twelve

# we have transformed $CO_2$ into products for flagship customers

**e·jet** by twelve

**CO2Made® / e·naphtha®**

E-Jet®: World's first jet fuel made from $CO_2$ electrolysis

U.S. AIR FORCE

Alaska AIRLINES

shopify

Microsoft

الاتحاد ETIHAD

IAG INTERNATIONALS AIRLINES GROUP

World's first $CO_2$Made® ingredients for Tide

P&G

World's first $CO_2$Made® auto parts

Mercedes-Benz

World's first $CO_2$Made® sunglass lenses

PANGAIA LAB × twelve

# Twelve is backed by the world's leading climate investors

**Over $700 million raised in company equity and project finance since 2021**

DC >C

CAPRICORN INVESTMENTGROUP

FIFTH WALL

Carbon Direct

TPG

HARVARD MANAGEMENT COMPANY

Emerson Collective

Munich RE

Microsoft

Lawrence Livermore National Laboratory

NASA

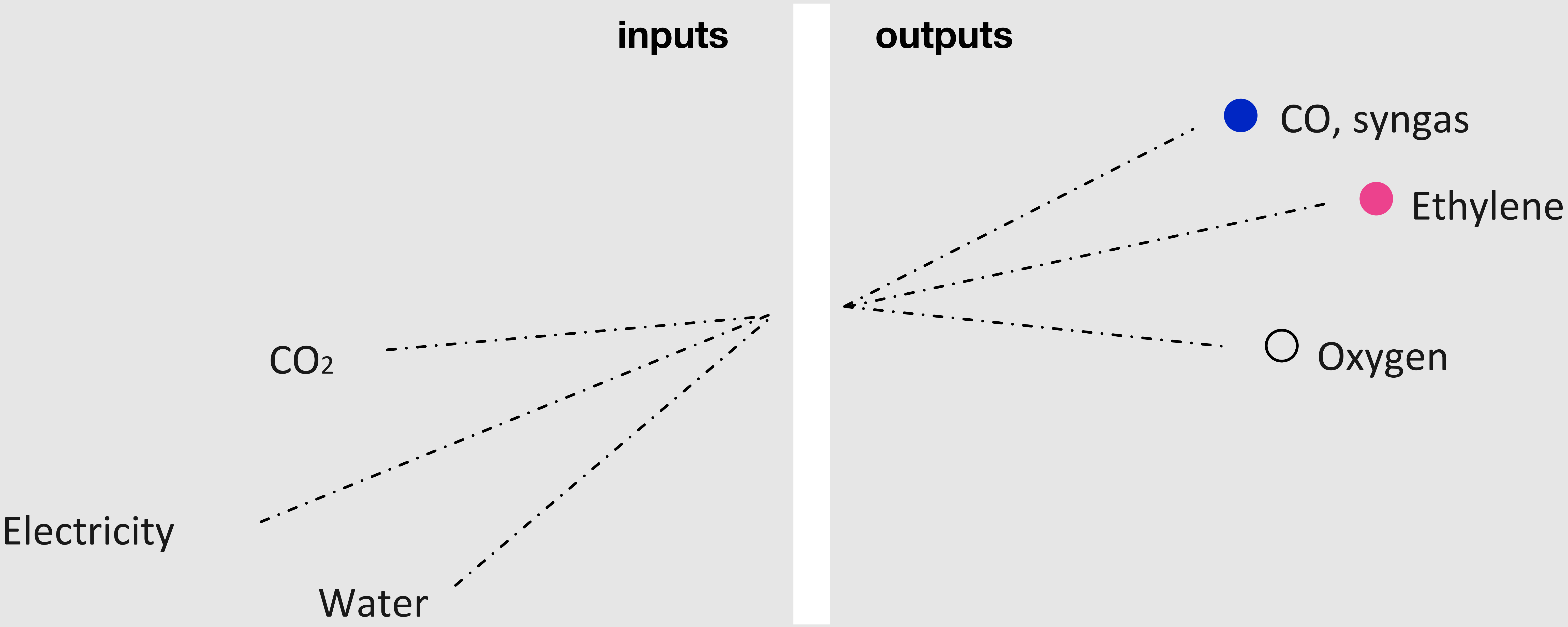
