



Energy and Power Community of Interest

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Energy & Power COI Overview



“If you are going to use energy as a weapon, you better have plenty of it.”

Enduring S&T Gaps

- Thermal limitations on capabilities, efficiencies, power densities
- High voltage, high frequency, high rate pulse power
- Extend duration to reduce energy resupply
- Power distribution flexibility
- Autonomous energy harvesting in operational environments

What’s driving E&P S&T?

- ***Greater electric power requirements for advanced weapons and sensors***
- Unique military systems not supported by commercial R&D require dedicated DoD S&T; DoD S&T essential to leveraging emerging commercial R&D
- Demand to enhance mission effectiveness and reduce operational risk through more effective and efficient use of operational energy

COI Purpose

Provide technologies to enable intelligent power & energy management and enhance operational effectiveness

Warfighter Opportunity Areas

Energy Optimized Platforms

Adaptive Power & Thermal Management System

Electric Weapons and High Power Sensors

Autonomous Platform

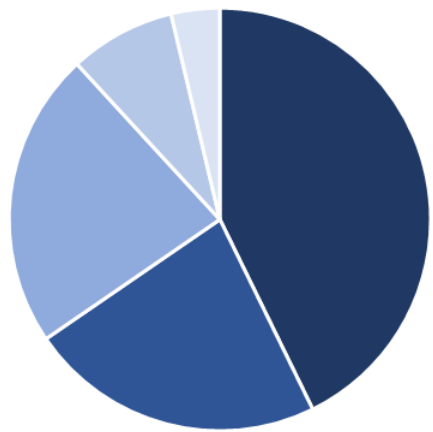
550 W fuel cell

Tactical Unit Energy Independence

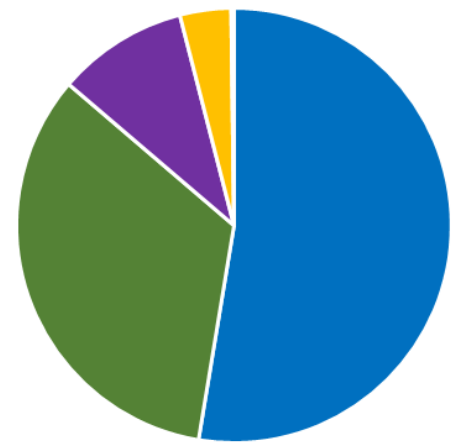
Adaptive Power Networks



E&P COI FY17 Funding



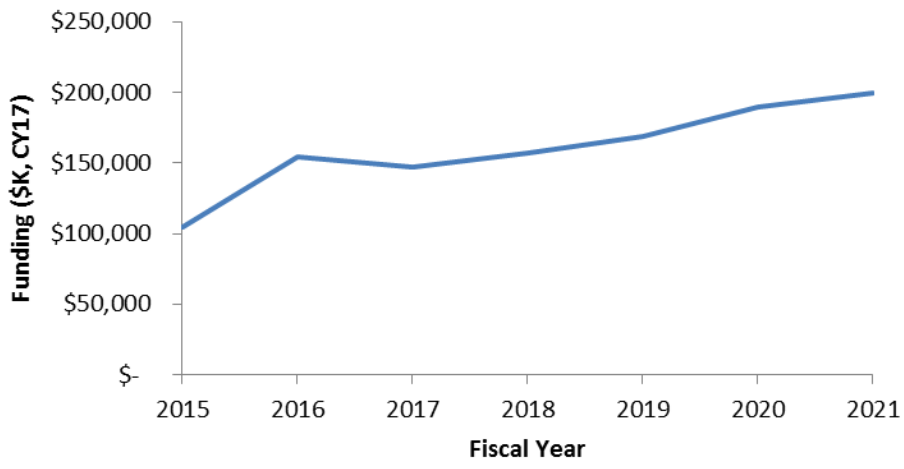
Power Control and Distribution	43%
Energy Storage	23%
Power Generation / Energy Conversion	22%
Electromechanical Conversion	8%
Thermal Transport and Control	4%



Navy	52%
Army	34%
OSD	10%
SOCOM	4%
MDA	<1%

Air Force \$\$ binned under Air Platforms COI

E&P COI Funding Profile



Investment profile:

- PB17 \$146.9M, 55% BA 2 & 45% BA 3
- PB17 5-year trend reflects current needs in:
 - Thermal Transport and Control
 - Power Generation and Energy Conversion
- Significant USAF Thermal Transport and Control funding aligned with Air Platform COI.



