SAND2012-6855C

Exceptional service in the national interest

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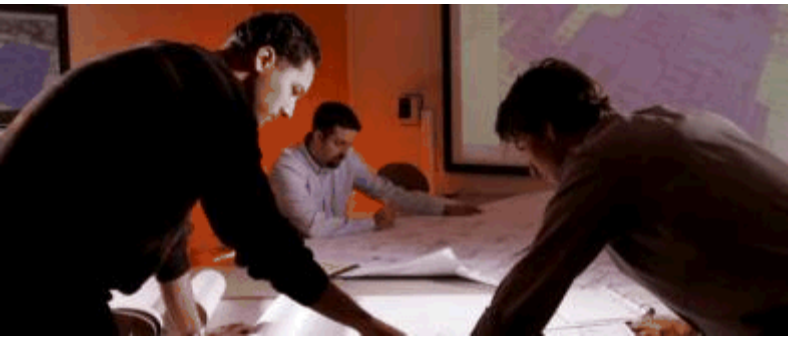

4th Annual Ground Vehicle Systems Engineering and Technology Symposium:

Operational Energy Panel Session

Sandia's Support of Military Operational Energy Challenges

Alan Nanco

Manager, Military and Operational Energy Systems Analysis

U.S. DEPARTMENT OF ENERGY | NNSA

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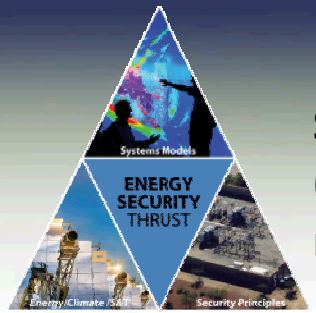
Sandia's Energy Security Mission

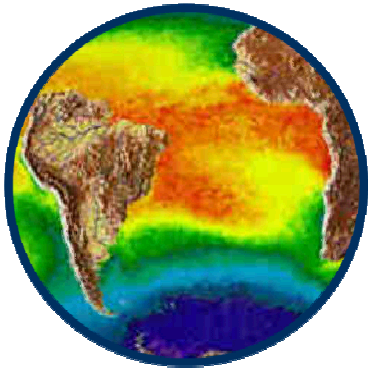


Sandia provides a wide range of security assessments and designs (i.e., energy/ information/cyber/operations/infrastructure) required to assure national security needs

Energy Security National Defense Challenges:

ASSURING OPERATIONAL ENERGY

- Renewable Energy Integration
- Component and System Reliability
- Secure Micro-grids
- Safe, Cost Effective Alternative Energy
- Cyber Secure Smart Controls
- Advanced Analytics and Optimization



ACCESSING CLIMATE CHANGE

- Atmospheric Measurements
- Regional-scale Models
- Consequence Analysis

REDUCING OIL DEPENDENCY

- Combustion Efficiency
- Alternative Fuels
- Safe/Reliable Storage
- S&T and R&D
- Unique T&E

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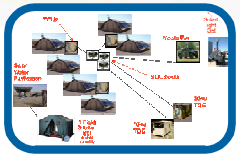
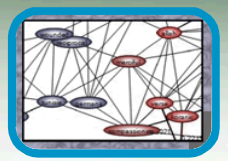
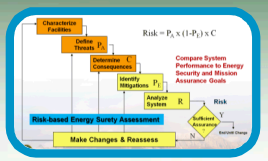
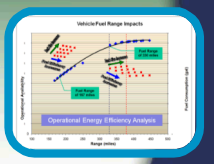
Proven Capabilities to Address Operational Energy Security Challenges throughout DoD Acquisition Life Cycle

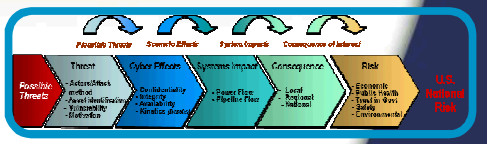
Transition Solutions to Industry and Government Applications


Implementation, Test and Evaluation & Sustainment Analysis



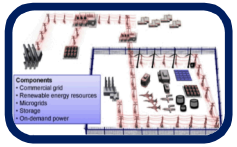





Modeling, Simulation & System Assessments

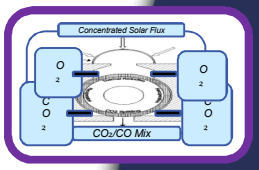
Energy Surety Life Cycle

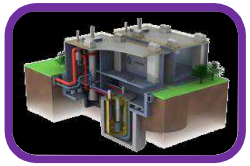
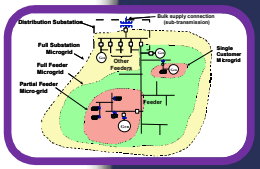





Research, Development and Prototyping

Conceptual Designs



Sandia has comprehensive modeling, analysis, design, development, test and evaluation approach for Energy Security Challenges

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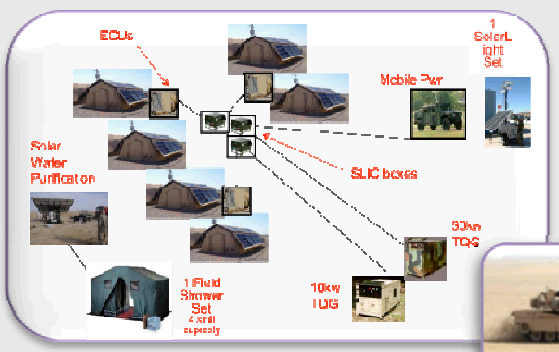
Military Systems Operational Energy Analytics

Military Modernization Programs

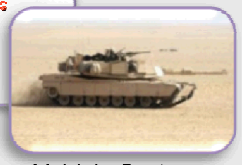
- Systems Performance Modeling, Simulation and Analysis
- Energy Efficiency Analyses
- Trade Studies
- Operational Effectiveness & Impacts
- System of Systems Assessments
- Reliability Analysis
- Optimization

Operational Energy Security Analyses



Forward Operating Bases

Soldier Systems



Vehicle Systems

Sandia's Projects and Experience with DoD Energy Security Challenges

Conceptual Designs/Assessments	Small Scale Demos	Large Scale Demos	Operational Energy Analyses
• Philadelphia Navy Yard – new FY11, DOE OE • Norfolk – new FY11, DOE OE • Camp Smith – completed FY10, DOE FEMP • Indian Head NWC – complete FY10, DOE OE • Ft. Sill – completed FY07, LDRD • Ft. Bliss – Phase 1 completed FY10, DOE FEMP • Ft. Carson – Nearing completion, DOE FEMP • Ft. Devens (99th ANG) – Conceptual design complete, DOE OE/DoD • Ft. Belvoir – Prelim design done, DOE OE/FEMP • Cannon AFB – New FY11 • Vandenberg AFB – Initial site visit complete, DOE FEMP • Kirtland AFB – 2/3 complete, DOE OE • Maxwell AFB – Conceptual design complete, now on demo • Creech AFB – Joint Energy and Physical Security Assessment – FY12	• Maxwell AFB – DOE OE/ Mostly DoD • Ft. Sill – SNL tech advisor • Ft Devens – BCIL – Operational Energy Storage System Demo FY12 start	• SPIDERS JCTD FY11-FY13 – Joint Base Hickam – Camp Smith – Ft. Carson • Ft Leonard Wood CBITEC Discussions underway for FY13 RDT&E Projects	• Ground Combat Systems Energy Efficiency KPP Analyses FY11 • Contingency Basing (e.g., FOBs) Architectures and Assessments FY12 Start • Operational Energy for Ground Systems, FOBs & Warfighters FY12 Start • USMC Expeditionary Energy Office FY12-FY13 • Ft. Deven BCIL M&S FY12

