



Reducing Warfighter Load by Increasing Energy Density

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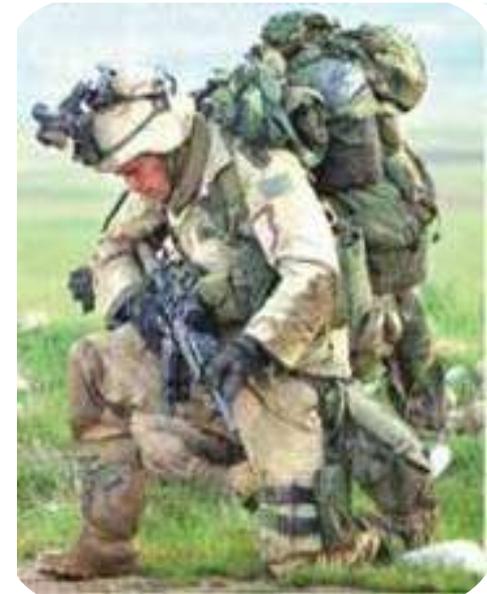
SFC
ENERGY



- 🔌 Problem Statement
- 🔌 Soldier Portable Energy Sources
- 🔌 Energy Density
- 🔌 Sample Soldier Load Study
- 🔌 SFC Overview
- 🔌 Summary

Problem Statement

- ⏻ Warfighter load ranges from 80-180 lbs based on mission and squad role
 - ⏻ Increased Fatigue
 - ⏻ Decreased Effectiveness
 - ⏻ Decreased Mission Duration
- ⏻ 30-40% of that load is dedicated to energy



The Warfighter needs a lighter power solution

Soldier Portable Energy Sources - Requirements

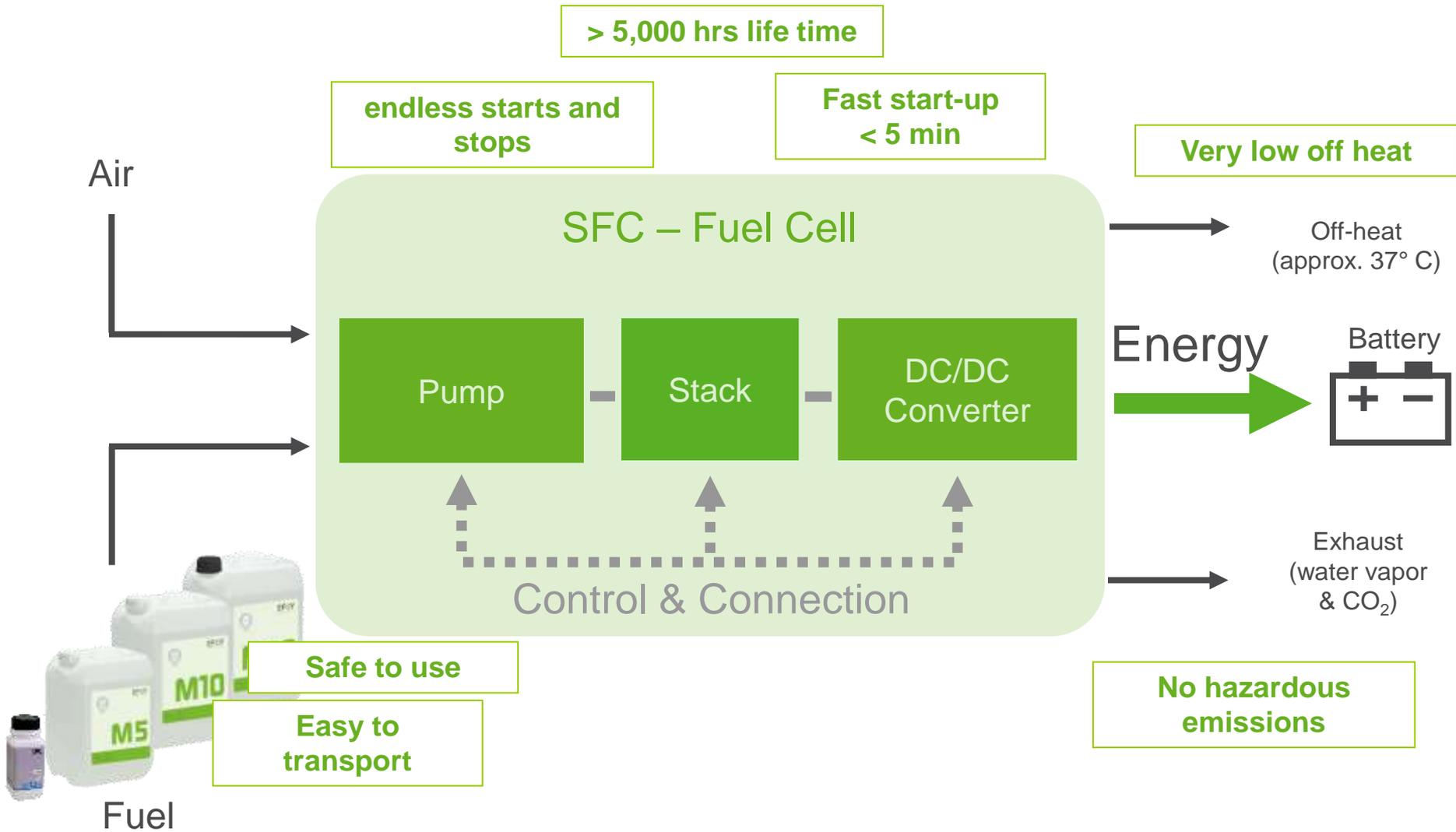
- 🔌 Lightweight and low volume
- 🔌 Capable of 500-700 Wh/day
- 🔌 Minimal operator management
- 🔌 Low signature (noise, heat, and visibility)
- 🔌 No hazardous emissions