FY16 Major E&P S&T Activities



- **New Efforts**

- Navy/Army efforts on Perovskite photovoltaics (PV) for light-weight and low-cost flexible solar with EPFL in Switzerland
- Army Center for Research in Extreme Batteries (CREB) opened
- Navy Combat Power & Energy Systems (CPES) OIPT
- USAF MegaWatt Tactical Aircraft (MWTa) program

- **Demonstrations & Events**

- HESM demos by Caterpillar (Large Power) and P&W/LM/UTAS (Aircraft)
- Army demo: fuel-cell military Chevy Colorado ZH2 prototype
- Navy demo: 3 kW Fuel Cell / Photovoltaic Hybrid Renewable, Sustainable Expeditionary Power (RSEP) System
- Navy WBG demos:
 - G.E. 165 kW SiC DC-DC converter at 200 kHz / 99% switching eff. (TRL3)
 - VA Tech 100 kW, 60 lb SiC DC-DC/AC-DC at 100 kHz for shipboard use
- USAF FY16 INVENT Ground Demos underway (complete FY17)



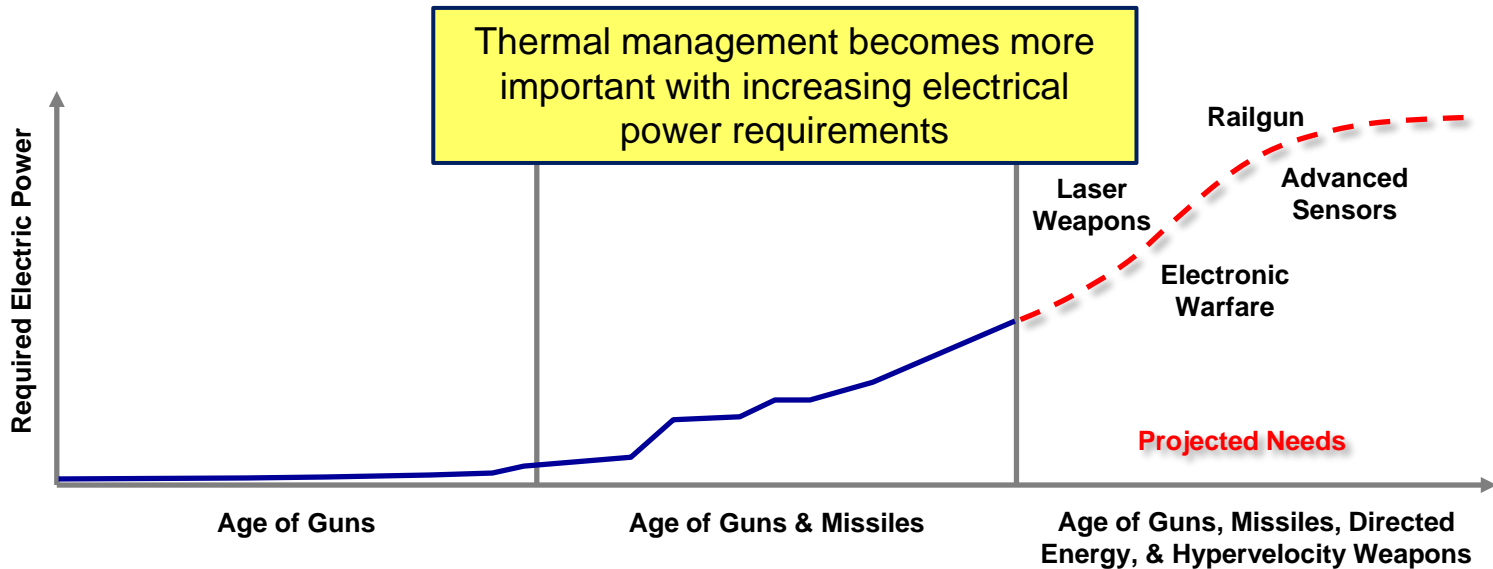
FY16 Major COI Accomplishments



- **E&P COI hosted Cross-COI TEM on Enabling DEW & HPS, March 22-23**
 - Aug. 24 ODASD(OE) OECIF FY17 Call for Proposals informed by TEM; 3 Proposals coordinated through COI were awarded:
