Gaseous and nvPM Turboshaft-Engine Emissions using 30%, 50% and 100% SAF

Motivation

Aircraft Engine Emissions - Climate Impact

SAF properties

Setup

Gaseous & PM Emissions

Summary & Outlook

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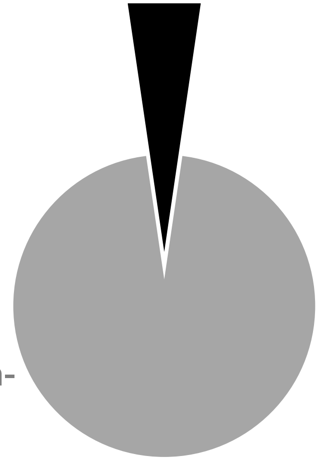
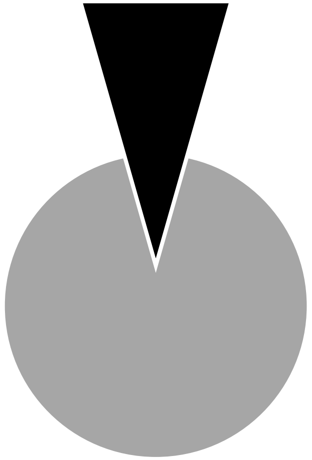
2.1 %

The global aviation industry produces around 2.1% of all human-induced CO2 emissions. [1]



12 %

Aviation is responsible for 12% of CO2 emissions from all transport sources, compared to 74% from road transport. [1]



CO_2-neutrality until 2050 – but how?

[1] ATAG, Waypoint 2050, Summary, 2nd Edition, 2021

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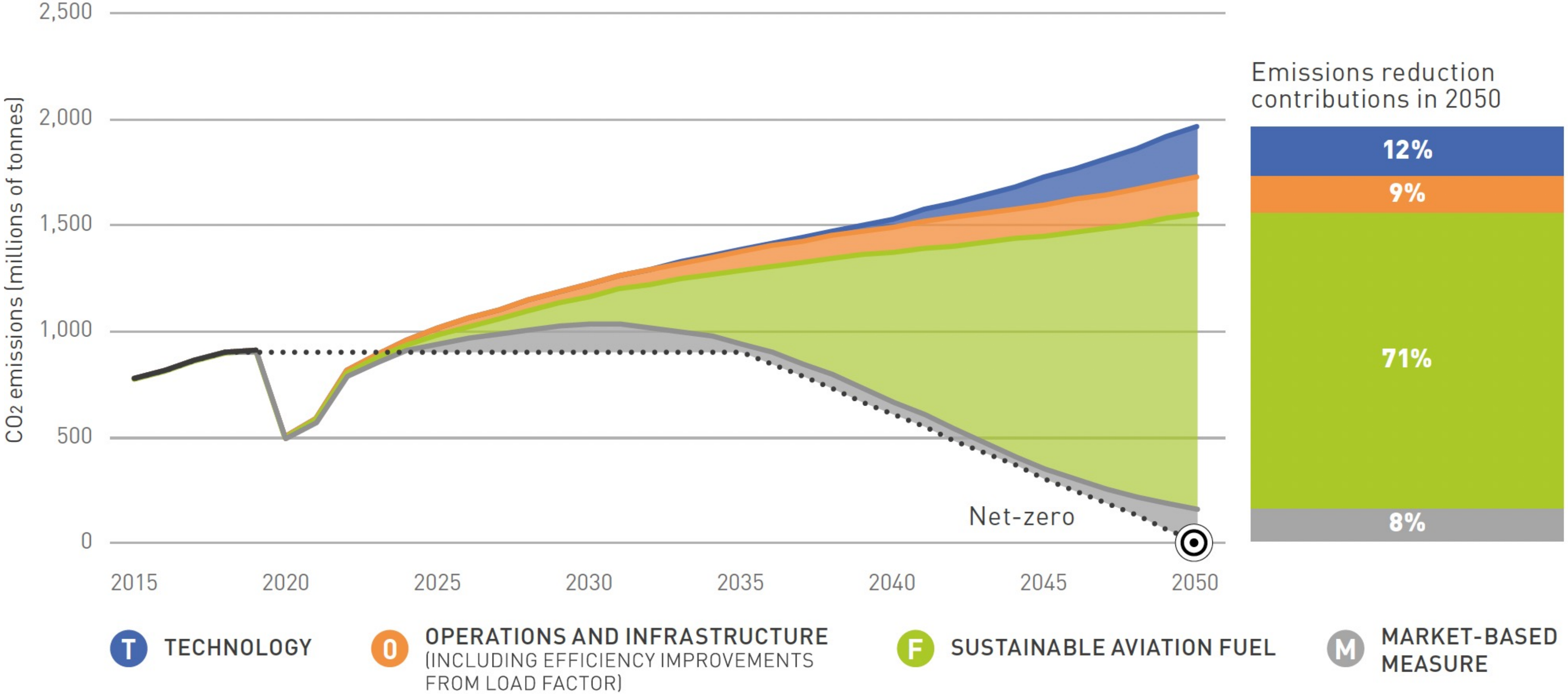
Motivation



