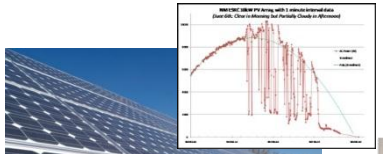






DC – a technology whose time has come again

How Direct-Current Microgrids are taking us back to the future

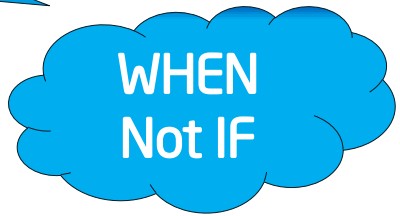
November 8, 2012

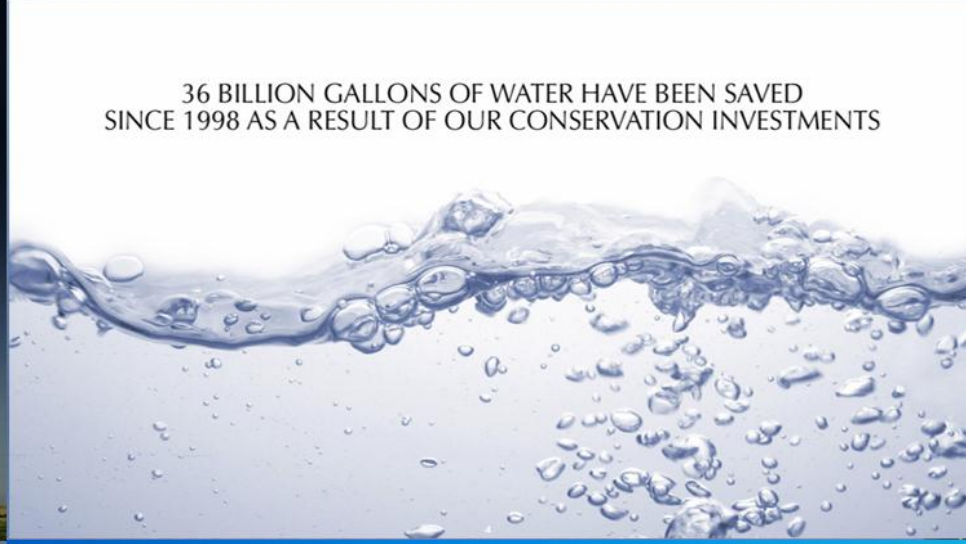
Guy AlLee
Research Scientist, Intel
Chair Campus/Building Microgrid TSC, EMerge Alliance

New Mexico Energy Systems Research Center

Overview

- Personal Energy
- The Case for DC Microgrids
- Commercial DC Microgrids & the EMerge Alliance
- Industry Standards & Specifications
- Instances, Examples and Sightings
- A Call to Action



