



DoD Energy Security Task Force

Mr. Al Shaffer

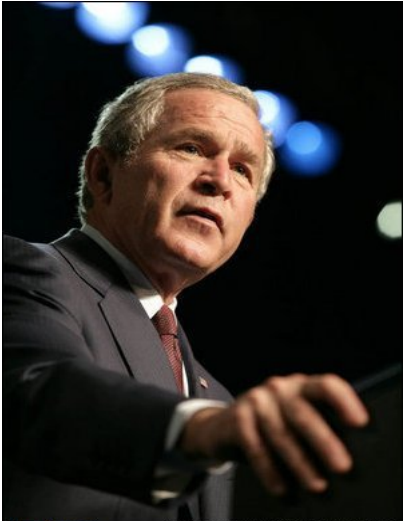
22 May 2007

Executive Director, Defense Energy Security Task Force

Director, Plans and Programs

Office of Director, Defense Research and Engineering

The Need for Energy Independence



“...The two biggest challenges that I would like to see solved in the next two and half years. One...the unfunded liabilities inherent in social security and medical care. ... **And the other is energy. ...It's not just a economical security issue, it's a national security issue.**

NBC Nightly News, 30 August 2006

“Bush said the **country's reliance on foreign oil 'jeopardizes our capacity to grow.** ...‘the problem is, we get oil from some parts of the world, and they simply don't like us...’

...The **key to limiting dependence is innovation,** and ... his **administration has a plan to spend money on new technologies.”**

Washington Post, 5 September 2006

U.S. Marine Corps Maj. Gen. Richard Zilmer, Al-Anbar Commander, submitted an **urgent request for renewable energy systems**, due to the vulnerability of American supply lines to insurgent attack by ambush or roadside bombs. The request said “**reducing the military's dependence on fuel for power generation could reduce the number of road-bound convoys.**” ...‘Without this solution [renewable energy systems], personnel loss rates are likely to continue at their current rate. Continued casualty accumulation exhibits potential to jeopardize mission success...’”

Defense News, August 2006



Energy Security Task Force



- Address Strategic Planning Guidance tasking:
 - **“Power and Energy Alternatives and Efficiency – DDR&E will chair a task Force with representatives from the Military Services, Defense Agencies, USD(ATL), USD(P), and USTRANSCOM to define an investment roadmap for lowering DoD’s fossil fuel requirements and develop alternate fuels.**
 - Findings on the total delivered cost of fuel consumed by DoD platforms, including logistics and force protection.
 - Proposals to improve energy efficiency of DoD platforms.
 - Recommendations to enable the production and use of alternate fuels, especially domestically-sourced fuels.”
- Provide options to manage financial and operational challenges generated by cost and availability of oil and other forms of energy

Task Force Successful--Leadership has directed it remain in place

How Easy it is to Forget

--A View from Summer 2006--

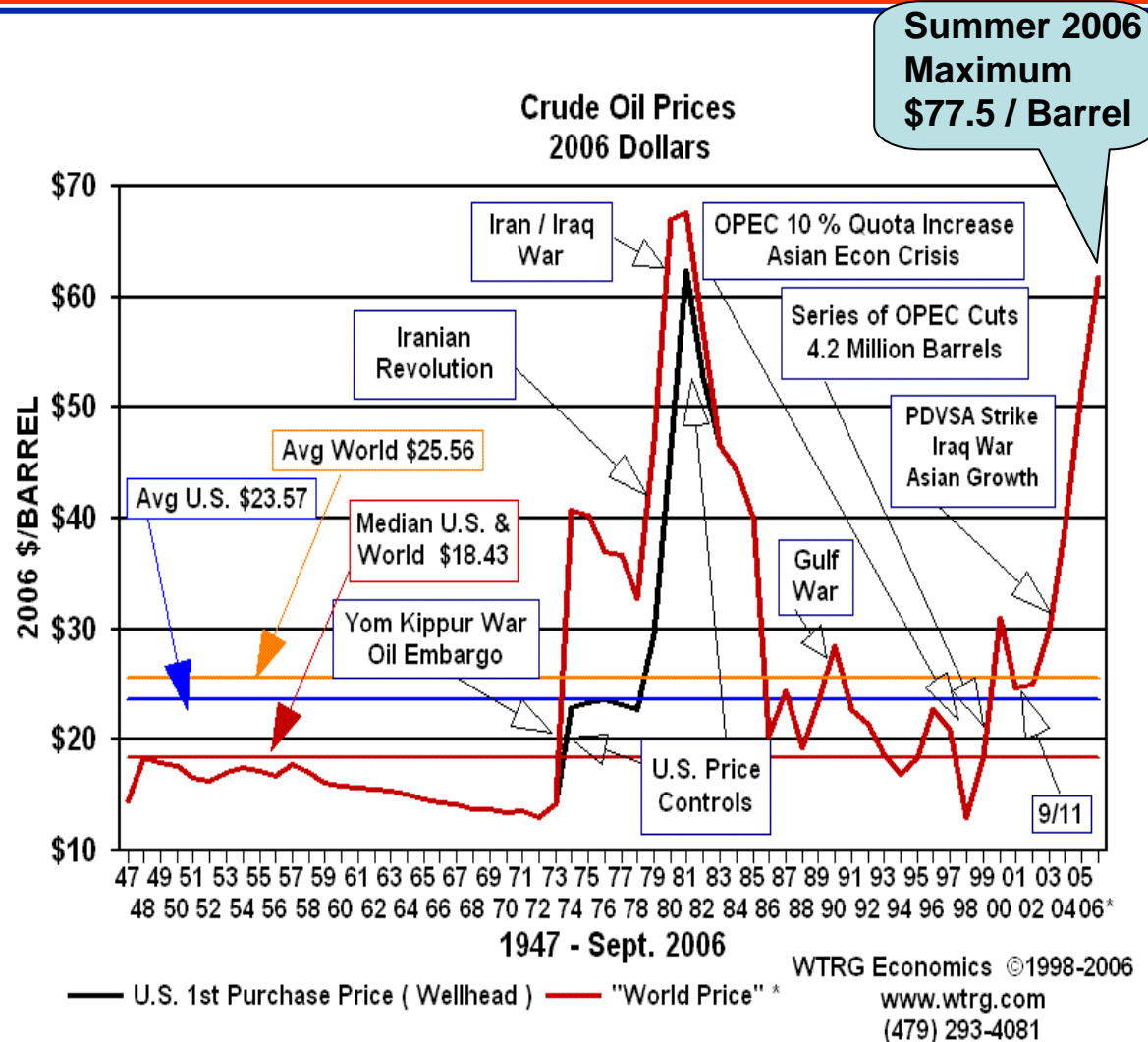


*Coming to a Summer
Near You*

How Easy it is to Forget--Reality



- Cost of energy proportional to price of crude oil
- Two major peak periods in last 60 years:
 - Iran Revolution (79)
 - and the rise of OPEC
 - Current (Iraq War, Asian Growth, Katrina)
- DoD fuel comes from Defense Energy Security Center (DESC)
 - Cost of fuel to DoD roughly Crude Cost + \$25 (refining and delivery)

