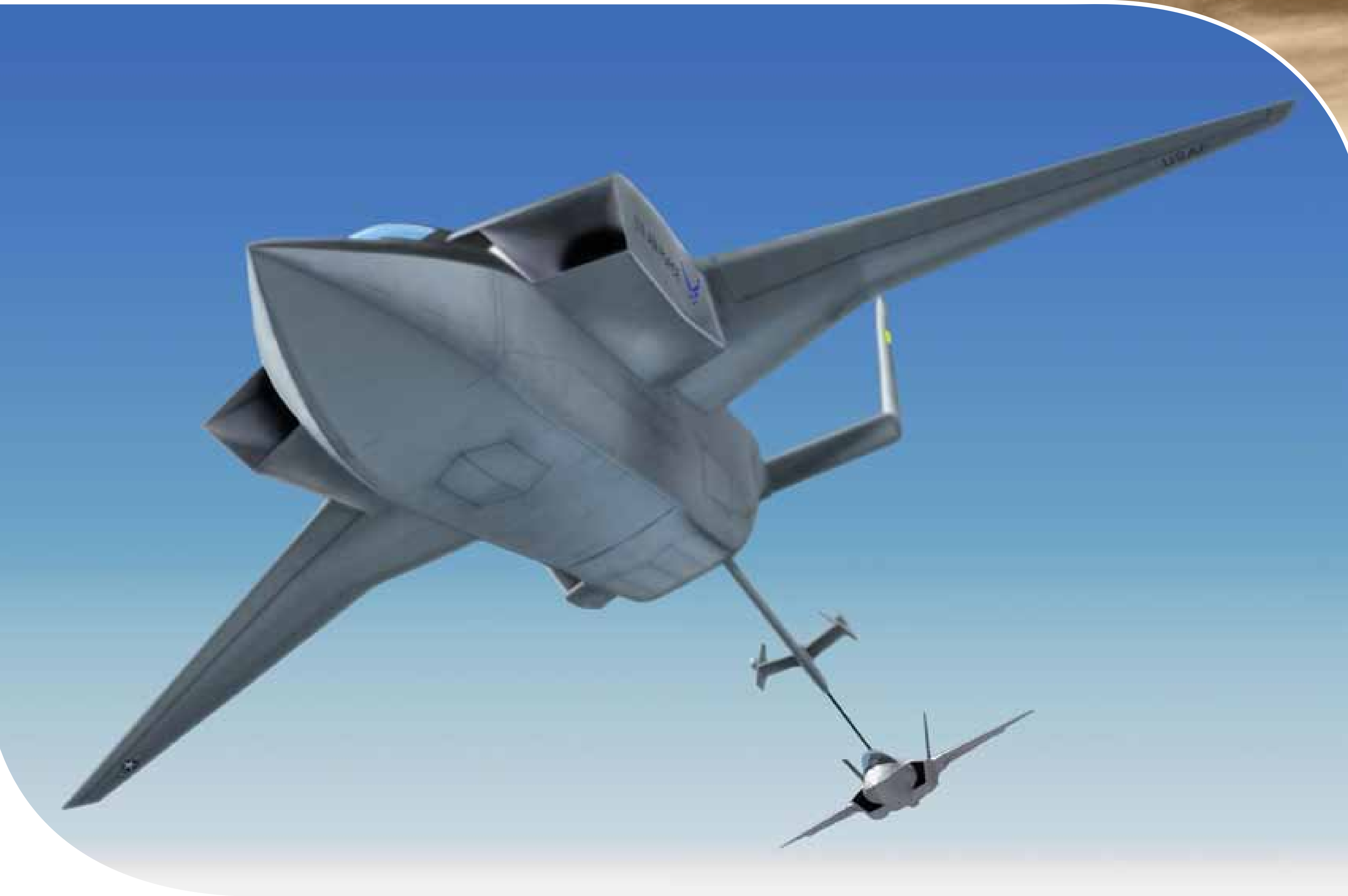
U.S. AIR FORCE



# AIR FORCE ACQUISITION & TECHNOLOGY ENERGY PLAN

## 2010





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The Acquisition and Technology Energy Plan, an appendix to the Air Force Energy Plan, serves as the operational framework for all military and civilian Air Force personnel in communicating Air Force acquisition energy goals, objectives, and metrics. The Acquisition and Technology Energy Plan aligns with the goals outlined in the Air Force Energy Plan and the Air Force Strategic Plan, and is aligned under the Agile Combat Support Master Plan. The Acquisition and Technology Energy Plan supports Air Force Policy Directive (AFPD) 90-17, *Energy Management* and Air Force Instruction (AFI) 90-1701, *Energy Management.* The Assistant Secretary of the Air Force for Acquisition (SAF/AQ) is the Office of Primary Responsibility (OPR) for the Acquisition and Technology Energy Plan.

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# Table of Contents

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# 1 Acquisition & Technology: Mission in Relation to Energy

The Air Force Energy Plan is built upon three goals that guide energy management within the Air Force. Each element of the plan is equally important. The goals are:

- Reduce Demand
- Increase Supply
- Culture Change

The Office of the Assistant Secretary of the Air Force for Acquisition (SAF/AQ) has a significant role in Air Force energy programs with responsibilities for science and technology; the integration of technology with Air Force requirements; technical management of systems engineering and integration; and acquisition contracting. Within SAF/AQ, three offices provide policy and oversight for Air Force energy programs. These offices are the Directorate of Global Power Programs (SAF/AQP), the Deputy Assistant Secretary of the Air Force (Science, Technology and Engineering) (SAF/AQR), and the Deputy Assistant Secretary of the Air Force (Acquisition Integration) (SAF/AQX). SAF/AQ provides the leadership, direction, policy, and resources to acquire superior systems, supplies, and services to accomplish the Air Force mission to *Fly, Fight,* and *Win…*in Air, Space, and Cyberspace.

SAF/AQR is the lead organization for energy matters in SAF/AQ. SAF/AQR directs, plans, and programs for basic research, applied research, and advanced technology development related to the Air Force energy program. SAF/AQP directs, plans, and programs for research, development, and acquisition of Global Power weapon systems. This office monitors the Air Force alternative fuel certification process for all weapon systems, and programs related to the integration of energy-saving technologies into the existing fleet. SAF/AQX provides acquisition integration for the fully burdened cost of fuel, as it relates to operational energy planning (*i.e.,* long-range planning, requirements, and the acquisition process that is not covered by SAF/AQR or SAF/AQP).

Retired Master Sgt. James Lucas holds up a jar of Fischer-Tropsch produced synthetic fuel, which is a 50/50 blend of JP-8 jet fuel and alternative fuel. The Air Force is testing the alternative fuel to help reduce U.S. dependency on foreign oil. Mr. Lucas is a machinist for the Arnold Engineering Development Center. (U.S. Air Force photo/ Staff Sgt. Bennie J. Davis III)

Air Force governance for acquisition and technology programs related to energy is coordinated by the Acquisition and Technology Working Group that reports to the Energy Senior Focus Group. SAF/AQ chairs the working group, which also includes members from the Deputy Chief of Staff, Logistics, Installations and Mission Support office (AF/A4/7), the Air Force Chief Scientist (AF/ST), and the Defense Energy Support Center (DESC).

In relation to the goals of the Air Force Energy Plan: *Reduce Demand, Increase Supply,* and *Culture Change,* the Acquisition and Technology Working Group is charged with developing energy options that increase warfighting capabilities through utilizing reliable alternative energy resources, enhancing energy efficiency, and reducing life cycle costs associated with Air Force acquisitions. From advanced design systems and efficient/adaptive engines to testing and certifying aircraft to run on alternative fuel blends, the Acquisition and Technology community plays a critical role in realizing the goals of the Air Force Energy Plan.

1Lt Alexis Marruffo setting up and field testing Battlefield Renewable Integrated Tactical Energy System (BRITES). BRITES consists of a power manager, battery, fuel cell, and energy harvesting component hybridized to supply extended soldier portable power.
(U.S. Air Force photo/Mr. Rich Higgins)

Energy programs in the Acquisition and Technology area can be divided into two groups: programs that use available technologies that are targeted at the legacy fleet, and science and technology programs that develop new, higher-capability weapon systems or technologies that can be retrofitted into the legacy fleet. Aviation operations use approximately 84 percent of the energy consumed by the Air Force, with jet fuel as the single largest energy commodity purchased by DoD. Most SAF/AQ programs are focused on weapon system capability improvements. Historically, improvements in weapon system capabilities resulted in the need for fewer platforms, reducing demand for aviation fuels. However, since the Air Force purchases fewer new platforms, additional emphasis will need to be placed on technologies that reduce fuel consumption and greenhouse gas emissions, while maintaining or increasing weapon system capabilities in the legacy fleet. In addition, a pipeline of new cutting-edge technologies such as advanced fuel efficient engines, light-weight materials, and advanced aircraft designs are needed to reconfigure legacy fleets with high capability systems that use less fuel and produce fewer emissions.

Innovation in both technology and processes may drive additional energy improvements. For example, some technologies that offer high payoffs for future aircraft may also yield significant energy savings in ground-based applications. Technologies, solutions, and approaches that integrate energy generation and distribution technologies for persistent intelligence, surveillance, and reconnaissance (ISR) platforms are fundamentally the same as those for distributed power at bases and forward operating locations. By analyzing sets of similar problems, technologies may be developed that provide multiple Air Force capabilities. Some technologies may need a maturation phase where size and weight are not critical design factors and thus a ground phase of technology maturation is then followed by an aircraft maturation phase. Notionally, concepts such as the power distribution for a persistent ISR platform might benefit from this type of approach. Adaptive thinking that weighs both aircraft and ground applications as technology pathways may offer new solutions to improve overall system efficiencies and improve operational resilience.

# 2 Strategic Approach

## Overview

The Air Force's overarching energy goals: *Reduce Demand, Increase Supply,* and *Culture Change,* are supported by the Acquisition and Technology Energy Plan. The Acquisition and Technology community will focus on the following areas to help meet the tenets of the Air Force Energy Plan:

- Alternative fuel evaluation and certification
- Aircraft component and subsystem technology development to increase efficiency and reduce fuel burn
- Fuel efficient engines for new platforms and the transition of fuel efficiency technologies into the legacy fleet
- Advanced aircraft designs and aircraft modifications
- Advanced lightweight composites and green materials
- Evaluation of new energy technologies to unique military applications

The Acquisition and Technology Energy Plan is structured around two primary strategies:

- Reducing fuel burn and greenhouse gas emissions in legacy systems via engine and aircraft upgrades
- Advanced Research and Development (R&D) to reduce fuel demand, increase fuel supply, and reduce greenhouse gas emissions in legacy and future systems

These strategies are designed to increase the trade space between capability and energy savings. Assumptions include no degradation of current capabilities, and no increase in acquisition, development, or maintenance costs.

Meeting the goals of the Acquisition and Technology Energy Plan requires a strategy that combines innovative research and development, strong technology transition pathways, and effective program execution to achieve key energy-specific objectives that reduce fuel burn and greenhouse gas emissions, while improving or maintaining weapon system capabilities.

