RENERGY

GREEN AVIATION IN TRØNDELAG

Collaboration project in Mid-Norway for the introduction of emission free aviation

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RENERGY er en ledende norsk energiklynge med over 100 bedrifter og organisasjoner fra hele verdikjeden for fornybar energi.

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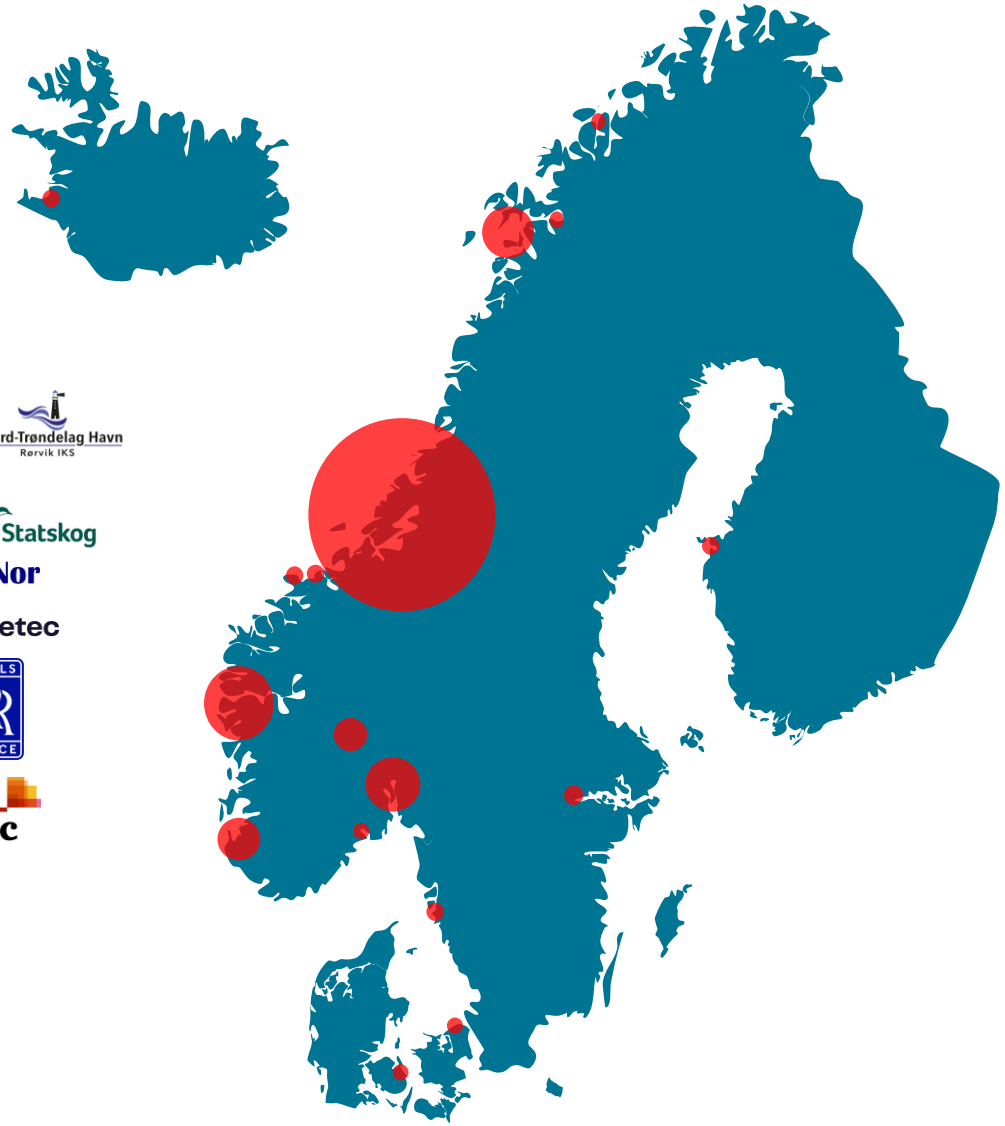