[1] ATAG: Balancing growth in connectivity with a comprehensive global air transport response to the climate emergency: a vision of net-zero aviation by mid-century, 2nd edition, 2021, Aggressive SAF deployment

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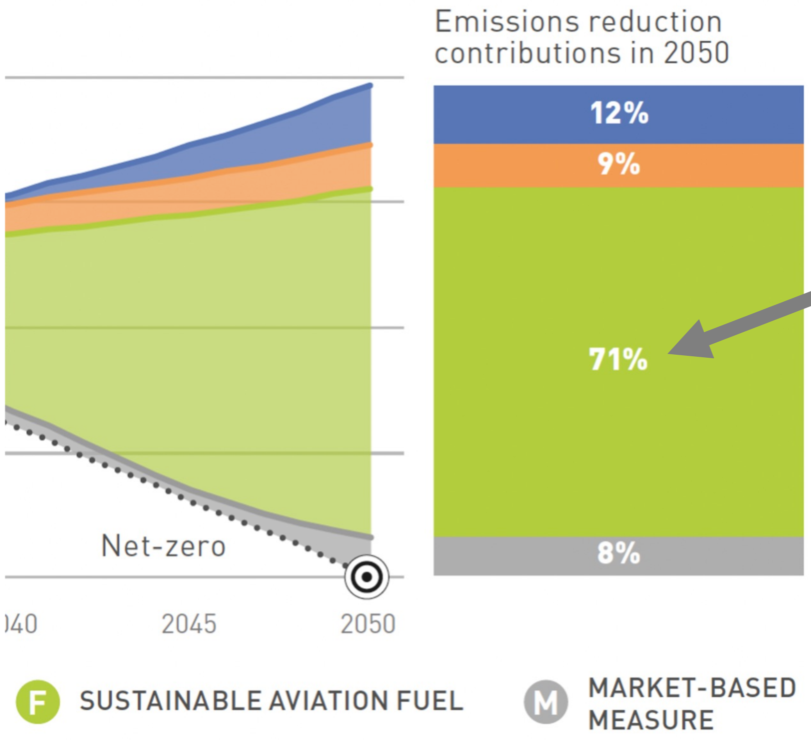
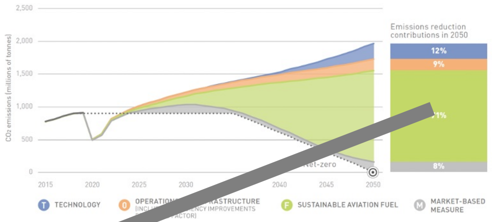
Motivation





SAF (and the production) is the most important milestone to CO_2 neutrality of the aviation sector

Some SAF are declared as „Drop-In" technology

SAF testig is therefore essential

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direct

Gaseous Emissions (CO, CO2, NOx, UHCs, PAHs, …)

Water vapour

PM Emissions (soot, aerosols, …)

… and more

other

Atmospheric processes and products (contrails, SOA, …)

… and more

[1] M. Masiol, R.M. Harrison / Atmospheric Environment 95 (2014) 409-455

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SAF properties

Blends with SAF up to 50% are approved and are declared as „Drop-In“.

There are also „non-Drop-In“ fuels – for these the infrastructure and engine design has to be adjusted (primary sealings)

	Hydrogen [weight %]	C/H ratio [mass-weighted]	H/C ratio [mol-weighted] α	Total Aromatics [vol.%]	Total Sulfur [weight %]	Napthalene [vol%]	Density at 15°C	Net heat [MJ/kg]	Smoke point [mm]
ASTM Specification	-	-	-	max. 26.5	max. 0.30	max. 3.0	775 to 840	min. 42.8	min. 18.0
Ref Jet A-1	14.01	6.14	1.94	15.8	0.09	0.8	799.3	43.1	24.3
30% SAF	14.36	5.97	1.99	11.1	0.06	0.6	791.1	43.3	29.7
50% SAF	14.57	5.86	2.00	7.9	0.04	0.4	785.5	43.5	34.3
100% SAF	15.10	5.62	2.12	<0.2	<0.0001	0.0	771.8	44.0	>45.0

