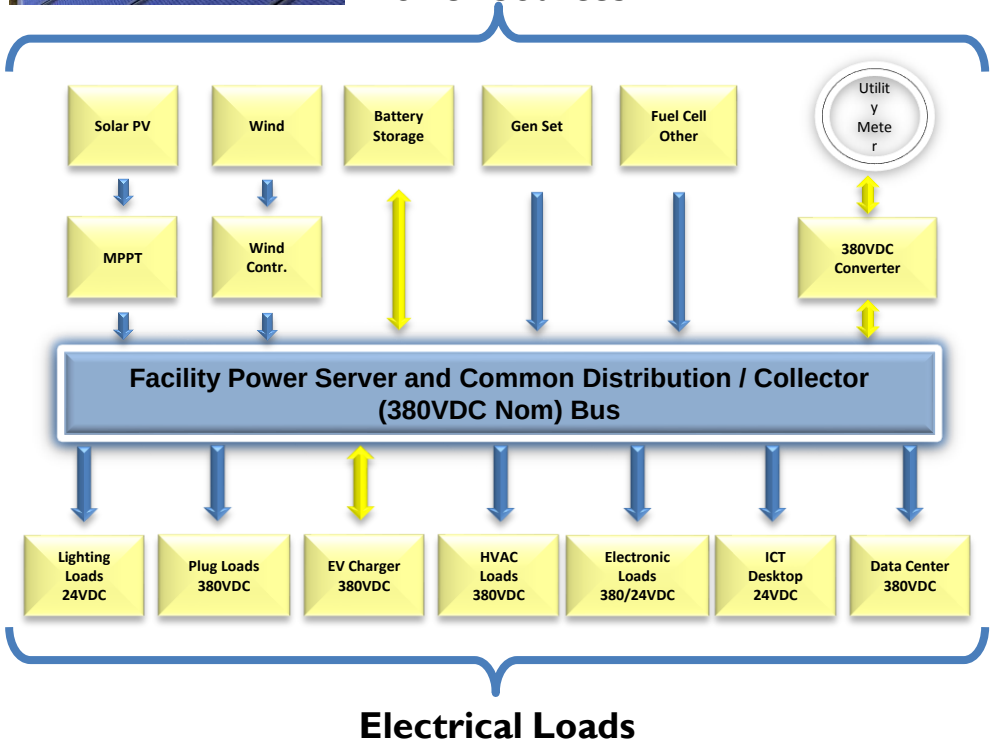


- **Higher Efficiency**
- **Minimal Conversion Loss**
- Lower Operating Expense
- Safer
- Fewer Components
- More Reliable
- Less Real Estate
- Reduced Carbon Footprint

About Hybrid AC/DC Microgrids

Basic DC Microgrid Distribution

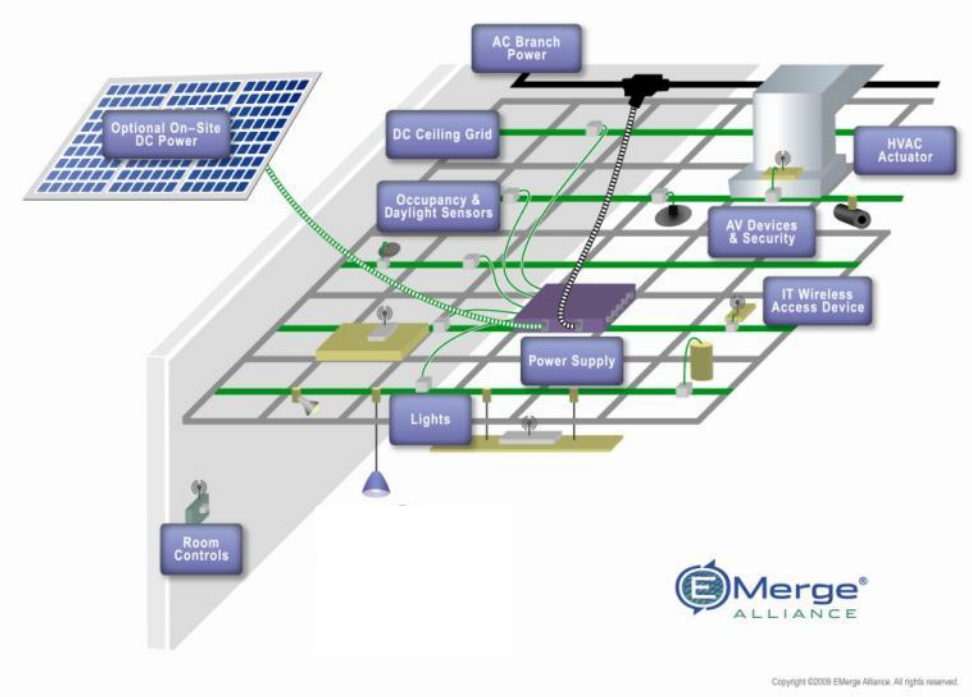
- Grid Connected –Islandable
- Multiple Site Based Sourced
  - Solar
  - Wind
  - Fuel Cell
  - LP/NG Generator
- According to EMerge Draft Standard C/BM TS V0.01
- Connectivity:
  - 380 Vdc Non-synchronous Distribution Bus
  - Rack Mounted Power Management
  - N+1 Conversion Redundancy
- Includes:
  - Up to 150 KW Loads
  - Scalable in 15KW increments
  - Rack Metering Power Use
  - N+1 to distribution bus
  - Direct dc failsafe Back-up Power
    - Battery
    - Emergency Gen Set