Soldier Portable Energy Sources

🔌 Direct Methanol Fuel Cells (DMFC)

🔌 Batteries

Soldier Portable Power Sources – DMFC Technology



🔋 JENNY 600S – portable fuel cell

- 🔋 Minimal operator management – single fuel cartridge lasts 16 hours
- 🔋 Low heat and noise signature
- 🔋 Operates without emissions
- 🔋 Ruggedized for military field operation



🔋 SFC Power Manager – portable energy management

- 🔋 Simple to use
- 🔋 Manages sources and loads without user input
- 🔋 Enables energy harvesting from different sources
- 🔋 Creates modular power network



SFC DMFC and Power Management systems offer immediate COTS solution!

Soldier Portable Energy Sources – DMFC (cont'd)

System	Weight (lbs (kg))	Size (in (mm))	Energy (Wh)
 <p>JENNY 600S</p>	<p>3.74 (1.7)</p>	<p>7.2 x 2.9 x 9.9 (184 x 74 x 252)</p>	<p>600/day</p>
 <p>M0.35 Cartridge</p>	<p>.82 (0.371)</p>	<p>6.5 x 2.4 x 2.4 (165 x 60 x 60)</p>	<p>400</p>
 <p>Power Manager 3G</p>	<p>1.05 (0.48)</p>	<p>5.2 x 3.4 x 2.4 (131 x 87 x 61)</p>	

batteries
30 Wh/kg



🔋 270 kg

11 kWh energy !

Methanol: 35 times higher energy density than batteries

Methanol combines superior energy density with easy handling, shipping and low cost.

Methanol (M10)
1,1 kWh/kg



🔋 8 kg, 10 l

Energy dense fuel leads to lower warfighter loads

Soldier Portable Energy Sources - Batteries

Battery Type	Voltage (V)	Capacity (Ah)	Size (in (mm))	Weight (lbs(kg))	Energy (Wh)
 BB-521	9.6	1.2	2.8 x 3.0 x 1.5 (71 x 75 x 38)	0.8 (0.35)	11.5
 BA-5590	15.0	15.0	5.0 x 4.4 x 2.4 (126 x 111 x 62)	2.2 (1)	225.0
 BB-2590	14.4	12.4	4.4 x 2.45 x 5 (112 x 62 x 127)	3.1 (1.4)	178.6
 AA	1.5	1.5	0.55D x 2 (14D x 50)	.05 (0.024)	2.3
 CR123	3.0	1.2	0.65D x 1.3 (16.5D x 34)	.04 (0.017)	3.7

High energy density – 1,400+ Wh/kg

That delivers **10 kWh** electricity

Methanol



Hydrogen



Lithium Batteries



Lead-acid batteries



Weight:

