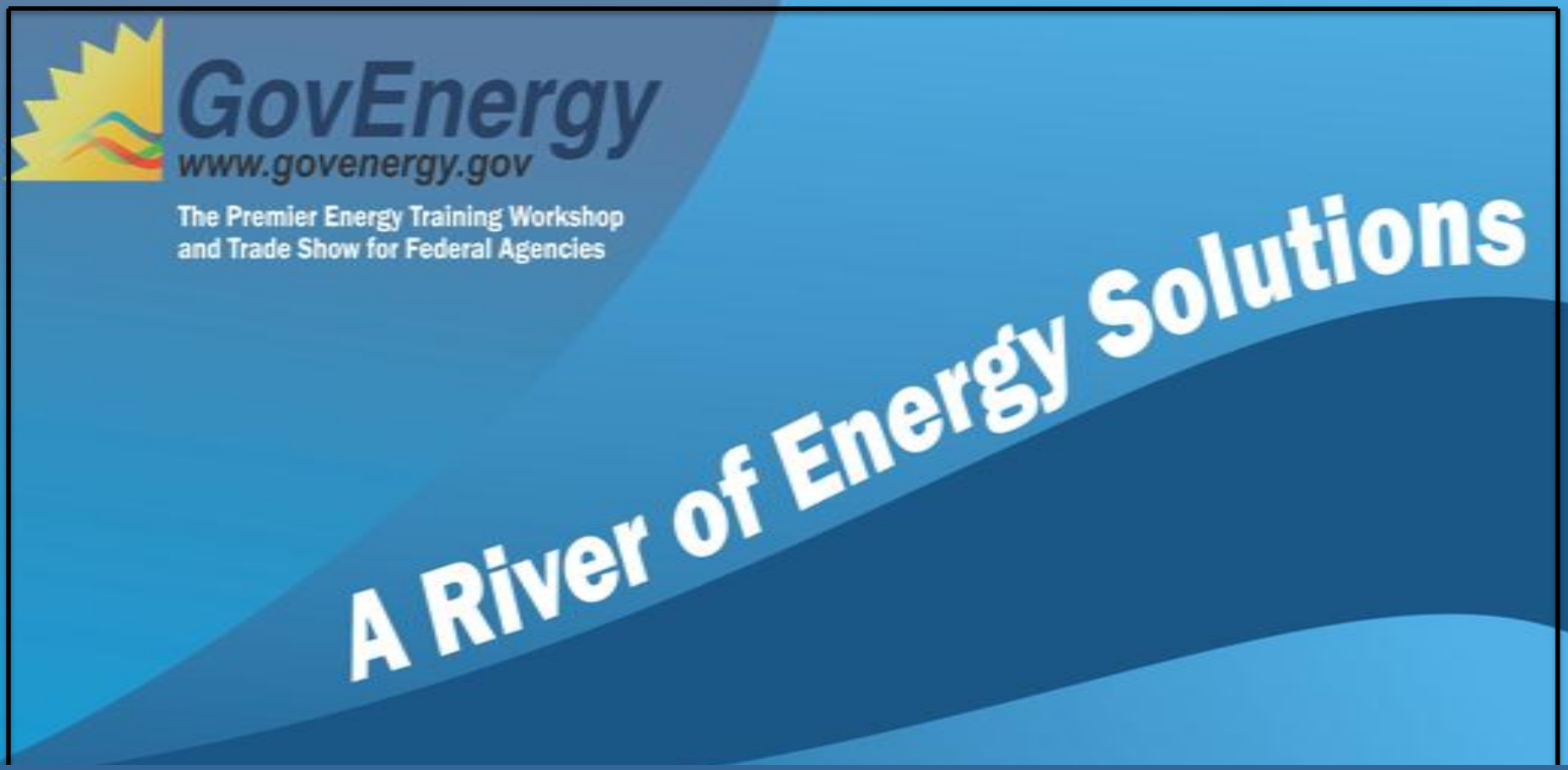


A Systems Approach to Energy in Remote Operations and Locations

Ron Sega
Vice President and Enterprise Executive for Energy and the Environment
Colorado State University
The Ohio State University

Overview

- Energy Systems Background
  - Related Government Work
    - Director of Defense Research and Engineering (DDR&E)
    - Under Secretary of the Air Force (USecAF)
  - Workforce
- Advances in “Stand Alone” Energy Options
  - Alternative Sources and Efficiency Solutions
  - “Aerospace” Systems Engineering Applied to Energy

GovEnergy
www.govenergy.gov

Director of Defense Research and Engineering, Department of Defense

- Three Areas of Increased Emphasis
  - National Aerospace Initiative
  - Surveillance and Knowledge Systems
  - Energy and Power Technologies
- Technical Systems Reviews
  - Technology Readiness Assessments
  - Task Force support to Systems Development
- Workforce Initiative
  - DUSD (Laboratories and Basic Sciences)
  - National Defense Education Program (NDEP)

GovEnergy
www.govenergy.gov

Energy & Power Technologies…
- Enabling a More Electric Force

POWER GENERATION

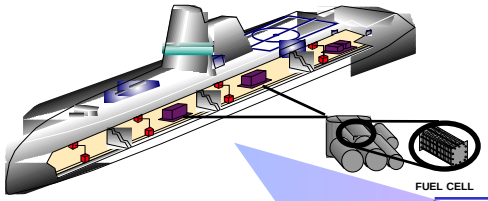
- Fuel Cells & Fuel Reforming
- Novel Power

ENERGY STORAGE

- Batteries
- Capacitors

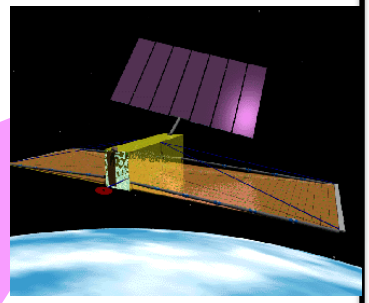
POWER CONTROL AND DISTRIBUTION

- Switching & Conditioning
- Power Transmission & Distribution
- Thermal Management

