



***Gulfstream's
Perspective - FAJFEDS***

Charles L. Etter

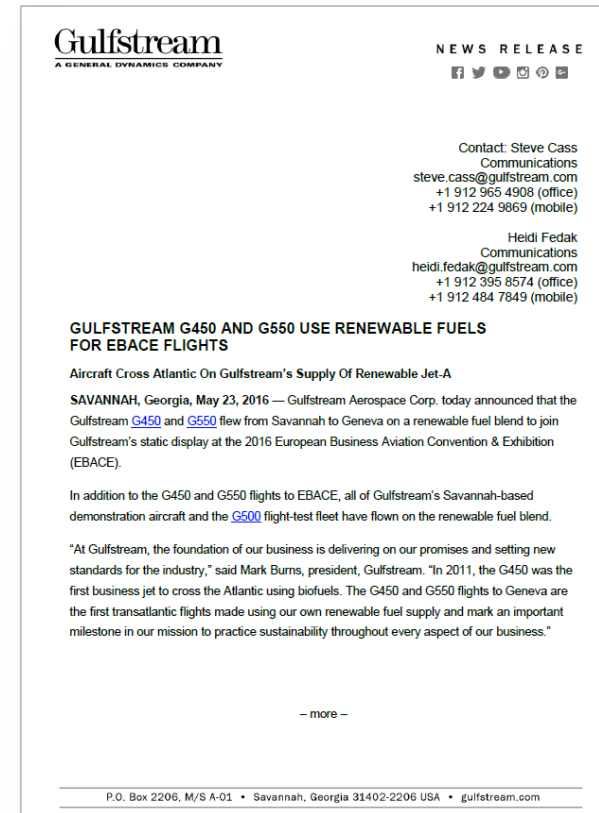
October 27, 2016

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Gulfstream - Renewable Fuels Program

- Three year contract with World Fuel Services
- Fuel Provider - AltAir
- First Delivery – April 2016
- Four G500 Flight Test Aircraft Flew on Renewable fuel
- G450 and G550 flew from Savannah to Geneva (EBACE) on this fuel
- Regular Usage by the F.A.S.T. airplanes
- Some Corporate Flights
- When fuel is available it will be offered to our customers

Press Release, May 23, 2016



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Gulfstream – Renewable Fuel Program



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Business Aviation Commitments - Climate Change

- Through organizations like NBAA, GAMA and IBAC Business Aviation has committed to being good Stewards of the Environment.
- Press Release On November 24, 2009

- Commitment is based on 4 pillars
 - Improved Technology
 - Improved Infrastructure & Operations
 - Use of Alternative Fuels
 - Market Based Measures



BUSINESS AVIATION AND CLIMATE CHANGE

Advocating for a global aviation sectoral approach in a post-Kyoto global framework

The global business aviation operating and manufacturing communities support the International Civil Aviation Organization's (ICAO) proposal for aviation sectoral management of targets and monitoring of greenhouse gas (GHG) emissions in a post-Kyoto Agreement. We support the ICAO Programme of Action on International Aviation and Climate Change and are in accord with the Declaration of the High Level Meeting on International Aviation and Climate Change convened by ICAO in Montreal on 7-9 October 2009.

Our record of achievement
Business aviation has established an excellent record of consistently improving fuel efficiency, delivering 40% improvement over the past 40 years. Business aviation's global CO₂ emissions are approximately 2% of all aviation and .04% of global man-made carbon emissions. Business aircraft are operated for specific missions and fly efficient, direct routes between airports. Modern navigation equipment, combined with the latest technologies in aircraft and engine design and operational best practices, provide for ever-improving fuel efficiency and reduced GHG emissions.

Our commitment
Nonetheless, our community is resolved to do even more. Business aviation manufacturing and operating communities have jointly developed an aggressive programme in support of ICAO targets. Achieving these targets will require not only sustained effort on the part of the entire business aviation community, but also a partnership between industry and government, and the development of realistic solutions that balance economic growth, progress and technology. The business aviation community therefore commits to the following specific targets:

- Carbon-neutral growth by 2020;
- An improvement in fuel efficiency of an average of 2% per year from today until 2020;
- A reduction in total CO₂ emissions by 50% by 2050 relative to 2005.