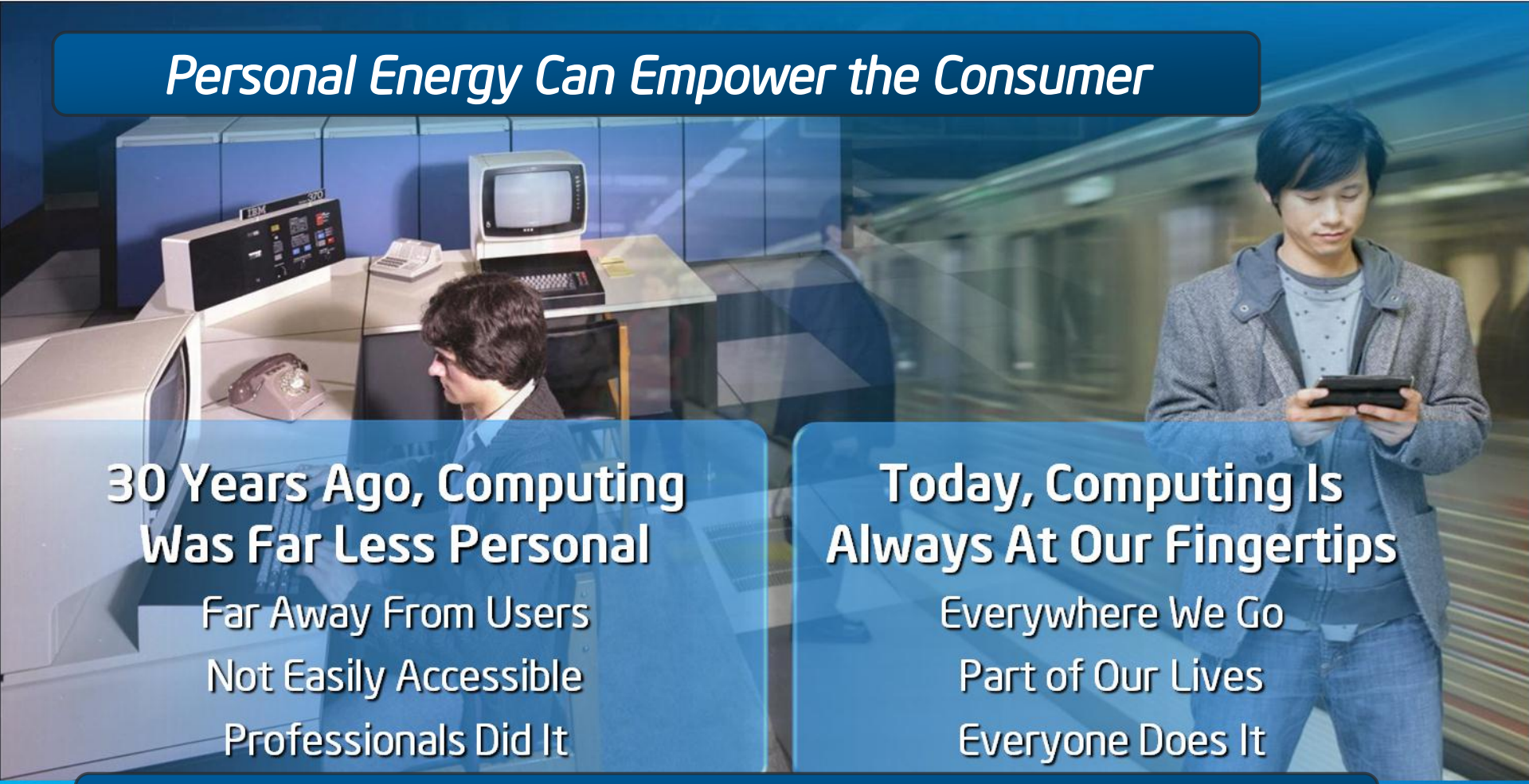


Intel Vision & Strategy

This decade we will create and extend computing technology to connect and enrich the lives of every person on earth.

- *PC, Datacenter, Adjacent Markets, Secure*
- *Care for our people, our planet*

Personal Energy Can Empower the Consumer



30 Years Ago, Computing Was Far Less Personal

Far Away From Users

Not Easily Accessible

Professionals Did It

Today, Computing Is Always At Our Fingertips

Everywhere We Go

Part of Our Lives

Everyone Does It

Make it Personal, Open, Scalable, Sustainable

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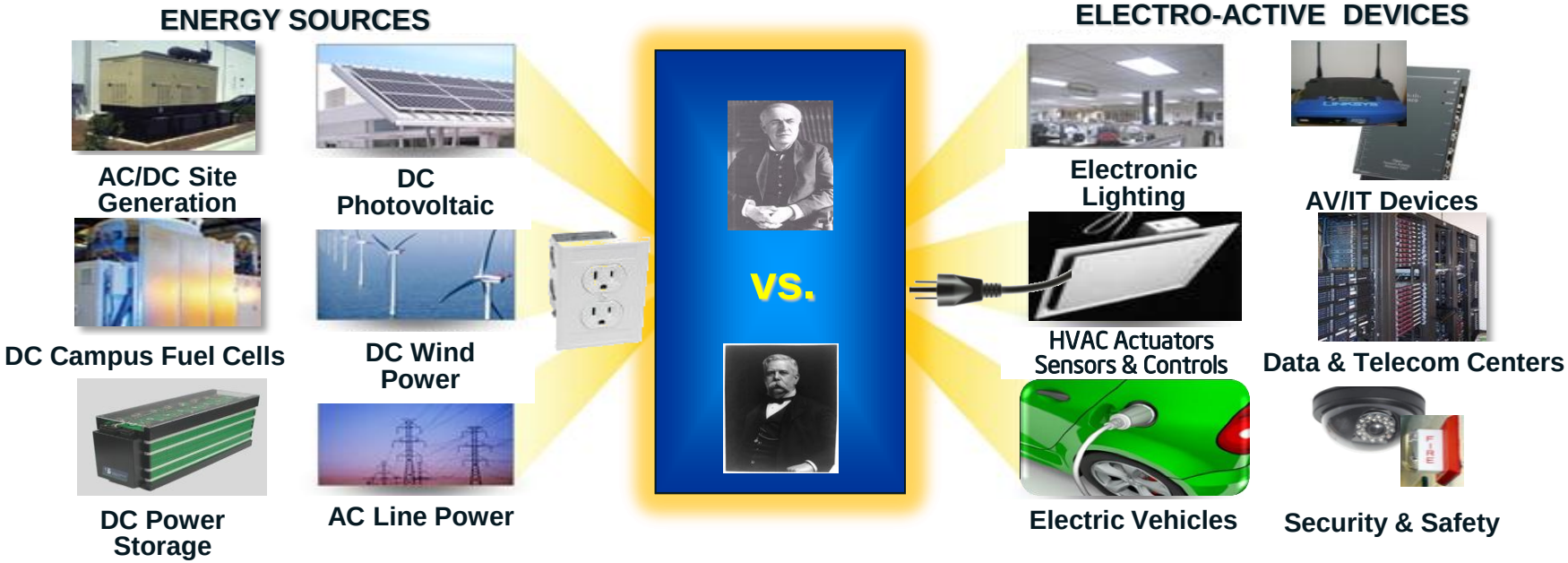
The Current Reality

