



# Are We at the Threshold of a New Era of DC Power Systems? *(DC Power Production, Delivery and Use)*

**Dennis P. Symanski**  
EPRI – Senior Technical Leader  
**Emerging Technology Summit**  
20-22OCT2014 – San Francisco, CA

# 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, integrate the next generation of plug-in electric vehicles, increase efficiency, and better harness renewable energy.

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

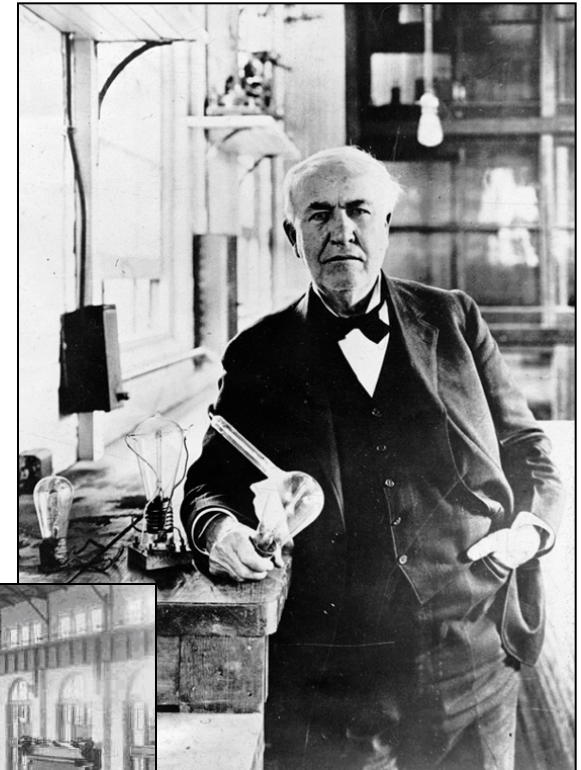
# Was Edison Right? (Early Micro-Grids!)



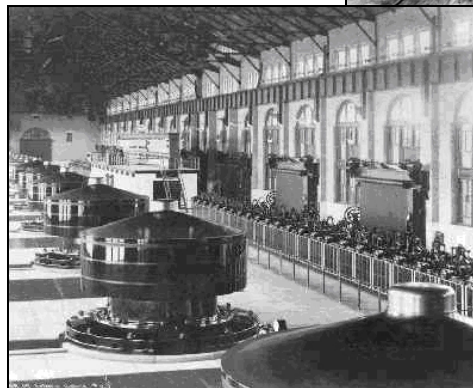
Edison's concept for electrification—which included royalties from his patents on direct current systems—was to deploy relatively small scale, individual DC plants to serve small areas—such as the Pearl Street Station. Pearl Street Station entered service in 1882 serving 85 customers with 400 lamps.

# The Case *Against* Edison— The Dawn of 20th Century

- Pearl Street Station could only extend for a mile—**distance**
- Separate electric lines needed to supply power to end-use equipment of different voltages—**cost, inflexibility**
- Giant polyphase AC generators produce electricity at Niagara Falls—**use of hydroelectric power**



*Thomas Edison*



*Adams Hydroelectric Plant, 1895*

# The Case *Against* Edison— The Dawn of 20th Century



*Nikola Tesla, Source: IEEE*

- William Stanley from Westinghouse invents transformer—**transformation enables long distance delivery**
- The desire to make use of hydroelectric power sources located far from urban load centers—**the advent of centralized grid**
- Nikola Tesla invents AC induction motor—**transformation of electricity to motion**