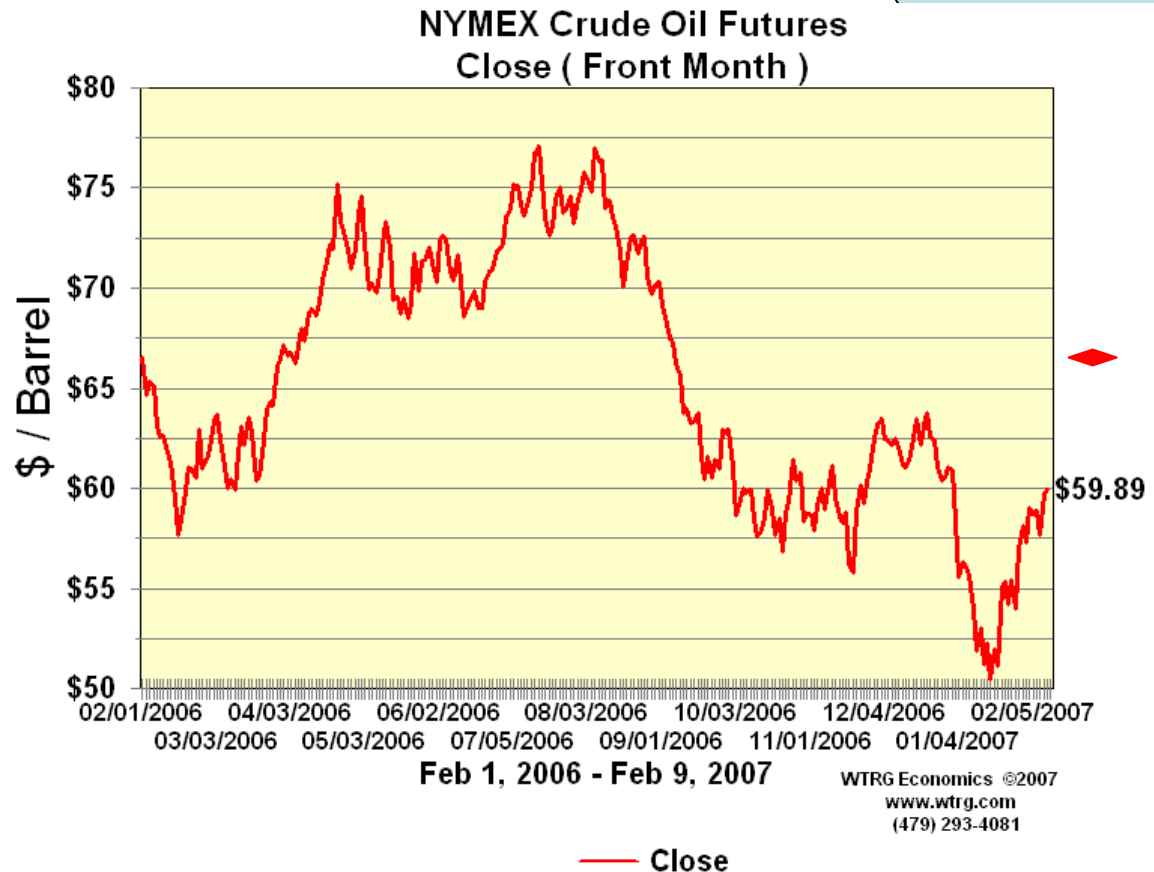


How Easy it is to Forget--Reality



Summer 2006
Maximum
\$77.5 / Barrel

- 2006 volatility continues.
- Current cost of energy down to below \$60 a barrel
- Sounds good, until compared against long term US Average
- 22 May -- \$66.27

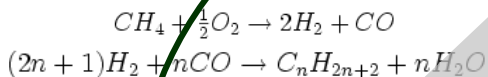


Energy Security Challenge



Supply

- Conventional fossil fuels
- Synthetic fossil fuels (e.g. coal, shale oil and tar sands derived fuels)
- Alternative fuels (e.g. biodiesel, alcohols, hydrogen, etc.)
- Renewables (e.g. solar, geothermal, wind)
- Novel supply (e.g. fuel cells)
- Exotics (e.g. isomers)



Demand

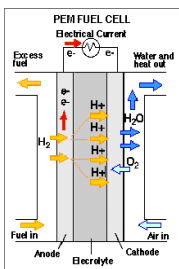
- Conservation Initiatives
- Fixed base
- Tactical base
- Platforms
- Efficiency
- Life-Cycle Cost



- Direct oil / fossil fuel costs
- Policy, processes and risk assessment
- Refining Capacity
- Doctrine

Assured Distribution

Convergence for Energy Security



Preliminary Observations



- Services have been addressing energy consumption
 - **Sec Army published Army Energy Strategy for Installations**
 - **Vice Chief Memo on Energy Conservation & Under SecAF Energy Senior Focus Group**
 - **Assistant Secretary of Navy memo directed energy conservation**

Installations

- DoD leads fed government in renewable energy – almost 9% electricity in FY05; Goal to achieve 25% by 2025
- Services reduced facilities energy use by about 30% from the 1985 baseline
- Navy awarded second geothermal power plant in FY05; Wind-diesel power plant at Guantanamo Bay
- AF has numerous renewable energy plants in operation and under development (geothermal, wind, solar); multiple awards for green power
- Energy Saving Performance Contracts widely used to defer costs
- Over 2.3:1 savings from Energy Conservation Improvement Program

Platforms

- DoD has doubled investment last five years for Energy & Power Tech Initiative. RESULT: enhanced batteries, fuel cells, etc...
- Army leading DoD effort to qualify Joint Battlefield Fuel & testing synthetic fuels in medium tactical vehicles
- Navy energy conservation program reduced use 15% for ships; 6% aircraft – restarted in FY08
- Air Force leading DoD effort to test synthetic fuels in aircraft (100K gallons)
- DLA RFI (20 bidders) for 200M gallons synthetic fuel
- Army Rapid Equipping Force to deploy renewable power to forward operating bases