## Legacy Systems

The Air Force developed specific goals around the two primary strategic areas of the Acquisition and Technology Energy Plan. The energy goals for legacy systems revolve around near-, mid-, and long-term aircraft and engine modifications, as well as alternative fuels certification processes. Legacy systems can meet goals for fuel burn reductions and reduced greenhouse gas emissions through a series of structured modifications as aircraft cycle through the depots. The insertion of improved engine technologies into engines as they cycle through the depot also preserves a diverse industrial base of engineers and parts suppliers that will be critical in the future for advanced weapon system designs and procurements. Targeted propulsion system upgrades, aircraft modifications and alternative fuel certifications should yield fuel use changes. At this time, energy efficiency improvements to legacy propulsion and aircraft systems are not funded. The following goals should be achievable with the proper funding:

- **Near-Term**—2016
  - Reduce fuel burn by 5 percent
  - Increase alternative fuel consumption to 50% of Air Force CONUS requirement
- **Mid-Term**—2020
  - Reduce fuel burn by 10 percent
- **Long-Term**—2030
  - Reduce fuel burn by 20 percent

## Research and Development

R&D goals include alternative fuels evaluation and certification, advanced aircraft subsystem technologies, efficient/adaptive engine technology development, and advanced platform designs, all of which are to be achieved by 2016 to meet the challenges of reducing demand in future systems and increasing potential fuel supplies in the near- and mid-term. The R&D goals are:

- **Reduce Demand**—Increase lift-to-drag ratio by 20 percent and reduce installed specific fuel consumption by 25 percent
- **Increase Availability**—Develop alternative fuels to enable 50 percent of the fuels purchased by 2016 to be 50/50 blends of alternative fuel with petroleum fuels

Air Force technology programs produce mature technologies through evaluation and testing to demonstrations that prove the viability of the concept. Technologies that have been demonstrated in a relevant environment can potentially mature through engineering and application across legacy platforms. The level of engineering and modification required to achieve the overall energy efficiency goal for the platform determines the time required for implementation, as shown in Figures 1 and 2.

Figure 1 provides a conceptual model for how the implementation of technology, whether it is the modification of engines or the redesign of wingtips, produces incremental reductions in energy usage associated with legacy platforms. The improvement is realized as the aircraft or engine cycles through the depot process and is then reincorporated into the fleet. For example, the modification of airframes to include winglets in commercial aircraft resulted in reduced drag, increased range, and an overall reduction in fuel burn. These aerodynamic shaping concepts offer similar benefits for some legacy aircraft.

Figure 2 illustrates the processes involved in the application of technology, from engineering and design optimization to technology integration in legacy platforms. For each new modification, a period of time is required for the engineering and production of new parts. In addition, depot processes must be modified to incorporate the design change into the depot cycle. The benefit of these modifications is gradual as the weapons are modified and returned to the fleet. Since the design of the weapon system is fixed, improvements in fuel burn also provide capability

**Figure 1** Implementation of Technologies to Enhance Energy Efficiency and Reduce Emissions: A Conceptual Model

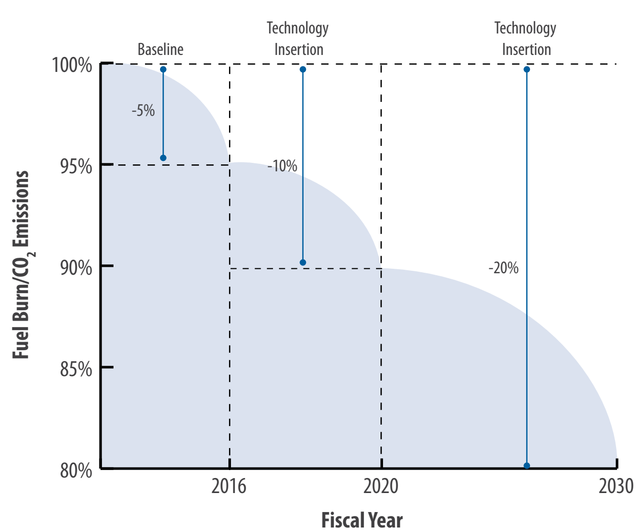
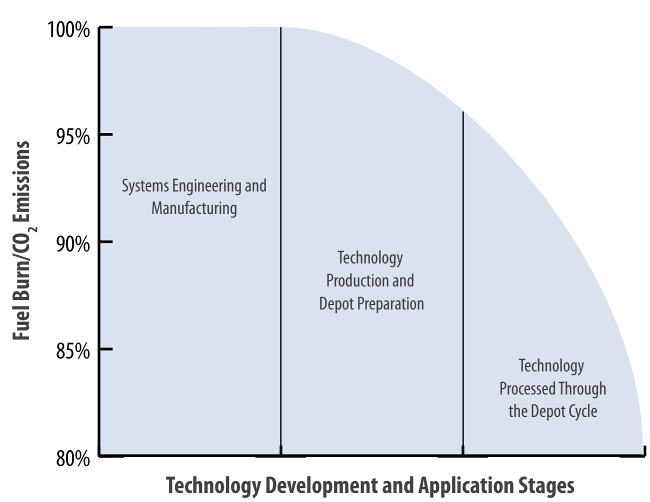



**Figure 2** Technology Application Curve: A Conceptual Model



enhancements. For example, an operator may choose to load less fuel and reduce overall fuel consumption for a given mission or could use the existing fill capacity of the fuel tanks to allow for extended range or increased loiter time.

The Air Force's R&D strategy for energy efficiency and emissions reduction assesses technology on three horizons: near-, mid-, and long-term. The near-term horizon is defined as technologies that are commercially available today. The Air Force can apply these off-the-shelf technologies to legacy aircraft to reduce fuel burn and greenhouse gas emissions while maintaining or enhancing platform capabilities. For example, incremental changes in platforms—such as upgrading engine seals or altering engine fan blades—can enhance the range and durability of existing platforms without completely retrofitting the airframe with a new engine. These "low-hanging fruit" modifications increase fuel efficiency immediately upon application to the fleet, are low cost, and can be performed as part of the overhaul process at depots.

Mid-term strategies focus on technologies that demonstrate a high Technology Readiness Level (TRL) and show technical viability but are not yet transitioned to commercial or Air Force equipment, as illustrated in Figure 3 below. By applying these technological advancements, weapon systems will gain improvements in fuel efficiencies and overall system capabilities. These modifications will require component engineering, parts production and integration into the depot process, and could provide opportunities for maintaining a robust industrial base. Aircraft aerodynamic modifications such as winglets, finlets, or advanced aerodynamic shaping concepts may require significant engineering, but could yield overall system improvements.

Long-term strategies focus on cutting-edge technologies that offer high potential payoffs, but are in the early stages of R&D. The Air Force is a known leader in turbine engine technology development, and this state-of-the-art technology results in capability enhancements such as improved fuel burn; improved performance, range, and energy efficiency; and increased maneuverability. The Air Force is continually testing technologies and assessing next generation R&D requirements to ensure mission effectiveness now and into the future. Developing pathways to bring these technologies into the legacy fleet of engines would provide performance, maintenance, and overall system capability improvements as well as reductions in fuel burn.

Assessing the stage at which technology is ready for deployment requires a systematic approach to the R&D cycle. From basic research to operational system development, the maturation stage of

**Figure 3** Technology Readiness Level

**Technology Readiness Level (TRL)**

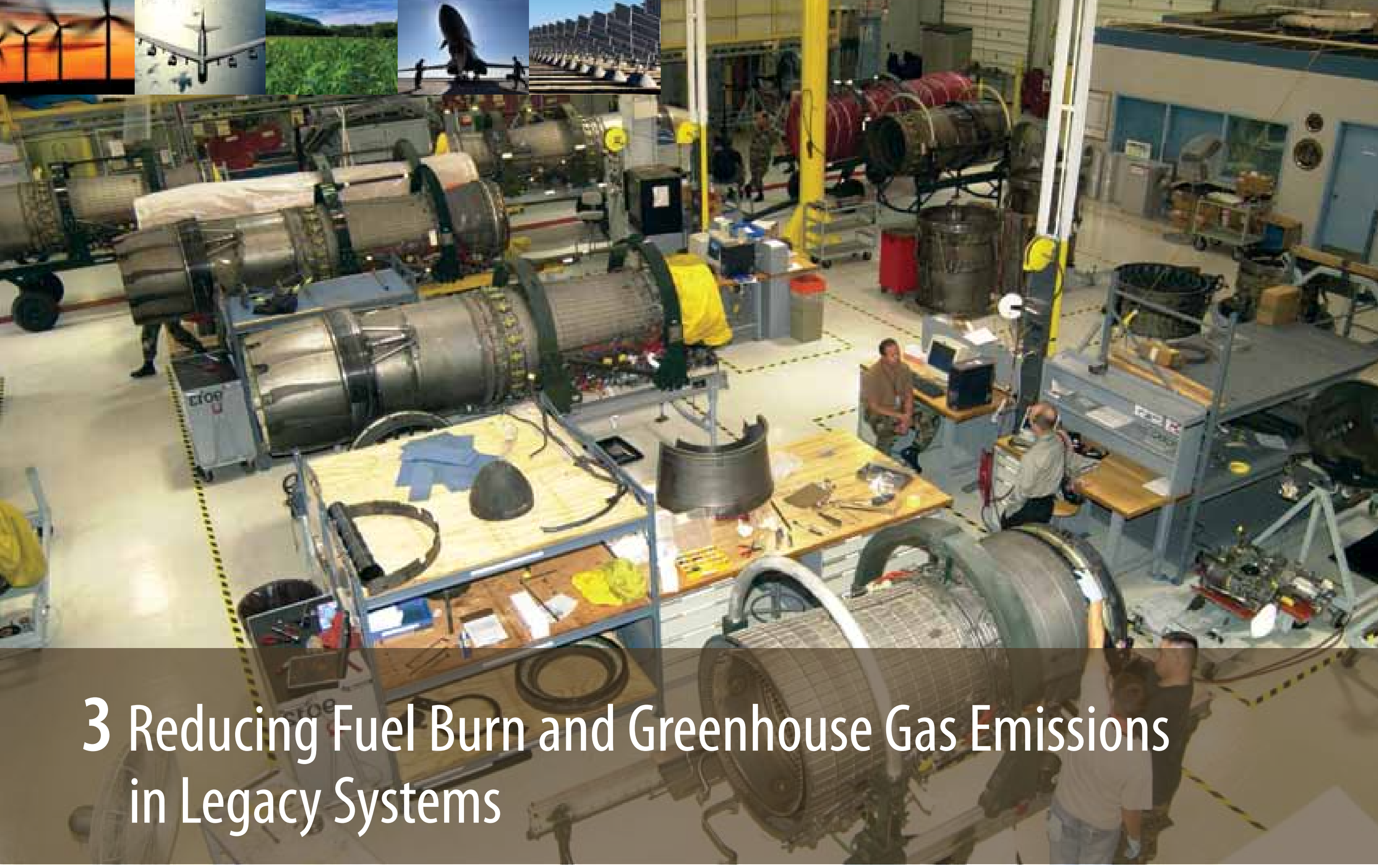
| TRL | Definition | Description |
|---|---|---|
| 1 | Basic principles observed & reported | Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Example might include paper studies of a technology's basic properties. |
| 2 | Technology concept and/or application formulated | Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative and there is no proof or detailed analysis to support the assumption. Examples are still limited to paper studies. |
| 3 | Analytical and experimental critical function and/or characteristic proof of concept | Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative. |
| 4 | Component and/or breadboard validation in laboratory environment | Basic technological components are integrated to establish that the pieces will work together. This is "low fidelity" compared to the eventual system. Examples include integration of 'ad hoc' hardware in a laboratory. |
| 5 | Component and/or breadboard validation in relevant environment | Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that the technology can be tested in a simulated environment. Examples include 'high fidelity' laboratory integration of components. |
| 6 | System/subsystem model or prototype demonstration in a relevant environment | Representative model or prototype system, which is well beyond the breadboard tested for TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high fidelity laboratory environment or in simulated operational environment. |
| 7 | System prototype demonstration in an operational environment | Prototype near or at planned operational system. Represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in an operational environment, such as in an aircraft, vehicle or space. Examples include testing the prototype in a test bed aircraft. |
| 8 | Actual system completed and 'flight qualified' through test and demonstration | Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications. |
| 9 | Actual system 'flight proven' through successful mission operations | Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. In almost all cases, this is the end of the last "bug fixing" aspects of true system development. Examples include using the system under operational mission conditions. |