🔋 8 kg

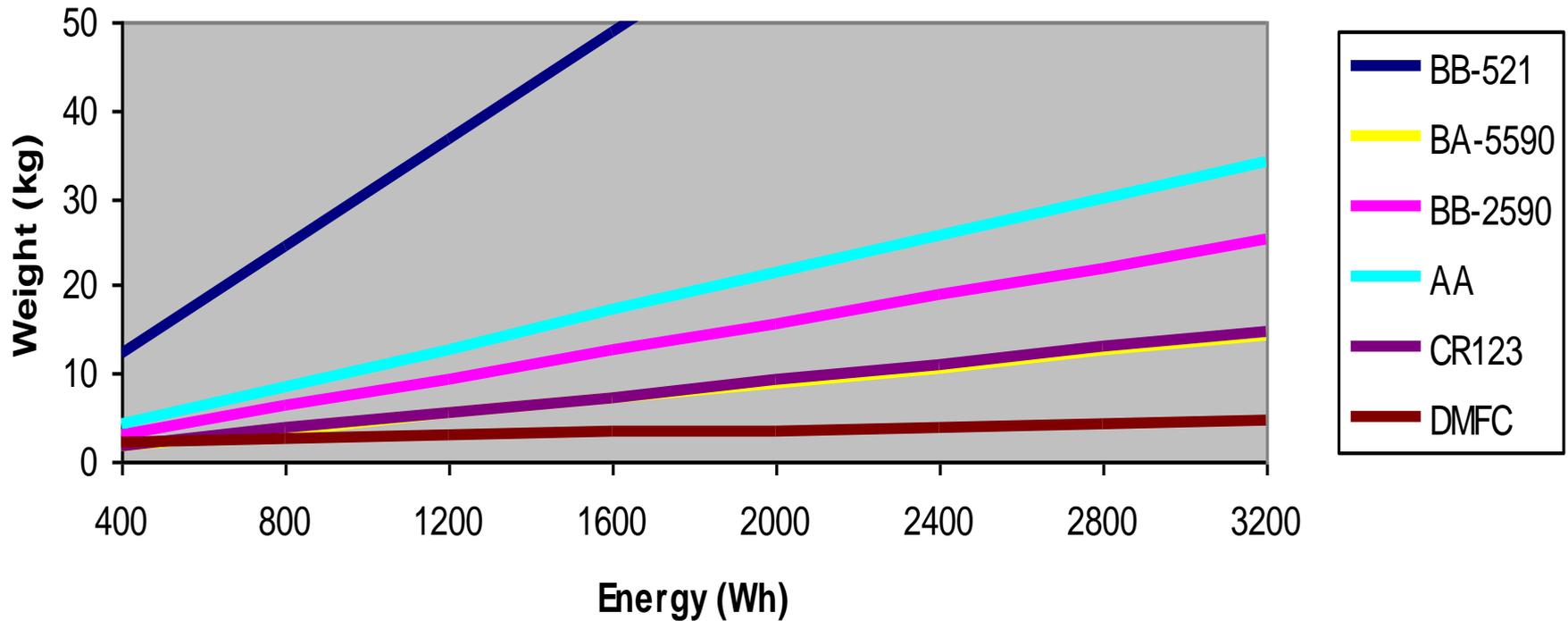
🔋 85 kg

🔋 110 kg

🔋 270 kg

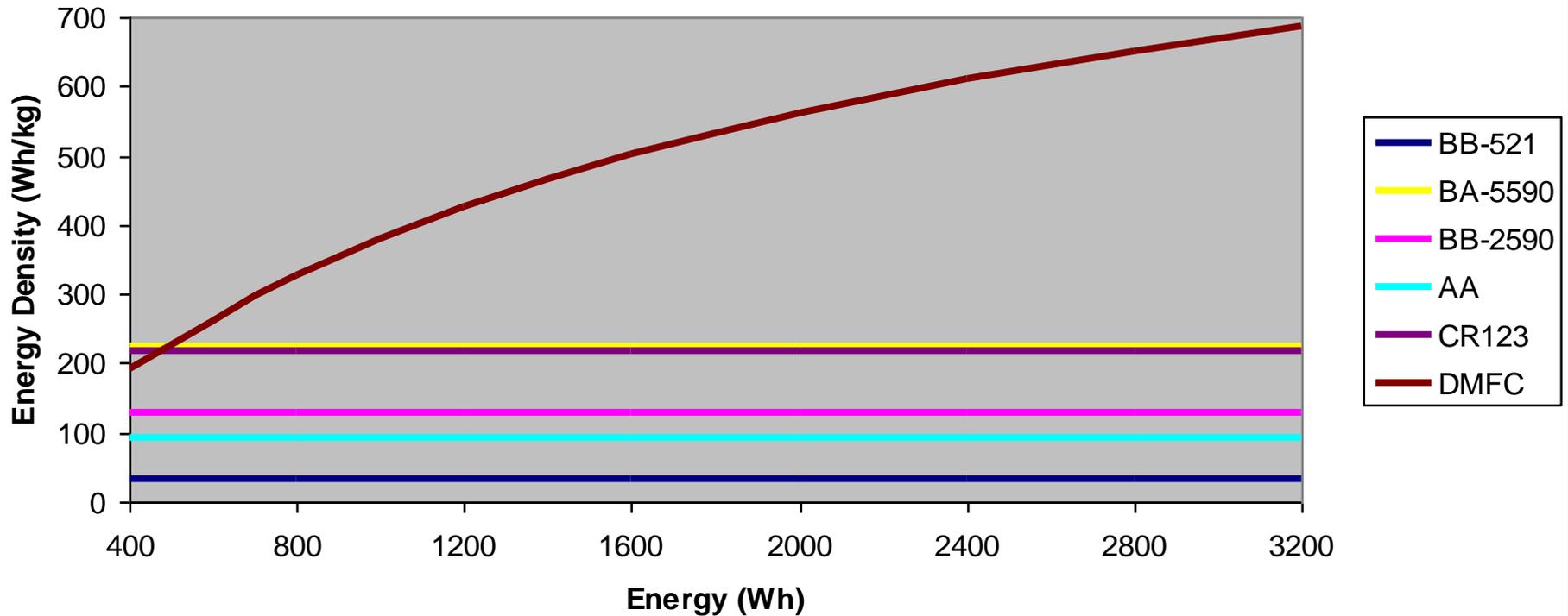
Methanol combines outstanding energy density with easy handling and low costs.

