Dynamic cost-benefit assessment of aviation biofuels

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Traditional view on Alternative Jet Fuel “viability”

Production costs

GHG emissions

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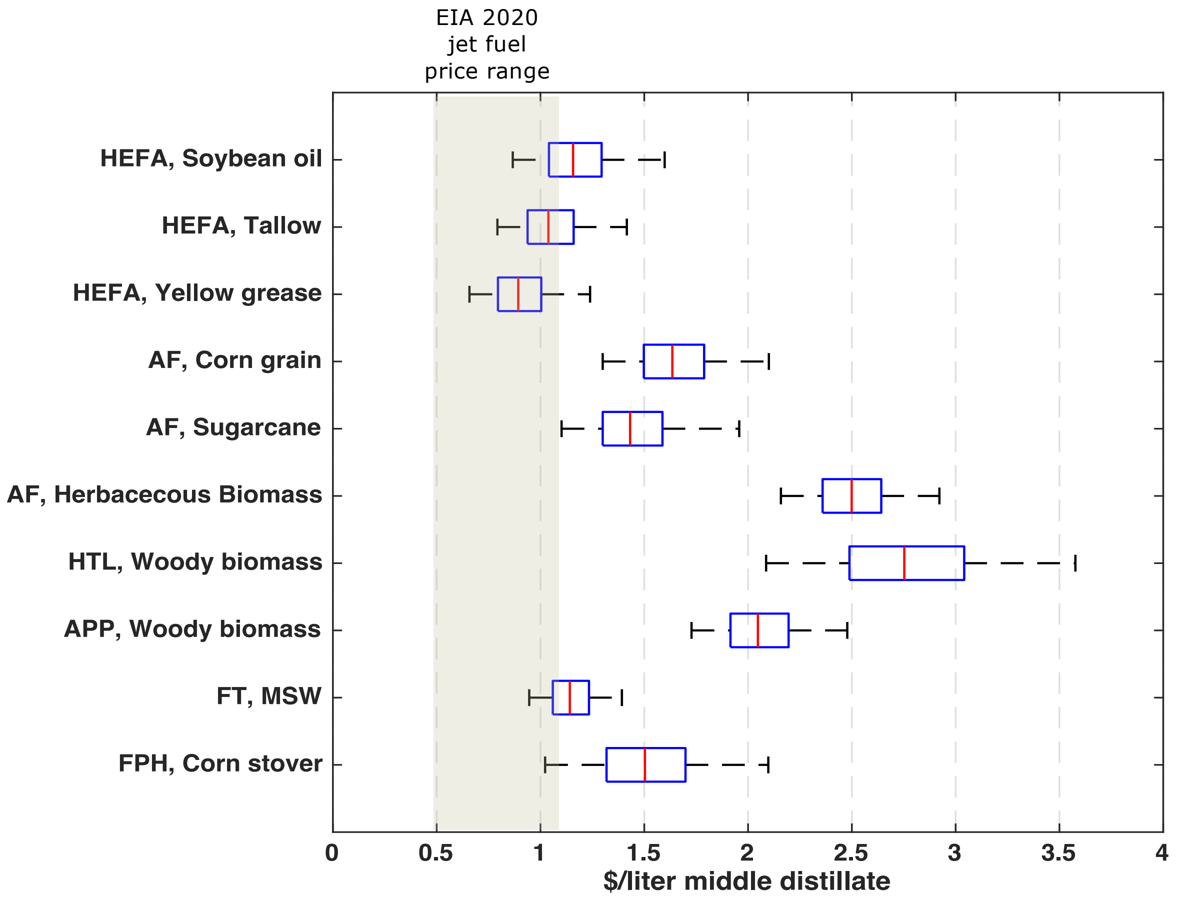
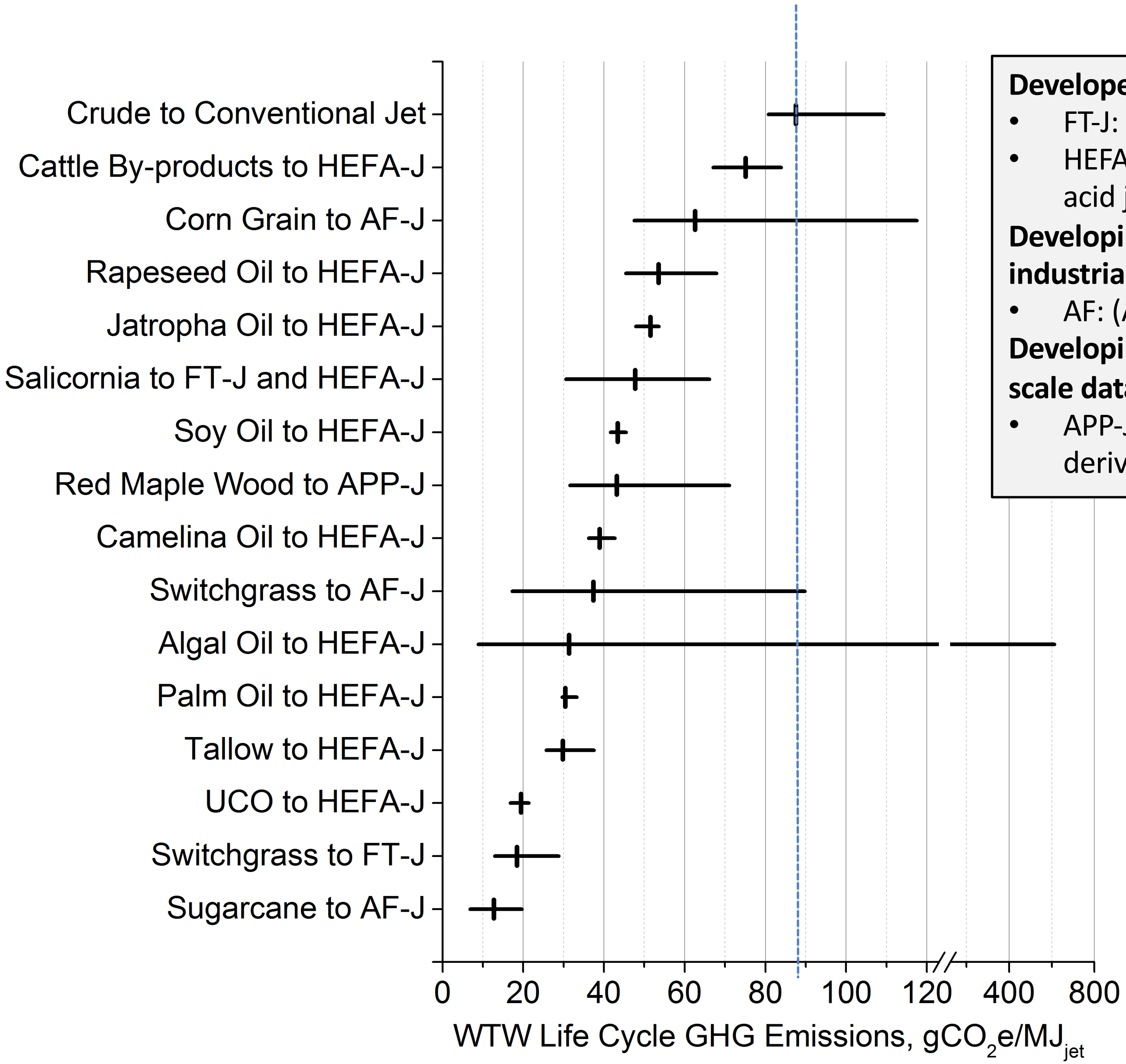
Static costing perspective