NREL

Lawrence Berkeley National Laboratory

Stanford University

Founded 2016, Stanford University

# we transform $CO_2$ into ingredients for chemicals, materials, and fuels



**inputs**

$CO_2$

Electricity

Water

**outputs**

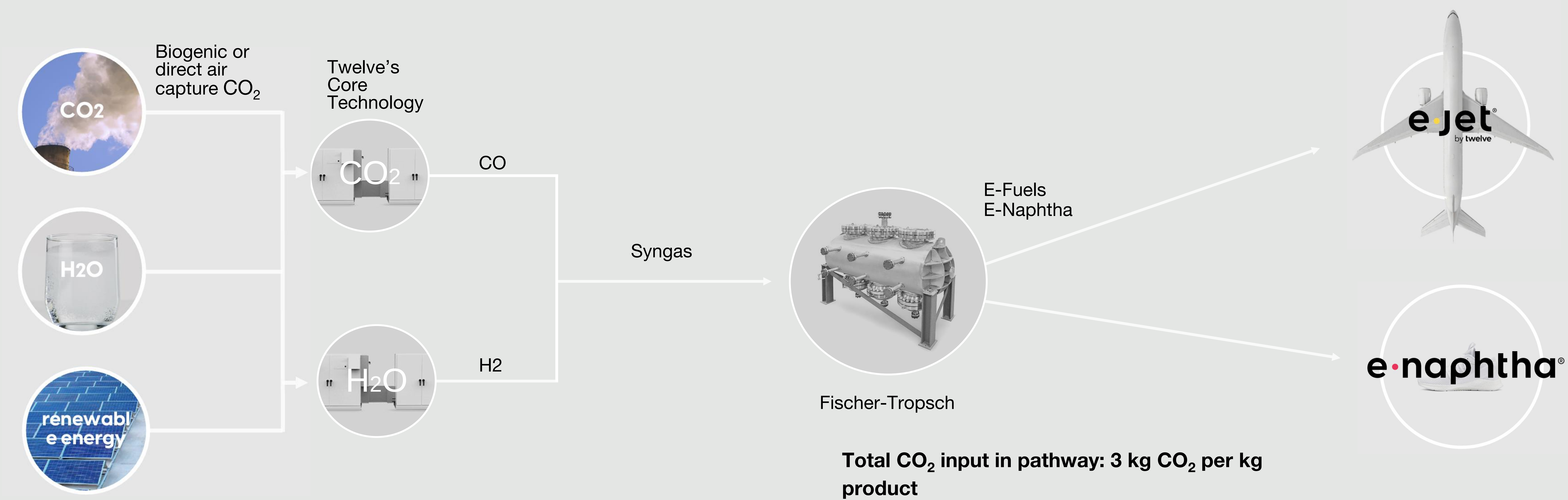
● CO, syngas

● Ethylene

○ Oxygen

**process: a platform technology that enables PEM electrolyzers to make carbon-based products**

# Twelve's AirPlant™ turns $CO_2$ into fuels and building blocks for materials



Biogenic or direct air capture $CO_2$

Twelve's Core Technology

CO

H2

Syngas

Fischer-Tropsch

E-Fuels
E-Naphtha

**Total $CO_2$ input in pathway: 3 kg $CO_2$ per kg product**

1.

Twelve combines proprietary low temperature $CO_2$ electrolysis with $H_2O$ electrolysis to produce syngas from captured $CO_2$ and water

2.