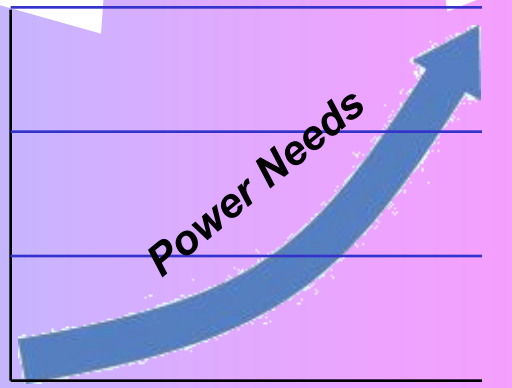


Electric Warship

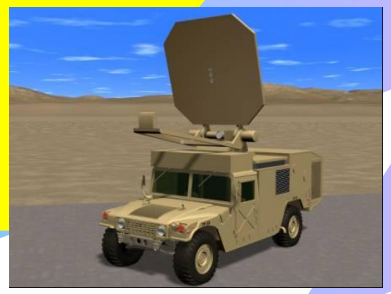
More Electric Aircraft



Space Based Radar



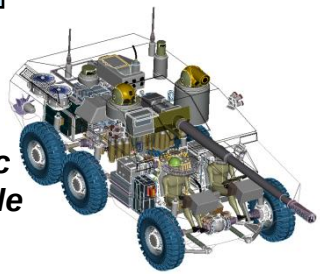
High Power Microwave



Warrior

New Operational Capabilities

Electric/Hybrid Weapons



Hybrid/Electric Combat Vehicle

GovEnergy
www.govenergy.gov

Under Secretary of the Air Force

- Space
  - Department of Defense Executive Agent for Space
  - Back to Basics in Acquisition and the Block Approach
    - Systems Engineering
    - Workforce
- Research and Development
  - Alignment with Needs and Redistribution of Risk
  - Stability in Basic Research
- Energy
  - "Make Energy a Consideration in All We Do"
  - Energy Strategy (Supply and Demand – with Metrics)

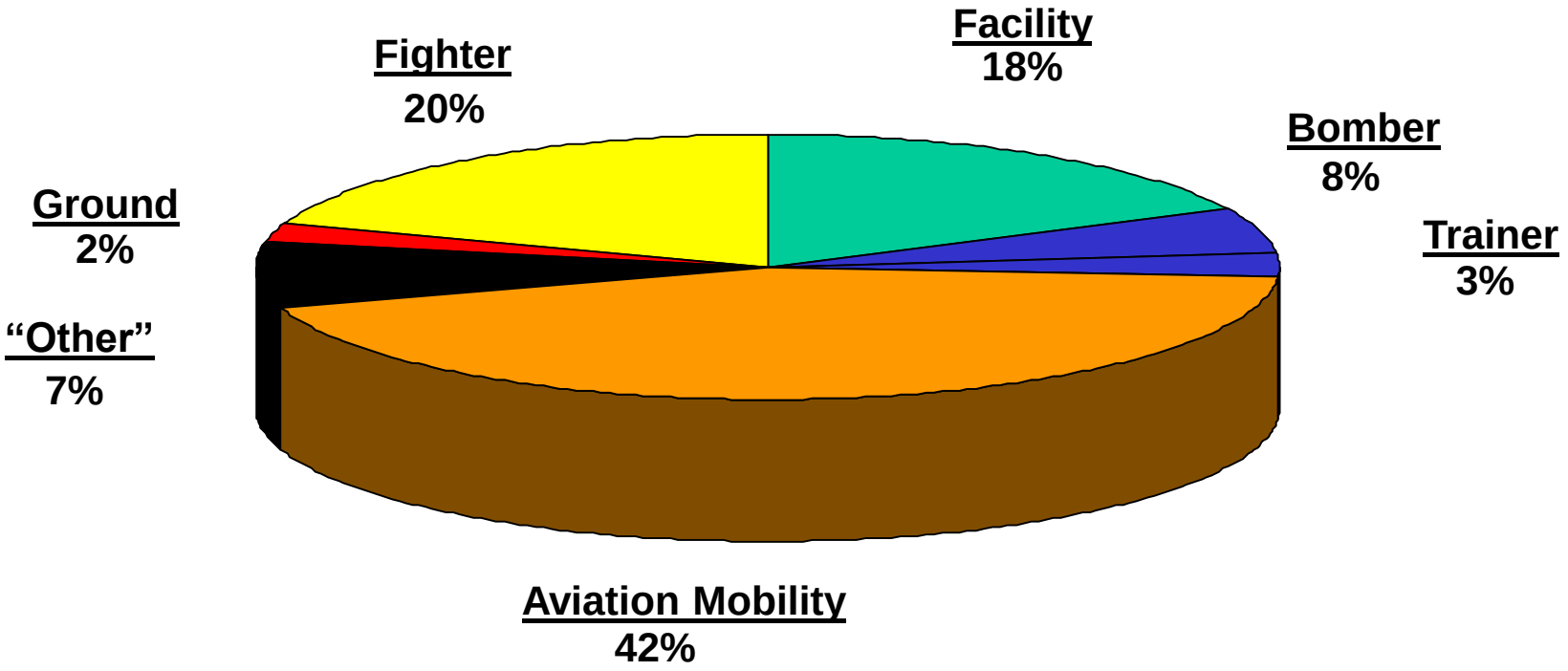
Air Force Energy Strategy

- Addressing Supply & Demand

"Make Energy a Consideration in All We Do"

- **Accelerate development and use of "Alternative" sources**
  - **Synthetic Fuel for Aviation**
  - **Renewable Energy for Installations**
- **Enhance energy efficiency -- aviation and infrastructure**
- **Promote a culture where Airmen conserve energy**

Air Force Energy Use (as Percentage of Cost)



