

The banner features a green and blue background with a stylized globe, a white airplane flying, and a sun with rays. The text is in white and blue.

ICAO Symposium on Non-CO₂ Aviation Emissions

16 — 18 September 2024
Montréal, Canada

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Speaker

Session 3: Mitigating Non-CO₂ Aviation Emissions –
What is possible
Part I – Innovative Technologies



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Mitigating Non-CO₂ Aviation Emissions

Theo Rindlisbacher

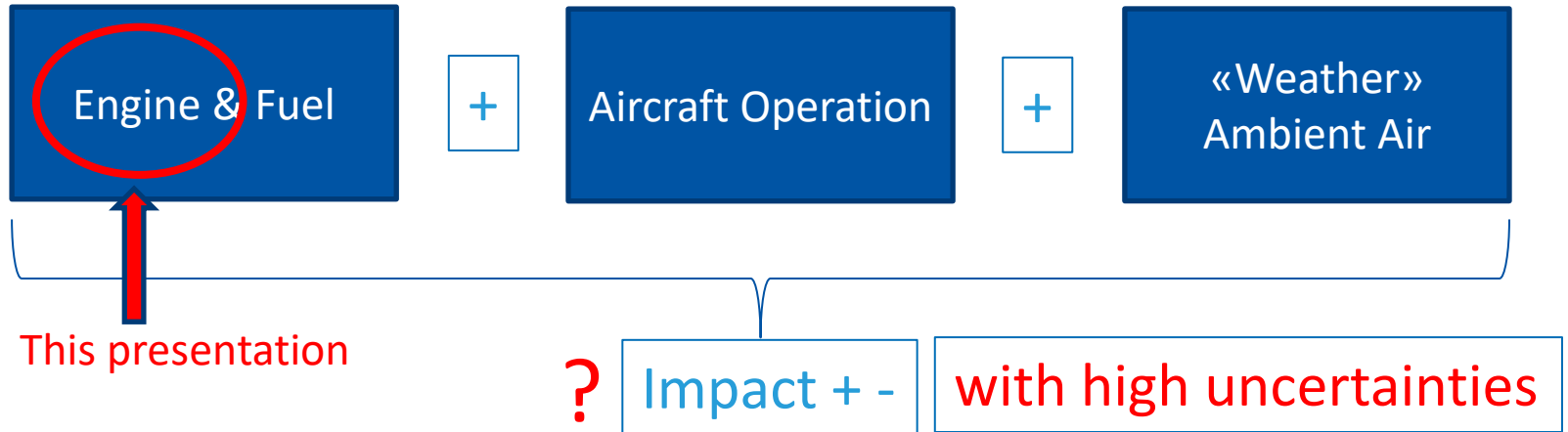
ICAO Symposium on Non-CO₂ Aviation Emissions

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A major problem

- Non-CO₂ climate impacts depend **on all three**:





Advice: Apply precautionary principle

- Non-CO₂ NO_x and particle engine emissions with climate impact are **pollutants** as well.
- Reduce these emissions at source is in any case beneficial for health protection as well.
- **Reduce to the degree it is technically feasible, economically reasonable and does not reduce the capability to produce more fuel efficient aircraft in the future (CO₂ reduction and fuel burn – NO_x trade-off!)**



Source: OEM

Only tiny amounts of the fuel are converted into billions of non-volatile (soot) particles per kg fuel.

- For non-volatile particle reduction (nvPM), the design of fuel injectors in conjunction with the combustion system is key. (traced and regulated by ICAO SARP since 2020)
- Engines can emit precursors for volatile particle formation. Sulfur free SAF will be important.
- Engine oil vapors may play a role: Innovative solutions could make use of catalytic materials to convert lubrication oil vapor into gases.



