Let’s start the clear sky revolution

Accelerating the path towards climate-neutral aviation

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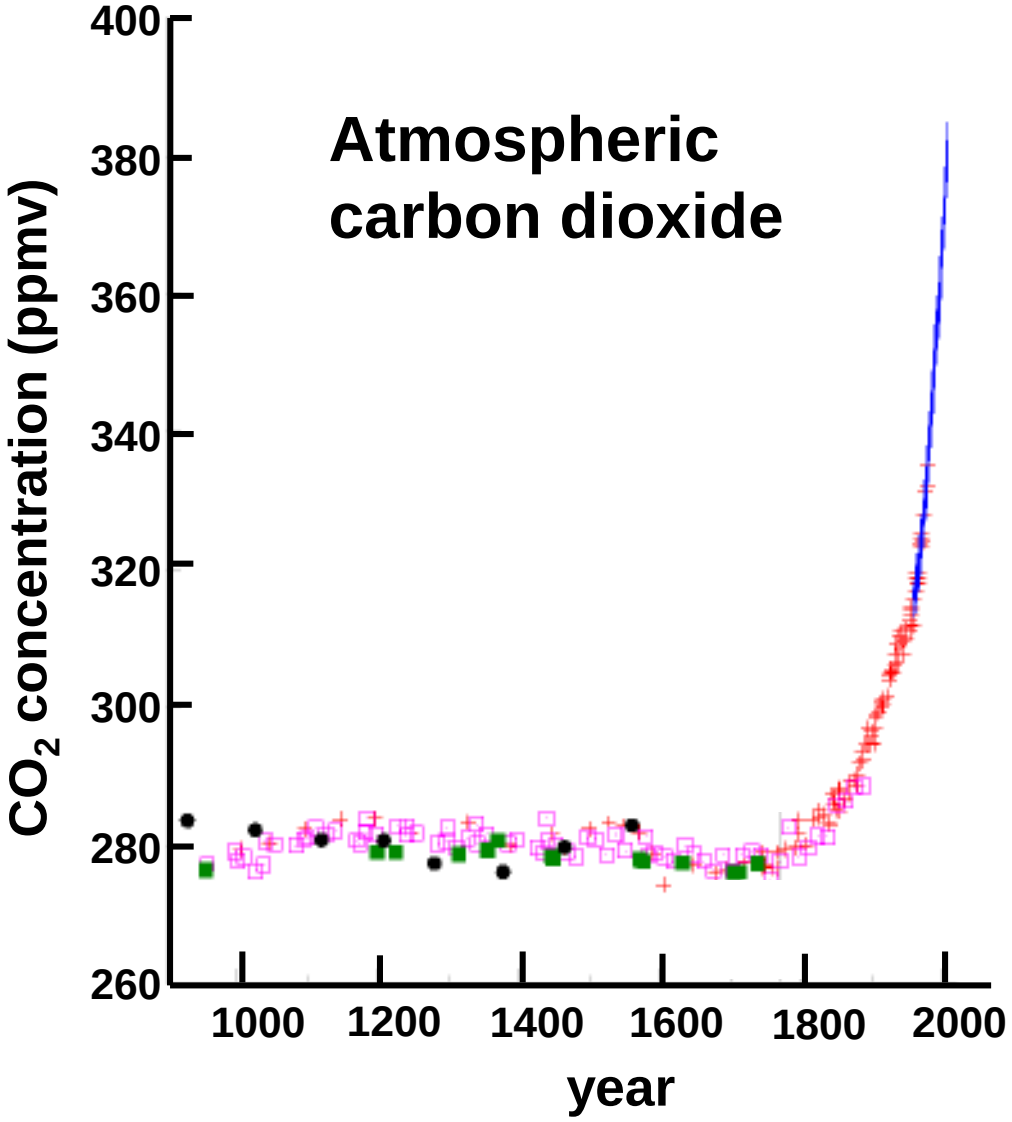
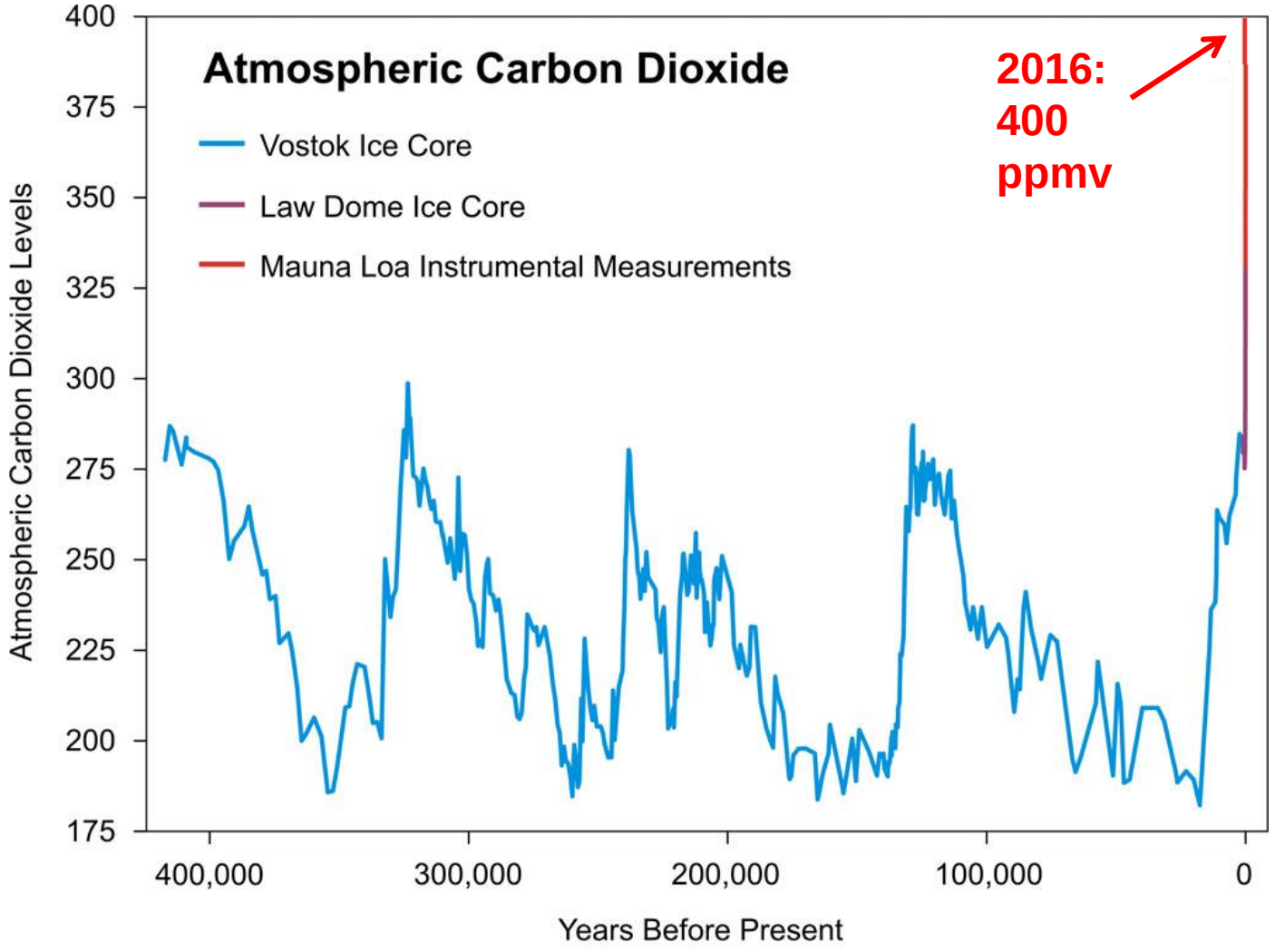
We all know this …