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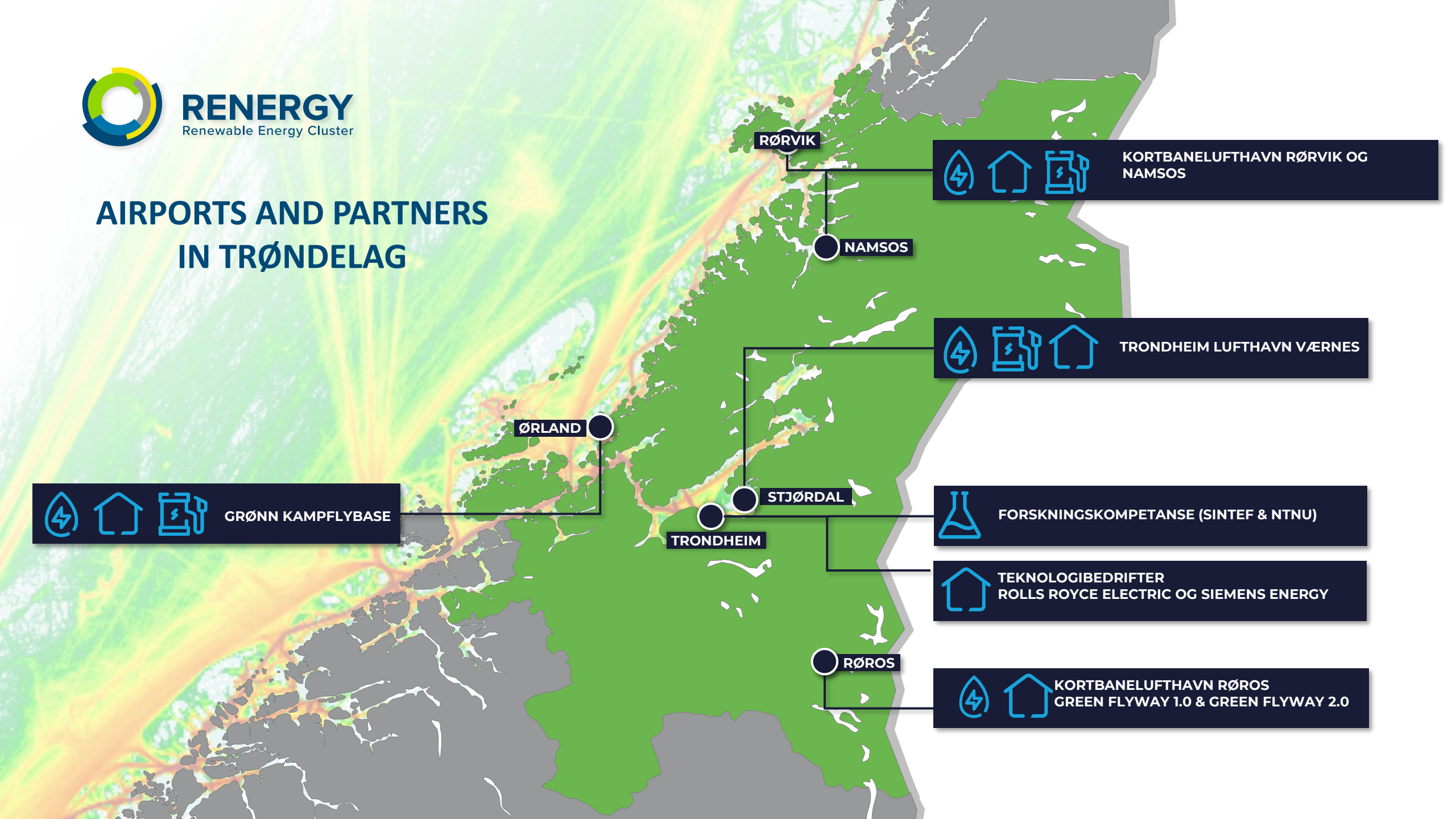
AIRPORTS AND PARTNERS IN TRØNDELAG



