

**EPRI**

ELECTRIC POWER  
RESEARCH INSTITUTE

## Residential & Commercial Use Of DC Power

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Senior Project Manager

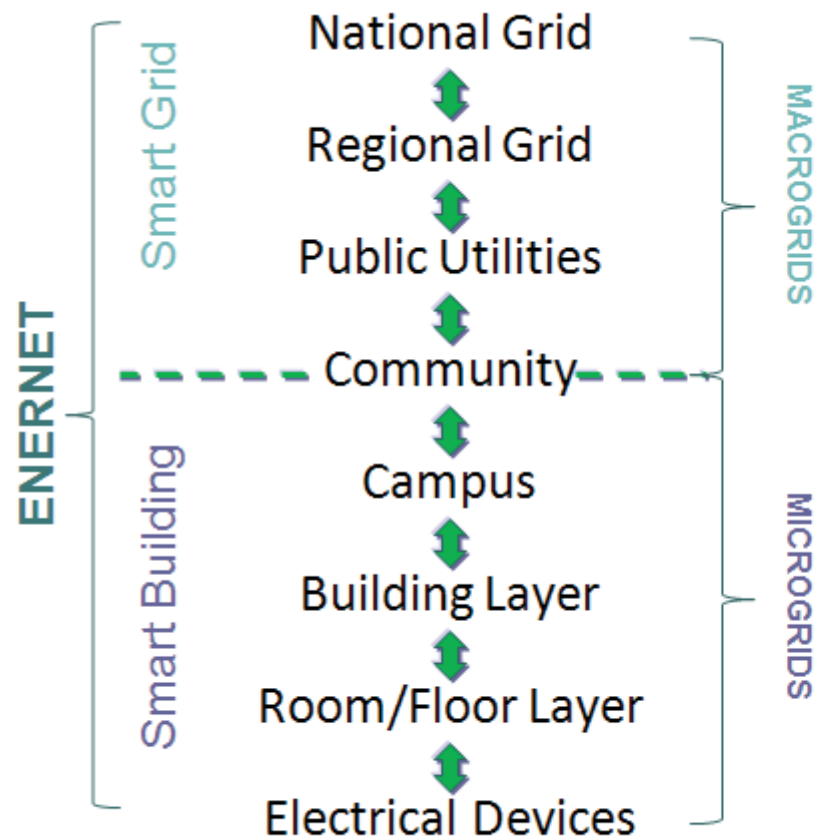
**NEMA, UL & NFPA**  
Low Voltage Direct Current Workshop  
08APR2011 – Arlington, VA

# From Dept of Energy Secretary Steven Chu

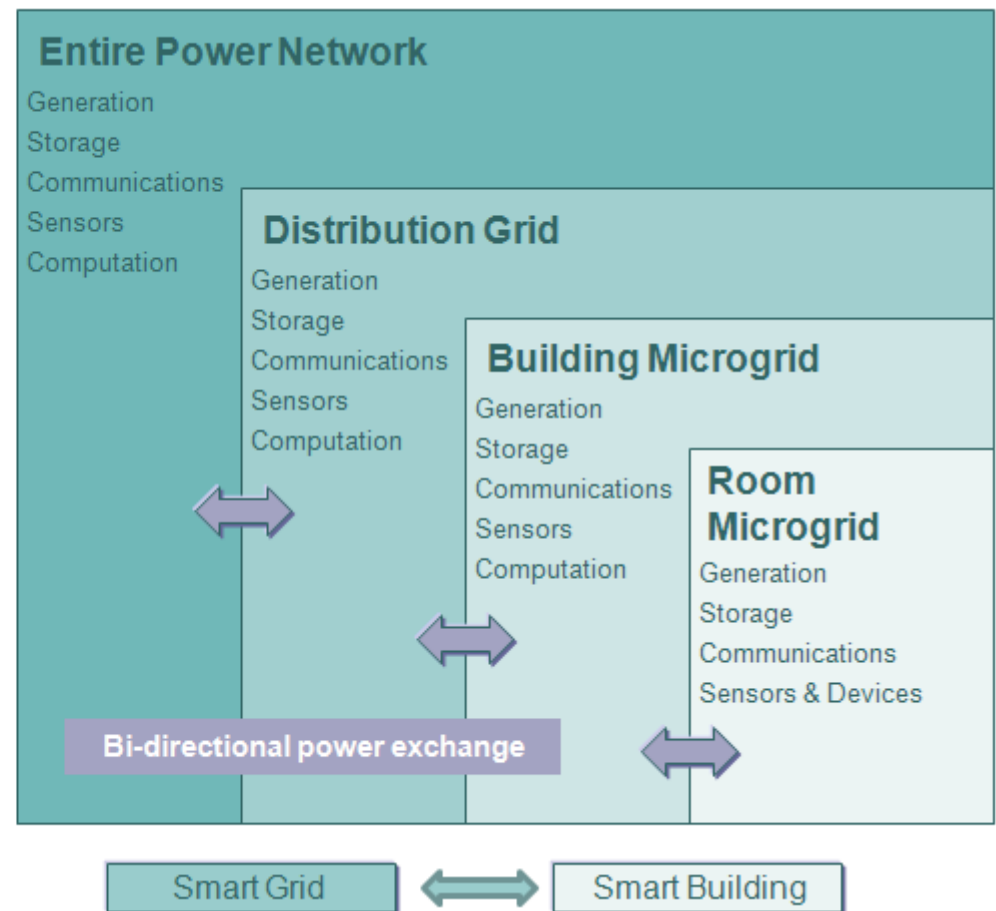
- As Energy Secretary Steven Chu has noted, “America cannot build a 21st Century energy economy with a mid-20th Century electricity system.”
- Transforming the current grid into a dynamic, resilient, and adaptable Smart Grid will be one of the biggest technological challenges of our times. The rewards, however, may be dramatic, enabling consumers to better control their electricity use, integrating the next generation of plug-in electric vehicles, increasing efficiency, and better harnessing renewable energy.

