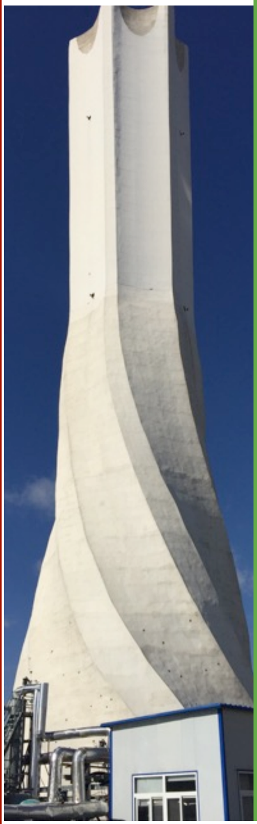
DC Research in North America: A Status Report



Chris Marnay & Daniel Gerber

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24 May 2019

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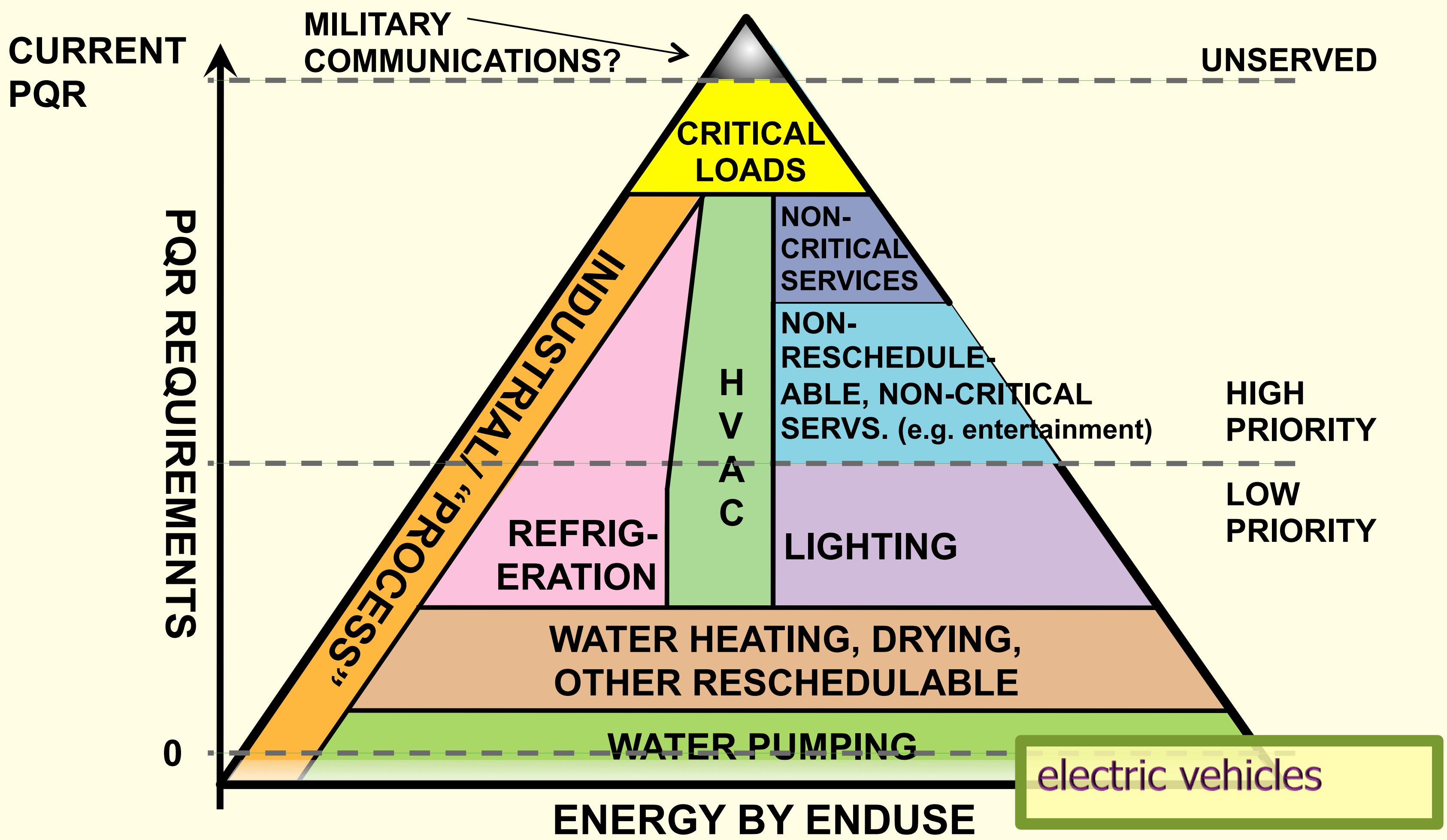
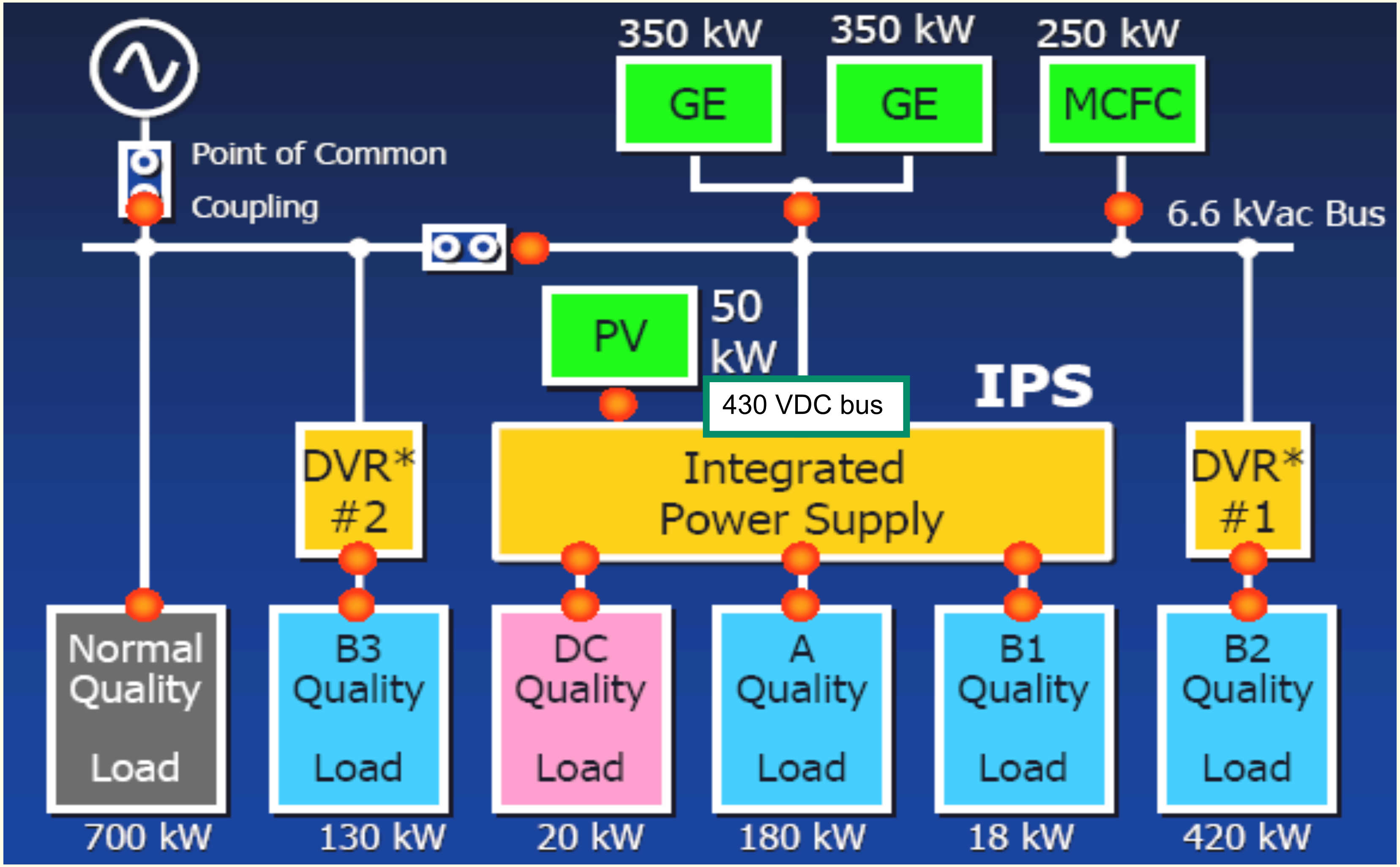
Outline