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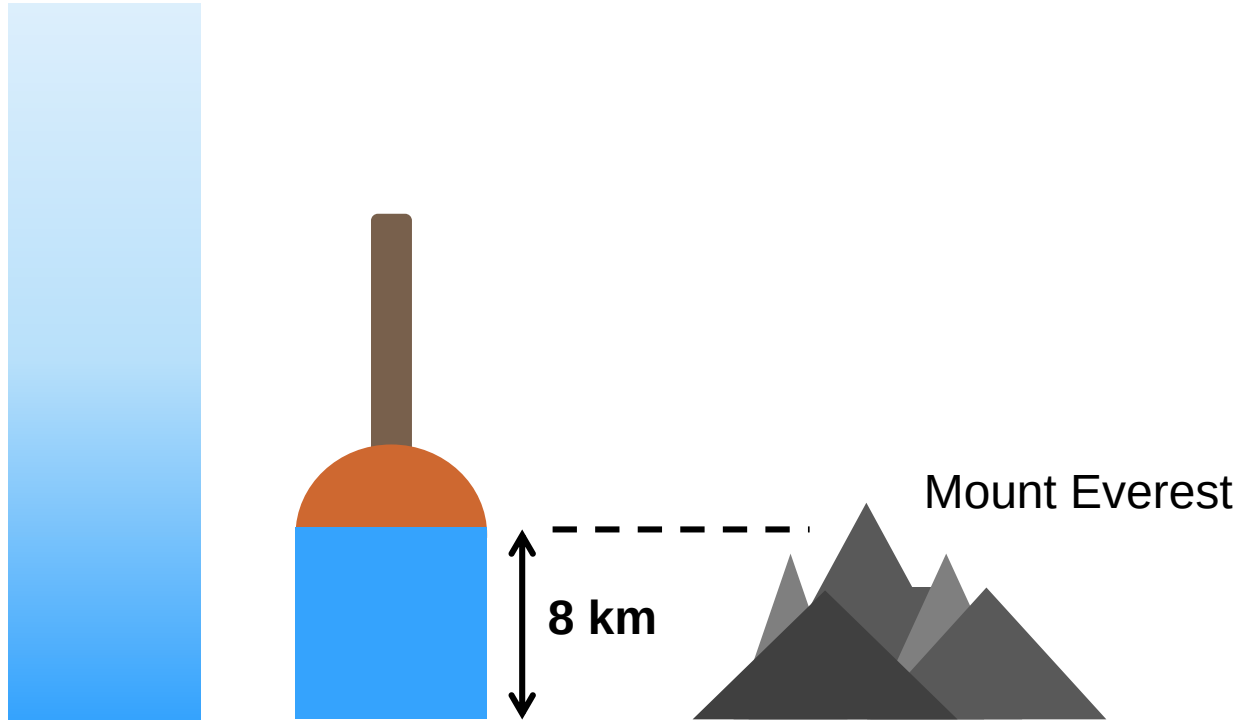
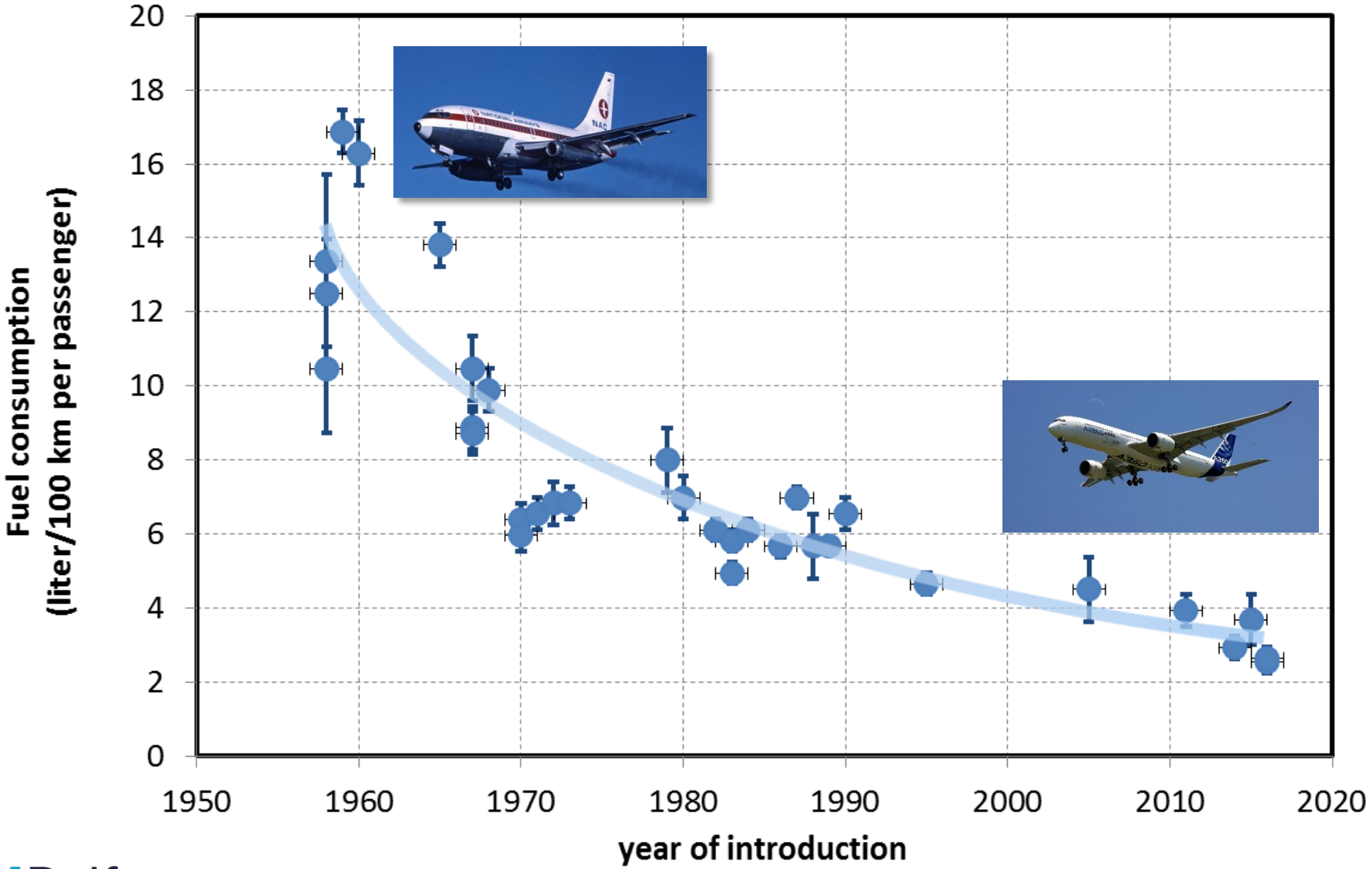
Our Earth atmosphere is limited

“Compressed” to a layer with a uniform sea level pressure our atmosphere is only 8 km thick!

