



*Fuel Cell Initiatives and Future Applications in
the U.S. Navy and U.S. Marine Corps*

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Grand Challenge

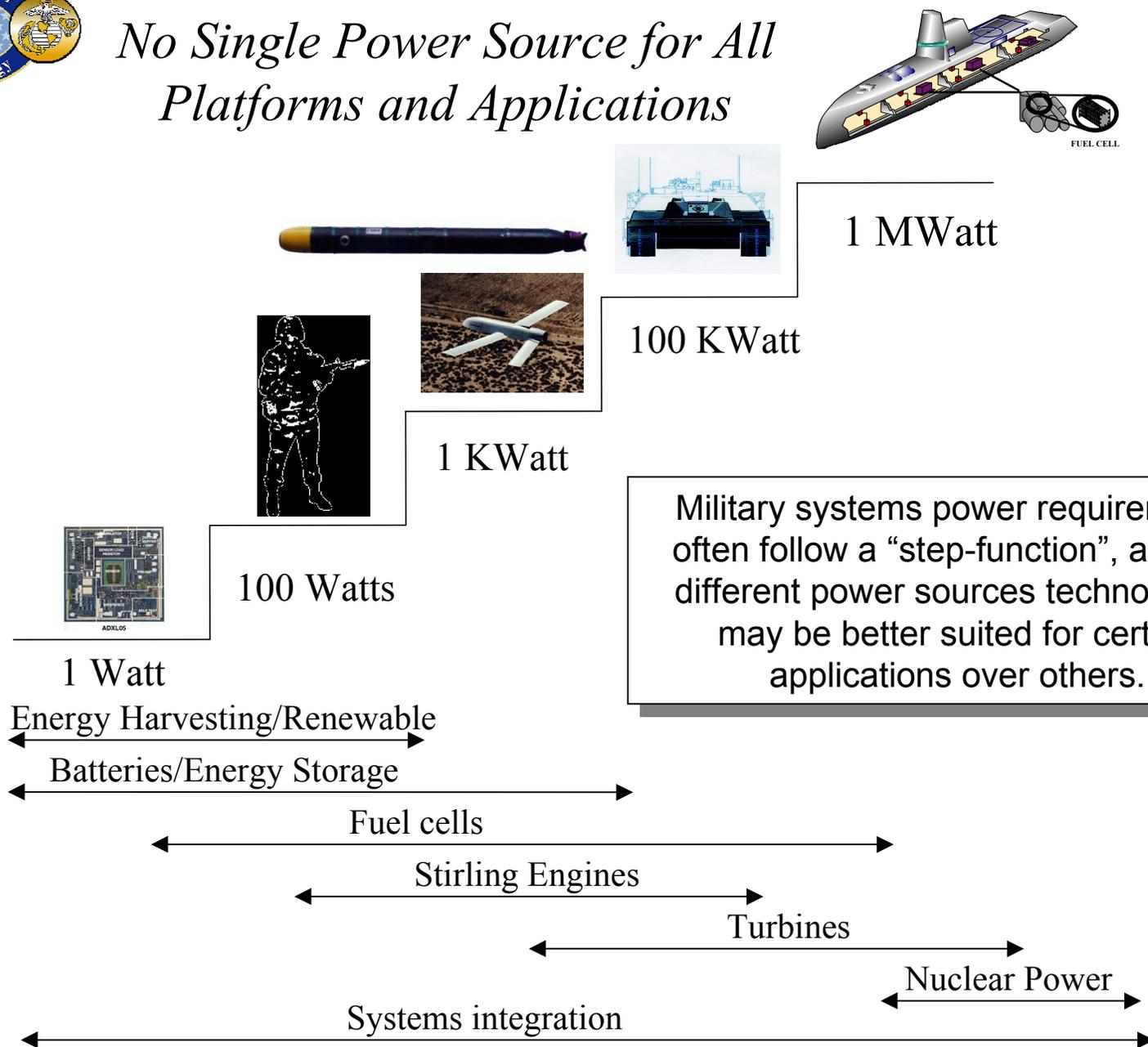


Electric Power Sources for the Navy and Marine Corps

Develop new, safe, efficient, environmentally friendly, non-petroleum based sources of power and power generation concepts that would support portable long-lived power sources for all future Marine-carried equipment and electric power sources required for all-electric ships and other Naval warfighting platforms