Source: Department of Defense (2006), Defense Acquisition Guidebook


A 72,000 pound, environmentally-friendly hybrid refueling truck was used for B-52 Stratofortress testing of the new 50/50 blend of alternative fuel. The refueling truck used the same Fischer-Tropsch and jet fuel JP-8 blend tested on the B-52. (Photo by Staff Sgt. Mark Woodbury)

technology can be assessed along a scale known as TRL. The TRL tool provides a framework for planning, managing, and assessing the pathways necessary to take technology from a concept to an operational system. When technologies are at TRL 6, they are ready for the additional engineering steps to mature them for incorporation into a future or legacy platform. Continuous analysis of TRL 6 technologies that support the Air Force energy goals will be a part of the technology and acquisition process.

As the Air Force enhances its operational platforms, whether it is through legacy system modifications or advanced R&D that is used in the design of future systems, energy will be a key part of the equation for the way forward. Energy is emerging as a significant strategic and tactical challenge that the Air Force must address in all of its acquisition and technology programs. In order to achieve maximum utility of legacy fleets and reduce energy consumption across platforms, the Air Force must apply existing technologies that enhance platform capabilities and energy efficiency to legacy systems and build bridges to create technology transition pathways across the Acquisition and Technology community for additional improvements over time.



# 3 Reducing Fuel Burn and Greenhouse Gas Emissions in Legacy Systems

## The Strategy

Improving the energy efficiency of the Air Force's tactical assets produces a series of win-win situations. A reduction in fuel consumption results in environmental benefits and cost savings that can be made available for maintaining military readiness. Additionally, fuel efficiency enhancements aid operational endeavors by reducing the demand and frequency of delivered fuel in the field, which pose logistical and security pressures.

The Air Force can reduce energy demand in legacy systems through a series of upgrades to engines and modifications to aircraft, which improve efficiency and reduce drag. Engine technologies that have been developed by the Air Force and industry, and have been applied to either military or commercial aircraft, are the "low hanging fruit" that can be harvested to achieve reduced fuel burn and greenhouse gas emissions. For example, improvements to seals, surface finishes of fan and turbine blades, improvements to blade tip clearance, and additional engine washes can be implemented with modest changes to depot processes. Advancing technologies such as advanced turbine and fan blade aerodynamic designs, improved engine blade materials, advanced combustors, advanced control systems, winglets, and other aerodynamic shaping enhancements would require additional engineering for targeted weapon systems but could reduce fuel burn significantly. In addition, some aircraft could benefit from replacing old fuel inefficient engines with state-of-the-art modern engines. Additionally, a series of legacy fleet improvements could enhance the industrial base of engineers and component suppliers during periods of limited new system procurements.

Increasing supply requires the review of emerging alternative fuels starting with the laboratory evaluation process through certification by the Air Force Alternative Fuel Certification Office (AFCO). The availability of alternative fuels from fossil, biomass, and combinations of fossil and biomass, offers the potential to increase supply, diversify the supplier base, and improve the overall characteristics of jet fuels. Certification processes must assure that the fuels are drop-in replacements that meet all performance and durability requirements compared to legacy petroleum fuels, and that risks are known and acceptable to weapon system single managers.

The Acquisition and Technology community is also committed to the culture change tenets by improving and streamlining processes that would implement technologies to reduce fuel burn and greenhouse gas emissions, promoting innovation for new technologies, and assuring appropriate resources are applied to energy-related systems.

The Air Force Acquisition and Technology Energy Plan for legacy fielded systems is comprised of four pillars (Figure 4):

- **Pillar 1**—Aircraft upgrades and modifications using off-the-shelf technologies (near-term—reduce fuel burn by 5 percent by 2016)
- **Pillar 2**—Aircraft upgrades and modifications that require moderate engineering and depot changes (mid-term—reduce fuel burn by 10 percent by 2020)

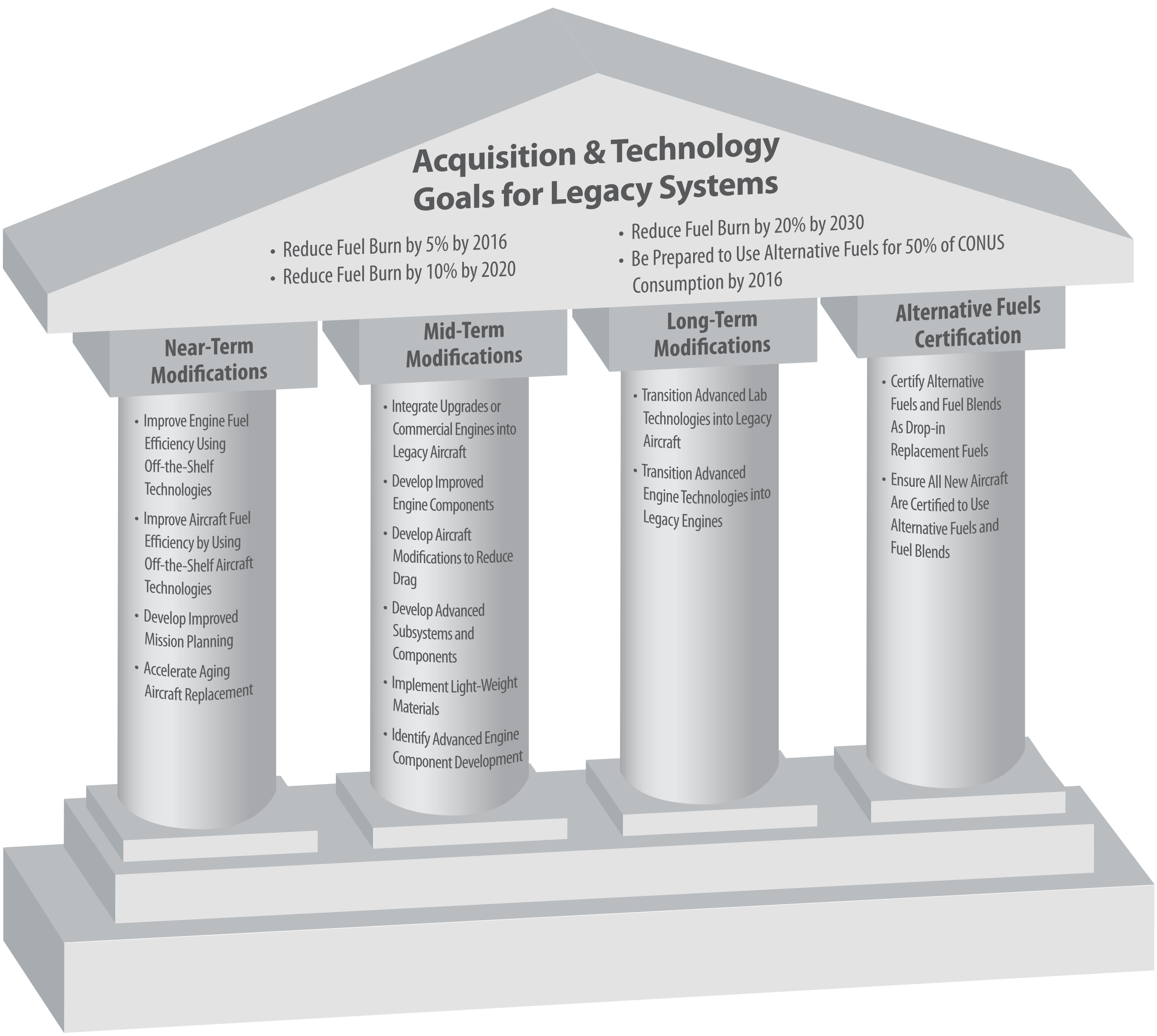
- **Pillar 3**—Transition of advanced engine and aircraft technologies from on-going science and technology (S&T) programs into aircraft upgrades for legacy systems (long-term—reduce fuel burn by 20 percent by 2030)
- **Pillar 4**—Certification of alternative fuels to increase supply and reduce greenhouse gas emissions

These legacy systems energy goals are built upon a framework of enabling processes that include the adoption of advanced aircraft and engine technologies when they are mature and available for integration into legacy systems, streamlining the engine modification process to enable continuous upgrades at appropriate times to keep engines current with existing technologies, and enhanced acquisition processes that enable rapid integration of advanced technologies into legacy systems to improve fuel burn and reduce greenhouse gas emissions.

The Air Force energy culture message is fostered through senior leaders to all members of the acquisition community including scientists, engineers, program managers, weapon system single managers and to the system operators and maintainers to make energy a consideration in all activities. Through mature acquisition programs, weapon system capability improvements can be achieved while simultaneously meeting reductions in fuel burn, greenhouse gas emissions, and achieving or exceeding system performance goals. For example, engine modifications that improve overall cycle efficiency often improve component sustainability.

Improved sustainability can improve readiness and other performance metrics. Fuel efficiency improvements increase range or loiter time with the same volume of fuel loaded on an aircraft. Weapon systems operators can use the improvements to meet fuel efficiency and greenhouse gas emissions reduction in training environments while taking advantage of the improved capabilities in combat.

**Figure 4** Strategic Pillars for Legacy Systems



## Pillar 1: Near-Term Aircraft and Engine Modifications

This pillar focuses on the identification, engineering, and modification of aircraft using near-term, off-the-shelf components and technologies to reduce fuel burn by 5 percent and reduce the associated greenhouse gas emissions. Technologies will consist of mature technologies that have been demonstrated in military or commercial engines, requiring minimal engineering, tooling, and impact on the engine or aircraft production through the depot process. Near-term modifications would be implemented as part of continuous upgrades to the build standards of the aircraft or engine as it moves through established depot processes. It is anticipated that there will be a lag time and additional cost for the development of proper engineering and depot equipment procedures for the implementation of the technology, but the benefits of the modifications would be realized as soon as the aircraft or engine completed the depot process and returned to operational units.