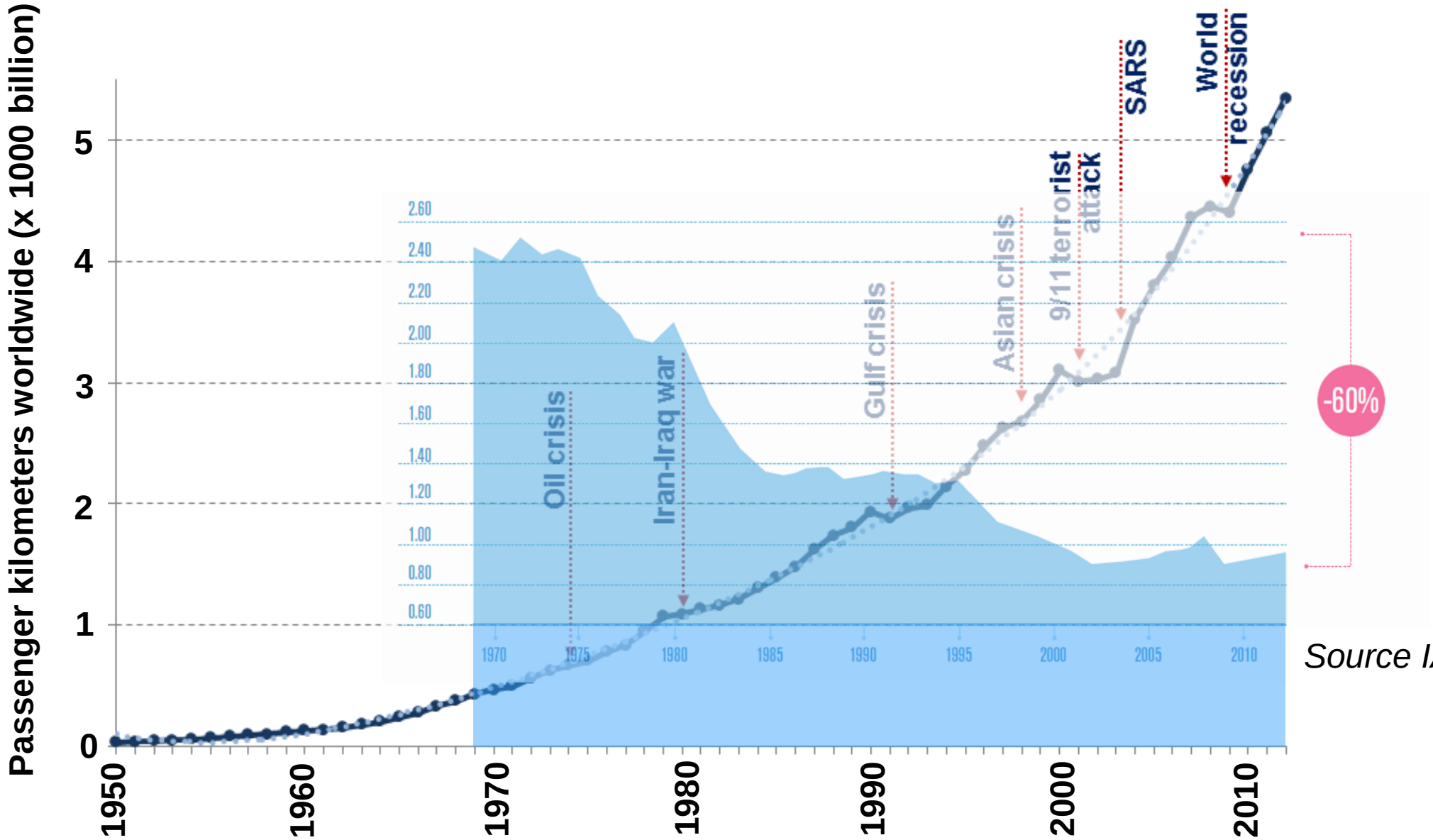


Picture: NASA

Fuel consumption per kilometer per passenger



Source of data: IATA Vision2050 report



Source IATA

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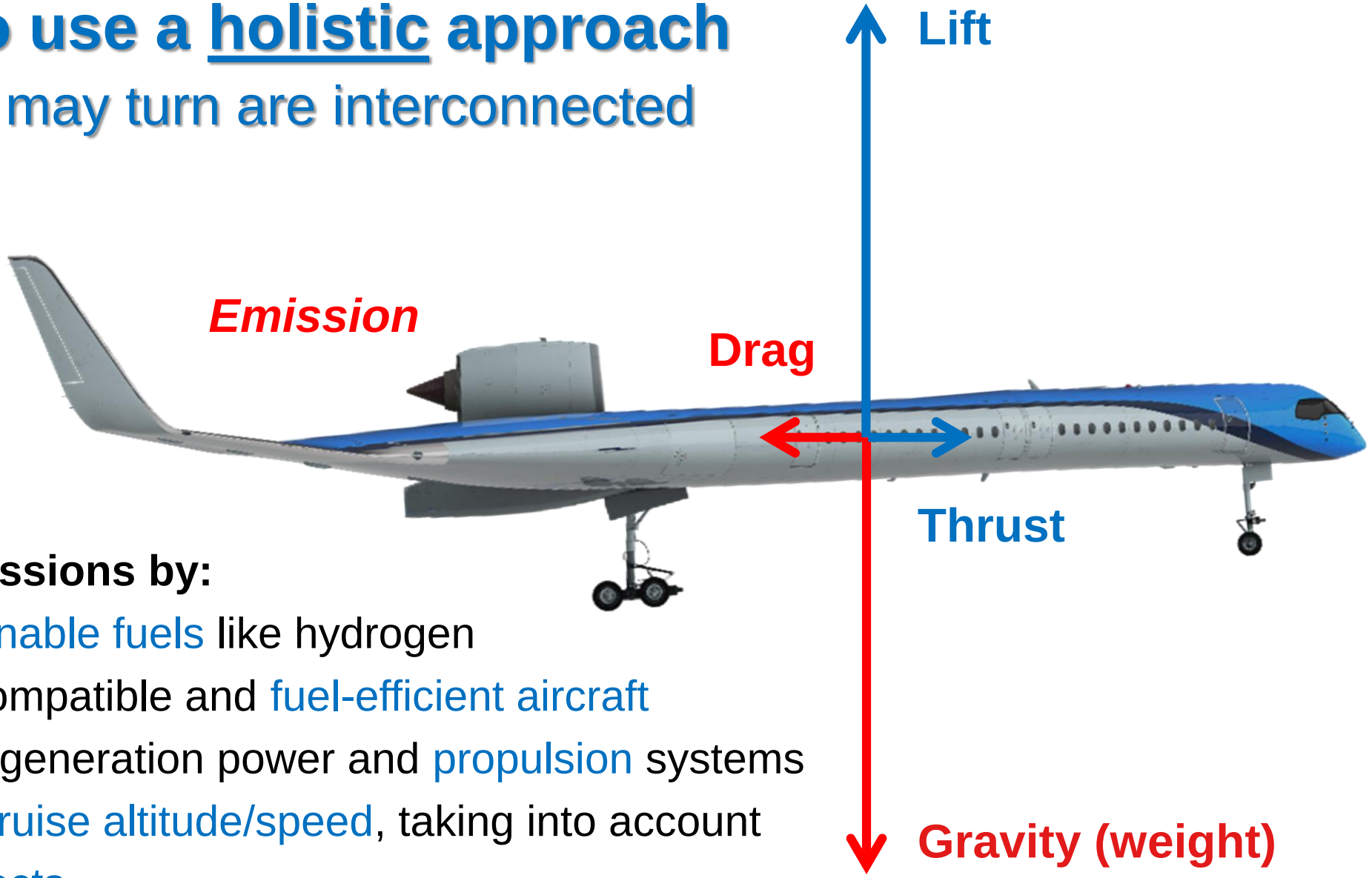
Current situation

