MAKING NET-ZERO, 1.5°C-ALIGNED AVIATION POSSIBLE
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The solutions: Fuel efficiency gains and SAFs are the main decarbonisation options

Two scenarios: Annual GHG emissions reduction, Gt CO₂e

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Cumulative GHG emissions of 22–21 Gt CO₂e between 2022 and 2050, compared with 47 Gt CO₂e in a Business-as-Usual scenario

Percent of cumulative GHG reduction, between 2022 and 2050

- **Fuel efficiency**: 40%–45%
  - More efficient turbines
  - More aerodynamic airframes
  - Air traffic management improvements

- **Novel propulsion aircraft**: 5%–15%
  - Hydrogen fuel cell/combustion aircraft
  - Battery-electric aircraft
  - Hybrid-electric aircraft

- **Power-to-Liquids**: 15%–25%
  - Jet fuel produced from renewable electricity and captured CO₂

- **Biofuels**: 20%–35%
  - Jet fuel produced from sustainable biomass

- **CO₂ Removals**: ~2%
  - E.g., direct air capture and storage

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What it will take

**Annual capital investments for net zero**, billion $ compared with a BAU scenario

- **2020s**: 40–50 billion
- **2030s**: 170–180 billion
- **2040s**: 270–290 billion

Annual average investments: ~$175 billion

95% of investments required for fuel production and upstream infrastructure

SAFs are about 2–5x more expensive than fossil jet fuel.

Historical fossil jet fuel price of past two decades:

- Fluctuations: $135–$1,590/t

Multiple of historical average jet fuel price

- **Biofuels**: 9
- **Power-to-Liquids**: 6

Average: $600–$650/t

**Resource requirements, share of global demand by 2050**

- **Renewable electricity**: 5–10%
  - 6,000–9,000 TWh out of 90,000–130,000 TW!

- **Green hydrogen**: 10–30%
  - 100–160 Mt out of 500–800 Mt

- **Sustainable biomass**: 5–25%
  - 4–12 EJ out of available supply of ~50–110 EJ

- **Captured carbon**
  - 0.50–0.85 Gt CO₂ out of ~12 Gt CO₂
  - CDR 5–10%

*For PTL and CDR

Despite higher fuel costs, the cost of flying could see no increase but stay constant or even decrease by 5% by 2050.
### Key milestones

<table>
<thead>
<tr>
<th>Share of SAFs on final jet fuel demand</th>
<th>2019</th>
<th>2030</th>
<th>2040</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0%</td>
<td>13%–15%</td>
<td>60%–65%</td>
<td>100%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SAF production</th>
<th>2019</th>
<th>2030</th>
<th>2040</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05 Mt</td>
<td>40–50 Mt</td>
<td>215–230 Mt</td>
<td>300–370 Mt</td>
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</tbody>
</table>

<table>
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<tr>
<th>Number of SAF plants</th>
<th>FEWER THAN 10</th>
<th>300–400</th>
<th>1,500–2,300</th>
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<tr>
<th>Number of hydrogen and battery-electric aircraft</th>
<th>2019</th>
<th>2030</th>
<th>2040</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>800–8,000</td>
<td>12,500–26,000</td>
<td>30,000–49,000</td>
<td></td>
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</tbody>
</table>

### Priorities for this decade

**INDUSTRY ACTION TO BOOST SUPPLY**
- Invest in RD&D for low-TRL technologies and efficiency measures to reduce energy demand
- Bring down feedstock costs (renewable electricity, hydrogen, sustainable biomass, and captured CO₂) and redirect biomass use from road transport to aviation
- Create industry consortia to share risk for first- and second-of-a-kind projects and supply 40–50 Mt SAF by 2030

**INDUSTRY ACTION TO BOOST DEMAND**
- Double current offtake agreements between SAF producers and customers by 2025, and increase volumes by a factor of 5 until 2030
- Boost advanced market commitments for low-carbon technologies
- Pool demand from multiple sectors (e.g. hydrogen demand for shipping, steel and aviation) to unlock economies of scale

**FINANCE ACTION**
- De-risk first-of-a-kind projects via public–private partnerships and financing consortia and develop fit-for-purpose financing models for first- and second-of-a-kind plants
- Encourage 1.5°C-aligned target-setting and disclosure of annual metrics to track progress
- Establish exclusion criteria to trigger divestments from non-1.5°C-aligned assets and companies

**GOVERNMENT ACTION**
- Establish national/regional blending mandates for SAFs or a GHG intensity reduction pathway via legal emission limits
- Reduce the cost differential between SAFs and fossil jet fuel, e.g., by direct or indirect subsidies (like a blender’s tax credit)
- De-risk first- and second-of-a-kind projects, e.g., via blended finance, concessional loans, capital grants, or long-term guarantees, and use green public procurement to increase the SAF share in public-sector air travel to 20% by 2030