Source: Department of Energy, Communications Requirement Of Smart Grid Technologies, October 5, 2010

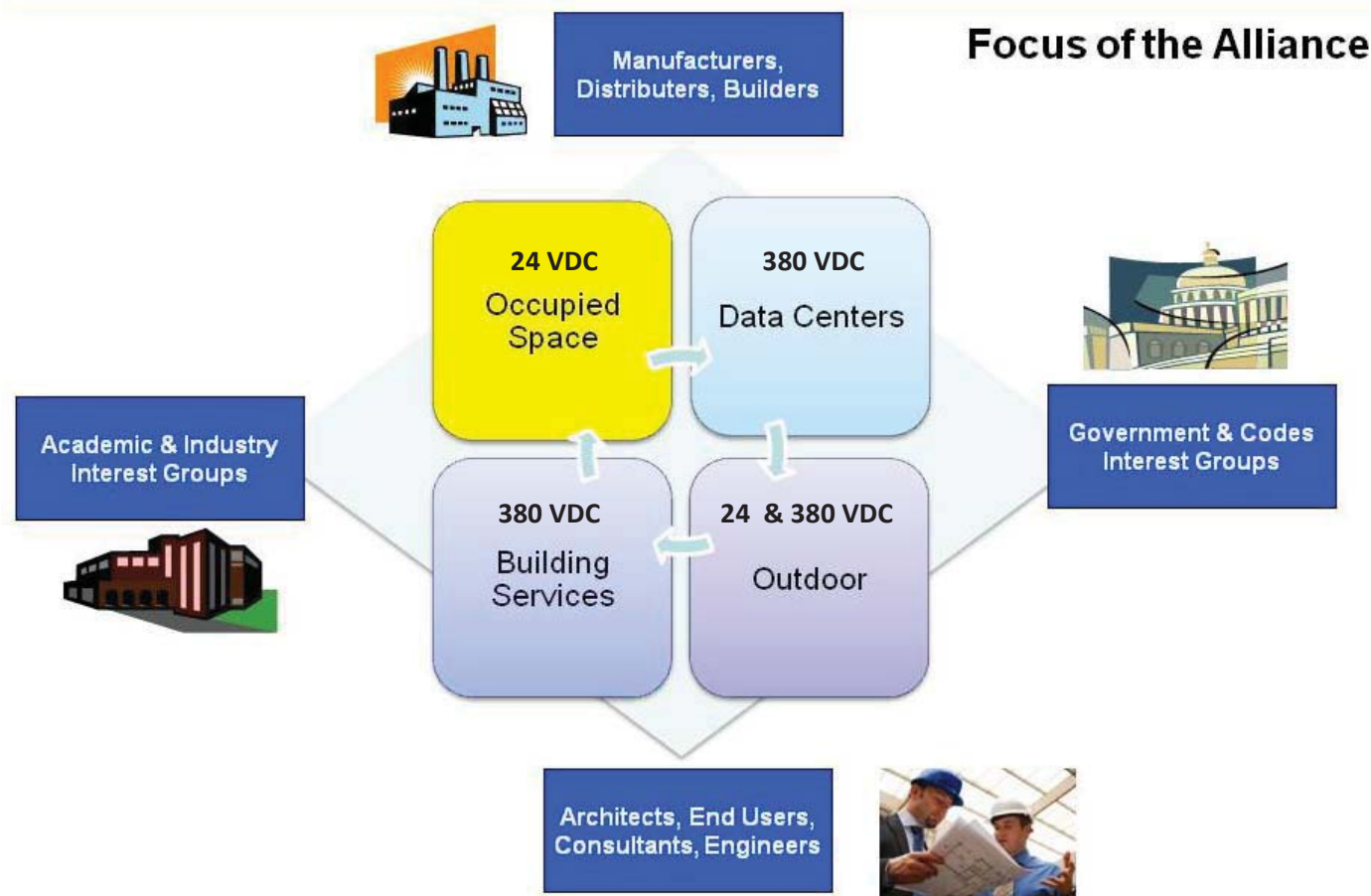
# Smart Grid to Smart Buildings



Source: EMerge Alliance Overview

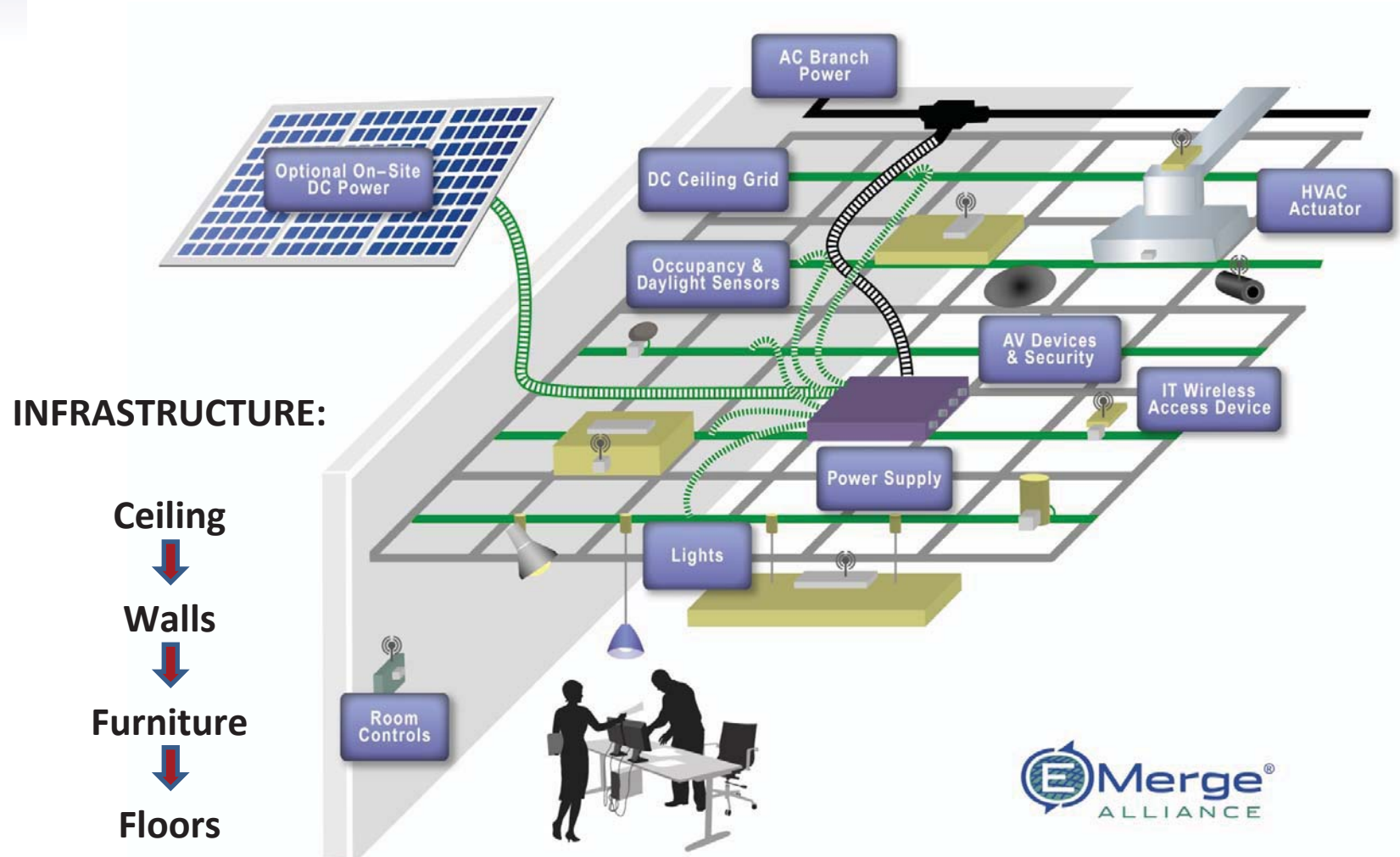


# DC Microgrids Throughout Buildings



Source: EMerge Alliance Overview

# EMerge Alliance Standard – 24VDC Ceiling View



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# Who Is EMerge?

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

## Members - Partial list, visit [EMergeAlliance.org](http://EMergeAlliance.org)

### Founding Governing Members



### Participating Members



### General Members



### Corresponding Organization Members



### Liaison Members



### Supporting Members

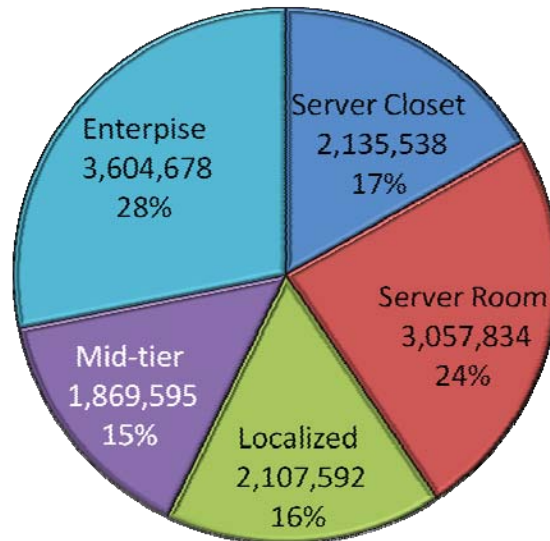


# Data Center Types, Sizes and Numbers

Type	Server Closet	Server Room	Localized Data Center	Mid-tier Data Center	Enterprise-Class Data Center