- 2 slides • changing paradigms (Chris)
- 9 slides • North American demos (Chris)
- 1 slide • US academic research (Daniel)
- 2 slides • DOE/CEC/other programs (Daniel)
- 3 slides • LBNL-NREL work (Daniel)
- 1 slide • Fort Collins Symposium (Chris)

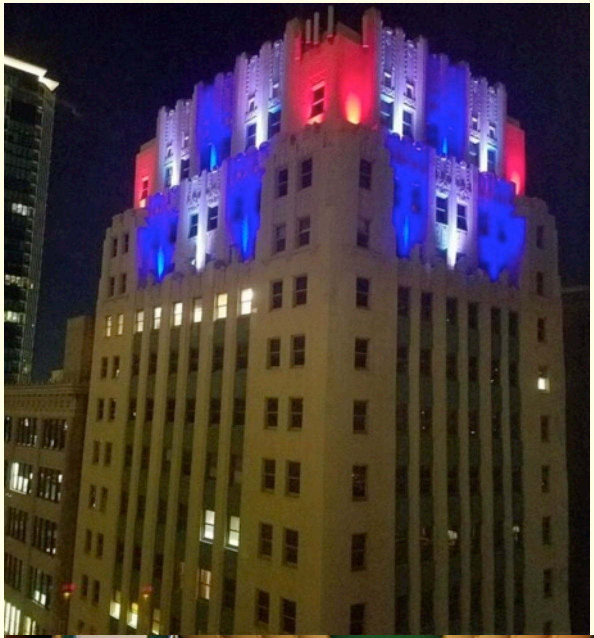
Heterogeneous PQR



Sendai Microgrid Schematic



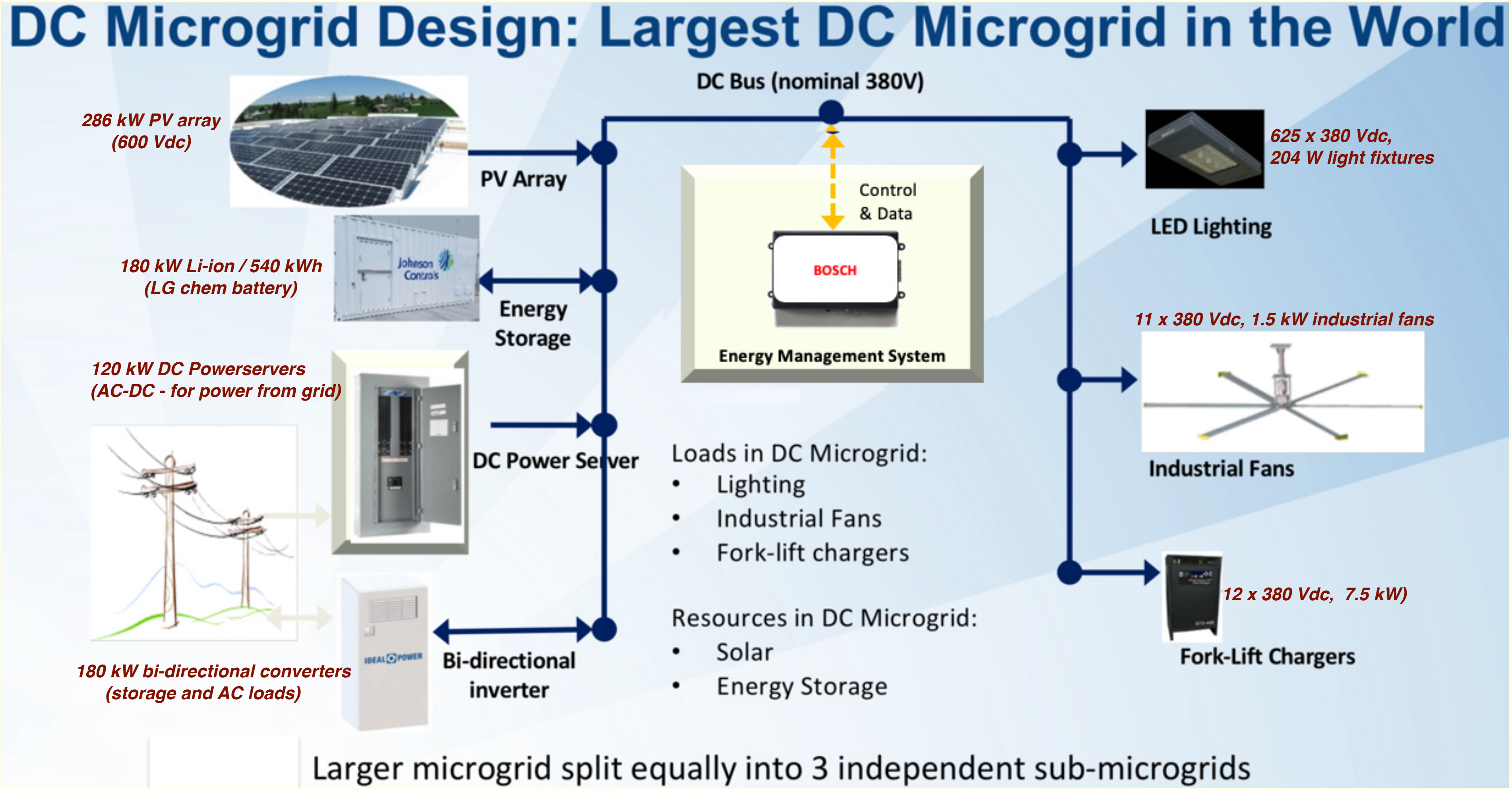
Sinclair Hotel, Dallas TX 1



- 1930's Art Deco historic hotel
- 16-storys, 165 rooms
- roof-top bar, no PV, 3-p 208V
- 0.8 mm^2 wiring (no conduit)
  48 V POE over all building
- AC exceptions: elevators, TVs,...
  - cordless hair dryer, iron, ...
  - workout energy collection
  - 332 kWh, 1 MW battery
  - 25% less lighting install cost
  - energy savings? shedding?

