

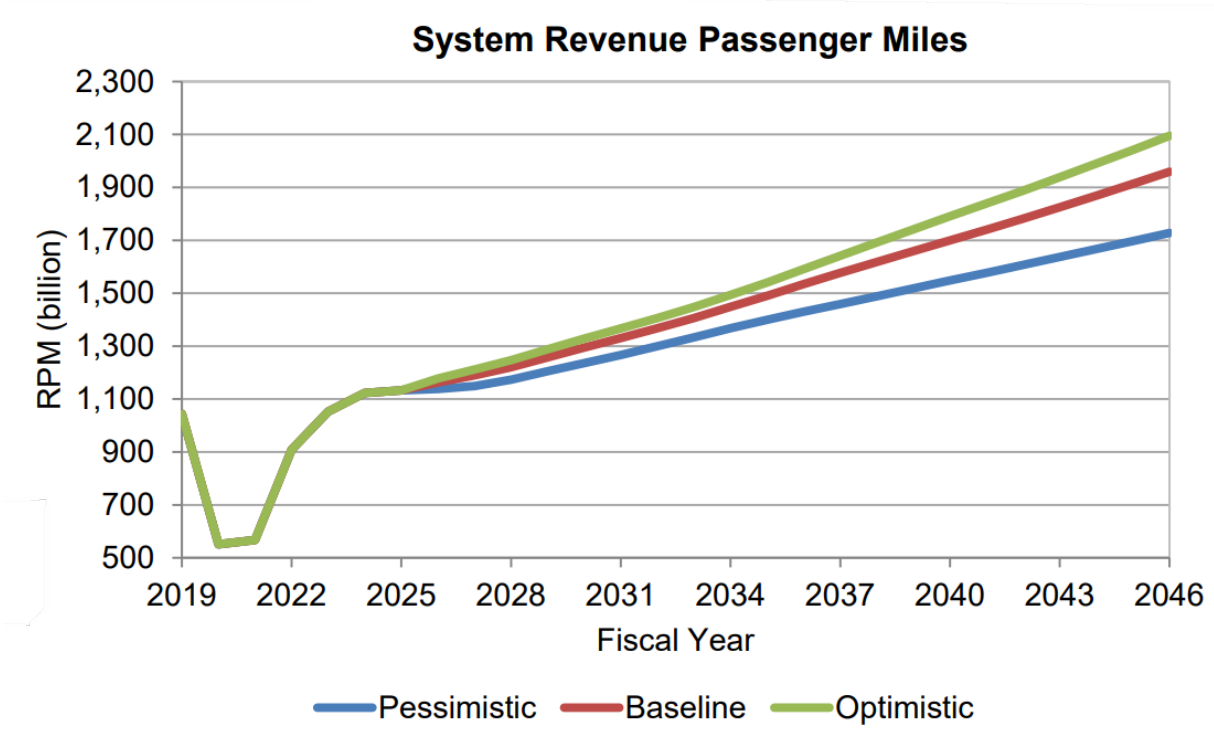
NASA Aeronautics on Airliners for 2050+ Energy Landscape