About Hybrid AC/DC Microgrids

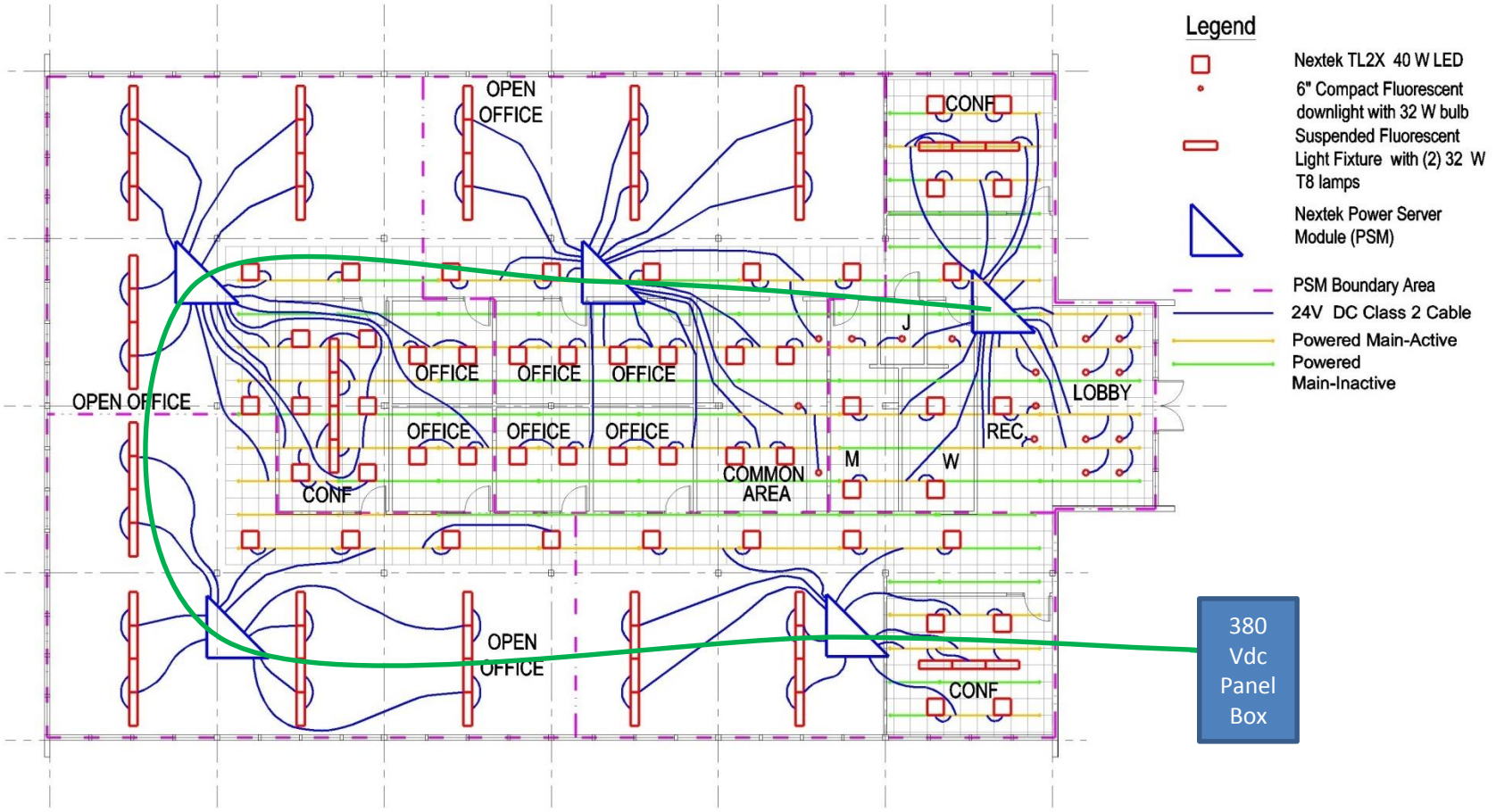
Occupied Space DC Distribution

- Plug & Play 24Vdc Class 2
  - 380Vdc Feed
  - Alt. Local 277Vac Feed
- According to NEC Article 393 & EMerge Standard OSS V1.1
- Divided into 4 Sections:
  1. Retrofit Existing Fluorescent with existing Manual controls
  2. Install New LED with ZigBee Wireless
  3. Install New LED with IP V4 Controls
  4. Install New LED with IP V6 Controls
- Includes:
  - Lighting
  - Powered Window Shading
  - IT Wireless Access Points
  - Local Sensors
  - Wireless Security
  - Underfloor Radiant Heat



About Hybrid AC/DC Microgrids

Example Test Bed Scenario –Office Space



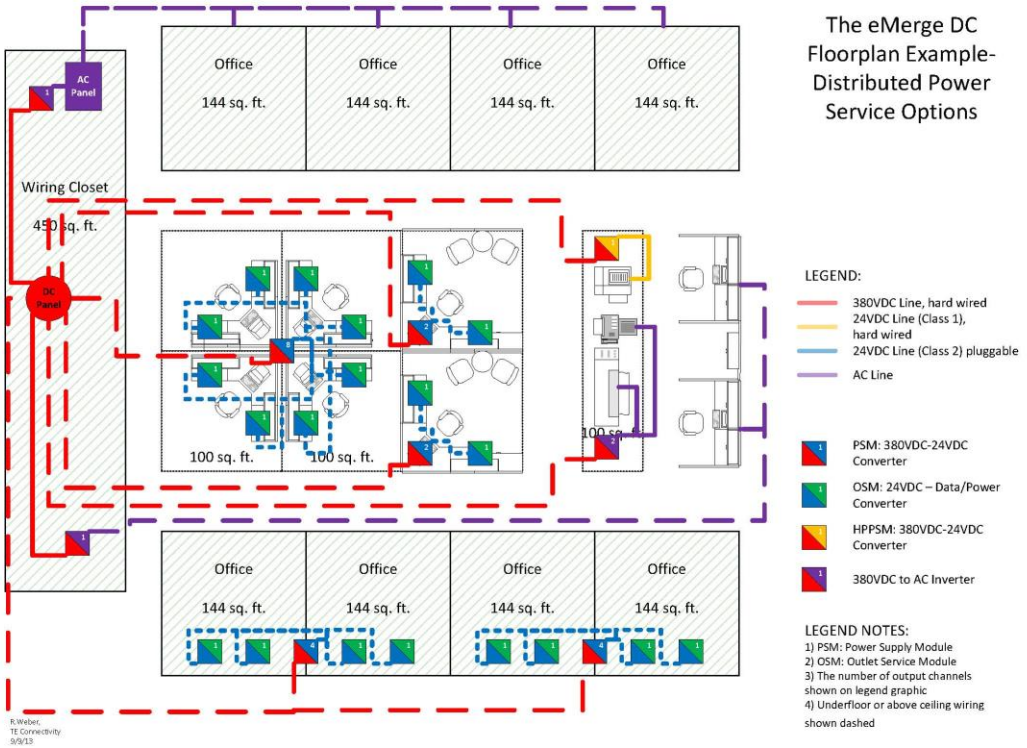
Hybrid Distribution:

Energized Ceiling Grid + Direct Connect Fixtures

About Hybrid AC/DC Microgrids

Office Workstation DC Power Distribution

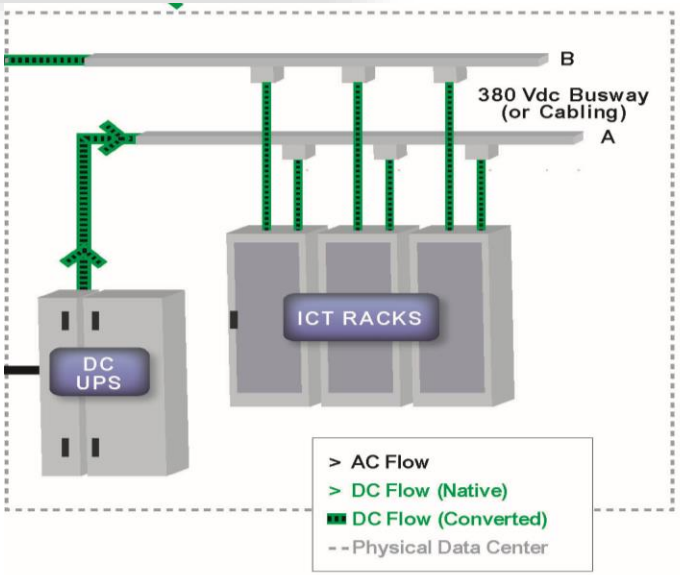
- Plug & Play 24Vdc Class 2
  - 380Vdc Feed
  - Alt. Local 120-220-277Vac Feeds
- According to EMerge Draft Standard TLF V0.01
- Desktop Connectivity:
  - USB-PD 5-20Vdc
  - PoE 48Vdc
  - IEEE UPAMD/P1823
  - 24 Vdc Native 5mm Plug
- Includes:
  - 100 or200 Watts/Desktops
  - Class 2 Touch Safe Outlets
  - Optional 120Vac Outlets
  - Power Use Monitoring via ZigBee or IP V6



About Hybrid AC/DC Microgrids

BAS & IT DC Power Distribution

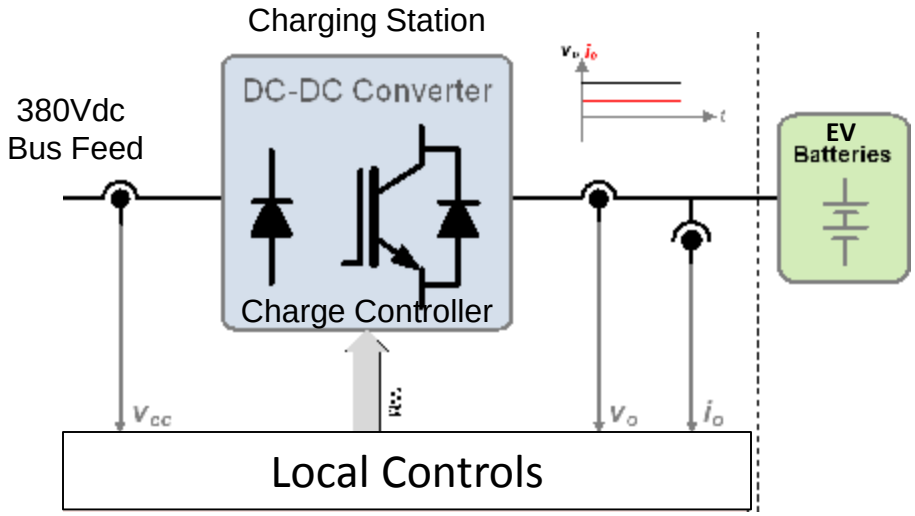
- Plug & Play 380Vdc Class 1
  - 380Vdc Feed
  - Alt. Local 208-480Vac Feed
- According to EMerge DTC 1.01
- Rack Connectivity:
  - 380 Vdc Busway to 380Vdc Rack Plug Strip
  - Direct Wire 380 Vdc to 380 Vdc Rack Plug Strip
- Includes:
  - Up to 100 A rated Service
  - UL Approved Arc-Safe Outlets
  - Rack Metering Power Use
  - Dual Feed (N+1 to Servers)
  - Direct dc failsafe Back-up Power



