

ENERGY STORAGE FOR MINIGRIDS

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President & CEO
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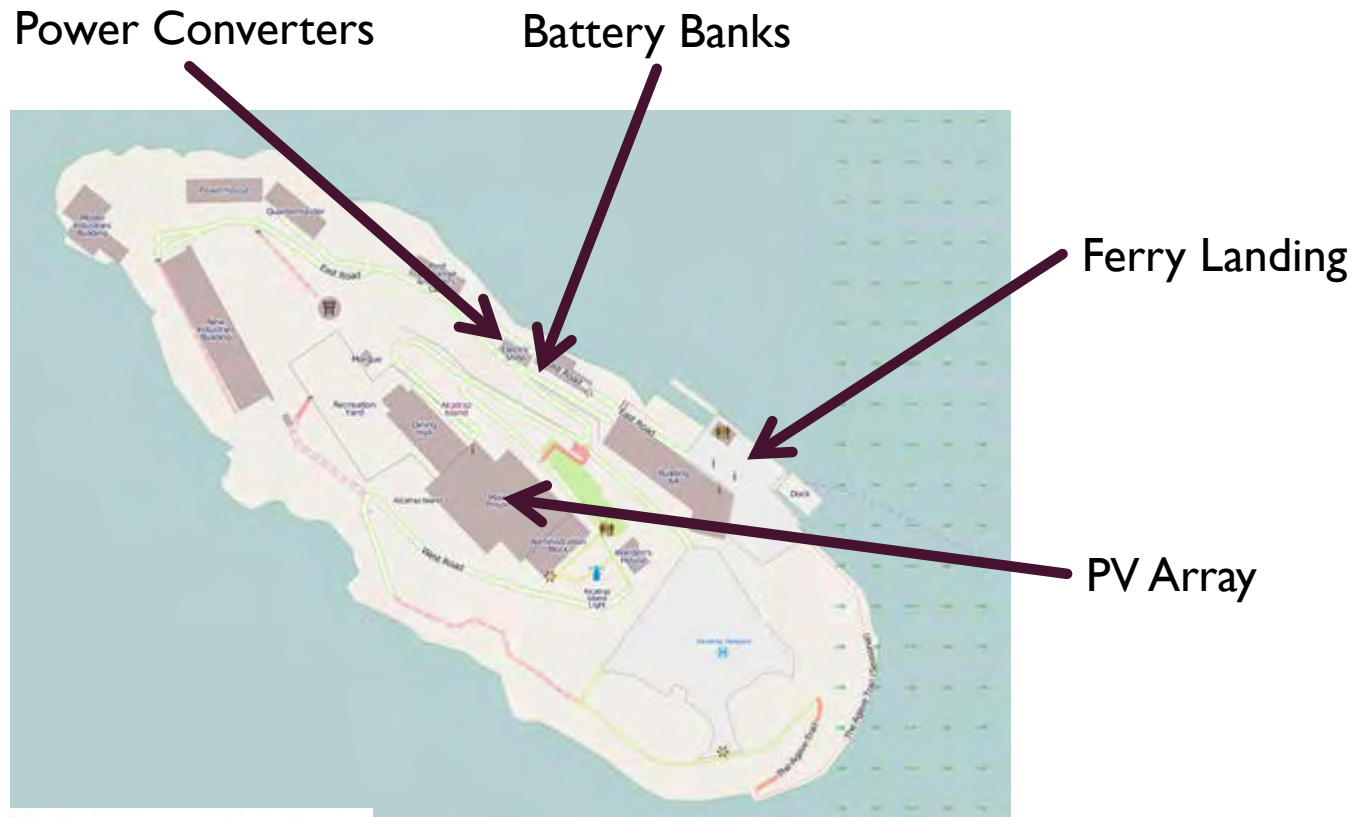
MODERN MICROGRIDS

- Alcatraz Island: USA's first modern solar microgrid
- ~2010 began an era combining:
 - Increased solar development
 - Improved deep-cycle battery technology
 - Remote distributed generation beyond diesel