PROBLEM: Mismatched AC and DC Power Distribution Requirements



RESULT: Lost Opportunity to Reduce Consumption, Improve Quality, Reliability

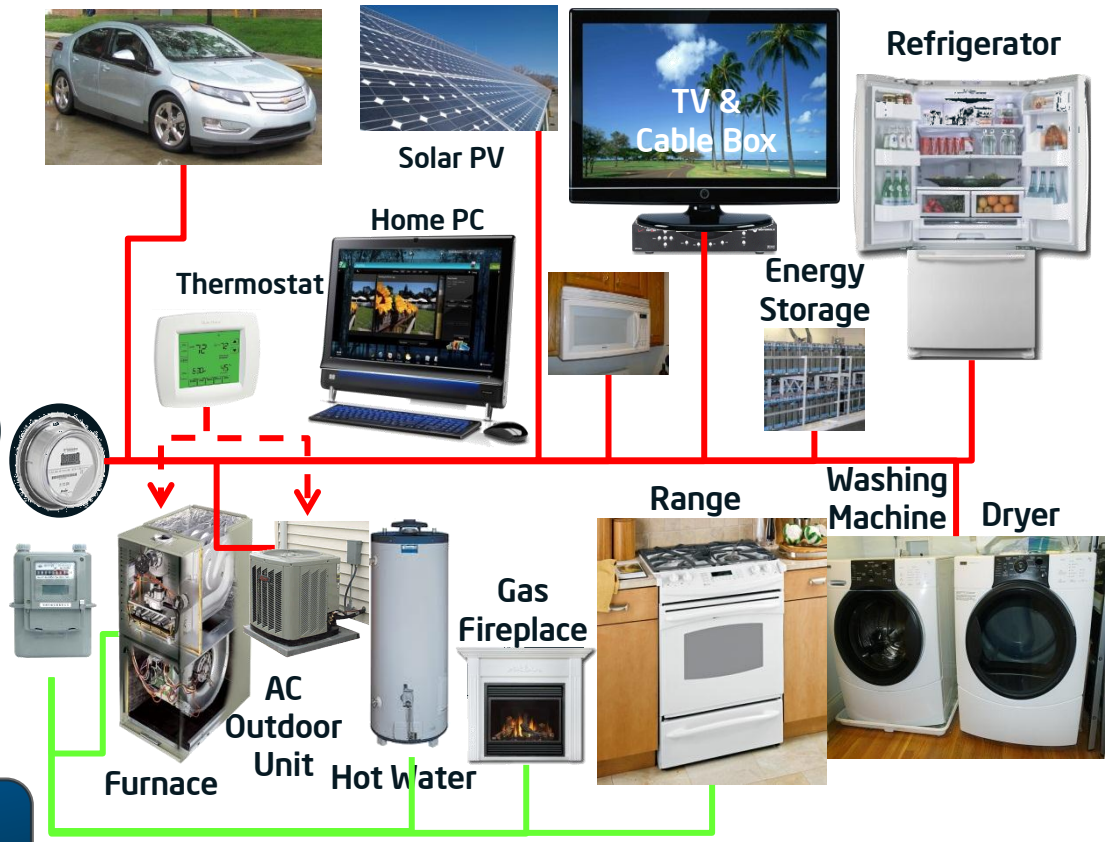
Direct-Current (DC) Microgrids

The world is already DC

- HVDC transmission
- 80% of power handled by power electronics (DC)[1]
- Alternate Energy (PV, Wind, Fuel Cells)
- Energy Storage (Batteries)
- Datacenters (ETSI 300 132-3)
- LEDs, EVs, VFD Motors
- DC can save 5-30% [2]

Keys to efficiency

- Higher Voltages
- Fewer Conversions



If we were doing the grid today, it would be DC

[1] Center for Power Electronics [2] EMerge Alliance

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What is the EMerge Alliance?

- Not-for-profit 501c -Part 6
- Open application standards - DC platform
- Eco-system development and promotion
- 100+ Member organizations and growing!

Who is the EMerge Alliance?

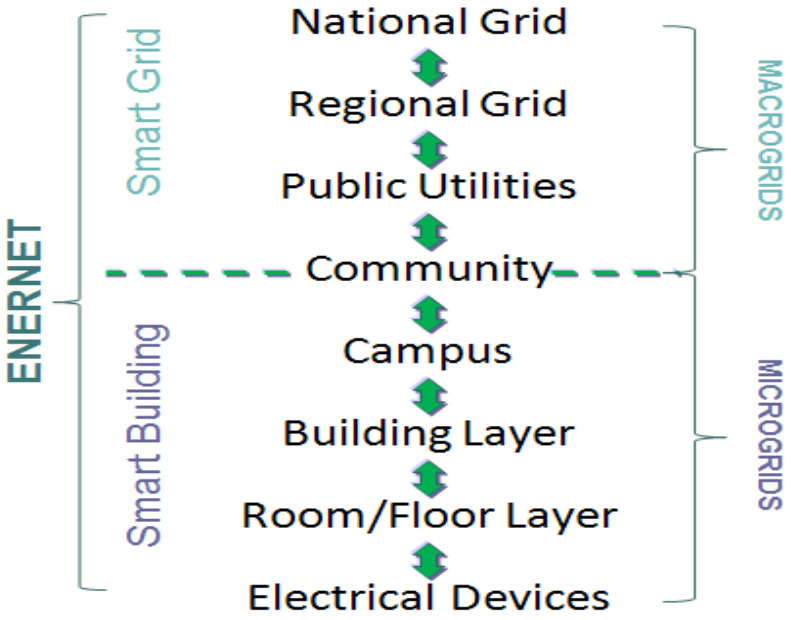
- Architects, Engineers
- Contractors/Builders/ Integrators
- Manufacturers - Service Providers
- Building Owners – Facility Managers
- National & Independent Labs
- Academic Institutions
- Codes & Standards Groups

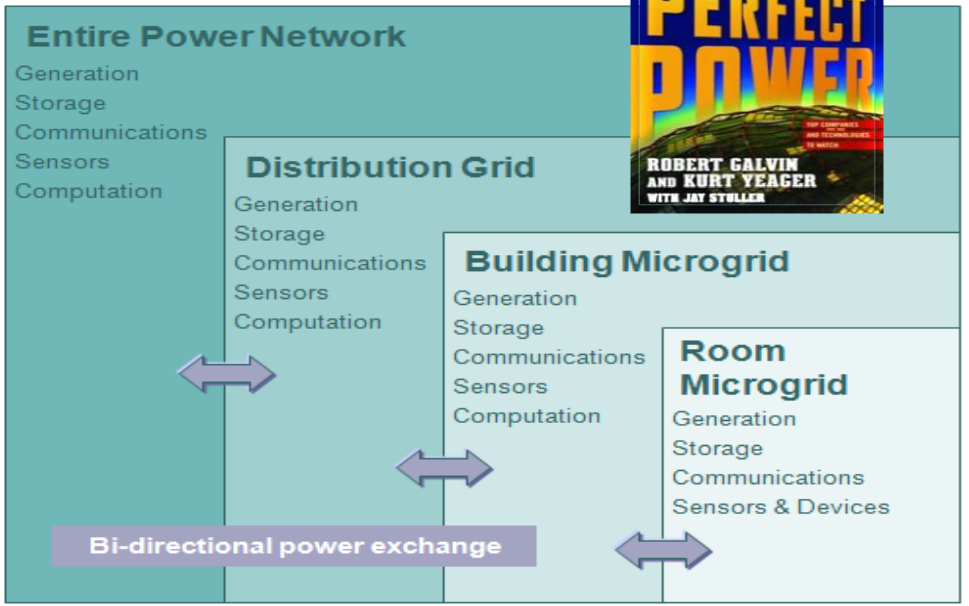
What is an EMerge Standard?