Energy vs. Weight of Various Power Sources



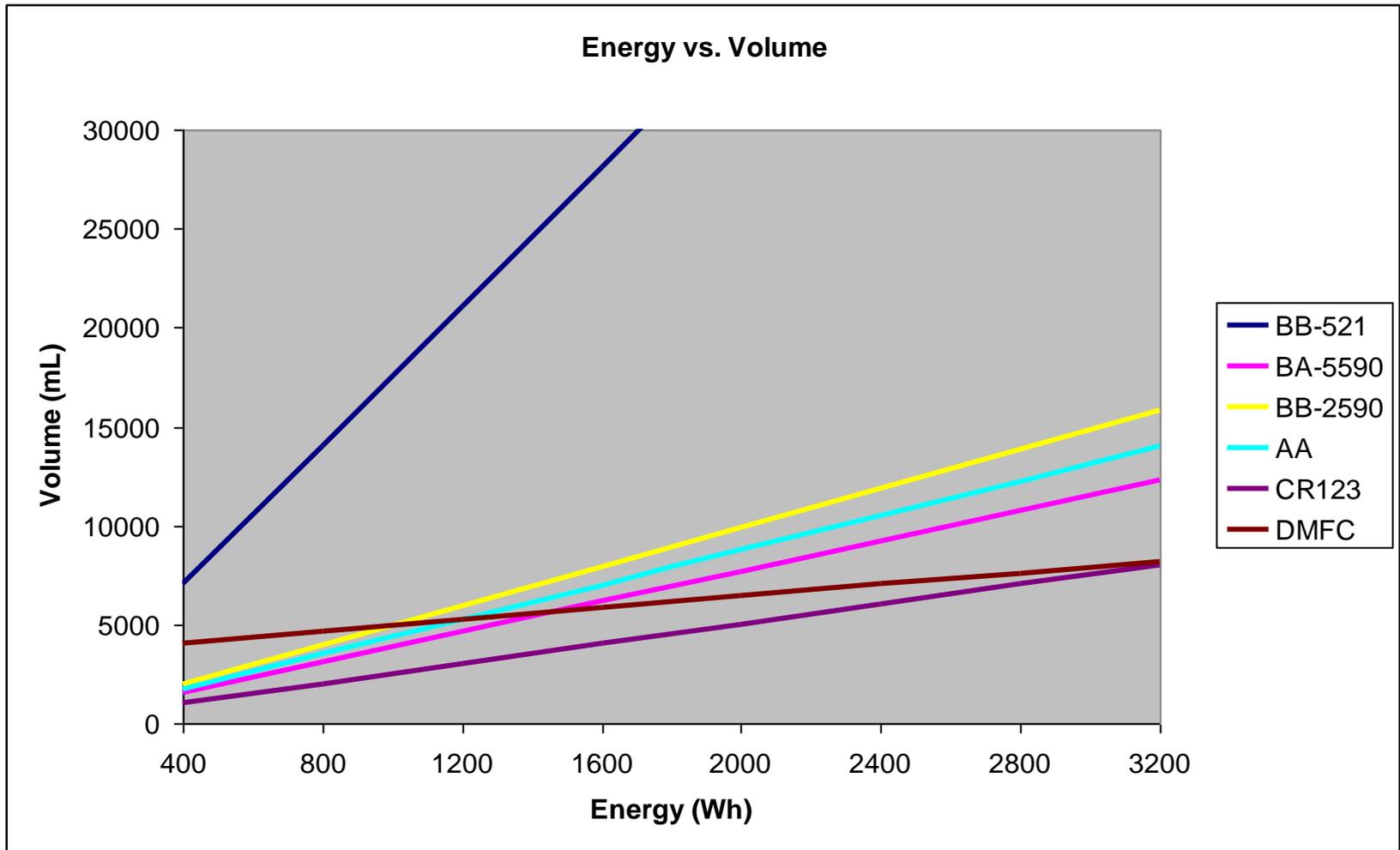
DMFC offers significant weight reduction vs. batteries

Energy vs. Energy Density



As energy need increases, DMFC energy density increases

Energy Density – Energy vs. Volume



Energy Density - Logistics Load

🔌 Pallet Size – 104 x 84 x 96 in, 10000 lbs

🔌 Load limited by weight, not volume

Battery Type	Weight	Energy (Wh)	Quantity per Pallet	Energy per Pallet	Pallets Needed for Same Energy as 1 Pallet of M28
BB-521	0.35	11.52	12,928	148,933	42.95
BA-5590	1	225	4,525	1,018,100	6.28
BB-2590	1.4	178.56	3,232	577,117	11.08
AA	0.024	2.25	188,537	424,208	15.08
CR123	0.017	3.7	266,170	984,828	6.50
M0.35	0.371	400	12,196	4,878,584	1.31
M28	22	31100	206	6,396,545	