About Hybrid AC/DC Microgrids

EV DC Fast-Charging Distribution

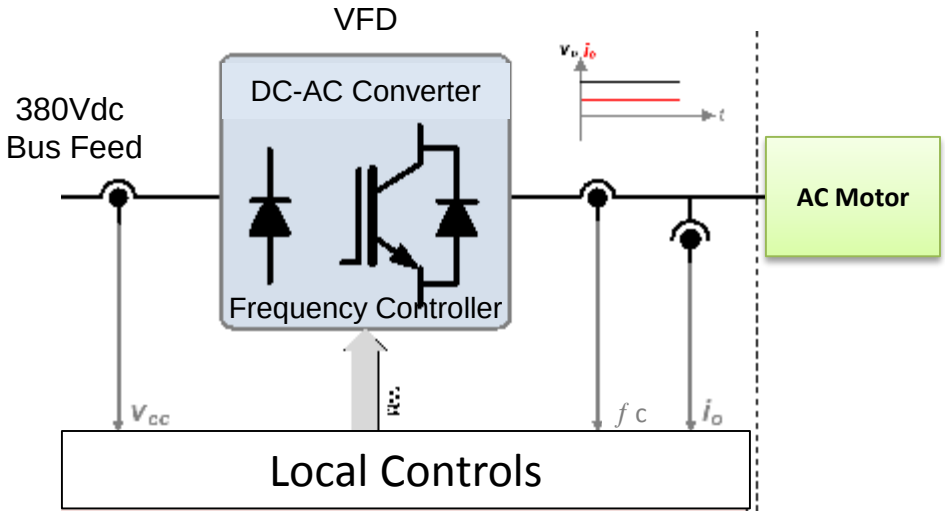
- DC Level 3 (Fast) Electric Vehicle Charging
- Charging Station Protocols
  - CHAdeMO
  - SAE
- According to EMerge Draft Standard C/BM TS V0.01
- Connectivity:
  - 380 Vdc Non-synchronous Distribution Bus
  - Power Management via DC Microgrid Control
  - Local Multi-Vehicle Charge Management
- Includes:
  - Authorization system
  - Online management with data per user via OCPP
  - Smart Simultaneous multi car charging
  - AC wallbox - external charging connections



About Hybrid AC/DC Microgrids

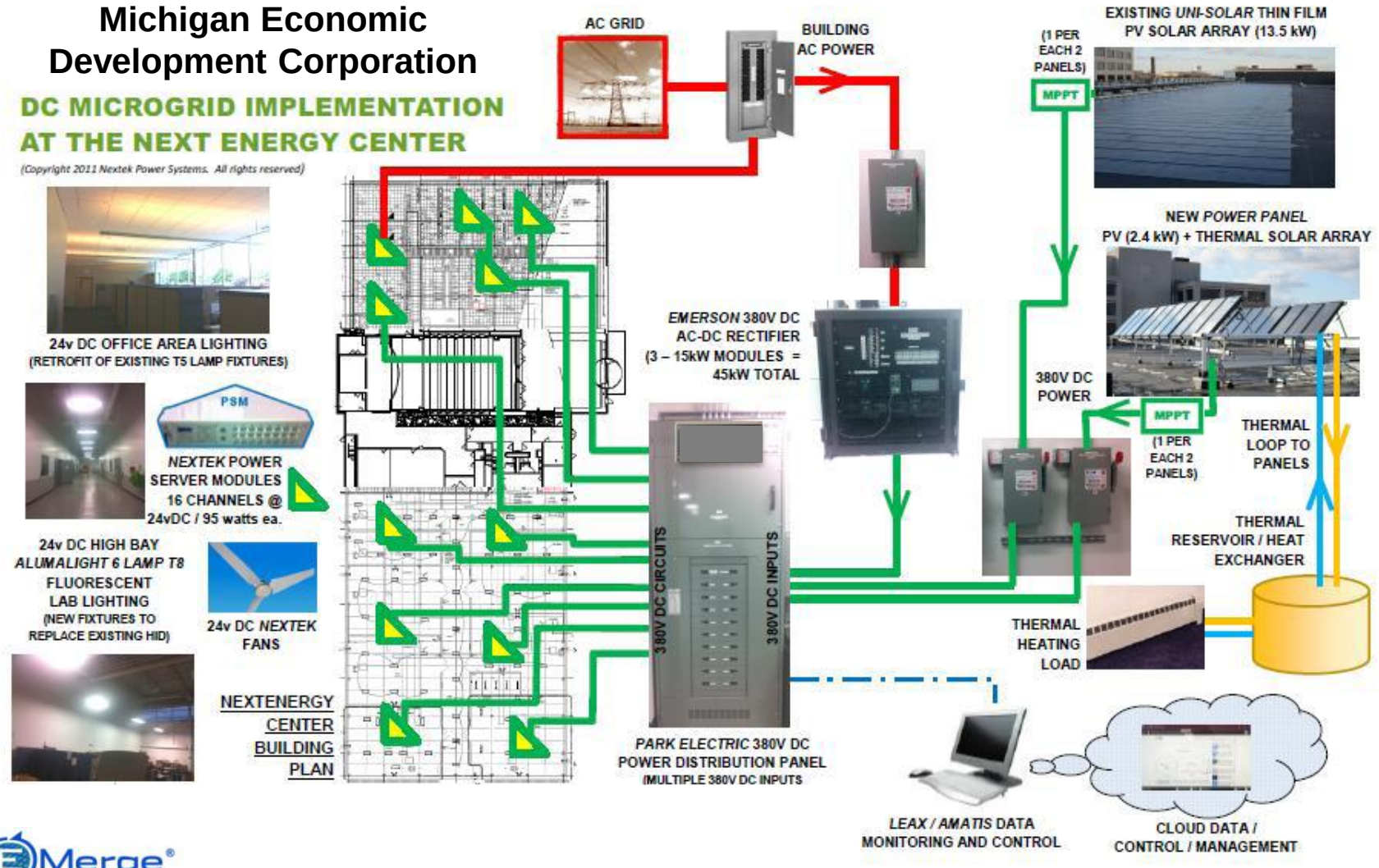
VFD Motor (HVAC) Power Distribution

- Grid Connected –Islandable
- Multiple Site Based Sourced
  - Solar
  - Wind
  - Fuel Cell
  - LP/NG Generator
- According to EMerge Draft Standard C/BM TS V0.01
- Connectivity:
  - 380 Vdc Non-synchronous Distribution Bus
  - Rack Mounted Power Management
  - N+1 Conversion Redundancy
- Includes:
  - Up to 150 KW Loads
  - Scalable in 15KW increments
  - Rack Metering Power Use
  - N+1 to distribution bus
  - Direct dc failsafe Back-up Power
    - Battery
    - Emergency Gen Set