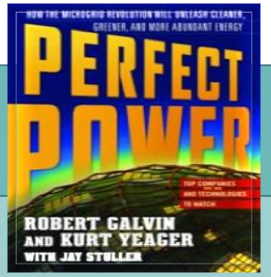
- Commercial Applications Standards
- Subordinate to safety, equipment standards
- Physical, electrical, operational interfaces
- Application definition - listing requirements of other standards (incl. IEC)

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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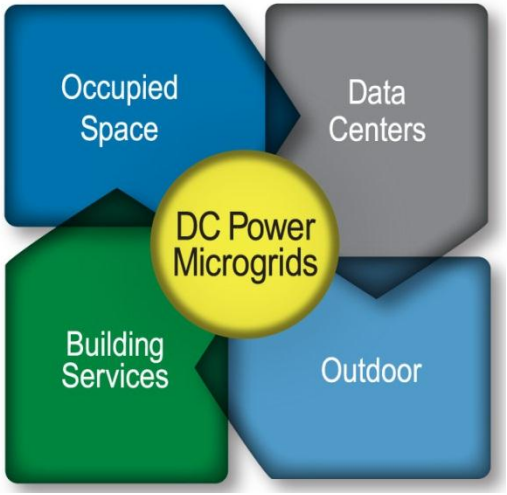
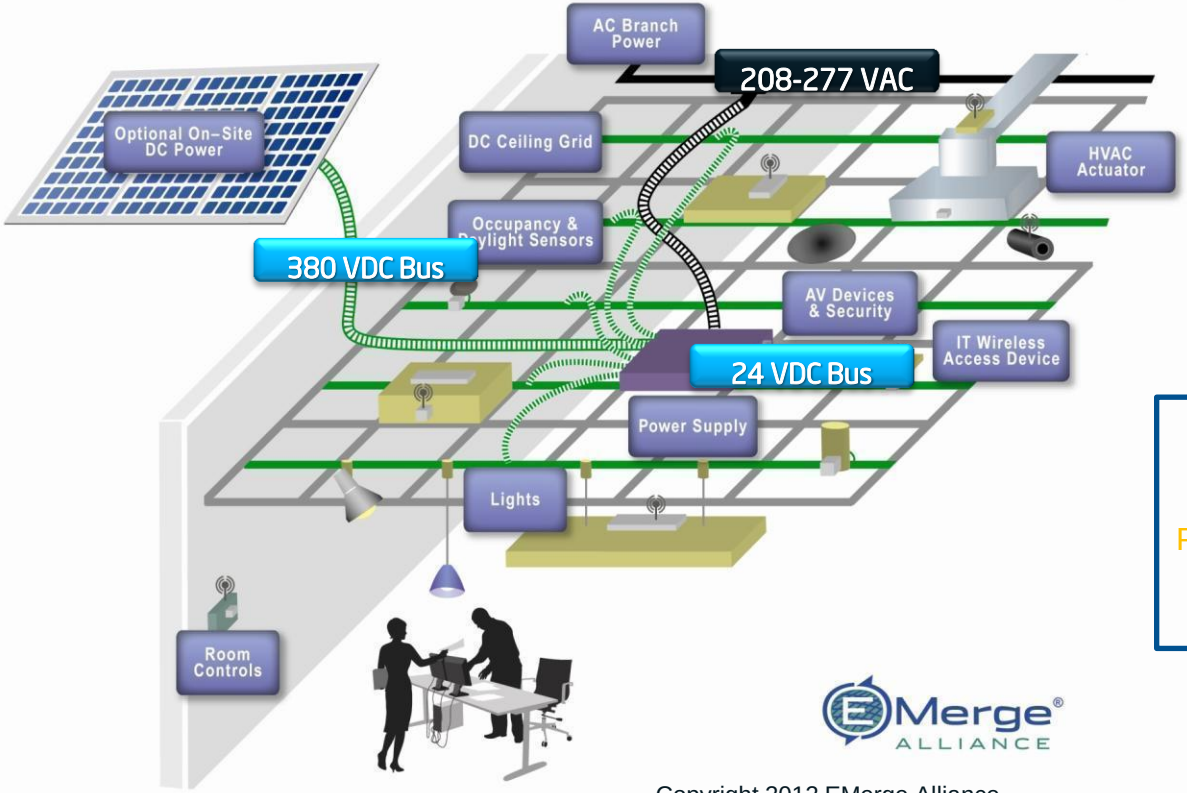
A Family of Open Power Standards for Hybrid DC Microgrids