<b>Scope</b>	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
<b>Power/cooling</b>	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
<b>Sq ft</b>	<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

# Data Center Type and Server Population

**Number of Servers by Data Center Type**



0.7% of data centers (Enterprise & Mid-tier)  
contain 43% of all servers

(Amazon/Apple/Facebook/Google/Yahoo)

They have staffs of internal electrical &  
mechanical engineers to design &  
construct efficient data centers

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99.3% of data centers (more than 2.5 million  
of them) contain 57% of all servers

(Hospitals/Hotels/Universities/Utilities/Banks  
/City Halls/Supermarkets/Chain Stores)

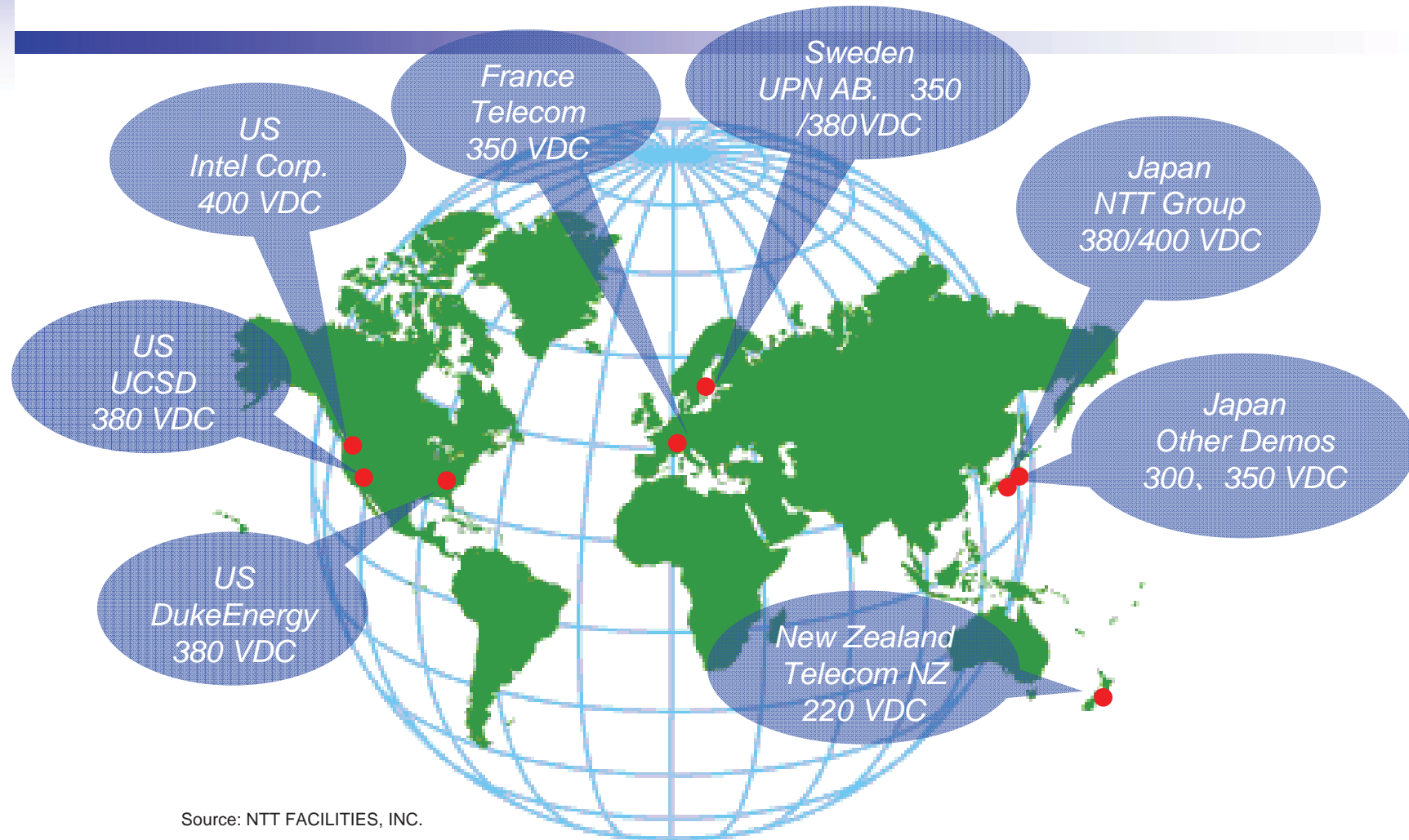
These data centers operators struggle with  
heat/space/power problems without much  
internal expertise