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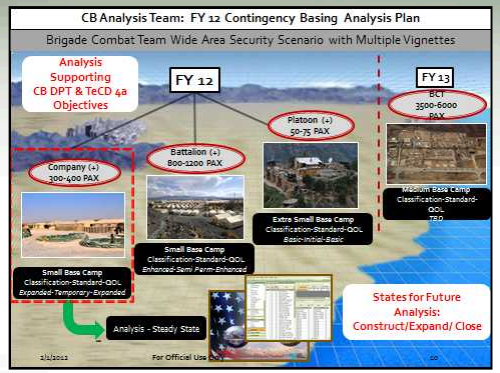
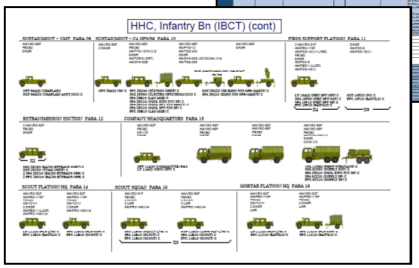
Contingency Basing Project – SoSAT Model Development Process & Analysis Approach

OPORD



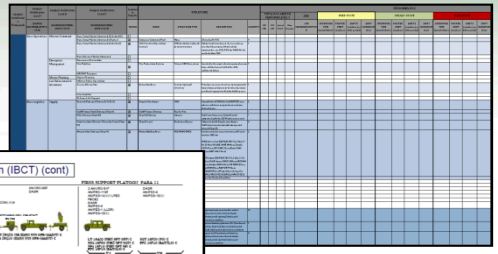
Defines the mission:
- CO+ Wide Area Security Ops
- CONOPS (e.g., sustain)

Tenant Unit

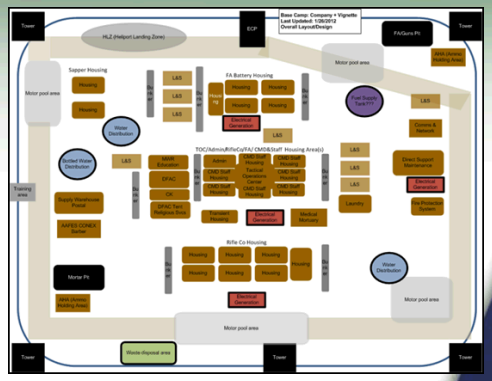


Mission determines Unit:
- IBCT Rifle CO w/FA BAT Augmentation (312 PAX)

Functional Decomposition



Base Camp Design



Force Development & Unit determines base camp required capabilities/systems:
- CO+ Wide Area Security Ops

System of Systems Modeling and Analysis

- SoSAT Baseline Model and Scenario
- SoSAT Future State Models "Improved Systems"

- Assess improvements against baseline via operational metrics (e.g., fuel consumption, water consumption, etc.) – define the "unit value" of improvement

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Base Camp Generator Power Simulation: Current Baseline vs. Microgrid Comparison

- **Discrete event simulation used to model generator performance**
- **Load profiles for each generator input to model**
  - Assumed PAX on COP influences power usage of tents
  - Assumed two Raid missions (plunge in PAX on COP) influence use of showers, latrines, kitchen, laundry
  - Transient housing assumed in use only 5 days
- **Generator model assumptions**
  - Standard TQG diesel generator efficiency and fuel usage curves used
  - Likelihood of generator start up failure is 0
  - Diesel fuel storage was assumed to be effectively infinite
  - The minimum and maximum capacities for all of the power distribution lines set to 10,000 kW and assumed to have perfect reliability
- **Modeled Base Case (spot generation) vs. Microgrid Case (assumed one large microgrid for entire Base)**