1st Standard: Occupied Space

Developed for commercial interiors

Status: Version 1.0 Issued, Version 2.0 in Committee development



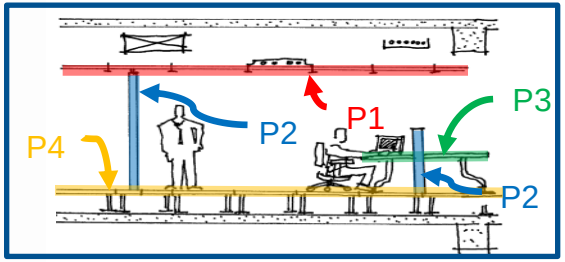
OCCUPIED SPACE INFRASTRUCTURE:

P1 = Ceiling

P2 = Walls

P3 = Furniture

P4 = Floors



EMerge ALLIANCE

EMerge Alliance Occupied Space Standard

Example Site Applications in the Field

PNC Financial
Headquarters Office
Pittsburgh, PA

lauckgroup
Architectural Office
Dallas, TX

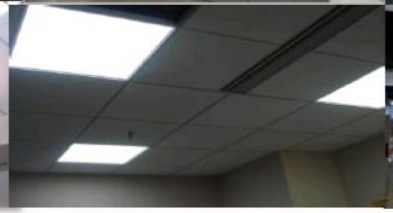
US Green Bldg Council
Conference Rooms
Washington, DC

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

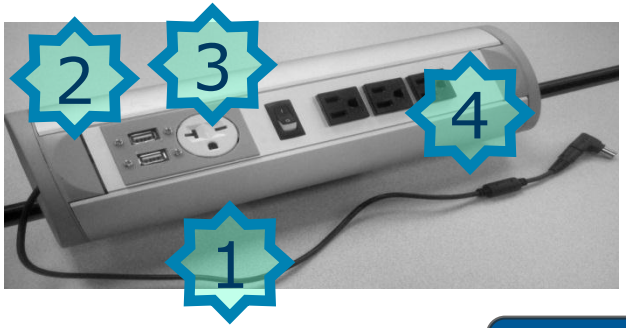
CA Lighting Tech Center
UC Davis Campus
Davis, CA

High Efficiency Mobile Worker Carrel

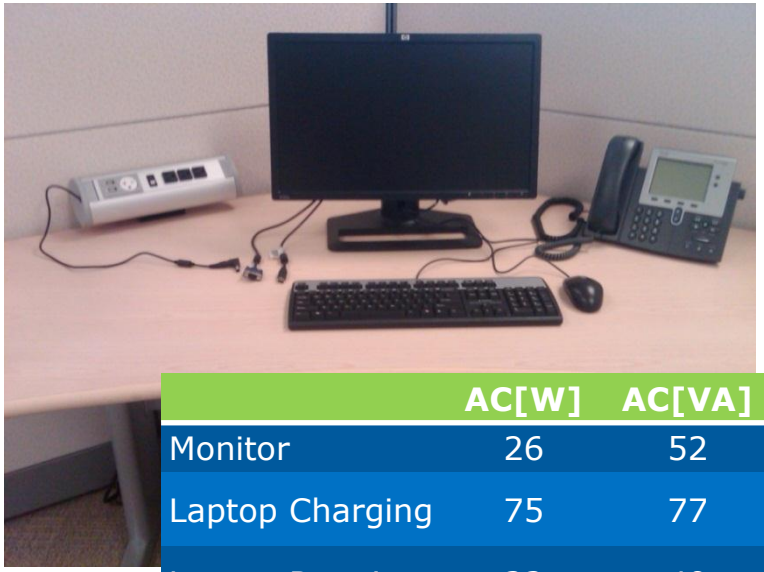
Everything at a mobile workstation can be more efficient with DC

- Laptop, Monitor, Phone
- Desk Motor
- DC Lighting

Power Outlet Prototype



1. 16-19VDC Laptop (changeable tips)
2. 5Vdc USB
3. 24VDC
4. 110VAC



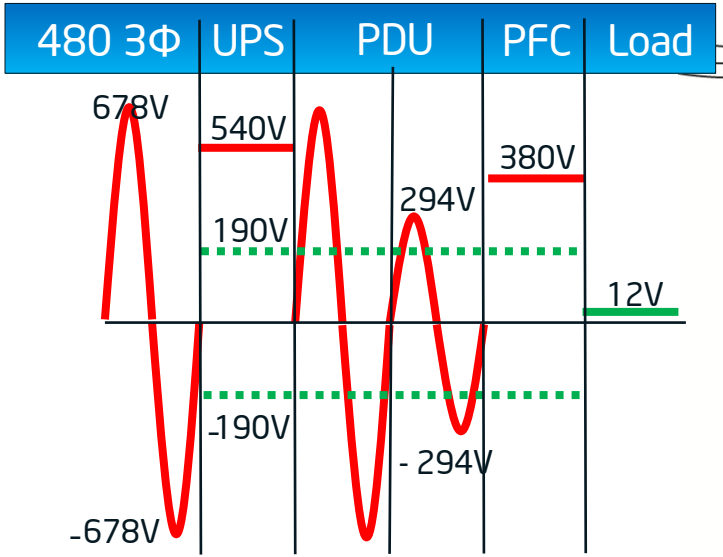
	AC[W]	AC[VA]	DC[W]
Monitor	26	52	23
Laptop Charging	75	77	67
Laptop Running	22	49	19
Phone – Idle	2	5	1.4
Phone Active	3	7	1.8
Cell Phone	5	8	3.2
Overhead Light	59	60	54
Total (Typical)	135	233	122