# 380VDC Data Center Activity

- Involved With Multiple 380VDC Demos
  - Universities
  - Electric Utilities
  - Telecom Industry
- Harmonizing Multiple 380VDC Spec Efforts
  - DC Power Partners Joining EMerge Alliance
  - European Telecommunications Standards Institute
  - International Electrotechnical Commission (SG4)
- Working With Many Manufacturers
  - IT Equipment As Well As Facility Equipment

# Worldwide ~380VDC Demos

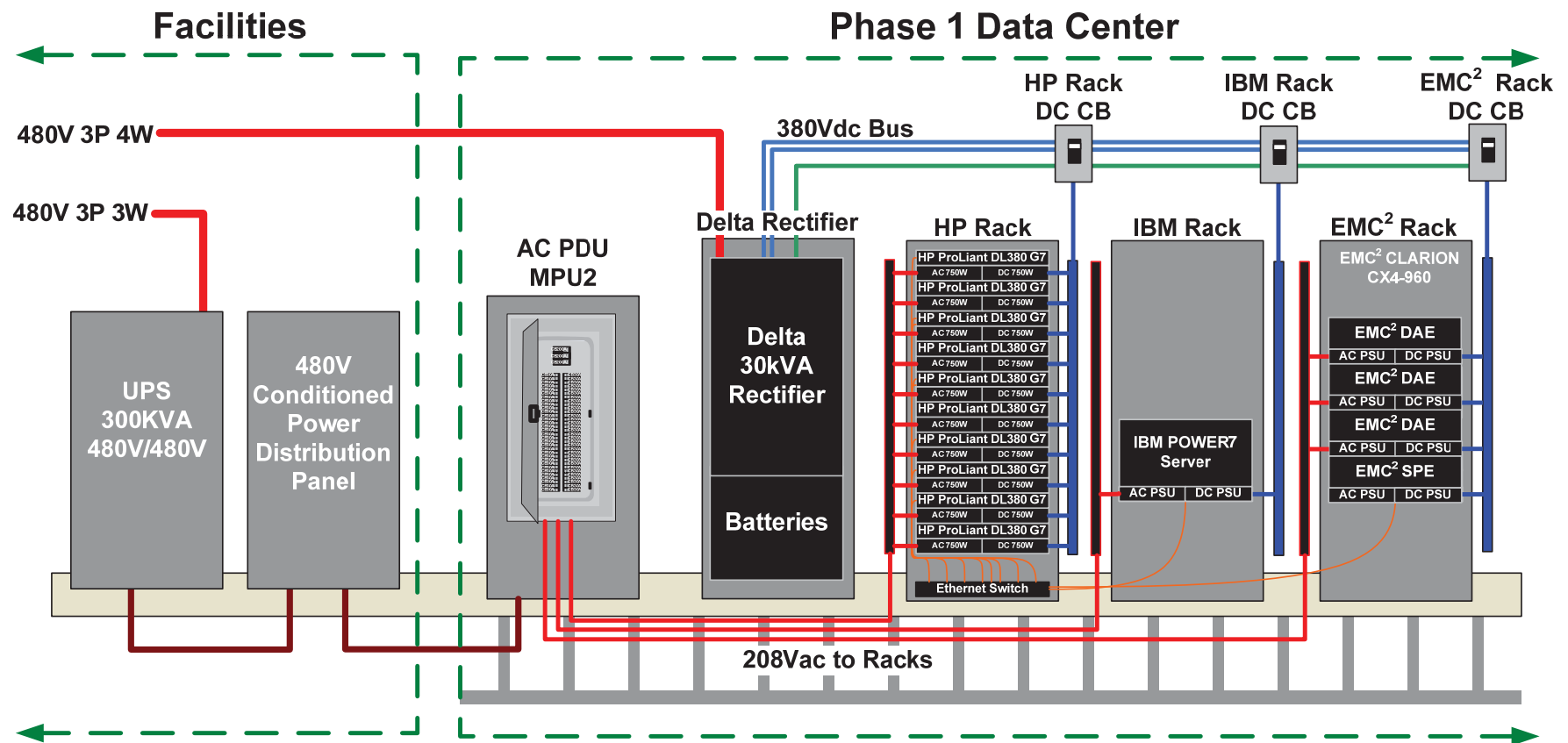


# Duke Energy 380VDC Data Center Demo

HP Servers  
IBM Servers  
EMC Storage Arrays  
Delta Rectifiers  
StarLine Busway  
Dranetz-BMI Metering