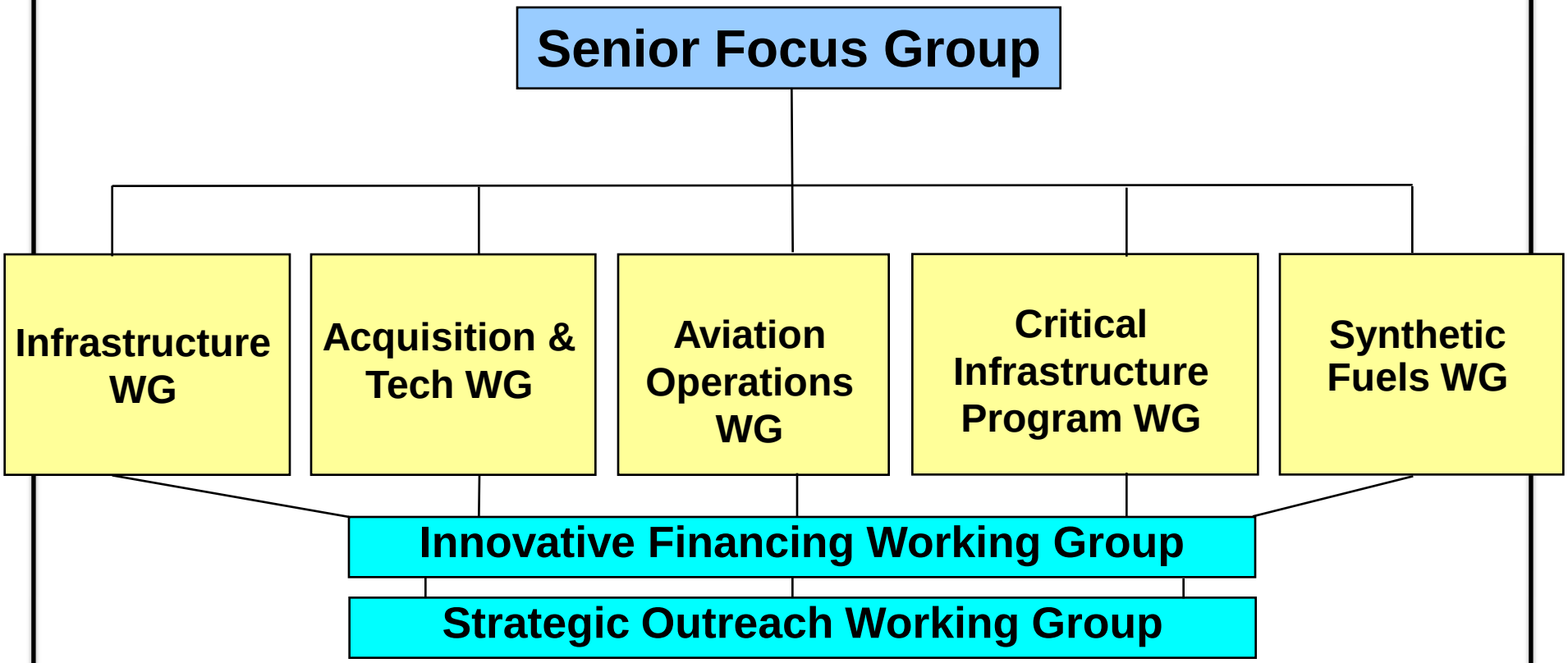
A $10/BBL INCREASE IN THE COST OF CRUDE OIL DRIVES A ~$600M/YR INCREASE IN THE COST TO AF OPERATIONS