# DC Pervades—End Use Devices



**DC Lighting**



**Home Entertainment Equipment**



**Home Office Equipment**



**Servers/  
Routers/  
IT Equipment**

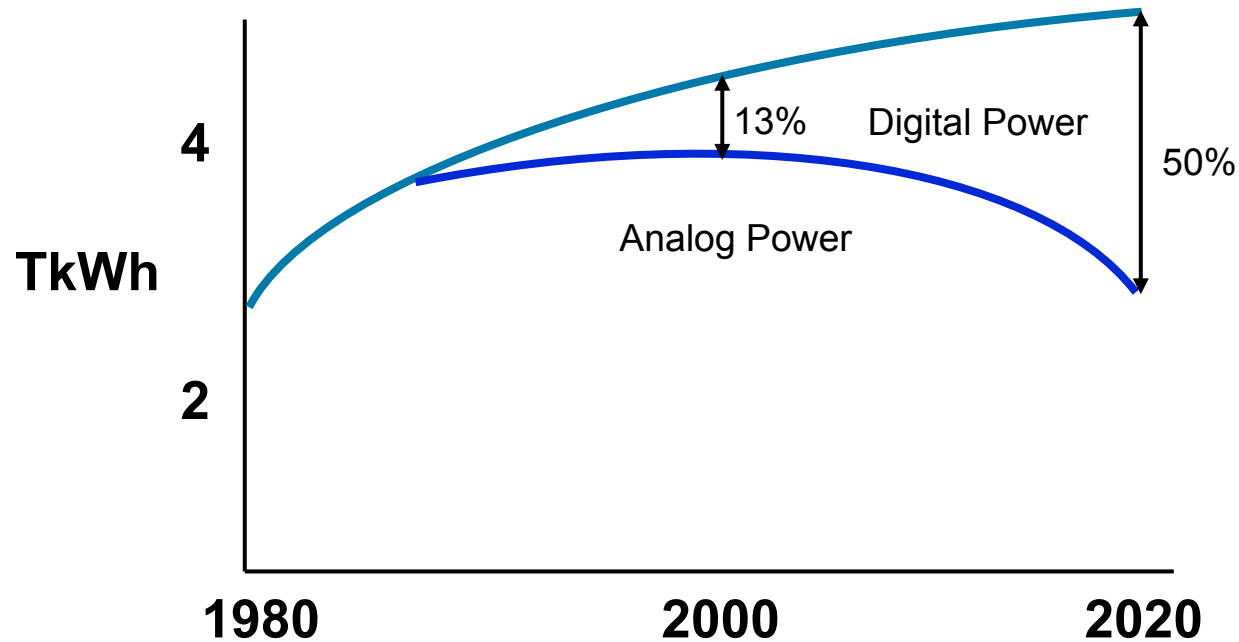


**Portable Devices**



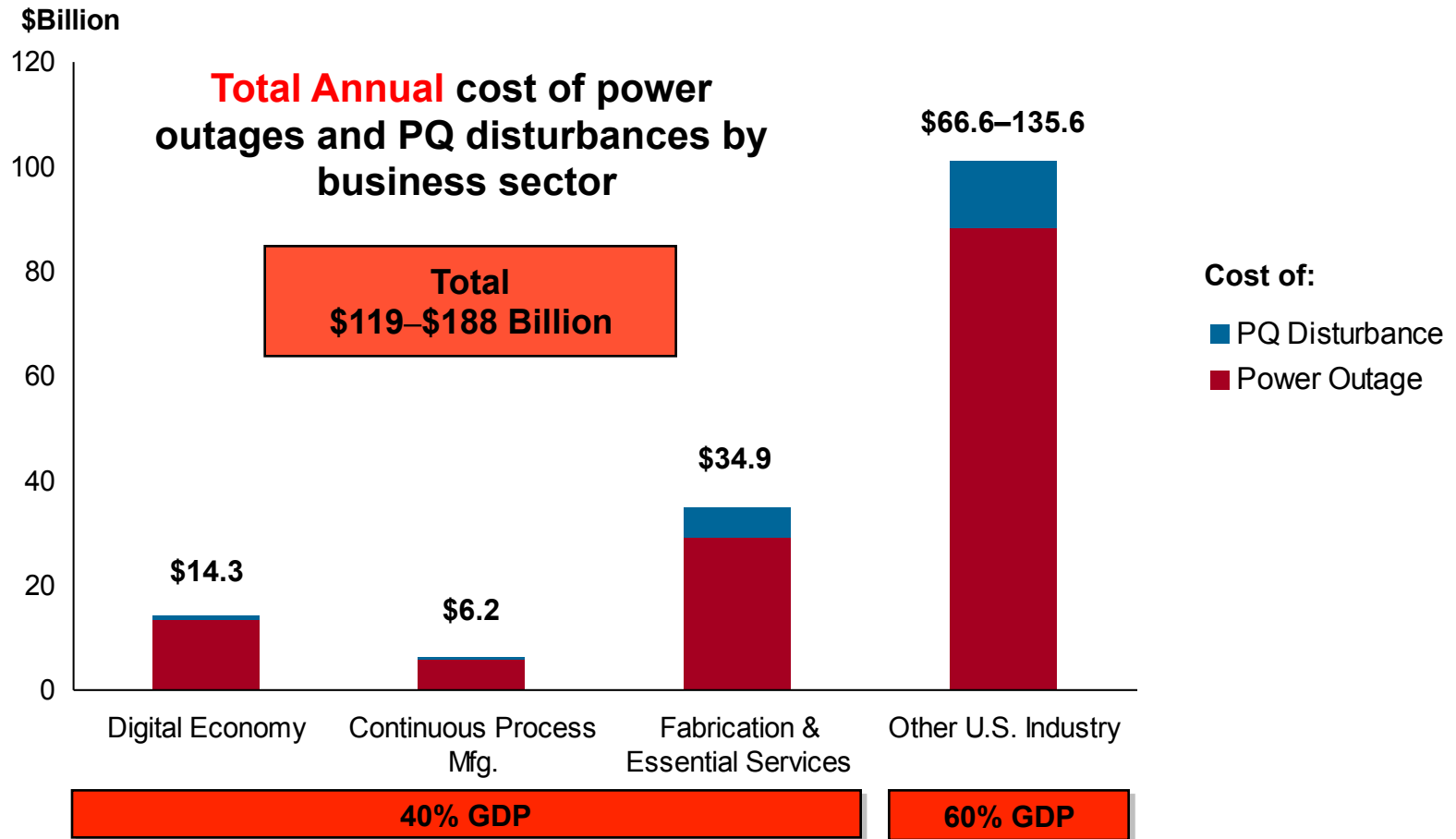
**Variable Frequency Drive (Air Conditioners, refrigerators, washing machines, etc.)**