# Duke Energy Data Center Set-Up



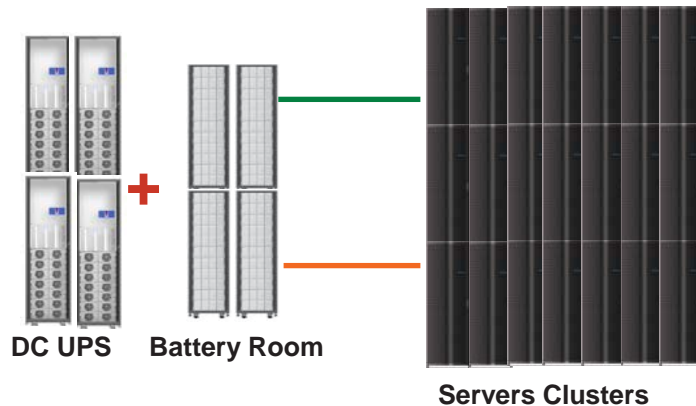
# Delta Products - DC UPS



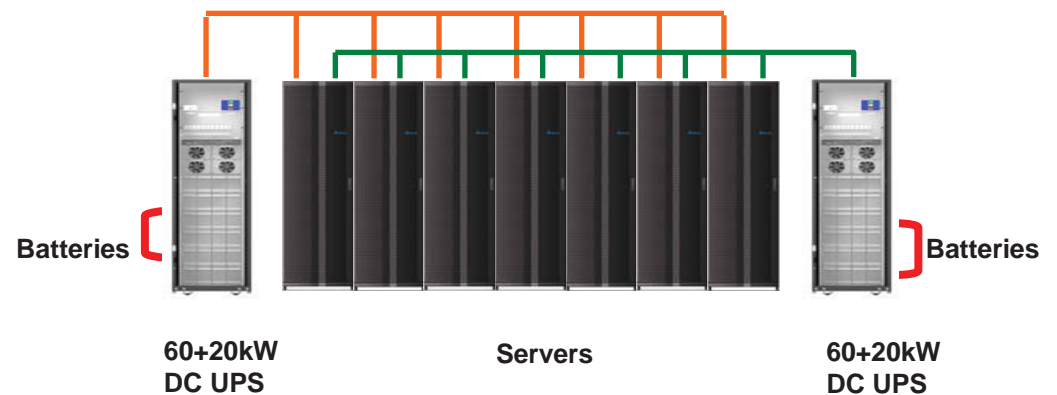
80kW 120kW 160kW ... 280kW

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

## Facility Configuration



## Row Configuration



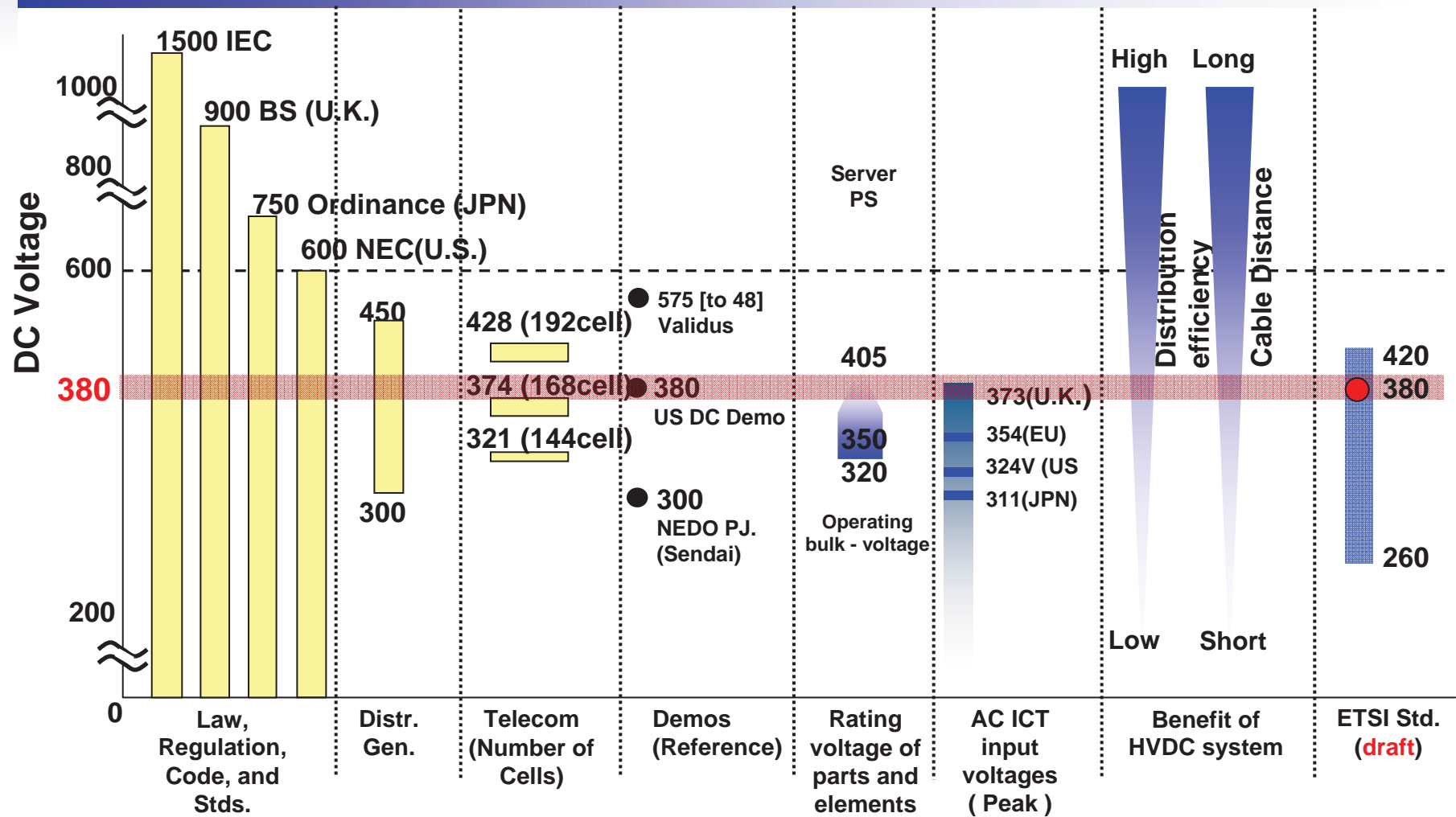
# Delta Products - Rectifier Module Spec

- Power Module capacity 20KW.
- Input voltage: 480/277V, 400/230V, 380/220V
- Input range: +15%~-20%of Nominal Voltage.
- Input power factor >0.99.
- Current Total Harmonic Distortion <5%.
- Output voltage 350/380/400Vdc (Nominal).
- Current balance accuracy < 3%.
- Output Voltage regulation < 1%
- Output short current limit: 75A.
- AC – DC efficiency : 96%.
- Fully DSP based digital control.
- Delta patented topology for 3 phase buck boost PFC.
- Swappable power module design .
- Dimension: 129(H) x 219(W) x 700(D) mm.
- Weight: 16.1 Kg