We will achieve these objectives through expected advances in four areas: technology, infrastructure and operational improvements, alternative fuels, and market based measures.

Consistent with ICAO recommendations and limitations on data availability, business aviation supports the development of an appropriate alternative metric within ICAO to measure and track business aviation emissions on a fleet basis.

Our needs
Given the global nature of aviation, internationally harmonized policies, rules and procedures are critical to ensure safe, efficient and balanced operations. Our community believes that ICAO must be assigned global sectoral responsibility over aviation emissions targets and monitoring.

Our promise
The business aviation sector has made remarkable improvements in its environmental performance over the last half century. The industry believes that if scope is given to the aviation community to manage environmental stewardship in partnership with industry and under the leadership of ICAO, all will enjoy a vibrant and healthy industry that will continue to proactively reduce its impact on the environment even as the demand for business aviation continues to grow.

www.ibac.org www.gama.aero

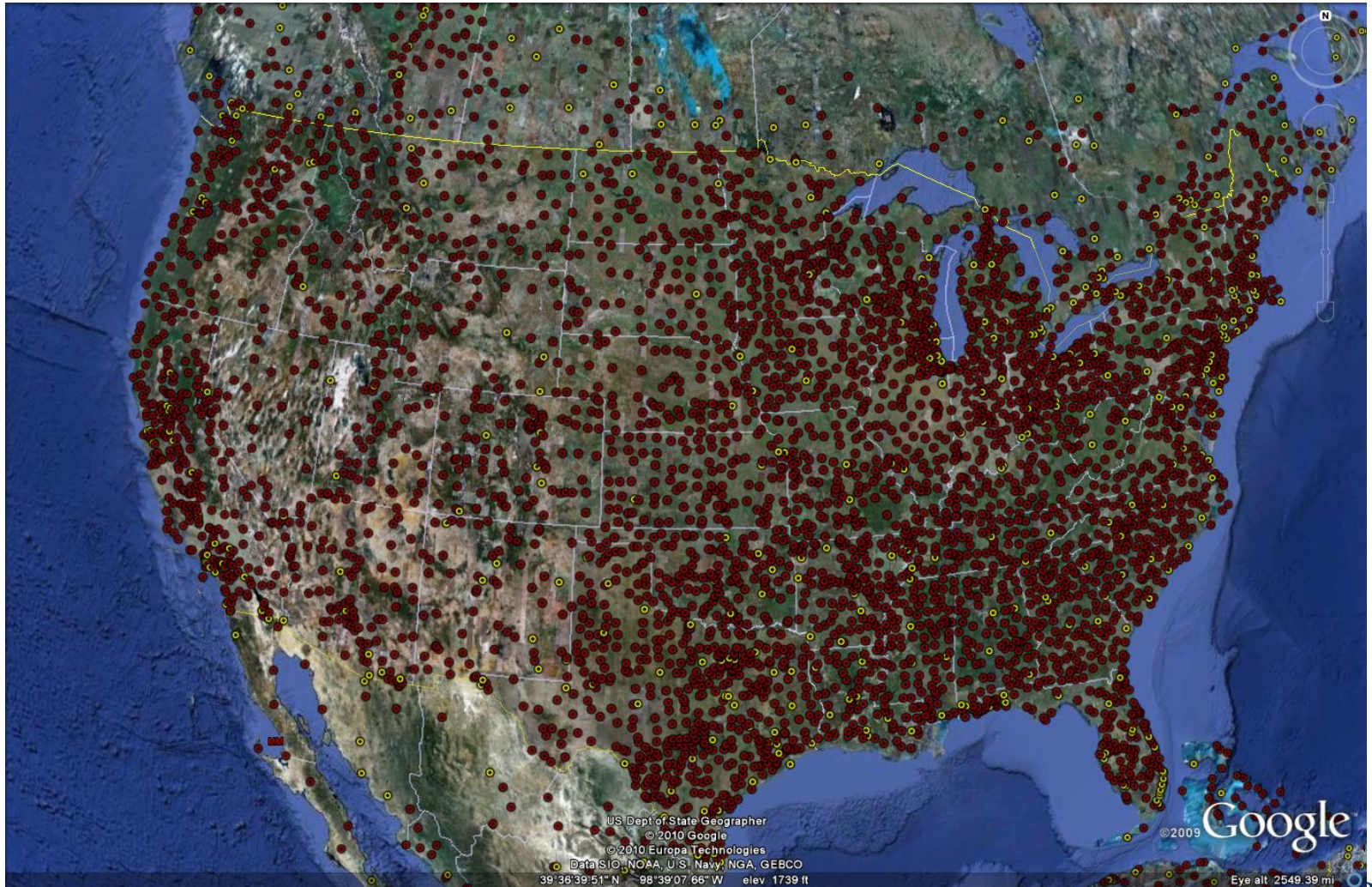
Business Aviation – Renewable Fuel

- Price (\$) ... needs to be competitive
- Supply... dependable
- Environmentally Responsible
- Drop-In... ASTM 1655
- Logistic
- Demand
 - Customers do have interest....
Customer Survey indicates more than 50% would purchase renewable fuel at Gulfstream even at a slightly higher price



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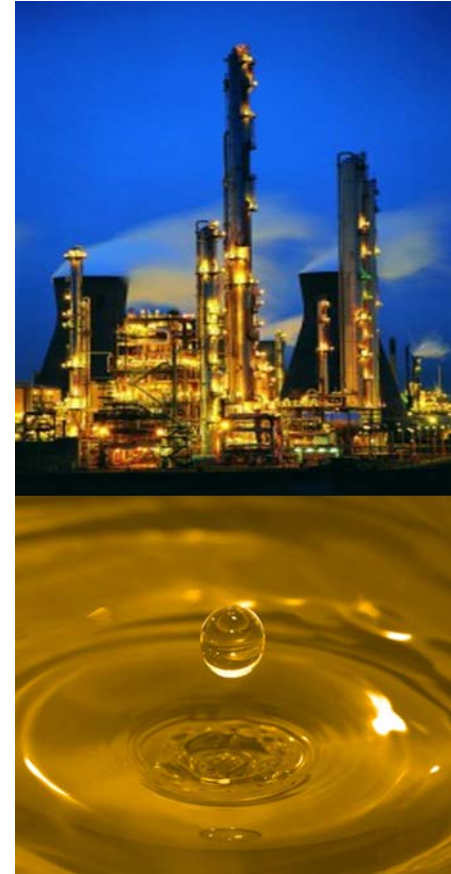