- Fuel consumption per passenger per km is comparable to that of a modern car
- The **large distances** and **massive number of passengers** are the main issue
- Aviation currently accounts for **2.5%** of the global CO_2 emission (pre Covid-19)
- This percentage will rise if we do not act
- Furthermore, **non-CO2 effects** ($NO_x \rightarrow O_3$, contrails) more than double the climate impact

We have to use a holistic approach

All knobs we may turn are interconnected

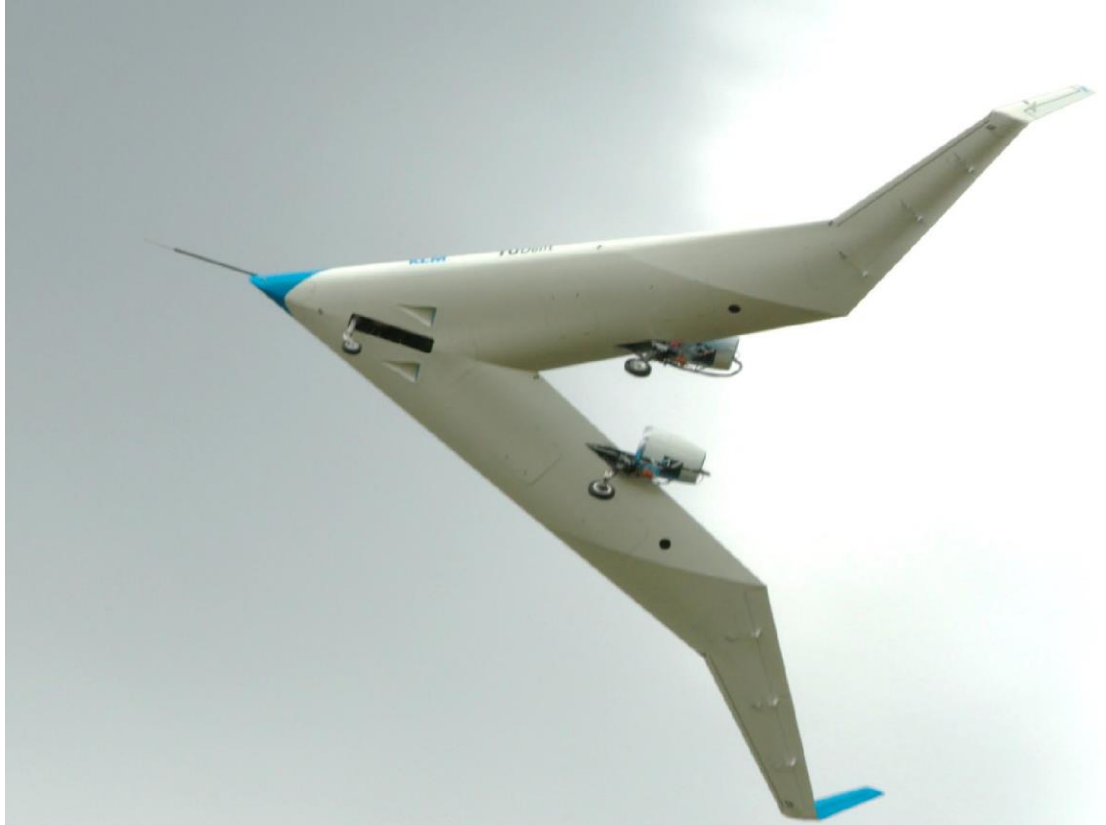


Reducing emissions by:

- Using sustainable fuels like hydrogen
- Designing compatible and fuel-efficient aircraft
- Having next generation power and propulsion systems
- Optimizing cruise altitude/speed, taking into account non-CO_2 effects

Energy-efficient planes are key

Scaled Flight Testing



Flying V

Example of new and efficient geometry (suitable for hydrogen)