Logistics load can be reduced significantly with DMFC

🔌 3 Load Configurations

- 🔌 Using batteries only

- 🔌 Using only DMFC

- 🔌 Using DMFC as battery charger

- 🔌 Based on total energy use of approximately 600 Wh/day

Sample Soldier Load Study – Batteries Only

Batteries	Quantity per Day	Energy (Wh per Battery)	Energy (Wh) per day
BB-521	3	11.52	34.56
BB-2590	3	178.56	535.68
AA	8	2.25	18
CR-123	4	3.7	14.8
		Total Energy (Wh) per day	603.04

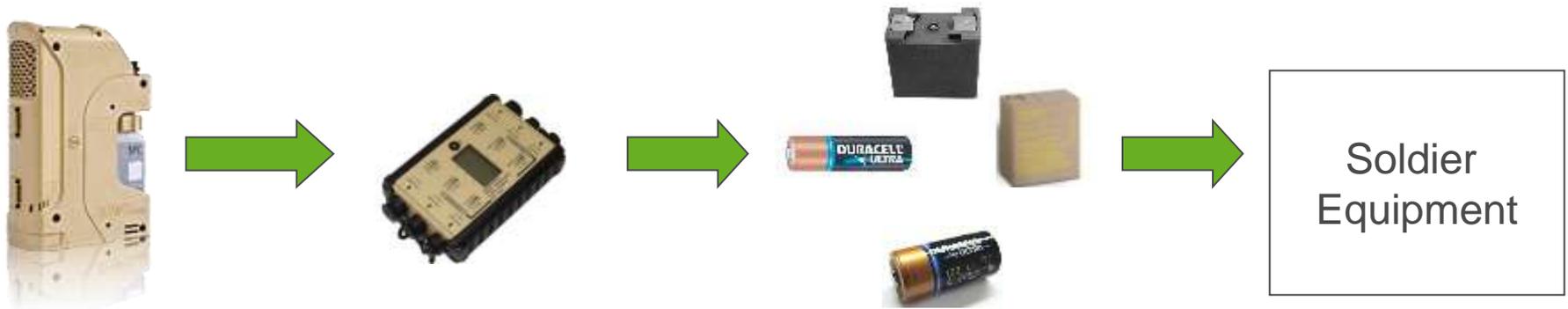
Sample Soldier Load Study – DMFC Only

- 🔌 All systems powered directly from DFMC
- 🔌 Power distributed via Power Manager 3G