Syngas is used to produce naphtha and drop-in fuels via Fischer-Tropsch process

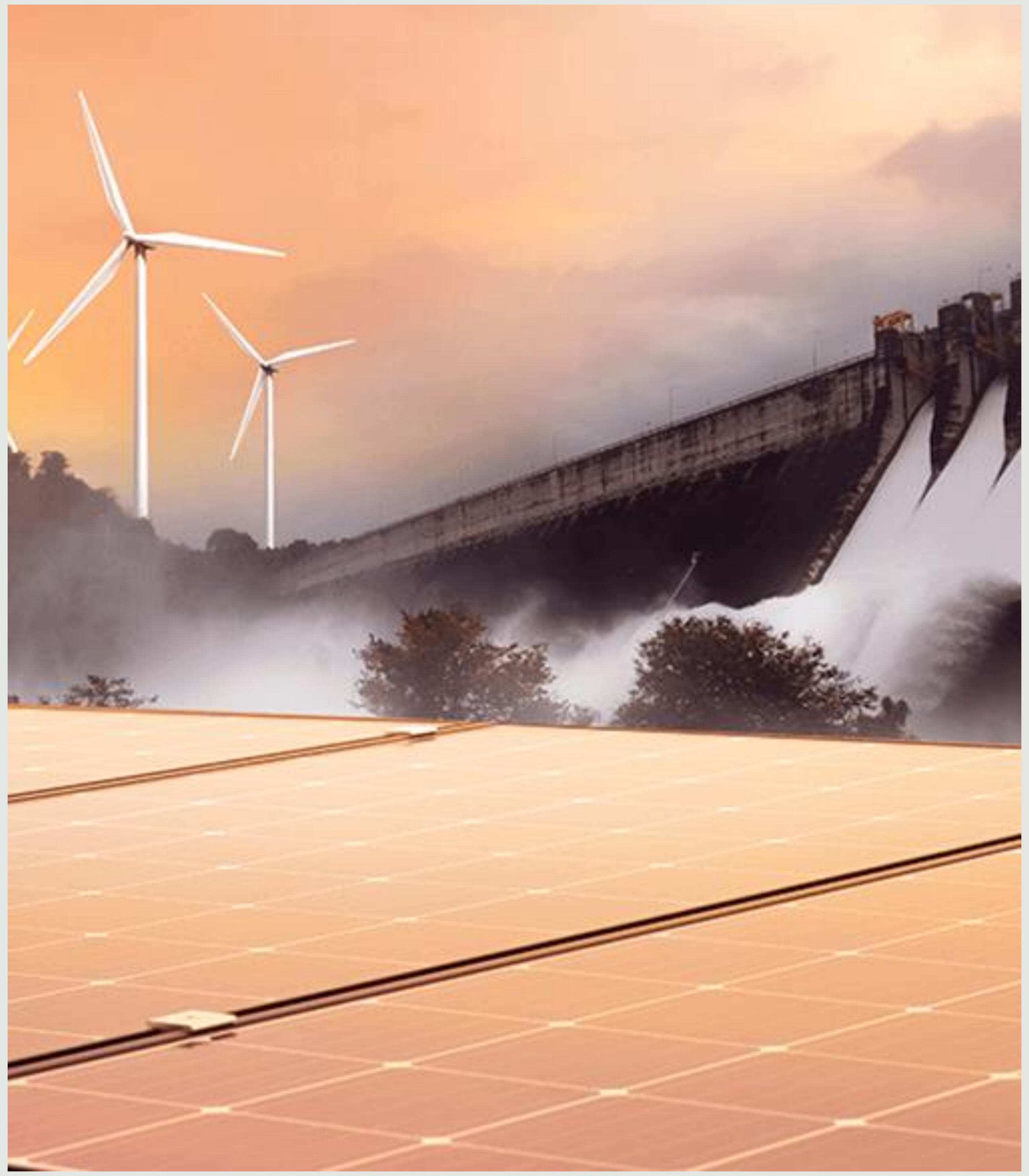
3.

Twelve's products are identical to conventional products with zero new emissions, zero fossil fuels, and zero tradeoffs in quality and performance