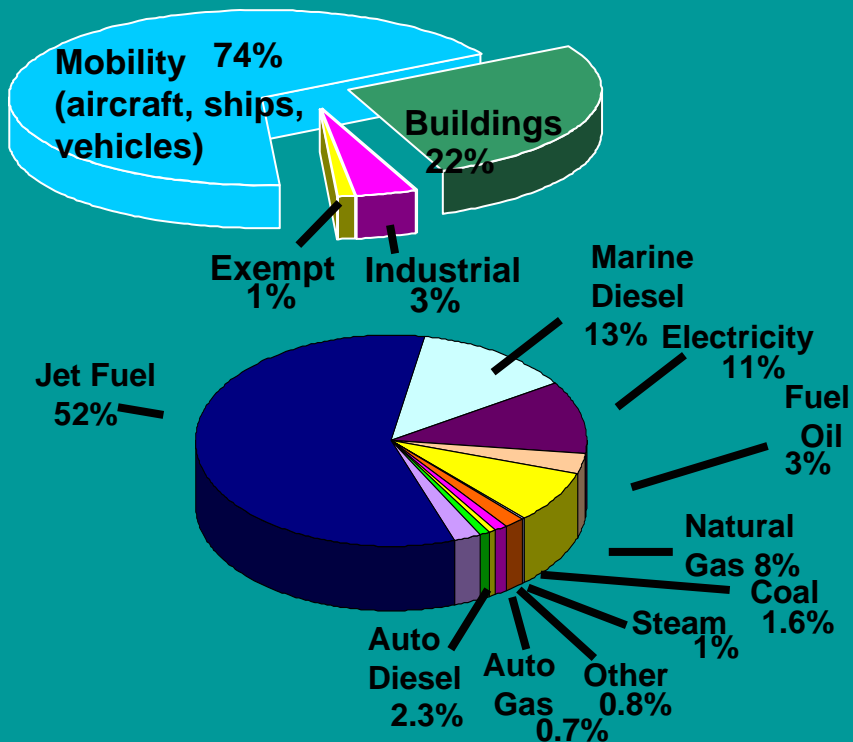
Energy Policy Act of 2005 requires further reduction for installations

DoD Energy Use and Cost



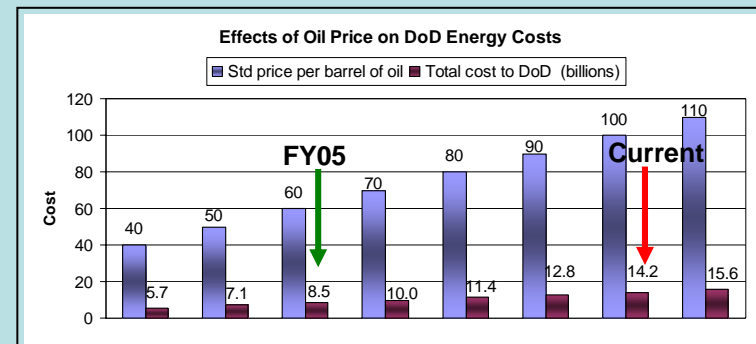
- Aviation Fuel (>52%) is largest energy commodity
- Mobility (74%) is the mission area with largest use
- \$10 per barrel increase in oil increases DoD costs by ~\$1.3B per year

DoD Consumption (FY05)



Cost

- FY07 PresBud built with oil at \$84/barrel; Current price: \$96.60/barrel
- DoD cost to users is roughly \$25 / barrel above world spot price (refining / distribution)
- Current costs provides a ~\$1.3B problem for each year in FYDP