Solar + Battery Microgrid on Alcatraz Island

PROJECT RESULTS



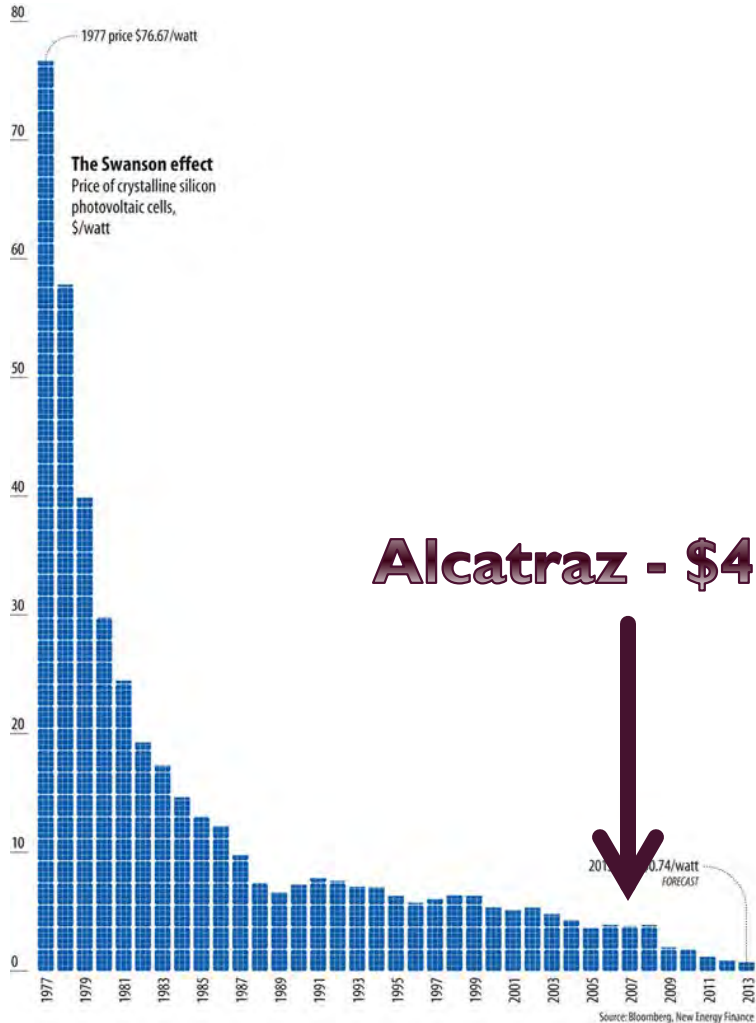
Electricity cost 2010: \$0.76 / kWh
Electricity cost today: \$0.71 / kWh

1.4 Million annual visitors



Generator runs every 2 days in winter, every three weeks in summer

IMPROVING ECONOMICS OF SOLAR ENERGY



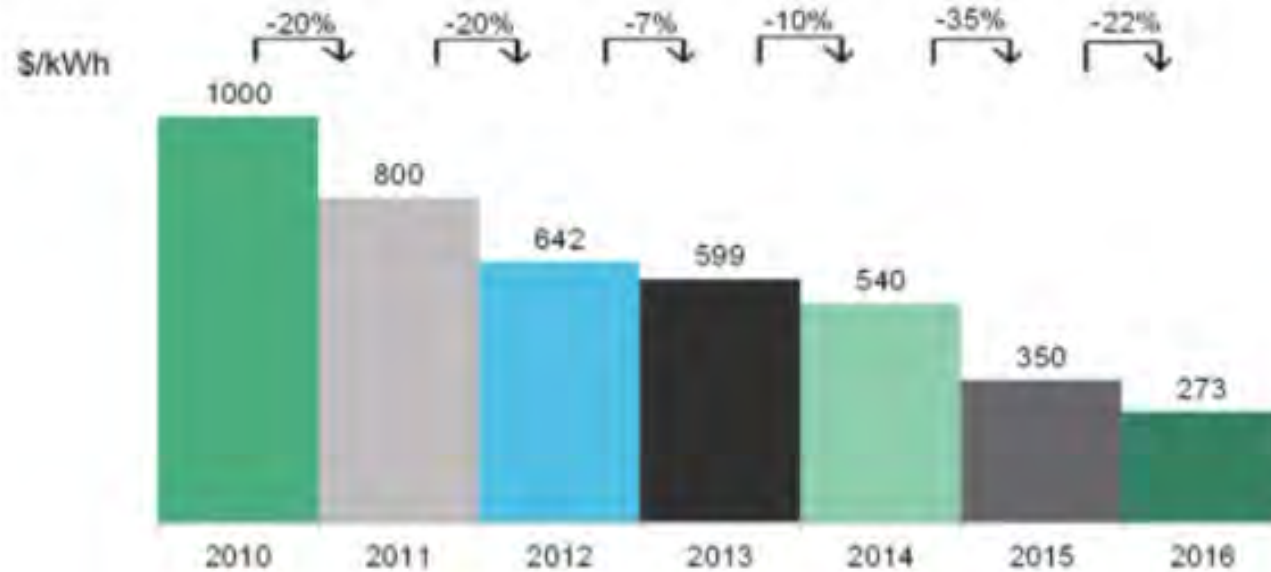
80 MW of Solar generation in Senegal
-- Power Africa