# Rise of the Digital Economy



- Demand for “digital quality” power is growing rapidly
- Requires much higher reliability and quality
- New devices have different characteristics

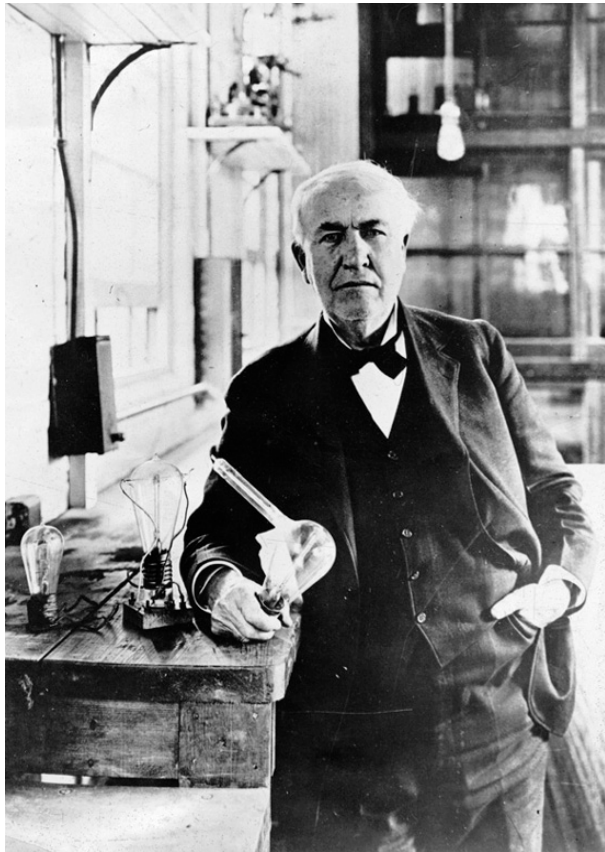
# A Toll Felt Throughout the U.S. Economy



Source: Primen Study: The Cost of Power Disturbances to Industrial & Digital Economy Companies



# The Case *For* Edison— The Dawn of the 21st Century



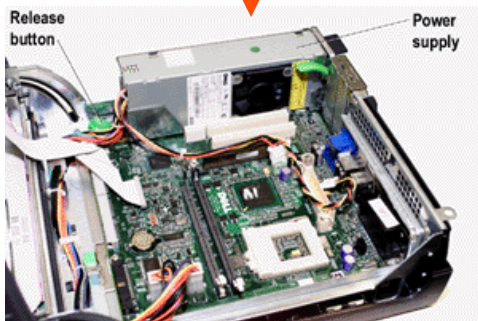
- Increasingly, equipment operates on DC, requiring conversion from AC sources—**the era of electronics**
- Distributed generation systems produce DC power—**the era of micro-grid**
- Storage devices such as batteries, flywheels and capacitors store and deliver DC power—**ease of integration**
- DC power could help power hybrid automobiles, transit buses, and commercial fleets (and vice versa)—**the era of electronics in transportation**

# The Case *For* Edison— The Dawn of the 21st Century

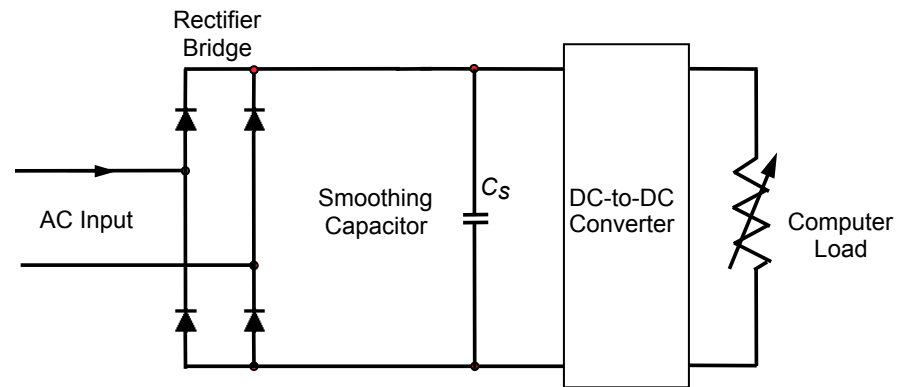
- DC power delivery could potentially enhance reliability & energy efficiency in data centers, a pressing need—**the era of Information technology**
- Improved inverters & power electronics allow DC power to be converted easily & efficiently to AC power & to different voltage levels—**removing the bottleneck of transformation**
- The evolution of central power architecture in computers & other equipment simplifies DC power delivery systems—**standardization of DC voltage**