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AIRBUS TUDelft KLM

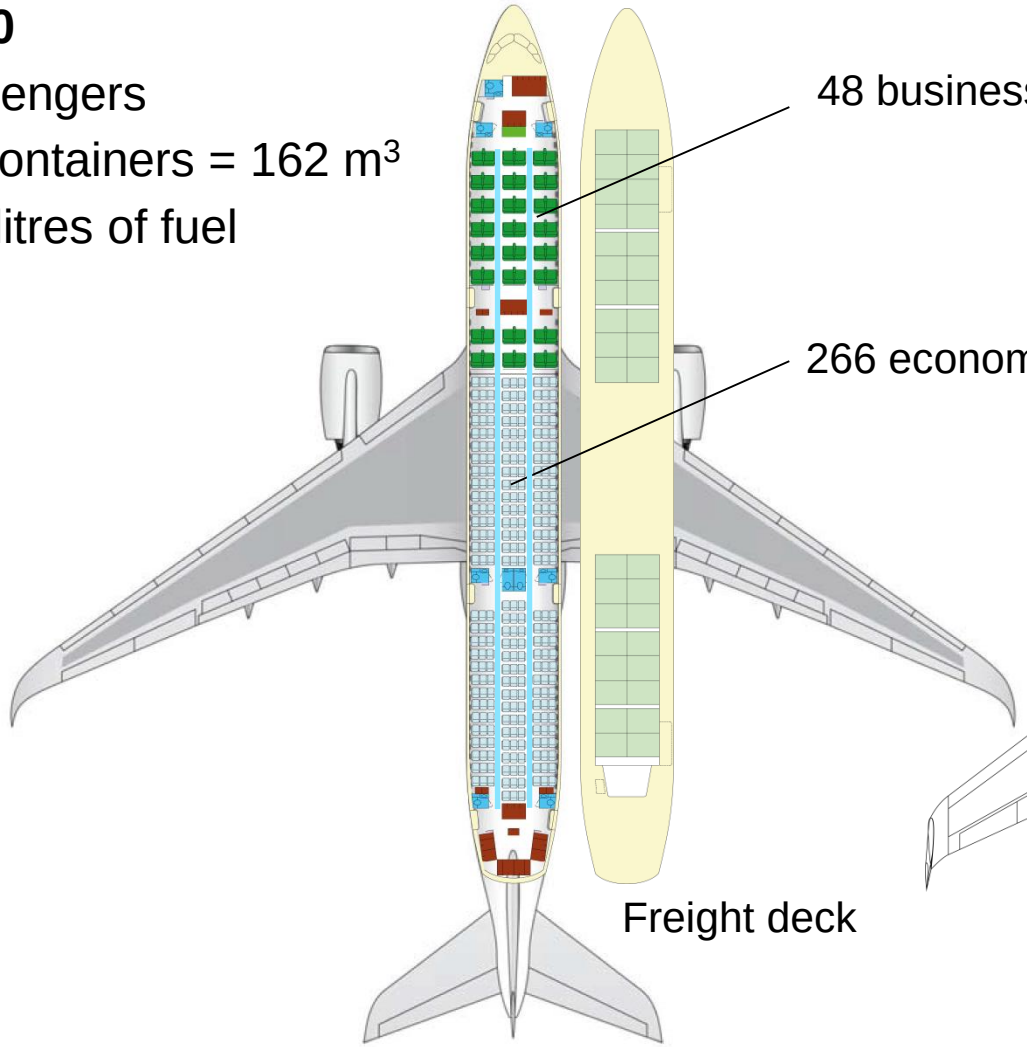
Flying V floor plan

A350-900

315 passengers

36 LD3 containers = 162 m^3

140,000 litres of fuel

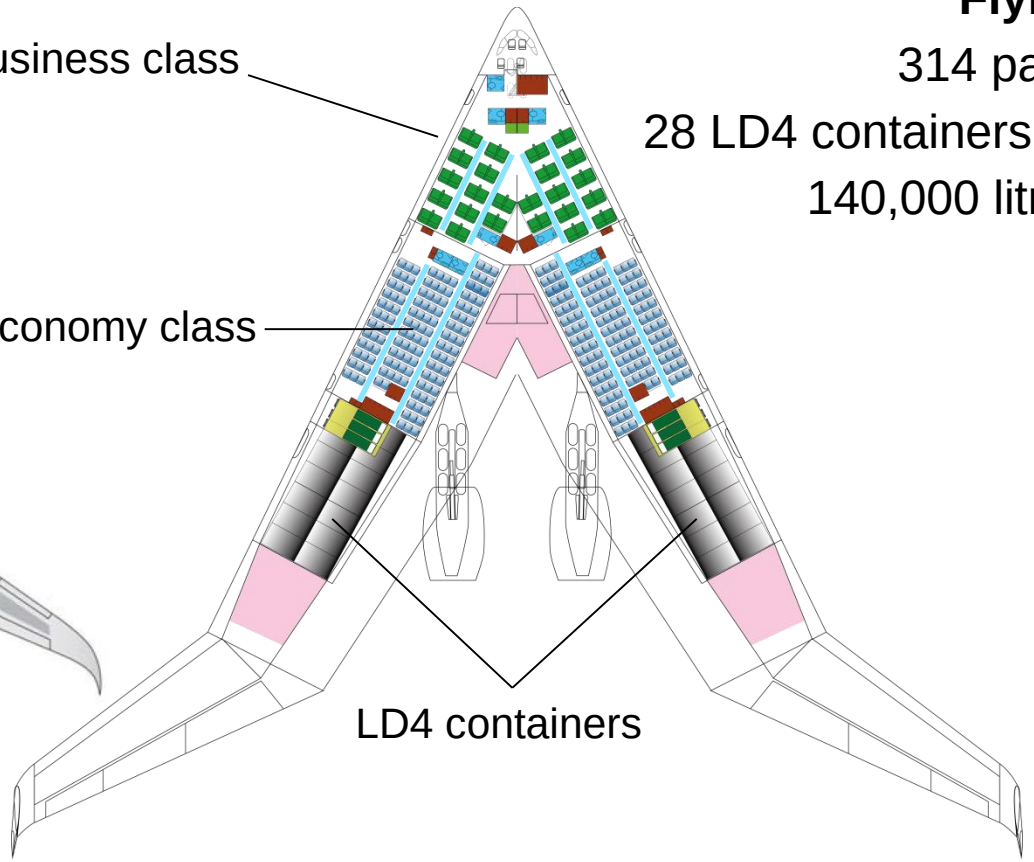


Flying V-900

314 passengers

28 LD4 containers = 160 m^3

140,000 litres of fuel



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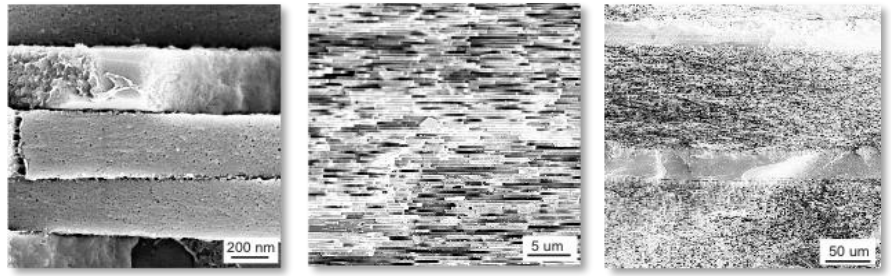
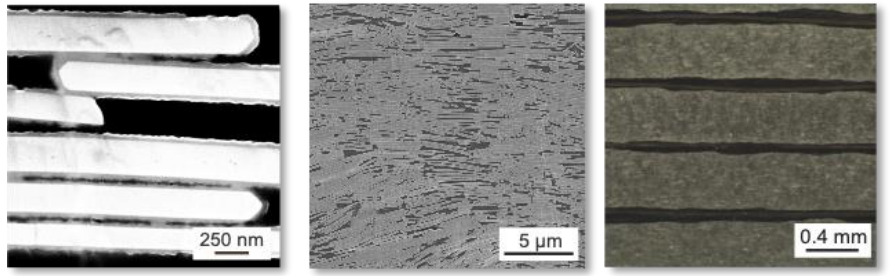
Lighter and tougher materials
Smart structures