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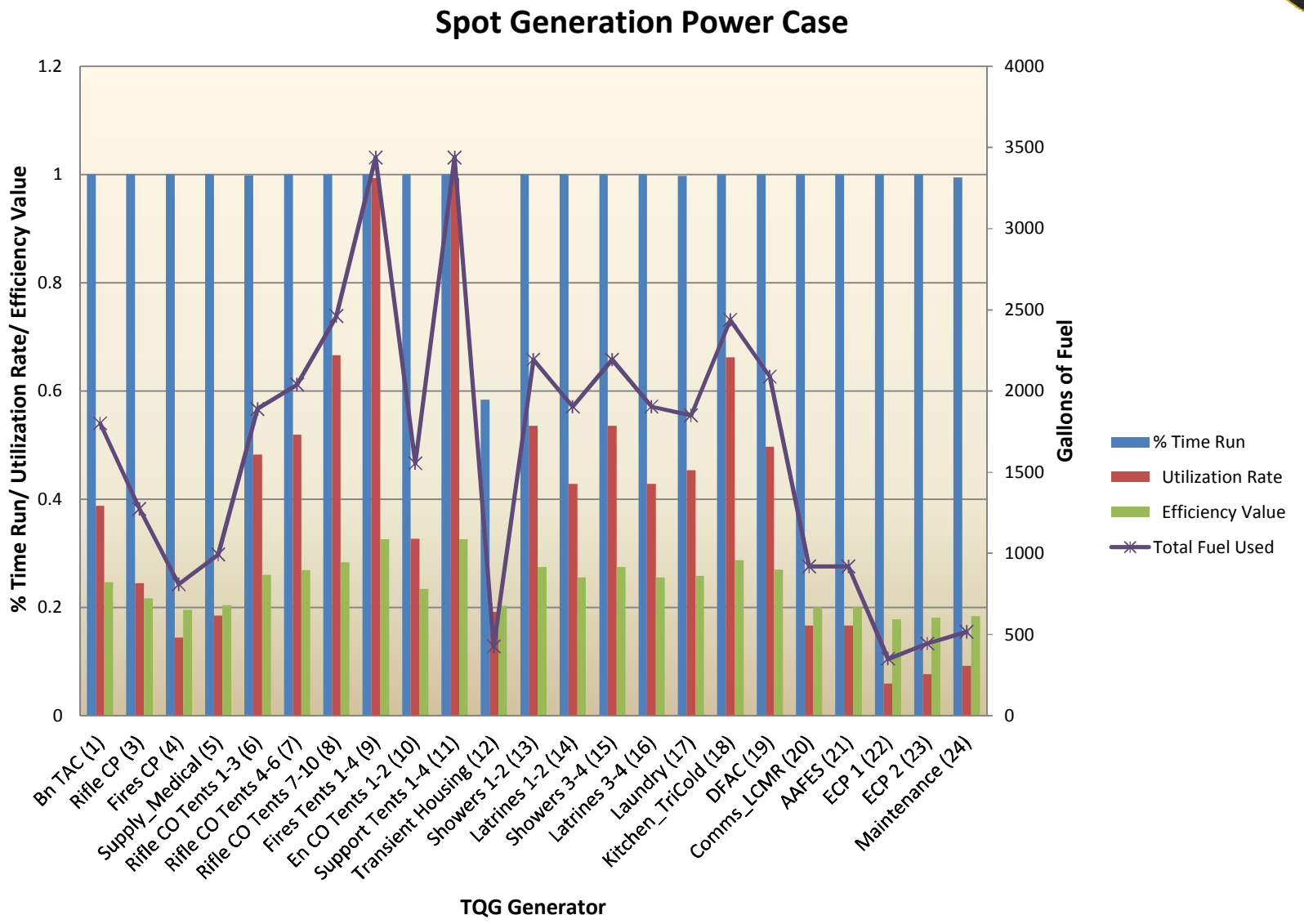
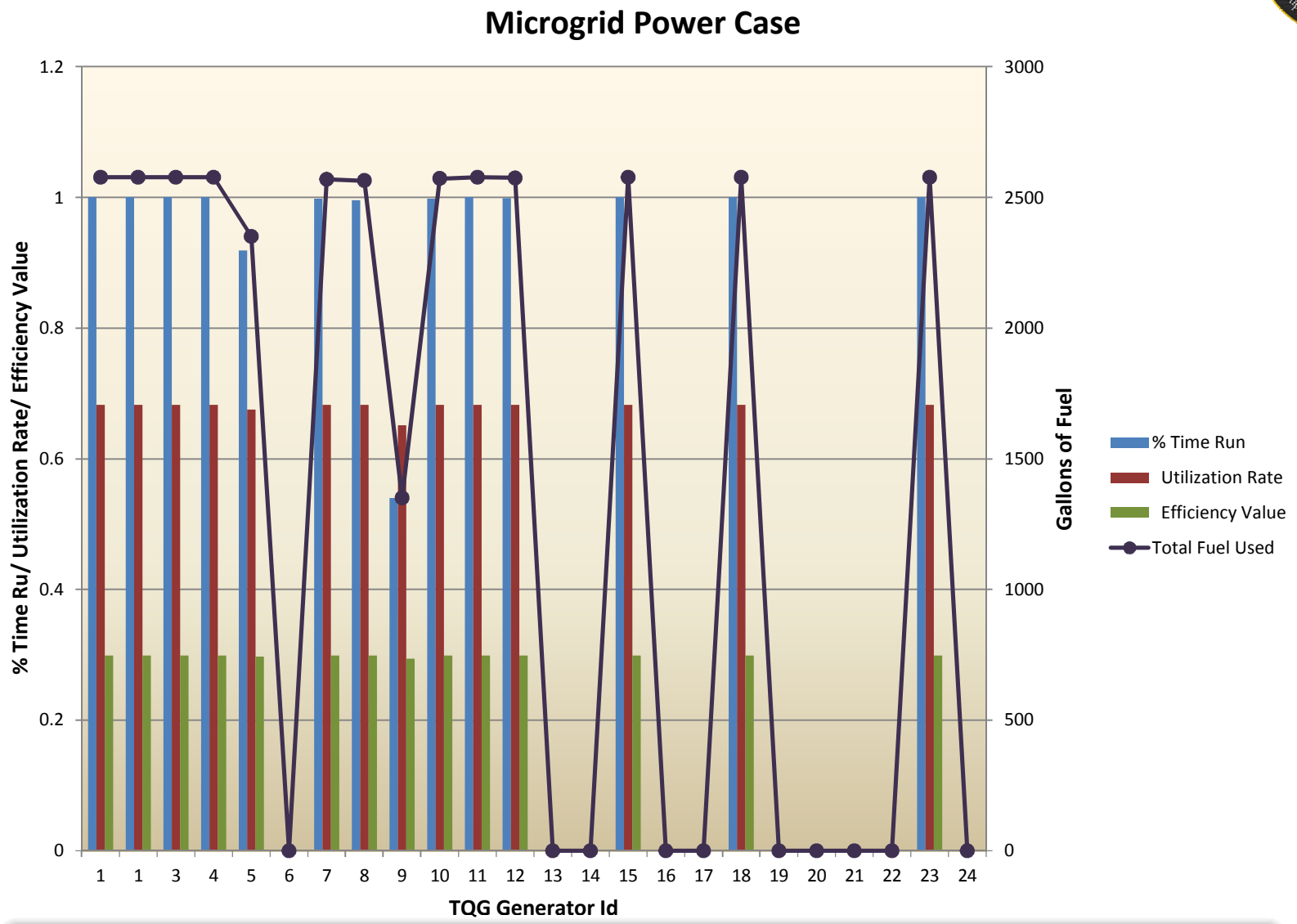
Base Camp Standard Generator Power Simulation



Base Camp Generators with Microgrid Power Simulation



Significant Reduction in Fuel Use and LOGPAC Deliveries

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Operational Energy Efficiency Key Performance Parameter (KPP Application) Example

- **SoSAT used to perform logistics and sustainment analysis for current Army ground combat systems**
  - Work with TRADOC, PM SBCT, CASCOM, and AMSAA to identify and obtain data
- **Operational Energy related systems analysis:**
  - Validate and assess operational fuel efficiency and range requirements
  - Assess the impacts of variations in auxiliary power unit (APU) usage time on system operational availability (Ao) and total fuel usage
  - Introduced new metrics *(e.g., sustainment availability)* to assess sustainment impacts beyond the operational availability metric

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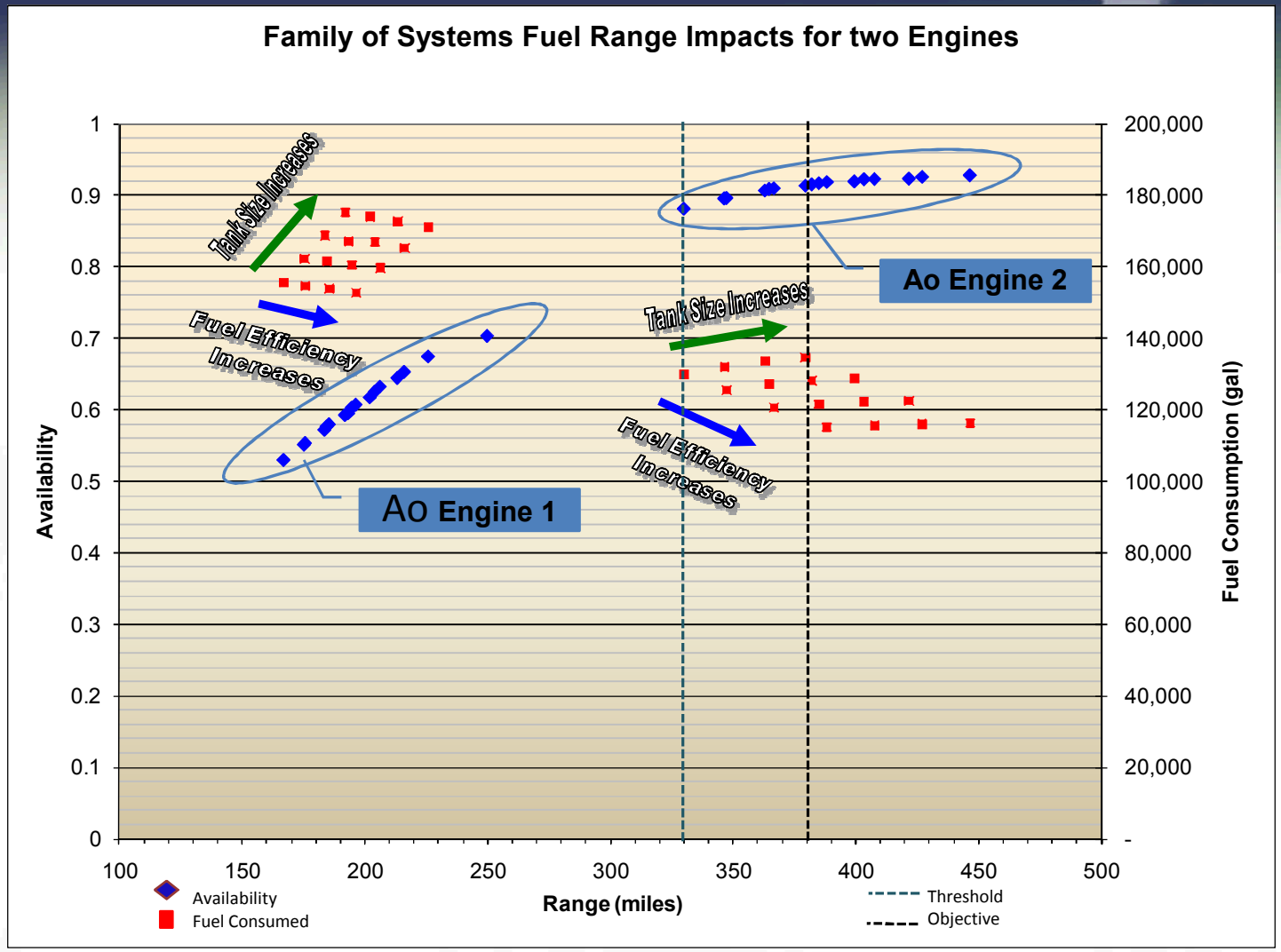
Operational Energy for Ground Systems: Platform Engine Upgrade Trade Study