SAFs are known to reduce the PM number & mass

the main cause is attributed to the lack of aromatics

[1] ASTM spec: D7566 – Annex 2

[2] ASTM D1655

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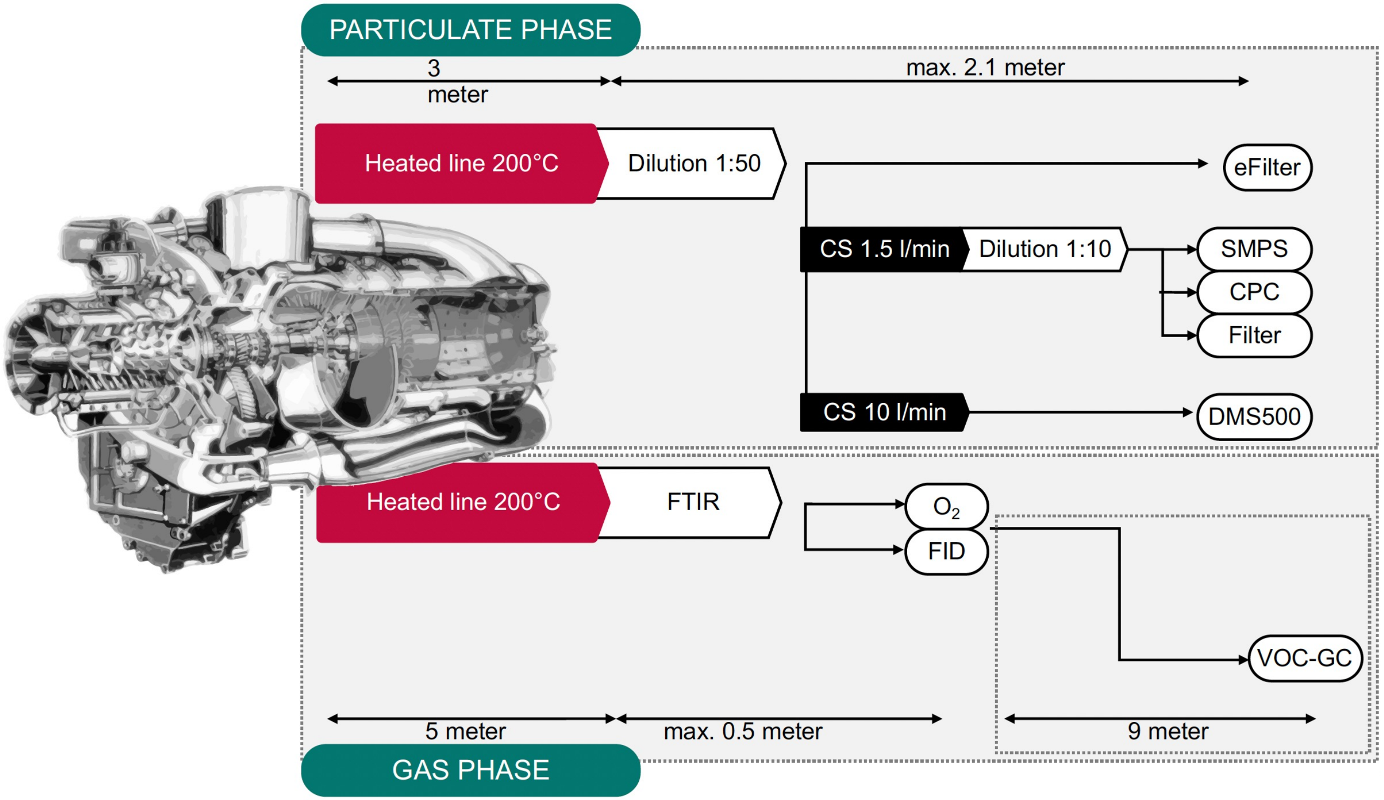
Setup



Allison 250-C20B turboshaft engine properties

	7% rated power – Ground-Idle	100% rated power – Take-Off
Fuel pressure [bar]	13	27
Fuel flow [g/s]	7.5	24
Total temperature combustor outlet [K]	907	1212
Total temperature combustor inlet [K]	399	536
Shaft power [kW]	17.5	250