Topology optimization

Biological

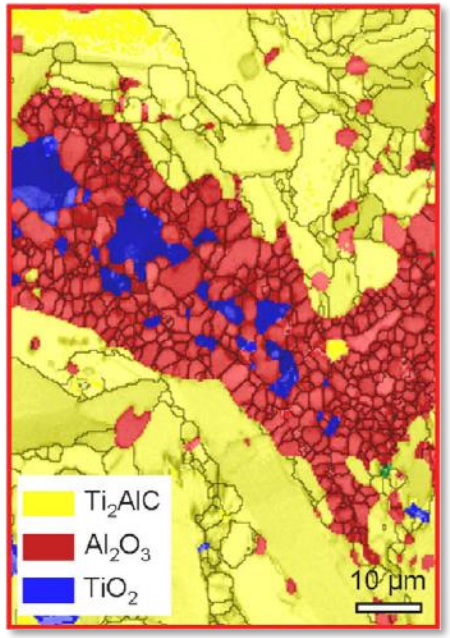


Synthetic

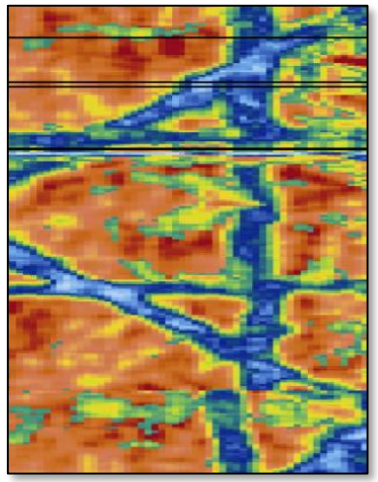


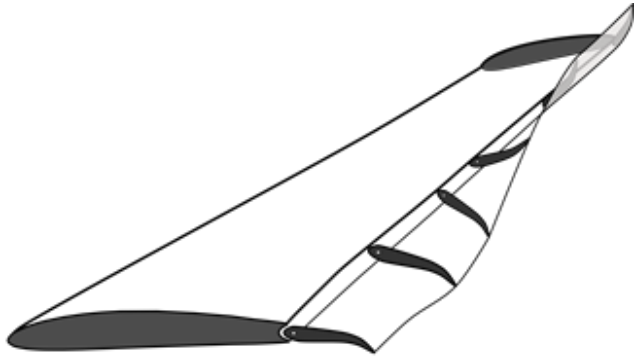
Stiffness Strength Resilience

Bio-inspired & bio-based materials

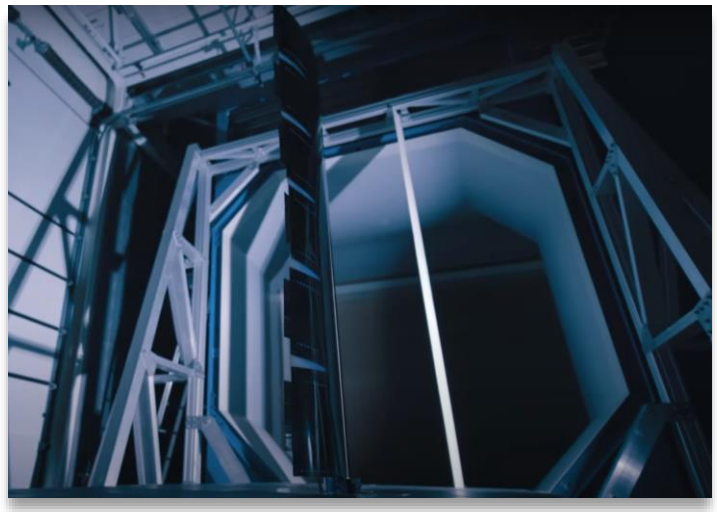


Self healing metals and ceramics





Autonomous morphing wing



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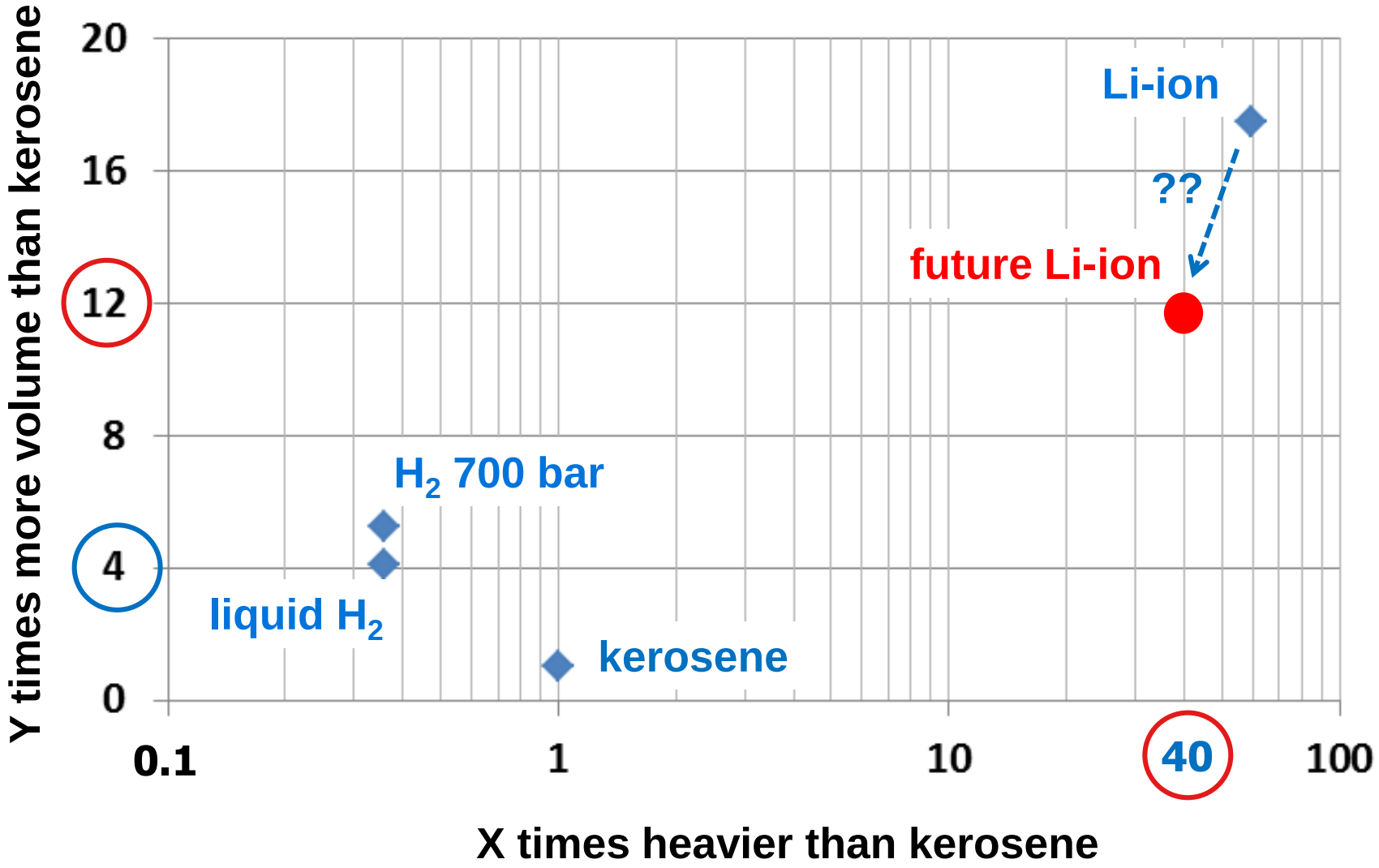
Sustainable energy carriers/fuels



Electric flying using batteries?

- Batteries factor 40 heavier than kerosene
- Electric engines are 2 times more efficient than conventional turbofan engines

→ Factor 20 weight disadvantage for future generation battery storage compared to jet fuel (at 6x more volume)

- Modern wide-body airliners for **long distance** (15.000 km) have fuel capacity of more than 140 ton.

  The battery-equivalent weighs nearly 3000 ton! **Not feasible**.

- Fuel weight decreases during flight. Battery weight not.

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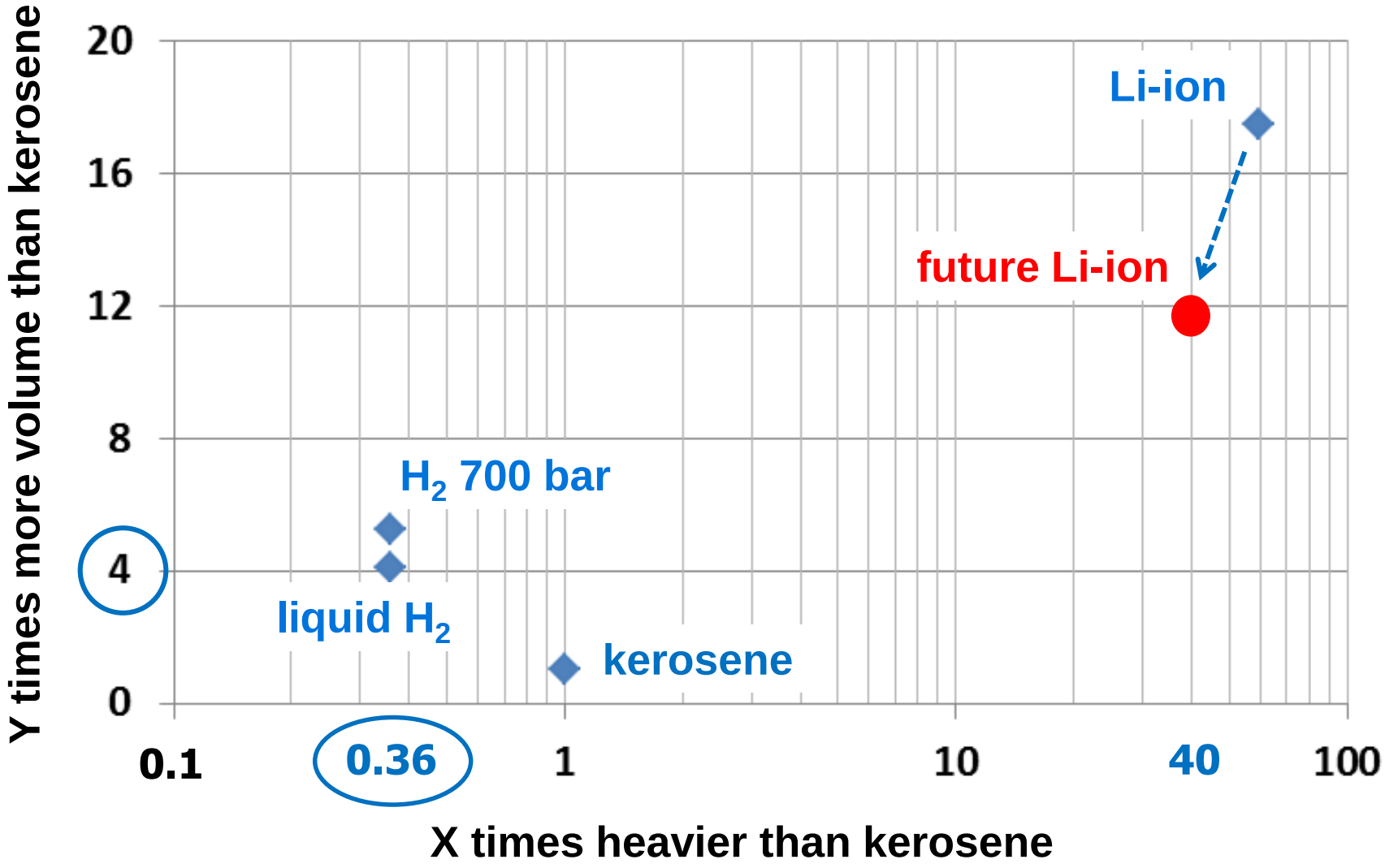
Hydrogen