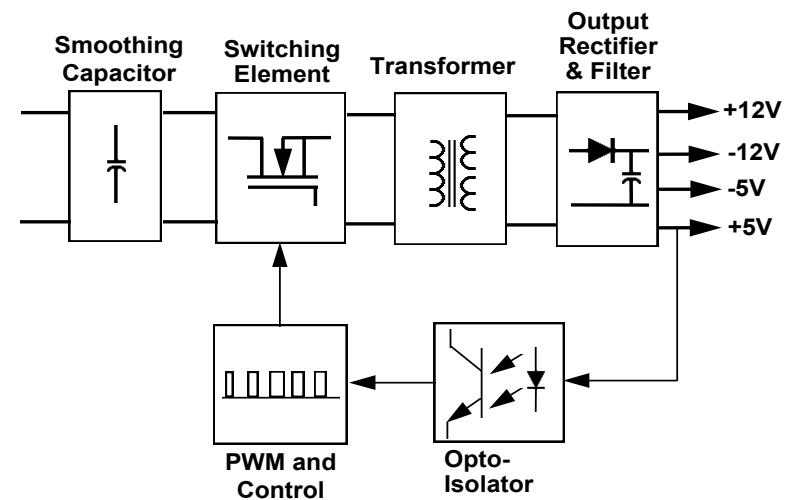
# Inside Every Piece of Electronic Equipment is an AC-DC Power Supply