About Hybrid AC/DC Microgrids

A Building/Campus Hybrid AC/DC Microgrid



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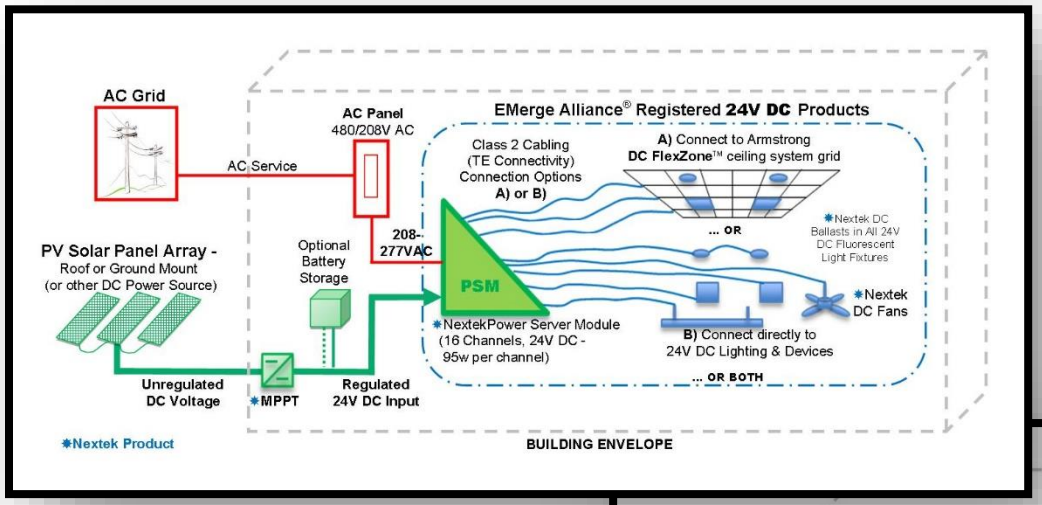
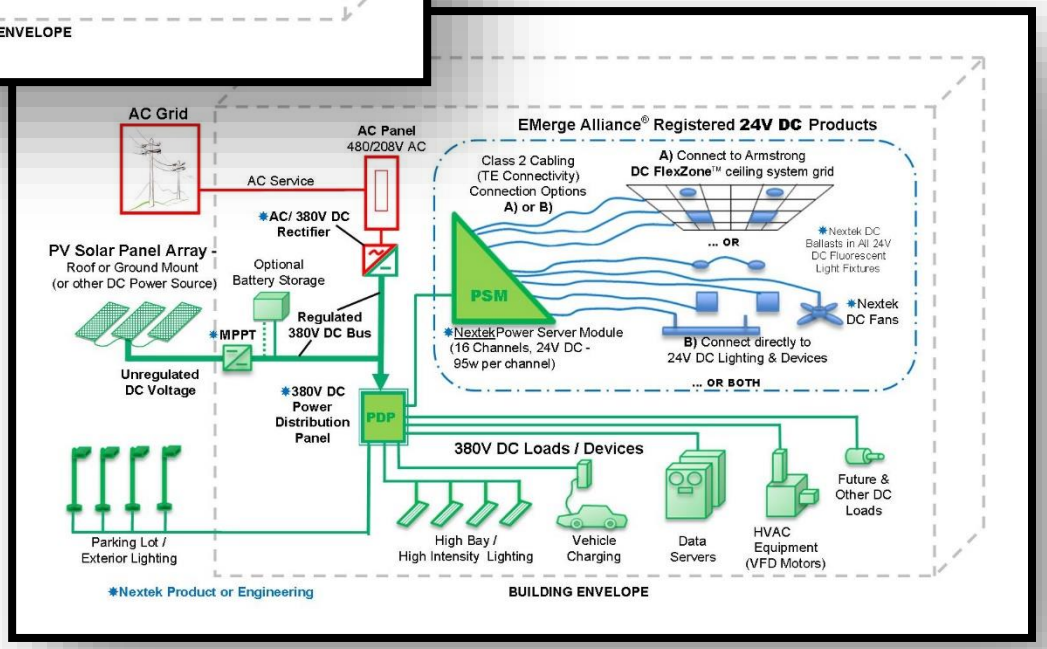
About Hybrid AC/DC Microgrids

DC Distribution – Scale To Suit



< 15,000 sf

- AC &/or DC In
- 24v DC Loads



> 15,000sf

- AC & / or DC In
- 380v DC Bus
- 380v DC Loads
- 24v DC Loads

About Key Enabling Technology

Isolated Gate Bi-polar Transistors

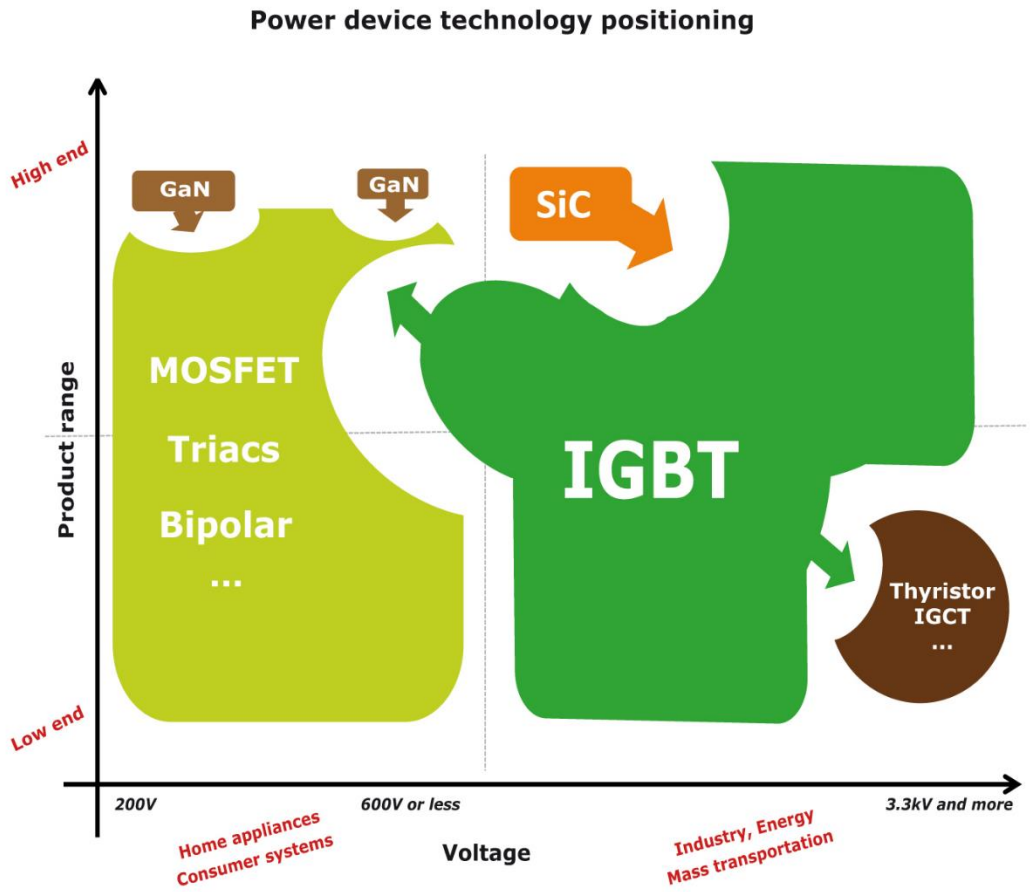
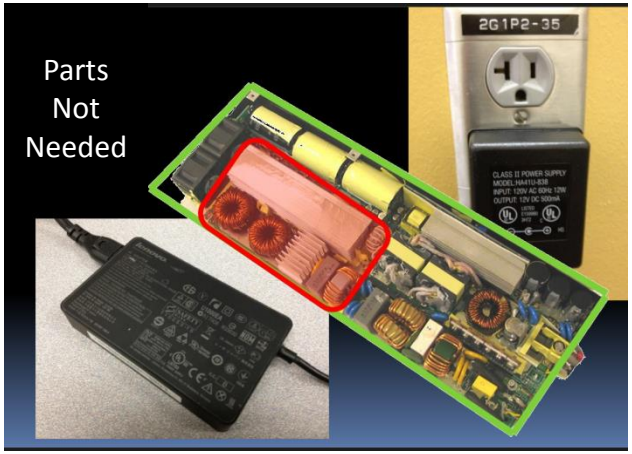


Figure7: IGBT Modul ABB P/N: 5SNA 1200E330100. 32 pieces are used per switch



About Hybrid AC/DC Microgrids's Maturity

Early Beta Site Deployment in the Occupied Space

Examples of DC Powered Interior Spaces:

PNC Financial Services
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

About Hybrid AC/DC Microgrids's Maturity

Early Benchmark Testing of Data Center 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

About Hybrid AC/DC Microgrids's Maturity

Case Study: Deployment of Commercial Occupied Space Standard

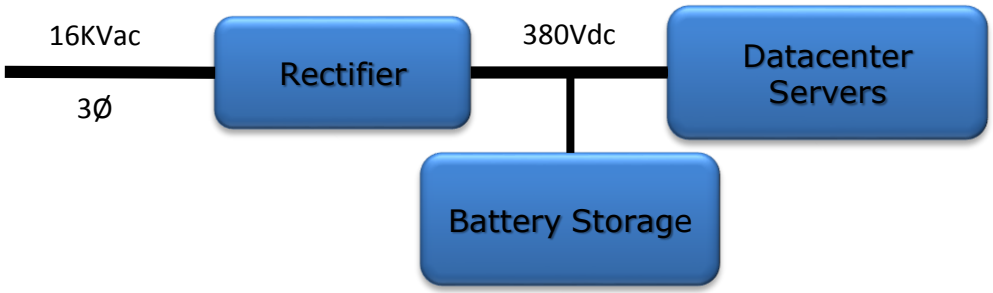
- PNC Financial Services Group Inc. announced it will debut its new net-zero energy bank branch during first quarter 2013 in Fort Lauderdale, Fla.
- PNC expects the branch to exceed LEED Platinum certification and be its most energy efficient, using 50 percent less energy than a typical branch.
- The bank features solar connected grid powered ceilings that distribute native dc electricity to power efficient solid-state LED lighting and controls.