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Short distances

Currently one and two-seaters
plus some rebuilts of 6-10 seaters

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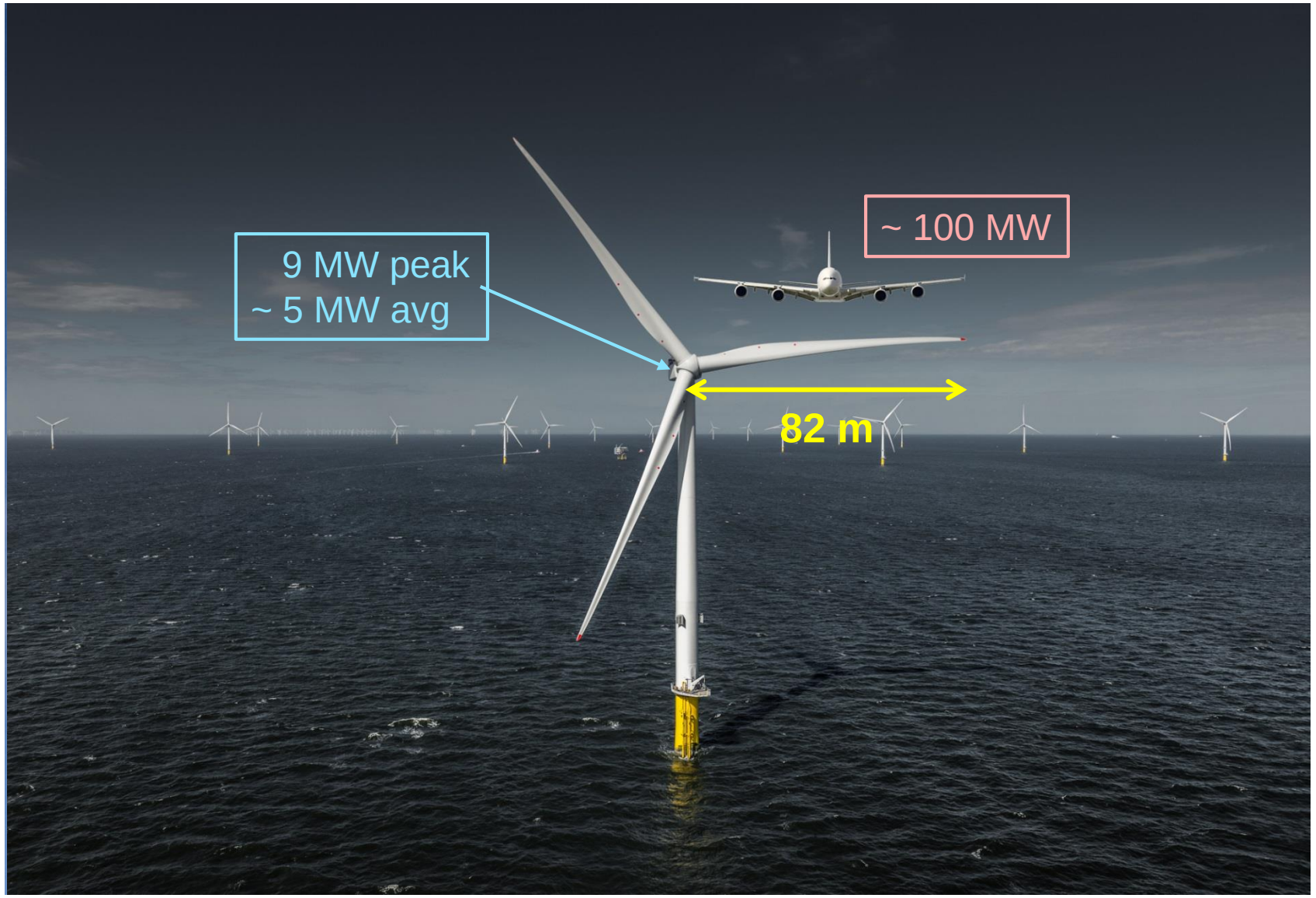
Challenges for electrical propulsion