No RIN credits or other subsidies included.
Do not cite, as preliminary.

Static GHG emissions perspective



Developed technologies

- FT-J: Fischer-Tropsch jet fuel
- HEFA-J: Hydroprocessed esters and fatty acid jet fuel

Developing technologies assessed using industrial- & lab scale data

- AF: (Advanced) fermentation jet fuel

Developing technologies assessed using lab-scale data

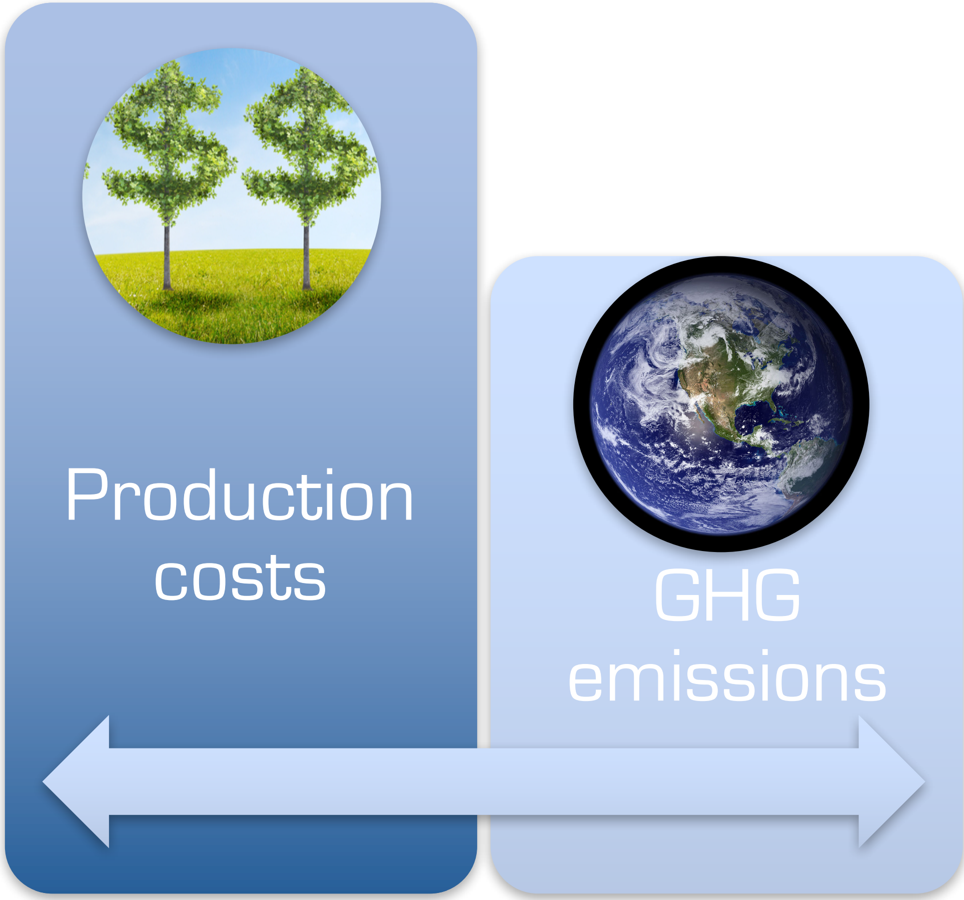
- APP-J: Aqueous phase processing derived jet fuel