Impact: Provided analytic underpinning for requirement validation as well as assessment of Brigade performance impacts of Engine trades

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Operational Energy Example: APU Requirements vs Fuel Efficiency Impacts

- **Problem:**
  - New mission requirements included significant APU usage time however current ground combat systems did not have APU capability
- **Goal of this analysis:**
  - Assess the operational energy impact of providing APUs at various usage rates on ground combat systems in a modular brigade
- **Analysis description:**
  - Modeled Brigade Combat Team (1190 ground vehicles and 300+ combat vehicles)
  - Analyzed baseline capabilities (0% APU), new mission requirements (100% of APU requirements), and several points in between (13%, 25%, and 75% of APU required usage)

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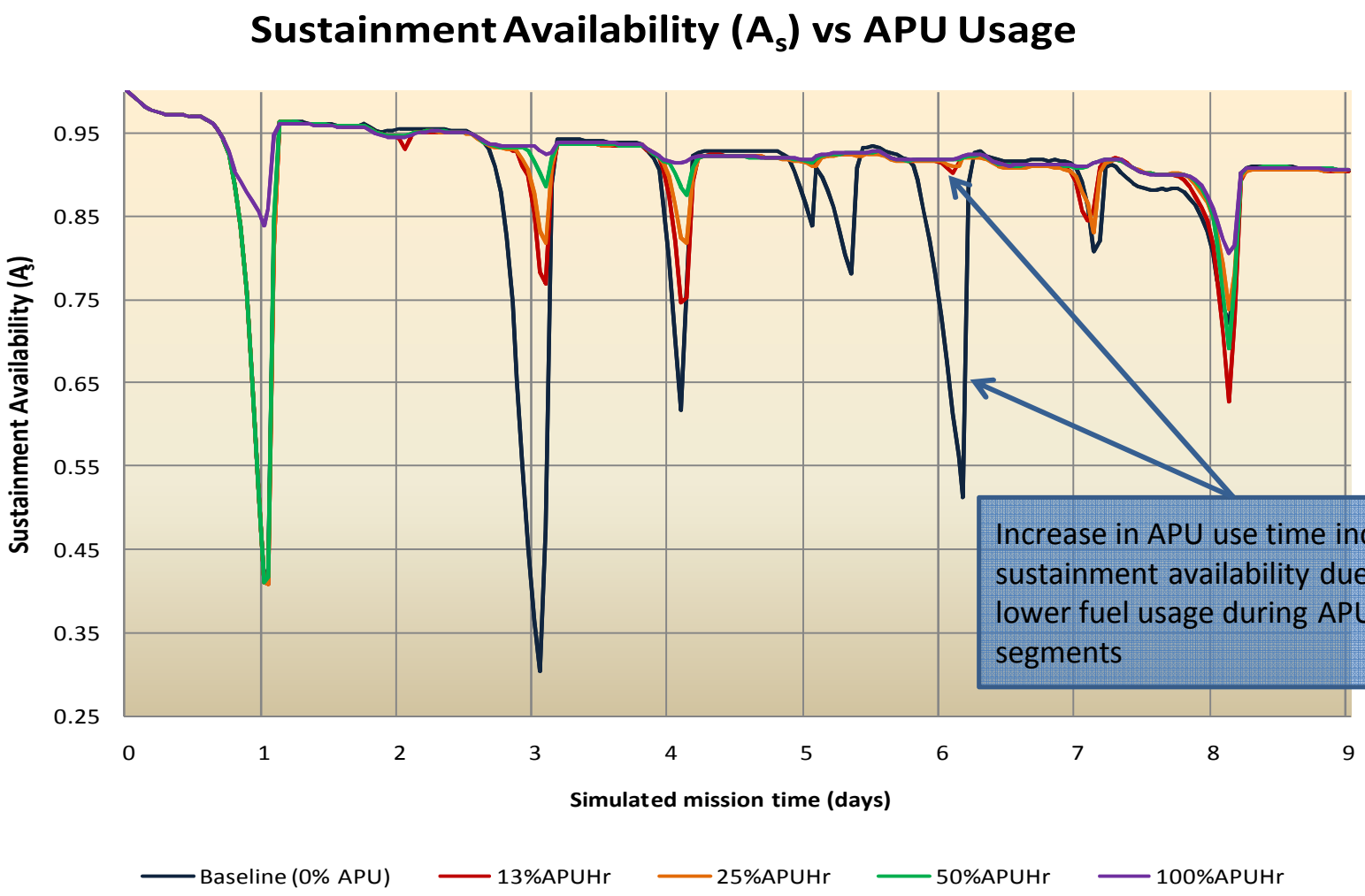
Impacts of APU Usage on FoS Sustainment Availability and Fuel Efficiency



Impact: Provided quantitative analyses for vehicle modernization decision to enhance energy efficiency and operational performance