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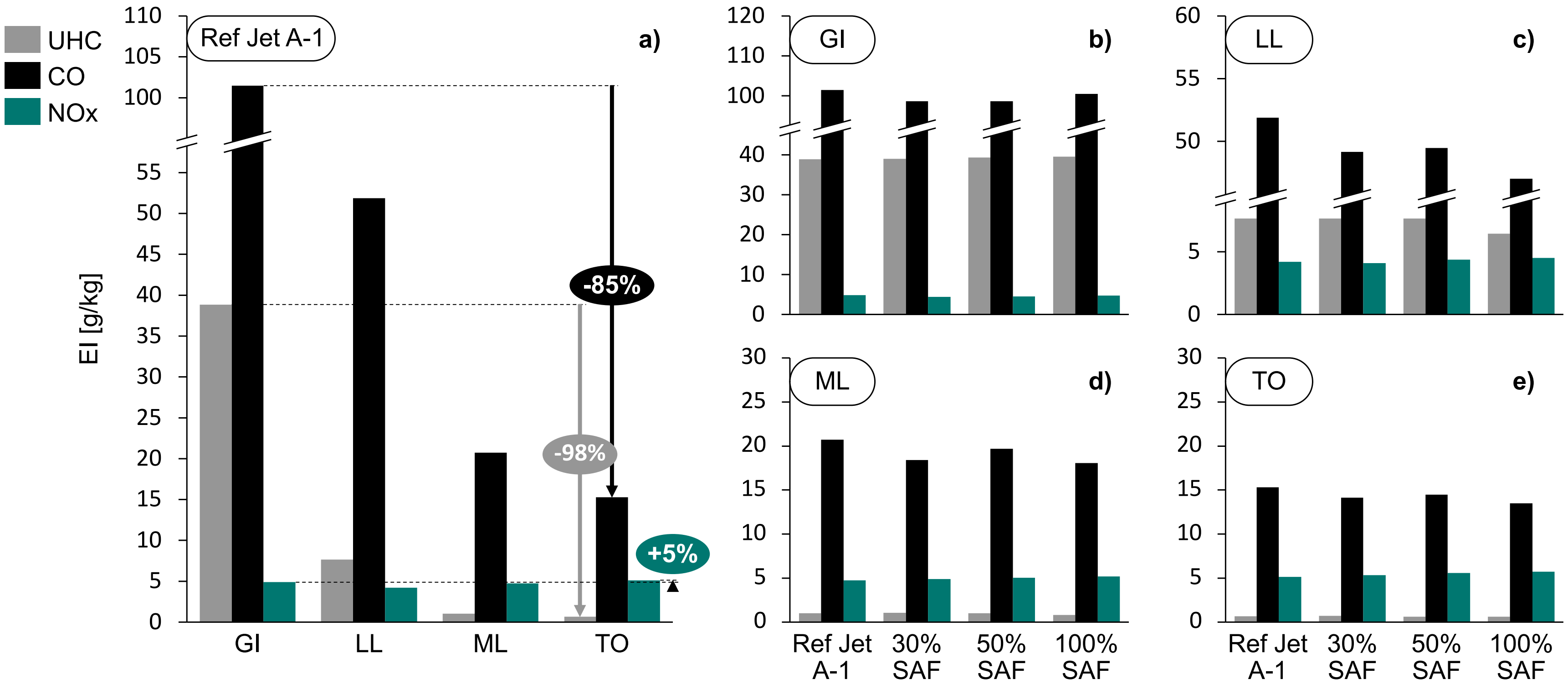
standard compounds



Only engine related emission-changing-behaviour

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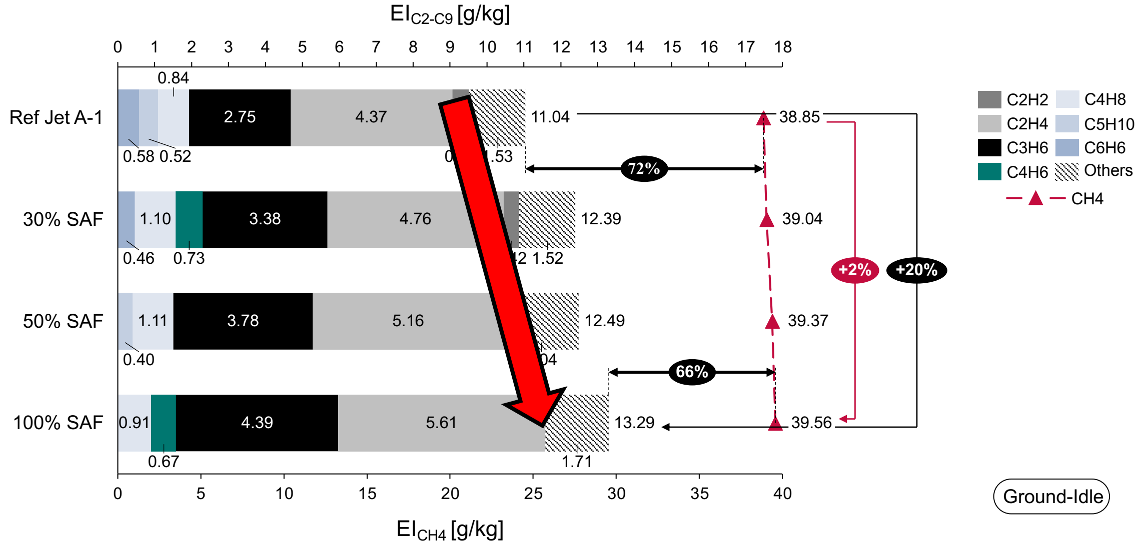
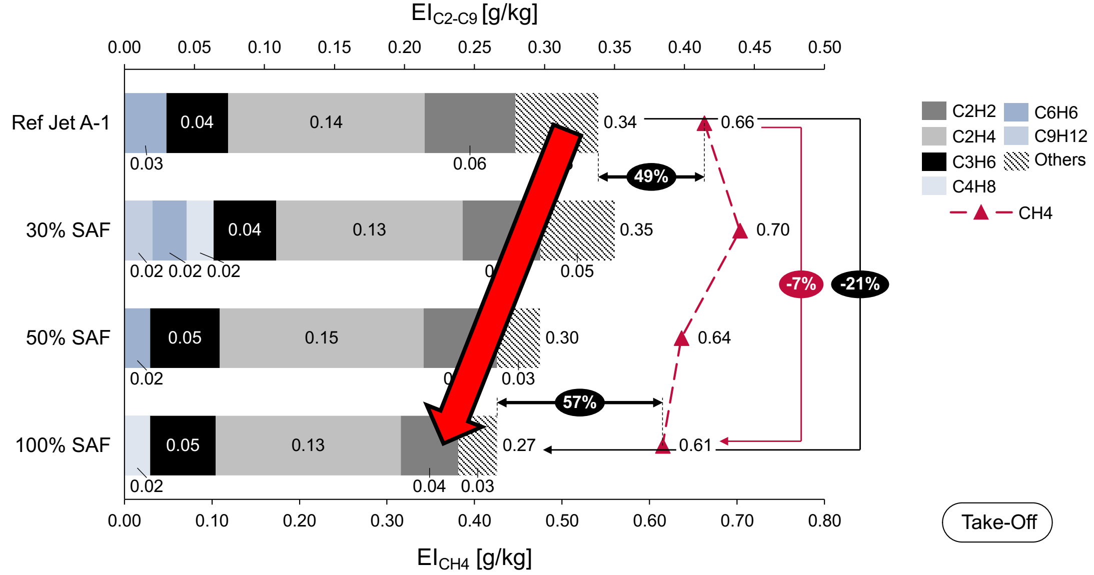
volatile organic compounds