- Results shown for production scenarios without land-use change

Results from Stratton et. al. (2011), Carter (2012), Staples et al. (2014), Seber et al. (2014), Bond et al. (2014) and on-going work. All data peer-reviewed with exception of APP results

Missing facets

1. Weighing up of costs and emissions



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Missing facets

2. Inclusion of fuel availability

Availability

Production costs

GHG emissions

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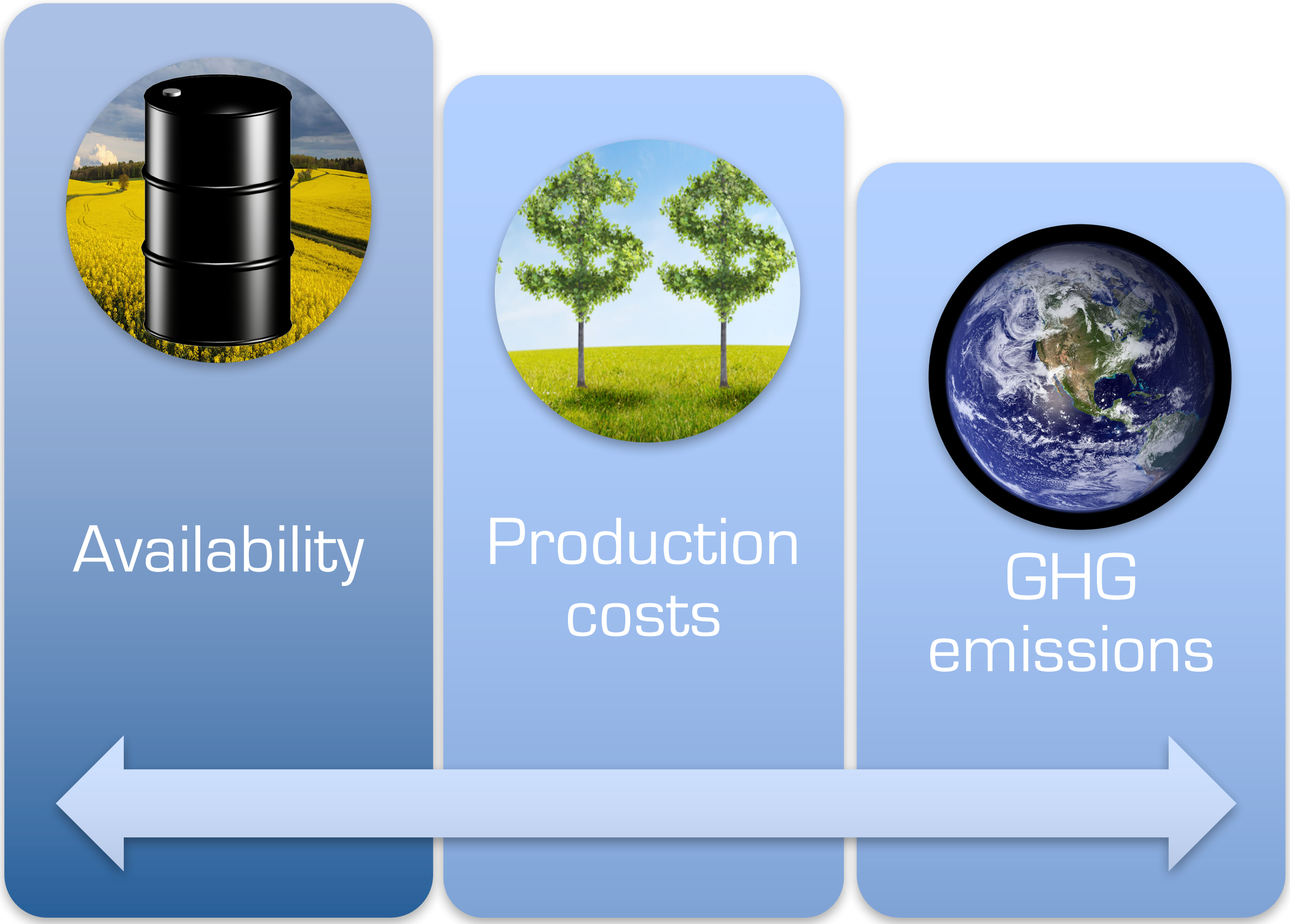
Missing facets