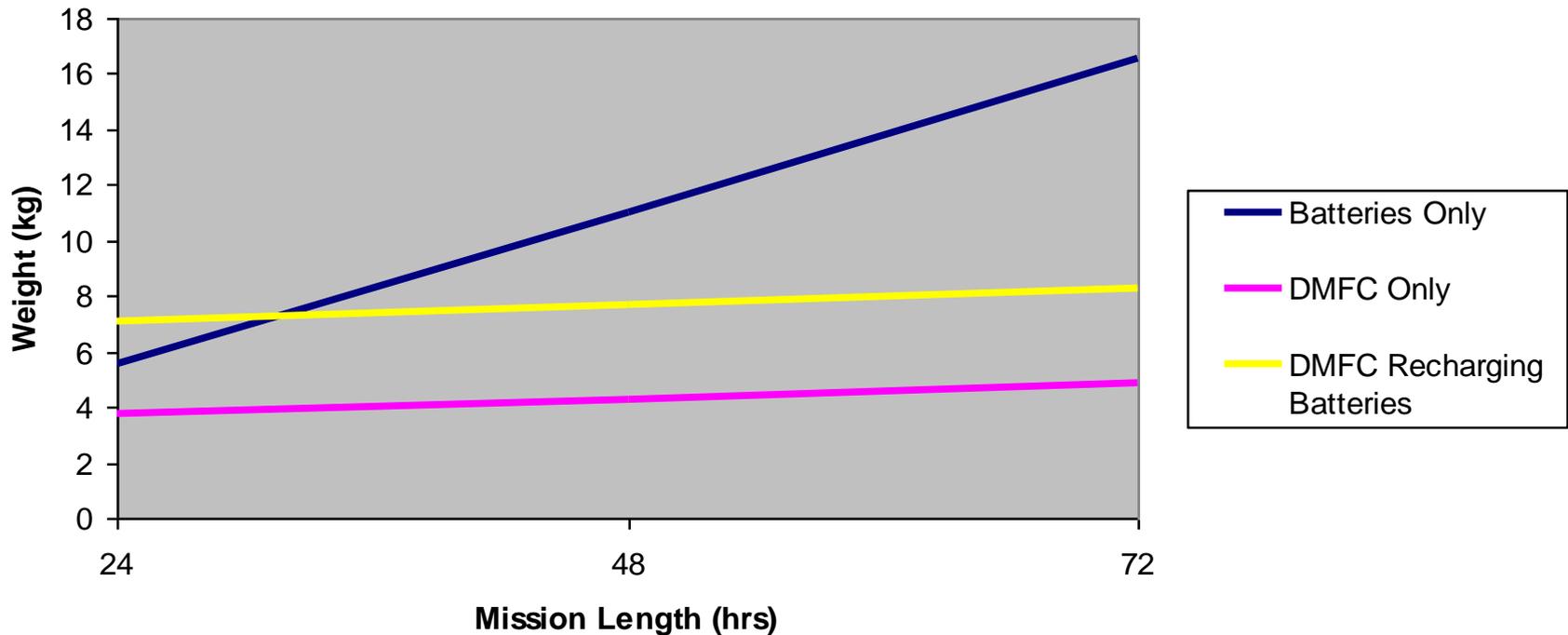


Soldier Load Study – DMFC as Battery Charger

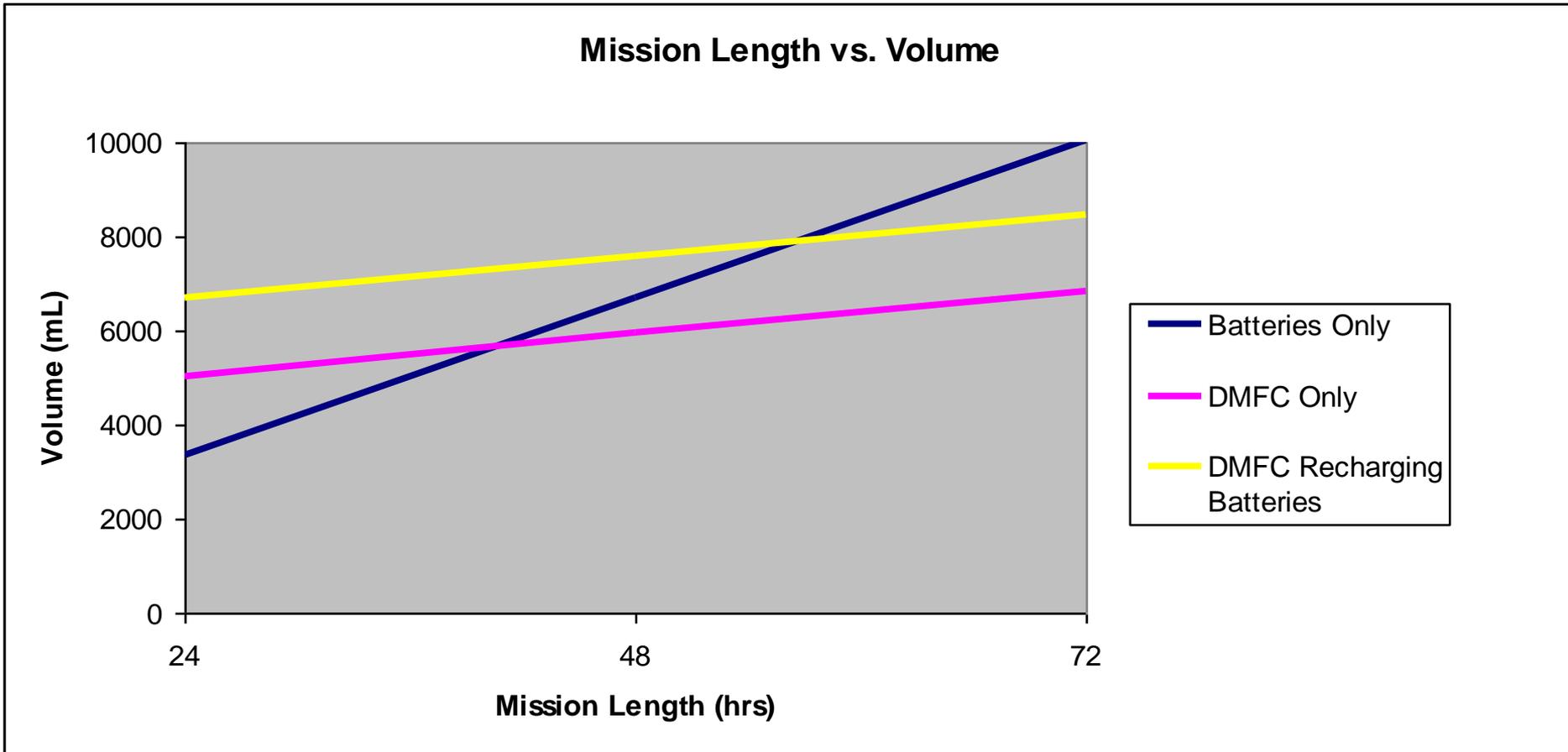
- ⏻ Systems powered by battery
- ⏻ Batteries recharged by DMFC
- ⏻ Spare batteries for recharging included in weight calculation (2 x BB-521, 2 x BB-2590, 8 x AA, 4 x CR123)



