MIT LABORATORY FOR AVIATION AND THE ENVIRONMENT

Seattle | *August 17, 2023*

Hydrogen production and transportation challenges

Florian Allroggen

Executive Director Aerospace Climate & Sustainability

What drives interest in using (L)H_2 as an aviation fuel?

Emissions

- *No direct CO_2 emissions*
- *Low production emissions if produced via electrolysis with renewable electricity*

Energy consumption of H_2 production (vs. SAF)

Higher energy conversion efficiency over Power-to-Liquids

Aircraft energy efficiency

Higher gravimetric energy density reduces energy consumption

Trade-off:
Lower volumetric energy density increases drag and structural weight of the airframe

MIT LABORATORY FOR AVIATION AND THE ENVIRONMENT

H_2 as an aviation fuel: production and logistics challenges

1. Scale
2. Supply chain to the airport
3. Airport energy distribution

MIT LABORATORY FOR
AVIATION AND
THE ENVIRONMENT

H_2 as an aviation fuel: production and logistics challenges

1

Scale

Energy needs to switch to an H_2-powered aviation system are large and require substantial investments

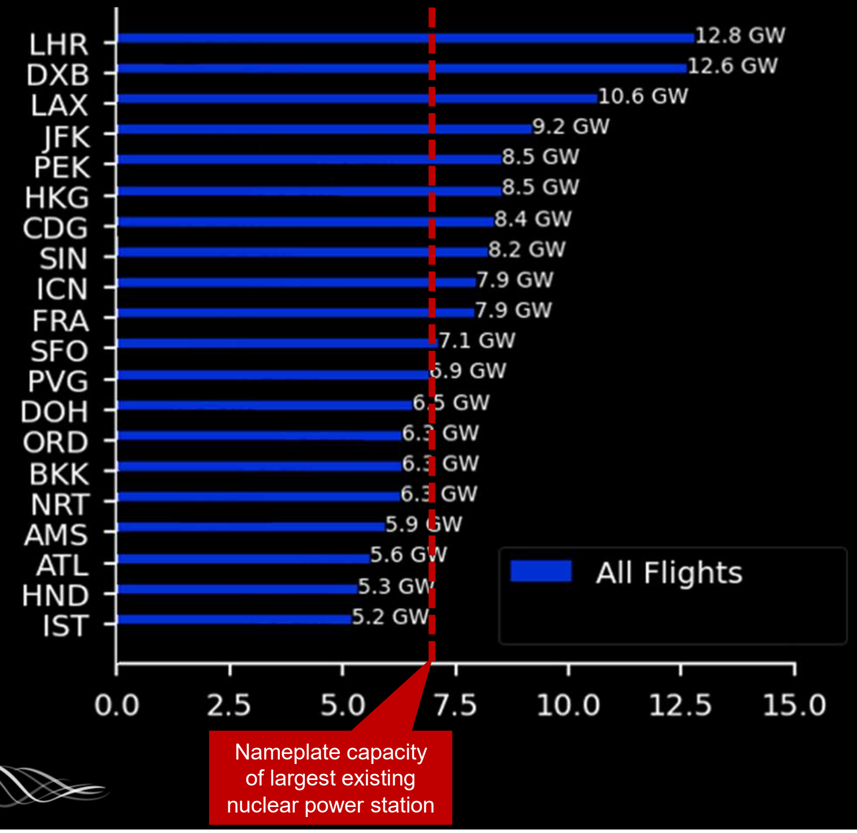
Supply chain to the airport 2

Airport energy distribution 3