Ref Jet A-1 vs. Blends and 100% SAF

- more VOC in GI with 100% SAF
- Less VOC in TO with 100% SAF

Engine & fuel related emission-changing-behaviour





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nvPM number concentration

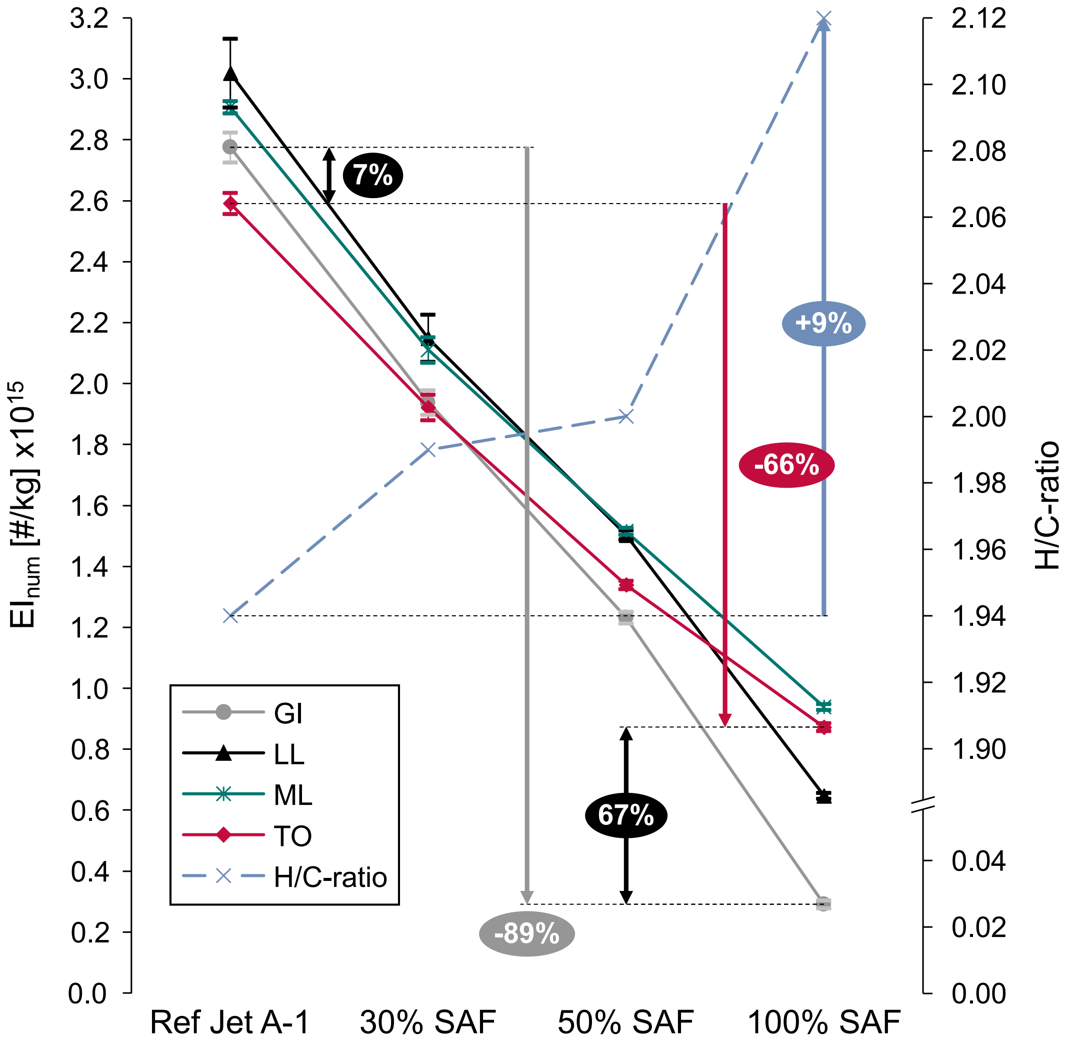
Ref Jet A-1