About Hybrid AC/DC Microgrids's Maturity

Case Study: Major Deployment of Data/Telecom Standard

Green.ch-ABB Zurich-West
380Vdc Data Center

- ABB/Validus Power Distribution
  - In: 16KV AC
  - Out: 1MW @ 380Vdc
  - Battery Backup: 10 mins
  - Backup Generation
- 1,100m^2 of 3,300m^2 Vdc
- HP 2U, Blades & Storage Servers
- Demonstrated Benefits
  - **10% Better Energy Efficiency**
  - **15% Lower Capital Cost**
  - **25% Smaller Footprint**
  - **20% Lower Installation Costs**



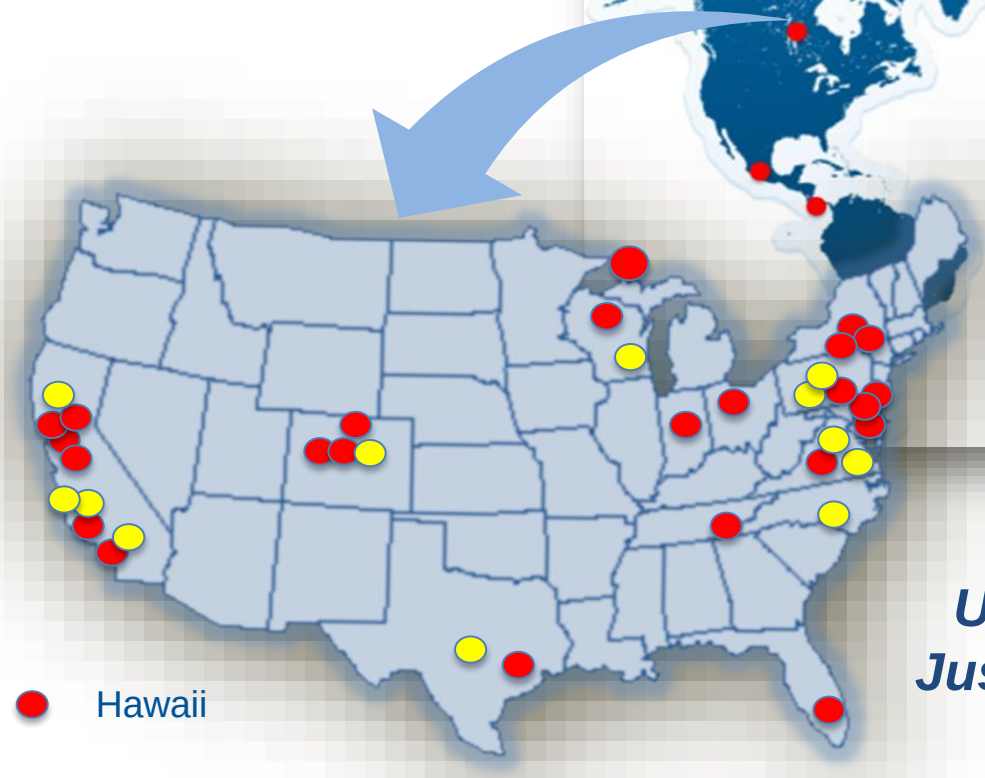
Photos courtesy of ABB* and HP*

About Hybrid AC/DC Microgrids's Maturity

DC – From a Global Perspective

China leads with over 600 DC Micro Grid Deployments.