What Airports are available to GA?



Yellow dots represent airport that have airline services
Red dots represent airport that are not served by airlines

Observations

- Good to see the recognition of the need for a more integrated strategy from the US government
- CNG by 2020 - Aviation is stifled by lack of supply of sustainable renewable fuel
 - Very limited supply and cost is high
 - Projected Supply still suffers from higher pricing than traditional Jet Fuel
 - Production from some facilities appear to be sold out over the next 5 years
- In order to continue to lower production cost, and increase capacity, every objective outlined in the strategy is warranted
 - Feedstock Development, Production and Logistics
 - Fuel Conversion and Scale-up
 - Testing and Evaluation
 - Integrated Challenges



Recommendations

- Quantity & Price
 - Address systemic issues to achieving production of sustainable alternative jet fuel at significant quantity at appropriate pricing – requires Research Develop Demonstration & Deployment (RDD&D)
- Lower Risk.... Promotes reasonable financing
 - RDD&D will also help lower risk (Technology, Feedstock, Policy, Financial/Economics, Engineering, Management, Execution), thereby assisting with commercial development, commercial finance, offtake discussions
- Suggest starting with discrete strategies, not the everything at once
 - Focus on the main points ... \$ + Lower Risk + Supply
- Need Success Stories
 - Helps advocate and build confidence more success
 - Helps robust engagement from feedstock producers
 - Take advantage of lowest cost solutions to advance commercialization