THE STORY OF AVIATION EMISSIONS

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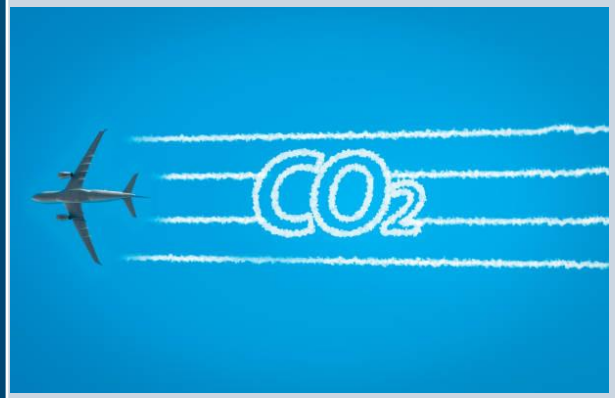
THE PROBLEM

Greenhouse gases is the problem to solve



STATUS

900 000 tonnes of CO_2

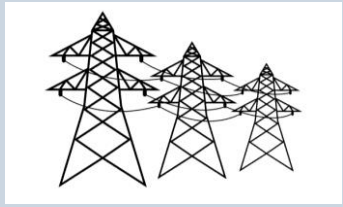
SOLUTIONS

Technology solutions are in development

Smaller planes than today

Cost driving is personnel, asset and maintenance – not fuel

SYNERGIES



THE PROBLEM – GREENHOUSE GASES

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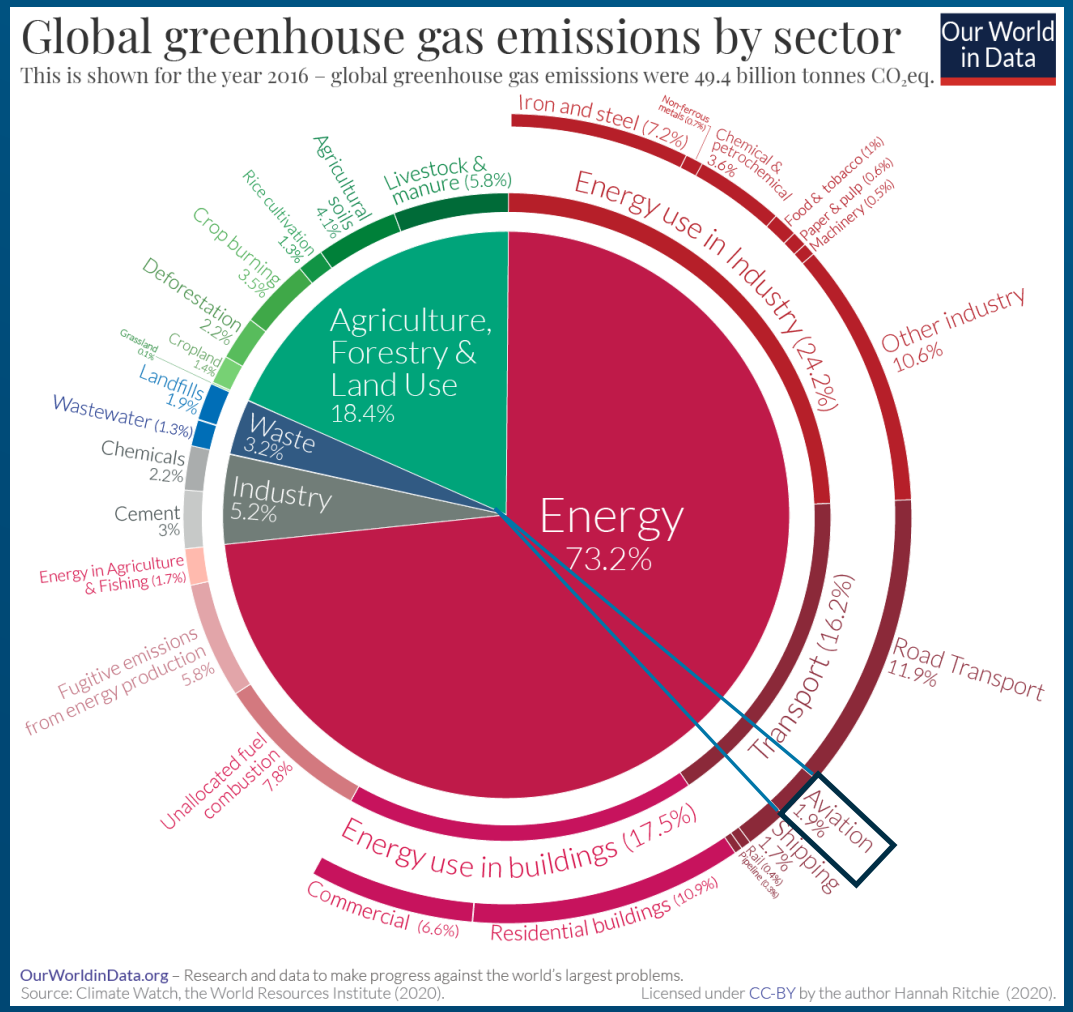