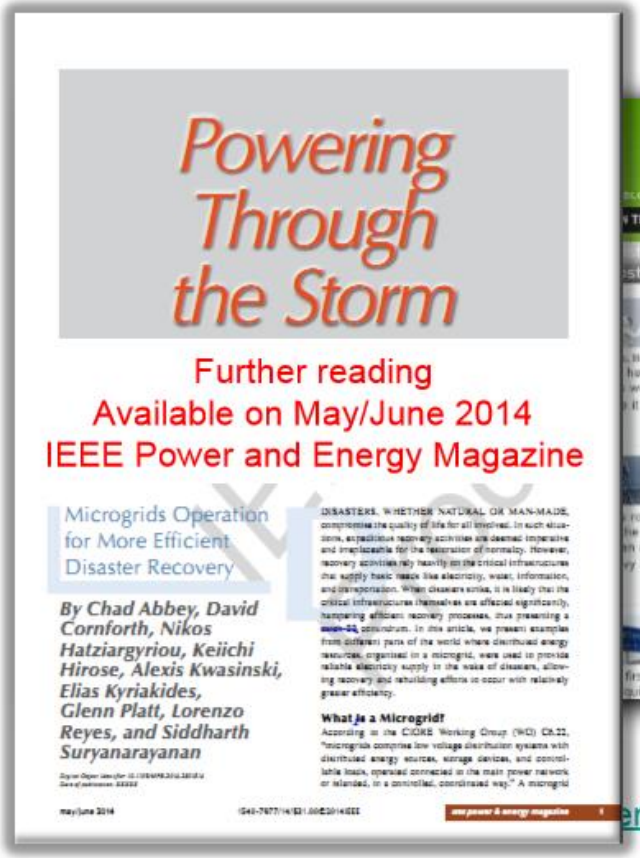
Global Sites



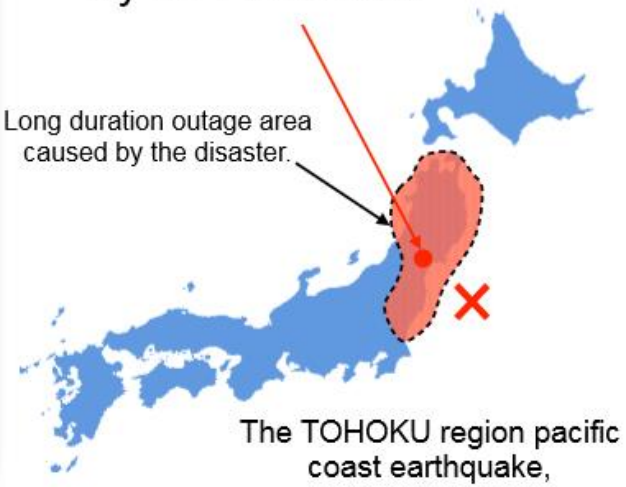
US DC Sites Just Beginning

About Hybrid AC/DC Microgrids's Maturity

DC – From a Global Perspective – A Special Case in Japan



SENDAI microgrid
by NTT Facilities

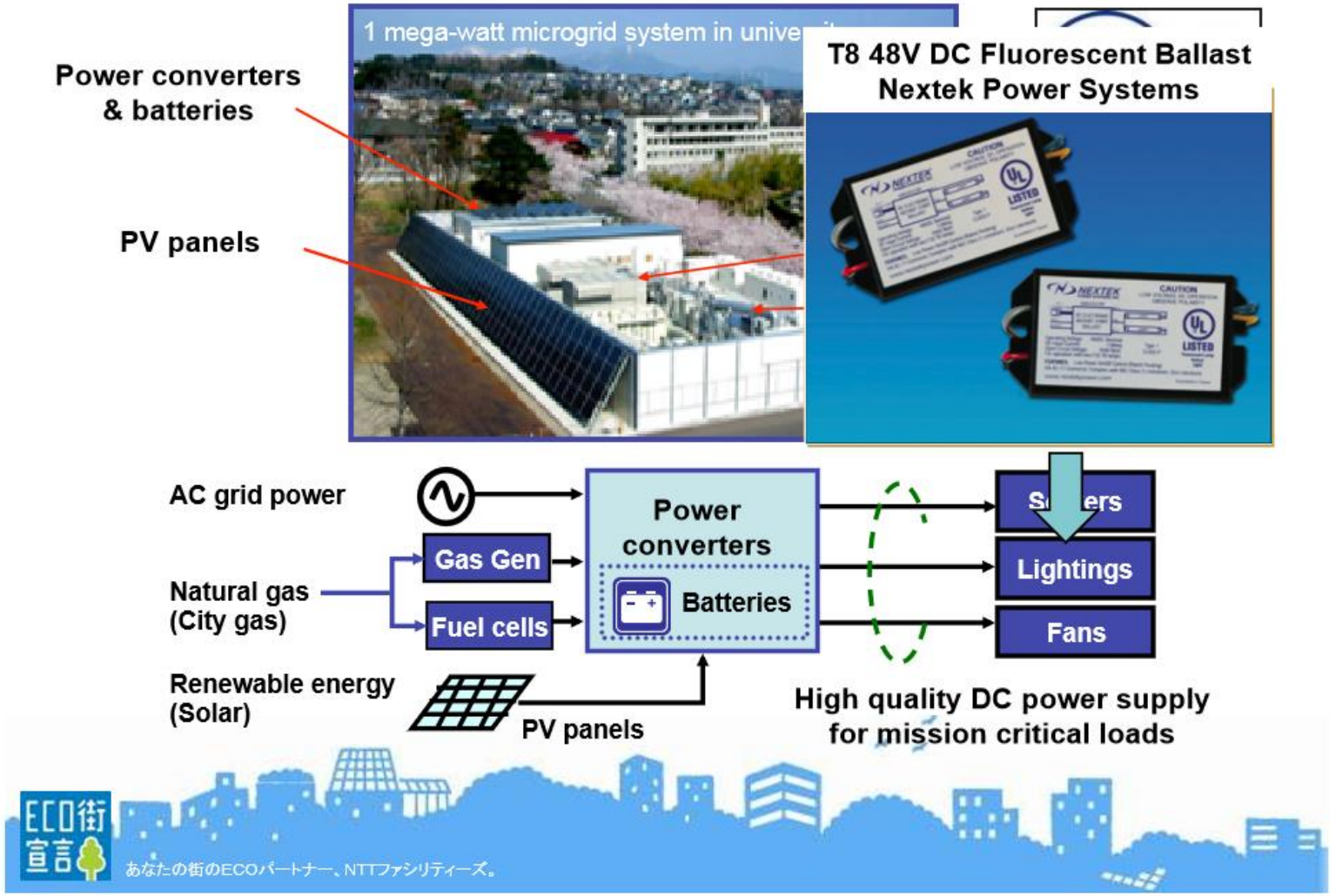


The TOHOKU region pacific coast earthquake, March 11, 2011

ergy/the-smarter-grid/a-microgrid-that-wouldnt-quit/0

About Hybrid AC/DC Microgrids's Maturity

DC – From a Global Perspective – A Special Case in Japan



About Hybrid AC/DC Microgrids's Maturity

DC – From a Global Perspective – A Special Case in Japan

About the Performance Impact and Benefits

Hybrid AC/DC Micro Grid Deployment Features

1. ***REDUCED EQUIPMENT COSTS***
2. ***REDUCED INSTALLATION LABOR COST***
3. ***EASILY RECONFIGURABLE***
4. ***IMPROVED SAFETY***
5. ***ENHANCED RELIABILITY***
6. ***BETTER SYSTEM RESILIANCY***
7. ***HIGHLY ARTICULATED DEMAND RESPONSE***
8. ***MAXIMUM ELECTRICAL EFFICIENCY***
9. ***ENHANCED CONTROL & ARTICULATION***
10. ***HIGHER USE OF ON-SITE CLEAN ENERGY***

About the Performance Impact and Benefits

Energy Savings Model Estimates

Category	DC Efficiency Δ		Units		Connected Load		KWh/Work Day		Senario 1		Senario 2		Senario 3		Senario 4		Senario 5	
Sources	Low	High	Min	Max	Min KW	Max KW	Min	Max	Min Wt	Max Wt	Min Wt	Max Wt	Min Wt	Max Wt	Min Wt	Max Wt	Min Wt	Max Wt
Utility	-2%	-1%	1	1	61	146	503	1,213	100%	100%	59%	41%	0%	0%	0%	0%	0%	0%
Fuel Cell	5%	7%	1	3	61	146	503	1,213	0%	0%	0%	0%	59%	41%	0%	0%	0%	0%
Solar SF	5%	7%	1000	5000	15	75	67.5	337.5	0%	0%	13%	28%	13%	28%	13%	28%	0%	0%
Generator	-2%	-1%	1	2	25	50	503	1,213	0%	0%	0%	0%	0%	0%	49%	41%	62%	61%
Turbine	5%	7%	1	3	5	15	140.5	374.0	0%	0%	28%	31%	28%	31%	28%	31%	28%	31%
Storage																		
Battery	7%	15%	1	2	25	50	50.0	100.0	0%	0%	0%	0%	0%	0%	10%	8%	10%	8%
Other	7%	15%	1	2	10	20	0.8	1.7	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Loads																		
Occupied Space	6%	10%	20,000	50,000	20	50	182.0	455.0	36%	37%	36%	37%	36%	37%	36%	37%	36%	37%
Desk Top	10%	15%	87	220	13	33	76.9	192.2	15%	16%	15%	16%	15%	16%	15%	16%	15%	16%
BAS	7%	15%	1	3	5	15	1.3	3.8	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
VFD (HP)	5%	7%	10	25	8	19	153.0	382.5	30%	32%	30%	32%	30%	32%	30%	32%	30%	32%
EV Charger	3%	5%	1	2	15	30	90.0	180.0	18%	15%	18%	15%	18%	15%	18%	15%	18%	15%
Total					**61**	**146**	**503**	**1,213**										
Est. Net Efficiency Improvement									**4%**	**9%**	**7%**	**13%**	**11%**	**16%**	**8%**	**14%**	**7%**	**12%**
Range												**4%**	**to**	**16%**				

Operating Conditions	
Scenario 1	Utility Power Only
Scenario 2	Utility with Solar & Wind
Scenario 3	Fuel Cell with Solar & Wind
Scenario 4	Daytime Emergency Mode (Generator with Solar & Wind)
Scenario 5	Nighttime Emergency Mode (Generator with Wind)