Mobility/aviation dominates costs

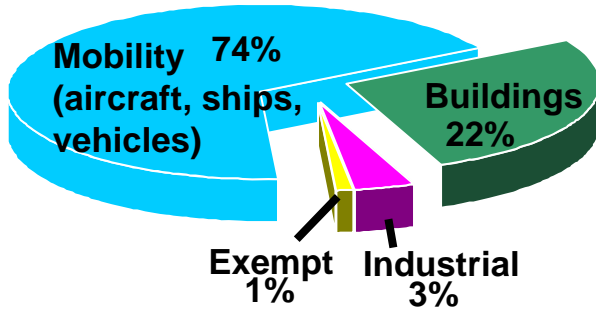
DoD Energy Consumption

- FY06 Compared to FY05 -

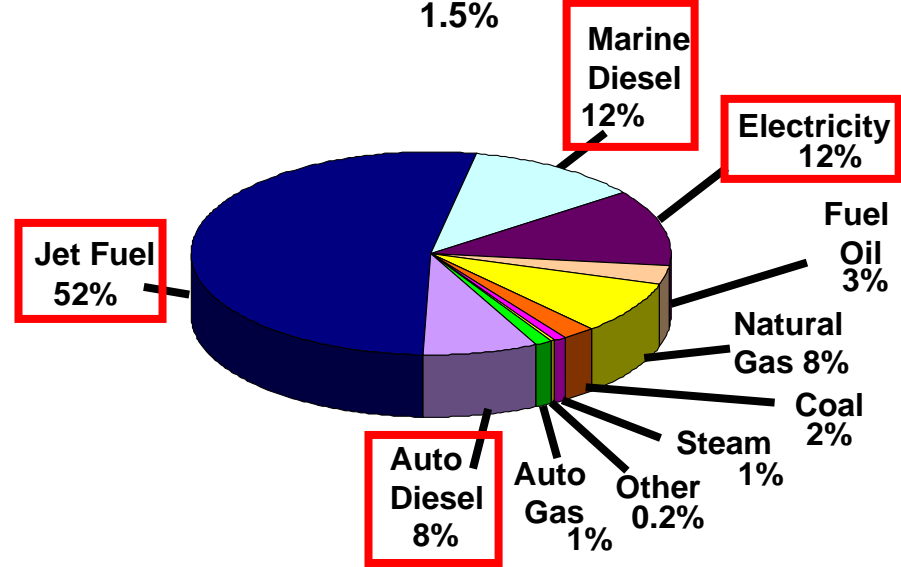
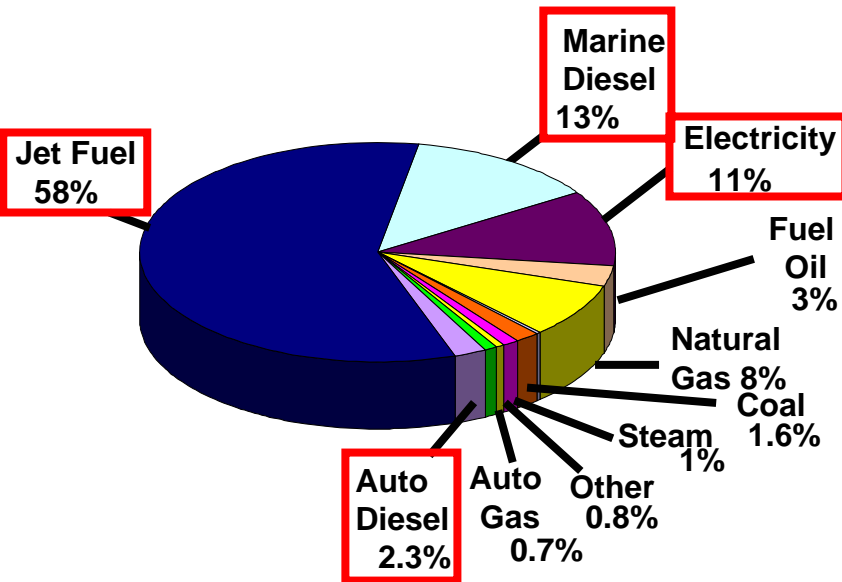
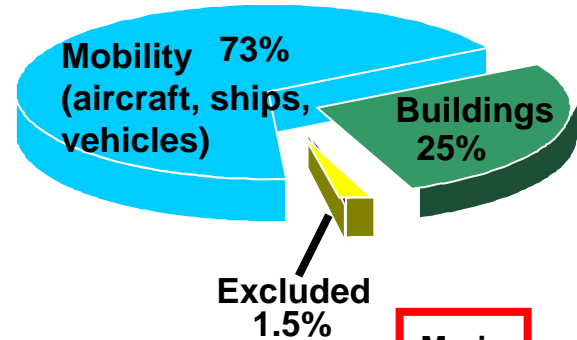


Energy use as a percent of consumption

FY05 Consumption



FY06 Consumption



FY05 Total Energy Cost: **\$10.9B**
 Total BTUs: **919.3 trillion**
 Standard price per barrel: **\$61.88 (avg)**

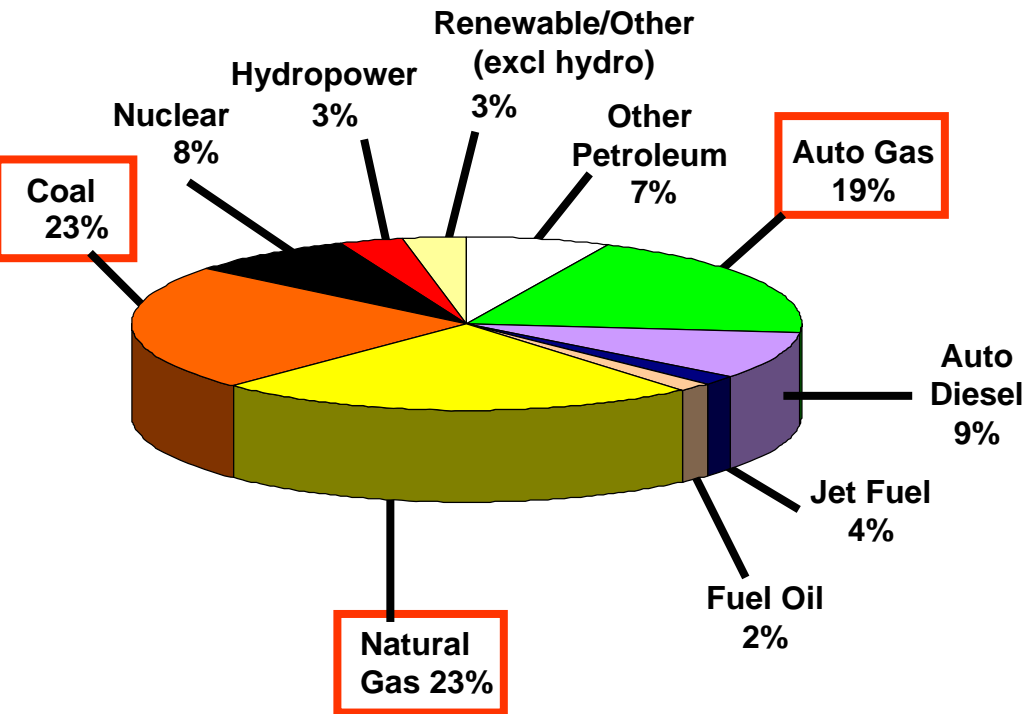
FY06 Total Energy Cost: **\$13.6B**
 Total BTUs: **832.5 trillion**
 Standard price per barrel: **\$91.52 (avg)**