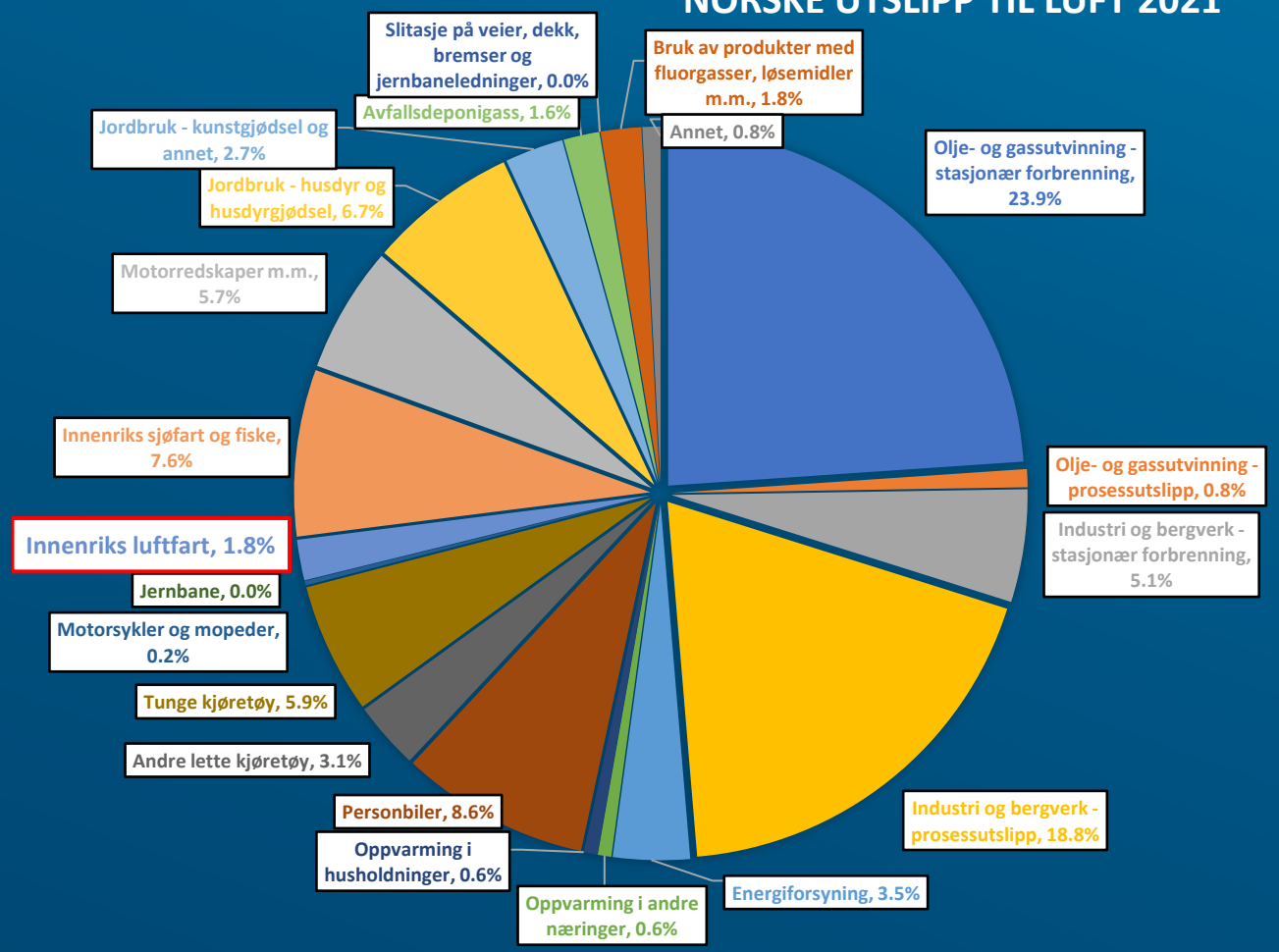

1.9 %

1.8 % - 3.0 %

EMISSIONS AND FUEL USAGE[1] - PERSPECTIVE

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Emissions and fuel usage

- Norwegian aviation: 900 000 tonnes CO_2
  - International aviation is not included
  - 550 million litres Jet A1 in 2021
- Same amount as gasses from trash deposits
- As much as products including Flourine gasses and solvents etc
- 1/3 of motor tools and appliances ($2.8 \cdot 10^6$ t CO_2)
- 2.6 % of the Polish coal power plant Belchatov

Energy

- 1 litre Jet A1 contains about 12.0 kWh
