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

ENERGY BY ENDUSE

CURRENT PQR

PQR REQUIREMENTS

MILITARY COMMUNICATIONS?

CRITICAL LOADS

HIGH PRIORITY

LOW PRIORITY

Heterogeneous PQR

WATER HEATING, DRYING, OTHER RESCHEDULABLE

WATER PUMPING

REFRIGERATION

INDUSTRIAL PROCESSES

NON-RESCHEDULEABLE, NON-CRITICAL SERVS. (e.g. entertainment)

NON-CRITICAL SERVICES

LIGHTING

HVAC

“UHAC”

WATER HEATING, DRYING, OTHER RESCHEDULABLE

WATER PUMPING

electric vehicles
Sendai Microgrid Schematic
Sinclair Hotel, Dallas TX

• 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?
Bosch, Chino CA (Los Angeles) 1

**DC Microgrid Design: Largest DC Microgrid in the World**

- **286 kW PV array (600 Vdc)**
- **180 kW Li-ion / 540 kWh (LG chem battery)**
- **120 kW DC Powerservers (AC-DC - for power from grid)**
- **180 kW bi-directional converters (storage and AC loads)**

**PV Array**
- **120 kW DC Powerservers**
- **180 kW Li-ion / 540 kWh**

**Energy Storage**
- **11 x 380 Vdc, 1.5 kW industrial fans**
- **12 x 380 Vdc, 7.5 kW Fork-Lift Chargers**

**DC Bus (nominal 380V)**
- **625 x 380 Vdc, 204 W light fixtures**
- **12 x 380 Vdc, 1.5 kW industrial fans**

**Energy Management System**
- **Loads in DC Microgrid:**
  - Lighting
  - Industrial Fans
  - Fork-lift chargers
- **Resources in DC Microgrid:**
  - Solar
  - Energy Storage

Larger microgrid split equally into 3 independent sub-microgrids

- **380 DC only, warehouse loads**
- **21% less energy, lower variability, resiliency**
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 single line diagram

March 15th 2019
Jorge Elizondo

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 2
US Academic DC Research Centers

National Labs (NREL, LBNL)

FREEDM Center, North Carolina State U

Powerhouse, Colorado State U

CAPS Center, Florida State U
Research Goals

- Compare AC and DC buildings
- 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

Research Goals

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

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

Bath Fan
48 V PoE
8-15% W saved

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

Zone Light, 380 V DC, 6% W saved
Team

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

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

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

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

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

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

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

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

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

CSU Powerhouse campus

Lory Student Center
Arigatou gozaimasu!
ありがとうございます。

Chris Marnay & Daniel Gerber

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