Energy Consumption

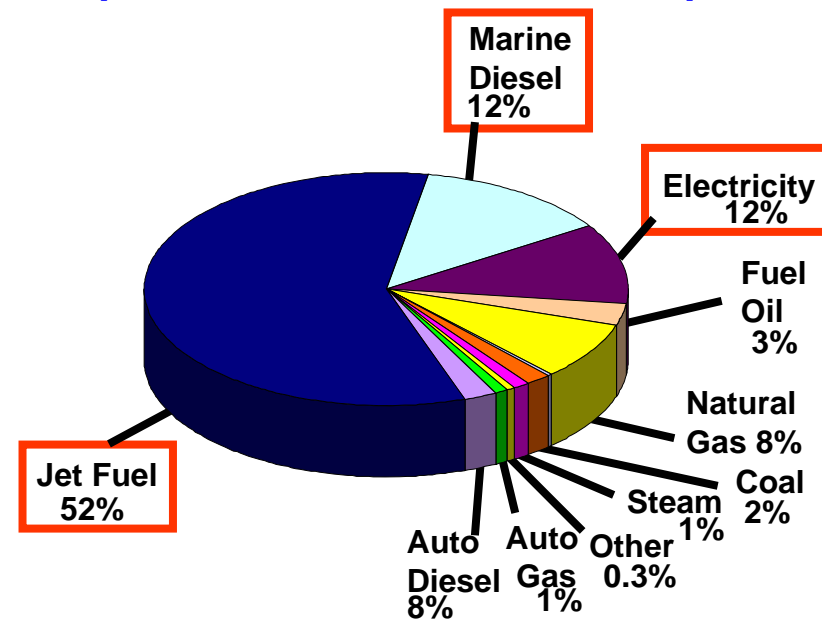
- DoD Compared to Rest of US -



US Energy Consumption by Type



DoD Energy Consumption by Type
Represents 1.2% of US consumption

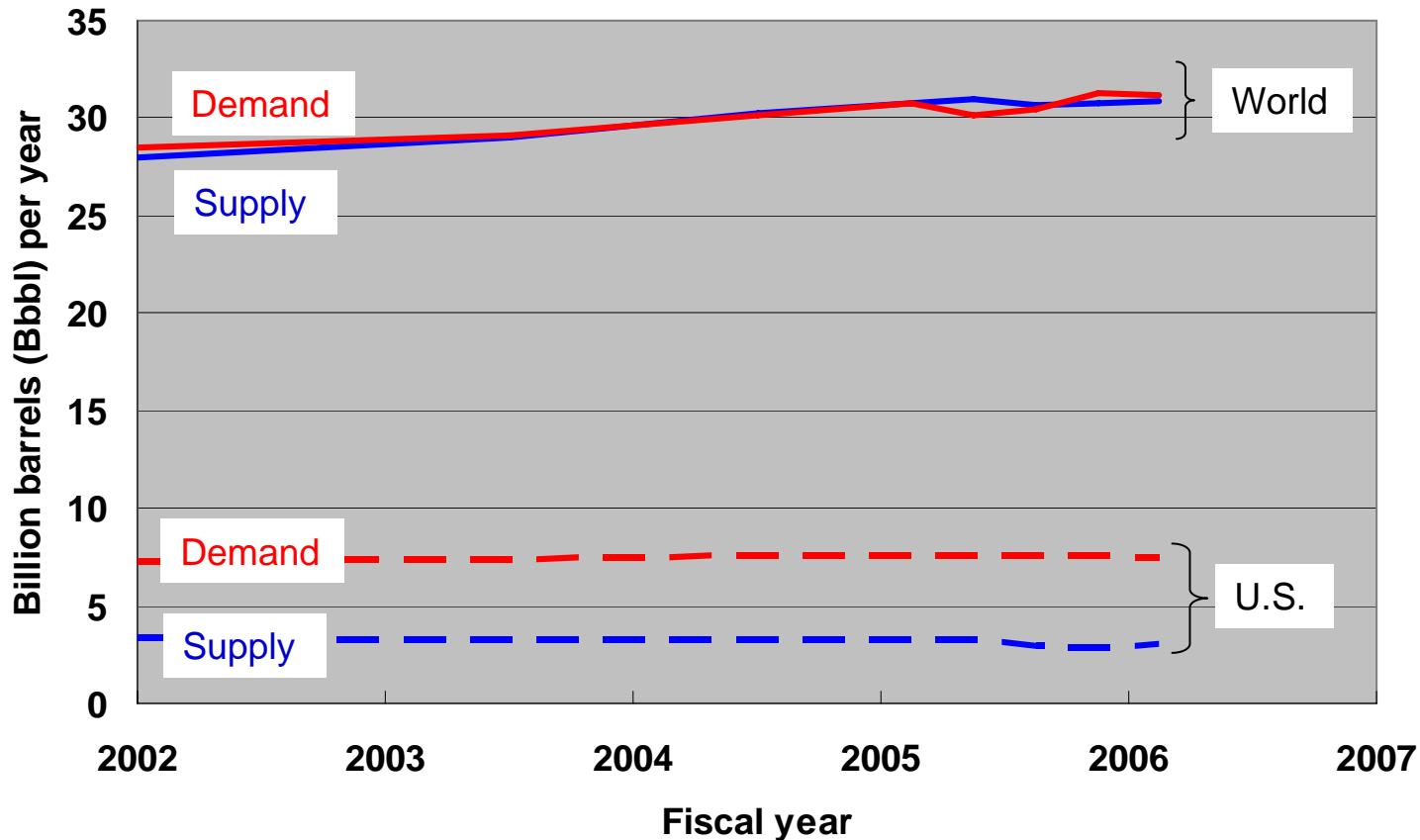


Source: EIA 2005 consumption data

Source: DoD Annual Energy Report for FY06

DoD/DOE working on different challenges

World and U.S. Supply and Demand



- World supply/demand is increasing faster than U.S. demand
 - U.S. consumption is ~25% of world supply
- China is presently responsible for preponderant fraction of recent world demand increase
 - India is an important emerging consumer

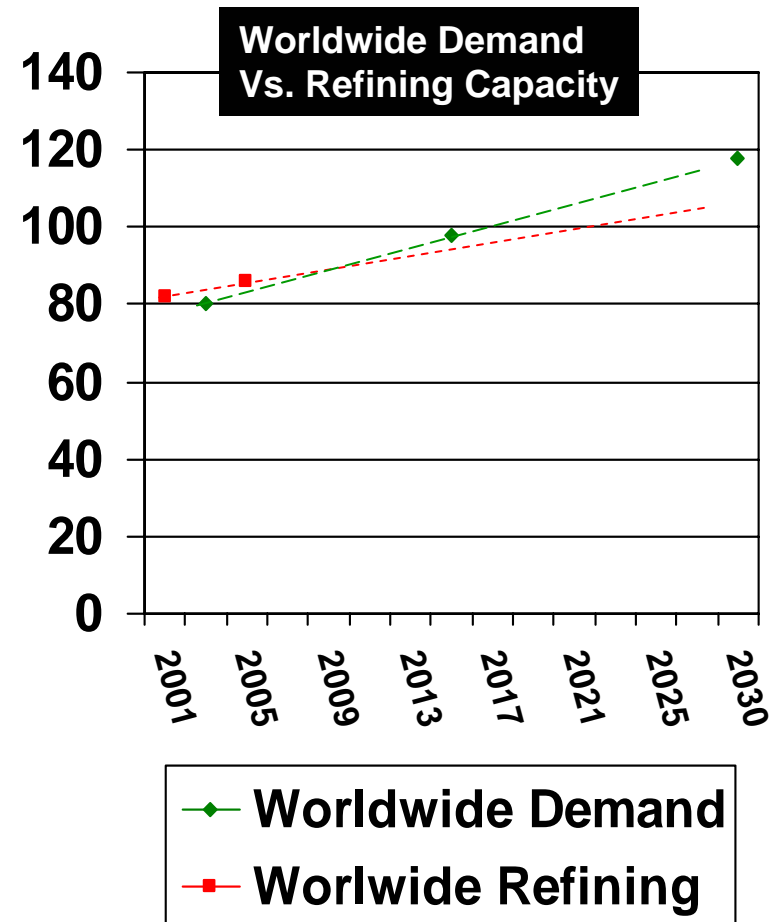
Demand vs Refining Capacity



- The real issue is that worldwide demand is growing faster than refining capacity by .75M barrels per day / year
- By about 2010, worldwide demand will exceed capacity
- Last US refinery built in 1976
- Refineries are not easy to build / bring operational