**Reducing Fuel Burn and Greenhouse Gas Emissions in Legacy Systems**

**Pillar 1: Near-Term Aircraft and Engine Modifications**

| Objectives | |
|---|---|
| **1.1** | Identify engine modifications that use existing off-the-shelf technologies. |
| **1.2** | Identify aircraft modifications that reduce drag. |
| **1.3** | Identify programs to improve mission planning, power management, and subsystem efficiencies. |

**Objective 1.1:** Identify engine modifications that use existing off-the-shelf technologies.

Technologies that have been demonstrated on military or commercial engines and are considered mature could be incorporated into the depot upgrade process. Technologies may include, but are not limited to new seals, tip tolerance improvements, new or reworked fan and turbine blades, improved controls, and new combustors. Technologies chosen will require minimal engineering for application on legacy engines, short lead times for production of parts, and minimal changes to the depot process.

**Objective 1.2:** Identify aircraft modifications that reduce drag.

Technologies may include, but are not limited to finlets, laminar flow nacelles, winglets, improved integration of antennae, and flow control modifications. Technologies chosen will require minimal engineering for application on legacy engines, short lead times for production of parts, and minimal changes to the depot process.

**Objective 1.3:** Identify programs to improve mission planning, power management, and subsystem efficiencies.

Mission planning and power management technologies will enhance fuel savings for operational aircraft. New energy efficient components will be implemented to reduce engine bleed, improve component efficiency, and reduce aircraft cooling or to improve overall aircraft energy and thermal management. Technologies chosen will require minimal engineering for application on legacy engines, short lead times for production of parts, and minimal changes to the depot process.

Since entering service in 1992, the F110-GE-129 has proven to be one of the most successful fighter engines in U.S. Air Force history. Because of the F110 engine's proven safety track record and heritage of high reliability, the F110 has been chosen to power more than 75% of the Air Force's single engine F-16 Block 50/52 aircraft.

## Pillar 2: Mid-Term Aircraft and Engine Modifications

This pillar focuses on the modernization of legacy systems through the use of fuel-efficient derivative, upgraded, or commercial technologies. Projected weapon system force structure for the next 15-20 years indicates that fielded systems will continue to dominate and new systems will be acquired at slower rates and in smaller numbers than the legacy fleets they replace. Modifications or upgrades of current engines can incorporate design improvements to reduce fuel burn and greenhouse gas emissions reduction and will provide immediate fuel savings to operational fleets. In addition, weapon systems will benefit from increased reliability, time on wing, safety, and reduced noise.


**Reducing Fuel Burn and Greenhouse Gas Emissions in Legacy Systems**

**Pillar 2: Mid-Term Aircraft and Engine Modifications**

| Objectives | |
|---|---|
| **2.1** | Identify advanced derivative, upgraded, or commercial engines insertion programs for system upgrades to provide fuel savings and reductions in greenhouse gas emissions for operational aircraft. |
| **2.2** | Identify advanced aircraft modification programs to reduce drag, improve system performance, and reduce fuel burn and greenhouse gas emissions. |
| **2.3** | Identify advanced aircraft subsystems modification programs to improve overall aircraft system efficiencies to reduce fuel burn and improve thermal performance. |
| **2.4** | Identify advanced components produced using light-weight and green materials. |
| **2.5** | Identify advanced sensor and computational capabilities to improve aircraft operations to reduce fuel burn. |
| **2.6** | Identify advanced engine component development to improve compressors, turbines and other engine components using existing off-the-shelf technologies. |

**Objective 2.1:** Identify advanced derivative, upgraded, or commercial engines insertion programs for system upgrades to provide fuel savings and reductions in greenhouse gas emissions for operational aircraft.

The Air Force will plan to develop, integrate, produce, and install these engines and major engine modifications during depot cycles. Emphasis will focus on engines and engine technologies that require moderate design, engineering, and aircraft modifications for implementation. Minor to moderate changes to depot and maintenance processes will be required to implement engine modifications. The Air Force will develop plans, schedules, and programs to insert advanced engine technologies and upgraded engines to maximize benefits while maintaining current depot maintenance schedules.

**Objective 2.2:** Identify advanced aircraft modification programs to reduce drag, improve system performance, and reduce fuel burn and greenhouse gas emissions.

Aircraft modification programs that require moderate engineering, fabrication, and modification of aircraft wings and fuselages will be developed.

**Objective 2.3:** Identify advanced aircraft subsystems modification programs to improve overall aircraft system efficiencies to reduce fuel burn and improve thermal performance.

The Air Force will develop program plans and roadmaps for project implementation and integration into depot modification processes based on projected lifetimes of the platform and mission requirements.

The F119-PW-100 turbofan is the only operational fifth generation fighter engine to date. It is the most advanced production engine, combining stealth technologies and vectored thrust with high thrust-to-weight performance to provide unprecedented maneuverability and survivability.

**Objective 2.4:** Identify advanced components produced using light-weight and green materials.

The Air Force will develop plans and roadmaps to reduce aircraft weight by programming replacements of components and structures with light-weight materials.

**Objective 2.5:** Identify advanced sensor and computational capabilities to improve aircraft operations to reduce fuel burn.

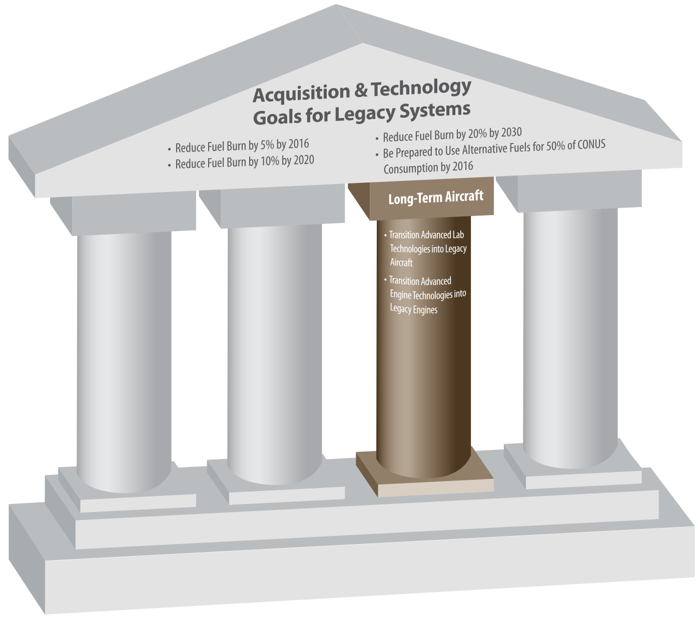
Technologies that improve mission planning, mission execution, formation flying, and other operational tools to reduce fuel usage should be pursued. The Air Force will develop plans and roadmaps for system integration.

**Objective 2.6:** Identify advanced engine component development to improve compressors, turbines and other engine components using existing off-the-shelf technologies.

Engine components that were developed in prior engine technology development programs, such as the Integrated High Performance Turbine Engine Technology (IHPTET) program or in the development of commercial engines, will form the basis for developing kits that may be incorporated in engines during overhaul or at intermediate repair stations. The Air Force will develop program roadmaps for the candidate engine and system modifications. The roadmaps will project fuel usage with technology incorporation and projected fuel savings to the goal timeframe and beyond. Minor to moderate changes to depot and maintenance processes will be required.

## Pillar 3: Long-Term Aircraft and Engine Modifications

As advanced technologies are developed, the Air Force should include them in the design trade space to integrate these technologies into legacy and new systems. Plans, management systems, and orderly execution are all relevant to moving the technologies to operational platforms. Technologies scheduled for maturity/production in 2016 should be implemented as soon as practical to reduce fuel burn and greenhouse gas emissions, and improve capabilities.




**Reducing Fuel Burn and Greenhouse Gas Emissions in Legacy Systems**

**Pillar 3: Long-Term Aircraft and Engine Modifications**

| Objectives | |
|---|---|
| **3.1** | Transition propulsion technologies designed for new systems into legacy equipment upgrades when matured to TRL 6 and align with energy reduction goals. |
| **3.2** | Transition laboratory technologies to fielded fleet based on laboratory push/operator pull requirements to update fleets. |

**Objective 3.1:** Transition propulsion technologies designed for new systems into legacy equipment upgrades when matured to TRL 6 and align with energy reduction goals.

The Air Force will consider technologies and development to TRL 9 for new operational systems.

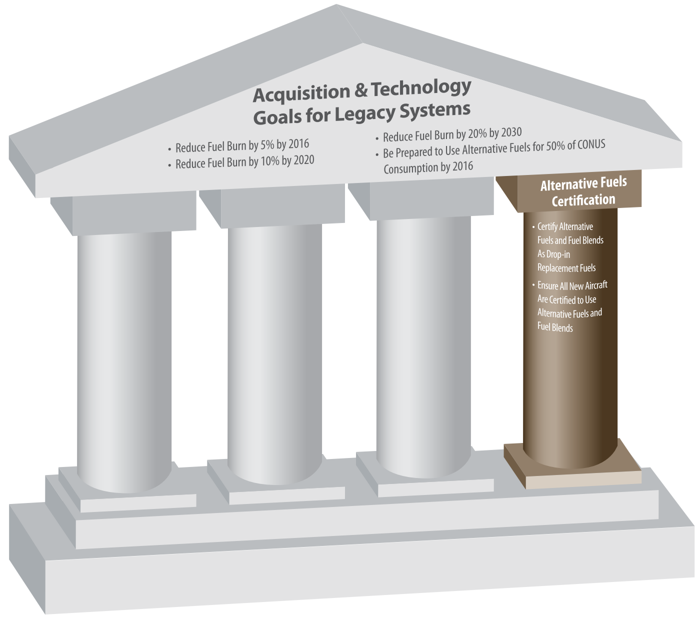
**Objective 3.2:** Transition laboratory technologies to fielded fleet based on laboratory push/operator pull requirements to update fleets.

Laboratory programs that have the potential to transition into legacy systems should be championed to the warfighting community. The Air Force will make available technologies to transition laboratory technology into fielded systems to promote more fuel efficient, safe, and reliable systems. Advanced light-weight and green materials, advanced energy efficient components and subsystems, advanced sensors and mission planning, and operational tools should be considered for fleet upgrades. Plans and roadmaps will be developed to identify the opportunity to implement these technologies.

The technologically advanced F135 is an evolution of the highly successful F119 engine for the F-22 Raptor. The F135-PW-100 will power the F-35A Lightning II, the U.S. Air Force multi-role aircraft (primary-air-to-ground) designed to replace the F-16 and A-10 and complement the F-22. The engine features advanced prognostics and health management systems, and is designed to substantially lower maintenance costs.

## Pillar 4: Alternative Fuels Certification

Alternative fuels produced from fossil, biomass, or a combination of both offer significant promise for increasing supply and offering feedstock and producer diversity in the marketplace. Since aircraft performance and safety cannot be compromised, a comprehensive fuel certification process has been established using Military Handbook 510 as the basis. The handbook uses a systems engineering approach to evaluate fuel physical and chemical properties in the context of aircraft performance and safety requirements. The process includes continuous updates to the Military Handbook based on lessons learned as certification progresses and serves as a foundational document for all Military Services and international allies.