3. Changes of viability over time



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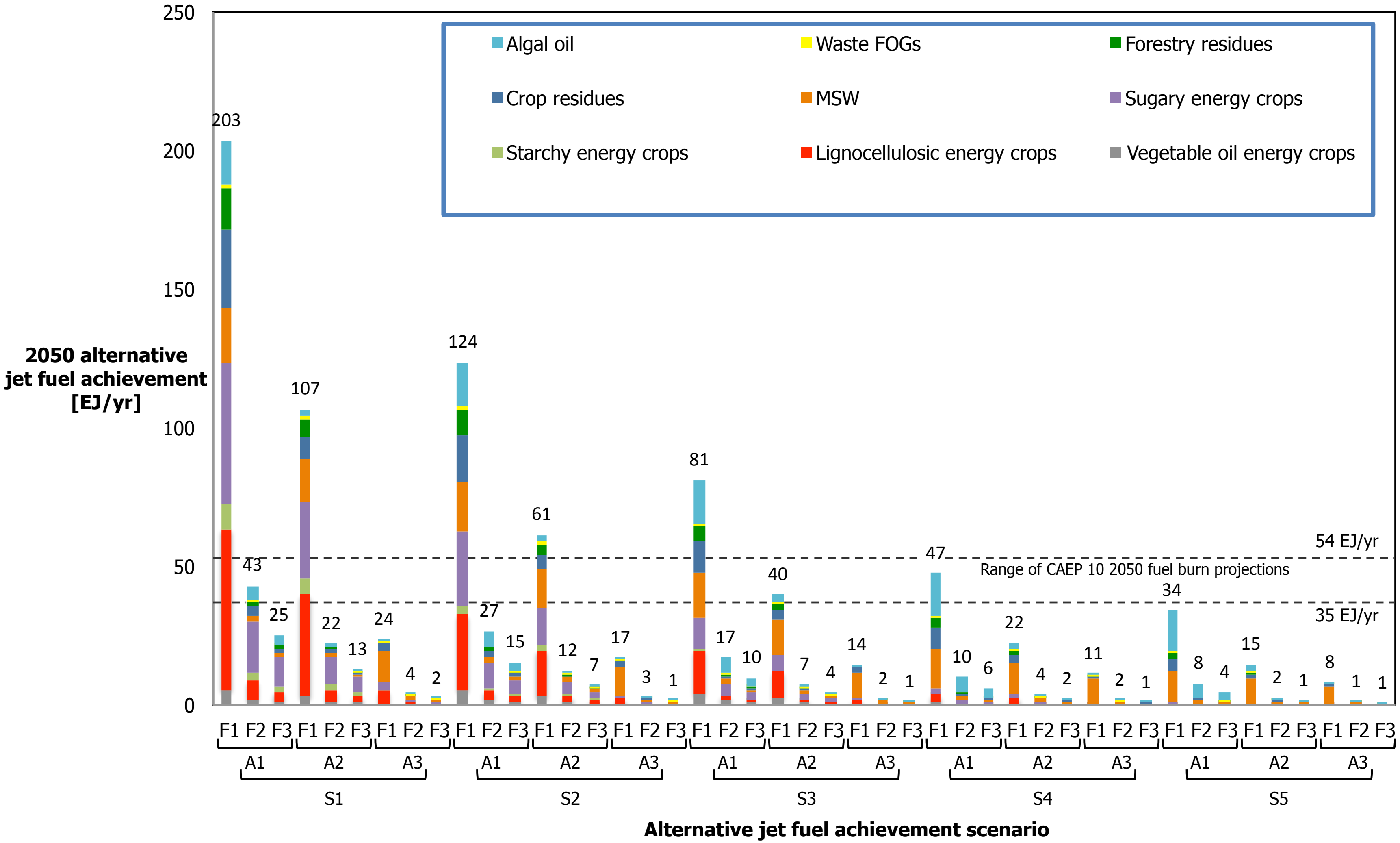
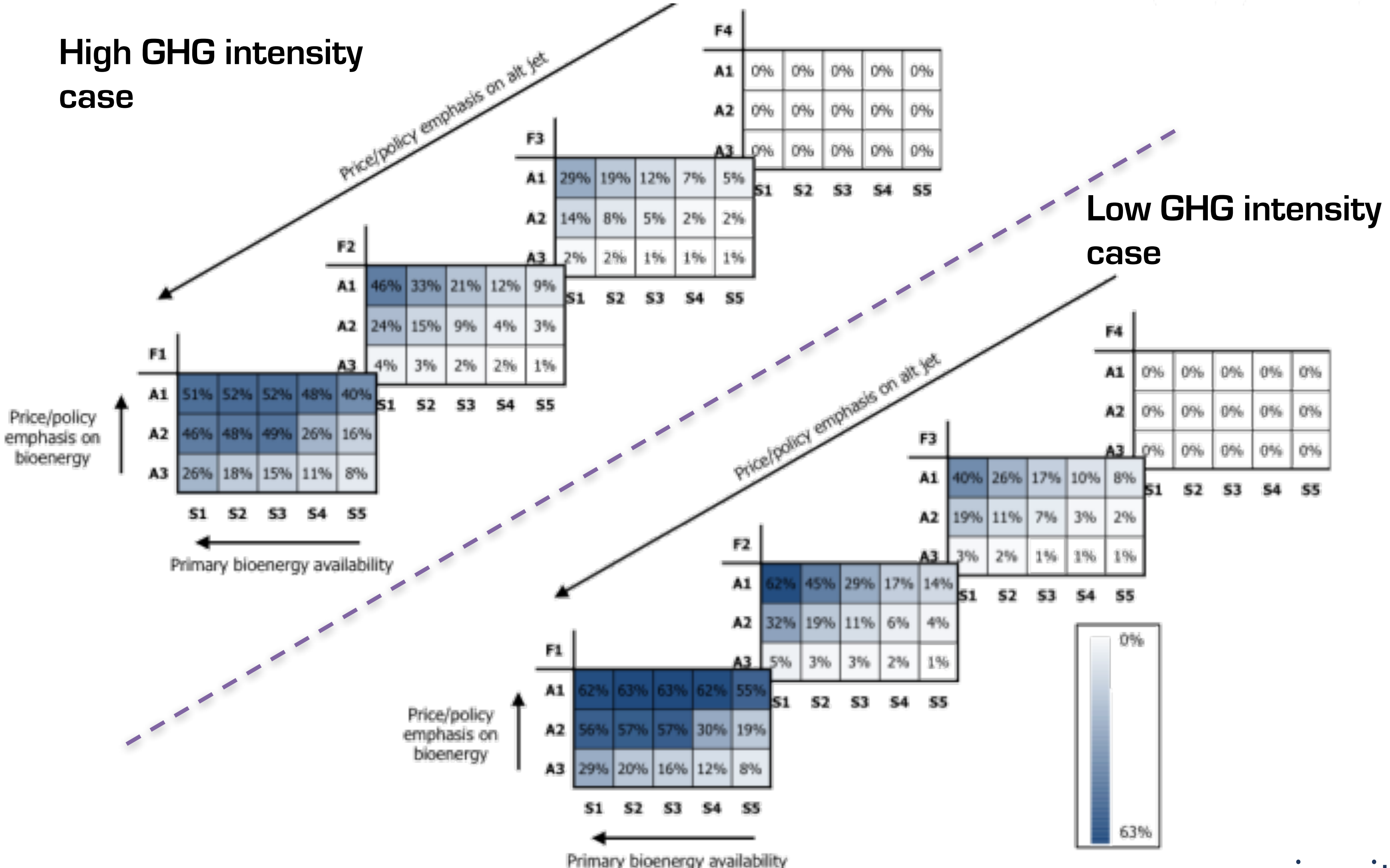
Future availability of alternative jet fuel and production ramp-up over time