Therefore, a real issue to supply and demand is refining capacity

MbPer Day



Source: De Bruyn Kops(2007) , Unpublished Manuscript Analytic Framework for the Cost of Transportation Fuels Derived from Oil and BioMass

Baseline Program

- Taxonomy -



DEMAND REDUCTION (Efficiencies)

SUPPLY SECURITY (Alternatives)

ENERGY

Weapon Systems/
Support Platforms

Installations

Futures/Fuels

Other Initiatives

Air

Buildings

Conventional
Liquids

Batteries

Ground

Non-Tactical
Vehicles

Synthetic
Liquids

Fuel Cells

Sea

Decision Processes

BioMass

Nanotech
for Energy

Combat Support
System

Acquisition Process
- Burdened
Cost of Fuel

Hydrogen

Distribution

Platform Efficiency
Investment Pilot

Renewables

Incentives

Overarching Recommendations

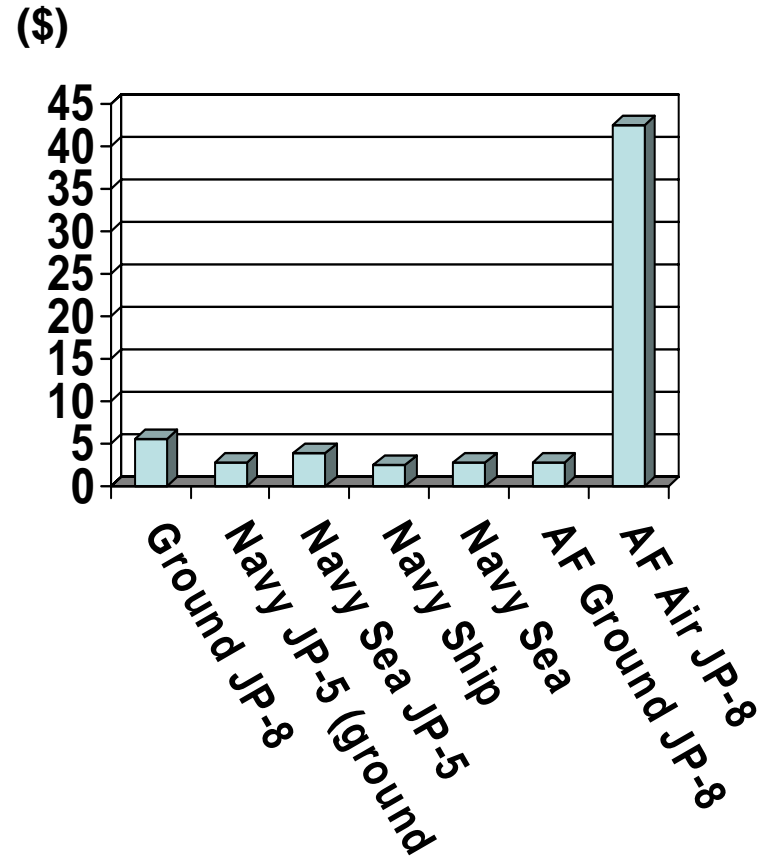


- Increase platform efficiency
 - **Revise policy to incorporate delivered cost of fuel in acquisition decisions**
 - **Develop and test efficient propulsion systems, power generators and machinery**
 - **Develop and prototype light weight vehicles and structures**
 - **Strive for operational efficiencies and simulation use**
- Accelerate installations' initiatives
 - **Meet or accelerate energy efficiency goals**
 - **Address non-tactical vehicles**
 - **Expand Energy Conservation Investment Program / Energy Saving Performance Contracts**
- Establish alternate fuels program
 - **Mature and test synthetic/alternative fuels**
 - **Measure and assess DoD energy progress**
 - **Develop incentives programs for alternate fuel industry**



Fully Burdened Cost of Fuel

- OSD Conducted Study of Fully Burdened Cost of Fuel
- Based on Defense Energy Supply Center Cost of Fuel \$2.30 per Gallon (currently higher)
- Fuel Prices Delivered Fuel Range from nominal increase (Navy Ship Fuel Ground Delivery) to roughly \$40 gallon increase (air delivered)
- Result: DoD Pilot Study of Using Fully Burdened Cost of Fuel in Acquisition Decisions