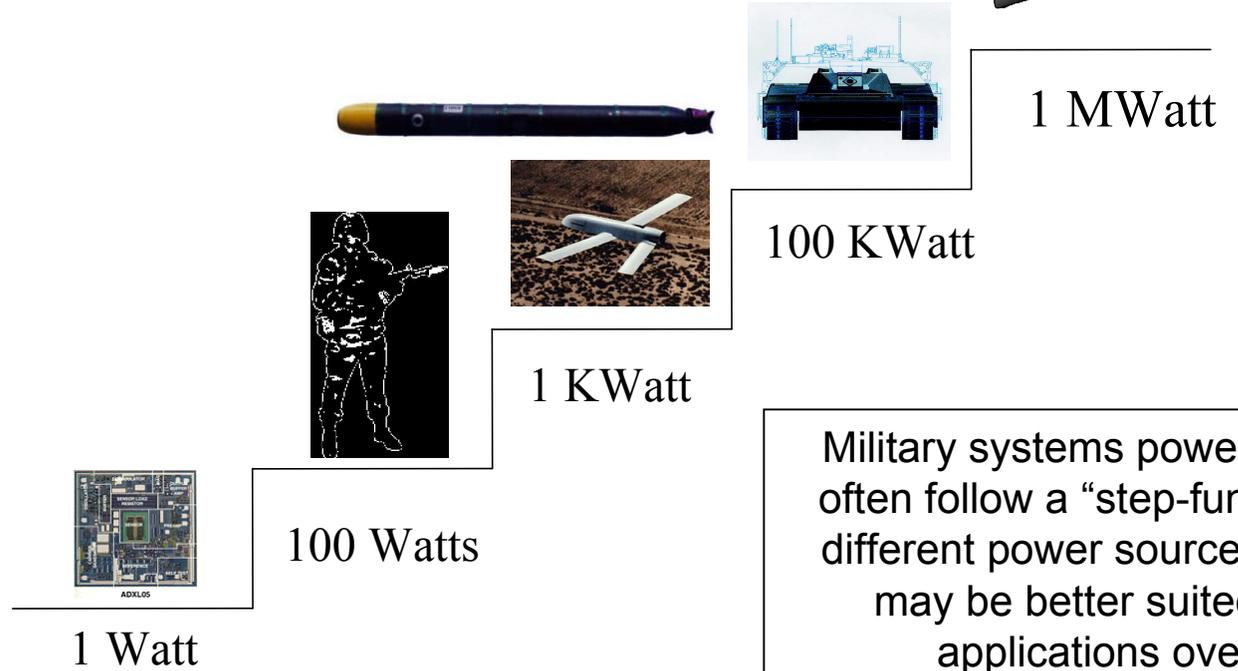
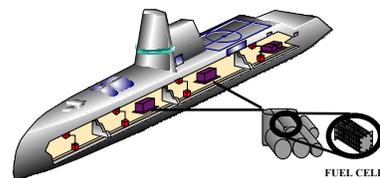


No Single Power Source for All Platforms and Applications





No Single Power Source for All Platforms and Applications



Military systems power requirements often follow a “step-function”, and so, different power sources technologies may be better suited for certain applications over others.

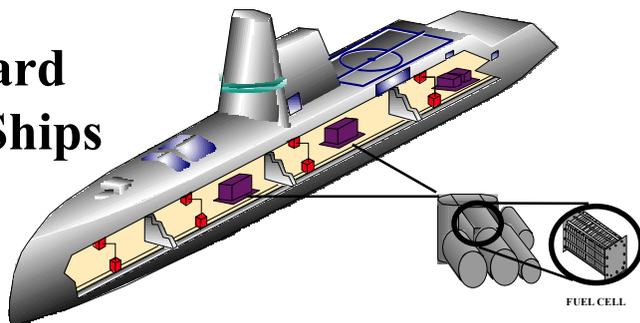
Fuel Cells

Systems Integration

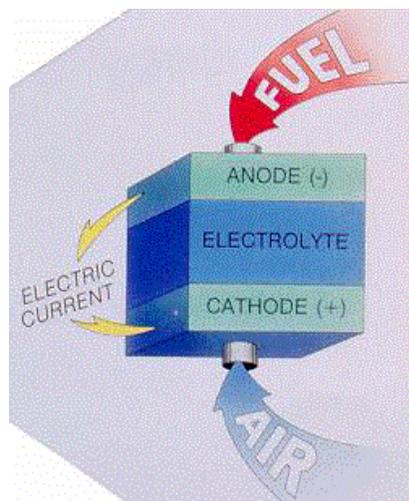


Ship Service Fuel Cell Program (SSFC)

**Navy, Coast Guard
& Commercial Ships**



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Challenges

- *Logistic Diesel Fuel Reforming*
- *Reformate Cleanup*
- *Efficient System Integration*
- *High Specific Power*
- *Transient Response*