  - 550 million litres Jet A1 contains 6.6 TWh
  - In 2022 Norwegian wind produced 14.8 TWh
  - If hydrogen is combusted instead, taking production, efficiencies and storage into account we need about the entire wind energy in Norway today to replace Jet A1 for national Norwegian aviation
  - For international aviation we need about another doubling
  - Trade-off between climate and environment

All numbers are from SSB for 2021

AIRPORTS IN MID-NORWAY

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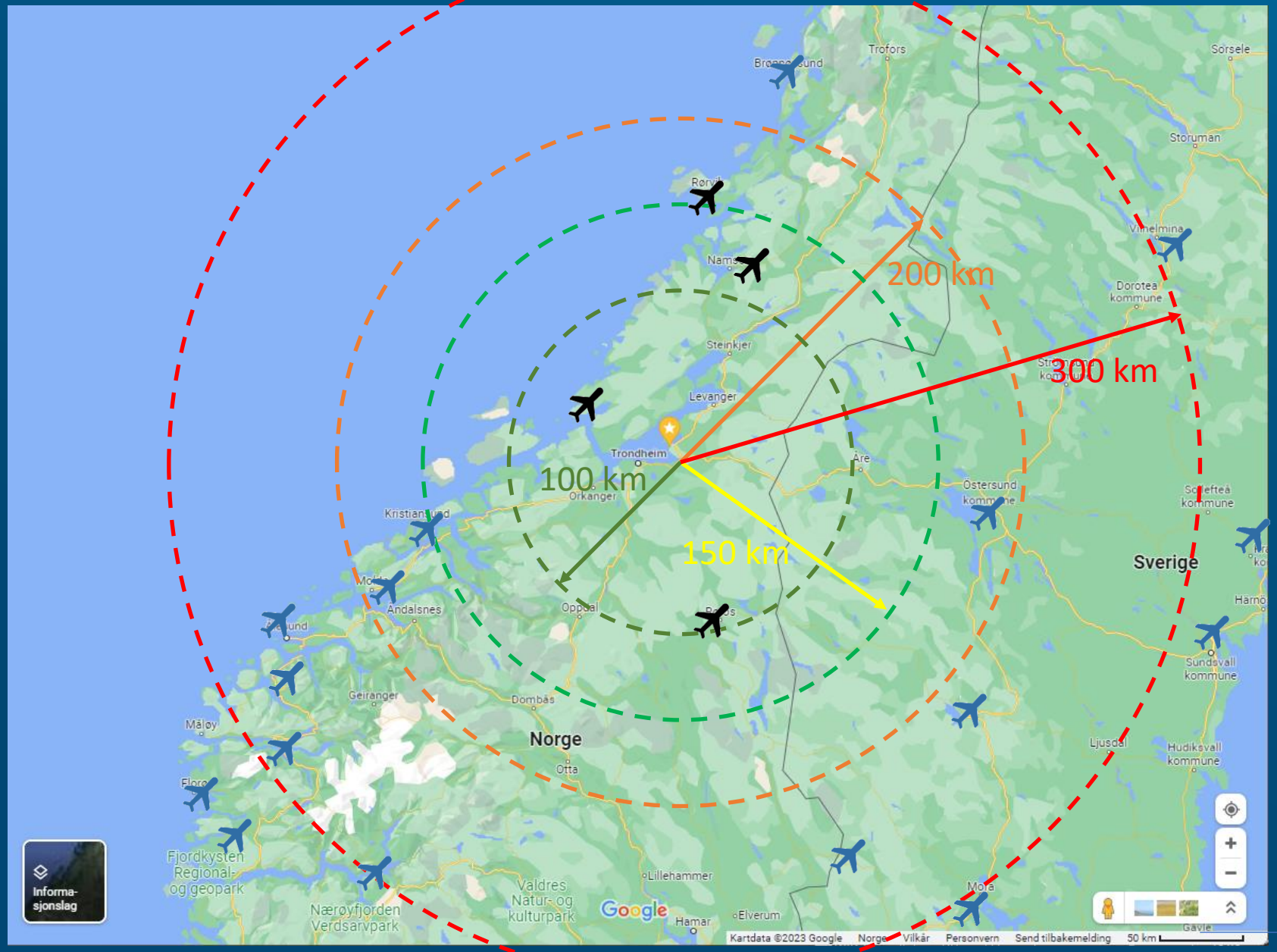