Source: DESC FY06 Cost Data

Fuels Enterprise System & Defense Utility Reporting System

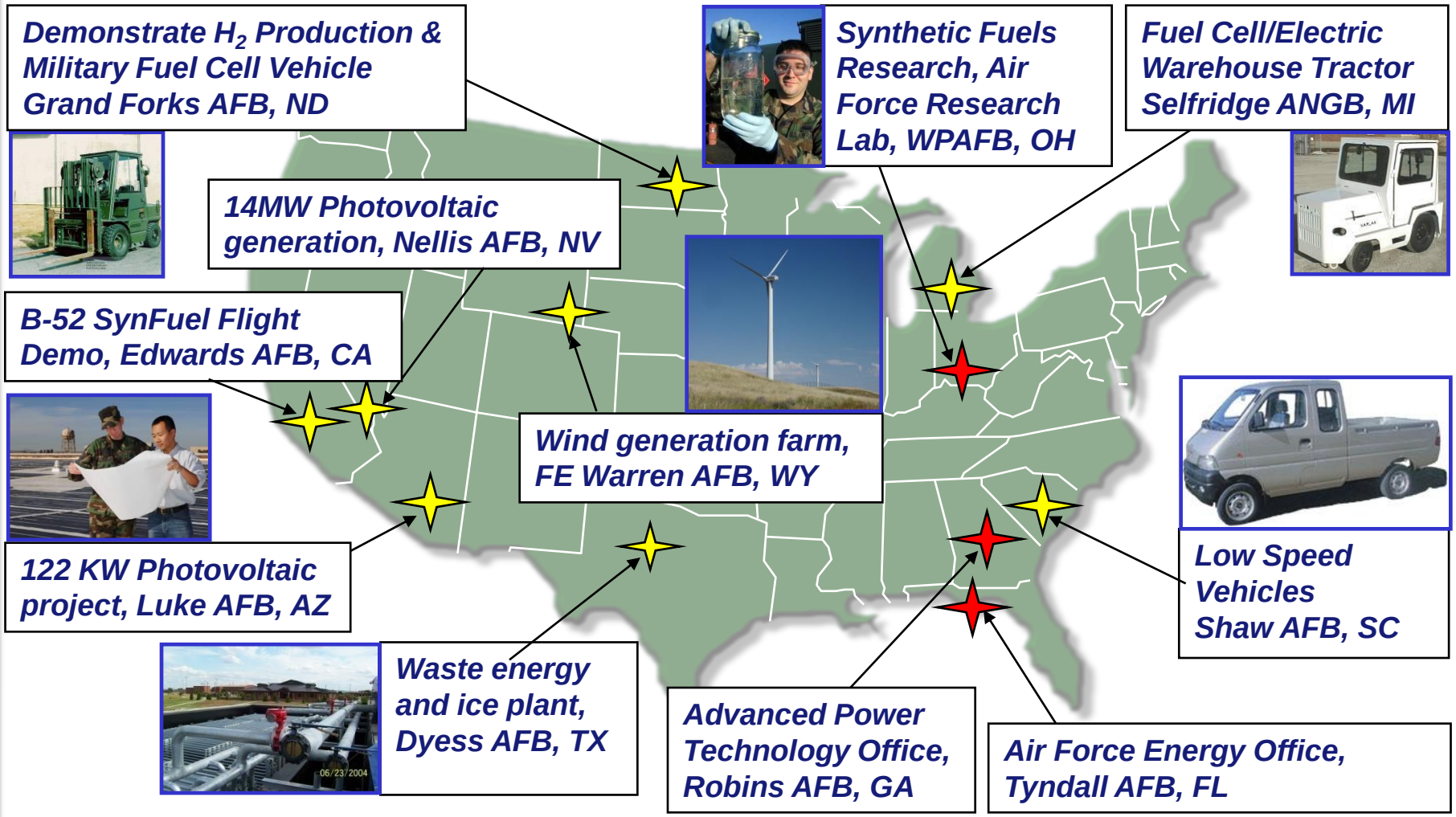
GovEnergy
www.govenergy.gov

Air Force Energy Strategy Oversight Structure



GovEnergy
www.govenergy.gov

Examples of Air Force Energy Initiatives in the United States



GovEnergy
www.govenergy.gov

Demonstration Sites

Center of Excellence

Synthetic Fuel Blend Engine Run (AFRL)

B-52 Initial Flight Test of Synthetic Fuel/JP-8 Blend—Flight Crew (September 2006)

GovEnergy
www.govenergy.gov

AF Energy Strategy
Senior Focus Group

- **Coordinated and developed various programs to improve supply and demand aspects of energy -- Established goals and metrics to manage progress.**

- **Improved efficiency in aviation and infrastructure operations and invested in more energy efficient future systems.**
  - **Infrastructure: Energy Savings / Cost Avoidance – 100,000 homes**
  - **Aviation: 9% reduction in flying hours, 7% reduction in jet fuel used**

- **Encouraged use of alternative sources of energy for infrastructure and aviation applications(AF uses approx. 2.5 billion gallons of fuel annually)**
  - **Infrastructure: Was the nation's largest single purchaser of renewable energy in FY05 (approx. one million megawatt-hours in FY05 and FY06)**
  - **Aviation: Supported synthetic fuel activities (currently exploring biofuel) --First B-52 test fight of a 50/50 blend of synthetic fuel and JP-8 in September 2006 – certified in August 2007**

GovEnergy
www.govenergy.gov

Organizational Awards Received by the Air Force (2005-2007)

- Green Power Partner of the Year Award
  -- Department of Energy (DOE) / Environmental Protection Agency (EPA)

- Climate Protection Award
  -- Environmental Protection Agency (EPA)

- Stratospheric Ozone Protection Award
  -- United Nations Environmental Programme and U.S. Environmental Protection Agency

- Presidential Award for Leadership in Federal Energy Management
  -- To U.S. Air Force Energy Strategy Senior Focus Group

GovEnergy
www.govenergy.gov

United Airlines / Rentech Engineering Validation Flight - *April 30, 2010 (Colorado)*

RenJet Fuel Loading

GovEnergy
www.govenergy.gov

Engines and Energy Conversion Lab
- Algae-Derived Transportation Fuels

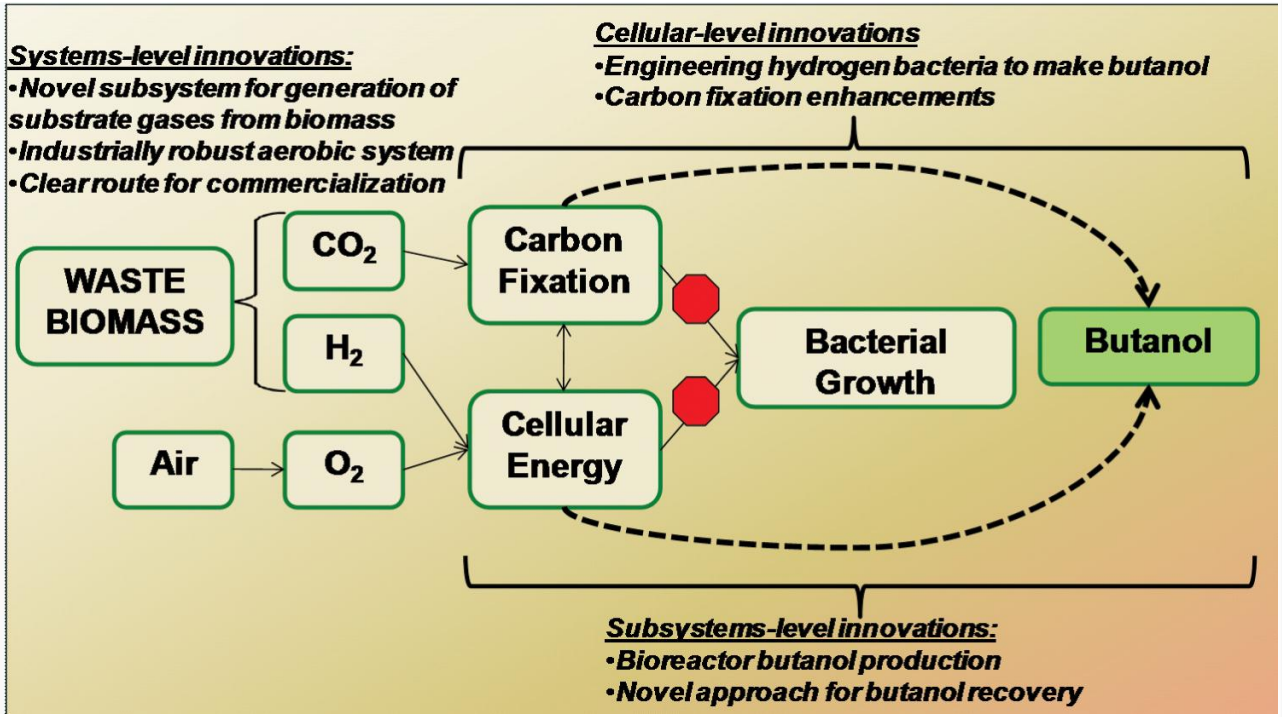
Colorado State University

SOLIX
Fueling a better world

GovEnergy
www.govenergy.gov

Bioconversion of Carbon Dioxide to Biofuels

- Create fuels without petroleum through efficient bioconversion of CO2 into infrastructure-compatible liquid biofuel (butanol) without using photosynthesis.



