

2011 Joint Service Power Expo
Session 22: Hybrid Systems



EARL ENERGY

The Power to Sustain Warfighter Dominance

Optimizing Generator Efficiency
with Energy Storage Technologies

Presented by

Doug Moorehead
President, Earl Energy

Earl Energy Overview

- Earl Energy is an energy systems engineering and product development firm, owned and led by veterans and headquartered in Portsmouth, VA
- We design, build, test, install, and service military power generation and energy management systems
- Affiliated with Earl Industries, a diversified industrial defense contractor with 900 employees and a global footprint
- 15 years of shipboard electrical power and control systems experience
- Expertise in electrical control panels, switchboards, power distribution, and full-scale automation systems
- Preferred power and controls vendor for Military Sealift Command

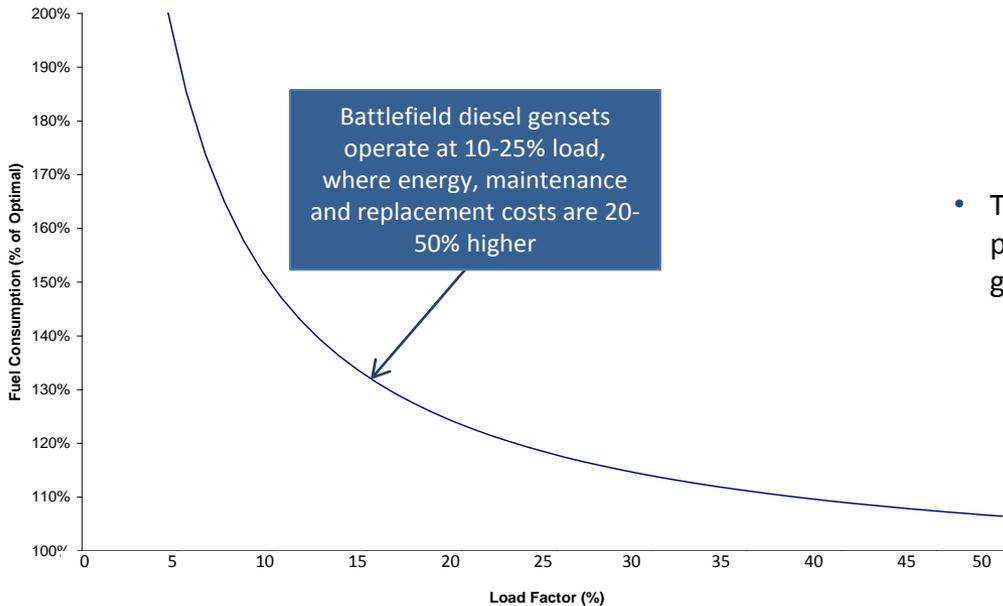
Doug Moorehead, President and Principal Investigator

- Director of Automotive and Grid-Level Energy Storage at A123 Systems, Inc.
- Original patent holder of A123 Systems, Inc. founding intellectual property
- Bachelor of Science, United States Naval Academy
- Master of Science in Materials and Engineering, Massachusetts Institute of Technology
- Master of Business Administration, Harvard Business School
- U.S. Navy SEAL, 9 years, Combat Veteran



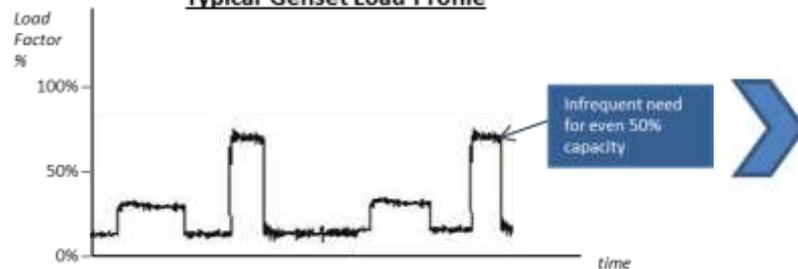
Generator Inefficiency & the Hybridization Solution

Diesel Fuel Consumption (Source: EPA)

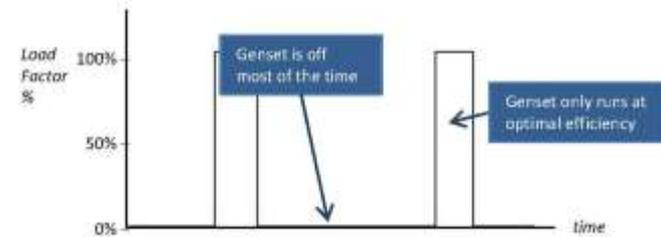


- Battlefield diesel generators typically operate at low load factors, resulting in **exponentially** higher:
 - Fuel consumption
 - Maintenance costs
 - Physical depreciation of the generator
 - Hazardous emissions of NO_x, SO_x, PM, and GHGs
- Through plug-and-play integration of small, high-performance energy storage systems, existing battlefield generators can be hybridized
 - Reduces generator runtime by 60-90%, with corresponding reduction in fuel consumption, maintenance and MTBF
 - Maintains 100% power reliability
 - Improves power quality
 - Increases overall sustainability of existing genset inventory and deployed power systems