MIT LABORATORY FOR AVIATION AND THE ENVIRONMENT

Energy demand for an LH_2-powered aviation system…

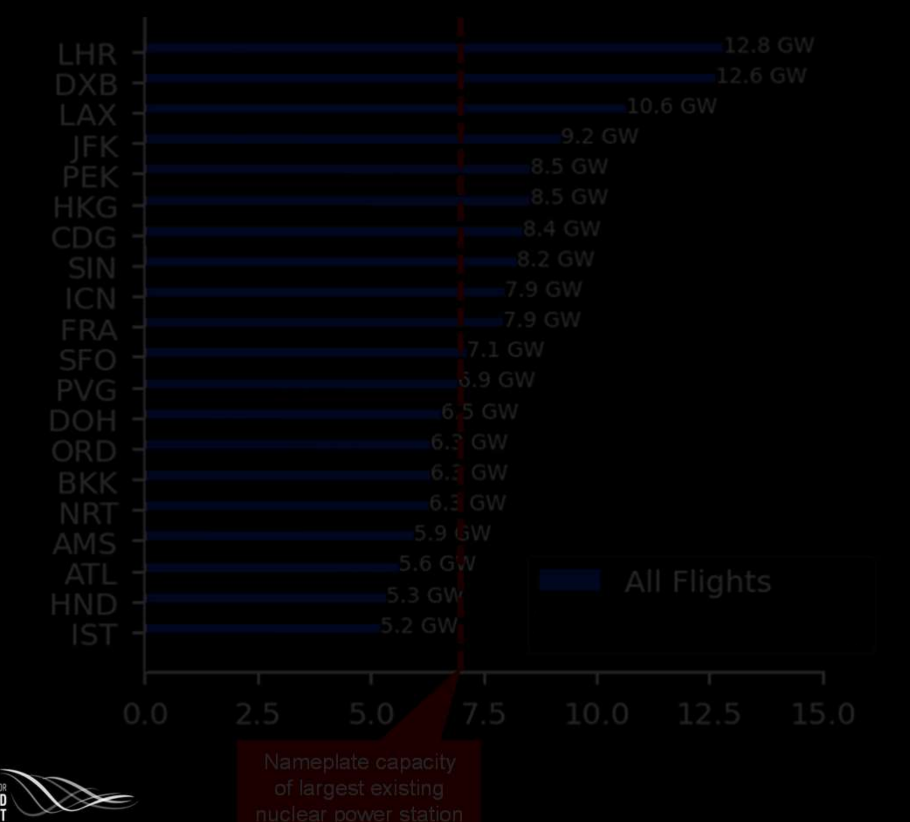
Electric energy consumption of LH_2 fuel production for major airports, Year 2019 traffic, *in GW, by airport*



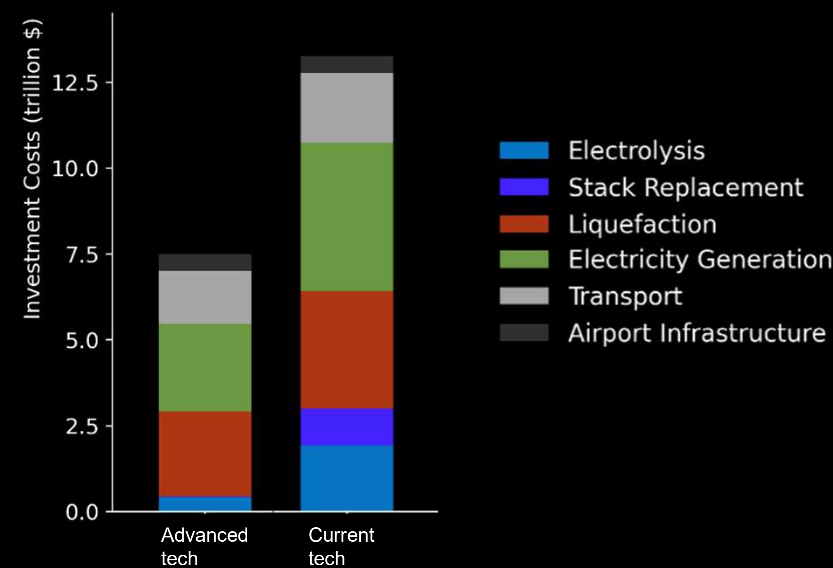
MIT LABORATORY FOR AVIATION AND THE ENVIRONMENT

… leads to significant investment requirements

Electric energy consumption of LH_2 fuel production for major airports, Year 2019 traffic, *in GW, by airport*



Required investments for full replacement of fuel demand for scheduled passenger aviation with LH_2 in 2050



For reference:

- 5% of global energy system invest. to reach 1.5C goal by 2050
- Annualized advanced scenario: $200 bn over 30 years
    - ~50% of current fuel production investment
    - Twice yearly Boeing and Airbus revenue combined

MIT LABORATORY FOR AVIATION AND THE ENVIRONMENT

H_2 as an aviation fuel: production and logistics challenges

1

Scale

Energy needs to switch to an H_2-powered aviation system are large and require substantial investments

2

Supply chain to the airport

H_2 production and distribution to the airport needs to carefully be re-imagined;