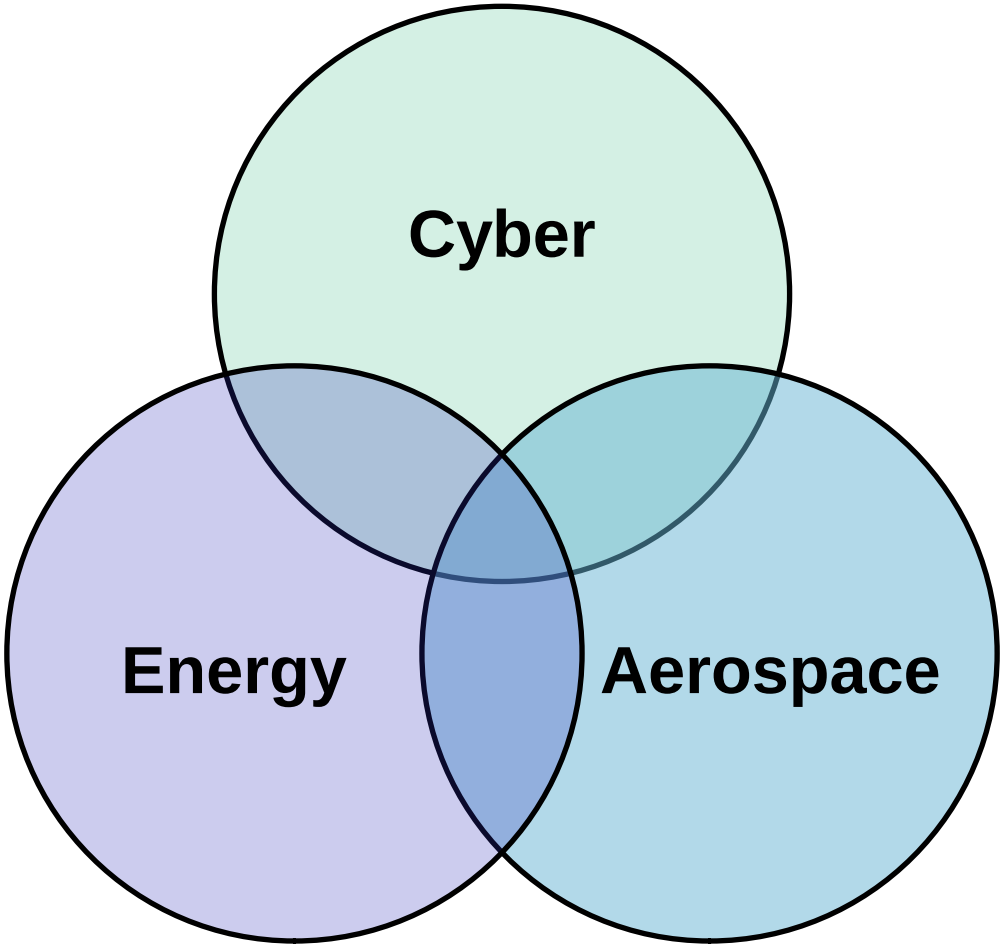
- ARPA-E research project provides viable alternative energy source to fossil fuels
  - Long-term objective: industrial process with significant economic opportunities