# key inputs unlocking product value proposition

**Biogenic sources of carbon dioxide**

Pulp and paper factories
Corn ethanol plants
Biogas facilities



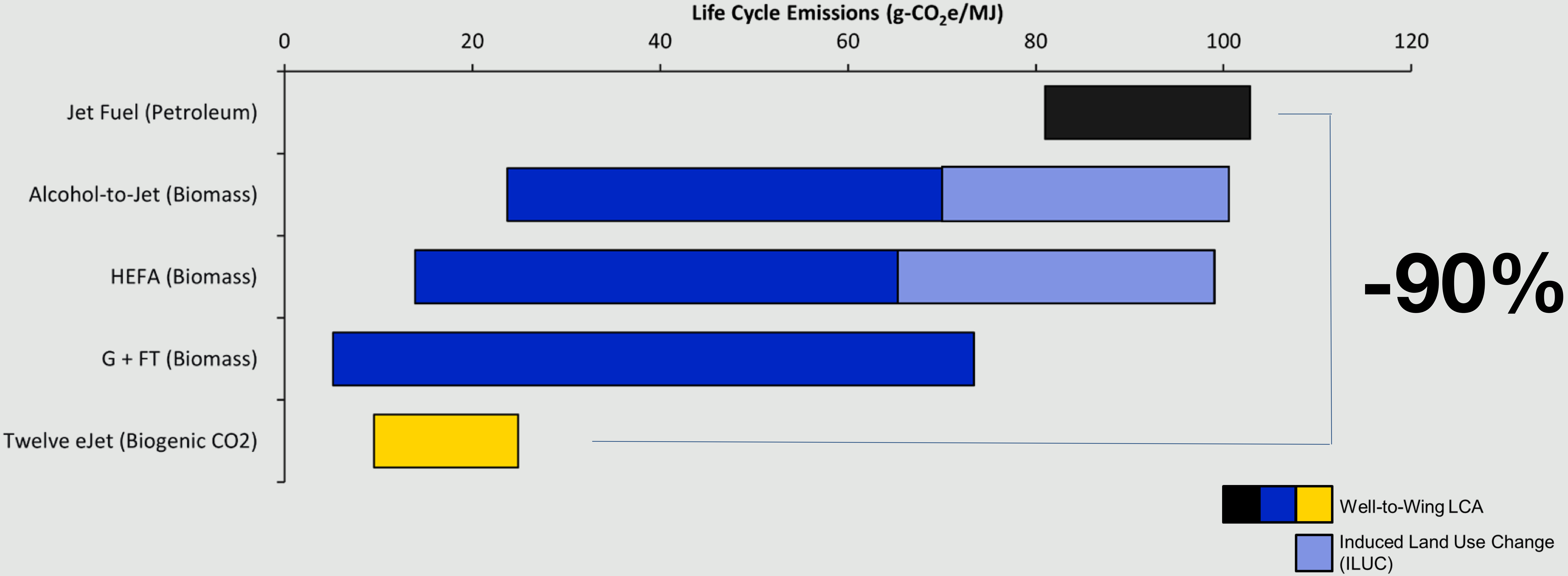
**Renewable sources of energy**

Solar, Wind, Hydro & Nuclear

**Green Hydrogen**

Direct acquisition
Water electrolysis

# E-Jet has 90% lower lifecycle emissions than fossil jet fuel

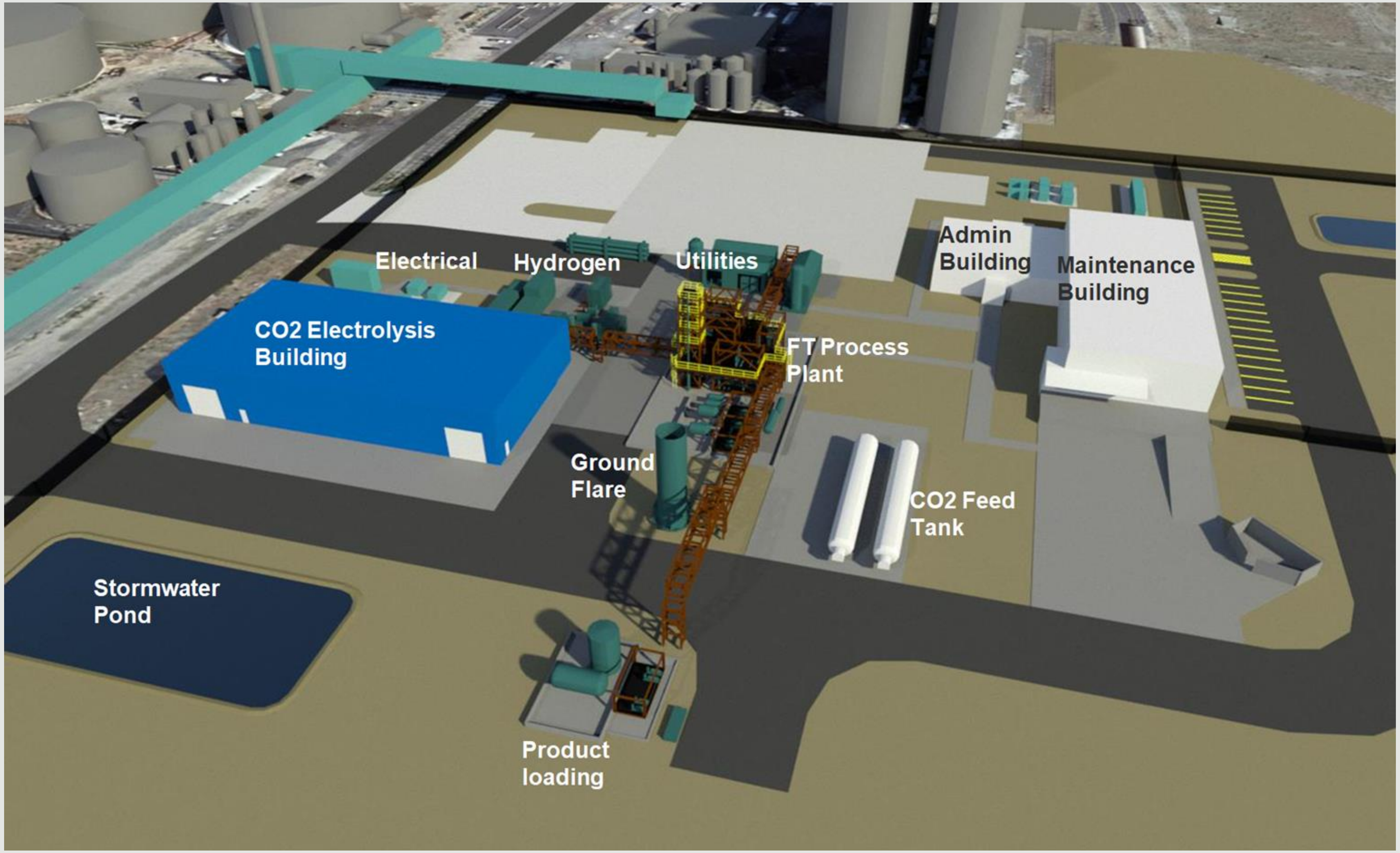


**Notes:**

- **Petroleum Jet Fuel** range depends on geography[1]
- **Biomass-Derived Jet Fuel** range depends on feedstock[2]
  (*Alcohol-to-Jet low to high:* Forestry Residues, Agricultural Residues, Sugarcane, Molasses, Herbaceous Energy Crops, Corn Grain)
  (*HEFA low to high:* Used Cooking Oil, Corn Oil, Palm Fatty Acid Distillate, Tallow, Brassica Carinata, Camelina, Soybean Oil, Rapeseed Oil, Palm Oil)
  (*G + FT low to high:* Agricultural Residues, Forestry Residues, Herbaceous Energy Crops, Short-Rotation Woody Crops, Municipal Solid Waste (40% non-biogenic component))
- **Twelve eJet** range depends on low-carbon electricity source (*low to high:* hydroelectric, nuclear, wind, solar)

[1] Jing, L. *et al. Nat Commun* **13**, 7853 (2022).
[2] ICAO (2022).