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Final Remarks

- Market Demand is here!
- Recycling carbon molecules within the biosphere is the right thing to do
- Carbon-Neutral Growth can be a reality
- Execute the Strategy with confidence

“The Earth is not a gift from our parents, it is a loan from our children” **Kenyan Proverb**

Feedstock Development, Production and Logistics Goals

A Woody Perennial Crops' Perspective

- Poplar and willow purpose-grown feedstocks have an indispensable role in securing raw material supply and quality .
- Coppice production systems are ready for commercial deployment: Adaptable production varieties, low establishment costs (e. g. plant once every 21 years), environmental sustainability studied, yields quantified, efficient harvest system, regional demonstration farms for extension and education, production economics worked out.

Gaps and Challenges in Framework

- Production system is sound, but market conditions require monetization of ecosystem services.
- Nutrient dynamics are needed to degree they affect willow biomass yields and greenhouse gas emissions at the field level.
- Molecular tools need to integrate with conventional improvement programs to accelerate gains in yield.
- Operability of biomass recovery equipment to be perfected for wet soil conditions.
- Improvements to storage system needed; changes in poplar-willow biomass quality with harvest season.

Feedstock Development, Production and Logistics Goals A Woody Perennial Crops' Perspective

Successes

- EPA feedstock approval for cellulosic biofuels produced from short-rotation poplar and willow.
- Willow production system demonstrated on 1,200 acres in the Northeast. Poplar demonstrated across 400 acres in five strategic regions of the Northwest and Southeast where refineries envisioned; published grower's manual.
- Identification of "top line" poplar varieties that combine good agronomic and conversion properties.
- Amendable to fractionation and production of high value products.
- Licensing of patented BESC technology for low lignin poplar varieties that may reduce cost of pretreatment and enzymatic hydrolysis.
- Poplar reproductive sterility as an enabling technology for commercial transgenes.
- Genome-wide association studies with multiple poplar species.
- Single-pass Case New Holland harvester developed for poplar and willow resulting in a 30% cost reduction and biomass that meets ISO standards for B1 wood chips.

FAJFRDS – Perspective Conversion

CAAFI Biennial General Meeting
October 27th, 2016



- Goals
 - Enable discovery, development, enhancement, and scale-up of conversion processes.
 - Develop conversion technologies
- Mature Technologies
 - Hydro-treatment and upgrading of waste oils or plant-based oils - HEFA
 - Synthesis gas into jet fuel - FT
- What is a Mature Technology...?
 - Should be defined as only section (Fuel Conversion) term is used.
 - Can we transition to the CAAFI FRL (Fuel Readiness level instead of Mature)
 - How do we maintain proper listing and not get stale going forward...?
 - Use a CAAFI list and reference.
- Can a conversion technology be immature with certain feedstocks...?

- Conversion Technologies
 - Midterm
 - Alcohol to Jet (ATJ)
 - Biochemical/Catalytic Conversion of Sugars to Hydrocarbons
 - Long-Term
 - Conversion of CO₂ to Ethanol
 - Processes involving Algal and microbial feedstocks
- Need to update with new conversion technologies on the horizon.
- How does R&D support unknown conversion technologies...?

CAAFI Biennial General Meeting 2016

Federal Alternative Jet Fuel R&D Strategy: Perspectives from Stakeholders - Fuel Testing and Evaluation

Walter E. Washington Convention Center, Washington, D.C.