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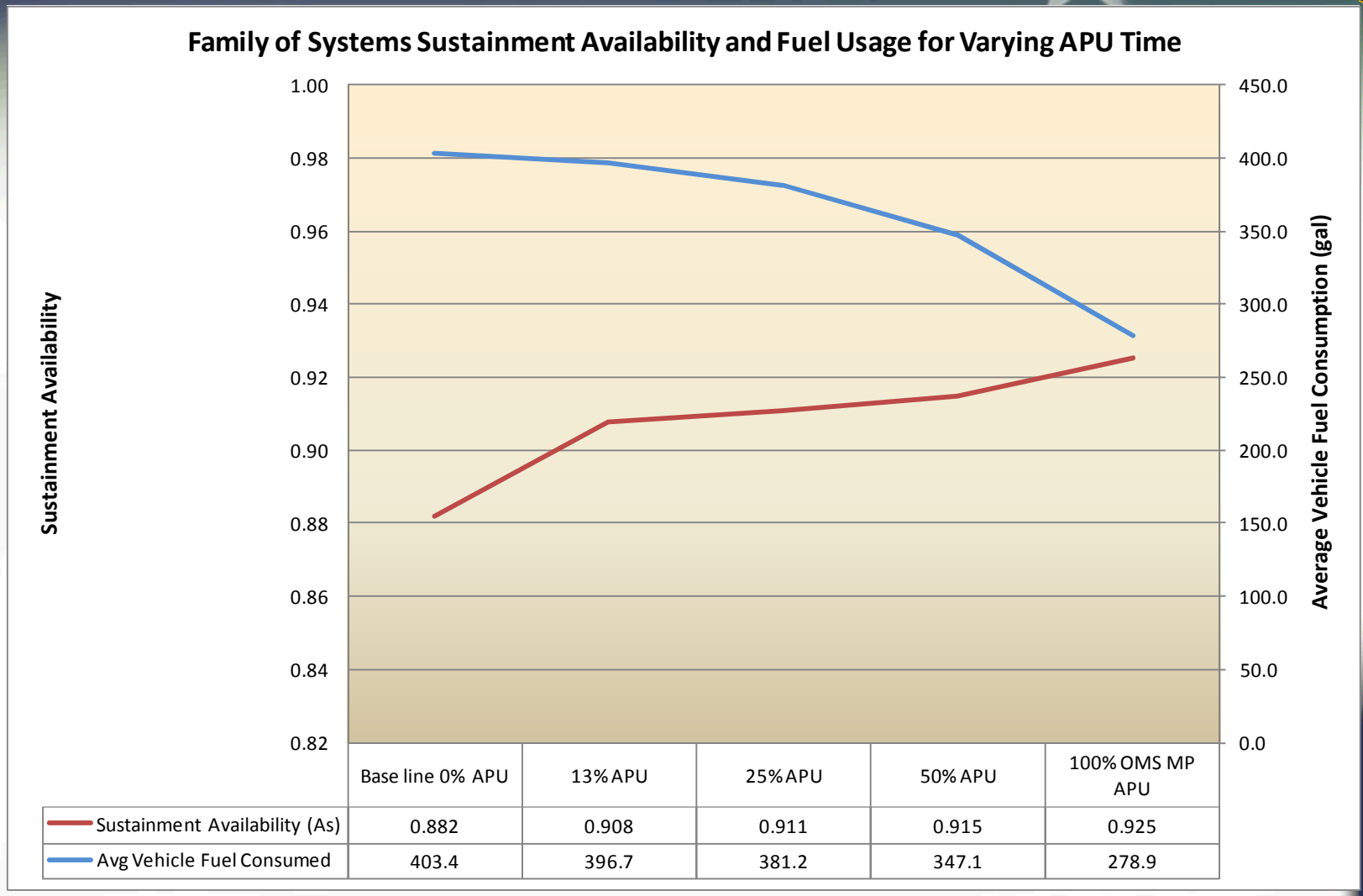
Operational Energy Efficiency: Impact of APU on Fuel Usage



	Base line 0% APU	13% APU	25% APU	50% APU	100% OMS MP APU
Sustainment Availability (As)	0.882	0.908	0.911	0.915	0.925
Avg Vehicle Fuel Consumed	403.4	396.7	381.2	347.1	278.9

Impact: Results provide analytical underpinnings for the requirement for systems to have APU capability

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Observations…

- Business Case Analysis is critical…
  - **"In God We Trust… All Others Bring Data…"** Mr. Frank Kendall, Under Secretary of Defense for Acquisition, Technology and Logistics (AT&L)
  - DoD and Military leaders are demanding analytic underpinnings for proposed modernization and improvement investments
- Complex System of Systems Modeling and Analysis is a "Team Sport" – Collaborations across the board are a must
- Data, Assumptions and Vetting is the "long pole in the tent" – Modeling and Analysis Results Must be Believable

BACK-UP

DOE National Laboratories Provide Unparalleled Energy Research, Development, Test and Evaluation Facilities and Capabilities to Support DoD's Operational Energy Needs

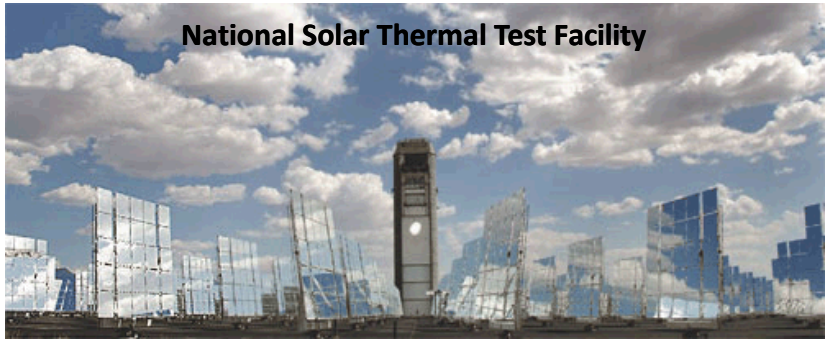

Distributed Energy Technologies Laboratory (DETL)


Supervisory Control & Data Acquisition (SCADA) Test Bed


Combustion Research Facility (CRF)


Joint BioEnergy Institute (JBEI)


Battery Abuse Testing Laboratory (BATLab)


National Solar Thermal Test Facility


Liquefied Natural Gas Fire


Center for Integrated Nanotechnologies (CINT)


National Infrastructure Simulation & Analysis Center (NISAC)


Red Sky High Performance Computing

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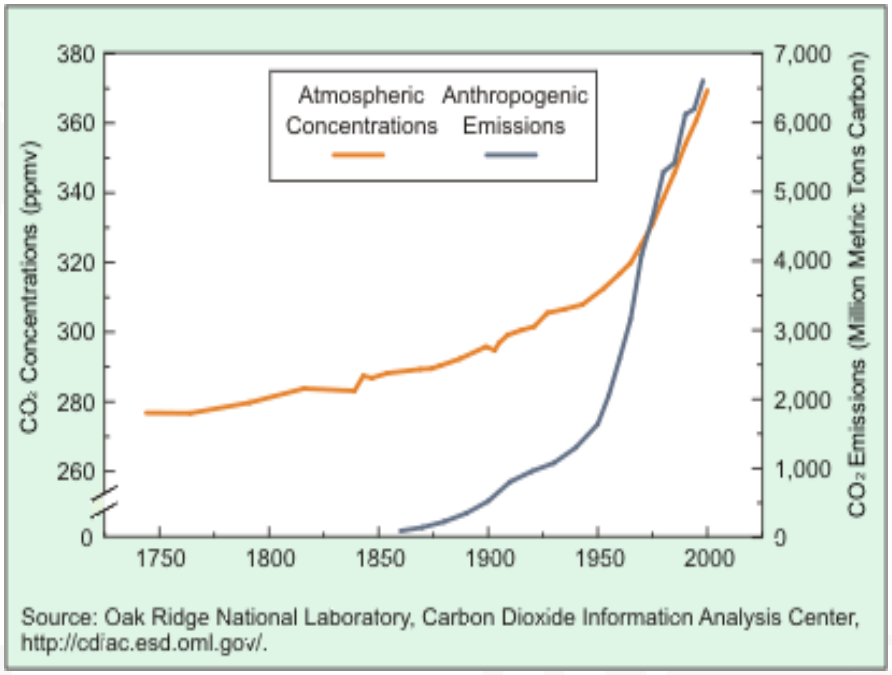
System of Systems Analysis Toolset (SoSAT) Overview