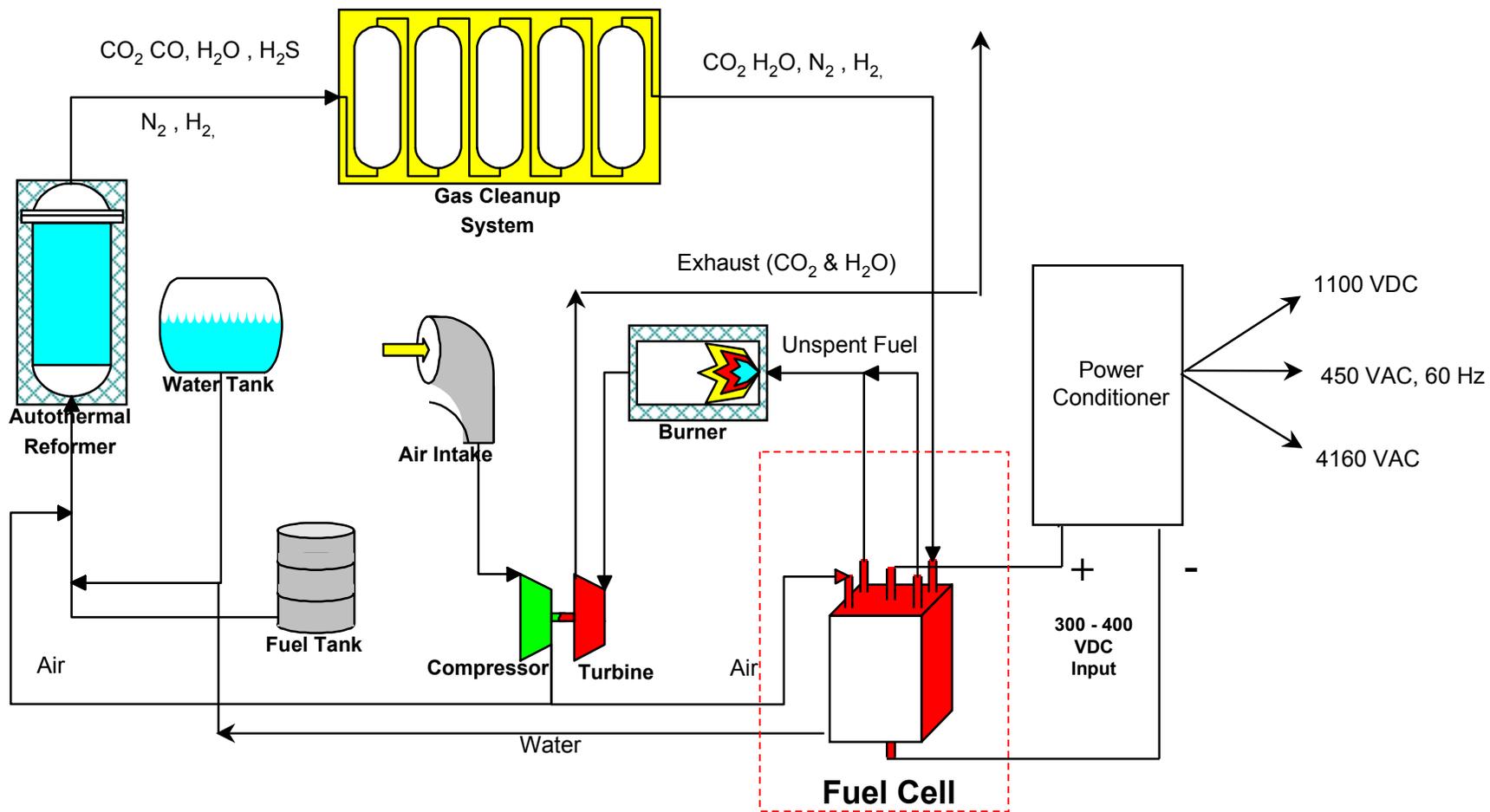
Payoffs

- ✓ *Increased Fuel Efficiency and Operational Range*
- ✓ *Distributed Power for Increased Survivability*
- ✓ *96% Reduction in NO_x, CO and HC Emissions*
- ✓ *30% Reduction in CO₂ Emissions*
- ✓ *\$0.6M to \$1M/yr/ship Savings*
- ✓ *Reduced Thermal and Visual Signatures*