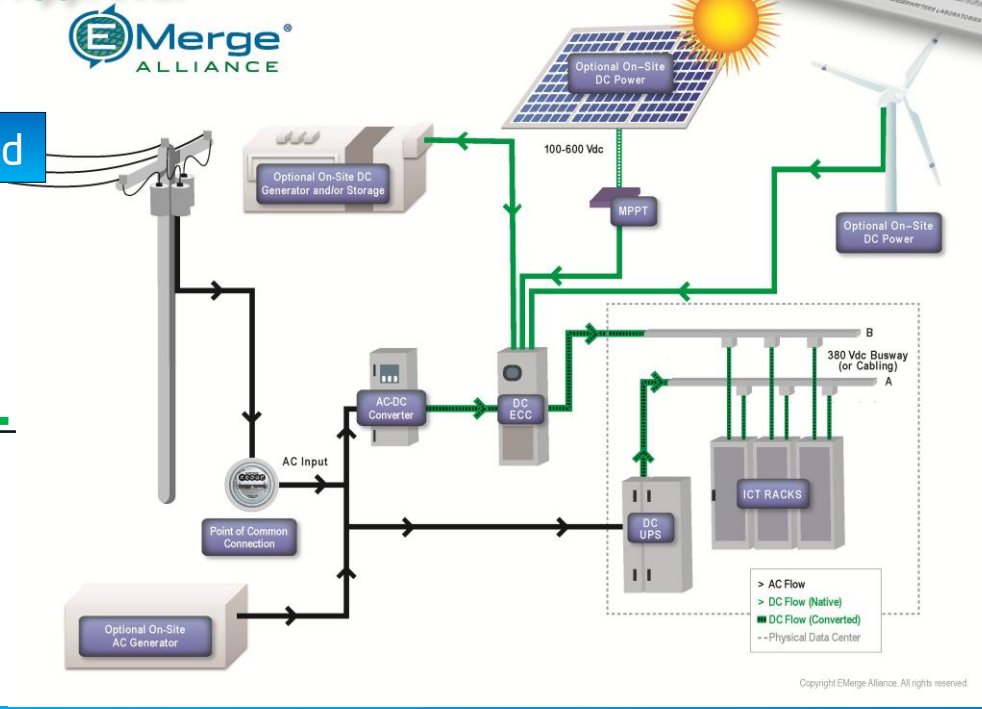
GWh savings available

2nd Standard: Data and Teleco

Developed for 380VDC ICT System

Status: Complete - Pending Final Approval





EMerge Alliance Data/Telecom Standard

Applications in the Field

Green.ch-ABB Zurich-West

380Vdc Data Center

ABB/Validus Power Distribution

- In: 16KV AC
- Out: 1MW @ 380Vdc
- Battery Backup: 10 mins
- Backup Generation

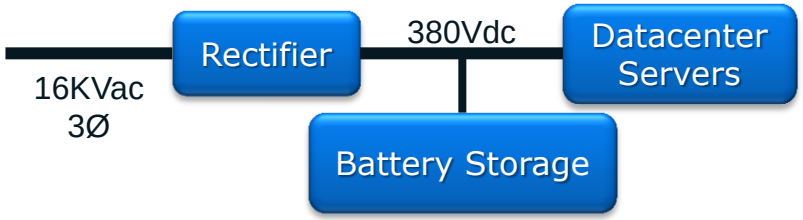
1,100m^2 of 3,300m^2 is Vdc

HP 2U, Blades & Storage Servers

Photos courtesy of ABB* and HP*

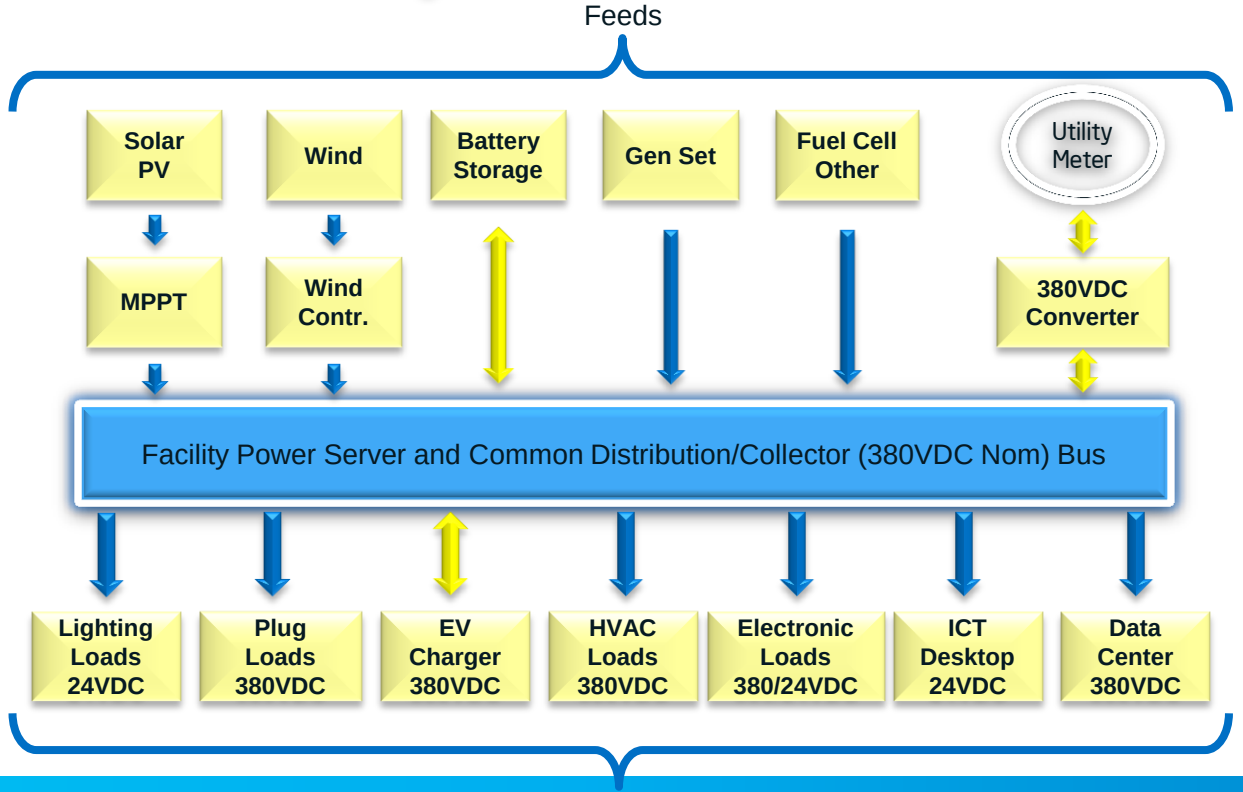
Demonstrated Benefits

- 10% Better Energy Efficiency
- 15% Lower Capital Cost
- 25% Smaller Footprint
- 20% Lower Installation Costs



Zero Net Energy Buildings (ZEB)

DC Microgrid with Renewable & Alternate Distributed Generation



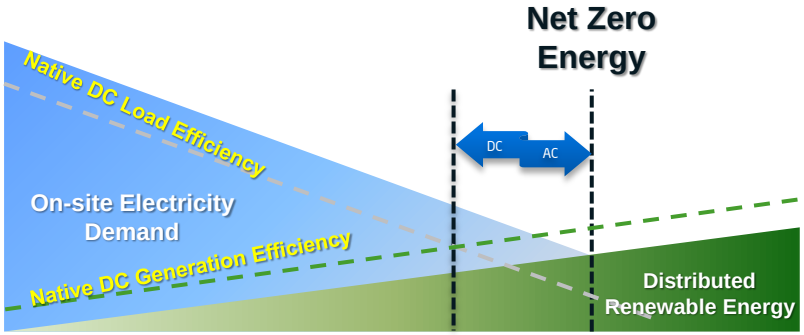
Slide Courtesy of EMERSON Network Power

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)

EMerge Alliance Occupied Space Standard

Example of Net Zero Energy Building



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.

Summary

Personal Energy – the next big thing.

Direct Current – not an if, but a when.

EMerge Alliance: single worldwide, harmonized suite of standards for DC microgrids

- 100 organizations around the world
- Commercial buildings & ZNE buildings faster

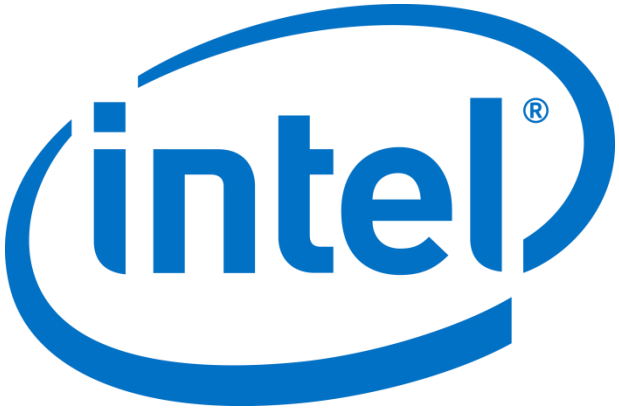
EMerge Alliance Standards are already in place for 24Vdc and 380Vdc.

- Being harmonized into International Standards by IEC, ETSI, UL, NEMA, NEC, etc.
- Real buildings with real products already

EMerge® ALLIANCE

DC, the power to change buildings