Gurhan Andac

Engineering Leader, Aviation Fuels & Additives, GE Aviation 



27 October'16

OEM tests (D4054 Tier 3-4)

* Bench:

- Spray tester (atomization), BECON (hot section durability)

* Sub-component:

- Fuel system simulator (corrosion, excessive vapor, etc.), single-cup/sector rig (LBO, ground/altitude relight, sub-idle efficiency)

* Component:

- Full Annular Combustor Rig (LBO, starts, efficiency, emissions, acoustics, profile/pattern, durability)

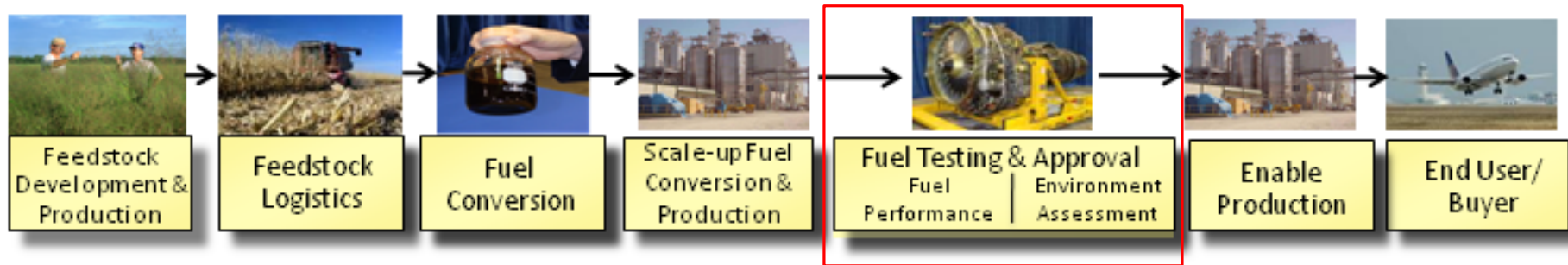
* Ground/Altitude engine:

- Starter-assist/spool-down starts, EGT, accel/decel transient operability, idle checks, take-off thrust transients, emissions, dynamics, LBO margin, endurance, augmentor performance & temperatures, APU starts, performance, and mode transitions

* Flight:

- Performance, accel/decel transients, windmill/starter-assist restarts, simulated missed approach, suction feed & APU tests

Test/Eval: Key part of dev't path



Agency Goals:

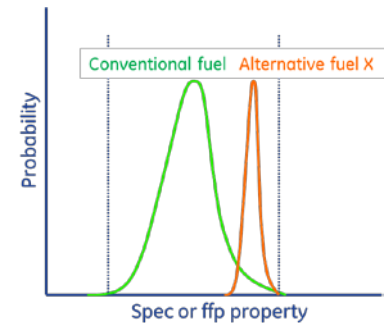
- * Facilitate civil and military approval of additional AJF pathways by enabling efficient evaluation for performance and safety through advancement of certification and qualification processes and collection and analysis of data (DOD, DOT, NASA)
- * Improve scientific understanding of how AJF composition impacts gas turbine combustion emissions and operability (DOC, DOD, DOT, NASA)

Current Gov't activities:

- CLEAN Testing, USAF & Navy Testing & ASCENT #31 “Alternative Jet Fuel Test & Evaluation”
- Jet Fuel Property Tracking Project
- CAAFI and ASTM “quick start” approach
- National Jet Fuel Combustion Program (NJFCP)
- ASCENT #33 “Alternative Fuels Test Database Library,” NIST thermophysical properties exp., modeling, and data activities
- DoD emissions measurements during combustion testing of AJF and DoD modeling efforts through SERDP
- ASCENT #13 “Micro-Physical Modeling & Analysis of ACCESS 2 Aviation Exhaust Observations” & #24 “Emissions Data Analysis for CLEAN, ACCESS, and Other Recent Tests”
- NASA’s AATT, ACCESS2 and ECLIF-2 programs on contrails
- NASA’s Low NOx Combustion Tests with real-time AJF blending

How else Gov't can help?