Dr. Nateri Madavan
NASA Advanced Air Vehicles Program

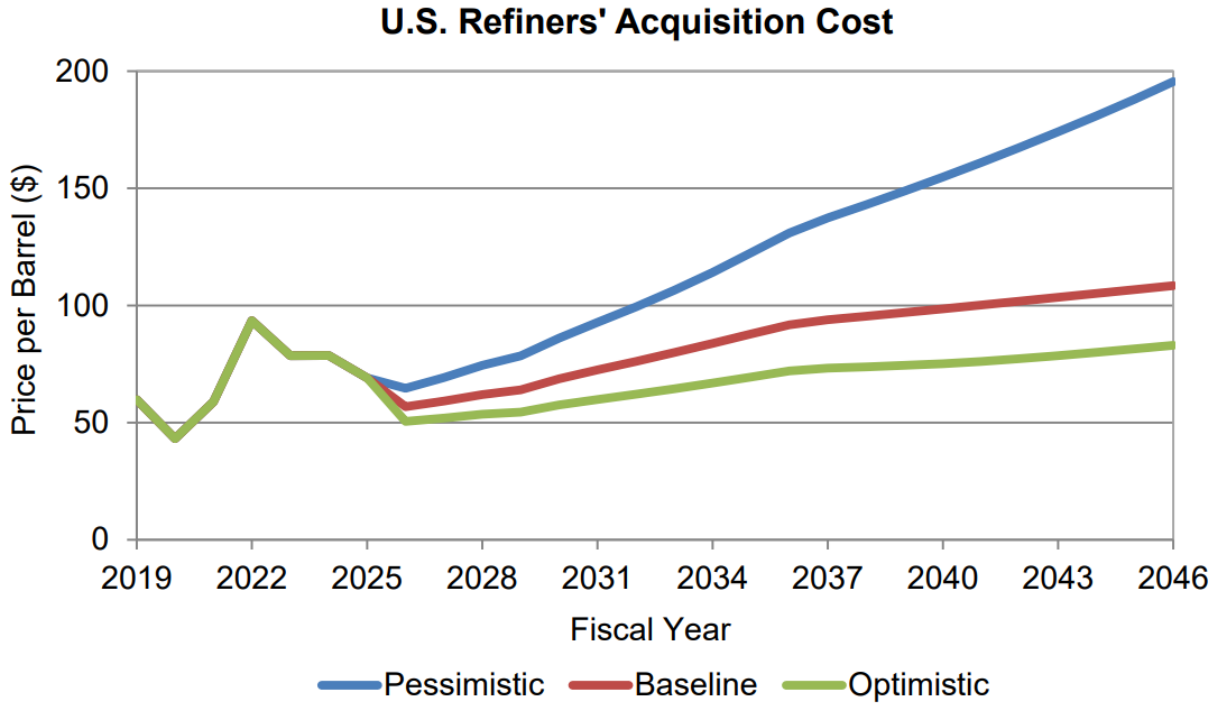
Slides prepared by Shannon Eichorn
NASA Advanced Air Vehicles Program