**Reducing Fuel Burn and Greenhouse Gas Emissions in Legacy Systems**

**Pillar 4: Alternative Fuels Certification**

| Objectives | |
|---|---|
| **4.1** | Certify alternative and synthetic fuels and fuel blends for use in legacy and emerging aircraft. |
| **4.2** | Ensure all new aircraft are certified for the use of alternative fuels as defined by specifications and the Air Force Alternative Fuels Certification Office (AFCO), as part of procurement requirements. |

**Objective 4.1:** Certify alternative and synthetic fuels and fuel blends for use in legacy and emerging aircraft.

The Air Force will certify fuels based on performance and capability criteria, such as the ability to be drop-in replacements for existing aircraft, equipment, and infrastructure. We will also assess alternative fuels in terms of greenhouse gas emissions, availability, and sustainability. Plans to certify all fielded weapon systems and Air Force equipment for alternative fuels produced from multiple resources and using a variety of processes to produce the fuel will be implemented.

**Objective 4.2:** Ensure all new aircraft are certified for the use of alternative fuels as defined by specifications and the Air Force Alternative Fuels Certification Office (AFCO), as part of procurement requirements.

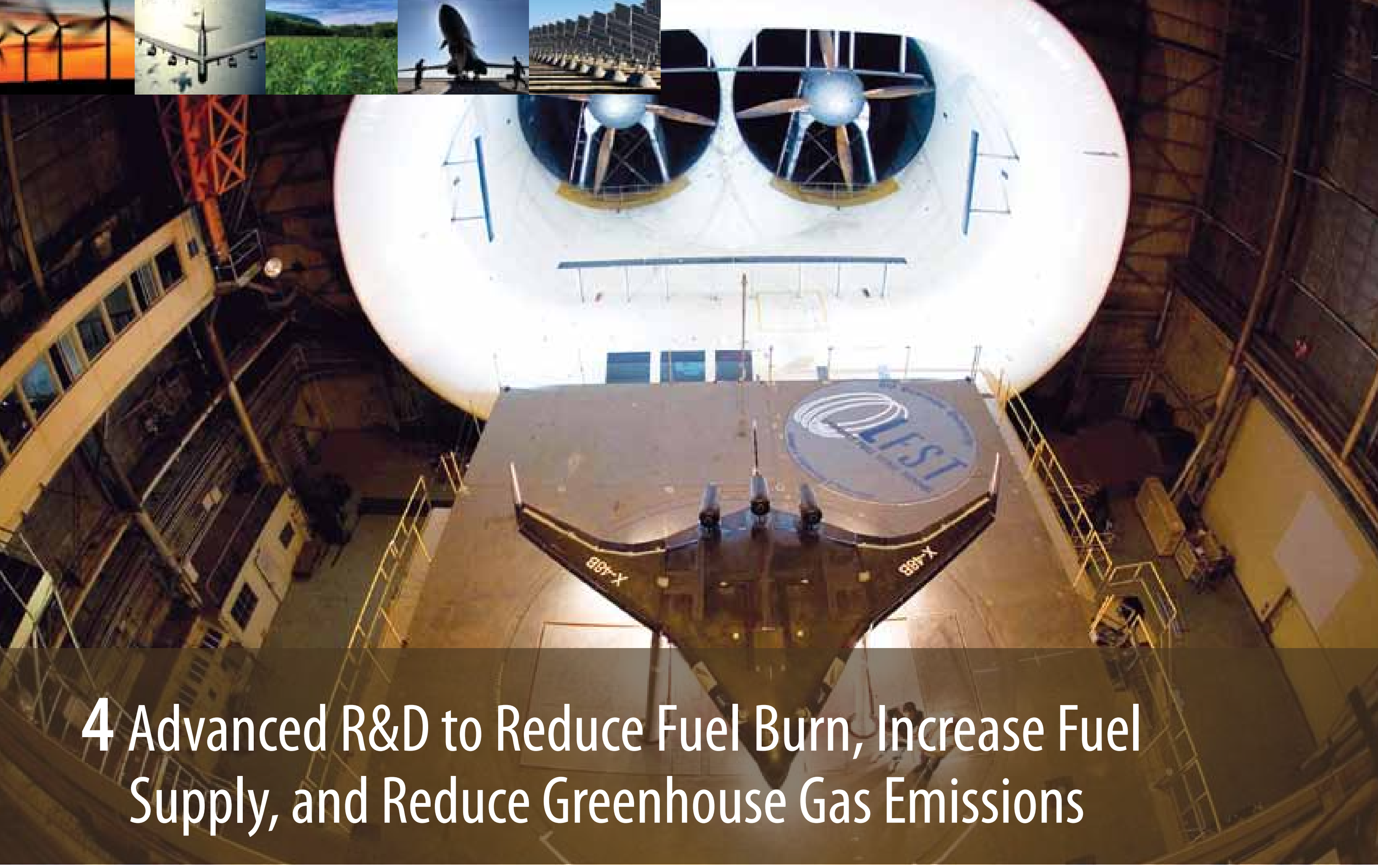
All new aircraft procurements must include provisions that all aircraft materials are fully compatible with current petroleum fuels and petroleum alternative fuel blends. The Air Force will identify problematic components during the certification process, such as nitrile o-rings, to eliminate them from future aircraft procurements or depot upgrades.


Staff Sgt. Joe Wallis, 31st Test and Evaluation Squadron, and Johnny Sniderhan, 912th Aircraft Maintenance Squadron, reveal the Fischer-Tropsch synthetic fuel blend certification logo painted on the side of a B-52H at the certification ceremony at Edwards Air Force Base. (Photo by Jet Fabara)

## Summary

A comprehensive program focused on the upgrade of legacy systems provides near-, mid-, and long-term benefits to Air Force energy programs. The application of technology and modernization of fielded systems will advance the Air Force's ability to provide fuel-efficient systems for operational use and greenhouse gas emission reductions. The program should be initiated at the earliest possible date to provide near-term benefits to the Air Force and warfighter, whereby the development of new technologies result in continuous improvements to reduce fuel usage and improve the environment.


An aging KC-135R Stratotanker sits inside the Oklahoma Air Logistics Center, Oklahoma, waiting for a full maintenance overhaul. The Oklahoma Air Logistics Center is the worldwide manager for a wide range of aircraft, engines, missiles, software/avionics, and accessories components. The center manages an inventory of 2,261 aircraft which include the B-1, B-2, B-52, C/KC-135, E-3, VC-25, VC-137 and 25 other contractor logistics support aircraft. (U.S. Air Force photo/Staff Sgt. Bennie J. Davis III)



# 4 Advanced R&D to Reduce Fuel Burn, Increase Fuel Supply, and Reduce Greenhouse Gas Emissions

## The Strategy

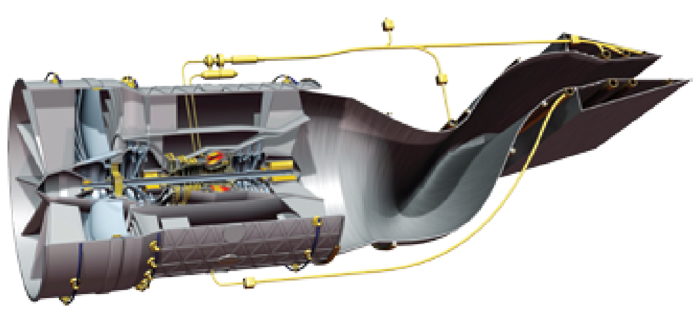
The Acquisition and Technology Energy Plan includes S&T programs to advance cutting-edge technologies, the integration of technologies into systems and fleets, and enable new capabilities that are energy efficient.

The Air Force Acquisition and Technology Energy Plan builds upon four pillars of improvements to the legacy fleet and four additional pillars related to new cutting-edge technologies under development. The advanced R&D strategy is to provide a pipeline of new technologies that significantly reduce fuel requirements, increase fuel supply, and greatly enhance weapon system capabilities. The technologies will mature to TRL 6 and either be integrated into new weapon systems or retrofitted into applicable legacy platforms. The elements annotated in the pillars of this program are potentially additive in nature to the benefits identified in the section entitled "Reducing Fuel Burn and Greenhouse Gas Emissions in Legacy Systems." The four pillars of the R&D strategy are:

- **Pillar 1**—Alternative Fuels Evaluation
- **Pillar 2**—Advanced Aircraft Technology to Increase Aero Efficiency
- **Pillar 3**—Efficient/Adaptive Engine Technologies
- **Pillar 4**—Advanced Design Systems for Energy Conversion

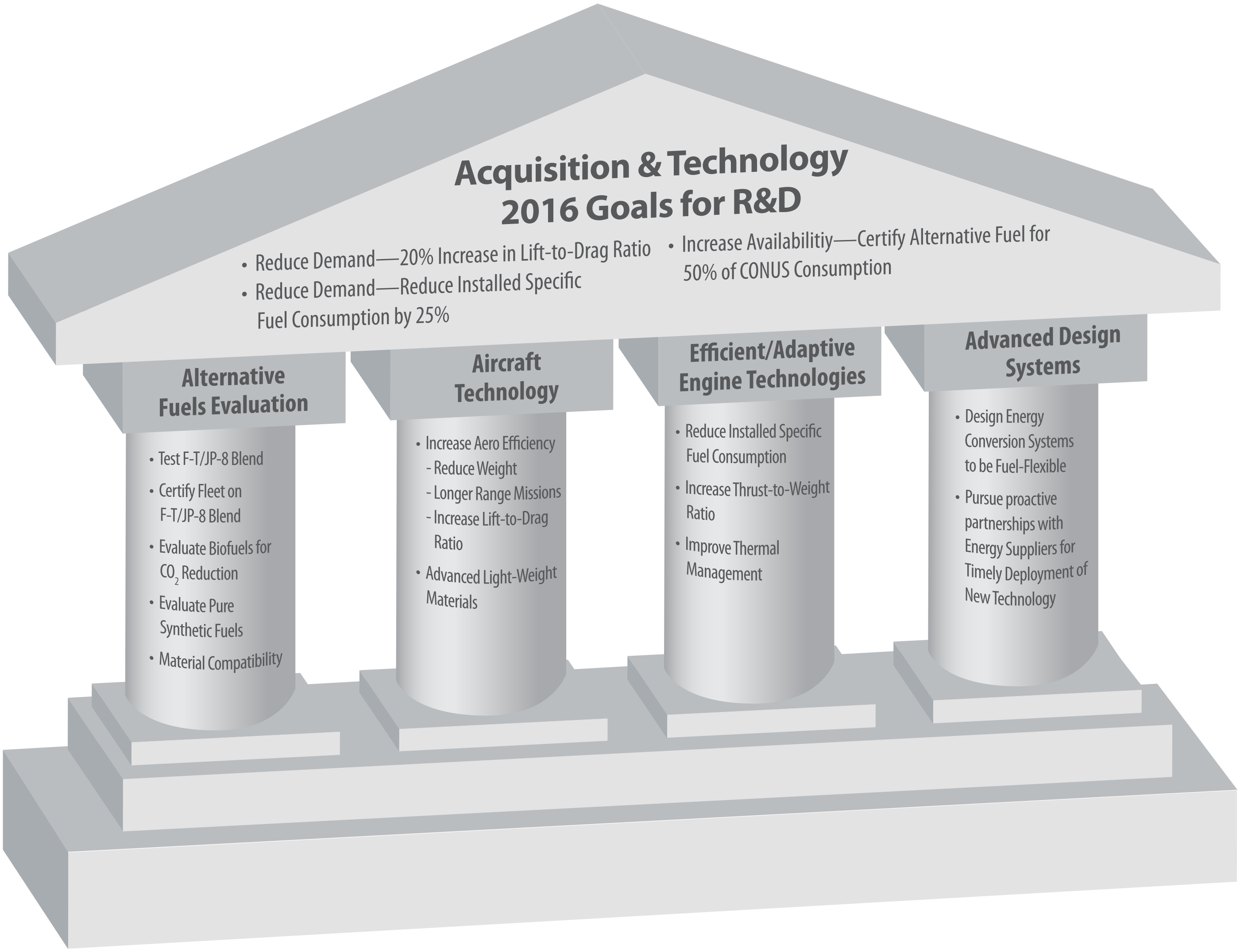
These four strategic pillars could increase the supply of the Air Force's number one energy resource–aviation fuel; develop advanced aircraft technologies to increase aero efficiency and reduce weight; develop fuel-efficient, adaptive engines and technology to improve aircraft system efficiency; and develop advanced energy conversion technologies.