- **SoSAT (System of Systems Analysis Toolset) is a suite of software tools:**
  - State Model tool
  - Stochastic simulation tool
  - Advanced data visualization tools
  - Reliability, consumables, and supply chain optimization tools

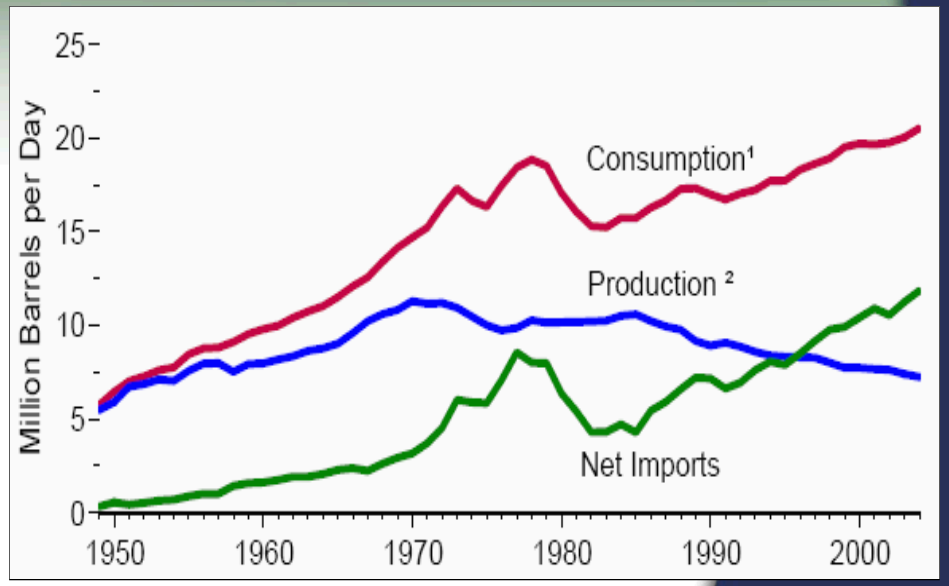
- **Initially designed to provide DoD and military services the capability to analyze large System of Systems (SoS) and all of its various platforms across multiple mission scenarios to assess multiple key performance parameters**
  - Supported multiple US Army Future Combat Systems (FCS) trade studies
  - Supported US Army PEO Integration with modeling and analysis of Logistics, Sustainment, Reliability Key Performance Parameters for Capability Packages
    - Key support provided to PM Ground Combat Vehicle CDD development
    - Ongoing support to Integrated Base Defense Architectural development
    - Participating in Contingency Basing Community of Practice – Modular Base Concepts exploration
  - US Army PEO Ground Combat Systems (PEO GCS) is using SoSAT for Fleet Management and Modernization Planning initiative
  - JPO MRAP using SoSAT for MATV assessments and analyses
  - Formal Verification, Validation & Accreditation effort with Army Organizations (AMSAA and ATEC)
  - Navy Littoral Combat Ship and Littoral Mine Warfare using SoSAT for their fleet modernization planning

The U.S. is Facing Unprecedented Transportation Fuels Challenges

- 96% of transportation energy comes from petroleum
- Two-thirds of petroleum is used for transportation—60%



Source: Oak Ridge National Laboratory, Carbon Dioxide Information Analysis Center, http://cdiac.esd.oml.gov/.



- In FY 2008, the U.S. spent nominally $400 billion dollars on imported oil
- Gasoline and diesel vehicles produce about 7 tons of CO_2 per year

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Oil & Transportation Linked

How can we reduce fuel demand and carbon footprint?

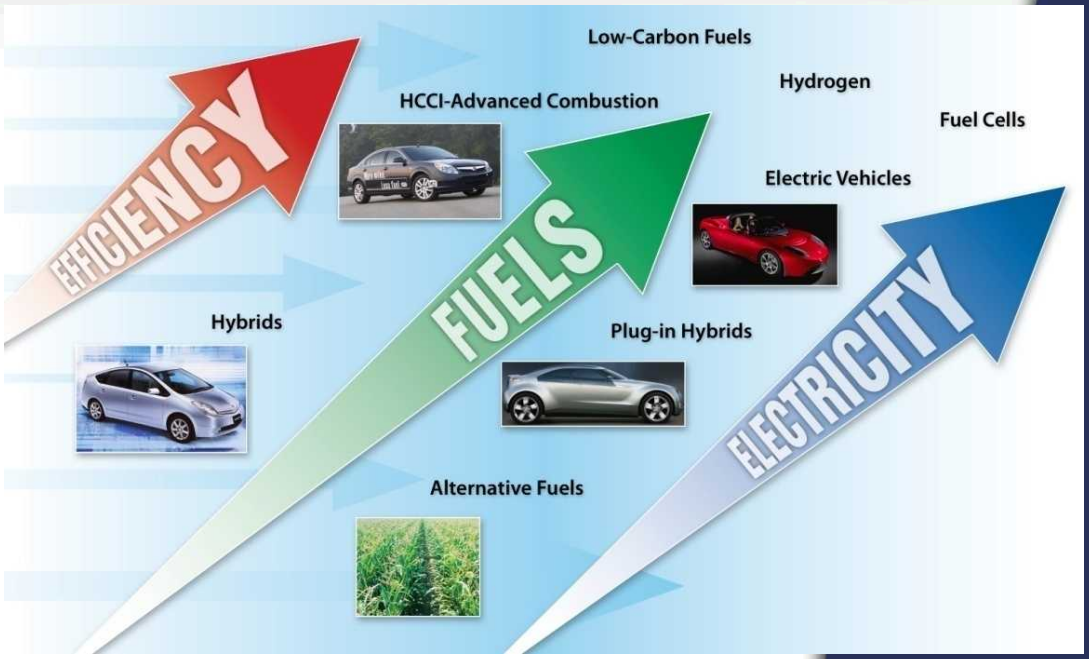
Strawman Scenario

100 %

Efficiency Gains: ~30%
Realizing full thermodynamic Efficiency of clean IC engine

Low Net Carbon Fuels: ~25%
Transitioning to > 25%

Electrification: ~25%
PHEV ~ 25%
EV ~ 10%



20 %

Oil Demand
Carbon Emission

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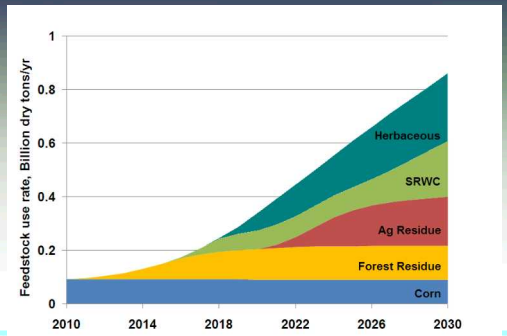
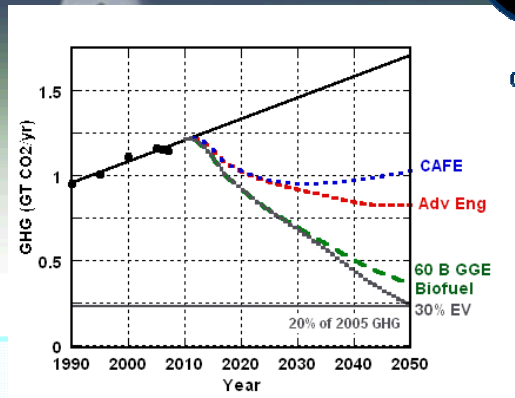
Variety of Approaches to Analyze Transportation Energy Options