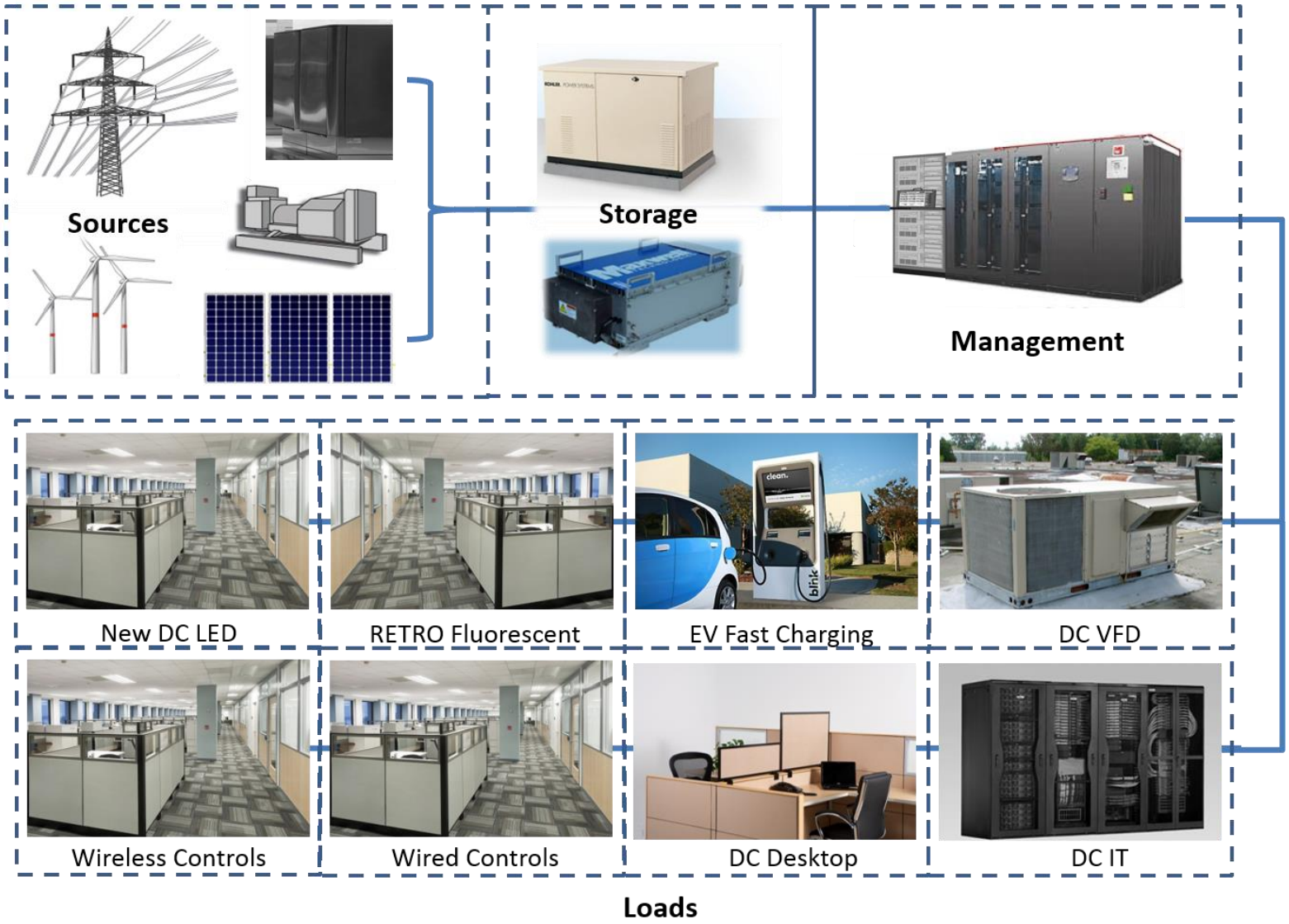
About the Deployment Vision

Hybrid AC/DC Micro Grid Deployment Options

- The deployment of enterprise level micro grids is anticipated to take two forms.
  - New Builds can implement micro grids only limited by commercial availability of design, construction and equipment availability.
  - Renovation, Retro-Fits, Repurposing, Replacement projects can implement micro grids on an opportunistic basis with the scale and scope being dictated by the project's goals and budget.
- The economic benefits are best expressed in TCO terms. The savings will typically outpace the cost of money (interest rates) with enough margin to promote investment based on competitive ROI. This will provide the potential for two primary means for financing:
  - Owner Financed
  - 3rd Party Performance Contract Financing
- The technology is a infrastructure driven game changer.
  - It fundamentally changes and simplifies the way alternate, clean, site-based electrical energy generation and storage is addressed in enterprise level power systems.

About the Deployment Vision

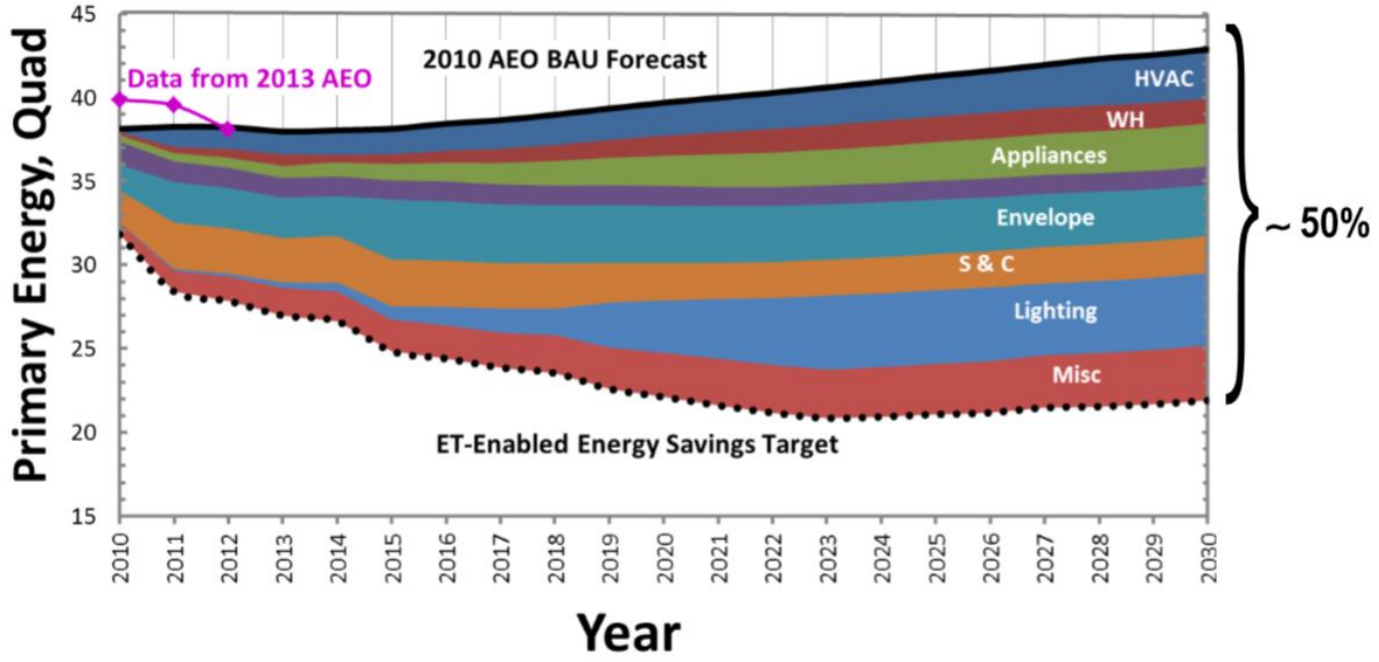
Existing & New Building Stock Can Be Equally Considered