intel


intel

The Eco-system is building… [Videos]

ABB ON DC Efficiency

NEI on DC

ABB CEO Joe Hogan on DC Future

EMerge Imagine

AC vs. DC

Additional sources of information

IEEE Power & Energy Magazine, Nov/Dec '12 Issue : Plugging into DC
http://magazine.ieee-pes.org/

Plug and Play Electricity http://blogs.intel.com/research/2010/04/plug_and_play_energy_efficienc.php

DC, An idea whose time has come and gone?
http://blogs.intel.com/research/2010/05/dc_-_an_idea_whose_time_has_co.php

EMerge Alliance http://emergealliance.org

Environmental view of 380VDC from Yale School of Forestry & Environmental Studies:
http://environment.research.yale.edu/documents/downloads/0-9/05-DC-Microgrids.pdf

Enernet: Internet Lessons for Solving Energy, Bob Metcalfe
http://www.slideshare.net/gigaom/bob-metcalfe-internet-history-applied-to-solving-energy

Electricity 2.0: Unlocking the Power of the Open Energy Network http://ndn.org/electricity20

SMART 2020: Enabling the low carbon economy in the information age, The Climate Group on behalf of the Global e-Sustainability Initiative (GeSI), ©2008 www.smart2020.org

World Energy Outlook 2009, International Energy Agency http://www.worldenergyoutlook.org/

Beyond the Smart Grid – Personal Energy Systems

- The Smart-Grid: automating the electricity supply system
- Personal Energy Systems can make user-centered energy a reality
- Microgrids – integral to Personal Energy
  - Local Generation
  - Local Energy Storage
- Plug-n-Play Energy Monitoring & Management
- Eco-Sense Buildings
  - Distributed sensors + personal feedback
- Zero Net Energy Buildings