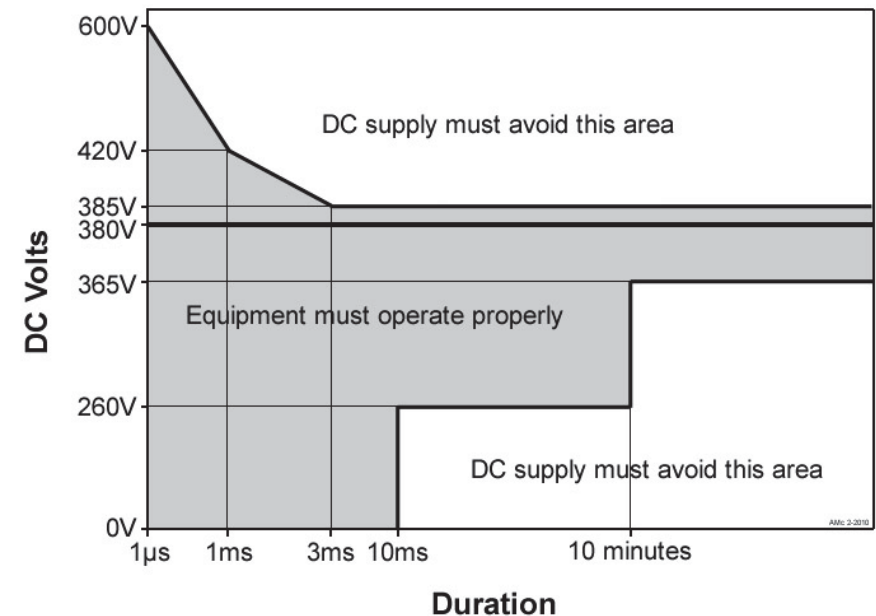
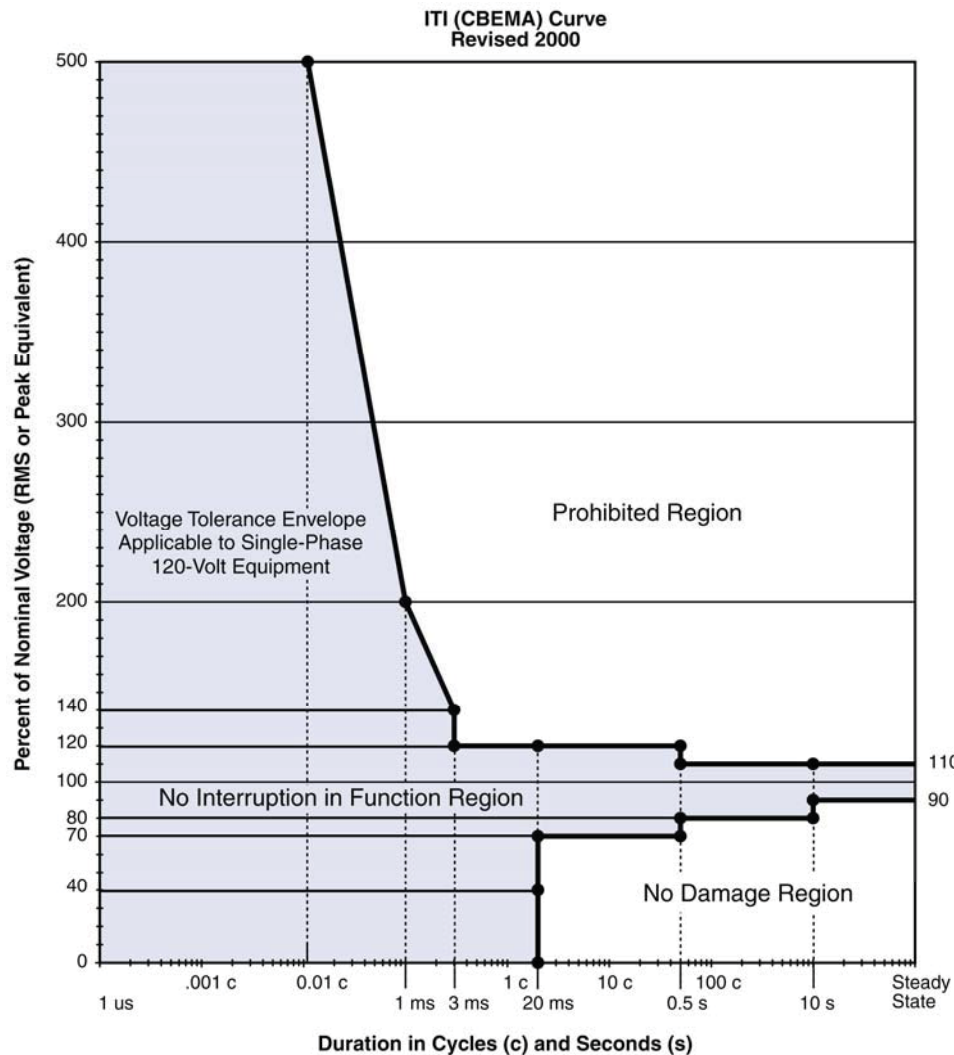