- 200 km range is enough for Trøndelag
- Longer range of course beneficial to get further
- For routes like Bergen/Oslo and other popular routes a range of 400/500 km needed

AIRPLANES IN DEVELOPMENT & WHEN

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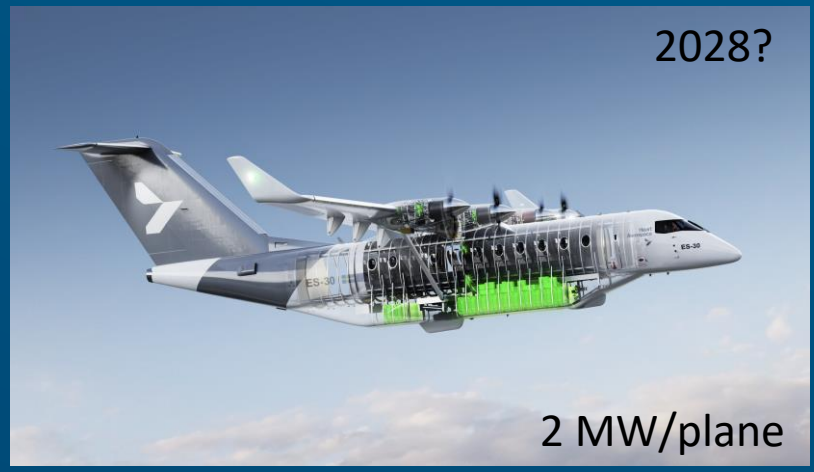
TECH BEING DEVLOPED

- Battery electric / limited range – 2030?
- Hydrogen electric – maybe 2035?
- Hydrogen combustion – Less energy dense than Jet A1 and cause NO_x and H_2O emissions
- SAF – reducing emissions but not zero
- Hybrids – likely solution but still cause emissions

2030?

SOLUTIONS

- Improved batteries – doubling of energy density – when?
- Maturing of Fuel Cell technology
- New GTs with hydrogen combustion


2028?

2 MW/plane

Requires a lot more renewable power!

REGIONAL AVIATION – TODAY VS FUTURE

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- Dash 8 – Widerøe – 39 PAX
- 2 pilots and cabin personnel

- Emission free airplane slightly smaller
  - Requires as many pilots and cabin personnel – lower maintenance and fuel cost – similar or higher asset costs

- Nationally Boeing 737-XXX – 180 PAX
- 2 pilots and 2+ cabin personnel

- If range is long enough to replace these planes
  - Many more airplanes
  - Requires more pilots
  - Probably higher asset costs as well since so many planes are need to replace it
  - New operating patterns needed

GREEN AVIATION IN TRØNDELAG

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FOCUS AREAS

- Preparations on the ground – what has to be done (Avinor)
- SAF – Hydrogen – What can be done in Mid-Norway?
- Effects on power production and distribution, requirements on grid etc
- Synergies with marine applications
- Drones - transport
- Follow development of batteries, fuel cells and airplanes
- Introduction for Lv132 (military airbase)