 - Open Systems for Controls of Integrated Propulsion, Power, and Thermal (AF)
 - Ultra High Density Hybrid Energy Storage Module for Laser Weapon System and Electronic Warfare Operations (Navy)
 - Thermally Enabling Architectures for Pulse Power Systems (Navy)
 - Dec. 20 Kick-Off of collaborations with HEL-JTO Advanced Concepts TAWG
 - Dec. 22 Industrial/DOE leverage opportunities survey with COI discretionary
 - Partnership with Air Platforms COI:
 - Hybrid Energy Storage Module transition to MegaWatt Tactical Aircraft Program
 - Combined ARAP proposed to integrate w/ engines



Increasing Platform and Capability Power Demands



Power and Energy demands have steadily increased and are projected to increase at a higher rate in the future; investment in energy, power, and thermal management S&T will be necessary to ensure availability of future power-intensive DEW/EW/HPS systems.

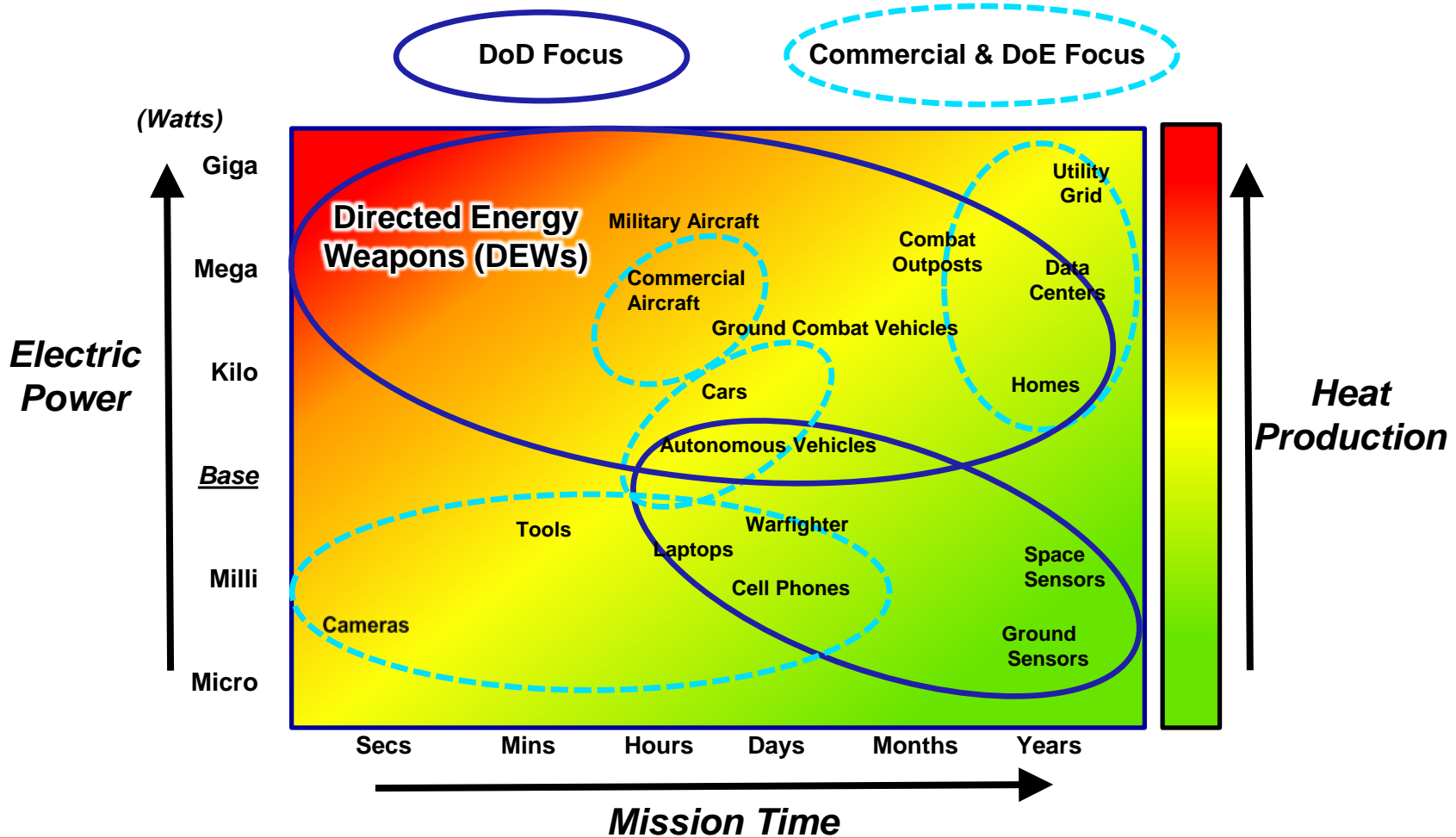
Management of increased power and energy demands apply across many platforms. Consideration of how directed energy and high power sensor systems will be powered needs to be included.