“Engie...and Meridiam...won an auction to build 60MW
of [solar] capacity...at a 60 per cent lower cost than
past solar projects in Senegal.”
-- Financial Times, April 2018

Today < \$0.35/W

IMPROVING ECONOMICS OF ADVANCED BATTERIES

BNEF lithium-ion battery price survey, 2010-16 (\$/kWh)



Commercial **price** of lithium-ion battery module(s) in 2018 ~\$245 / kWh

COMPETITIVE DISTRIBUTED MINIGRIDS



**Solar + Battery Microgrid
Ofu & Olosega (American Samoa)**
Price: \$0.24/kWh

Senegal

The average price of electricity in 2015 was (US\$**0.208**/kWh) for households and (US\$**0.196**/kWh) for industry. – enerdata.net

Kenyan Power Authority:
\$0.168 / kWh

Ghana:
\$0.19 – 0.32 / kWh USD (residential - commercial)

- Despite smaller size, solar + battery microgrids are becoming competitive with centralized power stations
 - Lower emissions
 - Less fuel supply risk
 - Easier to bring quickly to rural and remote areas
 - Price / Cost decreases expected to continue – \$0.12 / kWh in 5 years?

TECHNOLOGY STRATEGY FOR PRINCETON POWER

- **Energy Storage and Controls for Global Microgrids**

- Projects on 5 Continents: **Haiti, Jamaica, Bahamas, Kenya, Nigeria, Equatorial Guinea, Australia, American Samoa, Costa Rica, Guyana, Canada, Mexico, England**

- **Electric Vehicle Batteries**

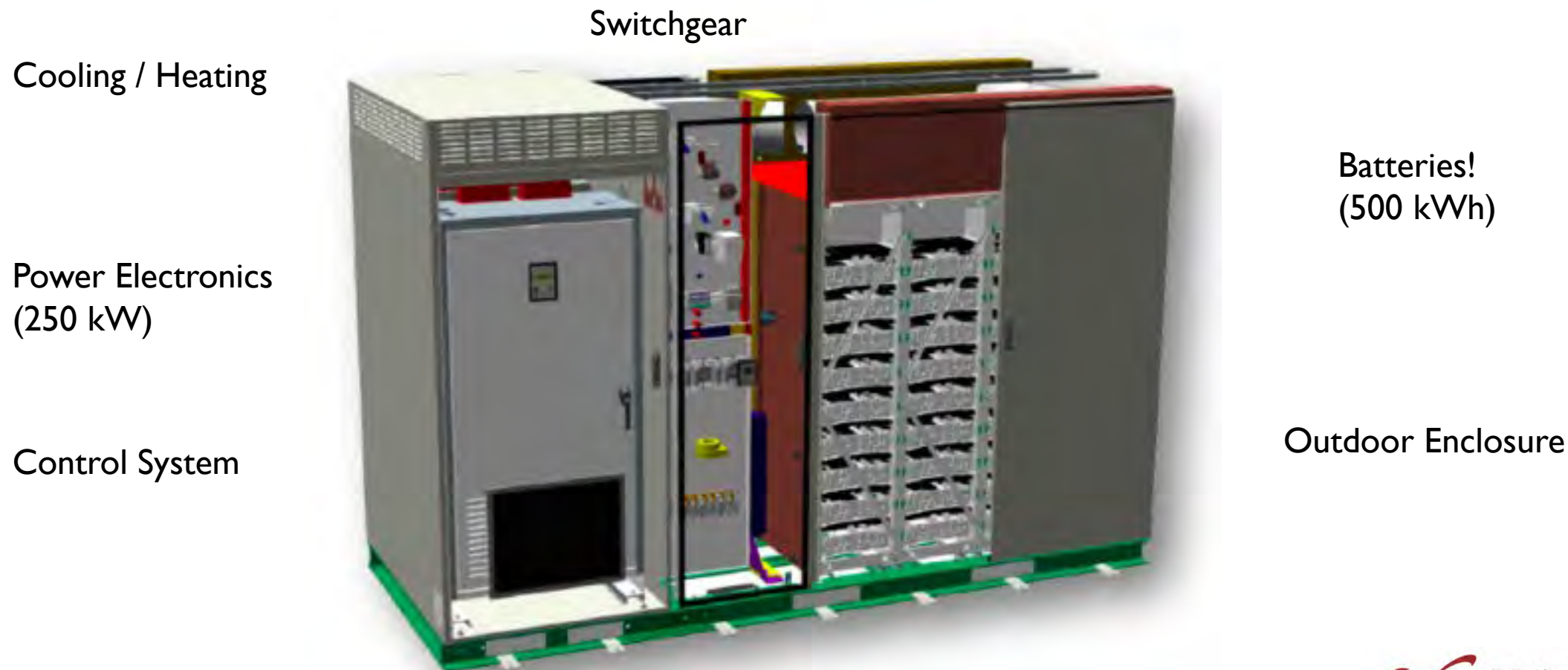
- Pioneering Projects with auto OEMs: **BMW, Mercedes, Honda, Nissan, Tesla**