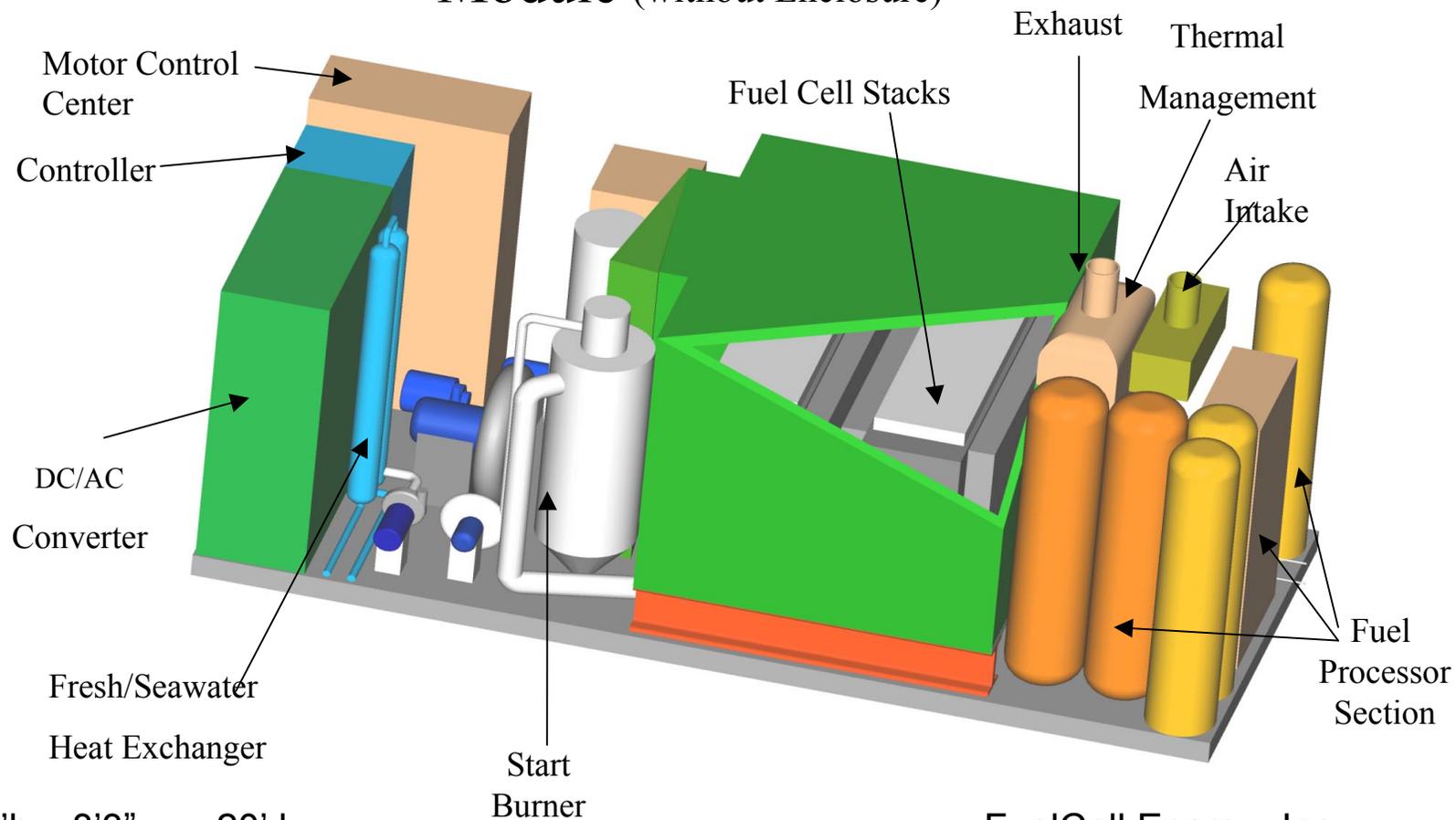
SSFC Fuel Processing Concepts

Fuel Processing is the Key to Fuel Cell Operation!!!



SSFC Scaled Demonstration

Conceptual 625 kW Molten Carbonate Fuel Cell Module (without Enclosure)