# first production plant



Location: Moses Lake, WA

Capacity: 5 BPD E-fuel

Production Start: H1 2024

Staff: 15-20 people

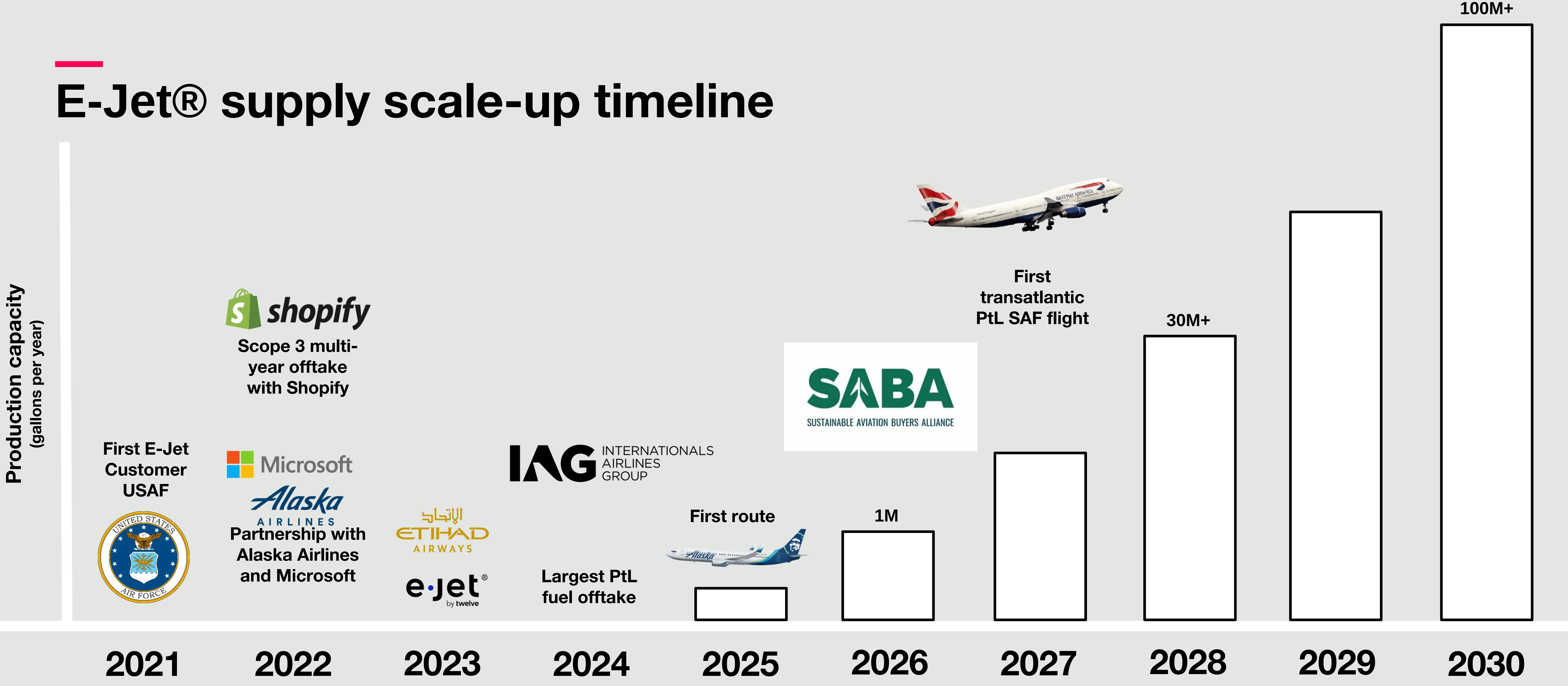
Operation: 24/7 operations

Products: SAF, naphtha

CO2: Corn-Ethanol Factory

Electricity: Hydro (100%)

# E-Jet® supply scale-up timeline



First E-Jet Customer USAF

Scope 3 multi-year offtake with Shopify

Partnership with Alaska Airlines and Microsoft

Largest PtL fuel offtake

First route

First transatlantic PtL SAF flight

| 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027–2030 |
|---|---|---|---|---|---|---|
| Delivered and Tested, ASTM compliant | Commercial $CO_2$ electrolyzer online in 2022 in Alameda, California | Etihad MOU; First E-Jet plant under construction, Moses Lake, WA | IAG large-scale, long-term deal signed | First flight using E-Jet; Continuous delivery to SeaTac airport | Production ramp-up at Moses Lake | Multiple new sites and scale-up across North America |