- EI_{num} changes not significantly between the engine power settings (EPS)

100% SAF

- EI_{num} significant lower at GI than at the other EPS

Biggest reduction potential with SAF in Ground-Idle



Results

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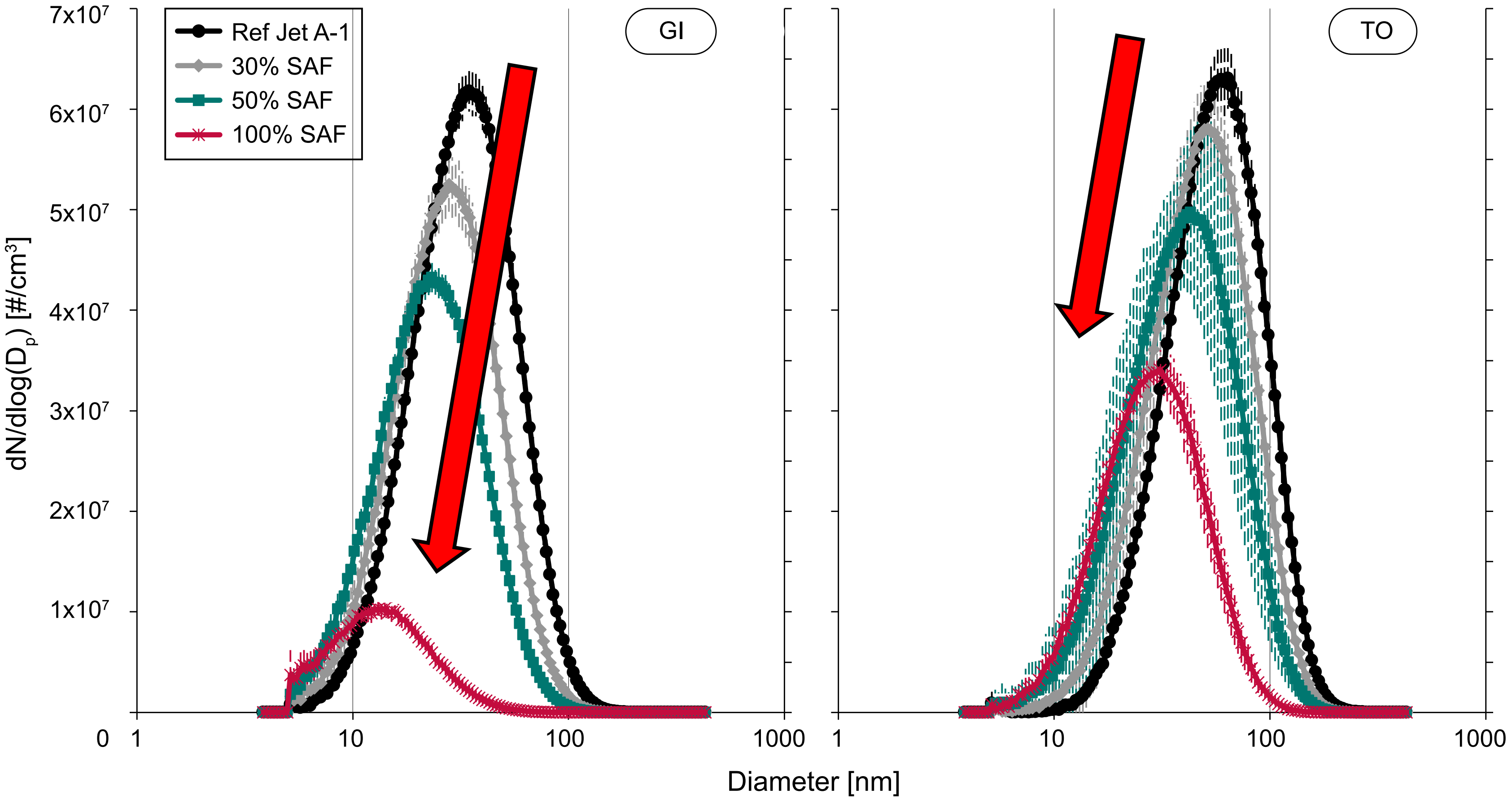
Size Distributions