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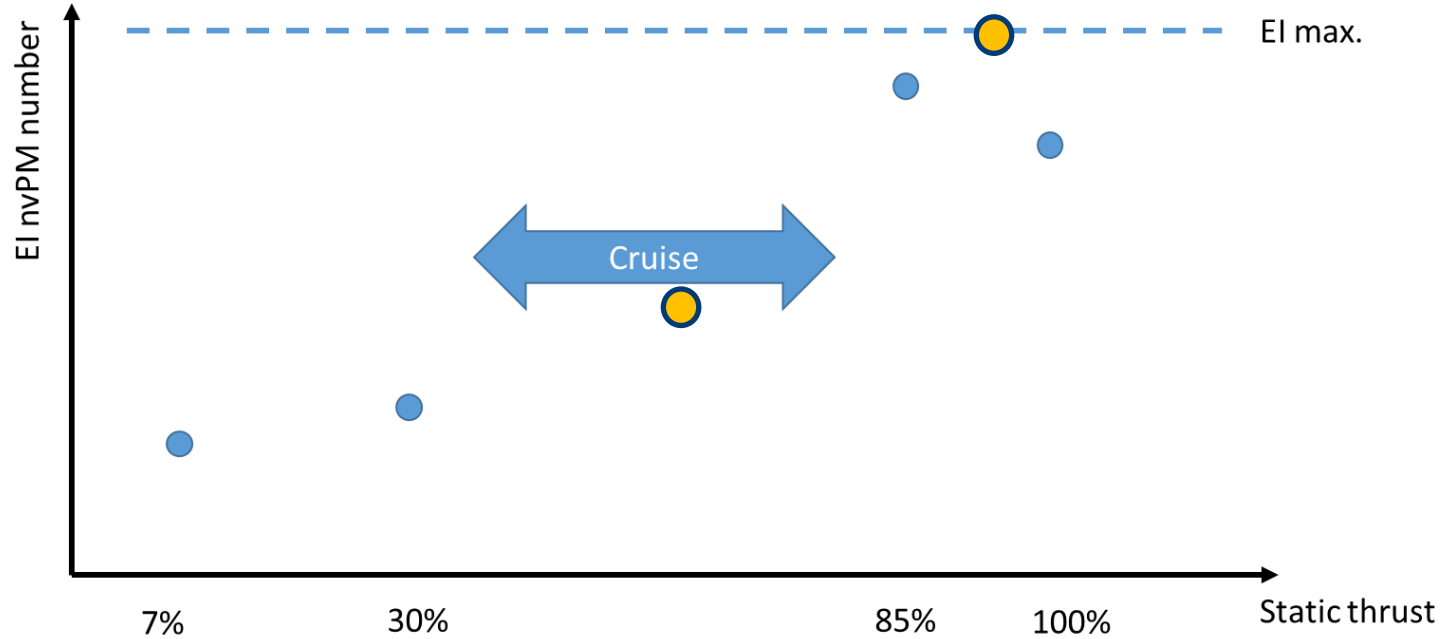
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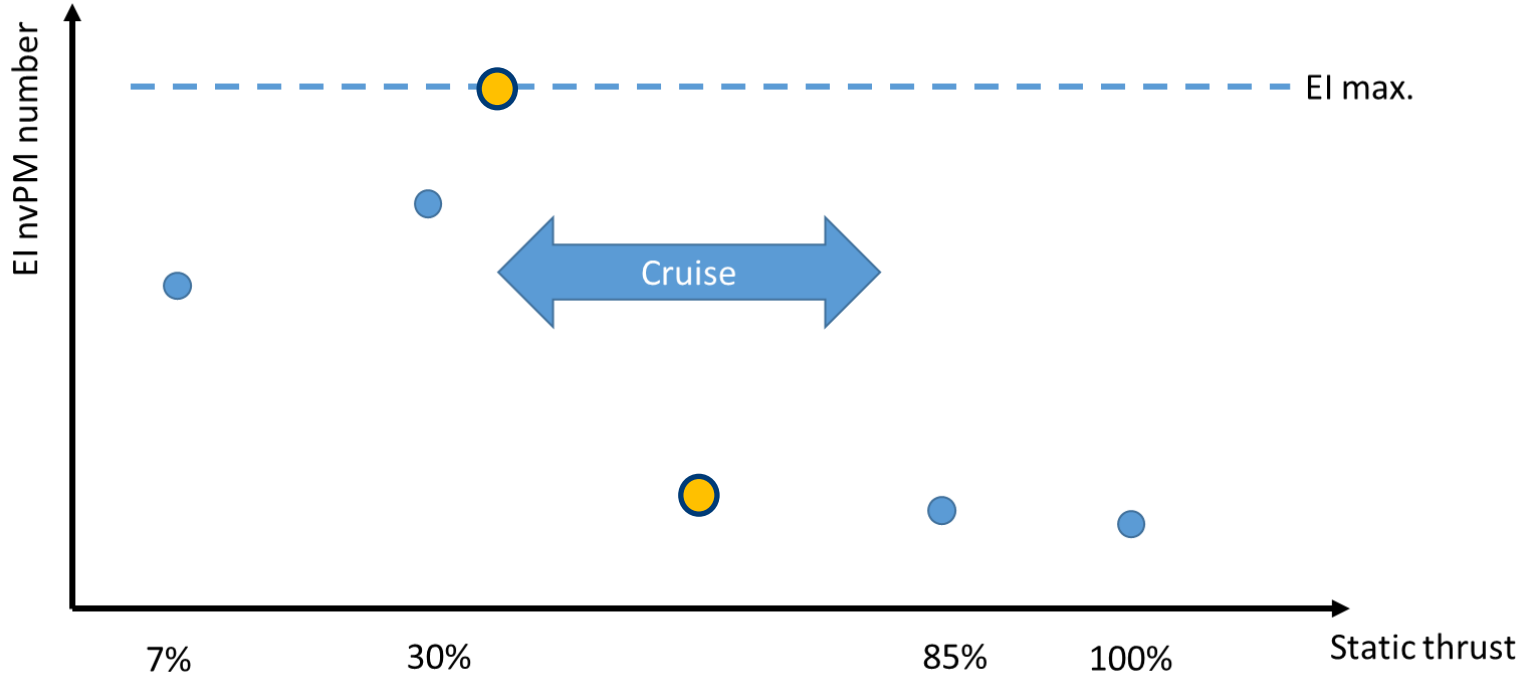
Mitigation of nvPM Emissions in Cruise

On 11 July 2024, the ICAO CAEP Steering Group agreed to include **new reporting points for nvPM** in ICAO Annex 16 Vol. II, which are **relevant for improving cruise emissions in the future:**



- nvPM mass and number emission factor at 57.5% static thrust (midpoint between 30 and 85% thrust)
- Thrust% at which the maximum nvPM mass and number emission factors occur.