*Schematic of a PC power supply*



*Schematic of a DC-to-DC converter inside power supply*



# DC Pervades—Distributed Resources



**Photovoltaic**



**Microturbine**



**Wind**

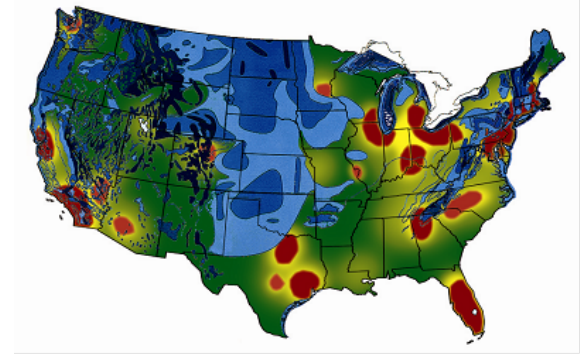


**Fuel Cell**



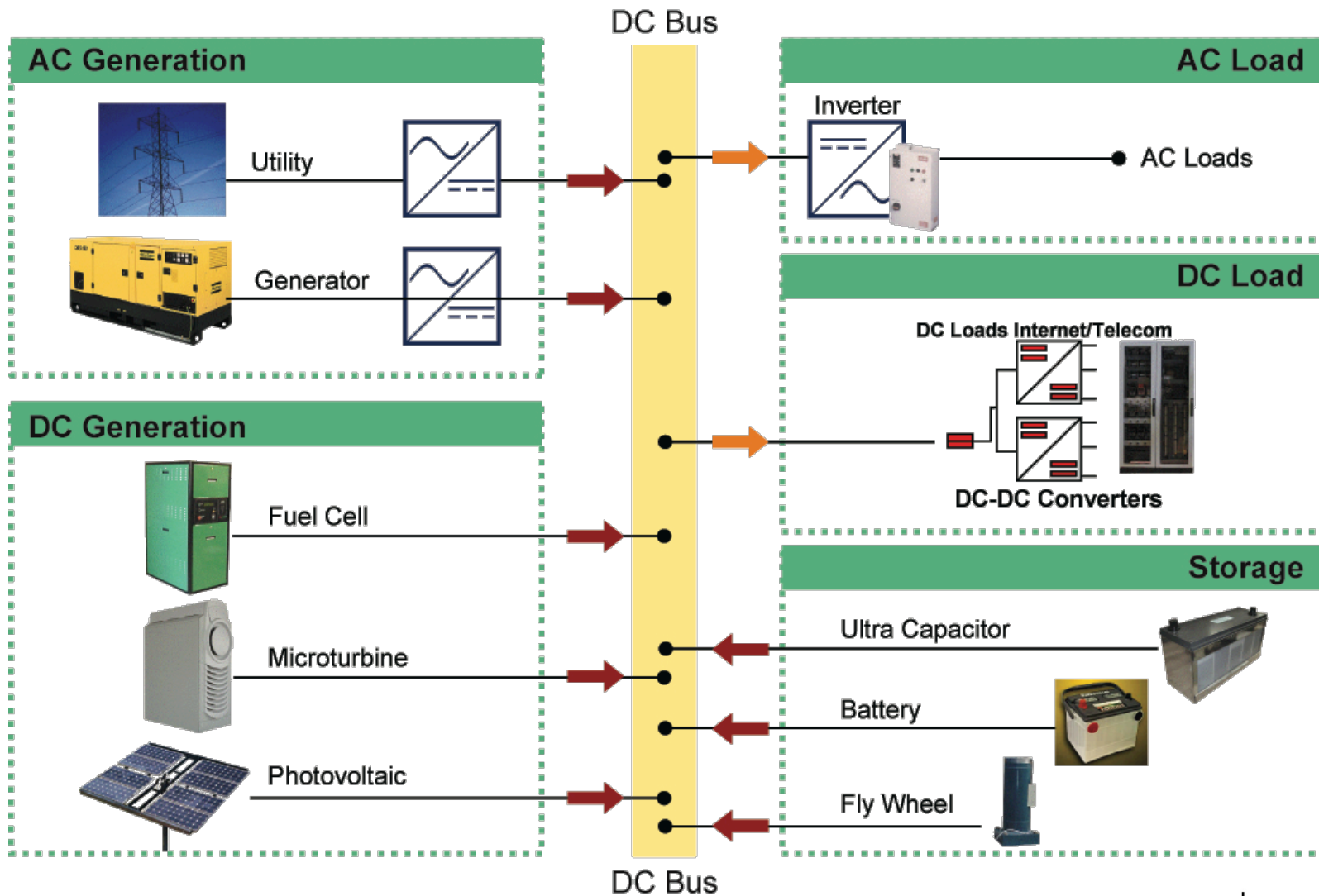
**Storage  
(e.g., Ultra Capacitors)**

# Renewable Energy & DC



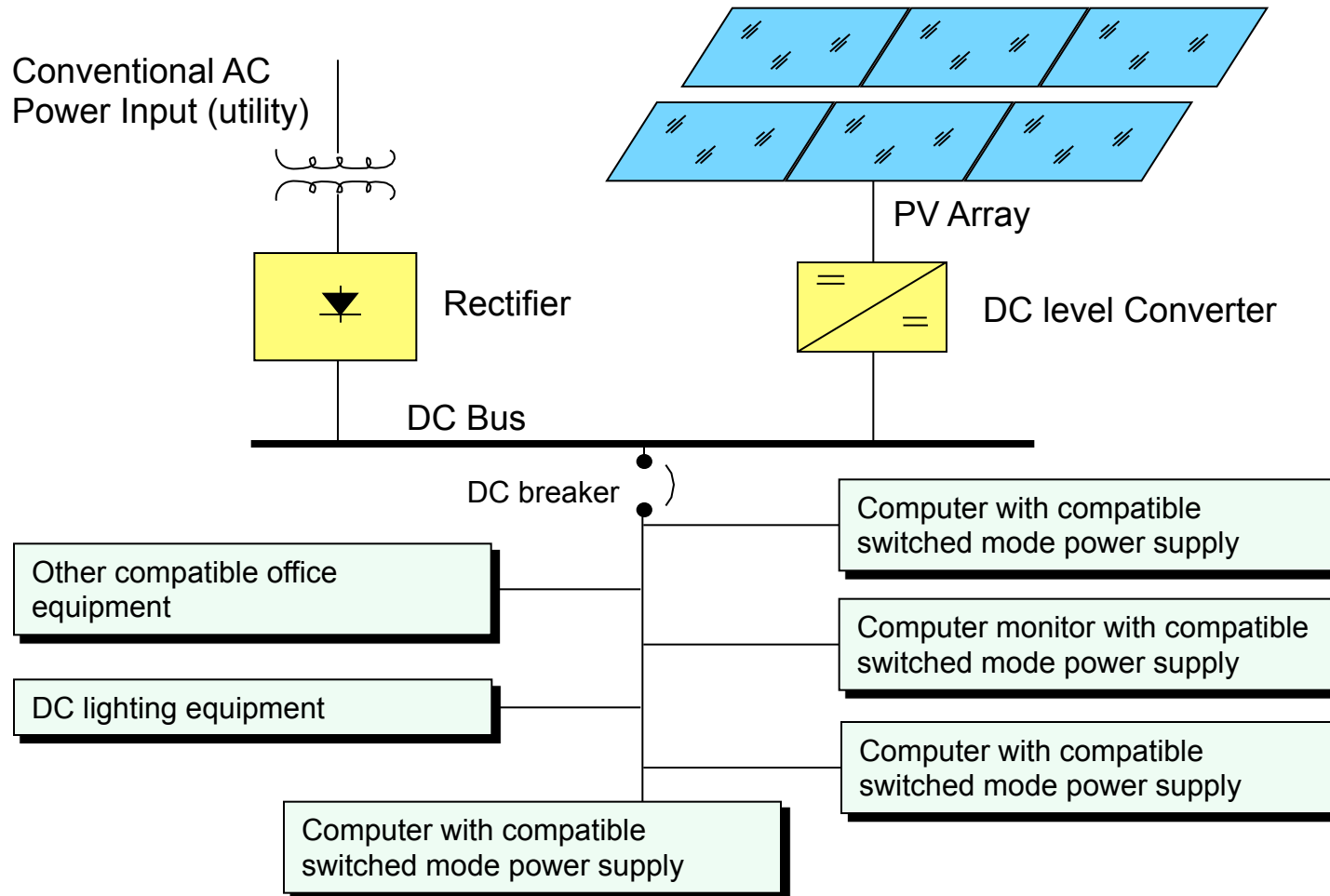
- DC seems particularly suited to renewable integration
- Sources (wind, solar, pumped hydro, geothermal, tidal) are far from load centers
- Wind turbines (variable speed) generate power at different frequencies, requiring conversions to and from DC
- Offshore wind suited for DC cable applications due to high capacitive charging with AC cables
- Photovoltaic cells & fuel cells also produce electricity as DC, eliminating the need to convert at source.