2050 global AJF production scenario results



- AJF achievement range from **0-203 EJ** (**4,600 Mt**) in 2050, replacing **up to 100%** of 2050 jet fuel demand

2050 global AJF GHG emissions reduction



- Emissions' reduction ranges from **0-63%**, compared to petroleum-derived jet fuel usage only.

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Production-ramp up assessment (1 of 4)

Aviation GHG emissions reduction	Required AJF production volume in 2050 (Mt/yr)	Number of additional biorefineries/yr	Capital investment/yr
2%	30	10	$2B - $12B
10%	130	40	$6B - $28B
17%	220	70	$12B - $50B
40%	570	170	$30B - $120B
63%	870	260	$40B - $180B

Assumptions: 5,000 bpd biorefinery with 50% jet fuel output share, capex range $35,000-140,000/bpd. Capex values are provided based on total biorefinery investment, not just jet-fuel portion. Fuel demand projections based on ICAO forecasts.

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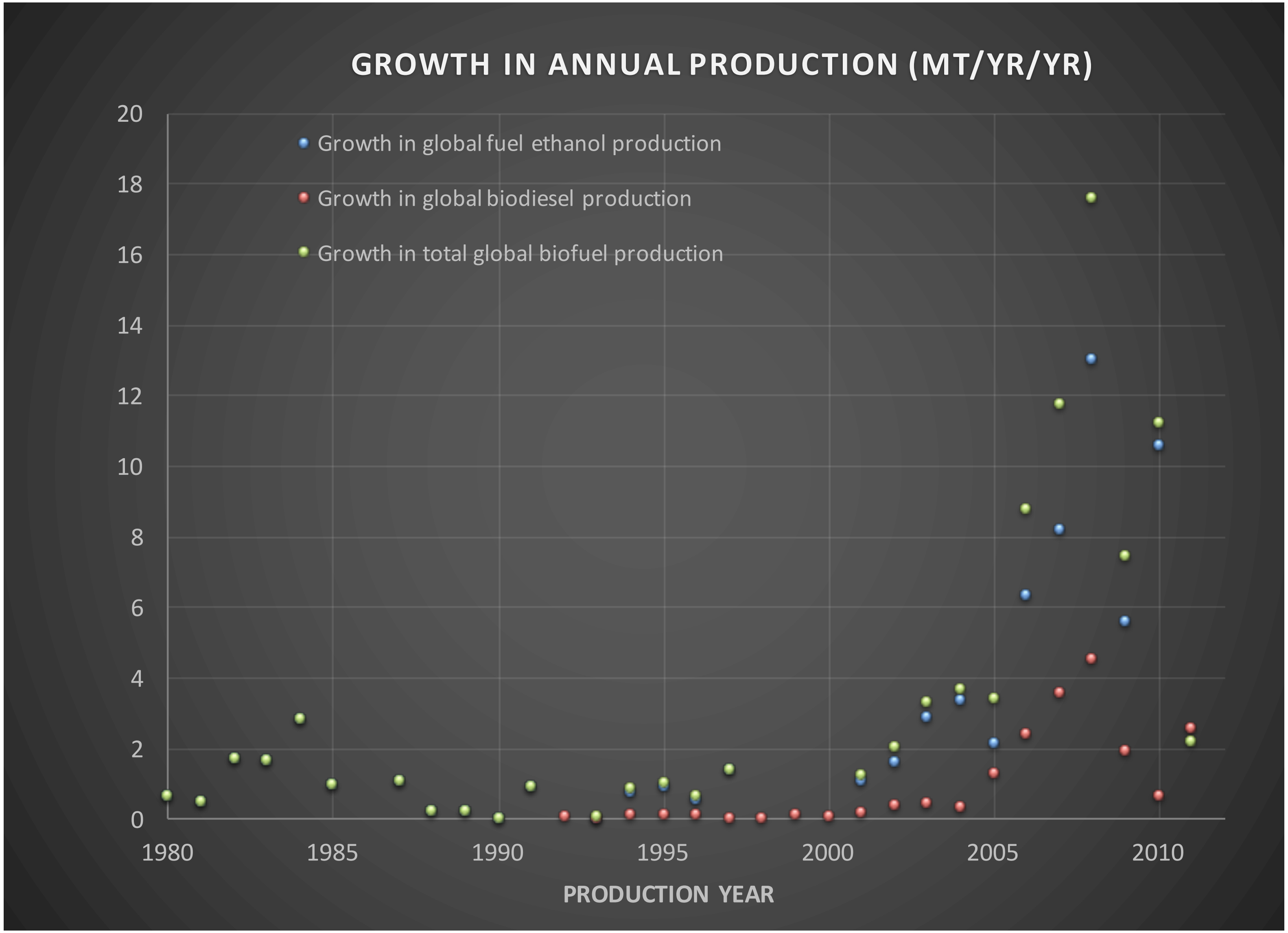
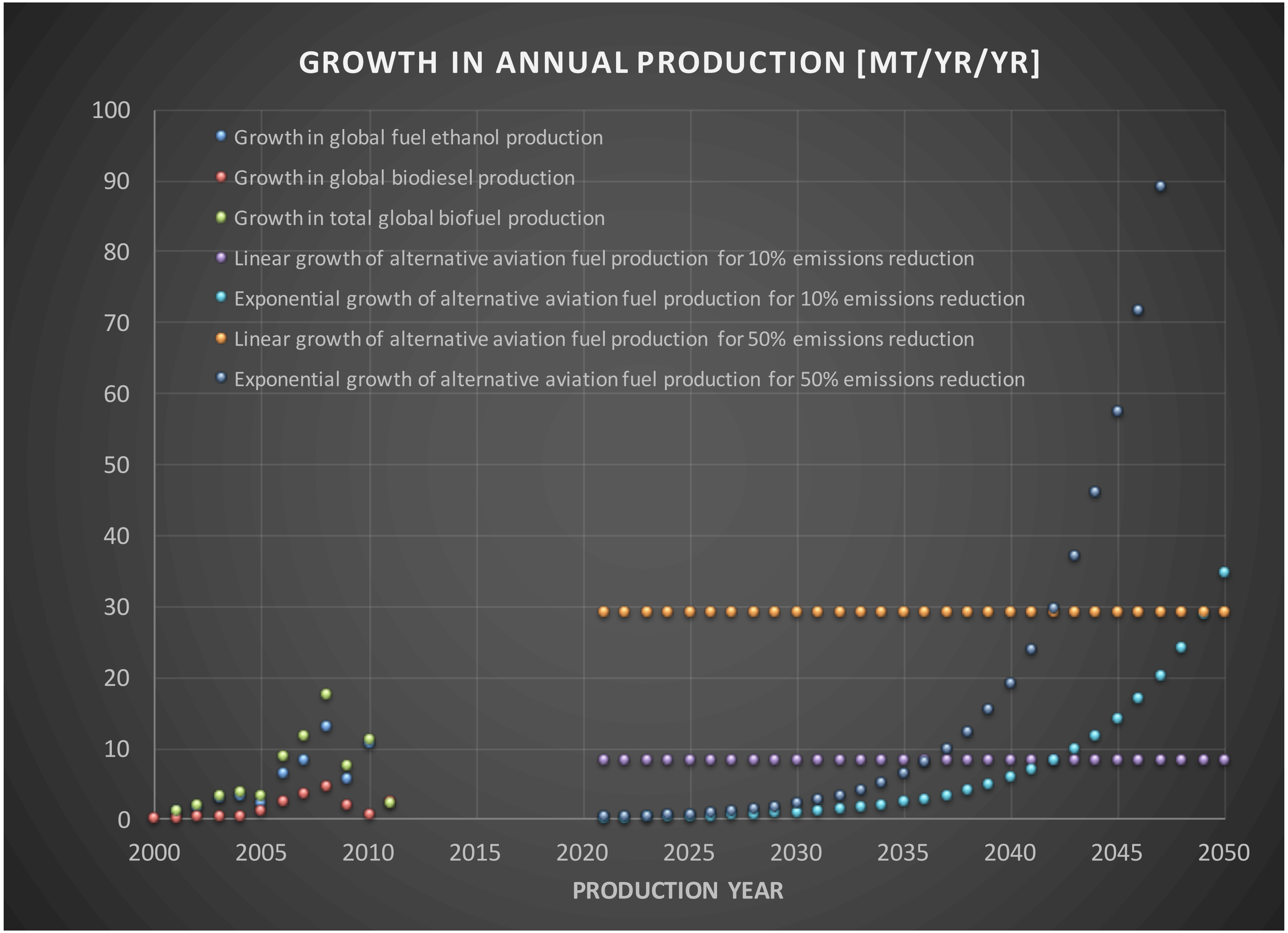
Production-ramp up assessment (2 of 4)