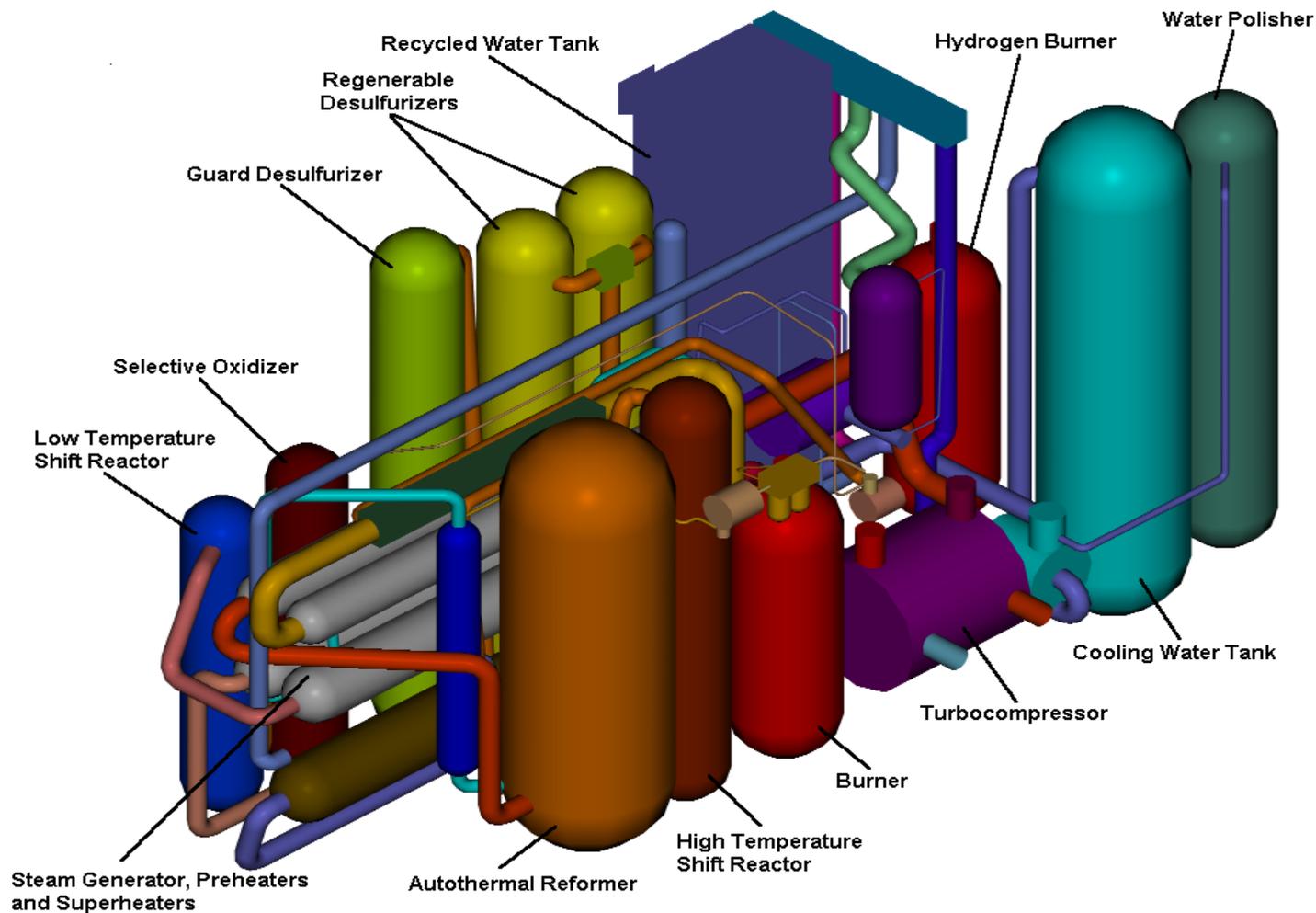
8'h x 8'3" w x 20' l

FuelCell Energy, Inc.



SSFC Scaled Demonstration

McDermott Technology 500kW SSFC Integrated Fuel Processor (IFP)