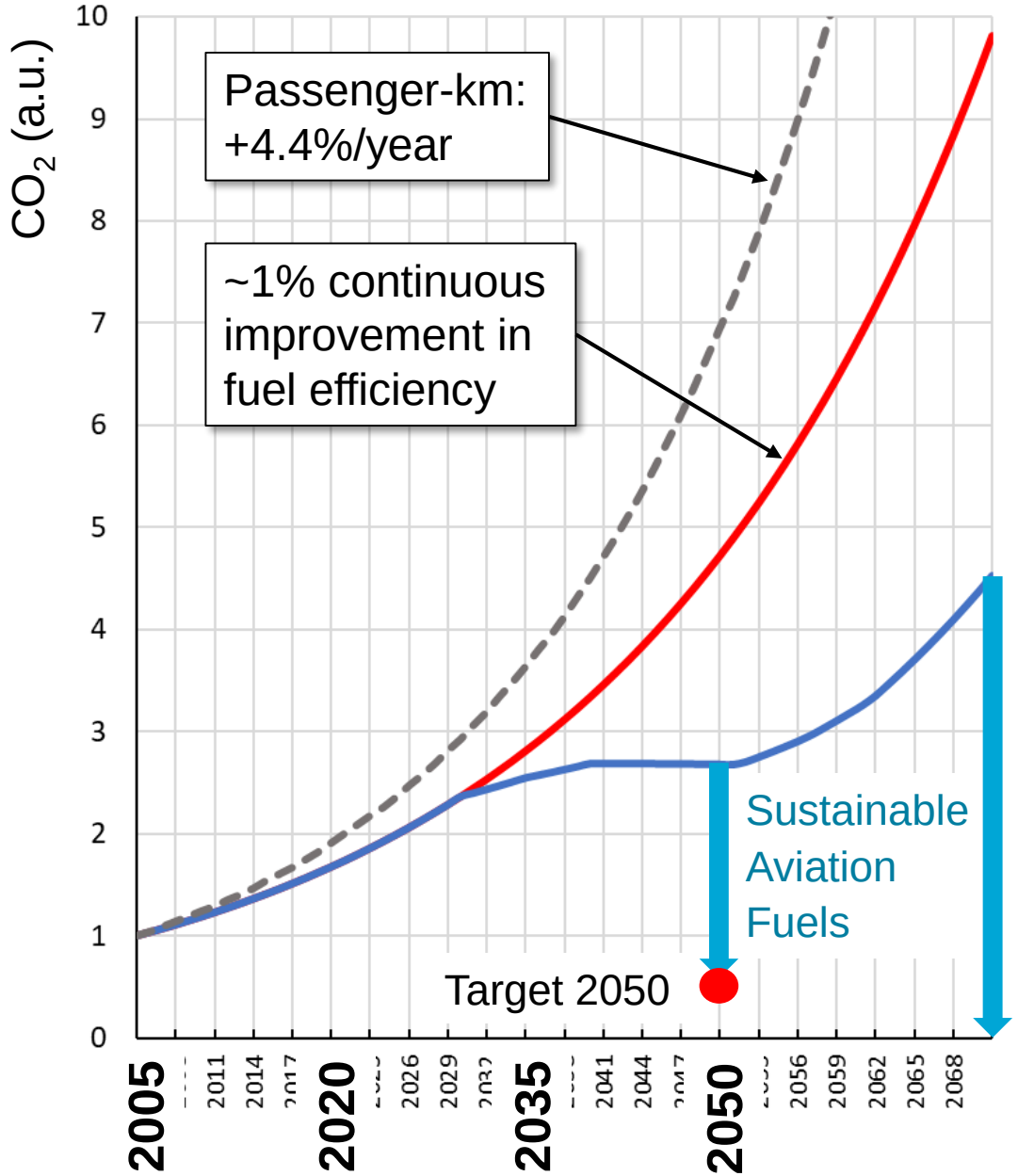


The challenge is massive

How to achieve a CO_2 emission by aviation at 50% of 2005 value in 2050?
Or even more ambitious: carbon-neutral in 2035!

- Current technology forecasts imply that **electric planes** will be limited to relatively **short distances / few pax**, thus having only small impact on aviation-related CO_2.
- When using *current* best-case scenarios regarding fuel efficiency and time-to-market, an overall **decrease of CO_2 emission will not occur.**
- **UNLESS, we switch to non-conventional planes carrying non-fossil fuels FAST**

The main question: which is the most promising route?



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Sustainable aviation fuels

Hydrogen, synthetic kerosene, synthetic methane

Trade-off needed

- **Availability** (sustainable energy demand, production efficiency, scale-up of demoplants)
- **Cost**
- **Infrastructure** required
- **Storability** (cryogenic, boil-off, diffusion)
- Impact on **volume and weight**
- **Safety**
- **Climate effects** (CO_2, NO_x -> O_3, contrails -> cirrus clouds, …)

Where do we encounter unrealistic requirements?

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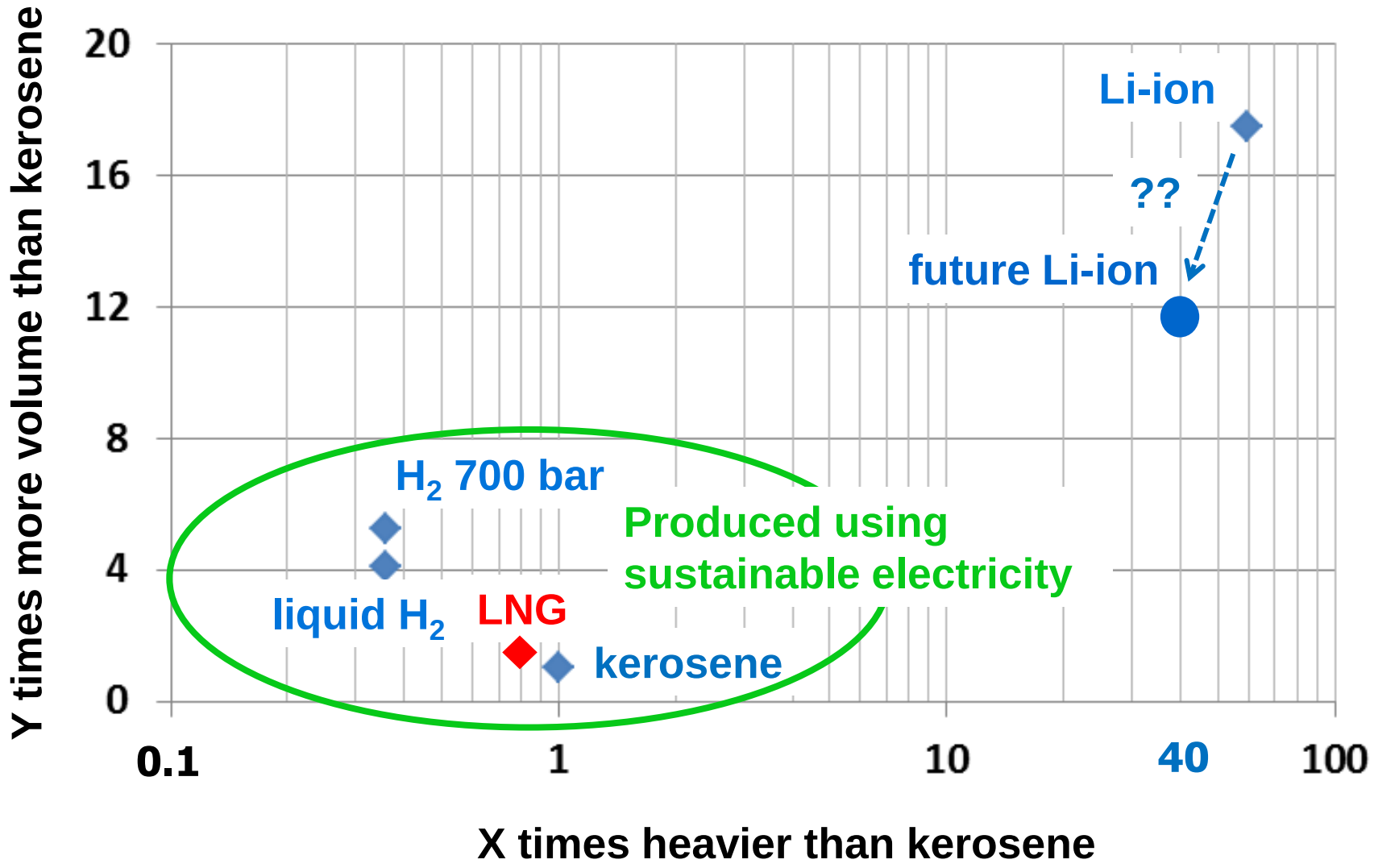
Methane alternative for kerosene or hydrogen?



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Conclusions

Electrical flight will be limited to short range and few passengers

Tackling the climate issue we urgently have to address medium and long-haul flights by developing ultra-efficient planes that use sustainable fuel only.

This requires revolutionary (system) changes

Using a multidisciplinary holistic approach

And a truly international collaboration

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