Mission Length vs. Weight



DMFC quickly becomes a weight saver



DMFC is comparable and gradually better than batteries

Soldier Load Study - Summary

Configuration	Weight (kg)	Weight Savings (kg)	Weight Savings (%)	Volume (L)	Volume Savings (L)	Volume Savings (%)
Batteries Only						
24 hrs	5.51			3.35		
48 hrs	11.02			6.69		
72 hrs	16.53			10.04		
DMFC Only						
24 hrs	3.74	1.77	32%	5.04	-1.69	-50%
48 hrs	4.30	6.72	61%	5.93	0.76	11%
72 hrs	4.86	11.67	71%	6.83	3.21	32%
DMFC Recharging Batteries						
24 hrs	7.12	-1.61	-29%	6.69	-3.34	-100%
48 hrs	7.68	3.34	30%	7.58	-0.89	-13%
72 hrs	8.23	8.30	50%	8.48	1.57	16%

DMFC can save 50-70% weight on a 72 hour mission

Facts and figures

- 🔌 Founded in 2000
- 🔌 Sole company developing, producing and selling commercially available DMFC products
- 🔌 Location:
 - 🔌 Brunnthal, Germany (HQ)
 - 🔌 Washington D.C., USA
- 🔌 Number of employees: 95
- 🔌 IPO in 2007



Products

- 🔌 Energy solutions and power management
- 🔌 DMFC fuel cell systems
- 🔌 Fuel cartridges

Winner of DoD Wearable Power Prize Competition 2008

System Requirements

- ⚡ Total system weight: ≤ 4 kg (including all equipment to operate the system)
- ⚡ Time Duration : 96 hours (92 hours bench test, 4 hours field test)
- ⚡ Voltage Out: 14 V DC and 28 V DC
- ⚡ Average Power: 20 Watts
- ⚡ Peak Power: 200 Watts -multiple increments up to 5 minutes

Winning Criteria

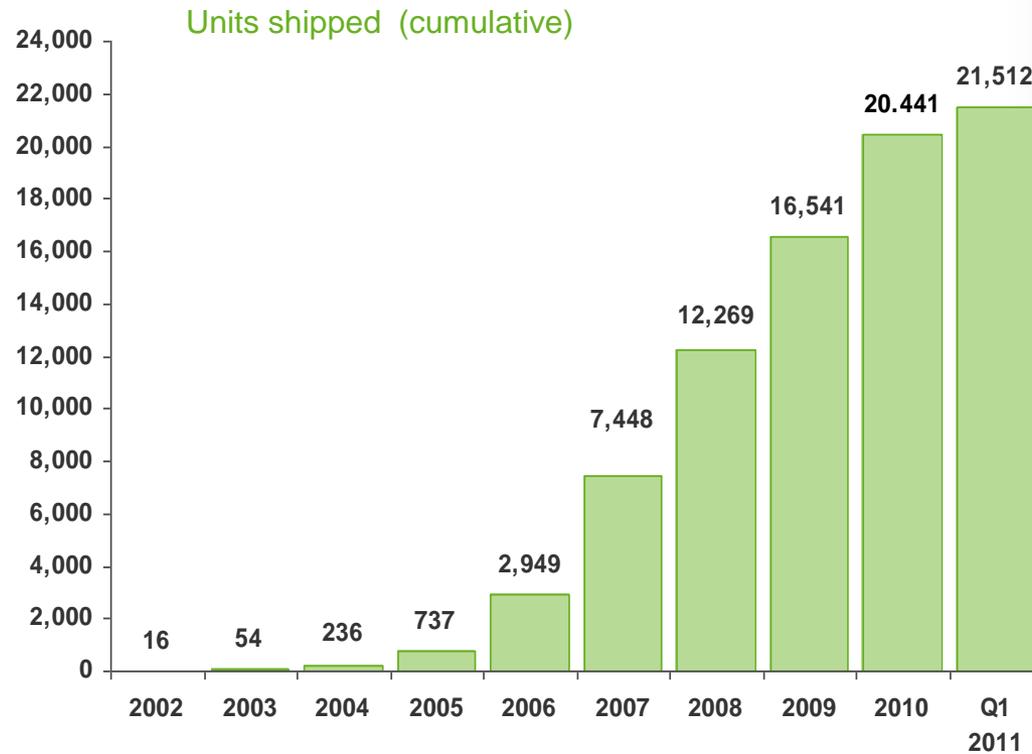
- ⚡ 1. Weight
- ⚡ 2. Protrusion (in case weights are identical)

Winner

- ⚡ 1st place: M-25 (SFC with DuPont)
- ⚡ 3rd place: JENNY 600S (SFC with CCLLC)



- 🔋 As of today, more than 20,000 fuel cell systems shipped
- 🔋 > 8 million operating hours in end user environments
- 🔋 Fully functional fuel infrastructure established in core markets



Defense

Weight Saving and Non-Detectability for:
Portable Power



Reliability and Non-Detectability of On-Board Power for:
Tactical Vehicles



Remote Industry

Dependability and Low Maintenance Cost for:
Traffic Technologies, Security, Environmental Monitoring