Sinclair Hotel, Dallas TX 2

Bosch, Chino CA (Los Angeles) 1

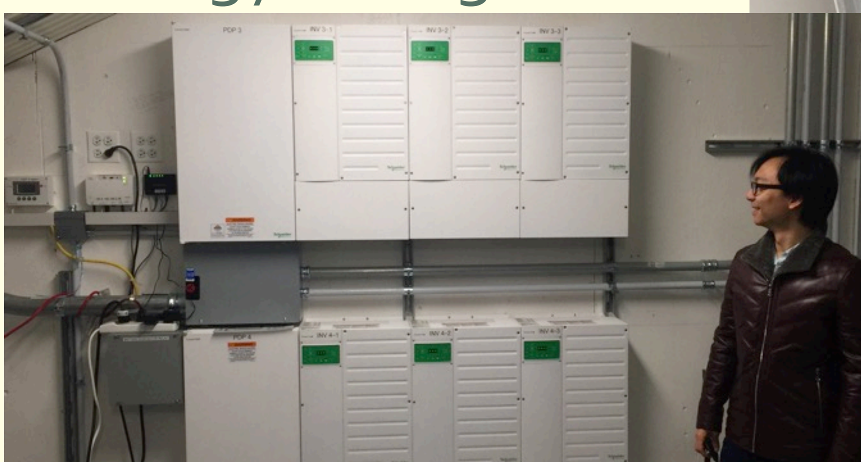


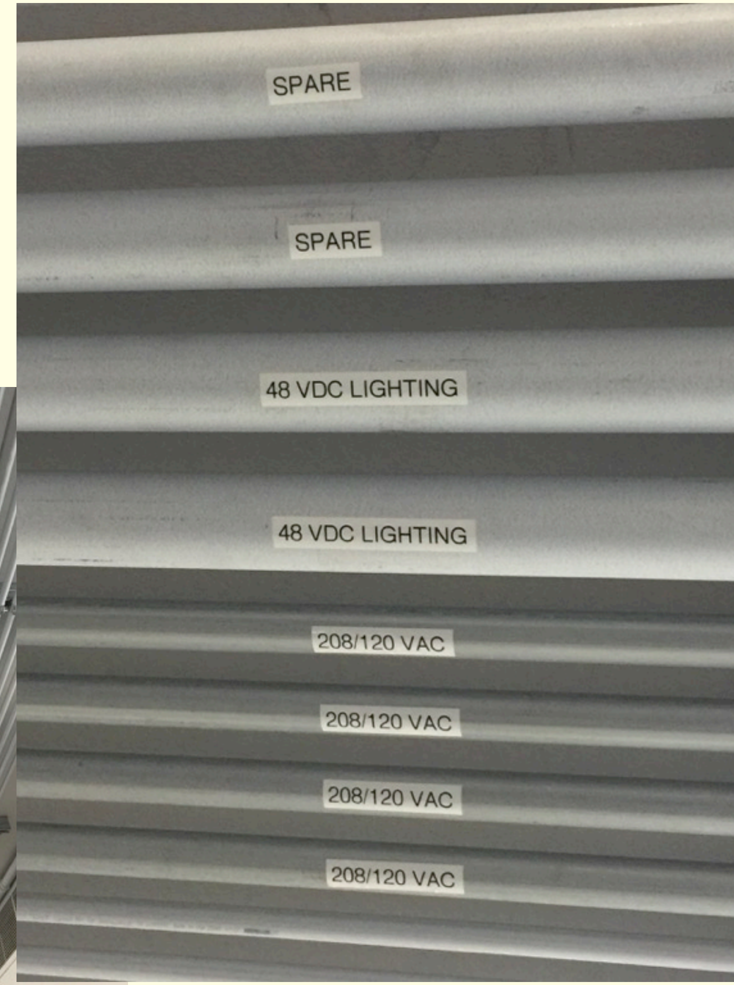
- 380 DC only, warehouse loads
- 21% less energy, lower variability, resiliency