About the Market Value of DC Applications

Key Driver of New Revenue Opportunities in Building Industry

ET-Enabled Cost-Effective Energy Savings

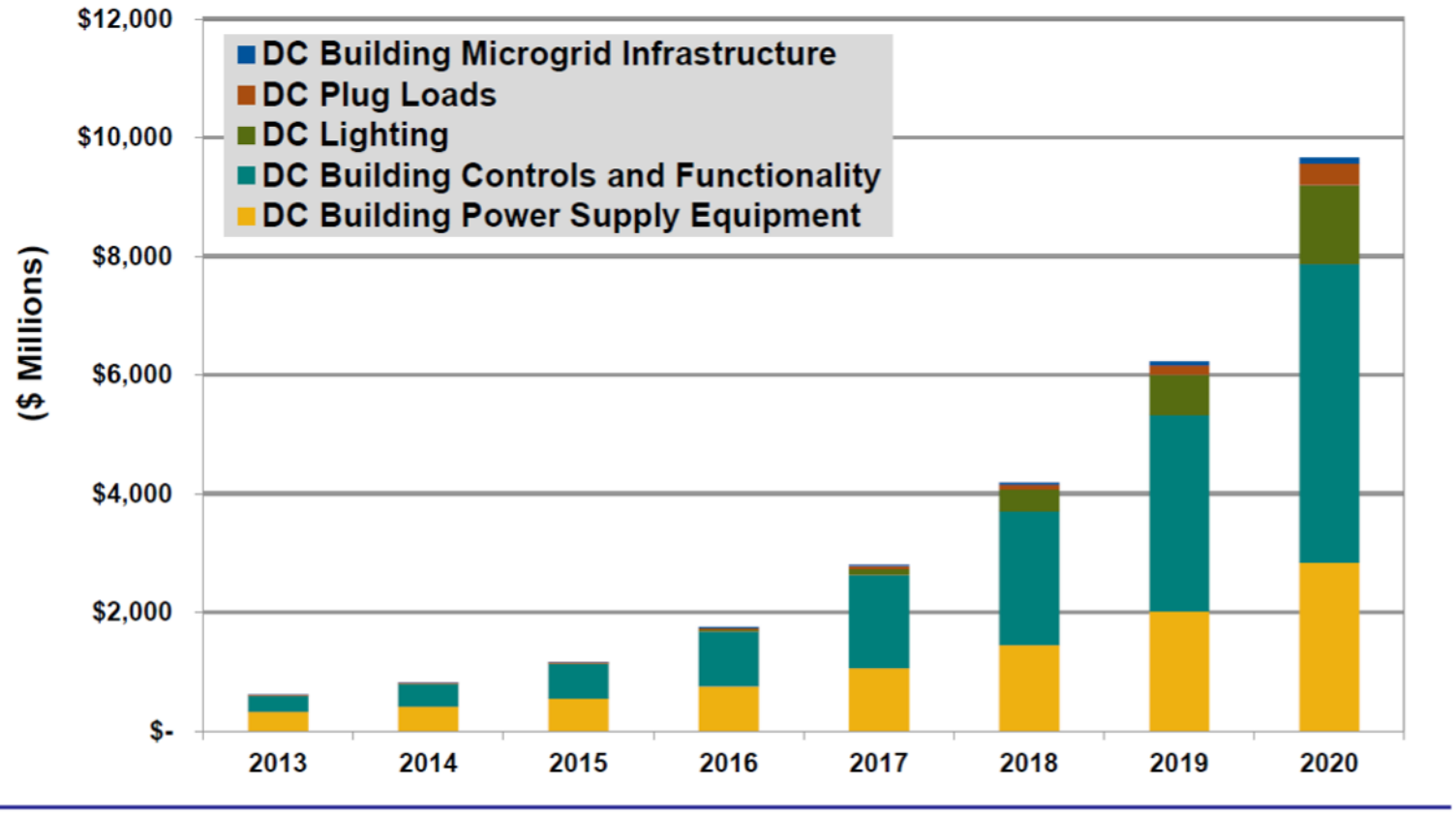


ET Goal: By 2030, develop technologies enabling 65% energy savings in lighting, 37% in water heating, 34% in windows/envelope, 29% in appliances, 24% in HVAC, and 18% in sensors & controls.

About the Market Value of DC Applications

DC Leads in New Revenue Opportunities in Building Industry

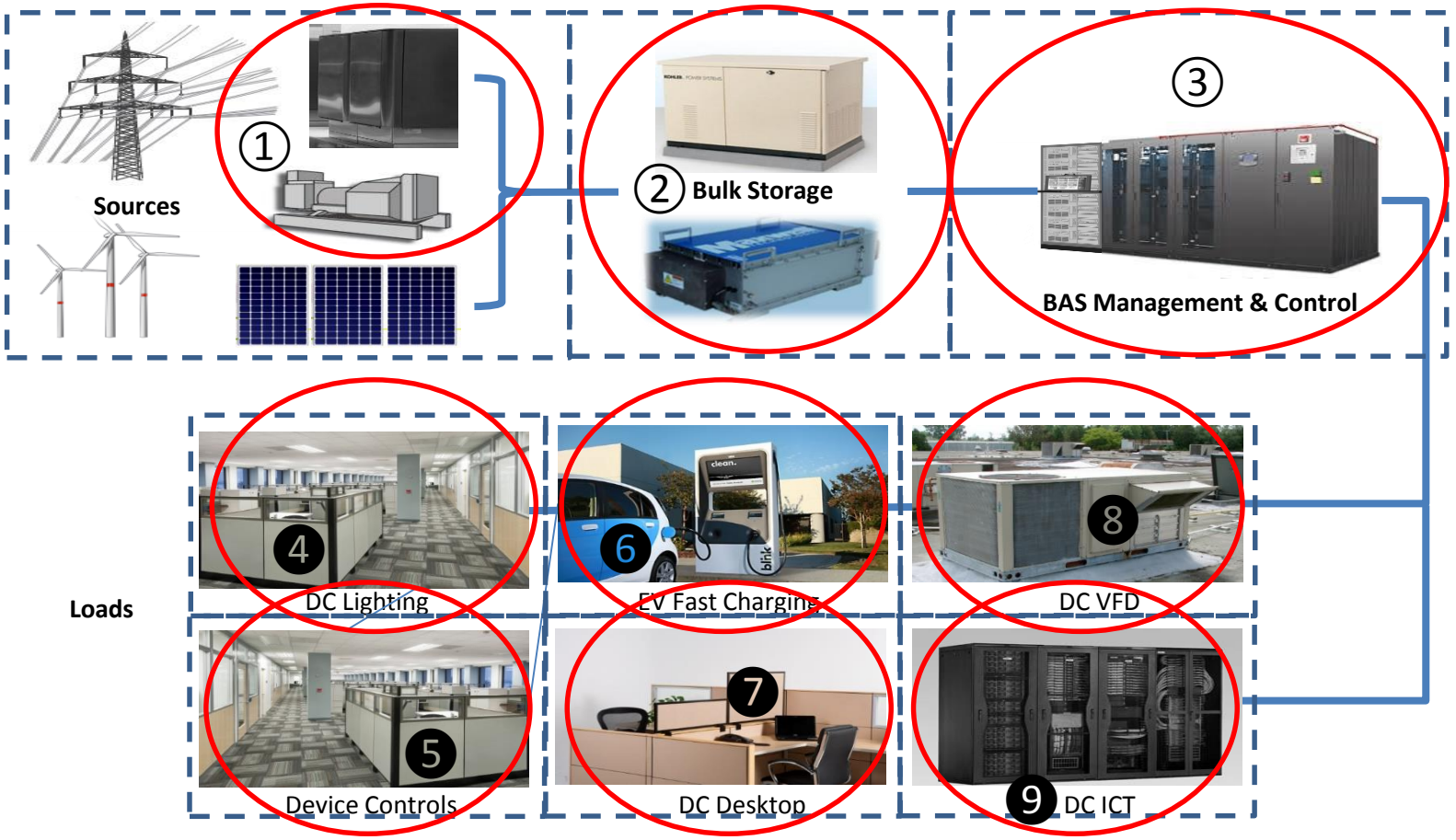
Projected DC Building Technologies Revenue Worldwide



Source: "DC Power for Commercial Buildings," Navigant Research, 2013

About the Market Value of DC Applications

Areas of Opportunity for Storage & Control in the Building Industry



1. **Black Start Ride-Thru for 'Spinning' Back-up Generation**
2. **Bulk Storage for Peak Demand Shaping and Longer Term Back-up**
3. **BAS DC UPS for Power Surety**
4. **DC Lighting Emergency & Demand Shaping Power**
5. **Occupied Space Device Control Portable Power**
6. **EV Fast-Charge Deep Cycle Reserve**
7. **DC Desktop UPS for Power Surety**
8. **DC VFD/Brushless DC Motor Peak Load Mitigation**
9. **DC ICT UPS for Power Surety**

About the Market Value of DC Applications

Key Attributes for Storage & Control in the Building Industry

- Uses DC Bus Voltage as key indicator of operational requirements of the storage controller.
- Assumes standardized bus voltages of 380 Vdc and 24Vdc
- Uses two closed loops:
  - Faster acting inner current control loop
  - Slower acting outer voltage control loop
- Charge & discharge mode of storage depends on output current direction.
- Uses boost converters and bidirectional DC/DC converters that share power by droop control to maintain the DC bus voltage in Island mode:
  - Nominal Load - the DC bus voltage is 'high' - Sources work in MPPT control mode - surplus power is provided to battery in charge state.
  - Load increase – local generation works in MPPT mode - the storage discontinues charging
  - Load exceeds local generation – storage starts to discharge regulating the bus voltage trigger voltage in order to maintain the power balance.
  - Load projection exceeds storage support – load curtailment begins using policy guidelines
- Control hierarchy monitors source, storage and load conditions to prioritize supply & demand power balance

APEC 2014
March 16-20, 2014
FORT WORTH TEXAS
The Premier Global Event in Applied Power Electronics™

Questions?

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