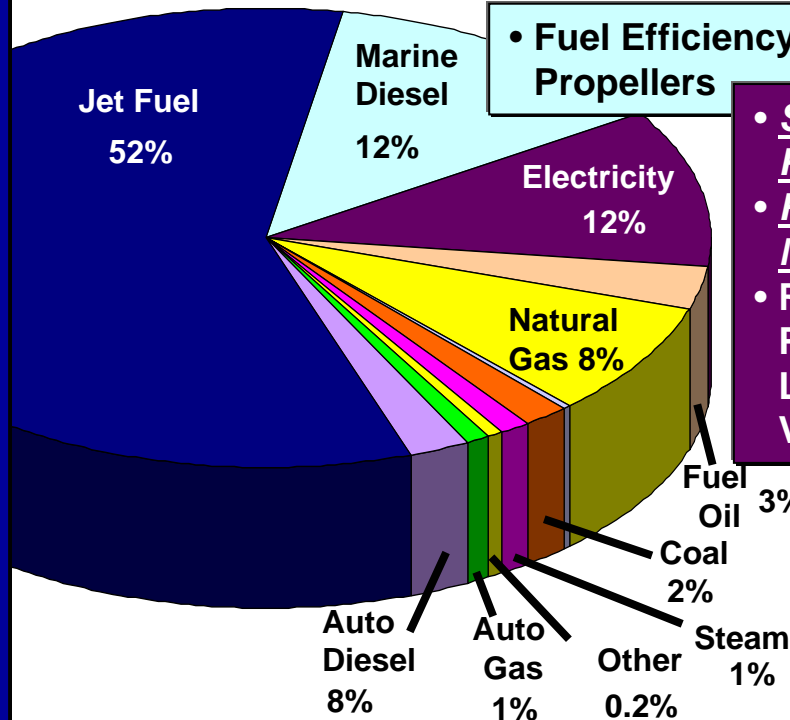
■ Fully Burdened Cost of Fuel

Summary of Options



- Test and Certify *Synfuels*
- Platform Efficiency Investment Pilot
- Small Heavy-Fueled Engine
- Long-Endurance UAV
- Highly Efficient Embedded Turbine Engine
- Fuel Efficiency Demonstrator (Ground Vehicles)
- Fuel Efficiency Coatings for Engines
- Test and Procure Commercial Fuel Efficiency Equipment
- Test and Procure *Hybrid Electric Power Stations*
- Trash-to-Oil/Energy Mobile Demonstrator
- Fuel Cells
- Simulators
- DoD Legacy Platform Energy Conservation Program
- Platform Resource Efficiency Managers
- Commercial Practices

Percent of Total DoD Energy Use



• Fuel Efficiency Coatings for Propellers

- Sustainable Design Practices
- Resource Efficiency Managers
- Renewable/Alternate Energy Projects via Enhanced Use Leasing/Public Private Ventures

- OTHER INITIATIVES**
- Value Fuel Efficiency in Acquisition Process/ Delivered Cost of Fuel
 - Incorporate Energy Scenarios in Wargaming
 - Warfighter Power Grand Challenge

- POM INITIATIVES**
- Transportable Hybrid Electric Power Stations
 - Adaptive Versatile Engine Technology (ADVENT)
 - Air Force Synthetic Fuels Certification
 - Energy Conservation Improvement Program Increase
 - Air Force Facility Energy Initiatives
 - Navy Energy Program
 - Air Force Airframe/Engine Washes
 - Low Speed Vehicles

Note: Underline and italics denotes funded programs

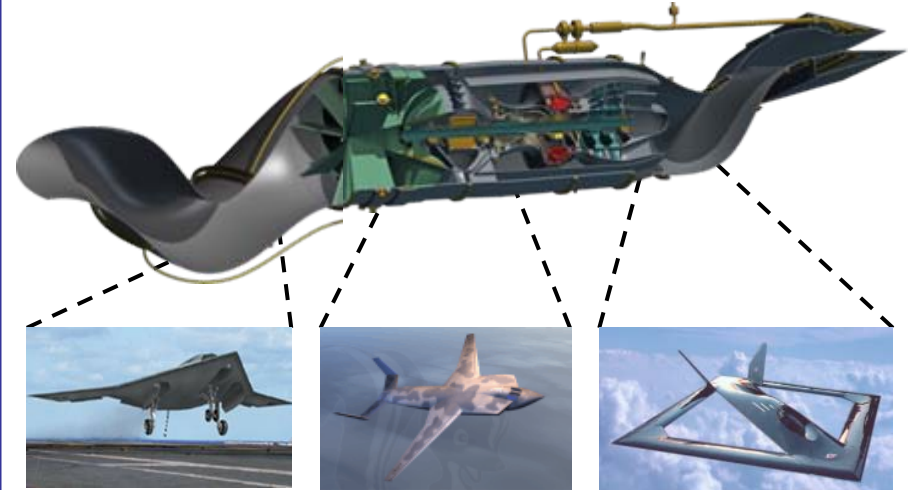


Air Platforms

- *Highly Efficient Embedded Turbine Engine* -

DESCRIPTION

- Accelerate development of fuel efficient, LO compatible subsonic propulsion that supports future ISR, mobility, and UCAV extreme endurance and range requirements
- High power extraction for multi-sensor suites is an integral part of program
- Addresses more than 80% of the aircraft fleet (mobility, fighters, etc.)



UAV's

Transports

ISR

BENEFITS/METRICS

- For Air Force, Navy and Army
- Theoretical performance enhancements of the concepts are:
 - 25% reduction in fuel consumption
 - 100-400 kW power extraction capability
- Technology Readiness Level (TRL) 6 integrated propulsion & power demonstration in FY08 vice FY14
- Potential savings: \$150M/year based on 5% savings

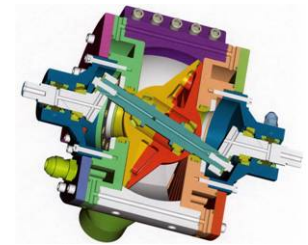


Air Platforms

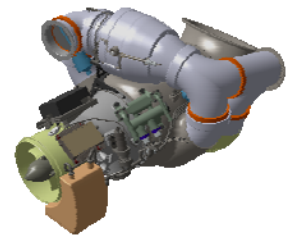
- Small Heavy Fueled Engine (SHFE) Quick Demo

DESCRIPTION

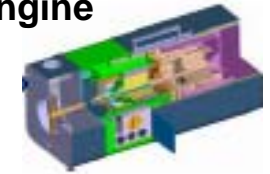
- For use in persistent ISR UAV's; Portable ground power generation
- Enable long duration UAVs, mobile ground power
- 20% increase in fuel efficiency; High power density
- Several candidate concepts (50 – 700 HP) identified (VAATE, SBIR)
- Select 3 for concept demonstration



Nutating Engine



Eccentric Engine



Rotary Engine Power Generation

BENEFITS/METRICS

- Increased fuel efficiency
 - Reduced logistics tail by using single battlefield fuel
-
- ROI: Based on engine utilization for 1000 50kW generators (@ \$4000/unit) operating ~ 4380hrs/yr

SAVINGS

- Savings: \$1.2M/yr @ \$5.62/gal (JP8)
- Payback: ~ 3.5yr @ \$4000/unit

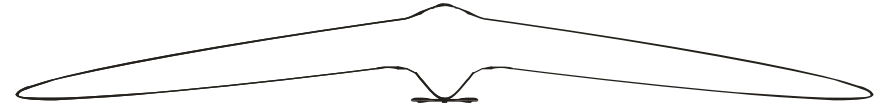


Air Platforms

- Long-Endurance UAV -

DESCRIPTION

- **Prototype carbon composite shell aircraft designed to fly up to 6 days and carry 1500 pound payload**
- **Can use conventional turboprop**
- **Maintains optimal Reynolds number**
- **Could fulfill persistent surveillance/reconnaissance missions**



BENEFITS/METRICS

- **Increased fuel efficiency and longer time on station**
 - **JASONS estimate 97% savings over conventional platform for refueling**
-
- **ROI: Based on replacing Global Hawk ~2 day loiter @ 1.6 MPG**

SAVINGS

- **6 day loiter (200% increase)**
- **Savings: \$4.7M/yr @ \$6.26/gal**

Ground Vehicles



- Fuel Efficiency Ground Vehicle Demonstrator -

DESCRIPTION

- Identify opportunities in fuel efficient technologies, lightweight components and armor, reduced weight structure/frame efficient propulsion/driveline and others as appropriate
- Build a virtual vehicle to predict performance, set objectives and establish test criteria
- Demonstrate decreased fuel consumption, without decreasing performance or capability, in a tactical vehicle using innovative design, advanced lightweight materials and fuel efficient components.