# Why 380VDC? – “Sweet Spot”



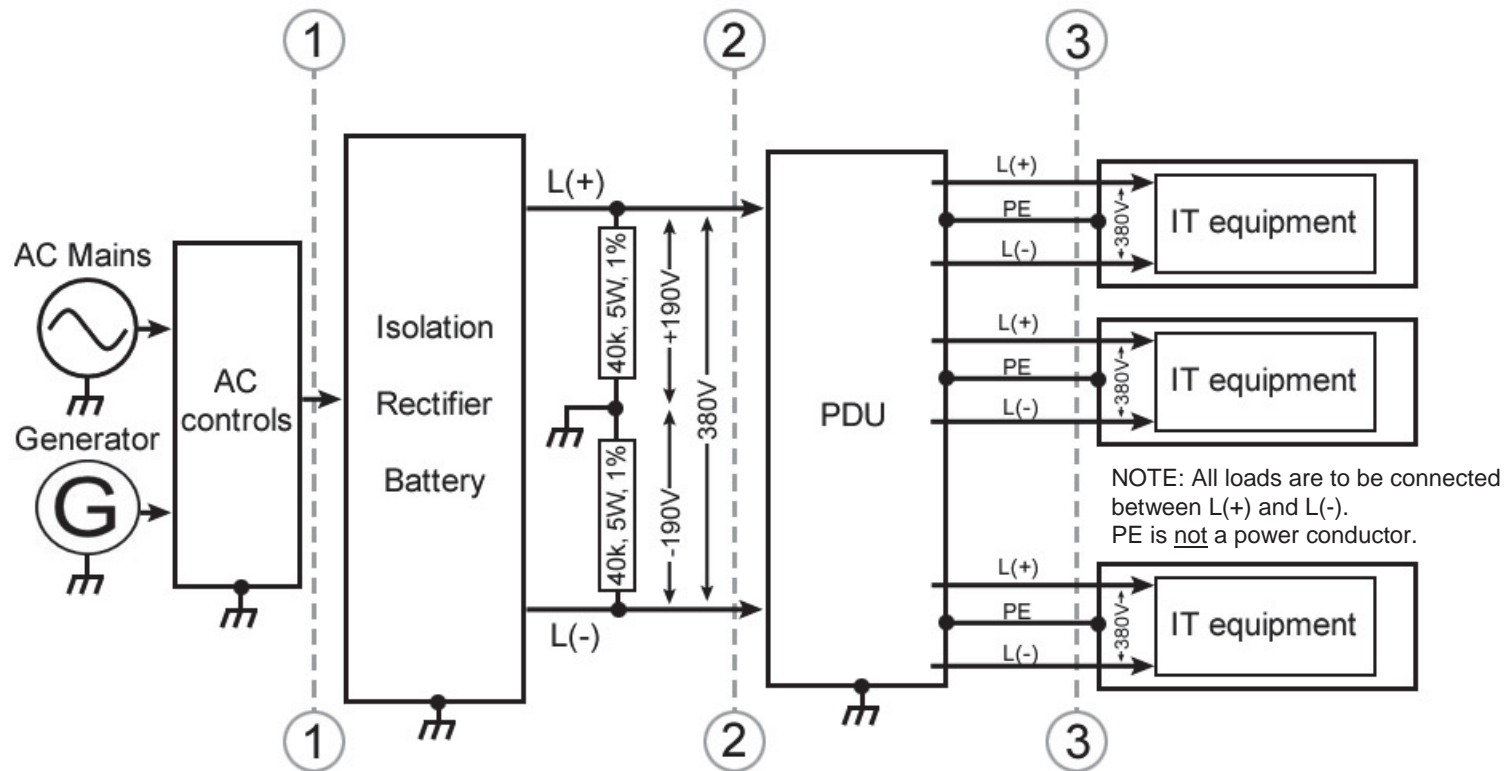
Edited from source: NTT FACILITIES, INC.

# 380VDC vs ITI(CBEMA) VAC Operating Ranges

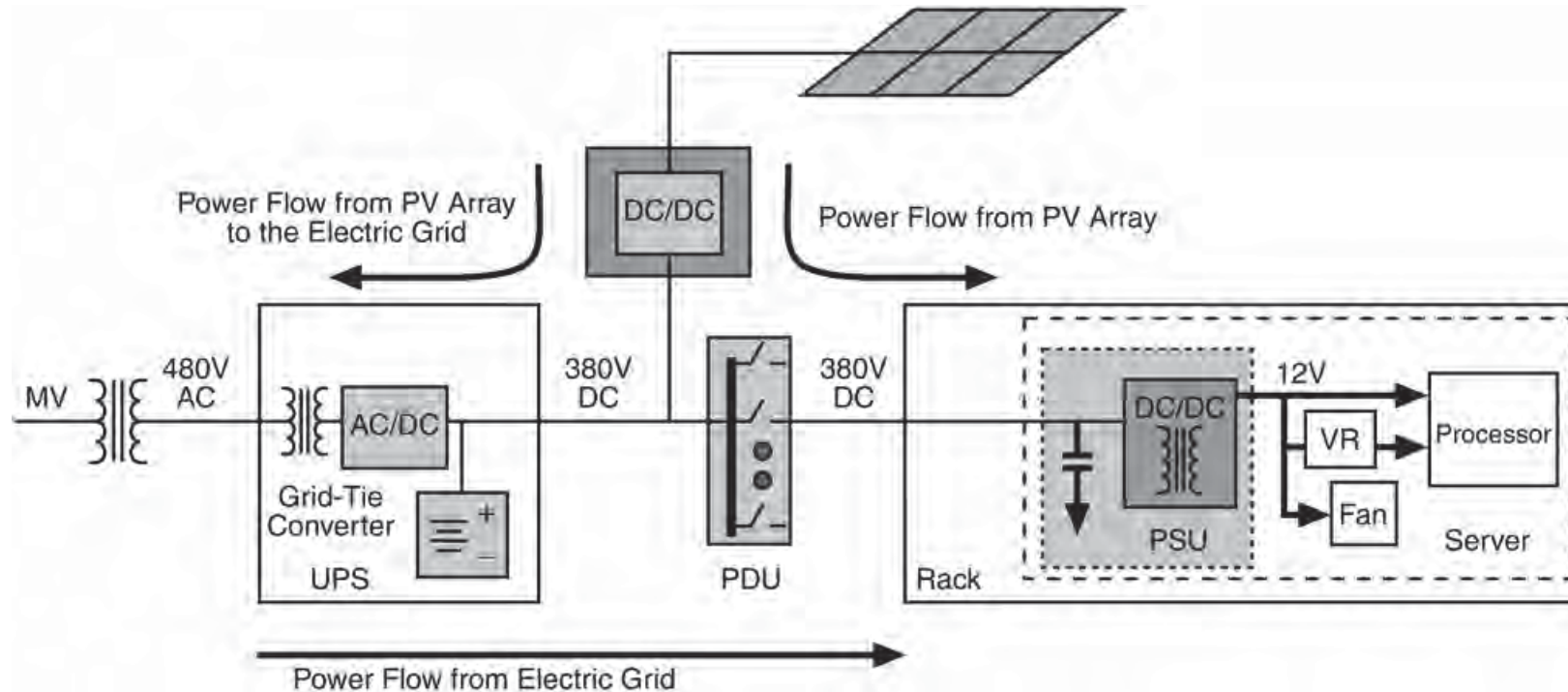


- Voltage Tolerance Envelope for traditional AC powered computers (left)
- New, DC version of curve, developed by EPRI with NTT and PSL (right)

# 380VDC Power Distribution



# Easier Integration Of Renewables



Reference to Nextek Power Systems US Patent 7,872,375 18JAN2011

# Benefits Summary Of 380VDC

- Higher Reliability
  - Fewer Conversions/Fewer Points Of Failure
- Higher Efficiency
  - Higher Efficiency Power Supplies & UPS
  - No PDU Transformer Needed
- Smaller Size
- Better Power Quality
- Easier Integration Of Renewable Energy
- Easier Integration of Energy Storage