Typical Genset Load Profile



Hybridized Genset Load Profile



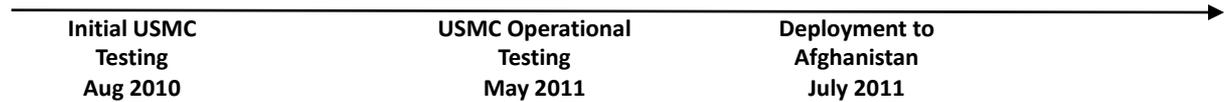
Earl Energy FlexGen Development Roadmap

Capabilities

- 18kW rated power
- 3x 120VAC, 3-phase outputs
- 5kW integrated PV
- AC & 3x DC inputs
- Integrated energy storage
- Dynamic load mgmt/shedding
- Automatic genset start/stop



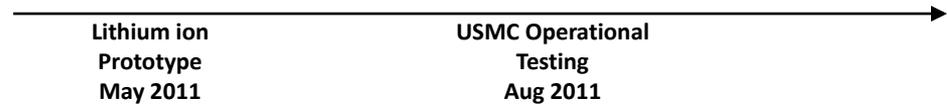
EARLCON



- 3kW rated power
- Integrated lithium ion energy storage
- AC & 3x DC inputs
- Automatic genset start/stop
- Man-portable



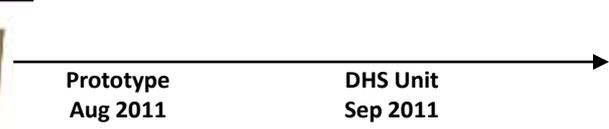
**FlexGen
3kW**



- 35, 60 and 100kW rated power
- 2x AC & 3x DC inputs
- Integrated lithium ion energy storage
- Automatic 2x input genset paralleling/phase matching
- Automatic genset start/stop