BENEFITS/METRICS

- Leverages on-going S&T investments and efforts supporting JLTV
- Candidate technologies/techniques to increase vehicle fuel efficiency and/or reduce weight:
 - Reduced Weight Structure/Frame
 - Lightweight Armor
 - Lightweight Vehicle Components
 - Efficient Propulsion
 - Efficient Driveline
 - Other

SAVINGS

- Baseline is Heavy HMMWV Capabilities (approx 8mpg@45mph). Fuel savings estimated 30-40%
- Potential savings: \$95M/year for 118,000 vehicles. Assumes 4000 miles per year at a fuel cost of \$5.85/gallon + 20% added fuel for idling based on an average speed of 45 mph

Power Systems

- Transportable Hybrid Electric Power for Forward Deployed Forces -



DESCRIPTION

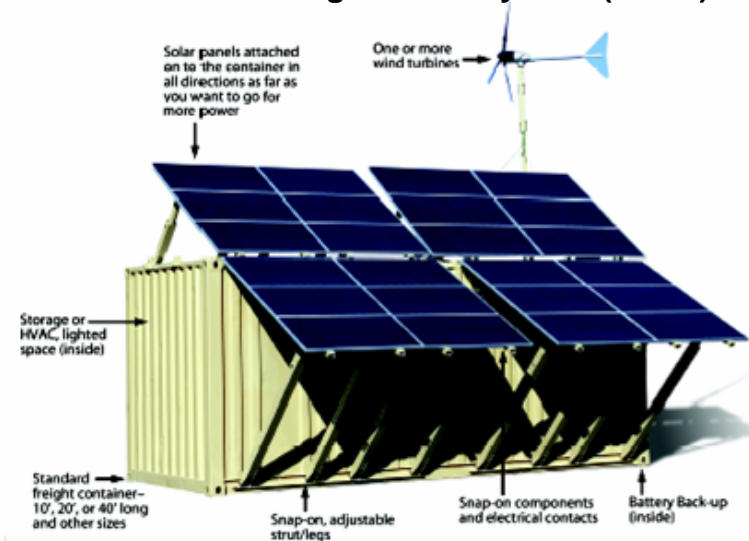
- Increase R&D and procurement tails to fund additional hybrid electric power generators for Rapid Equipping Force

BENEFITS/METRICS

- Provides energy security by reducing re-supply requirements



Tactical Alternating Current System (TACS)



Mobile Power Station (MPS)



Power Systems

- Fuel Cells -

DESCRIPTION

- Develop and demonstrate a family of 3kW, 8kw, 15kW and 50kW very compact & mobile high temp fuel cell systems
- Powers all critical equipment (e.g. GPS, Radio/Comms, Computers, C4ISR gear, Laser Designator , etc.)
- Silent, portable power system eliminating dependence on large generator/grid power for battery charging
- Provides a better power source (weight and available energy) to the Soldier and APU applications for vehicles for missions >24 hours

BENEFITS/METRICS

- Provides onboard mobile power generation for increasing power demands
- Highly fuel efficient, approximately 55%
- Enables salient operation for stealth missions
- Compatible with future fuel (synthetic and desulfurized JP-8)
- Low IR signatures and environmental emissions
- Enables quick recharging of batteries



Solid Oxide Fuel Cell Stack



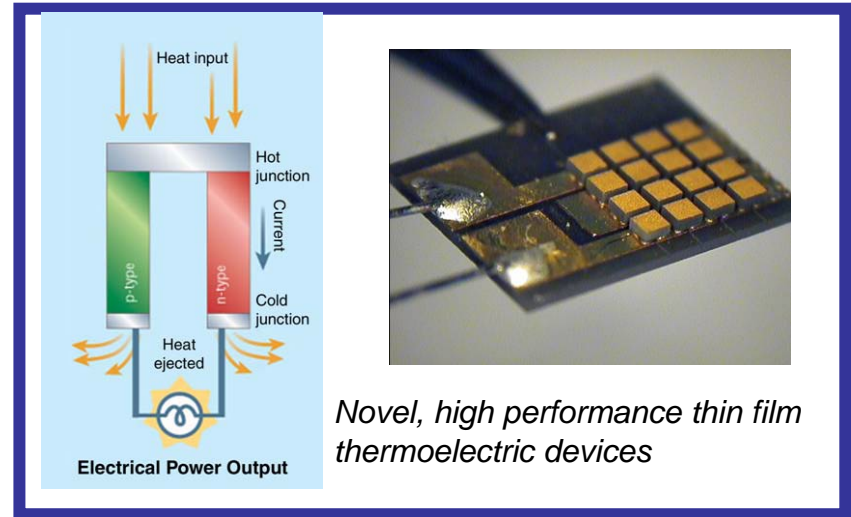
SOFC APU



Thermal to Electric Energy Conversion

DESCRIPTION

- Build large-scale demonstration to efficiently convert waste heat and/or high grade thermal sources of energy directly to electricity
- Leverage DoD investments in materials for efficient heat to electric conversion
- Recent breakthroughs in thin film promise high efficiencies ($> 10\%$) and high power densities ($> 5 \text{ W/cm}^2$)



BENEFITS/METRICS

- Many efforts already on-going at DARPA, ONR, NASA, and DOE
- Potential for up to 10% improvements in engine efficiency for DoD platforms
- Breakthroughs in thin film materials yet to be scaled up and/or transitioned to bulk materials for large scale power ($> 1 \text{ kW}$) demonstrations

Summary



- **DoD Involved in a number of activities to improve Energy Efficiency, Energy Alternatives**
- **No apparent “easy solution”**
- **Need to continue to refine options and alternatives**