# Other DC Applications

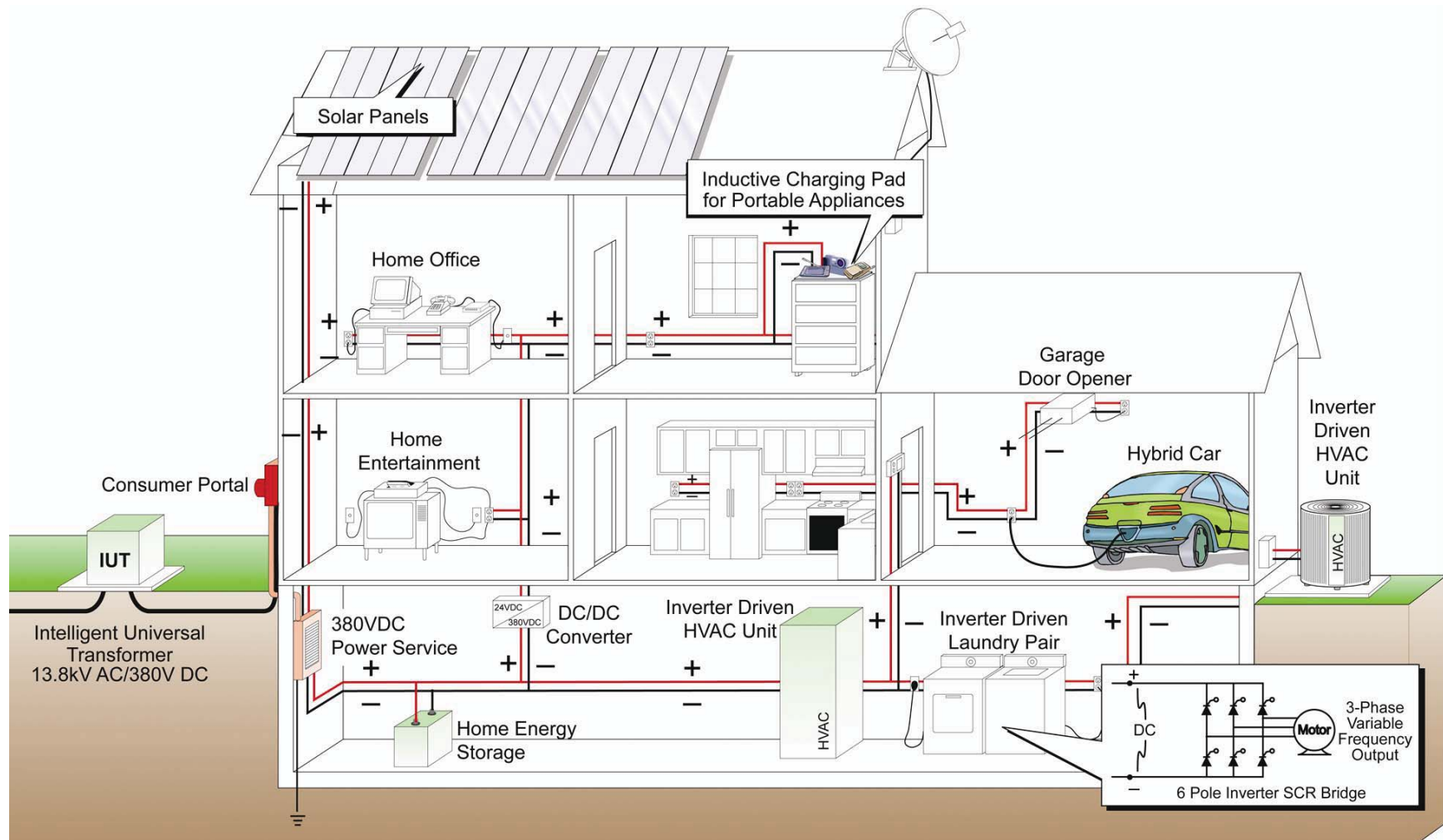
- 380VDC Uses
  - Telecom Central Offices (Operating Today At 48VDC)
  - Variable Speed Drives (Washers/Dryers/Air Cond)
  - Other Home Appliances (Stoves/Ovens)
  - “Rapid Charger” For Plug-in Electric Vehicles
- 24VDC Uses
  - Lighting
  - Consumer Electronics (TVs, PCs, Projectors)
- EMerge Alliance Members Working On Both Voltages



# DC Challenges

- Standardizing on DC Voltages
  - 24VDC & 380VDC looking like leading candidates
- Safety Agency Approval/Listing (e.g. UL)
  - DC & AC Products Both Need These Approvals
- Paradigm Shift
  - Back To Some Of Thomas Edison's DC Ideas
  - We Are Used To The "AC" World Today
- Vendor Selection
  - Many AC Vendors To Choose From
  - Fewer DC Vendors Available --- At Least For Now

# DC-Powered Home - Fantasy or Future Reality?



# DC-Powered Home - Fantasy or Future Reality?

- My own home already has many DC-Powered products with “external” power supplies:
  - My Laptop Computer (20 V – 4.5 A)
  - My Cell Phone (5 V – 550 mA)
  - My Wife’s Cell Phone (5 V – 350 mA)
  - 4 Wireless Phones (6.5 V – 500 mA)
  - Wireless Internet Router (5 V – 2.5 A)
  - 2 Cable Modems (12 V – 750 mA)
  - Electric Razor (12 V – 400 mA)
  - Powered USB Port (5 V – 3.8 A)
  - Battery Operated Vacuum Cleaner (10 V – 250 mA)

# DC-Powered Home - Fantasy or Future Reality?

- My own home already has many DC-Powered products with “internal” power supplies:
  - BlueRay DVD Player (26 W)
  - 2 Cable Set-Top Boxes (4.2 A)
  - Bose Home Theatre System (300 W)
  - 54” Plasma TV (465 W)
  - 36” LCD TV (175 W)
  - PC Mini-Tower (6 A)
  - 19” LCD Display (1.2 A)

# DC-Powered Home - Fantasy or Future Reality?

- My own home also has many BIG AC-Powered loads:
  - Microwave Oven (240 V – 8.3 kW)
  - Dishwasher (120 V – 11 A)
  - Toaster (120 V – 1050 W)
  - Coffee Pot (120 V – 1100 W)
  - Clothes Washer (120 V – 7 A)
  - Electric Clothes Drier (240 V – 5600 W)
  - Refrigerator (120 V – 8.3 A)
  - Electric Cook-top (240 V – 8.8 kW)
  - Electric Oven (240 V – 3600 W)



# Together...Shaping the Future of Electricity