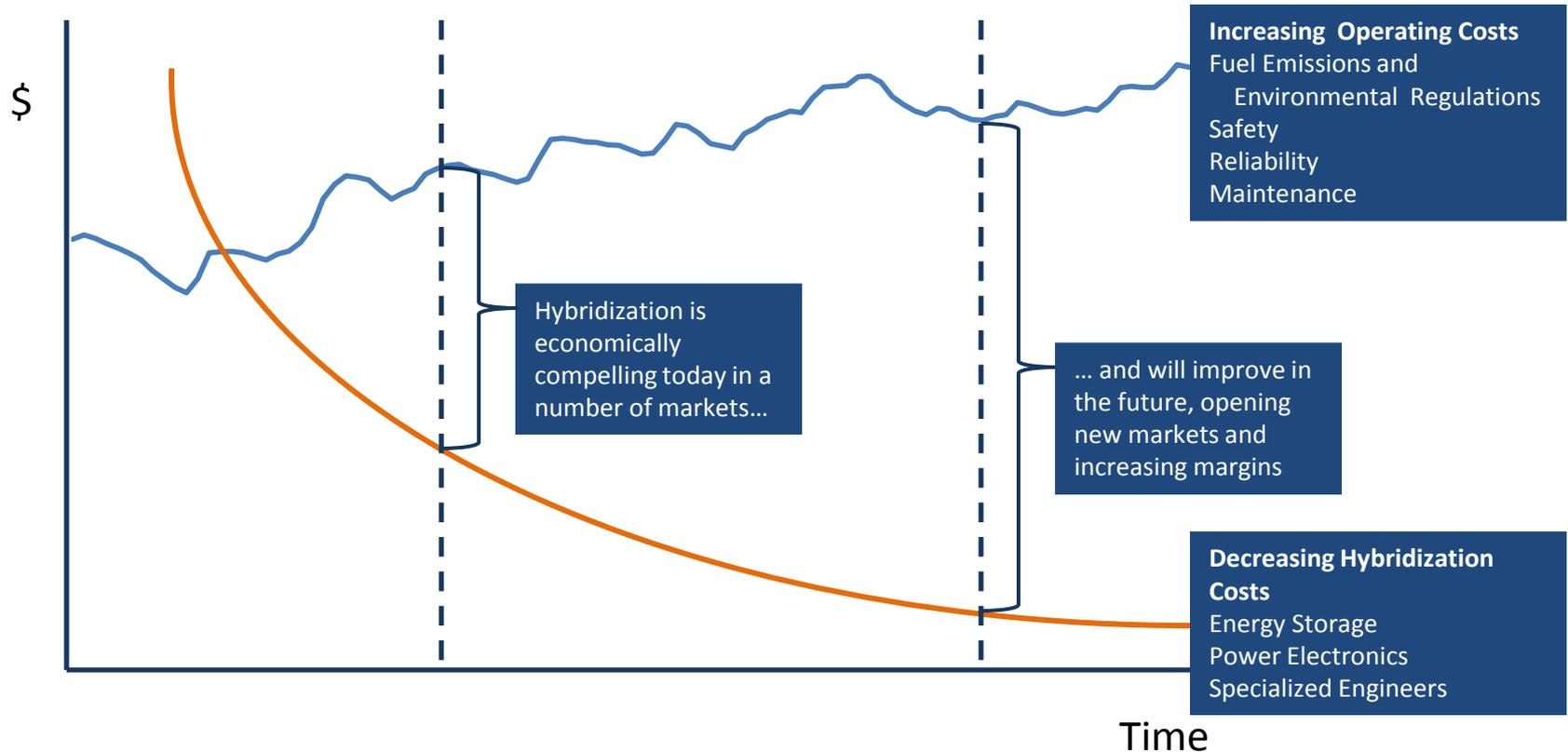


**FlexGen
35kW
60kW
100kW**



Why Now?

- Energy storage and large-scale power conversion technology have benefitted from 5+ years of significant government and private investment resulting in lower costs and improved performance, reliability, and safety
- In a number of large markets, the costs of hybridization are now competitive economically with traditional power systems



Business Case Analysis

- 5kW EARLCON with integrated energy storage participated in Aug 2010 ExFOB Phase IV in Twentynine Palms, CA
 - NSWC test results confirmed 93% reduction in fuel consumption of 6kW generator
 - Excluding renewable power sources, hybridization of generator alone reduced fuel consumption by 60%
- USMC MARCORSSYSCOM issued sole source contract for 2x EARLCONs in Feb 2011 to power battalion-level Combat Operations Centers (COC)
- FlexGen generator hybridization of a 3kW Tactical Quiet Generator (TQG) delivers a cash payback period of 4-5 months and total savings of \$68,000 over the 9-year life of the system
- Enables the TQG to turn off for 20-21 hours per day
- Reduces maintenance, emissions, sound, and vibration by ~80%
- Extends generator replacement cycle by 4x to approximately 5 years
- Our financial analysis excludes the positive financial and competitive impacts of the reductions in emissions, sound, and vibration
- The primary drivers of payback are electrical load profile, fuel consumption, and fuel cost

Key Assumptions

- Genset price: \$10,400; no salvage value
- Genset lifecycle: 10,000 hours
- Genset annual maintenance: \$2,500
- 24/365 operation
- Diesel fuel cost: \$7.50-\$30/gal
- Hybridization system lifecycle: 9 years
- Battery service: 18 months

Example - 3kW TQG at \$7.50 ADP

Annual Generator Power Output	4,011 kWh
Cost of Power at Optimal Power Factor	\$ 1.95
Annual Cost of Power at Optimal Power Factor	\$ 7,828
Actual Cost per kWh (incl. fuel & maint.)	\$ 5.28
Observed Annual Cost of Power	\$ 21,168
Annual Cost of Generator Inefficiency	\$ 13,340
Production Cost of 3kW Hybridization System	\$ 5,750
Payback period (months)	5.2



Off-Grid Markets & Sales

- The market for generator hybridization is large, spanning multiple customer segments, identified by the following characteristics:



High fuel delivery costs – battlefield, remote locations, at sea



High maintenance costs – dangerous, harsh or remote locations, at sea, highly technical equipment, mission-oriented power systems



High generator utilization rates – where gensets provide prime power, where engineers factor in excess capacity as a rule



Emissions restrictions/incentives – European markets tax carbon emissions, in-port vessels, harbor dredging



Silent and low vibration power – military operational security, luxury yachts, highly instrumented equipment



Clean, high quality power – sensitive instrumentation



Mission-critical power – uninterruptible power supplies

Inform

Energy surveys
Identify/quantify inefficiencies
Collect configuration data

Reliability

Put products in customers' hands
Flawless field service/support

Endorsement

Third party validation
Ports, EPA, IMO, NGOs

Measure

Prove business case
Improve product design

Thank You

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