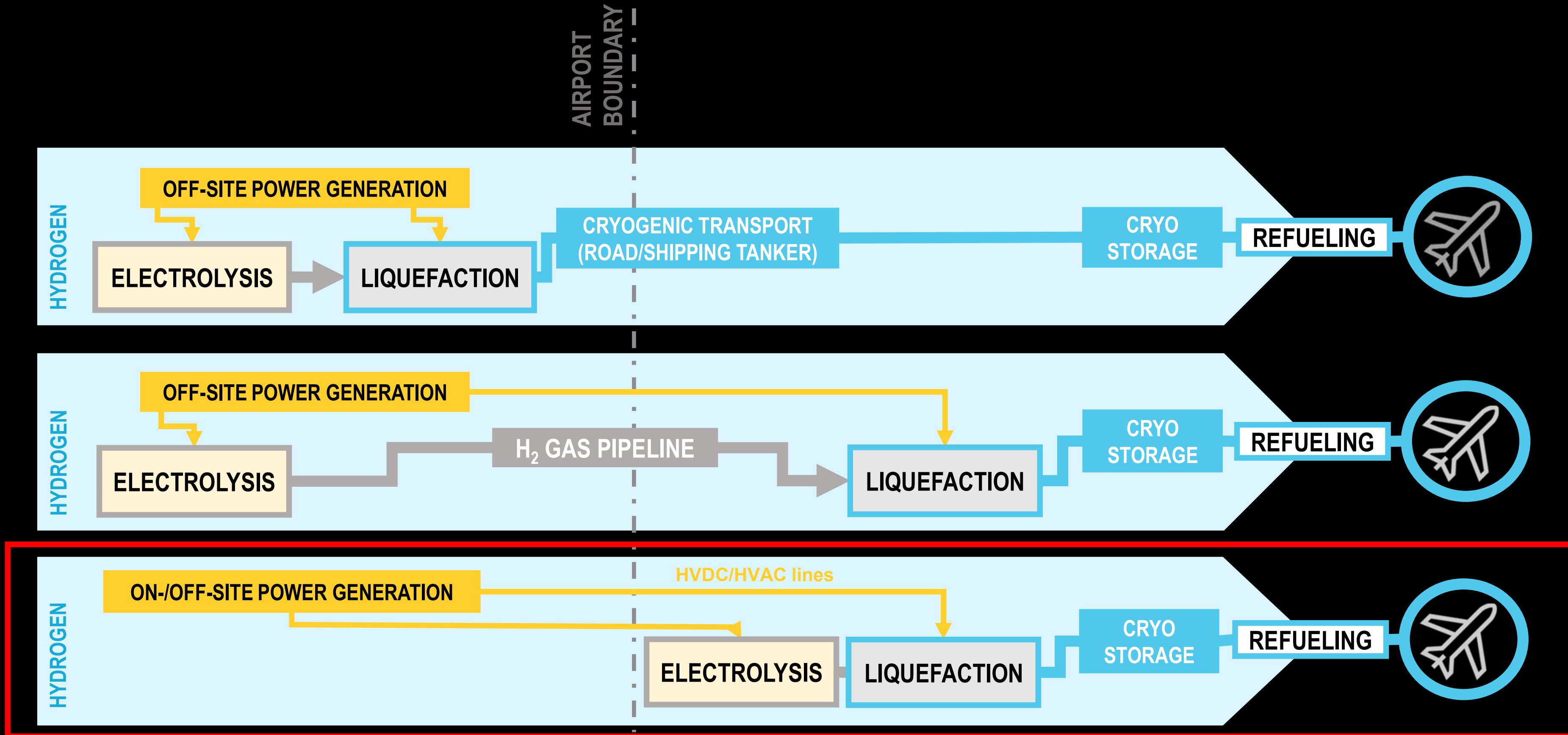
Design will impact on cost distributions across the globe