Unique DoD Energy, Power, & Cooling S&T Challenges



DoD platforms have unique energy, power & cooling S&T challenges that are amplified by the limited size & weight available on current & future tactical platforms





Electric Weapons and High Power Sensors



- 2015 E&P COI Roadmap identified priorities and gaps for Directed Energy Weapons (DEW) and High Power Sensors (HPS)
- A Technical Exchange Meeting (TEM) was held to look at S&T needed to field this capability
 - Included COIs: Sensors, Electronic Warfare, Ground and Sea Platforms, Air Platforms, and Weapons
- The TEM reviewed platforms in the ground, sea, and air domains and identified challenges to fielding DEW and HPS by taxonomy area and weapon capability
- The TEM identified five cross-domain energy and power S&T challenges to fielding DEW and HPS systems:
 - The ability to dissipate thermal energy from static and dynamic loads
 - Integrated controls for propulsion, power, and thermal
 - High density power generation while meeting SWaP constraints
 - High density energy storage for stochastic and dynamic loads
 - M&S for improved understanding of the system dynamics



Energy & Power S&T Challenges for High Energy Lasers



Platforms	Power Generation & Energy Conversion	Energy Storage	Power Control & Distribution	Electro-mechanical Conversion	Thermal Transport & Control	Integrated Architectures & Controls
Air	Red	Yellow	Yellow	Green	Red	Red
Ground	Red	Green	Yellow	Green	Red	Yellow
Sea	Green	Yellow	Yellow	Green	Yellow	Yellow

Red: E&P S&T poses a high challenge to fielding the capability on platforms
Yellow: E&P S&T poses a moderate challenge to fielding the capability on desired platforms
Green: E&P S&T poses minimal challenge to fielding the capability



E&P COI Takeaways



- **Value of COI:** “Team Sport” approach to foundational challenges: *Hybrid Energy Storage, Wide Bandgap Power Electronics, OECIF, etc.*
 - Team of integral E&P S&T leaders within Services, broader community (IAPG)
 - Provides a consistent vision for E&P needs for industry and academia across all COIs
- **Value of Cross-COI Engagements:** Reliance 21 construct provides outreach into other technology and capability/application areas
 - DEW & HPS TEM Example:
 - Formed naturally around understanding & communicating specific challenge
 - Laid foundation for multiple new and potential funding directions (e.g., OECIF)



E&P COI Summary



E&P COI Priorities:

- **Integrated power and thermal management** (higher E&P needs across systems / power ranges)
- **Integrated, intelligent power distribution**
- **Architectures, interfaces, and standards for reconfigurable power** (energy networks / microgrids)
- **Higher power / temperature / efficiency E&P devices and components** (continuous & pulse power)
- **Extended energy storage, harvesting, and recovery**

Current S&T Gaps:

- **Thermal limitations on capabilities, efficiencies, power densities** (need for thermal management)
- **Power distribution flexibility** (need for reconfigurable, adaptive energy networks / microgrids)
- **Indigenous energy** (need for autonomous energy harvesting in operational environments)
- **Resilient power** (need for integrated power & thermal models across platforms and systems)
- **Extended duration / reduced resupply energy** (need for higher energy density storage and greater conversion efficiencies)

Engagement Opportunities:

- Army Research Laboratory Open Campus effort
 - Energy and Power is one focus of the new ARL South Campus
- Defense Innovation Marketplace
- NDIA Annual Science and Technology Conference
- ARPA-E Annual Energy Innovation Summit