Mobility - APU

Reliability of On-Board Power and Reduction of Fleet Operating Costs for:

Special Purpose Vehicles



E-Mobility

Combined Heat and Power Source for:

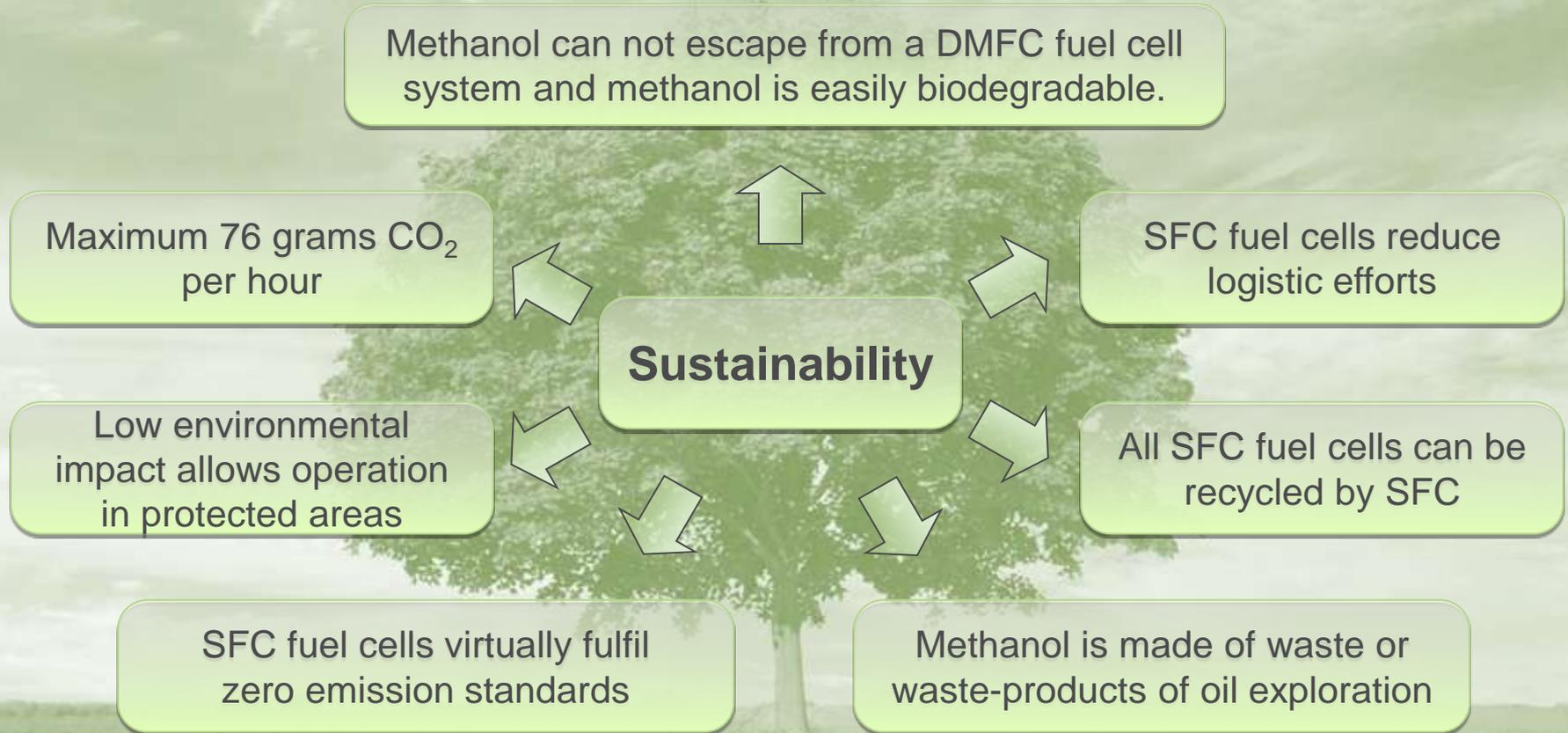
Increased performance and user acceptance of battery vehicles



Leisure

Comfortonomy for:
Motor Homes, Cabins and Boats







Federal Bureau of Investigations



U.S. AIR FORCE

US AFSOC



US Army PEO Soldier, Natick Soldier Center, ATEC



Bundeswehr

German Armed Forces



Austria Armed Forces



NATO- & PfP States – Canada, Denmark, France, Finland,
The Netherlands, Norway, South Africa, Sweden,
Switzerland, Great Britain

Advantage	Benefit
High Energy Density	50-70% Weight Reduction on 72-hour missions; at least 400% reduction in logistical load
COTS Technology	Reliable, Readily available solution can be deployed today
Minimal waste	Load decreases as more energy is used
Plug-and-play, self-regulating	Simple to use, minimal operator management
Modular energy system	Power can be sources from batteries, fuel cell, solar panel, AC, and vehicle power

DMFC offers a simple, reliable, readily available solution for reducing warfighter load

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Thank you for your attention!

References

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