3

Airport energy distribution

MIT LABORATORY FOR AVIATION AND THE ENVIRONMENT

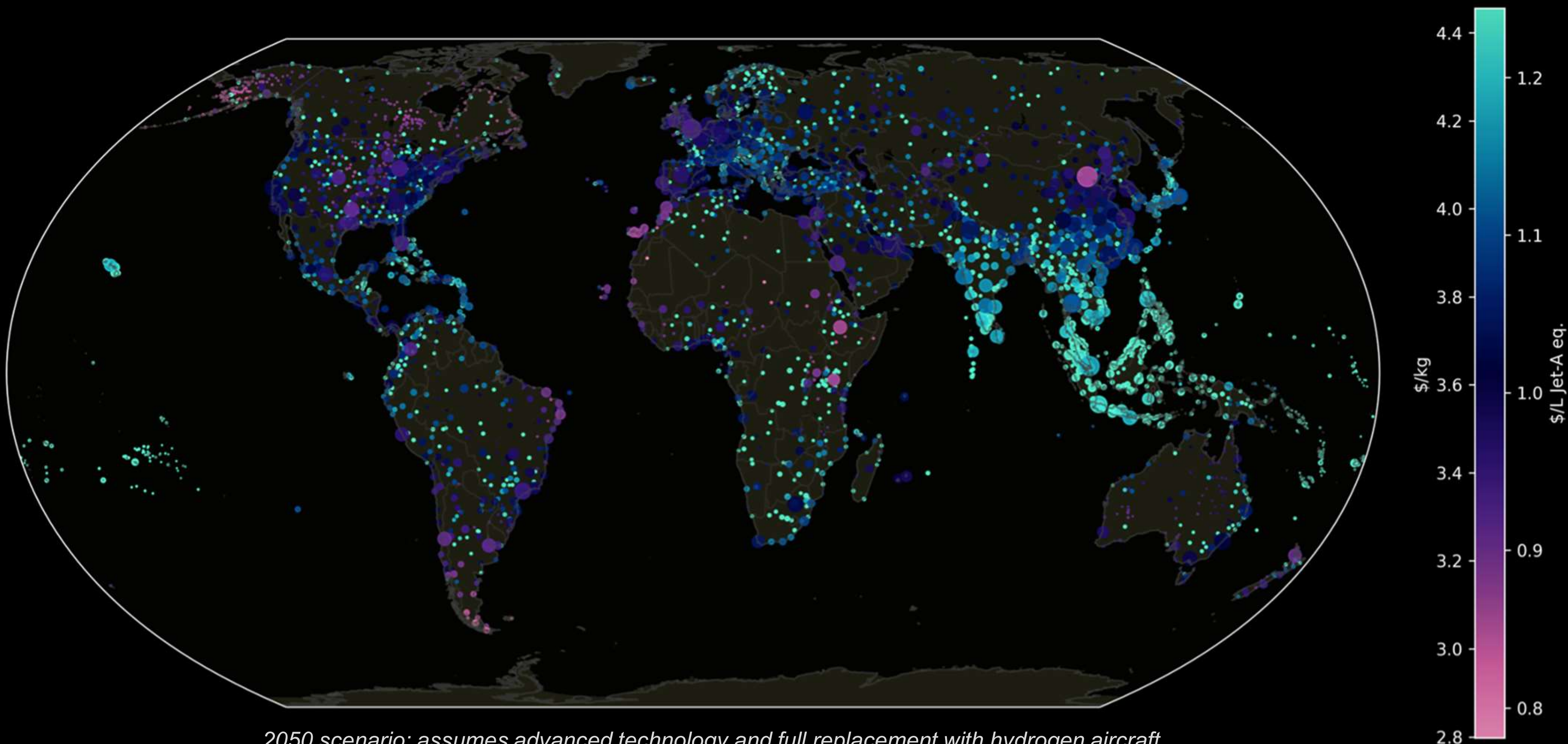
Supply chain design for an H_2-powered aviation system



LH_2 production at the airport (or in close proximity to the airport) minimizes the cost of hydrogen supply.

MIT LABORATORY FOR AVIATION AND THE ENVIRONMENT

Due to transportation cost and local resource availability, (L)H2 cost will vary across global airports



2050 scenario; assumes advanced technology and full replacement with hydrogen aircraft

H_2 as an aviation fuel: production and logistics challenges

1

Scale

Energy needs to switch to an H_2-powered aviation system are large and require substantial investments

Supply chain to the airport

H_2 production and distribution to the airport needs to carefully be re-imagined;

Design will impact on cost distributions across the globe

2

Airport energy distribution

H_2 distribution system at the airport required, with an investment of ~$250bn

Negative impacts on aircraft turnaround time must be avoided

3

MIT LABORATORY FOR AVIATION AND THE ENVIRONMENT

H_2 as an aviation fuel: production and logistics challenges

1

Scale

Energy needs to switch to an H_2-powered aviation system are larg…
and req…

Supply chain to the airport

H_2 production and distribution to the… needs to carefully be re-ima…

Design will impa… …ss the globe…

2

…rt energy distribution

H_2 distribution system at the airport required, with an investment of ~$250bn

Negative impacts on aircraft turnaround time must be avoided

3

With careful planning, none of these challenges render the adoption of LH_2 as an energy carrier for aviation impossible.

MIT LABORATORY FOR AVIATION AND THE ENVIRONMENT


MIT LABORATORY FOR
AVIATION AND
THE ENVIRONMENT
LAE.MIT.EDU