- * Support **OEM reviews** of test and eval data
- * **Long-term** effects of AJFs
- * **Dynamics/acoustics** impact of AJFs
- * **Fully synthetic** AJFs
- * **Higher heating value** associated with some AJFs and the potential **benefits** of this in the engine cycle to reduce emissions (lower fuel burn)
- * New/improved property **test methods**
- * Continue funding to understand impact of AJF on **nvPM** (particulate) emissions (studies show minimal impact on NO_x, CO and UHC with AJFs). Include H correction methodology.
- * (Long shot) tailor AJFs to develop **compact** robust **combustion systems** that can reduce engine length/weight and ultimately reduce fuel burn/CO₂



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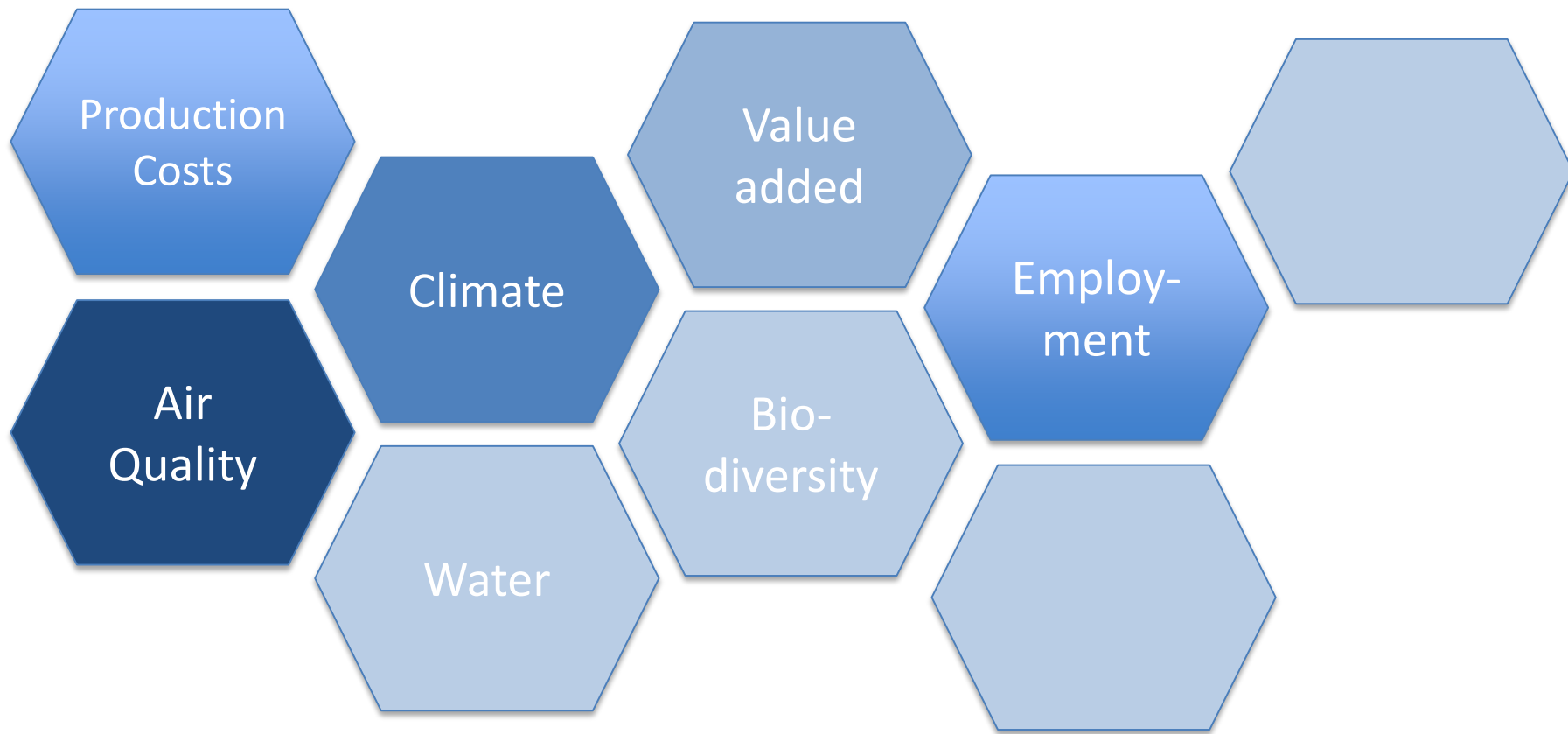
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Integrated challenges