GovEnergy
www.govenergy.gov

THE OHIO STATE UNIVERSITY

R. Tabita, S.T. Yang

Technical Disciplines / Communities Needed for Secure Energy Solutions



GovEnergy
www.govenergy.gov

STS-76

Space Shuttle Atlantis to Mir

1996

GovEnergy
www.govenergy.gov

GovEnergy
www.govenergy.gov

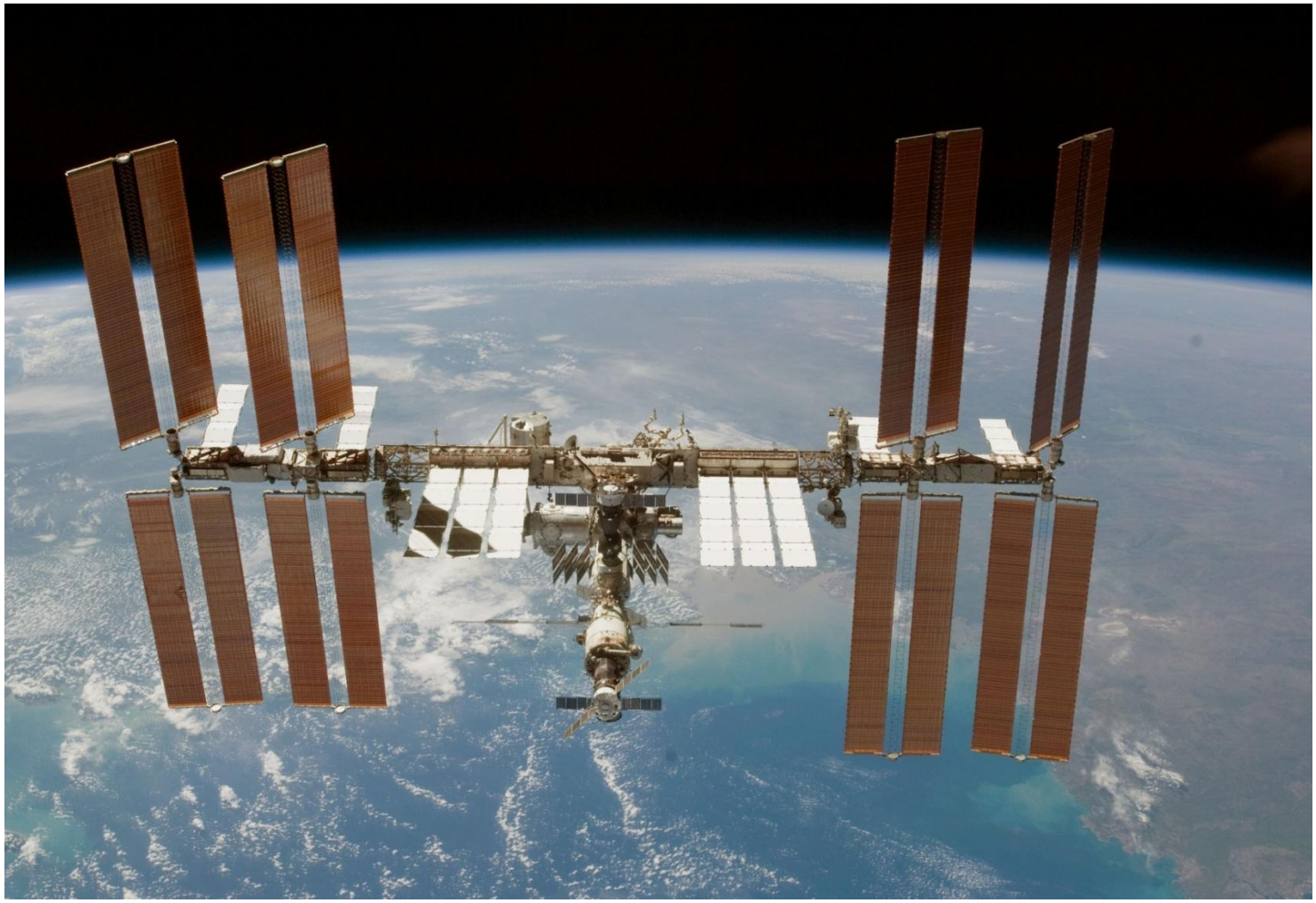
GovEnergy
www.govenergy.gov

GovEnergy
www.govenergy.gov

GovEnergy
www.govenergy.gov

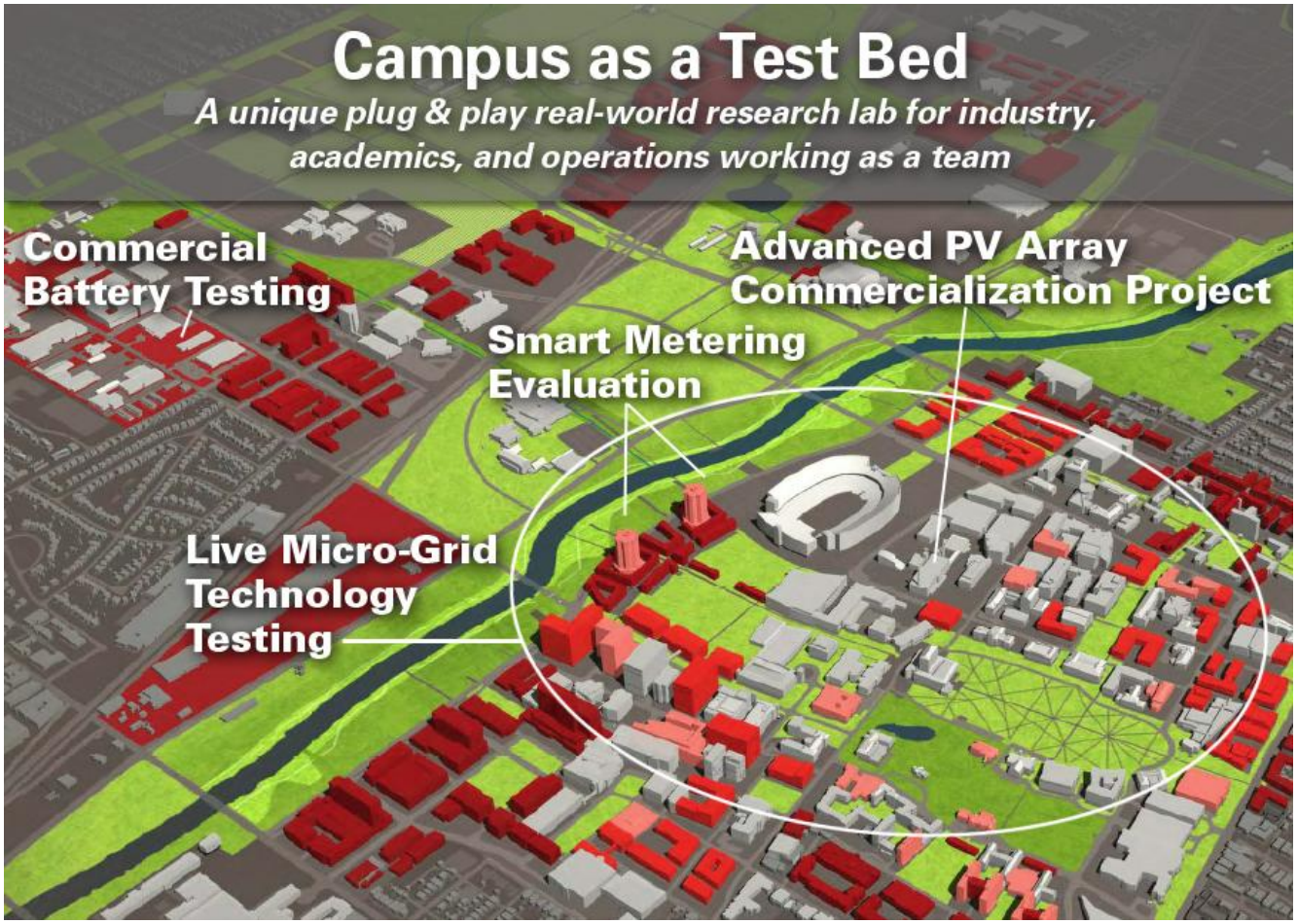
Atlanti-

International Space Station



GovEnergy
www.govenergy.gov

Integrating Academics, Research, and Operations



- Establish a "living labortory" with unique real world data
- Commercialization opportunity for industry
- Potential projects:
  - Live microgrid technology testing
  - Piezoelectric roads
  - Increased awareness of energy use (e.g. dashboards)