Aviation's Increasing Energy Demand



Source: FAA Aerospace Forecast Fiscal Years 2026-2046

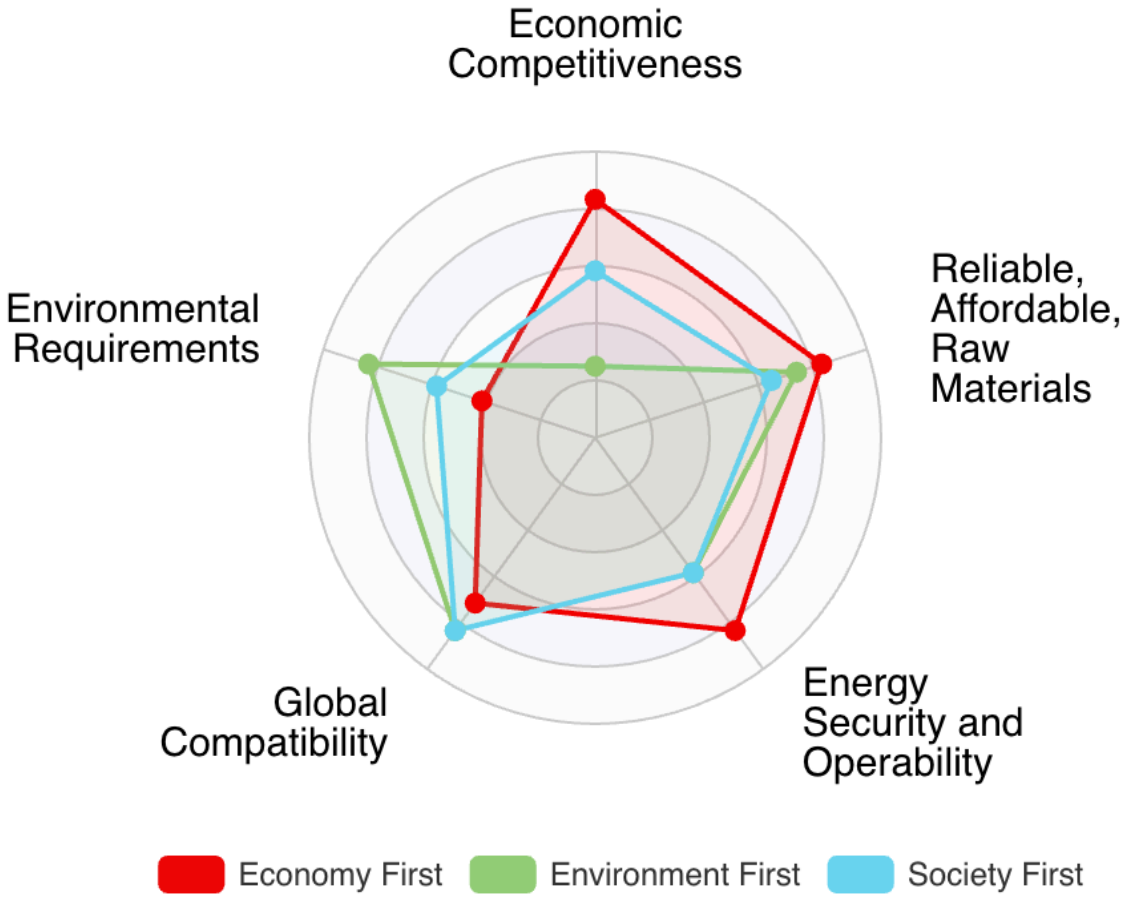


Source: S&P Global, APO-100



Alternative fuels needed to hedge future risk.

What would be a successful alternative fuel?



Opportunities

- Energy Resilience
- Domestic Sources
- Lifecycle emissions
- Near-term availability
- Ensure global compatibility
- Transition path to future fuels

- Cost
- Performance

Barriers

- Infrastructure
- Supply
- Cross-sector dynamics
- Differing optimal fuels

Answers depend on priority.

2050 Energy Carrier Comparison

	Jet A	SAF	LNG	Liquified Ethane	LH2	Battery Electric
Availability and Cost	Baseline	Scaling challenges	Available	Available	Uncertain	Uncertain
Lifecycle emissions	Baseline	Better	Better	Better	Best	Better
Aircraft Design	Existing	Existing[2]	New Designs[2]	New Designs[2]	Research advancements and new designs[2]	Range Limited[2]
Distribution Infrastructure	Existing	Existing[2]	Existing but needs connected to airport[2]		None[2]	Existing but needs connected to airport[2]
Airport Infrastructure	Existing	Existing	New fueling infrastructure[2]	Difficult handling[1]	Lew liquefaction technology[2]	New charging infrastructure

1 – NLR/TP-5400-100028 An Overview of Potential Future Aviation Energy Carriers
2 – Aurora AACES Study Overview AIAA 2026-4061



Cryo fuels show promise but need new infrastructure.