Source: Data from Brown (2012) .

Production-ramp up assessment (3 of 4)



Source: Historical data from Brown (2012) , other values own calculations.

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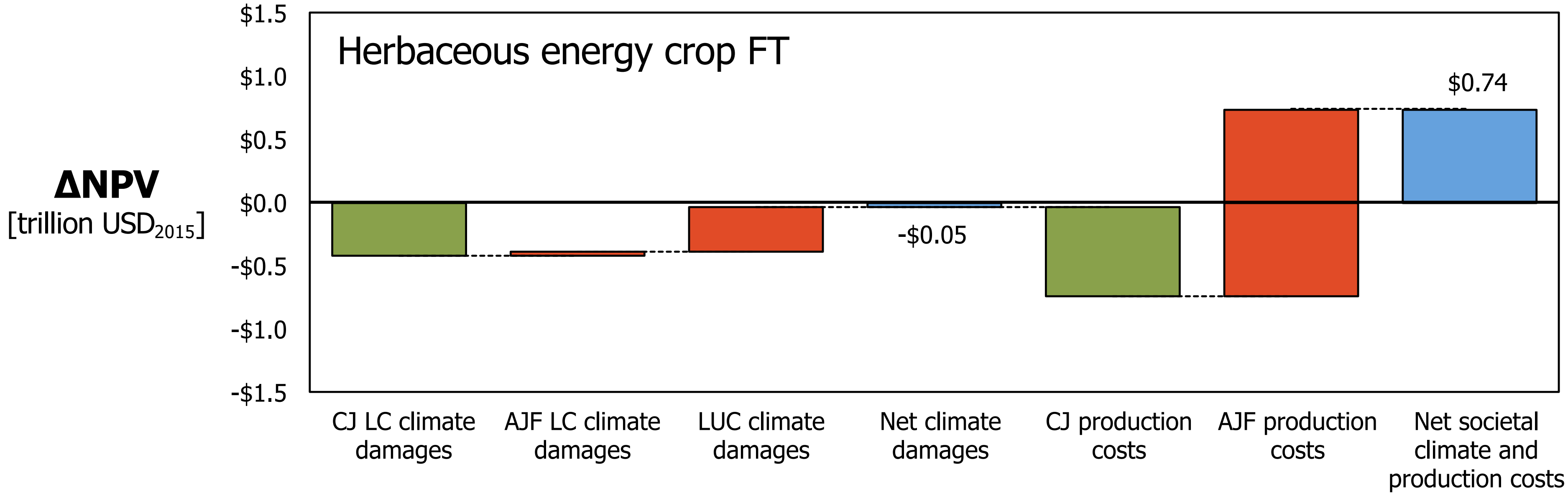
Production-ramp up assessment (4 of 4)

Annual **growth in AJF production** out to 2050 needs to be on the order of recently observed growth of 5-15 Mt/yr (**100k-300k bpd**) in global biofuel production capacity to **achieve between 10% and 20%** emissions reduction by 2050

Growth needs to **significantly exceed** historical global biofuel production growth rates for total GHG emission reductions of **greater than 20%.**

Weighing up additional production costs and GHG emission benefits

Herbaceous FT jet fuel example



Do not cite, as preliminary.
Results are specific to the assumptions below and cannot be generalized