Forums

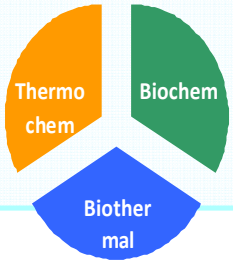


Scenarios

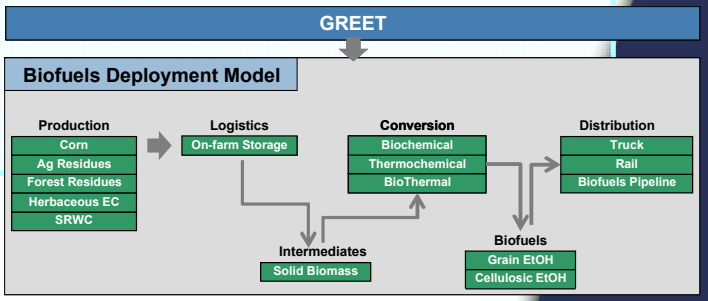


Trade-offs

Biomass
Gasification
Syngas
Catalysts
Ethanol



Biomass
Enzymes
Sugars
Microorganisms
Ethanol



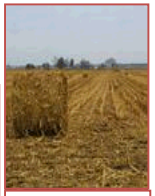
Simulations


SRWC


Forest Residue

Biomass
Gasification
Syngas
Microorganisms
Ethanol


Herba-ceous


Ag Residue

Architectures

We focus on understanding context and informing decisions

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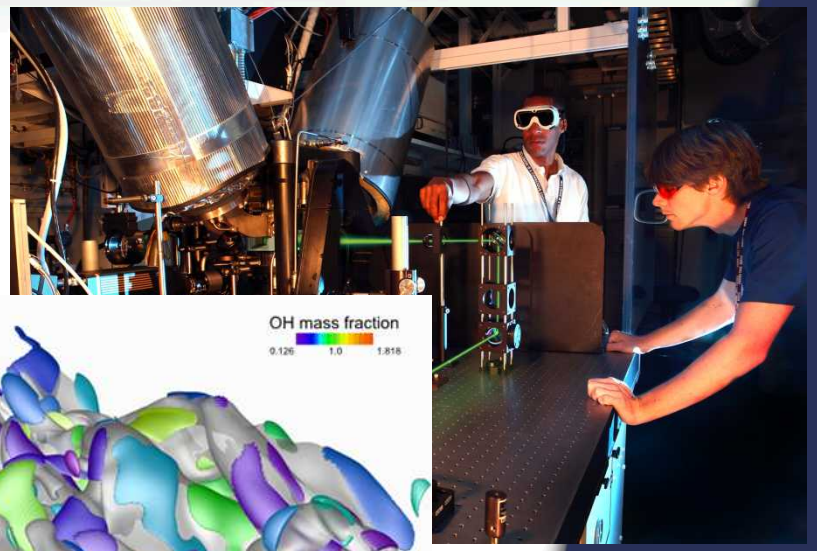
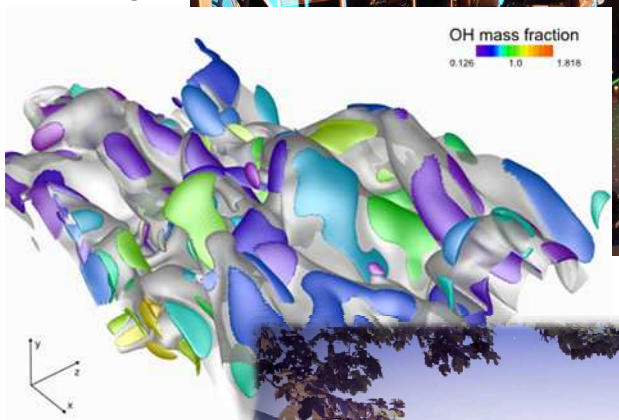
Combustion Research Facility

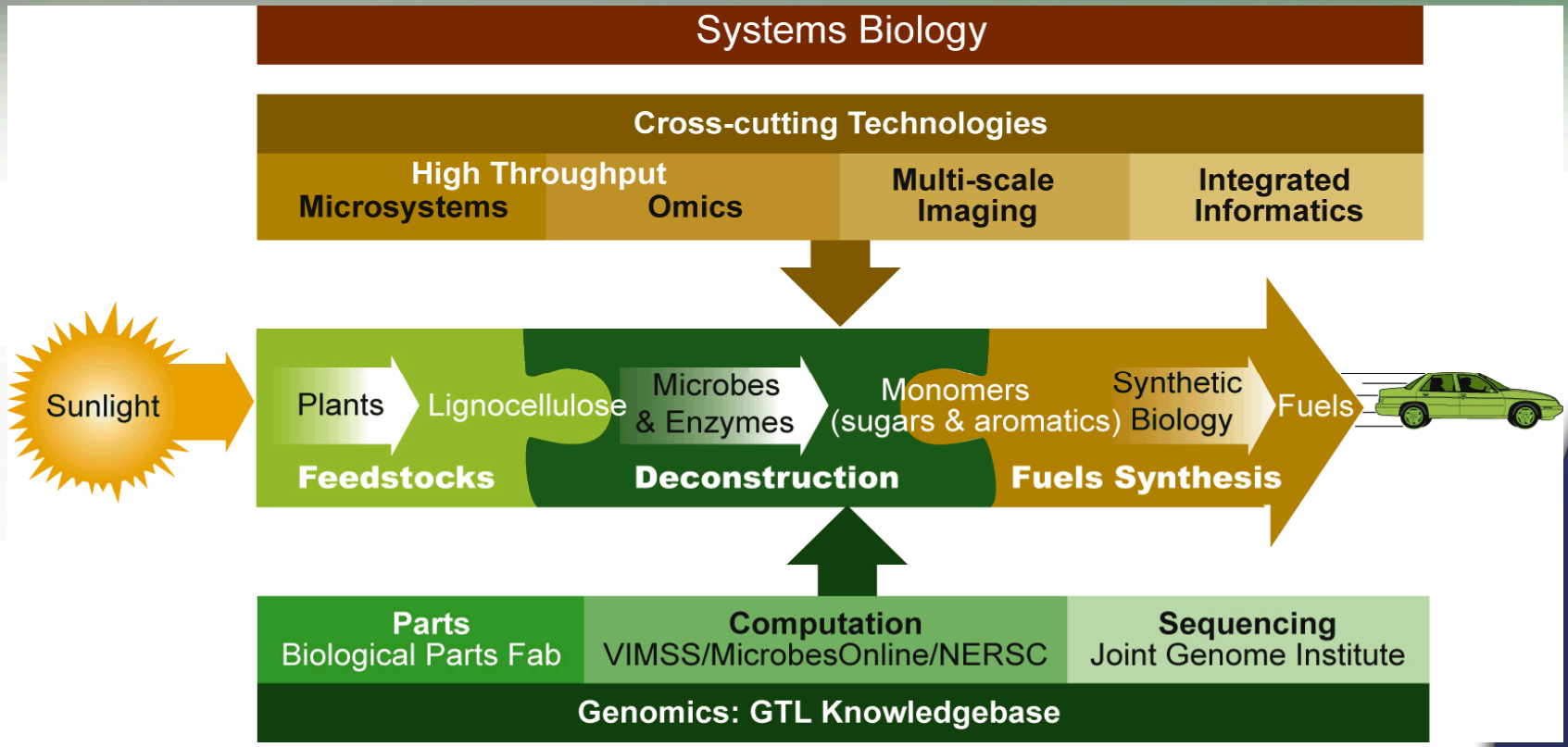
The DOE/BES Collaborative Research Facility dedicated to combustion science and technology for the twenty-first century