The Promise of Cryogenic Fuels

2030s

2075+



Scale up to support kerosene-based fuel demand

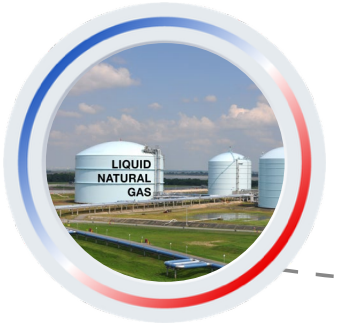
Reduced aviation net emissions

Reduce cost at pumps

SAF

- **Reduced aviation net emissions**
- **Increased energy resilience**
- **Fuel Savings**

- **Reduced aviation emissions**
- **Increased energy resilience**
- **Increased fuel savings**



Cryo temp for aviation
Cryo tanks for aviation and airports

LNG connection to airports

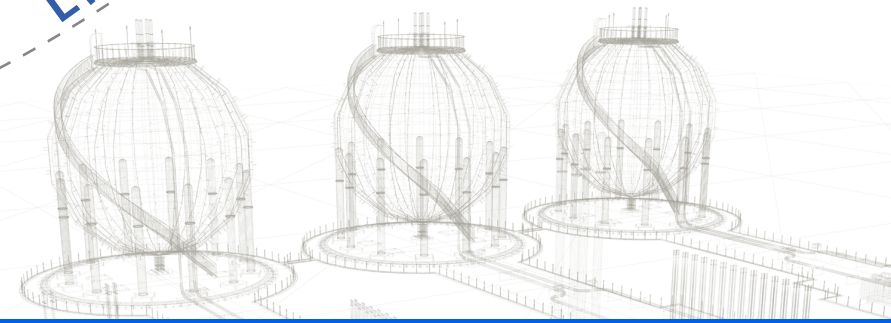
LNG



LH_2 temp for aviation
LH_2 tanks for aviation and airports

LH_2 availability for airports

LH_2

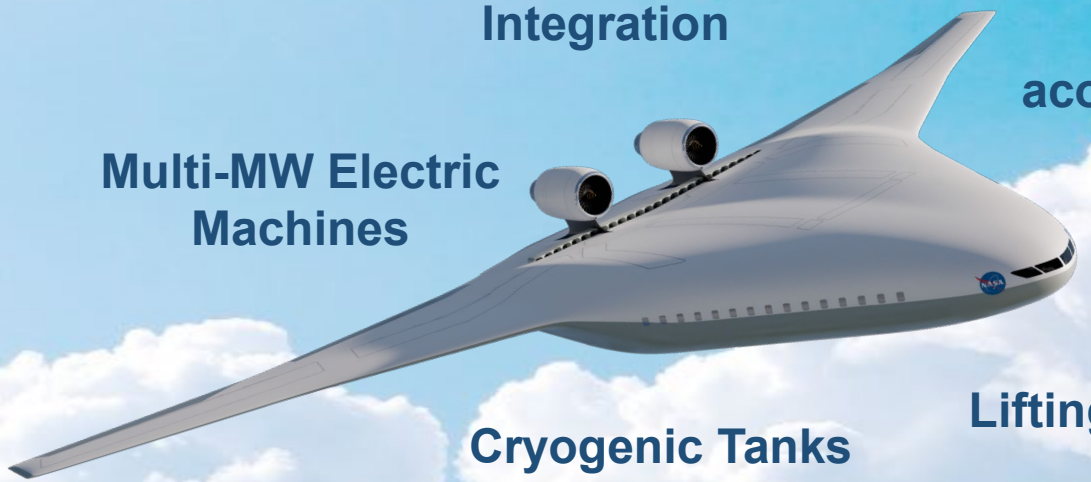




LNG can be a stepping stone to future benefits

What will future airliners need?





Next Generation Propulsors and Powerplants

Hybrid-Electric Propulsion

Propulsion-Airframe Integration

Propulsion-Airframe Aero-acoustics

Multi-MW Electric Machines

Lifting Body

High-Rate Advanced Composites

Advanced Wing

Cryogenic Tanks and Thermal Management

Airport Infrastructure Compatibility

New Fuel Standards and Operational Procedures

Clear Pathways to Certification




35TH CONGRESS OF THE
INTERNATIONAL COUNCIL OF
THE AERONAUTICAL SCIENCES
ICAS2026
SYDNEY | AUSTRALIA
13-17 SEPT 2026
icas2026.com