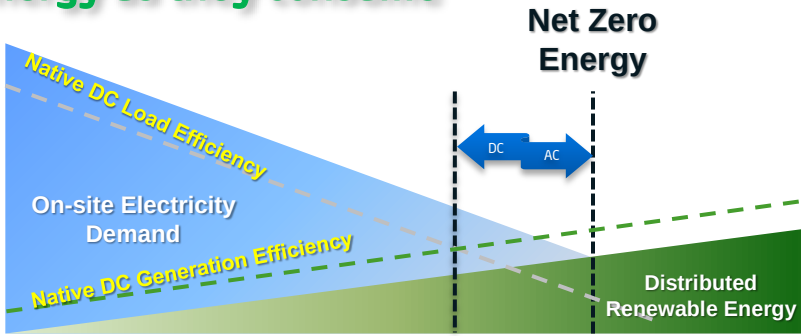
Net Zero Energy Building Model

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**

Energy Savings
Opportunities for Building Owners

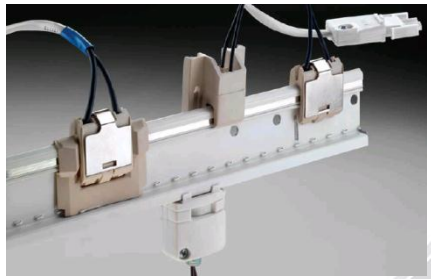
Building Applications *(in priority timing of EMerge Alliance*)*	% of Building Energy	Potential Energy Savings - DC	Keys to Maximizing Efficiency in Going DC
Interiors (Lighting)**	28%**	**Up to 15%**	LED, Renewables
Data/Telecom	17%	**Up to 30%**	Higher voltage conversions, Renewables
Service/Utility (HVAC)	36%	**Up to 10%**	Renewables
Outdoor	6%	**Up to 10%**	LED, Renewables
Other (misc equip loads)	13%	**Up to 5%**	Different voltage conversions

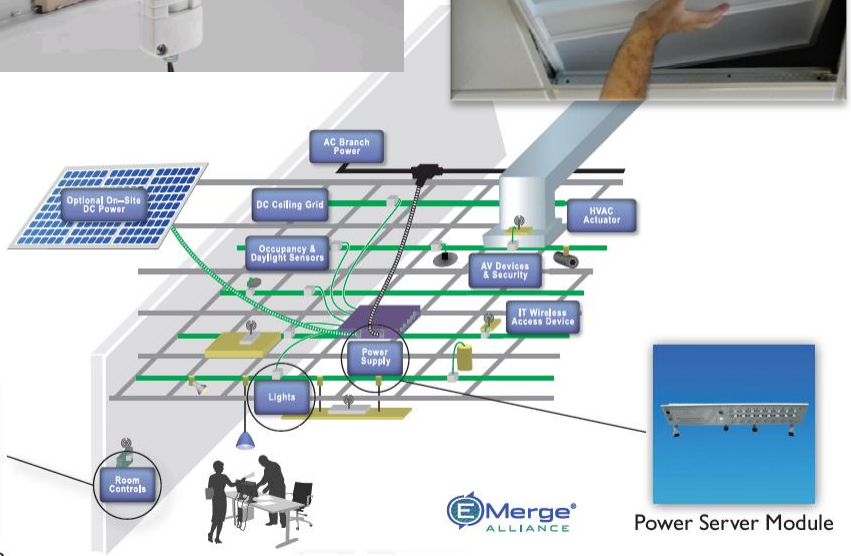
Vision: DC Microgrids Throughout Buildings

**Higher energy use in office buildings, up to 40%

High Efficiency / Highly Configurable DC Lighting

- Class II, 24Vdc touch-safe power in ceiling grid
- Does not require electrician to reconfigure spaces
- Up to 40% more efficient
- 2.5x Longer Fixture Life
- Eliminates separate Emergency Lighting circuits w/ battery in ballast
- 380Vdc building backbone
- Consistent with alternate energy sources





PS Manager Software

Power Server Module

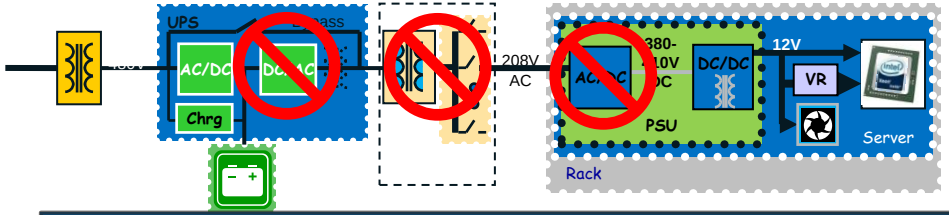
380VDC To Class II Touch-safe 24VDC in ceiling rails for high-efficiency office lighting

Direct-Current Microgrid: 380Vdc the New Standard

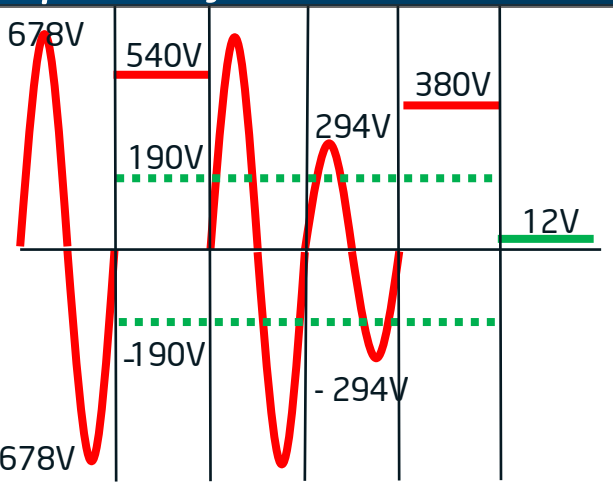
ETSI 300132-3-1 v2.1.13 (1) (2011)

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↑ + Conversions↓

- Volume Priced Parts (< 420Vdc)

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

EMerge Alliance Data/Telecom Standard

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

http://www.youtube.com/watch?feature=player_detailpage&v=0GkUlrY-aYI

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

intel

Information/Collaboration/Harmonization