Bosch, Chino CA (Los Angeles) 2

Keating Gym Nanogrid, IIT Chicago 1

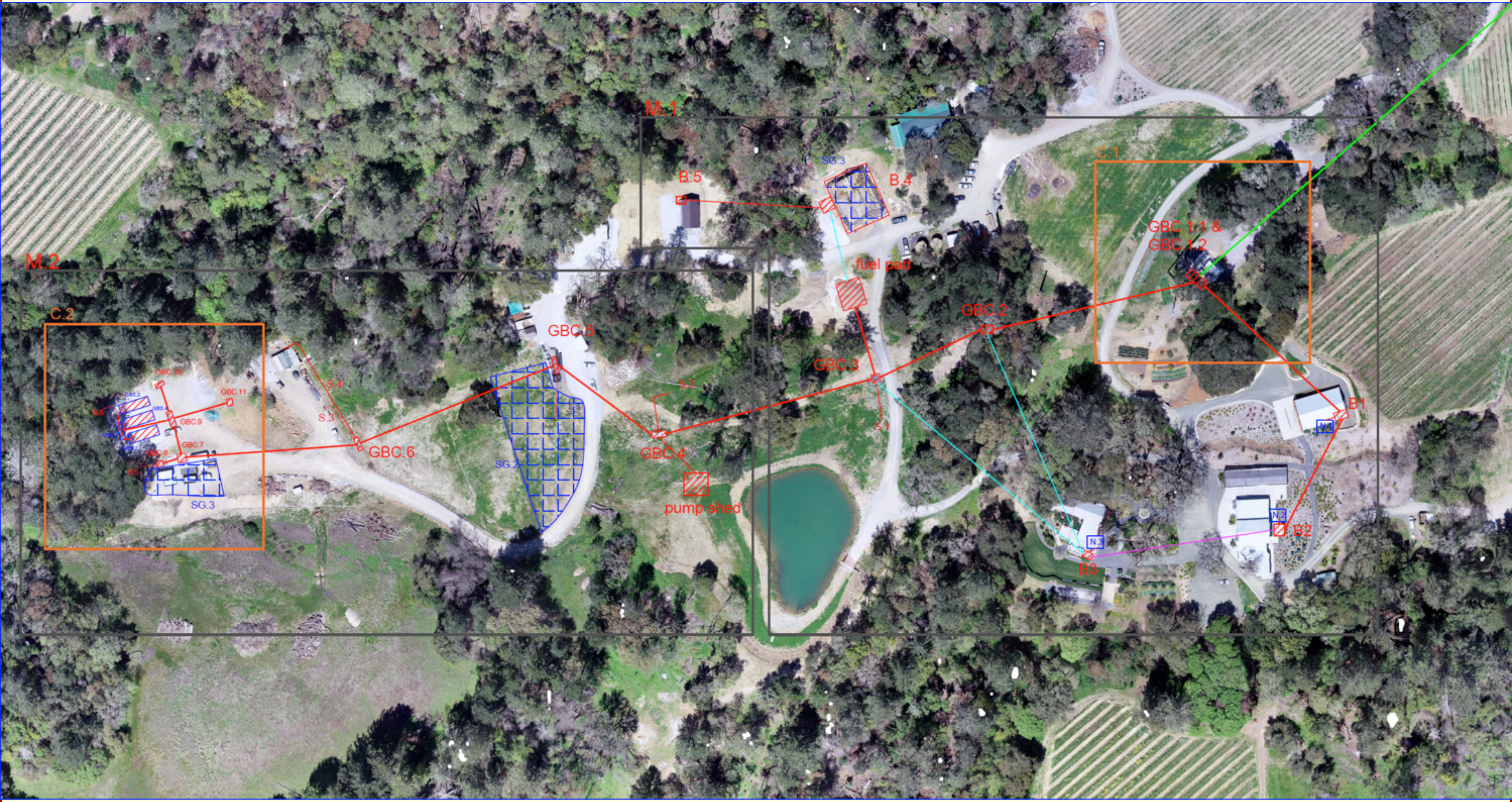
- a local network able to island
- 180 kW PV, building peak 90 kW
- sodium-ion batteries
- advanced controls
- hybrid circuits
- energy savings?