Mode of the PNSD shifts to smaller particle diameters which is related to the reduction in PM mass

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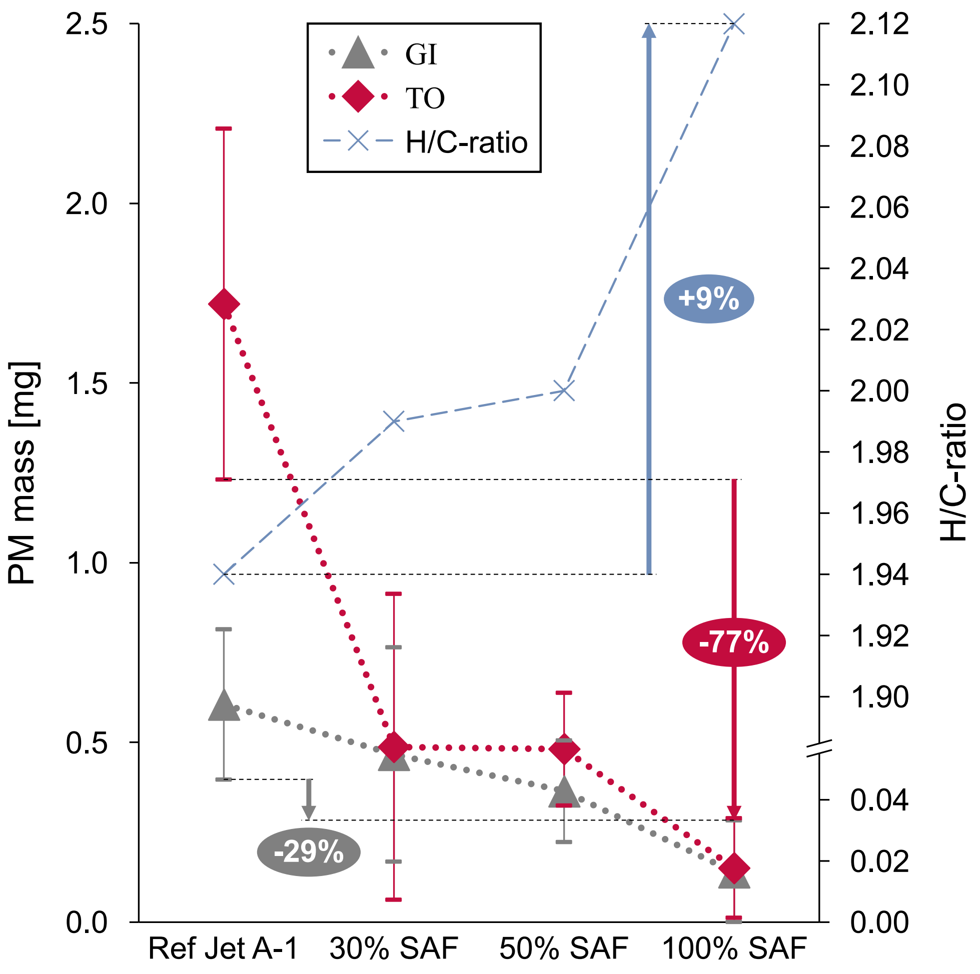
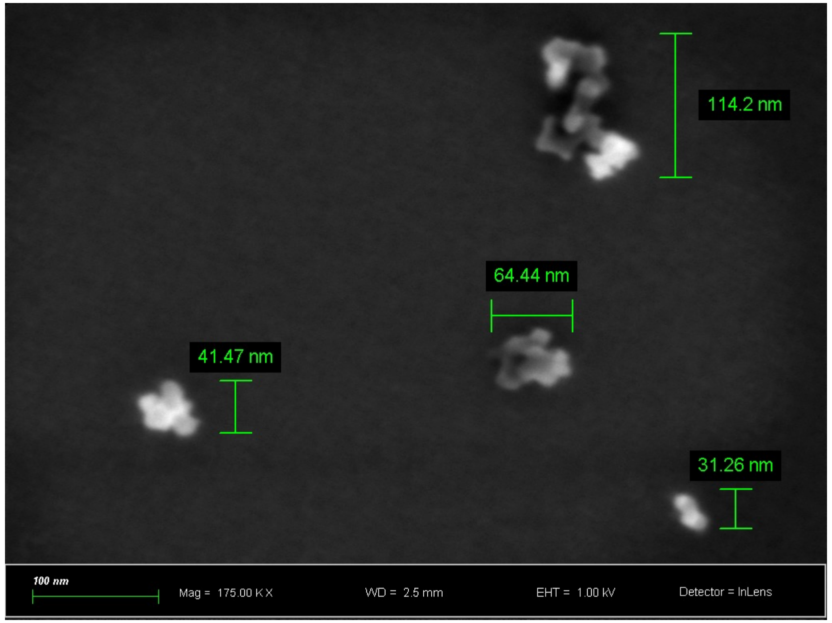
Results