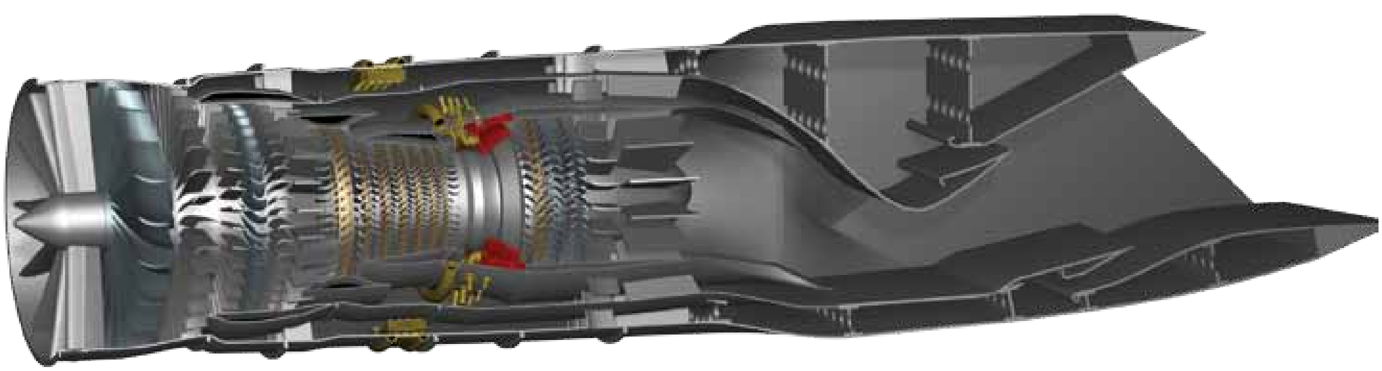
The strategic goals of the Acquisition and Technology Energy Plan are built upon a framework of processes, such as a streamlined alternative fuel certification process and the incorporation of more fuel-efficient engines into systems. The energy culture message is fostered by senior leaders to all members of the acquisition community, including scientists, engineers, program managers, weapon system single managers, and system operators and maintainers.



AFRL is conducting research studies on Highly Efficient Embedded Turbine Engine (HEETE) technologies. HEETE will combine adaptive features with high overall pressure ratio components and integrated thermal management systems to produce highly fuel-efficient, low observable (LO) compatible subsonic propulsion.

**Figure 5** Strategic Pillars for Advanced Research and Development

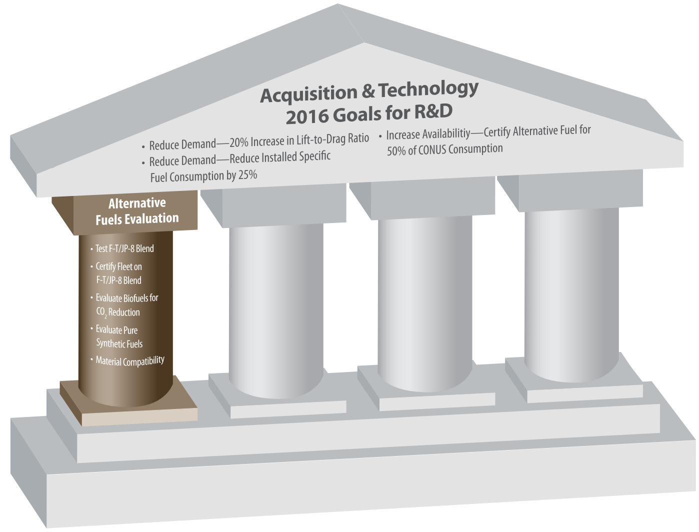


The Air Force Research Laboratory's (AFRL) Project ADVENT (Adaptive Versatile Engine Technology) is a flagship effort under the Versatile Affordable Advanced Turbine Engines Program, or VAATE, which is managed by the Propulsion Directorate. ADVENT is a multi-design point engine that incorporates the best characteristics of high performance and fuel efficient jet engines into a single adaptive engine.

## Pillar 1: Alternative Fuels Evaluation

This pillar focuses on evaluating alternative and synthetic fuels from all domestic energy resources. These fuels must be fully fungible, drop-in replacements for existing petroleum-derived fuels and offer the same or improved performance, operational effectiveness, and not change the durability or maintenance of weapon systems. Alternative fuels must be greener than existing petroleum fuels and analyzed from a ground (or field) to engine exhaust standpoint.




**Advanced R&D to Reduce Fuel Burn, Increase Fuel Supply, and Reduce Greenhouse Gas Emissions**

**Pillar 1: Alternative Fuels Evaluation**

| Objectives | |
|---|---|
| **1.1** | Meet or exceed operational performance criteria and be fit-for-purpose for use in all Air Force equipment. |
| **1.2** | Alternative fuels must be evaluated to assure that they are fully fungible and drop-in replacements for petroleum-derived JP-8. |
| **1.3** | Transition alternative fuel technology from the Air Force Research Laboratory (AFRL) to the AFCO at TRL 6. |
| **1.4** | Alternative fuels will be evaluated for environmental characteristics including emissions from the exhaust of engines, such as NOx, SOx, unburned hydrocarbons, particulate emissions, and greenhouse gas emissions. |
| **1.5** | Develop new analysis techniques, metrics, and other techniques to evaluate the performance of alternative fuels from a cost, environmental, performance, technical suitability, and overall system durability standpoint. |
| **1.6** | Alternative fuels will be evaluated to determine suitability for operational use from a wide range of U.S. domestic resources to assure long-term availability, sustainability, and choices to allow for competitive products compared to petroleum-derived fuels. |
| **1.7** | Establish collaborative programs with the other Services, government agencies, the commercial sector, and foreign allies on alternative fuels, fuel technologies, and fuel certification to ensure interoperability. |

**Objective 1.1:** Meet or exceed operational performance criteria and be fit-for-purpose for use in all Air Force equipment.

Alternative fuel evaluations must be conducted to achieve TRL 6 to enable transition to the Alternative Fuels Certification Office (AFCO).

**Objective 1.2:** Alternative fuels must be evaluated to assure that they are fully fungible and drop-in replacements for petroleum-derived JP-8.

Evaluations must be conducted for aircraft, engines, subsystems, ground refueling equipment including trucks, hydrants and storage systems, and in-ground support equipment. Fuels and fuel blends must be compatible with fuel system materials and not pose any additional health or safety hazards. Fuels and fuel candidates will be evaluated for toxicity and all aspects of fuel handling safety.

**Objective 1.3:** Transition alternative fuel technology from the Air Force Research Laboratory (AFRL) to the AFCO at TRL 6.

The AFCO will evaluate operational performance and suitability, and ensure durability and maintenance is not compromised, such that the fuel or fuel blend can be used in an unrestricted manner by all Air Force systems that use JP-8 fuel.

**Objective 1.4:** Alternative fuels will be evaluated for environmental characteristics including emissions from the exhaust of engines, such as NOx, SOx, unburned hydrocarbons, particulate emissions, and greenhouse gas emissions.

In addition, alternative fuels must be characterized for greenhouse gas emissions that are produced from a ground (or field) to wake basis. Acceptable alternative fuels must have a greenhouse gas life cycle footprint that is greener than petroleum-derived jet fuels.

**Objective 1.5:** Develop new analysis techniques, metrics, and other techniques to evaluate the performance of alternative fuels from a cost, environmental, performance, technical suitability, and overall system durability standpoint.

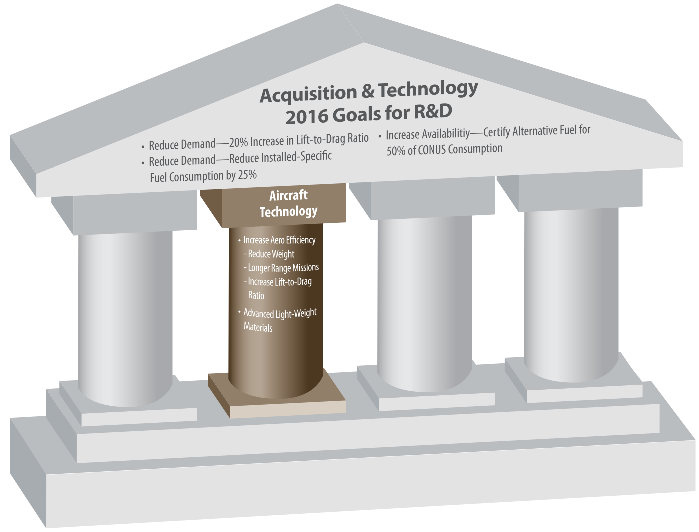
These "rules and tools" should be robust, peer-reviewed, and address all key aspects of the production and use of the alternative fuel.

**Objective 1.6:** Alternative fuels will be evaluated to determine suitability for operational use from a wide range of U.S. domestic resources to assure long-term availability, sustainability, and choices to allow for competitive products compared to petroleum-derived fuels.

**Objective 1.7:** Establish collaborative programs with the other Services, government agencies, the commercial sector, and foreign allies on alternative fuels, fuel technologies, and fuel certification to ensure interoperability.

## Pillar 2: Advanced Aircraft Technology to Increase Aero Efficiency

Advanced aircraft design and flight management technologies reduce overall fuel burn, provide higher capability aircraft designs, and increase range and loiter time. Improvement designs enhance lift-to-drag ratios, reduce fuel burn, and improve system capabilities. These technologies are made possible by advanced, light-weight materials and innovative manufacturing techniques.