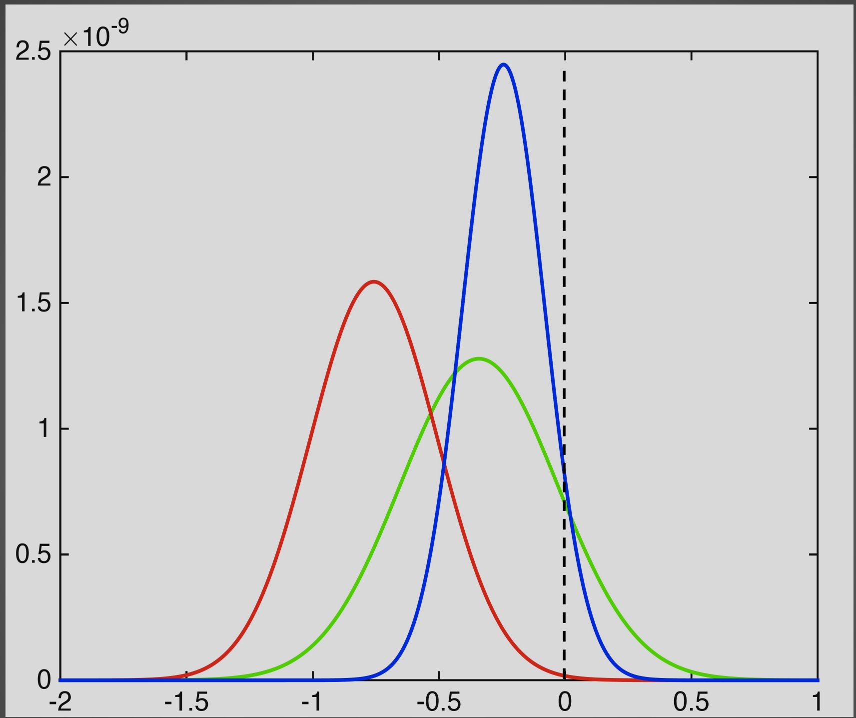
CJ: Conventional jet fuel from petroleum
AJF: Alternative jet fuel
LC: Lifecycle
LUC: Land-use change

Assumptions used:

- 150 Mt/yr. AJF mandate for 2035 (~30% global jet fuel burn)
- Learning curve effects for alternative jet fuels as production increases
- Increases in agricultural productivity
- Changes in carbon intensity of conventional jet fuel

MSW to jet example

Investor perspective:

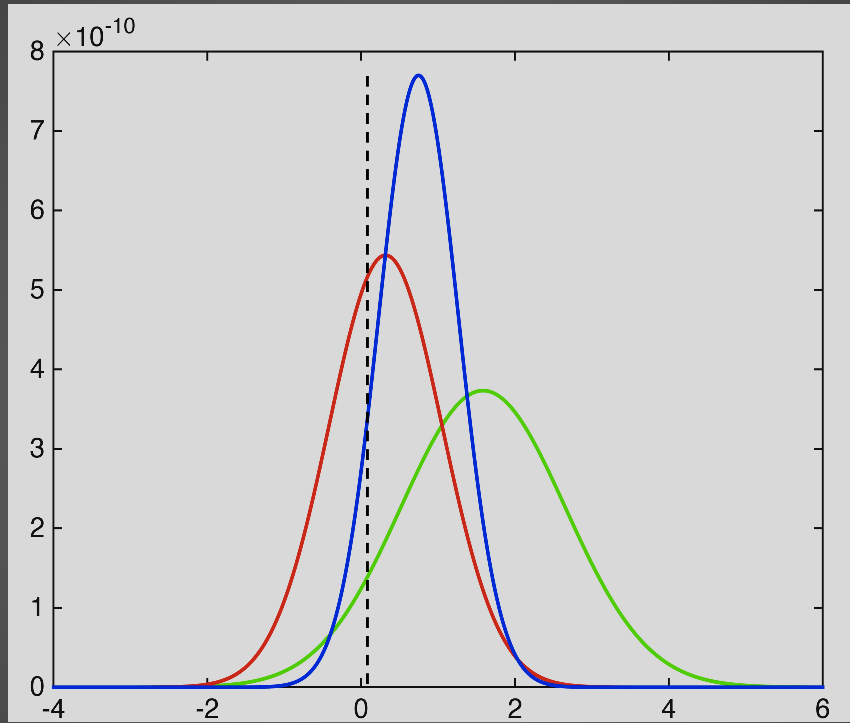


Net present value ($B)*

Probability of NPV>0:

14%, 0.1%, 7%

"Societal" perspective:



Net present value ($B)

Probability of NPV>0:

93%, 67%, 92.5%

FT MD
Plasma FT MD
ATJ MD

*No RIN credits included

Results are specific to the assumptions below and cannot be generalized

Assumptions used for societal case

- Costs of carbon based on US EPA social costs of carbon
- Societal costs of capital of 3.2%
- Taxes and subsidies excluded as they constitute transfers

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Summary statement

- There is a **large alternative jet fuel potential** whose usage could significantly **reduce** aviation **GHG emissions**.
- Aviation biofuels, on average, will remain **more expensive** than conventional jet fuel in the **short to medium term**, therefore, in order to get fuels into the market, **policy incentives** will be required.
- **Significant investment** is necessary in order to achieve a substantial aviation biofuel market penetration:
  - Annual capital investment **similar** to **highest** annual **investment** in **road transportation biofuels** for **10-20% emissions' reduction** out to 2050
- **Higher costs** for aviation biofuels are **justified** from a societal perspective as long as the environmental benefits **compensate** for the additional costs. In order to achieve this, **significant cost** savings will need to be realized for many pathways.

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Work presented here may not represent the views of the FAA.

Thank you for your attention!

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