# DC Power System of the Future for Mission Critical Facility

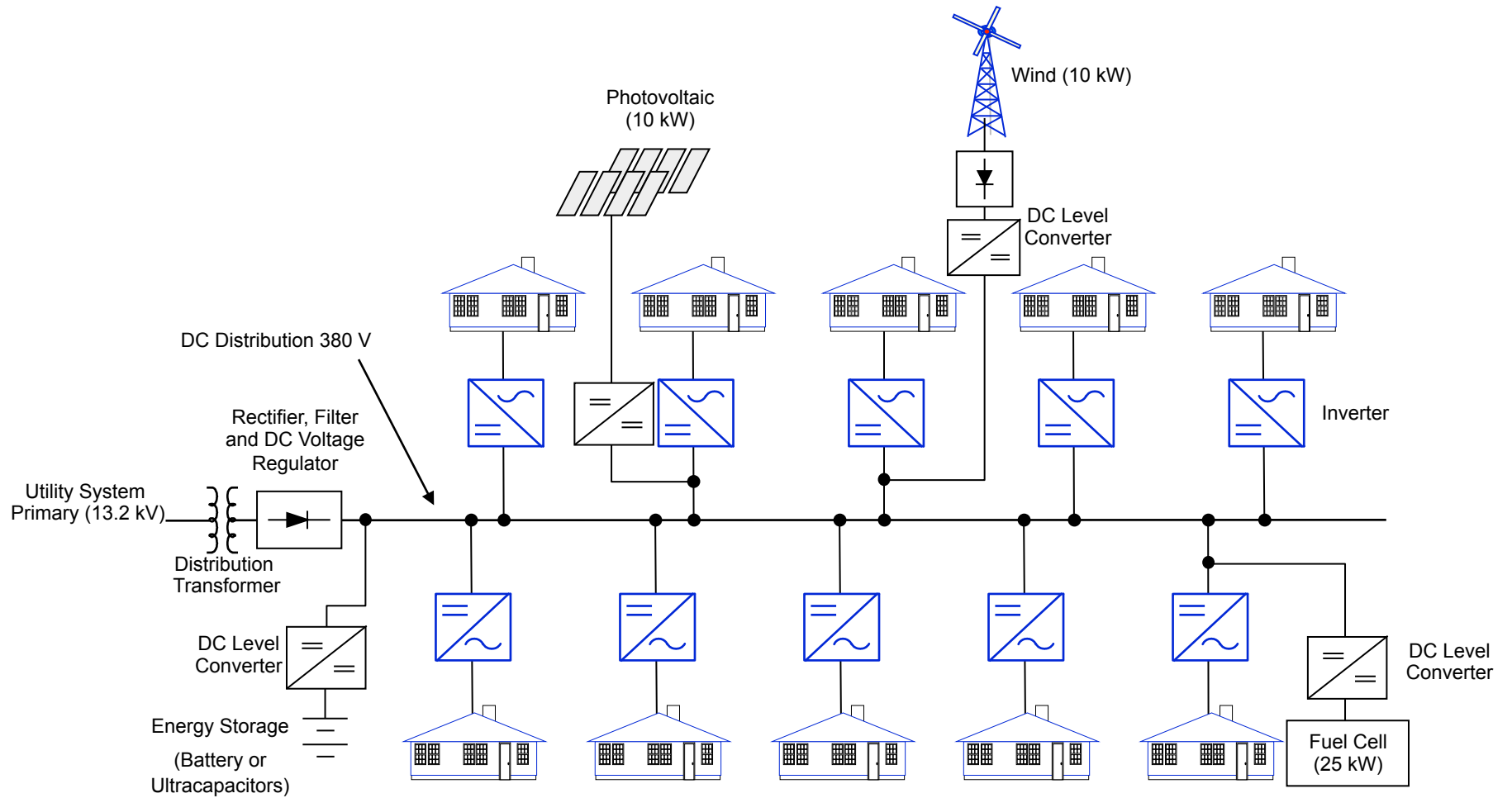


# Direct DC—Making PV more Effective

## Example of PV Supplemented Office Equipment

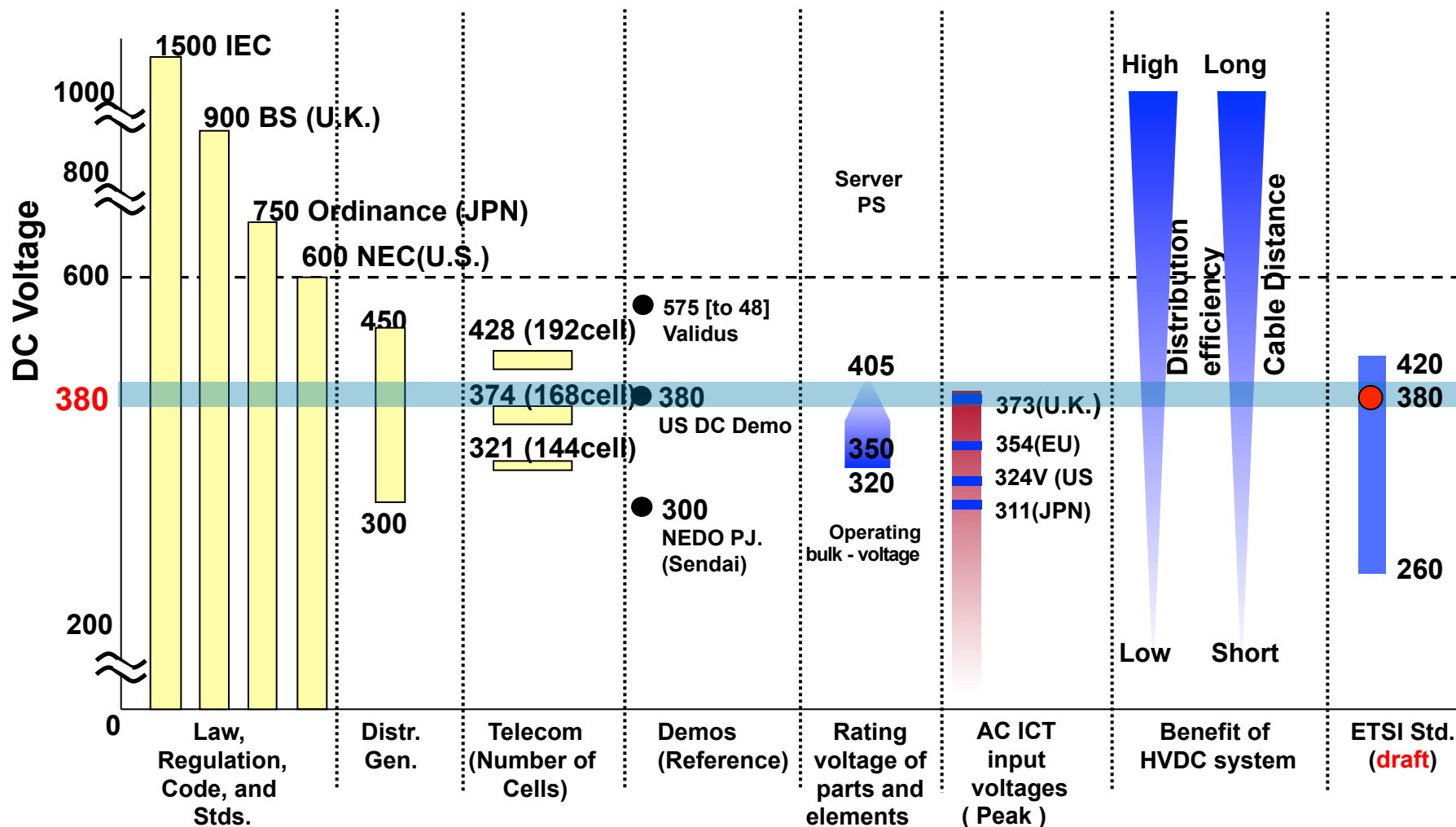


# DC Micro-grid



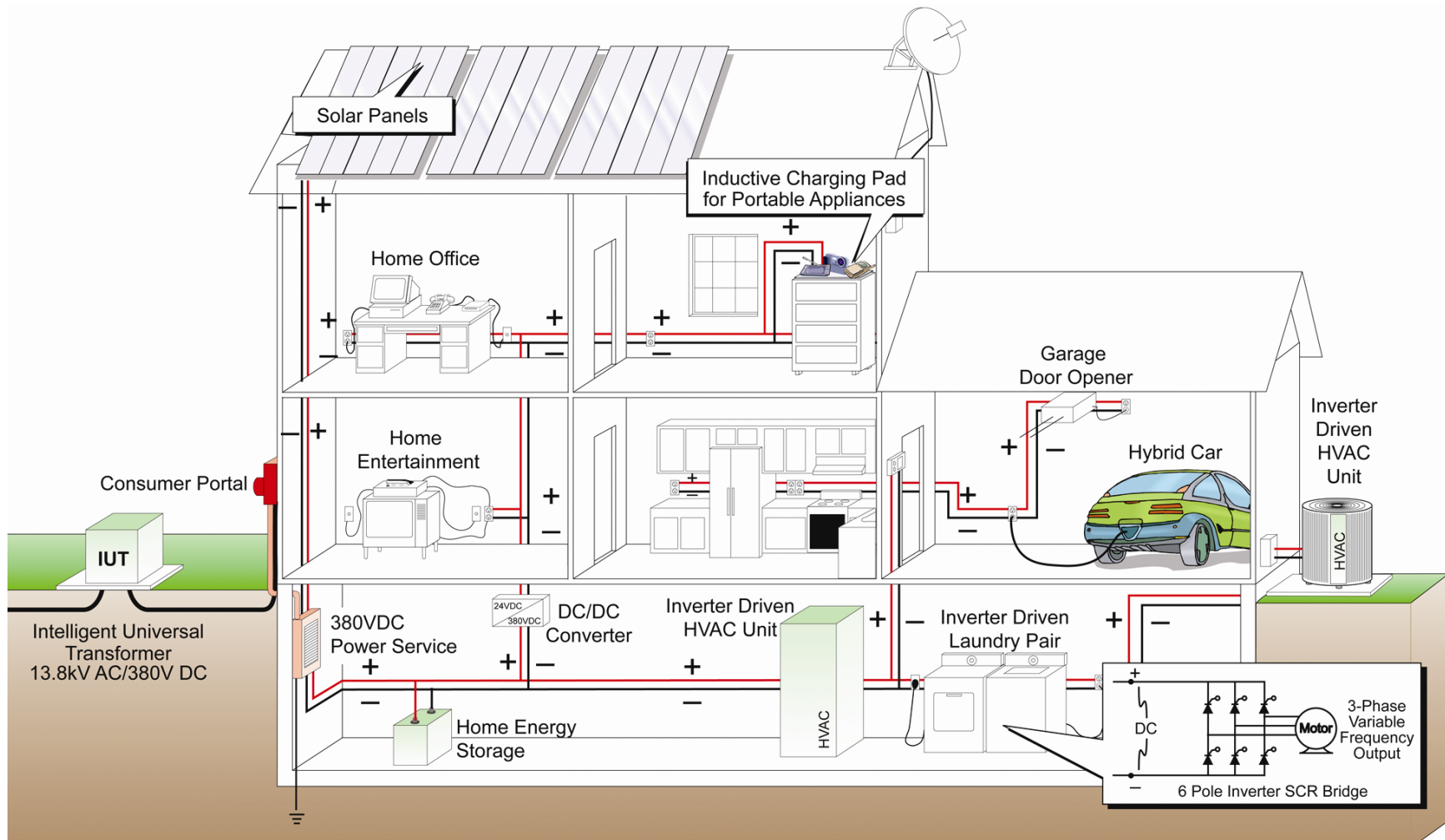


# Why 380VDC? – “Sweet Spot”



Edited from source: NTT FACILITIES, INC.

# Can the House of the Future be DC?



# Obstacles to DC Power in the 21st Century

- The fear of change
- The business case for DC power delivery is not yet clear
- Most equipment is not yet plug ready for DC input
- Safety and protection standards are still evolving
- Standard practice for design, installation and maintenance are not mature
- Lack of standardizations on voltage level
- Direct powered AC induction motor is still the workhorse of the industry



# Together...Shaping the Future of Electricity