Robert Malina

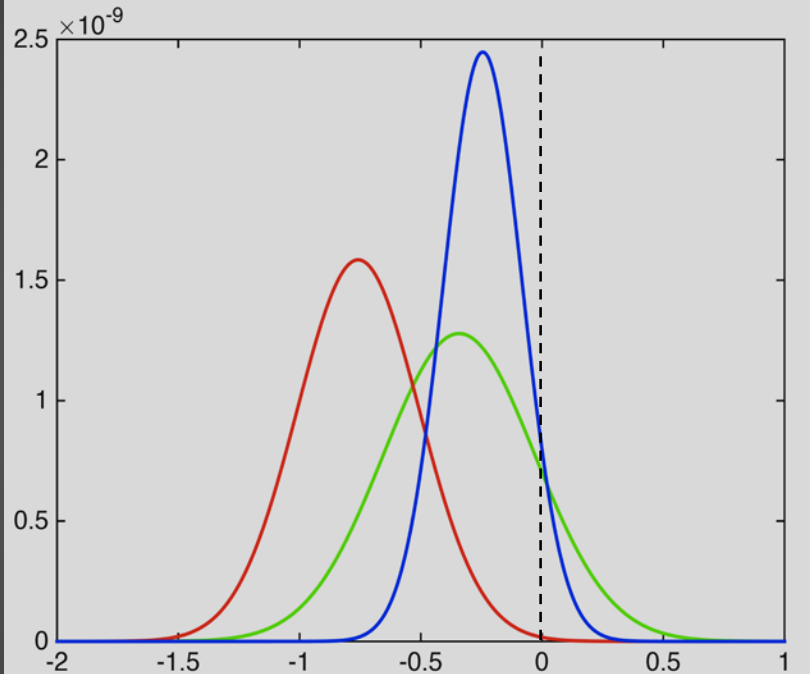
CAAFI General Meeting
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Integrated challenges: From investor perspective to societal perspective

Investor perspective:

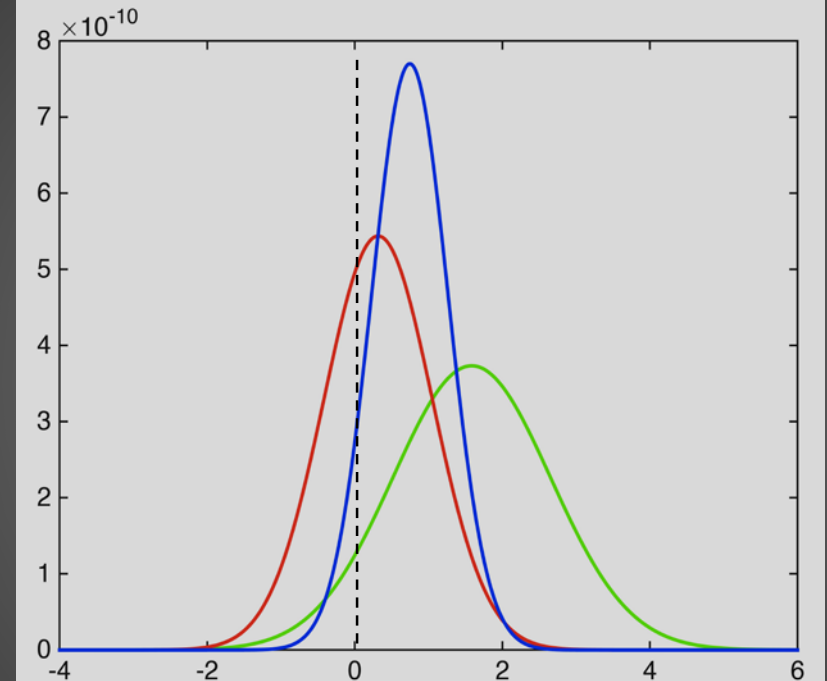


Net present value (\$B)

Probability of NPV>0:

14% 0.1% 7%

“Societal” perspective:



Net present value (\$B)

Probability of NPV>0:

93% 67% 93%