**Advanced R&D to Reduce Fuel Burn, Increase Fuel Supply, and Reduce Greenhouse Gas Emissions**

**Pillar 2: Advanced Aircraft Technology to Increase Aero Efficiency**

| Objectives | |
|---|---|
| **2.1** | Develop advanced technologies to increase the aero efficiency of new aircraft to reduce fuel burn. |
| **2.2** | Develop advanced technologies to increase the aero efficiency of aircraft. |
| **2.3** | Develop advanced technologies to increase the range and loiter capabilities of aircraft. |
| **2.4** | Develop innovative, light-weight materials and manufacturing technologies. |
| **2.5** | Develop advanced energy management, power generation, and thermal management systems to improve overall aircraft subsystem efficiencies and reduce penalties associated with high cooling demands. |
| **2.6** | Develop advanced technologies to improve flight operations and formation flying, advanced sensors, and new aircraft flight management systems for new and legacy aircraft. |

**Objective 2.1:** Develop advanced technologies to increase the aero efficiency of new aircraft to reduce fuel burn.

Technologies may include, but are not limited to designs that utilize advanced light-weight materials; technologies that improve the control of air flow over wings; fuselages and engines that increase the amount of laminar flow and reduce turbulence; adaptive wing structures; blended wings; winglets; finlets; and advanced computation techniques.

**Objective 2.2:** Develop advanced technologies to increase the aero efficiency of aircraft.

The Air Force will assess emerging advanced technologies for applications on new and legacy platforms to reduce drag and improve flight control. We will also implement new structures, configurations, components, and materials where applicable.

**Objective 2.3:** Develop advanced technologies to increase the range and loiter capabilities of aircraft.

These technologies will require advanced aircraft configurations, fuel-efficient engines, improved aircraft power generation, improved energy efficient subsystem integration and thermal management, and hybrid energy systems.

**Objective 2.4:** Develop innovative, light-weight materials and manufacturing technologies.

The Air Force will develop plans and roadmaps to implement advanced materials and manufacturing technologies into the modification and upgrading of legacy systems where applicable.

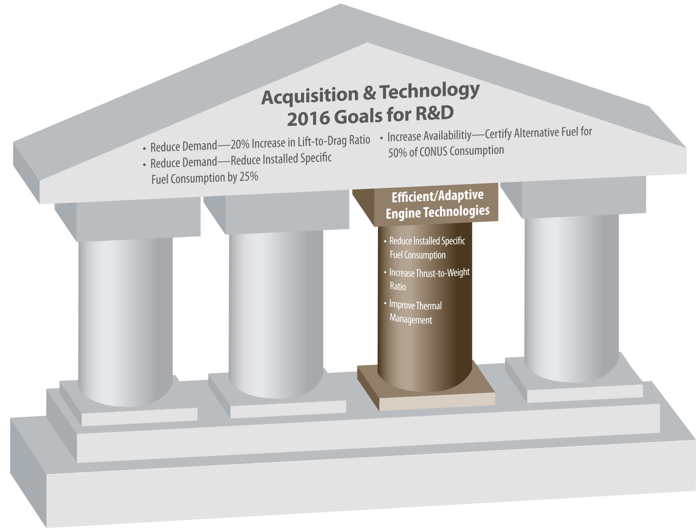
**Objective 2.5:** Develop advanced energy management, power generation, and thermal management systems to improve overall aircraft subsystem efficiencies and reduce penalties associated with high cooling demands.

The Air Force must demonstrate system of systems integration technologies for energy-efficient components. We will develop modeling and simulation techniques to improve the design of new weapon systems and to identify opportunities for integration into legacy systems. Energy efficiency strategies that benefit both aircraft and ground applications will be evaluated and technology maturation pathways that include demonstrations on both ground and aircraft applications will be established.

**Objective 2.6:** Develop advanced technologies to improve flight operations and formation flying, advanced sensors, and new aircraft flight management systems for new and legacy aircraft.

## Pillar 3: Efficient/Adaptive Engine Technologies

The current Air Force fuel bill for aircraft operations reached $6 billion in FY2008. The Air Force is currently burning 7 million gallons of fuel every day with the concomitant daily emission of 76,200 tons of $CO_2$. Growing environmental concerns regarding $CO_2$ generation, particularly in Europe, raise the likely possibility of reduced operations in the future for U.S. forces in Europe with traditional military systems. Additionally, if a cap and trade system is established in the United States, Air Force fleet capabilities may be limited.




The United States *"National Plan for Aeronautics Research and Development and Related Infrastructure"* includes a primary long-term goal to reduce system-specific fuel consumption (and $CO_2$ generation) by more than 30 percent over (current) gas turbine engines. Current technical approaches include: efficient, high-overall pressure-ratio compression systems; variable-cycle engine technologies; advanced high-temperature materials and more effective turbine blade cooling; and techniques to more efficiently recuperate energy while satisfying total weapon system thermal and power requirements. The objectives below guide turbine engine-related investments to accomplish these challenging long-term goals.

**Advanced R&D to Reduce Fuel Burn, Increase Fuel Supply, and Reduce Greenhouse Gas Emissions**

**Pillar 3: Efficient/Adaptive Engine Technologies**

| Objectives | |
|---|---|
| **3.1** | Develop advanced turbine engine technologies to provide improved fuel efficiency, thrust-to-weight, and durability of fielded and emerging weapon systems. |
| **3.2** | Conduct demonstrations of small-scale propulsion system technologies to TRL 6 to reduce fuel consumption for Unmanned Air Vehicles (UAV) and improve on-board power generation capabilities. |
| **3.3** | Develop advanced high Mach number (M3-4) expendable engine technologies as an alternative capability for system wide fleet fuel reductions. |
| **3.4** | Develop advanced large fan turbine engine technologies to TRL 6 that are adaptive throughout the flight envelope. These technologies should provide 25 percent or greater reduction in specific fuel consumption and emissions, while increasing current operational capability. |
| **3.5** | Develop advanced large fan turbine engine technologies and associated materials technologies to TRL 6. These technologies will demonstrate a high overall pressure ratio propulsion system with 25 percent or greater specific fuel consumption reduction. |
| **3.6** | Combine the results of Objectives 3.4 and 3.5 to develop and demonstrate an ultra fuel-efficient propulsion system. This system will bring together adaptive-cycle features, high overall pressure ratio, and reduce specific fuel consumption by 35 percent. |
| **3.7** | Develop advanced engine and airframe integration technologies to increase the overall efficiency of propulsion for aircraft. |
| **3.8** | Improve the overall operation and thermal management of aircraft through the use of integrated thermal energy management systems that maximize energy usage and minimize waste engine heat rejection. |
| **3.9** | Develop and verify turbine engine sustainment technologies in TRL 6 demonstrators to proactively ensure propulsion safety and affordable readiness for our warfighters. |

**Objective 3.1:** Develop advanced turbine engine technologies to provide improved fuel efficiency, thrust-to-weight, and durability of fielded and emerging weapon systems.

**Objective 3.2:** Conduct demonstrations of small-scale propulsion system technologies to TRL 6 to reduce fuel consumption for Unmanned Air Vehicles (UAV) and improve on-board power generation capabilities.

**Objective 3.3:** Develop advanced high Mach number (M3-4) expendable engine technologies as an alternative capability for system wide fleet fuel reductions.

These technologies provide options for future weapon systems to defeat threats, which may reduce overall fleet fuel burn.

**Objective 3.4:** Develop advanced large fan turbine engine technologies to TRL 6 that are adaptive throughout the flight envelope. These technologies should provide 25 percent or greater reduction in specific fuel consumption and emissions, while increasing current operational capability.

**Objective 3.5:** Develop advanced large fan turbine engine technologies and associated materials technologies to TRL 6. These technologies will demonstrate a high overall pressure ratio propulsion system with 25 percent or greater specific fuel consumption reduction.

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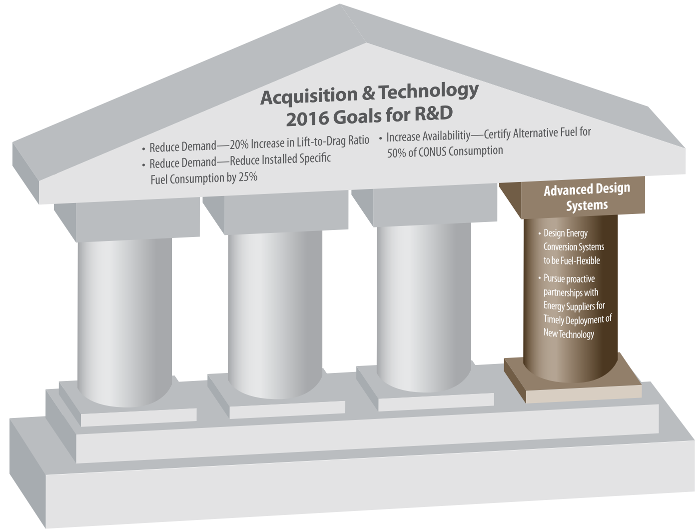
**Objective 3.9:** Develop and verify turbine engine sustainment technologies in TRL 6 demonstrators to proactively ensure propulsion safety and affordable readiness for our warfighters.

## Pillar 4: Advanced Design Systems for Energy Conversion

The Air Force can achieve energy savings, reduce greenhouse gas emissions and provide a more robust, resilient infrastructure by developing advanced materials, material manufacturing processes, energy generation and power storage technologies, advanced hybrid concepts, advanced aircraft thermal management, fuel efficiency technologies, and new modeling and simulation tools. Technologies should enhance military capabilities, fill military unique niches, and provide overall operational resiliency.




**Advanced R&D to Reduce Fuel Burn, Increase Fuel Supply, and Reduce Greenhouse Gas Emissions**

**Pillar 4: Advanced Design Systems for Energy Conversion**

| Objectives | |
|---|---|
| **4.1** | Evaluate advanced energy conversion systems to exploit renewable energy sources, enable flexible fuel capabilities, and promote advanced hybrid concepts to increase overall system efficiencies. |
| **4.2** | Evaluate advanced energy storage capabilities to help integrate energy production potentials with energy demand requirements. |
| **4.3** | Conduct advanced energy system evaluations on a leveraged and collaborative basis with other government agencies, industry, and academia. |
| **4.4** | Consider the fully burdened cost of fuel and the implications of fuel logistics at the end use of the system in all advanced aircraft and equipment design. |
| **4.5** | Design and develop materials and device architectures to produce efficient, low cost, and flexible photovoltaic devices. |
| **4.6** | Evaluate energy harvesting technologies to improve overall system efficiencies of solar cell technologies. |
| **4.7** | Develop nano-based materials for improved energy and power density, significantly improving performance. |
| **4.8** | Evaluate high energy density storage systems for high voltage and pulse power applications that meet the military operational environment. |
| **4.9** | Develop materials process technologies that will deliver strong, light-weight, high-performance materials to reduce aircraft and engine weight, improve engine performance, and enhance fuel efficiency and emission reductions for advanced turbine engines. |
| **4.10** | Develop materials and process technologies that eliminate the use of materials that create large greenhouse gas footprints and high levels of energy consumption. |
| **4.11** | Develop advanced analysis tools and models to integrate alternative energy technologies into Air Force operations. |
| **4.12** | Use commercial alternative energy technologies for the military, and modify as required. |
| **4.13** | Evaluate deployable renewable energy and integrated power systems for forward bases and grid resiliency for CONUS bases. |
| **4.14** | Develop wireless energy power transmission capabilities. |
| **4.15** | Improve manufacturing readiness and affordability of advanced aerospace battery and photovoltaic cell technologies. |

**Objective 4.1:** Evaluate advanced energy conversion systems to exploit renewable energy sources, enable flexible fuel capabilities, and promote advanced hybrid concepts to increase overall system efficiencies.