Keating Gym Nanogrid, IIT Chicago 2

Silver Cloud, Sonoma Co, California 1

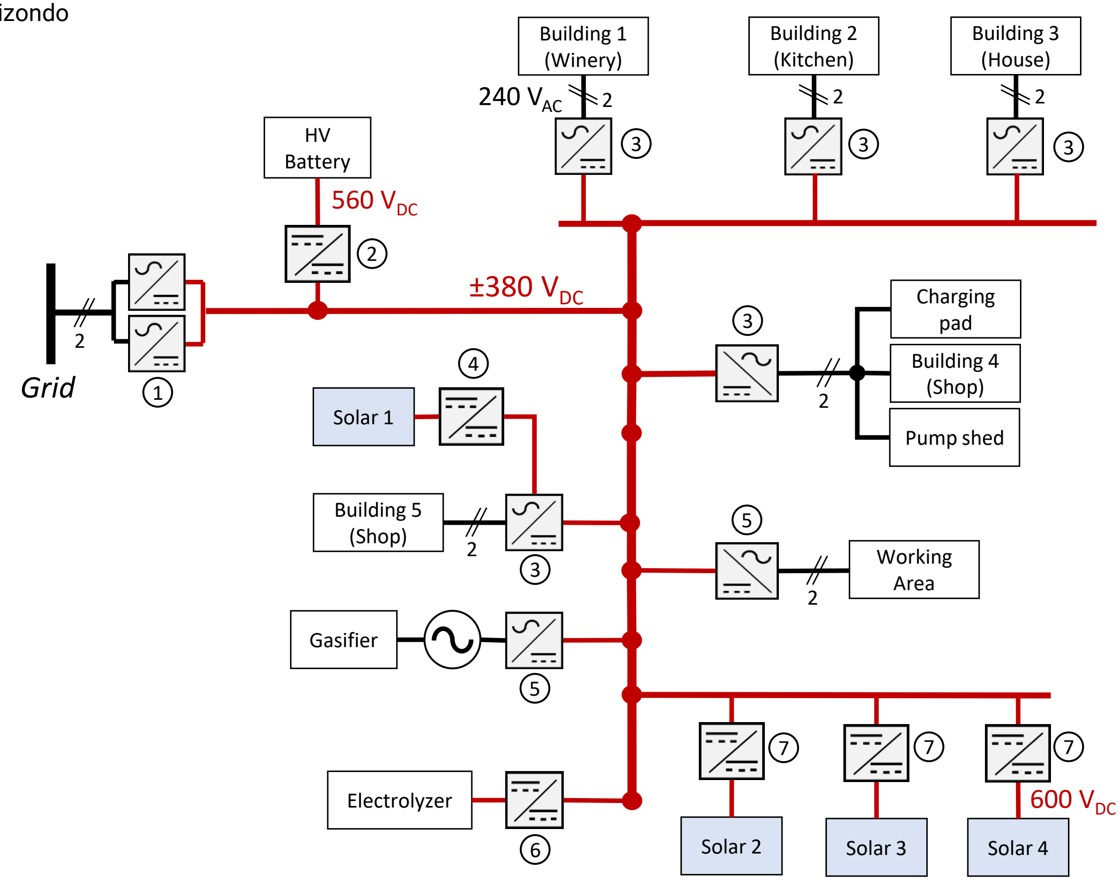


Silver Cloud, Sonoma Co, California 2

Silver Cloud single line diagram

March 15th 2019
Jorge Elizondo

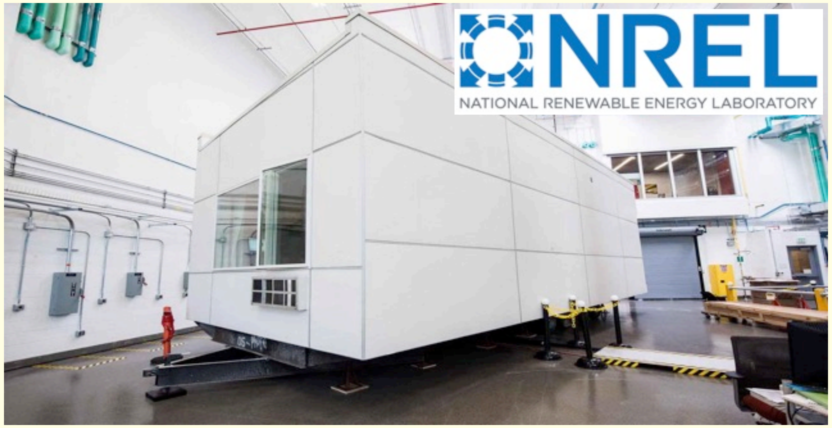
HEILA™ Technologies Inc.



1. Solar Edge *or* Pika *or* SMA + EPIC
2. Siemens SINAMICS
3. Nanogrid Box
4. eIQ vBoost
5. Ideal Power Inverter
6. Control Concepts Power Supply
7. Alencon SPOT

Silver Cloud, Sonoma Co, California 3

US Academic DC Research Centers



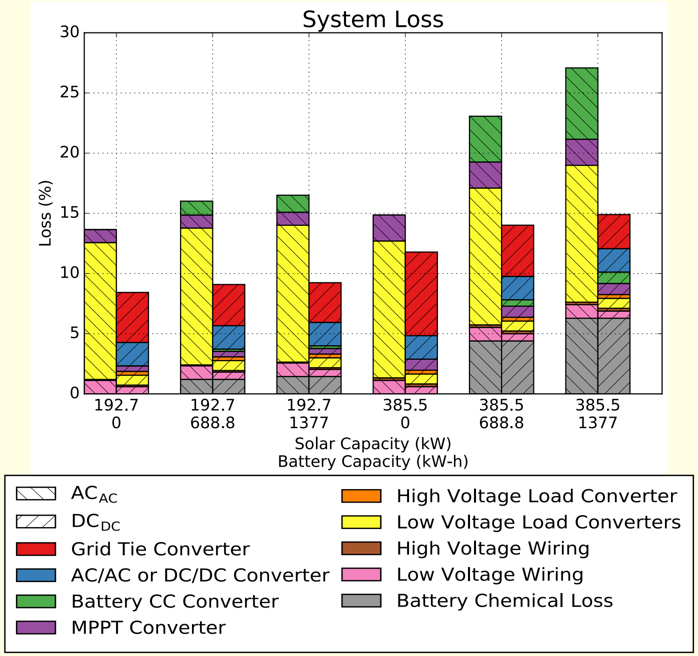
National Labs (NREL, LBNL)