- Overall, around 90% of aviation NOx is emitted at high altitude, may affect surface Ozone, too.
- Significant NOx reductions trade with fuel burn (CO₂)!
- Future NOx climate impact unclear!
- Therefore CAUTION, but
- Current NOx regulation is designed as a surrogate for *local air quality* at airports.
- Innovative technologies may bring cruise NOx reductions greater than anticipated from current NOx regulation (landing and take-off cycle, LTO)



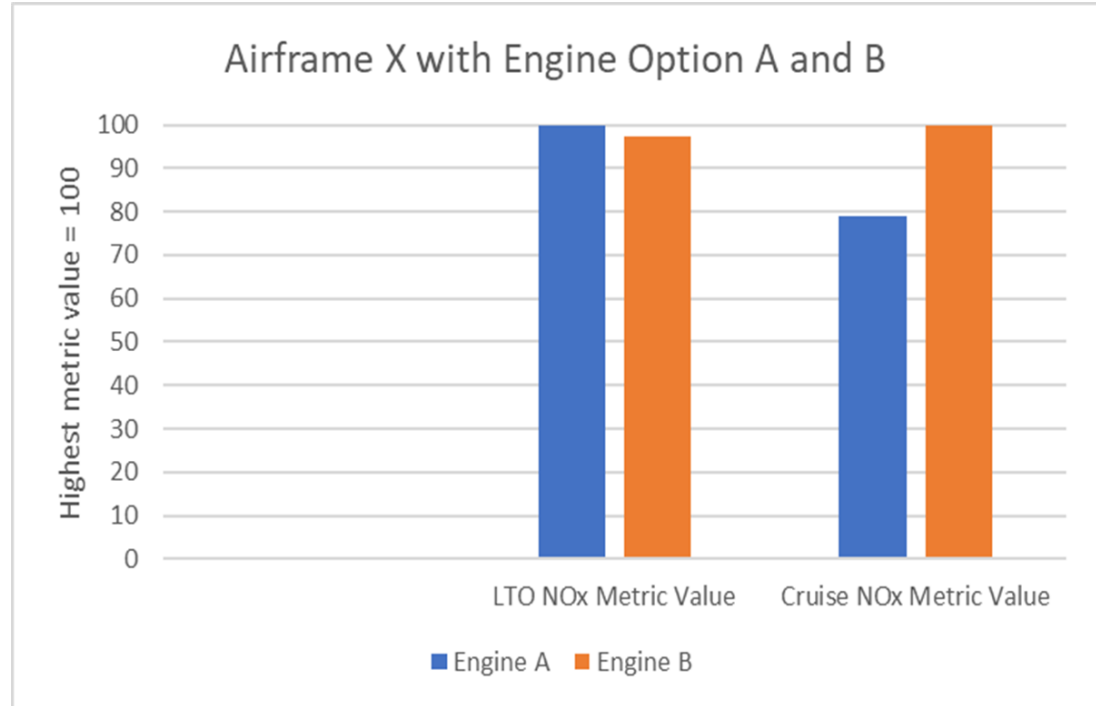
- ICAO CAEP Emissions Technical Working Group developed a **cruise NOx metric**, which makes basically use of the existing certification point at 85% thrust.
- Pending agreement in CAEP/13 (Feb. 2025) this could be developed into a **reporting requirement for engine cruise NOx comparisons**.
- As innovative technology has emerged, the current LTO NOx limits can be considered outdated. Pending agreement in CAEP/13, new LTO stringency could be developed (with caveat in red)

Caution: future NOx stringency should not lead to more CO₂. Target: Stabilisation of absolute NOx emissions



How the cruise NOx metric works

- Example: Airframe with two engine options, similar thrust rating and fuel efficiency.
- Most modern engines
- Engine A superior in cruise, not visible in LTO metric





- At engine level, use precautionary principle. ICAO developing:
 - New nvPM reporting relevant for cruise (already agreed at CAEP level for SARP)
 - New cruise NOx metric to better assess cruise NOx engine emission performance (Finalisation and Implementation pending CAEP/13 and ICAO Council decisions)
- Innovation will bring substantial reductions in PM emissions
- Modern combustion technology can stabilise (likely not reduce) absolute NOx emissions, while improving on aircraft fuel efficiency.
- The ICAO LTO NOx regulatory limit can be considered outdated. Suggestion to update LTO stringency, while taking care of fuel burn.
- A finalised cruise NOx metric with reporting would complement the LTO NOx regulation for improved cruise NOx performance.



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THANK YOU