Program Timeline/Transition

FY 00 01 02 03 04 05 06 07 08 09 10 11

Fleet Introduction

Ship Platform Managers

IPS Transition Full Scale

Design, Fabrication, Operation and Testing of Full Scale Ship Service Fuel Cell

PR 03

ONR/NAVSEA Advanced Technology Development

500KW IFP Design

Fabrication, and Testing of 500KW ATR Integrated Fuel Processor

Design, Fabrication, and Testing of 625KW MCFC Demonstrator

At Sea Evaluation 625KW Demonstrator

Design, Fabrication, and Testing of HPFC Demonstrator

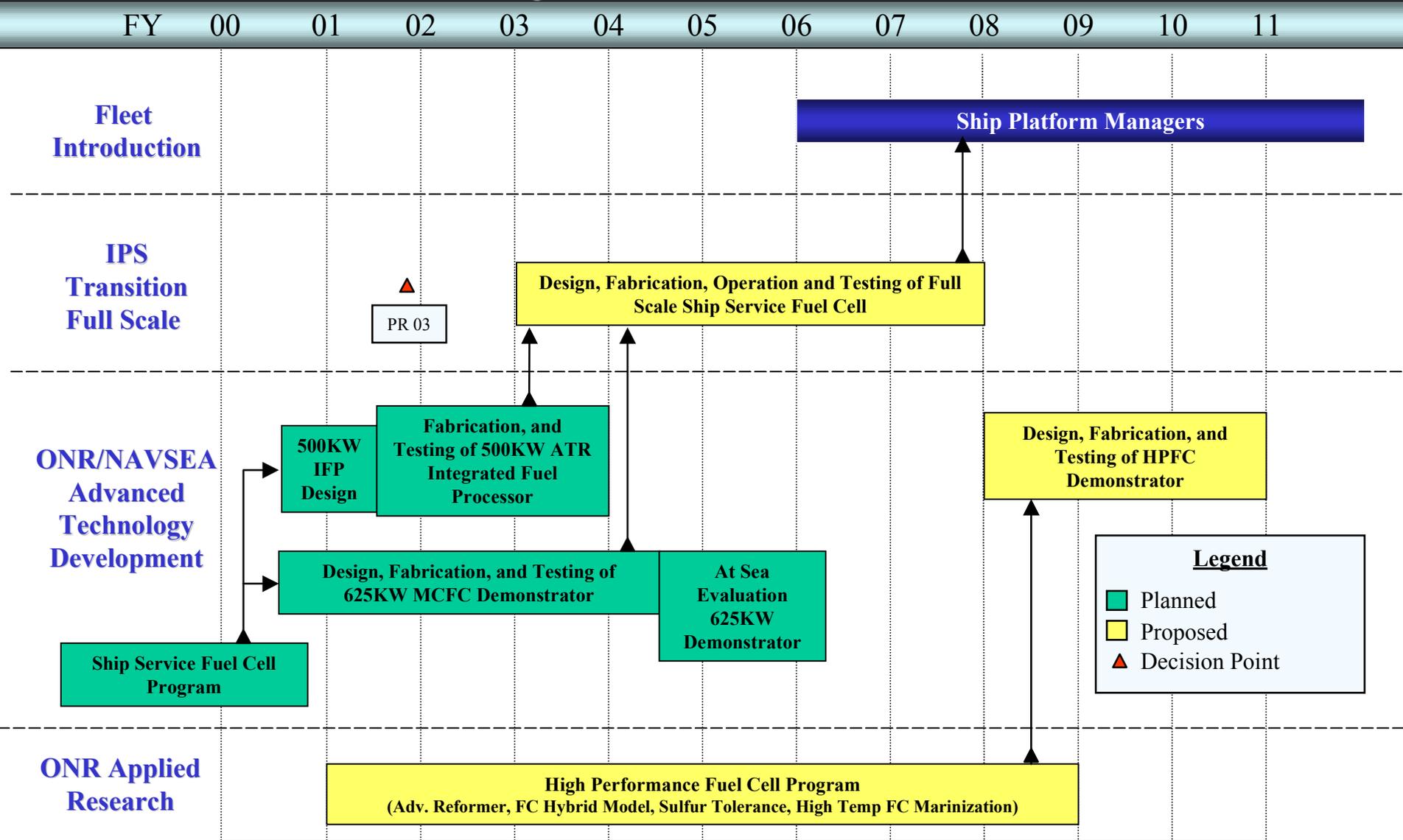
Ship Service Fuel Cell Program

Legend

- Planned
- Proposed
- Decision Point

ONR Applied Research

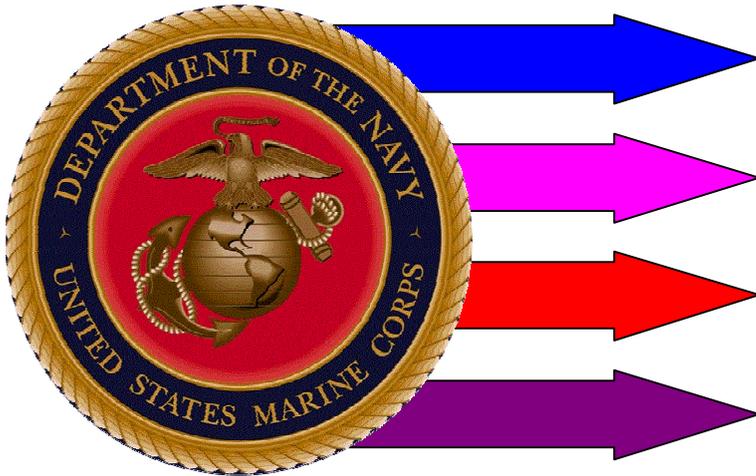
High Performance Fuel Cell Program
(Adv. Reformer, FC Hybrid Model, Sulfur Tolerance, High Temp FC Marinization)





Direct Diesel-to-Electric SOFC

*Marine Corps
Electrical Power*



- Field Generators
- Individual Marine
- Future Vehicles
- Autonomous Vehicles



29 Palms, CA, 8-10 Oct 1999

Fuel Cells aboard Humvee



Ball Aerospace



Ten PRC-119 Radios

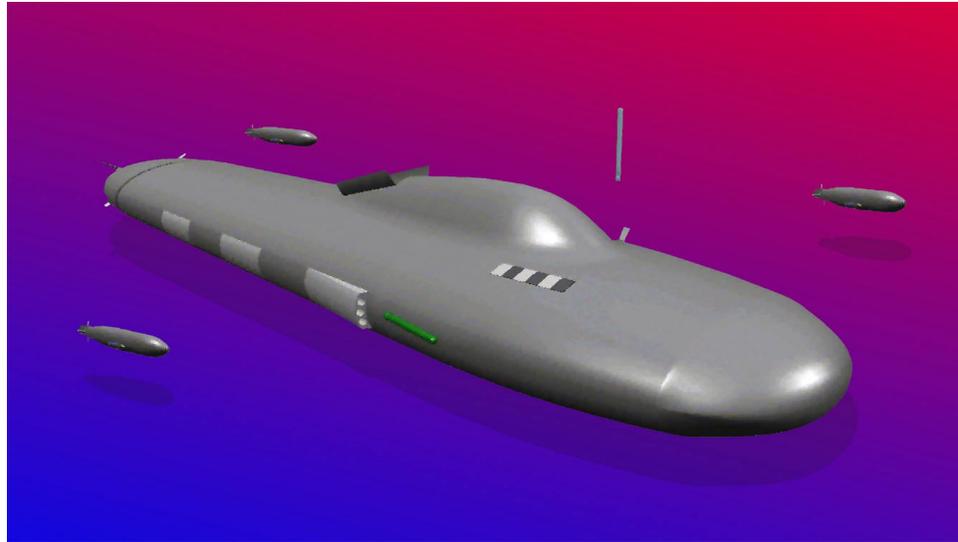


COST ESTIMATE FOR EXERCISE

- **BA5590 BATTERIES = \$1800**
- **FUEL CELLS = \$100**



Autonomous Undersea Vehicles (AUVs)





