Electrification of aviation: Accelerating the transition

Sustainable Aviation? Digital seminar
Western Norway University of Applied Sciences (HVL)
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Norway is totally dependent on aviation.

44 airports

Norway’s Air Navigation Service Provider
Paris Agreement

1.5 – 2 °C
80-95% emission reduction by 2050
Be sure to wash your hands and all will be well.

COVID-19

Recession

Climate Change
Norwegian aviation fossil free by 2050

(No fossil fuels will be used on flights within and from Norway from 2050)
Emissions per passenger km decreasing

Average SAS and Norwegian
GHG EMISSIONS CIVIL AVIATION NORWAY 1990-2018

(I tillegg kommer effekten av utslipp i høye luftlag)
Air traffic total emissions worldwide increasing

Source: IATA
Aviation emission reductions

- More energy efficient aircraft
- Sustainable Aviation Fuels (SAF)
  - Jet biofuels
  - E-fuels
- New technologies
  - Electrification
  - Hydrogen
Time frame: **2030 (?)**

- **Short haul:** Battery electric (small aircraft)
  - Energy efficient!

- **Regional:** Hybrid electric and/or fuel cell
  - Short routes can be flown 100% electric
  - Share of hydrocarbons

- **Long haul:** SAF (= non fossil hydrocarbons)
  - Jet biofuel
  - e-fuel
Sustainable Aviation Fuels (SAF)

- 2009: Certified
- Pro: Can be dropped into current aircraft and infrastructure
- Con: Production low – price high
- 2014: First SAF flights in Norway
- 2016-2018: A limited volume available at Avinor’s airports in Oslo and Bergen
- 2020: Drop-in mandate of 0.5% advanced biofuels in Norway. Political goal of 30% by 2030
Electrification

- Battery
- Parallel hybrid
  - Serial hybrid
- Fuel cell | H2

Electric motor
Airbus E-Fan 1.1
Crossed the English Channel 2015
Pipistrel Alpha Electro (2018)

- Empty weight: 382.5 kg
- Maximum take-off weight: 560 kg
- Cruising speed: 85 Kts (157 km/h)
- Range: 70 NM (130 km) + 20% reserve
- Battery: 21 kWh (20 kWh usable)
- Charging: up to 400V/32A

www.avinor.no/elfly
Short RWY network in Norway:
74% of all flights shorter than 300 KM

- 88 Citypairs < 100KM
- 140 Citypairs < 150KM
- 183 Citypairs < 200KM
- 249 Citypairs < 300KM
- 290 Citypairs < 400KM
- 310 Citypairs < 500KM
- 337 Citypairs < 1041km
# Introducing Airbus ZEROe

<table>
<thead>
<tr>
<th>Aircraft Type</th>
<th>Passengers</th>
<th>Range</th>
<th>Storage &amp; Distribution System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turboprop</td>
<td>&lt;100</td>
<td>1,000+nm</td>
<td>Liquid Hydrogen Storage &amp; Distribution System</td>
</tr>
<tr>
<td>Blended-Wing Body</td>
<td>&lt;200</td>
<td>2,000+nm</td>
<td>Liquid Hydrogen Storage &amp; Distribution System</td>
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<tr>
<td>Turbofan</td>
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**Description:**
- **Turboprop:** Designed for short to medium distances, capable of carrying less than 100 passengers with a range exceeding 1,000 nautical miles. Utilizes hydrogen hybrid turboprop engines to achieve zero emissions.
- **Blended-Wing Body:** A long-range aircraft with a capacity of less than 200 passengers, capable of flying over 2,000 nautical miles, powered by liquid hydrogen storage and distribution system.
- **Turbofan:** Details about the turbofan variant are not provided in the image.
H2

- Fuel cell = electrified aircraft
- Sustainable Aviation Fuels (hydrotreatment)
- E-fuels (carbon + H2 electrolyzed)
- Direct combustion (Cryogenic?)

⇒ Massive H2-efforts world wide
Forslag til program for introduksjon av elektrifiserte fly i kommersiell luftfart

Trondheim, 5. mars 2020
Summary of recommended goals, measures and instruments

Goals
- Norway will be a driving force and arena for the development, testing and early implementation of electrified aircraft
- By 2030, the first ordinary domestic scheduled flights will be operated with electrified aircraft
- By 2040, all civil domestic aviation in Norway will be operated with electrified aircraft, reducing greenhouse gas emissions by at least 80% compared with 2020

Technological development
- International innovation cooperation
- National coordination
- Innovation arena/centre in Norway
  - Collective expertise
  - Access to infrastructure and airspace
  - Financial support for testing and development

Risk mitigation
- Grants for charging infrastructure
- Support scheme for purchase of aircraft
- Possible State guarantee concerning residual value
- VAT exemption for light aircraft

Operation
- Requirements for routes covered by a public service obligation (with grant scheme)
- Exemption from air passenger duty
- Exemption from VAT on tickets for air travel
- Reduced electricity tax for charging of aircraft
- Reduced aviation charges (evaluated in accordance with EU regulations)
CONSEQUENCES FOR AVINOR’S INFRASTRUCTURE?

• Mapping electricity capacity on Avinor’s airports
• Looking into innovative and flexible charging solutions
• Or will fuel cells/H2 be the preferred solution?
CONCLUDING REMARKS

- Norway is totally dependent on aviation
- Green House Gas emissions must be mitigated
- Airlines investing in more energy efficient aircraft
- Sustainable aviation fuels already available
- Electrified passenger aircraft will be a reality
- Hydrogen is part of the solution