GovEnergy
www.govenergy.gov

Concept for an Integrated National Secure Smart Grid Test Center

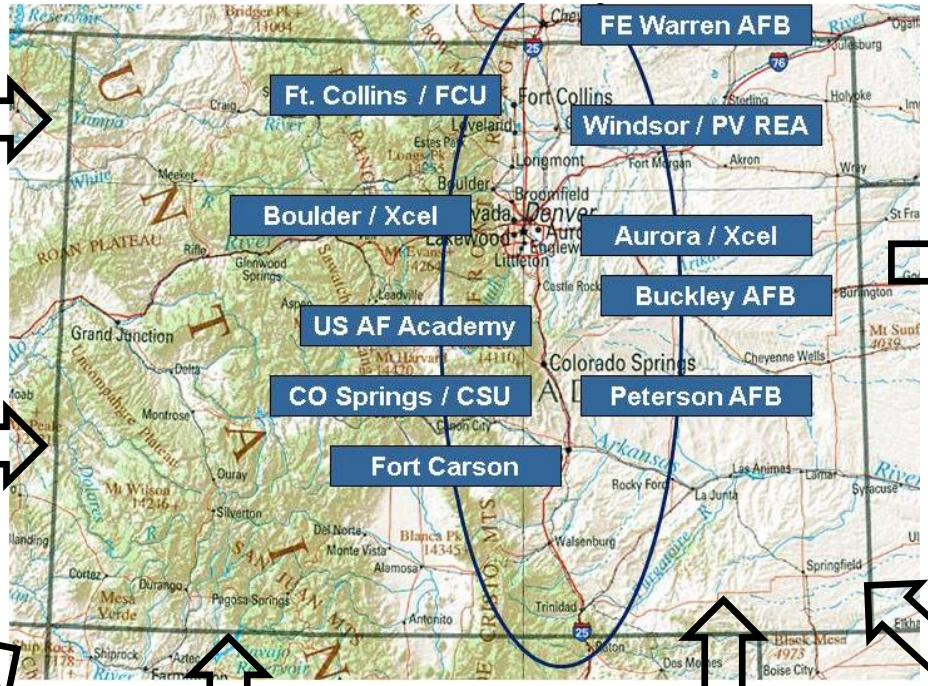
Colorado State University

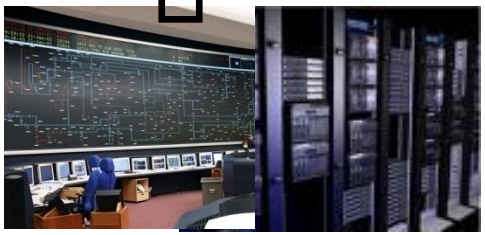
Rocky Mountain Secure Smart Grid "Test Bed"

NREL Labs

InteGrid Lab

Universities and National Labs





Smart Grid Analytics and Training Center

National Model

- Standards
- Best Practices
- Security Models
- Business Models
- Benefits
- Scaling Strategies
- Policy/Regulatory Requirements
- R&D Opportunities