AUV PEM Fuel Cell Operating on Diesel

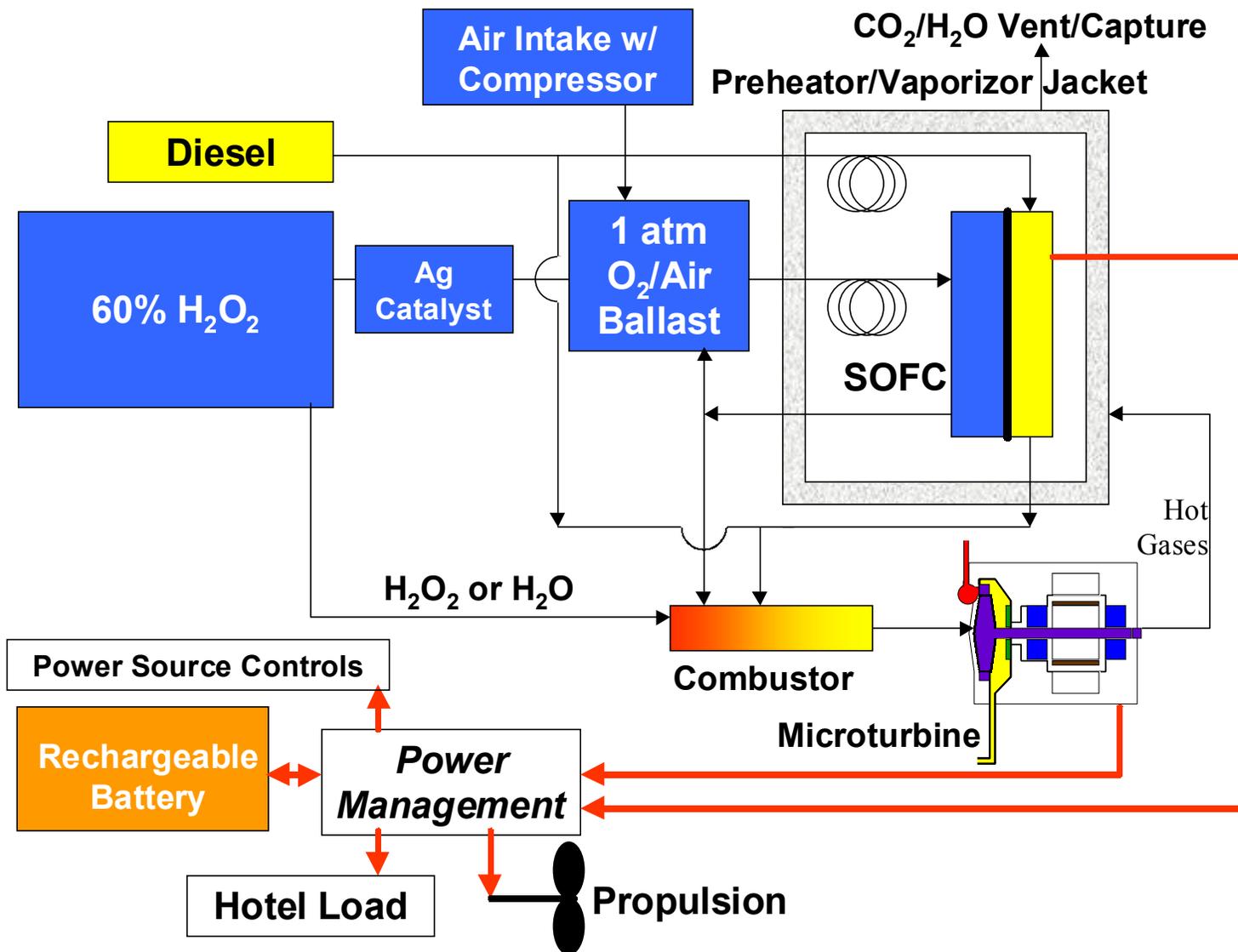
PEM Fuel Cell System for 4 kW and 100 kWh

Components	Weight (kg)
PEM Fuel Cell	10
Fuel System	
Diesel Fuel	14
Reformer + Pump	31
O ₂ -generator/CO ₂ /S-absorber	178 ←
Other Auxiliaries	15
Totals	248
Add 10% for Structure	273
Specific Energy (w-hr/kg)	<u>350</u>