CONCLUSION AND FINAL REMARKS

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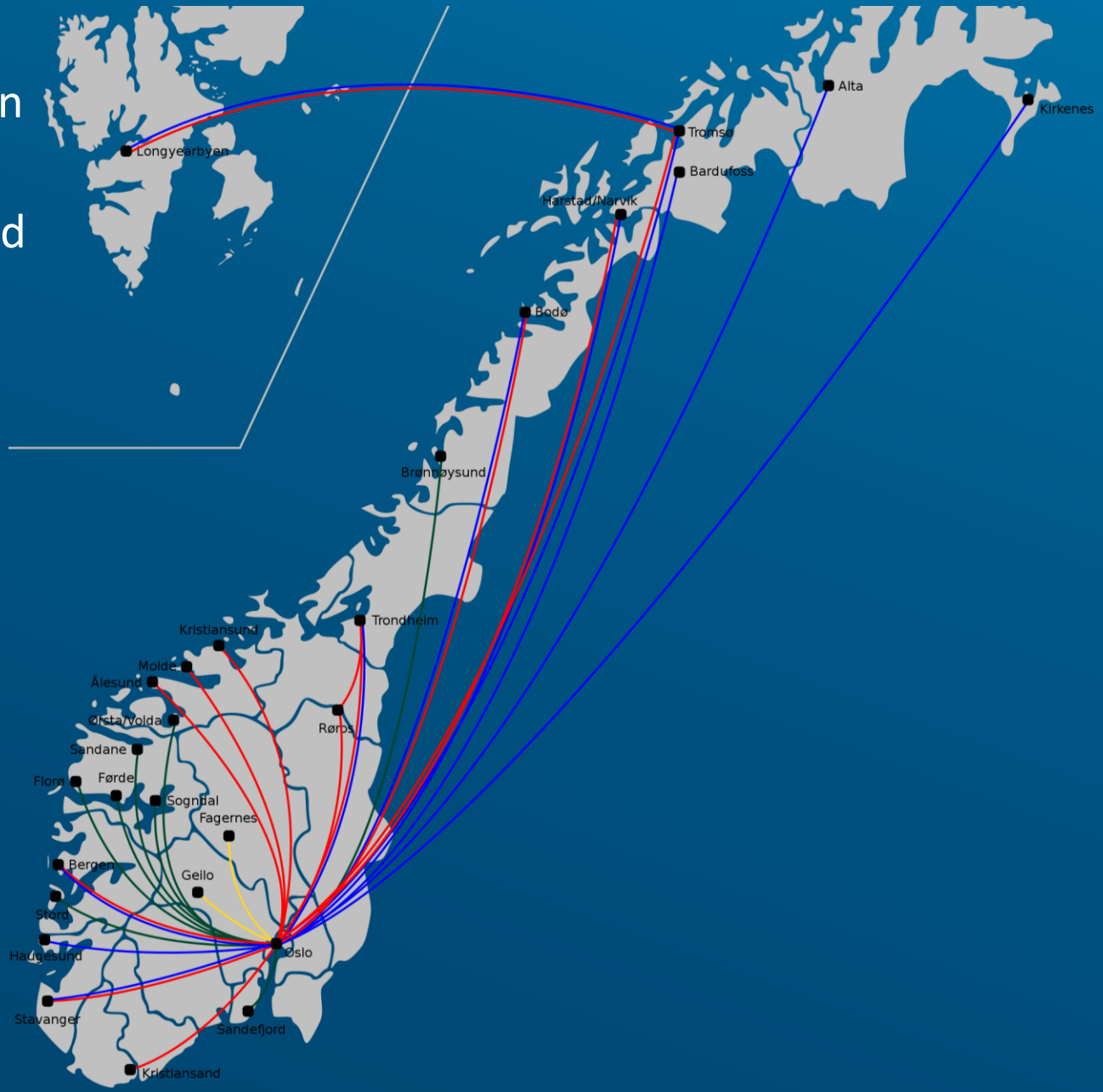
- Technology is being developed – uncertain when and what will come first – follow what happens
- More power needed and upgrades of power grid
  - Looking into power and energy demand
- Bring collaboration in all of Norway together – National team rather than regional competition
- Identify business opportunities in Mid-Norway
  - SAF
  - E-Fuels
  - Hydrogen
- Synergies with marine initiatives
  - Hydrogen
  - Batteries



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