FREEDM Center, North Carolina State U

Powerhouse, Colorado State U

CAPS Center, Florida State U

US Department of Energy
Clean Energy Research Center (CERC) Program



Description	Network	Average LCC Savings (US$)
Total First Cost ($)	AC	252,000
	DC	301,000
Net Annual Electricity Consumption (kWh/yr)	AC	177,000
	DC	101,000
Average LCC Savings ($)	AC vs. DC	61,000
% Cases with Net Benefit	AC vs. DC	>90%
Average Payback Period (yr)	AC vs. DC	~1

$$\text{Payback} = \frac{\text{First Cost}_{\text{DC System}} - \text{First Cost}_{\text{AC System}}}{\text{Operating Cost}_{\text{AC System}} - \text{Operating Cost}_{\text{DC System}}}$$

$$\text{LCC} = \text{First Cost} + \sum_{y=1}^{\text{Lifetime}} \frac{\text{Operating Cost(y)}}{(1 + \text{Discount Rate})^{y}}$$

Research Goals

- <u>Compare AC and DC buildings</u>
- Simulations to determine efficiency savings
- Conduct techno-economic analysis
- Experimental validation (next slide)

Efficiency Results

- 12% baseline efficiency savings with DC
- Most savings with large solar and battery
- Dominant AC loss: **wall adapters**
- Dominant DC loss: **grid-tie inverter**

Techno-Economic Analysis

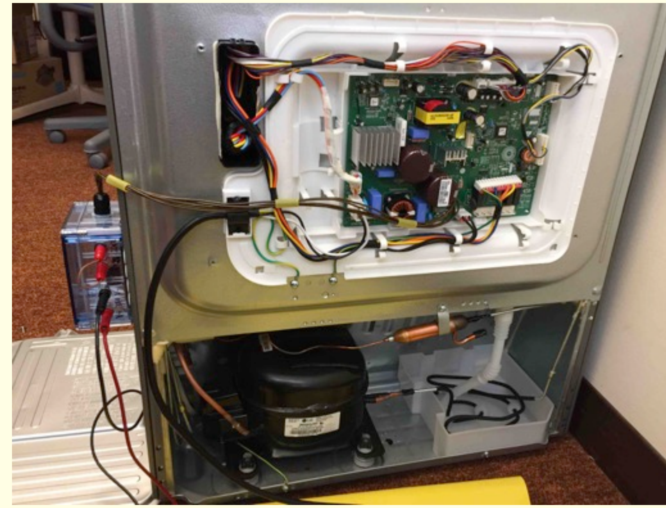
- Results determined from market cost data, grid tariffs, and Monte-Carlo analysis
- First cost is higher for DC
- With significant efficiency savings, the payback period is less than a year

California Energy Commission Direct DC Plug Loads for ZNE Buildings

FUNDING PROVIDED BY THE CALIFORNIA ENERGY COMMISSION

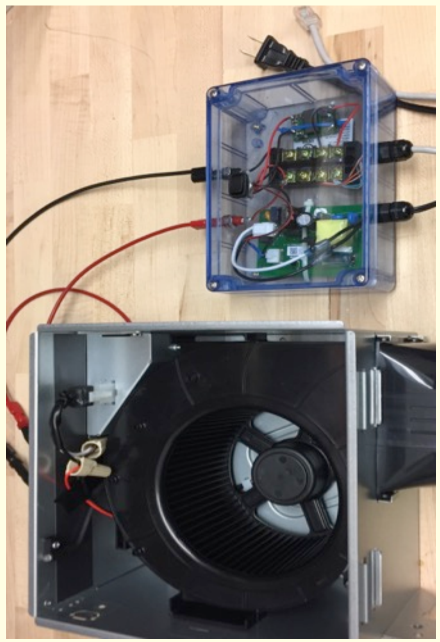
Research Goals

- Modify AC plug loads for direct-DC input
- Demonstrate savings in consumption and cost



Refrigerator, 380 V DC, 1% W saved
(since original doesn't have PFC)

Task Lamp
15 V USB-C
~5% W saved



Bath Fan
48 V PoE
8-15% W saved

Zone Light, 380 V DC, 6% W saved

Team

Michael Deru
Mechanical engineer with expertise in integration and validation of high efficiency building systems

Richard Brown
Systems engineer with expertise in integration and validation of networked controls and power systems in buildings

Willy Bernal
Electrical engineer with expertise on benchmarking emerging green technologies and microgrids configuration and operation

Bruce Nordman
Architect focused on networked controls and local power distribution in buildings

Stephen Frank
Electrical engineer focused on controls and optimized electricity distribution systems for buildings

Vagelis Vossos
Physicist focusing on efficiency versus cost-effectiveness in building systems and equipment, with several publications on DC systems.