- O₂ and CO₂/S-Absorbers = >65% Total System Weight
- Relatively Low Specific Energy ⇒ 400 Wh/kg Goal



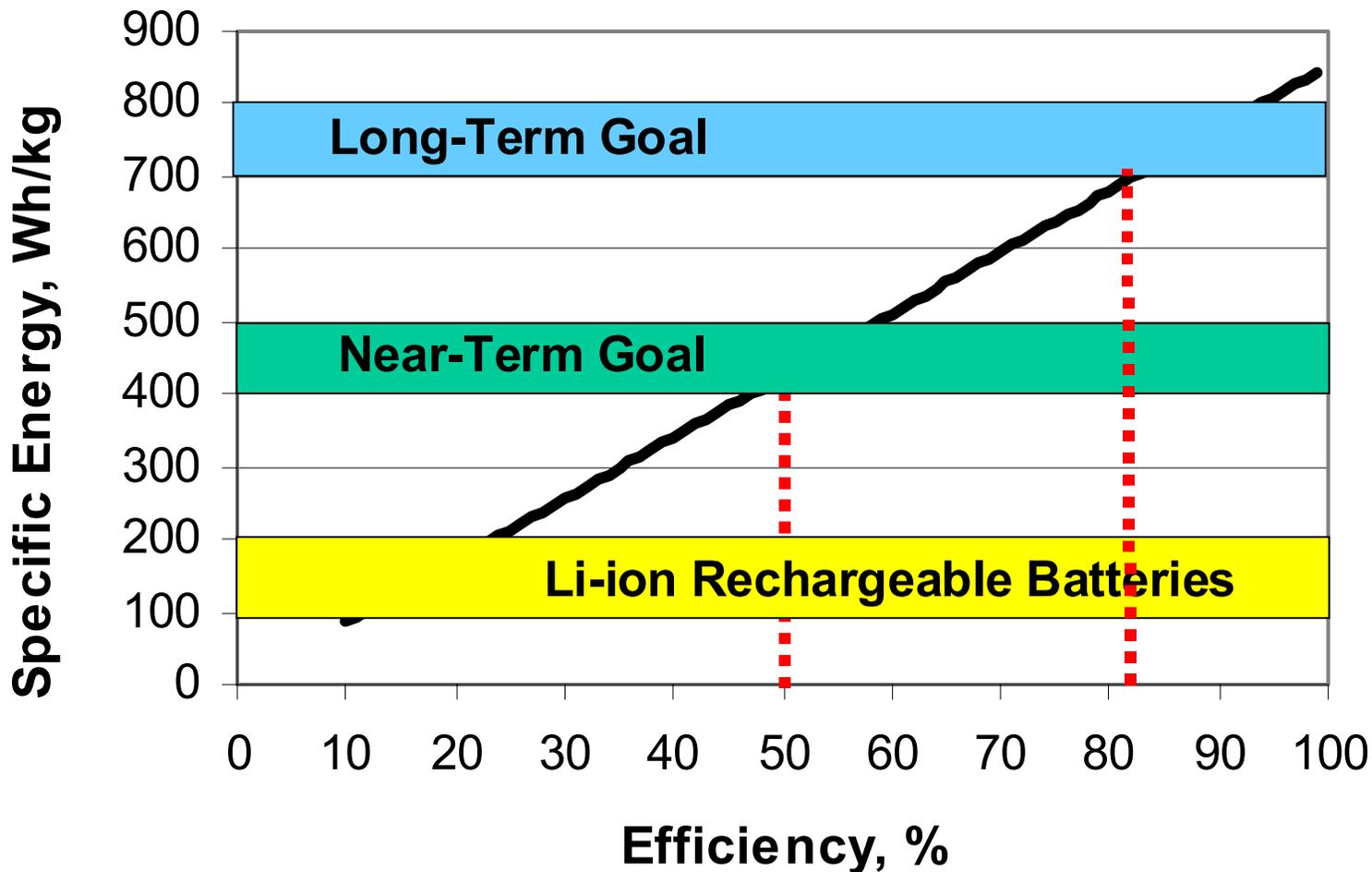
SOFC Hybrid Concept for AUV





SOFC Hybrid Concept for AUV

SOFC/Microturbine using Diesel/60% H₂O₂



15 kg Diesel, 184 Kg 60% H₂O₂, & 30 kg (SOFC + BOP)



Fuel Cells for the Navy & Marine Corps

- Fuel Cells Applications
 - Shipboard power
 - Autonomous vehicles
 - Person-portable power
 - Field generators
 - Ground and sea combat vehicles
- Major Challenges
 - Operation on logistics fuels
 - Other fuels under consideration (e.g., synthetic diesels)
 - Operation in anaerobic environments
 - Compact, lightweight, rugged