The Air Force will explore applications of the technology for advanced air platforms and forward operating bases, while researching technology maturation pathways that benefit both air platforms and ground applications.

**Objective 4.2:** Evaluate advanced energy storage capabilities to help integrate energy production potentials with energy demand requirements.

**Objective 4.3:** Conduct advanced energy system evaluations on a leveraged and collaborative basis with other government agencies, industry, and academia.

The Air Force will develop only unique technologies that fulfill a defined military niche, significantly enhance military capability, or enable compliance with executive orders and mandates.

**Objective 4.4:** Consider the fully burdened cost of fuel and the implications of fuel logistics at the end use of the system in all advanced aircraft and equipment design.

The Air Force will apply the requirements related to the analysis of the fully burdened cost of fuel to advanced technology development as applicable.

**Objective 4.5:** Design and develop materials and device architectures to produce efficient, low cost, and flexible photovoltaic devices.

Applications must fill a unique Air Force military niche, enhance operations, or be relevant to air, space, and forward deployed operations.

**Objective 4.6:** Evaluate energy harvesting technologies to improve overall system efficiencies of solar cell technologies.

**Objective 4.7:** Develop nano-based materials for improved energy and power density, significantly improving performance.

Explore novel uses of nanotechnology to store energy and provide power.

**Objective 4.8:** Evaluate high energy density storage systems for high voltage and pulse power applications that meet the military operational environment.

**Objective 4.9:** Develop materials process technologies that will deliver strong, light-weight, high-performance materials to reduce aircraft and engine weight, improve engine performance, and enhance fuel efficiency and emission reductions for advanced turbine engines.

**Objective 4.10:** Develop materials and process technologies that eliminate the use of materials that create large greenhouse gas footprints and high levels of energy consumption.

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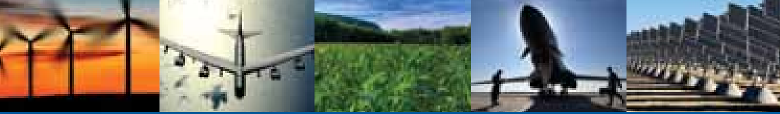
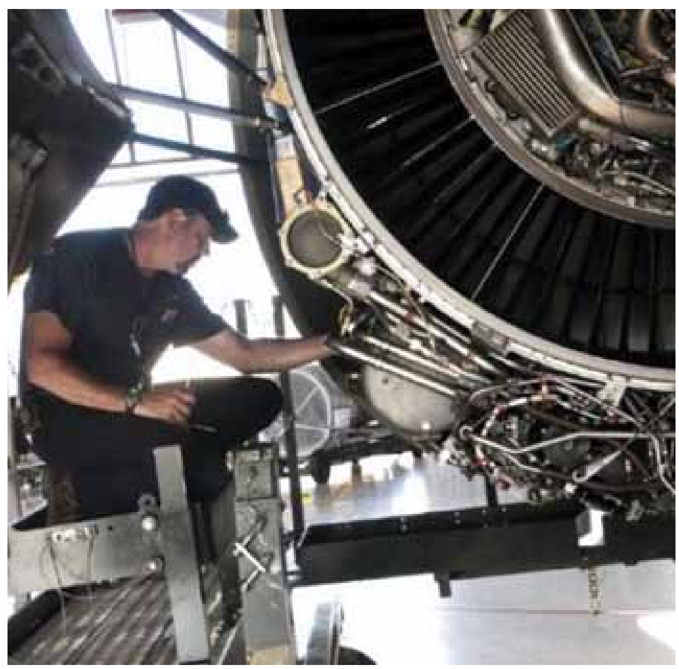


# 5 Governance Structure

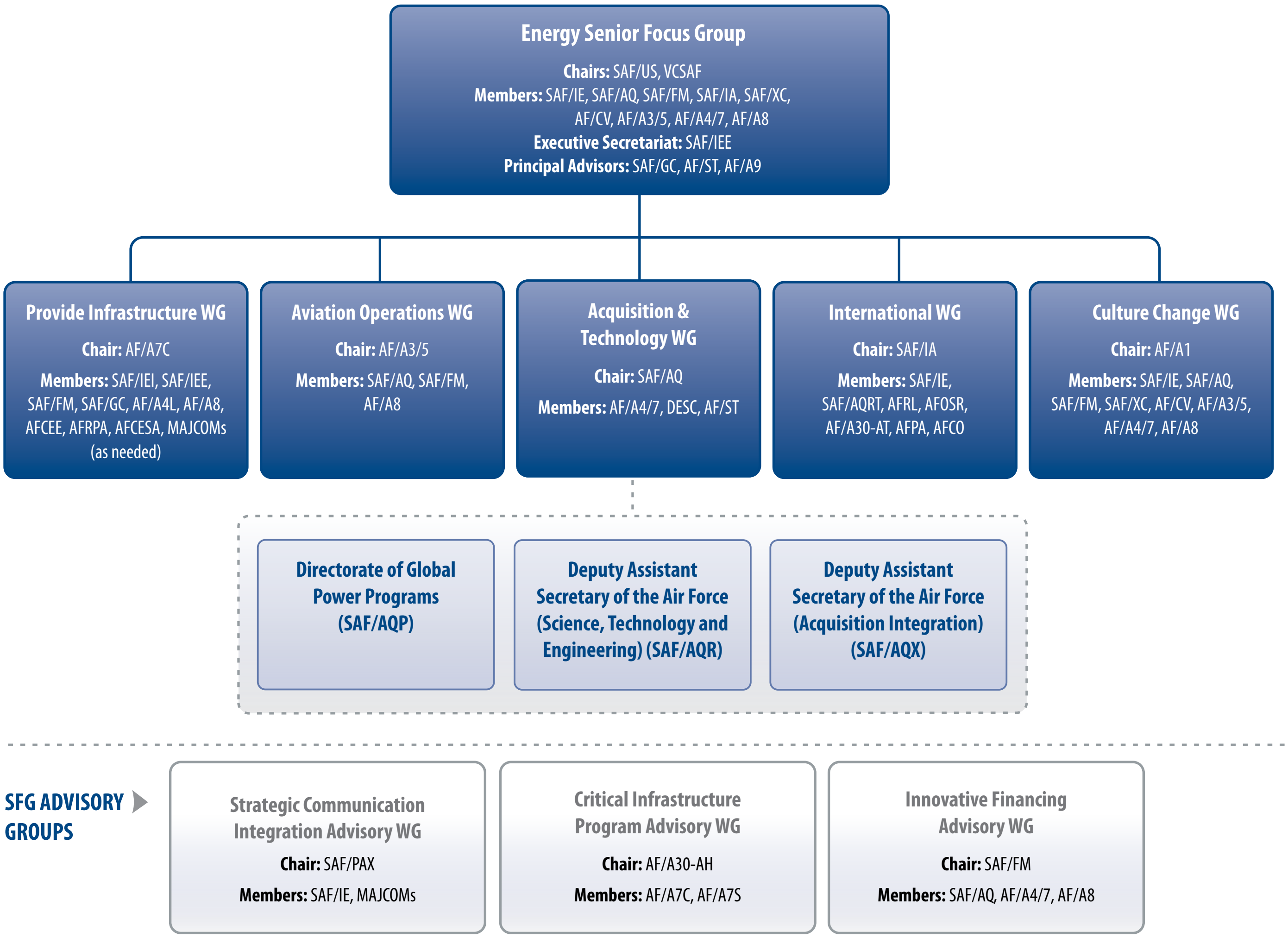
Air Force governance for acquisition and technology programs related to energy is coordinated by the Acquisition and Technology Working Group that reports to the Energy Senior Focus Group. SAF/AQ chairs this working group, which also includes members from AF/A4/7, AF/ST, and the Defense Energy Support Center (Figure 6).

Within SAF/AQ, three offices provide policy and oversight for Air Force energy programs. These offices are the Directorate of Global Power Programs (SAF/AQP), the Deputy Assistant Secretary of the Air Force (Science, Technology and Engineering) (SAF/AQR), the Deputy Assistant Secretary of the Air Force (Acquisition Integration) (SAF/AQX). The additional SAF/AQ functional and capability offices provide input and guidance as appropriate.



Ron Lucas, 97th Maintenance Directorate C-17 Globemaster III jet engine mechanic, works on an engine replacement for a C-17 during a home station check. (U.S. Air Force photo/Senior Airman Cherice Bryant)

**Figure 6** Air Force Energy Governance Structure



# 6 Conclusion

The Air Force Acquisition and Technology Energy Plan provides guidance for energy improvements and reductions in greenhouse gas emissions for the legacy fleet, and promotes a series of bold technologies that will bring positive changes in energy use within new systems or as upgrades in the future to legacy systems. The Air Force is a leader in aerospace technologies and will continue to provide state-of-the-art solutions that bolster our mission capabilities, while also reducing the amount of fuel burned and greenhouse gas emissions generated.

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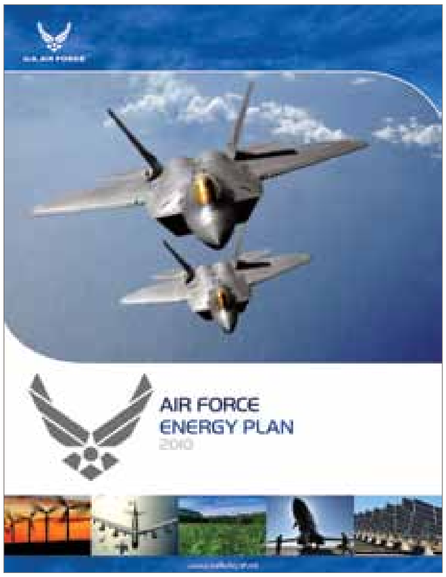


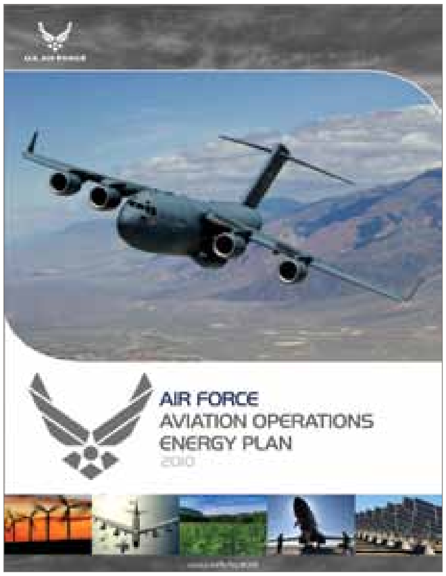




# AIR FORCE ACQUISITION & TECHNOLOGY ENERGY PLAN

2010

SAF/AQ