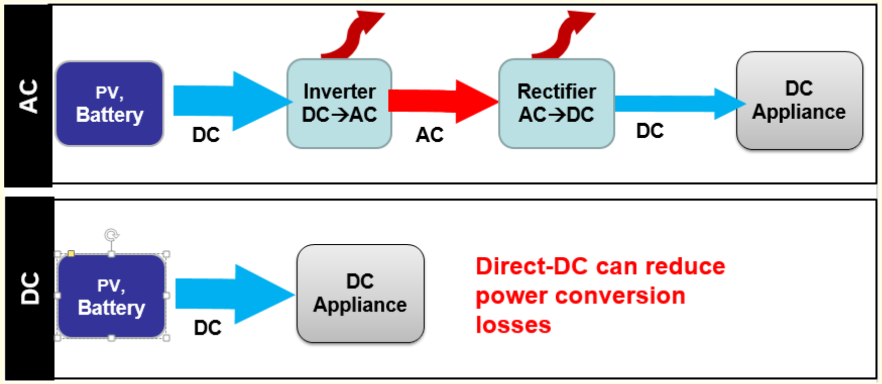
Omkar Ghatpande
Electrical engineer with expertise in design and manufacturing of renewable power distribution systems

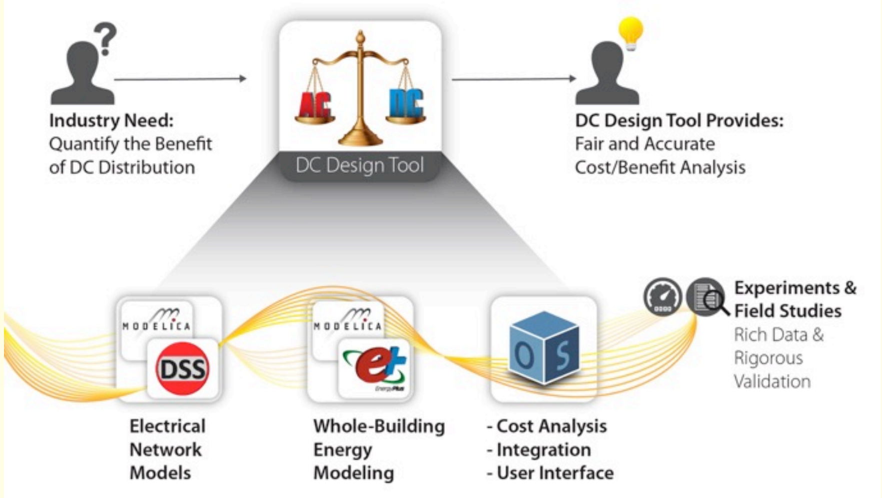
Daniel Gerber
Electrical engineer with expertise modeling and prototyping efficient power electronics for DC power

NREL/LBNL DC Design Tool

Research Goals

- Develop an Energy Design and Scoping Tool for DC systems
- Target audience: building planners, designers, and engineers who are considering deployment of DC distribution systems
- Extends DOE's tools: EnergyPlus and the OpenStudio
- Enable user to assess and compare the energy efficiency and life-cycle cost of a design
- Validate the DC Design Tool using collected experimental and field data





NREL/LBL DC Field Testing

NREL NATIONAL RENEWABLE ENERGY LABORATORY

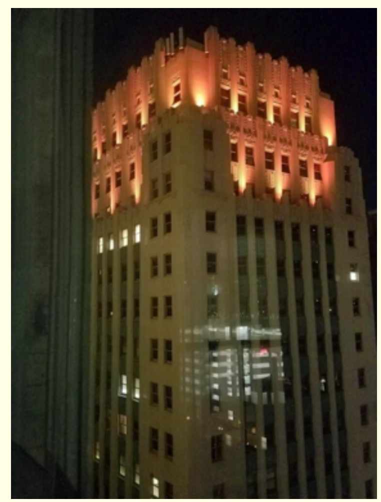
BERKELEY LAB

Research Goals

- Establish evaluation methods and metrics for DC-systems
- Measure and evaluate the performance of several buildings with new DC distribution installations
- Assess technical barriers inhibiting robust adoption of DC systems
- Identify opportunities to optimize DC-system performance

Xingye Solar
Shenzhen

IBEW Building
San Leandro



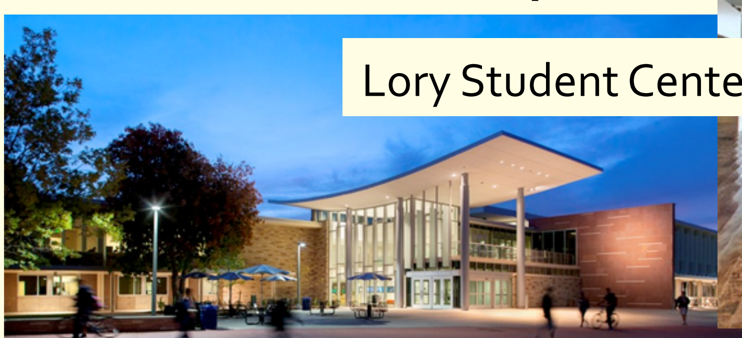
Marriott Sinclair
Fort Worth

IBR Building
Shenzhen

Fort Collins 2019 Symposium on Microgrids


CSU Powerhouse campus

- 15th in Microgrid Symposium series
- 9-12 August 2019 on Colorado State University campus
- by invitation only
- limited to 120-140 experts


Lory Student Center

Arigatou gozaimasu!
ありがとうございます。

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