Own-Operate

Host Partners

Design-Build

Tech Partners

GovEnergy
www.govenergy.gov

Engines and Energy Conversion Lab

- **Distribution / Controls Technologies**

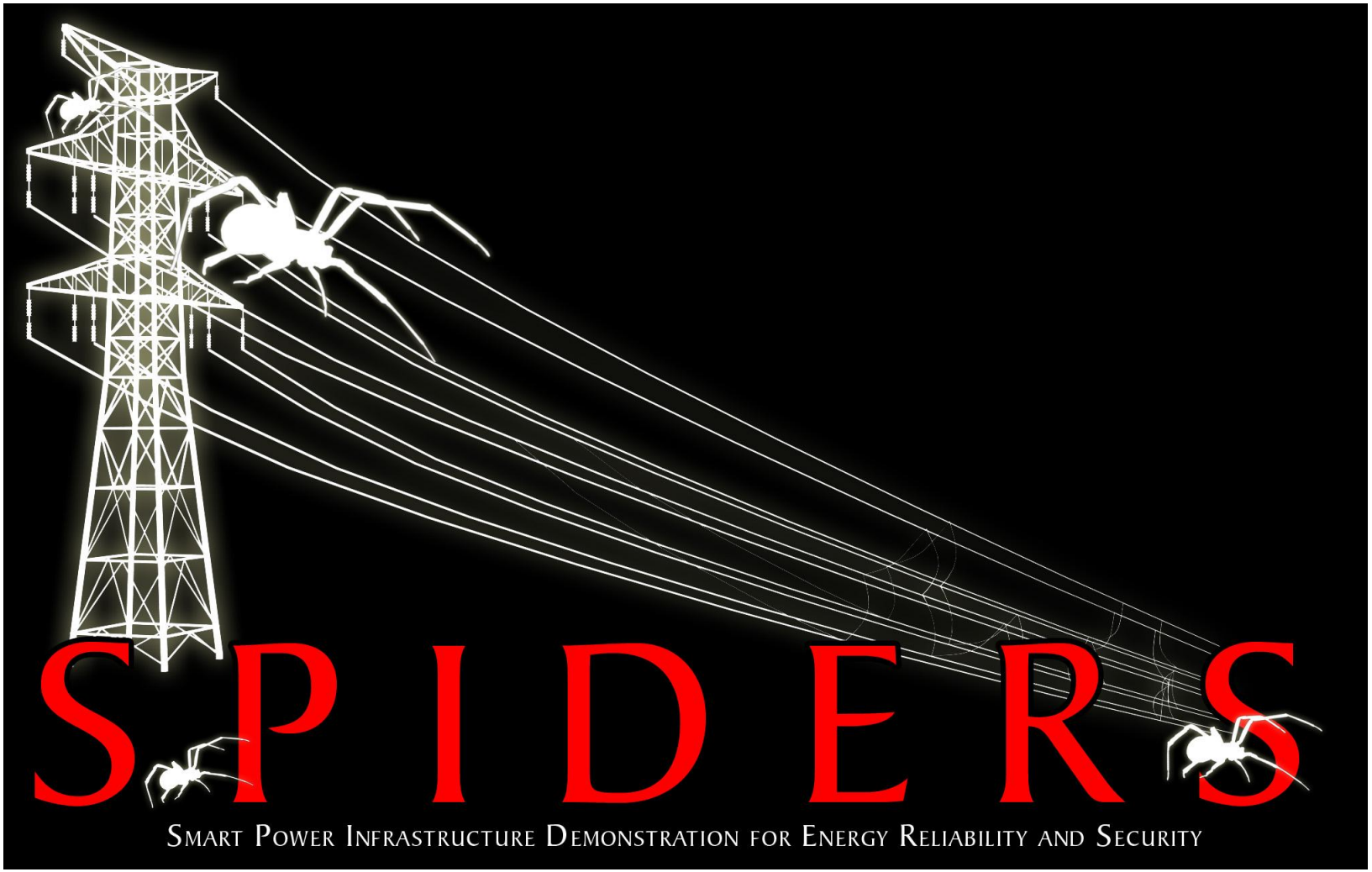
GovEnergy
www.govenergy.gov

“FortZED” – Zero Energy District

- “Research, Development and Demonstration of a Coordinated and Integrated System of 3.5 MW of Mixed Distributed Resources in Fort Collins, Colorado, to Achieve a 20-30% Peak Load Reduction of Multiple Distribution Feeders” – DoE funded proposal ($6.5M + $5M)
- Modernize and transform the electrical distribution system
- Improved efficiency and reliability
- Demonstration includes aggregation of distributed energy resources (DER) from approximately 5 participant locations
- Fort Collins Utilities -- Adding Smart Meters (AMI) with support of an ARRA/DoE Award

GovEnergy
www.govenergy.gov

SPIDERS – Smart Power Infrastructure for Energy Reliability and Security



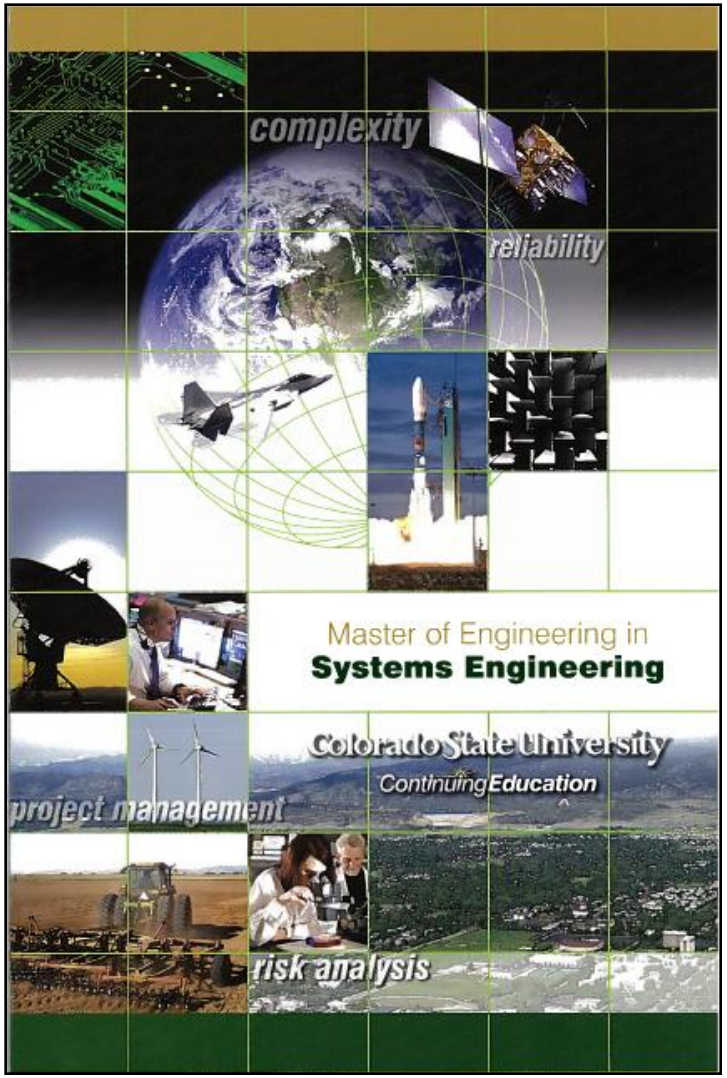
GovEnergy
www.govenergy.gov

Systems Engineering

- Trend toward increasing complexity of systems
  - Aerospace, Energy, Environment, Health Care, etc.
- Needs of industry and government
  - National Surveys
  - Colorado Industry and Government Surveys
- Systems engineering education at CSU
  - Undergraduate emphasis on systems approach
  - Master of Engineering in Systems Engineering began in the Fall of 2008
  - M.S. and Ph.D. in Systems Engineering with an emphasize Energy Systems began in the Fall of 2010

Master of Engineering in Systems Engineering

- **Customer-driven program**
  - Great survey response
  - Working professional focus
  - Began Fall 2008
  - Flexible delivery modes (in-class, out-of-class, synchronous and/or asynchronous)
  - National experts present case studies
- **Final Project / Thesis**
  - Align with Needs
  - Example: Microgrid with Renewables Optimization



GovEnergy
www.govenergy.gov

Renewable Energy Systems for Forward Operating Bases

A Simulations-Based Optimization Approach

Nathan C. McCaskey, 2d Lt, USAF

Colorado State University

Sample Recommendations*

- Photovoltaics (PV) should be considered as highly desirable for reducing fuel consumption
- Wind energy can augment PV at FOBs
- "Value of Leave-Behind Energy" should be used to assess impact of leave-behind strategy
- Tools described in study should be used for site-specific planning
- Install measurement equipment along with renewables installation

Reference: McCaskey's Study

GovEnergy
www.govenergy.gov

Concluding Thoughts

"We owe our current prosperity, security, and good health to the investments of past generations, and we are obliged to renew those commitments in education, research, and innovation policies to ensure that the American people continue to benefit from the remarkable opportunities provided by the rapid development of the global economy and it's not inconsiderable underpinning in science and technology."

Reference: Rising Above The Gathering Storm: Energizing and Employing America for a Brighter Economic Future, National Academy of Sciences, 2005

GovEnergy
www.govenergy.gov