PM mass





Reduction in PM mass is more evident in TO engine power setting due to the bigger GMD of the soot particles

Summary

- ✓ SAF is the main driver of decarbonisation in the aviation sector
- ✓ SAF properties are different compared to Jet A-1, resulting in a different emission behaviour of VOC & PM, while the standard gaseous compounds are comparable
- ✓ The PM reduction is a function of:
  - ✓ proportion of SAF (low aromatics) in the fuel
  - ✓ engine (combustor) technology

Outlook

Next SAF-campaign with FT-SPK including measuring: PM mass & number, SOA (DOFR), PAHs (REMPI-ToF)

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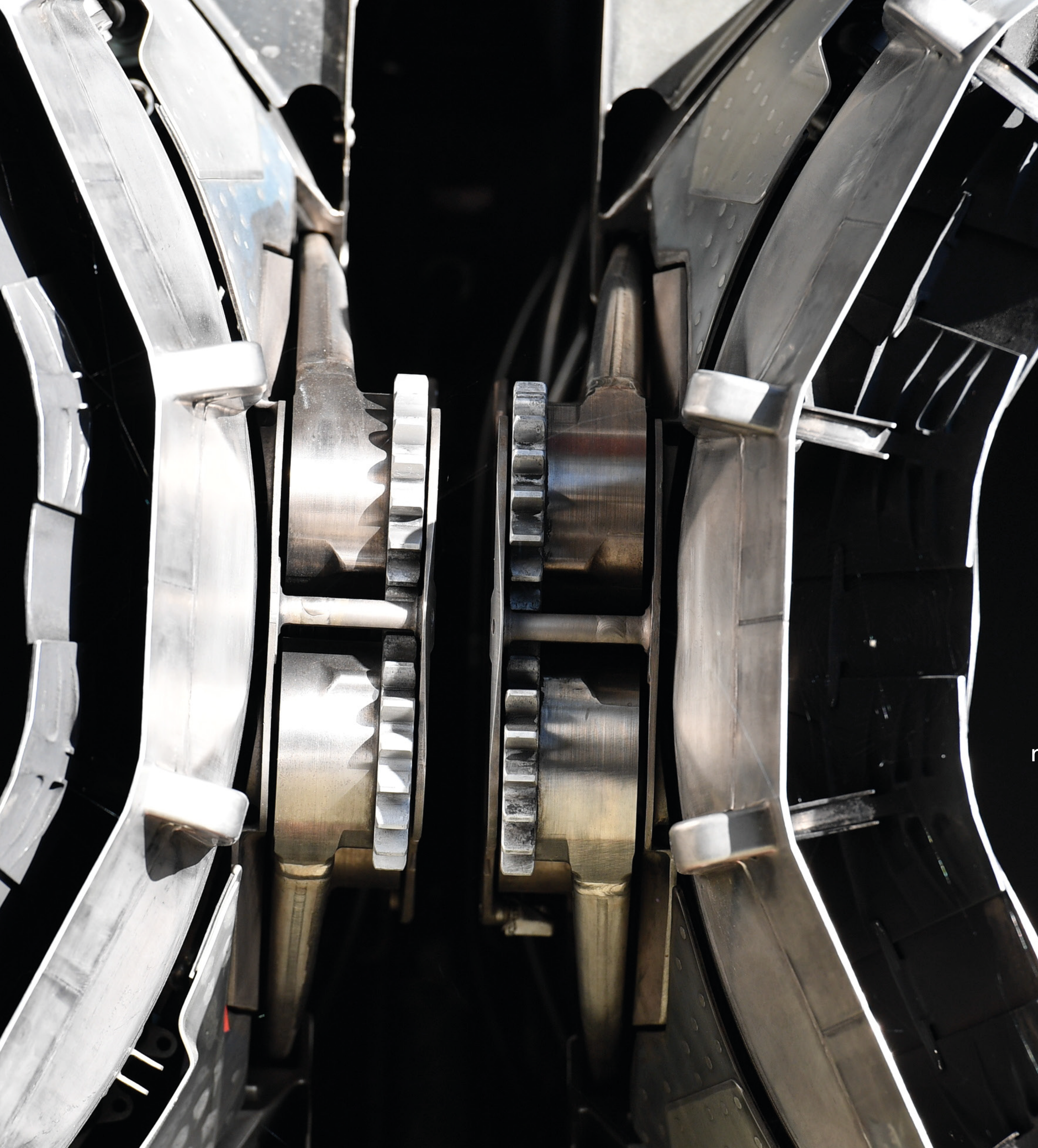

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