- **Energy Storage Market Leader**

- > 50% of US' installed base uses our products

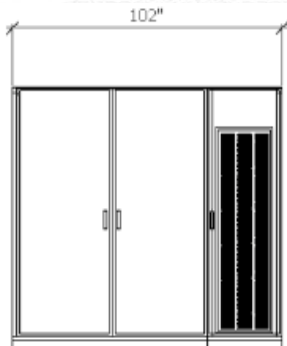
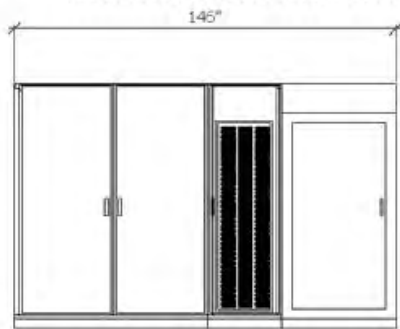
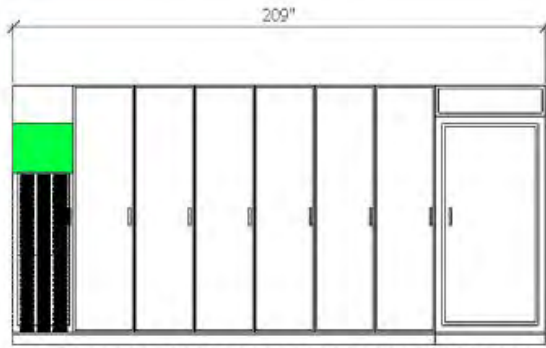


WHAT'S IN A MODERN BATTERY SYSTEM?



Pre-engineered, pre-manufactured, ships from the US and installs in ~8 hours

ENERGY STORAGE EVOLUTION



2015 "1st Generation"



2017

- 30% size reduction
- 30% cost reduction



cost, size
maintenance

2019

- 50% smaller than 1st Generation
- Half the cost of 1st Generation

2ND-LIFE / USED ELECTRIC CAR BATTERIES



BMW i3 Battery Packs (x8)

Outdoor operation, high temperatures

Efficient, long-life



OPPORTUNITIES

- Distributed Energy for Rural Communities
- Lower-cost, low emission diesel displacement
- Transportation electrification
- Resiliency for remote communities



Les Anglais, Haiti



ANDLINGER CENTER FOR ENERGY AND THE ENVIRONMENT

- Founded in 2015
- World-leading Faculty and research on:
 - Smart windows
 - Battery energy storage
 - Climate science
 - Energy efficient building design and comfort
 - Energy system analysis
- Global Collaborations on Policy, Standards, Technology



THANK YOU!

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