- **82,000-square-foot office and laboratory facility**
- **36 highly specialized labs**
- **New 8000 square-foot computational laboratory under construction**
- **Keys to CRF's success:**
  - **Common scientific purpose**
  - **Collocation and collaboration**
  - **End applications oriented**
  - **Full spectrum of basic to applied**





Joint Bio Energy Institute (JBEI)



Partnership

Universities: UC Berkeley, UC Davis, Stanford

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Extensive Experience with Technology Development and Transition Across the Entire Acquisition Lifecycle

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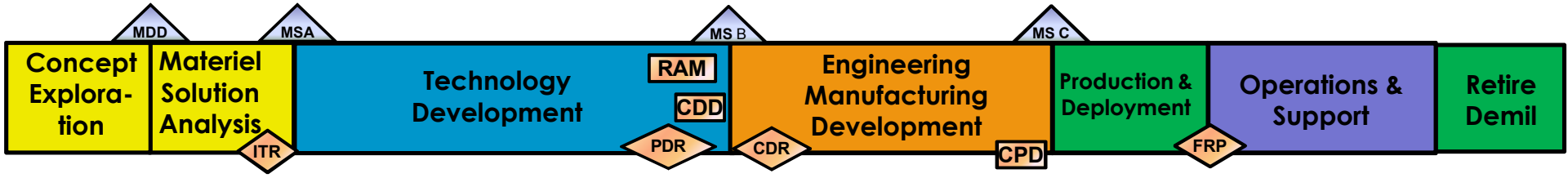
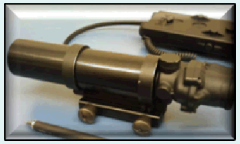




Army Adaptive Optics Rifle Scope Prototype

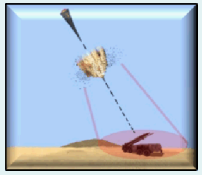
Bradley Modernization Analysis

PM Stryker Technology Analysis

US Navy RMMV Reliability Analysis

Apache Recap

US Navy LCAC Readiness Optimization



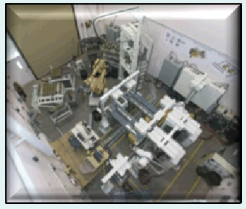
Army Hypersonic Weapon Prototype

Joint Operational Energy Initiative

Joint Contingency Basing Initiative

US Army Abrams Modernization Analysis

Joint Strike Fighter Enterprise Modeling



Joint Munitions Robotics Demil Systems

Sandia plays a critical role from Concept Development & Pre-Competitive Technology Development through the entire DoD Acquisition Life Cycles

Sandia offers a unique combination of Security Principles, System Modeling & Analyses and RDT&E Capabilities

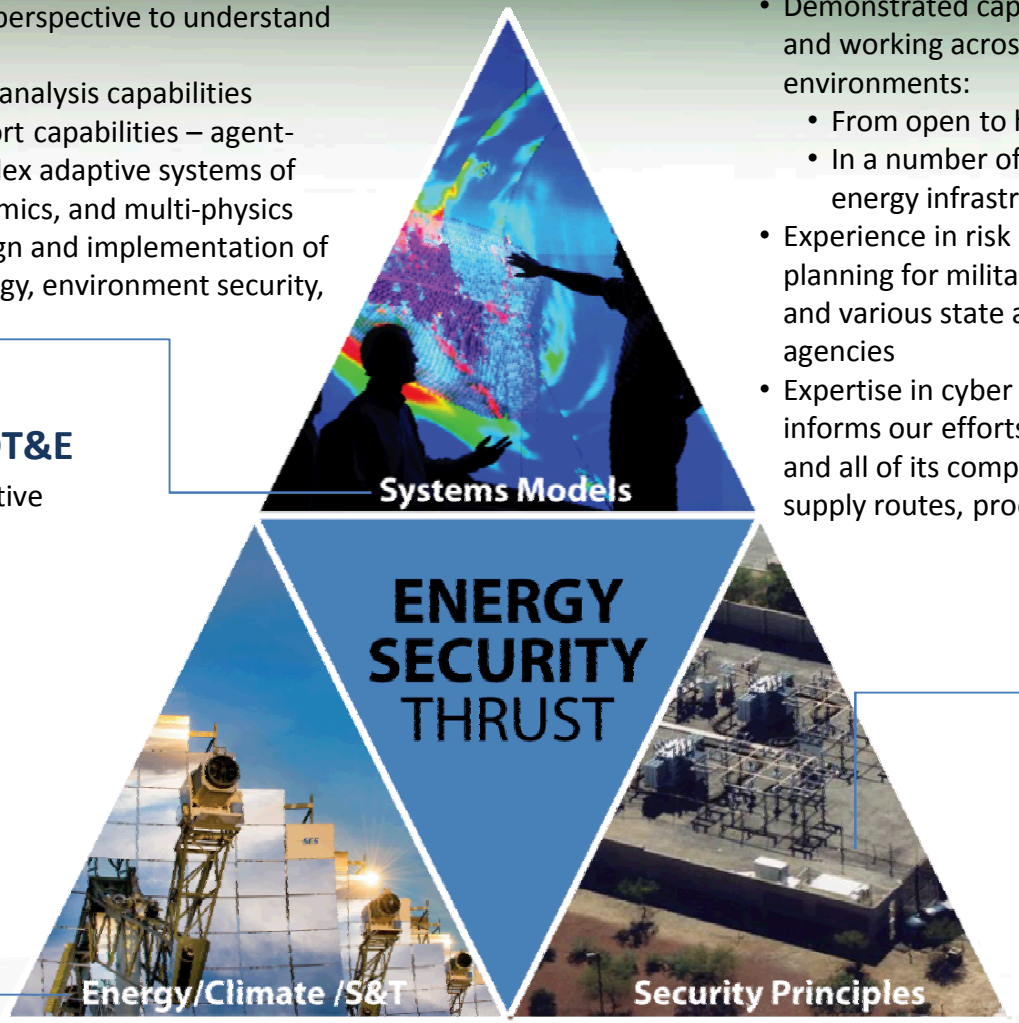
SYSTEMS MODELS & ANALYSES

- Science-based system perspective to understand complex systems
- Systems modeling and analysis capabilities
- Specific decision-support capabilities – agent-based modeling, complex adaptive systems of systems, systems dynamics, and multi-physics
- Used to guide the design and implementation of policies related to energy, environment security, and climate

ENERGY/CLIMATE/RDT&E

Develop reliable, cost-effective new energy and climate technologies

- Energy storage
- Combustion
- Nuclear energy
- Nanoscience
- Renewable energy
- Sensing systems



SECURITY PRINCIPLES

- Demonstrated capability in understanding and working across a continuum of security environments:
  - From open to highly secure,
  - In a number of sectors, particularly energy infrastructure
- Experience in risk assessments and scenario planning for military installations, industry and various state and Federal government agencies
- Expertise in cyber and nuclear security informs our efforts to secure energy systems and all of its components (infrastructure, supply routes, products, enterprises, etc.)

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