# contact us

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The Power-to-Liquid Advantage

www.twelve.co

# the future is fossil free

# our board

**Anne Roby, Independent Board Director**
Former EVP of Praxair, Linde, Member of the National Academy of Engineering

**Zack Bogue, Board Member**
Co-founder and managing partner @ DCVC

**Ion Yadigaroglu, Board Member**
Co-founder and partner @ Capricorn Investment Group

**Elizabeth Stone, Board member**
Principal @ TPG Rise Climate

Founders

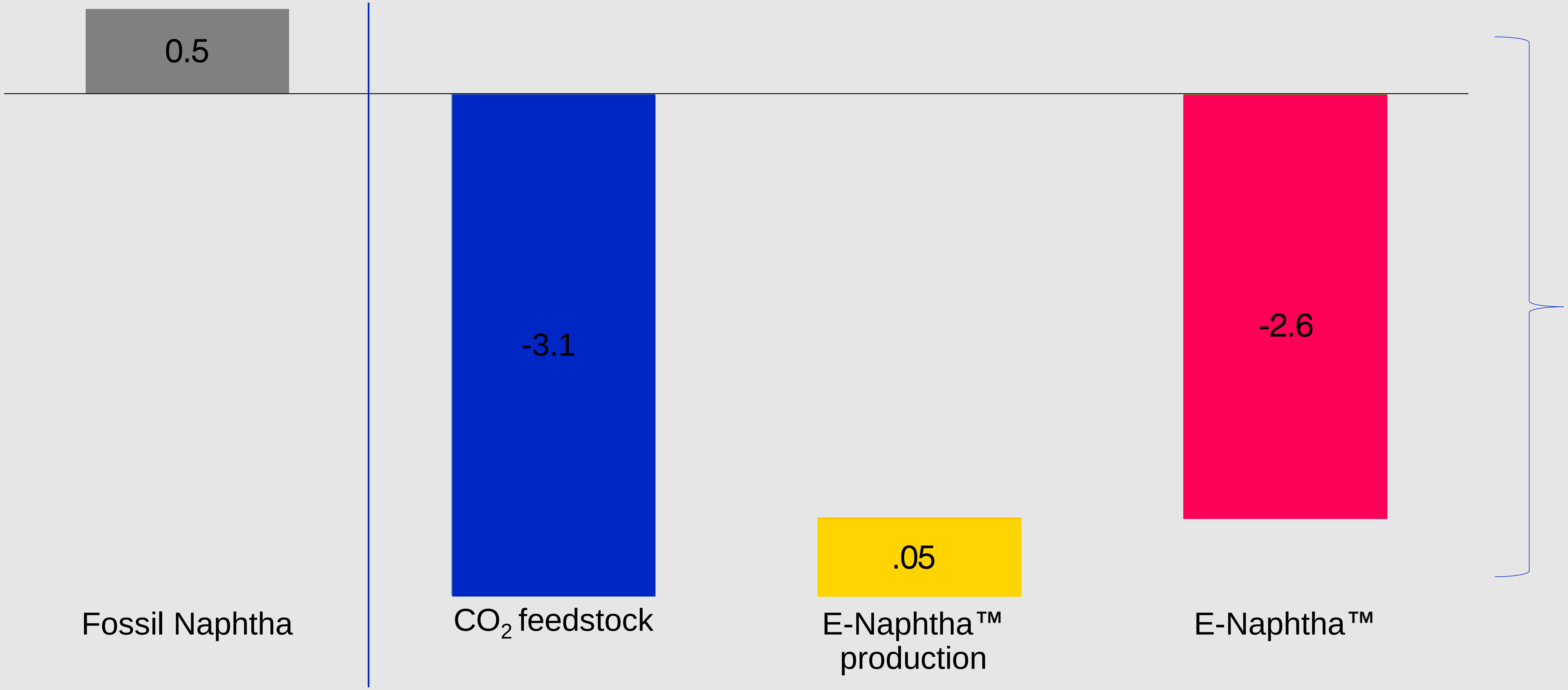
**Dr. Kendra Kuhl, CTO**
PhD in Chemistry, Stanford
Post Doc, SLAC National Lab

**Dr. Etosha Cave, CSO**
PhD in Mechanical Eng., Stanford

**Nicholas Flanders, CEO**
MBA/MS Stanford, McKinsey, COO Levo

# E-Naphtha™ is carbon negative

Cradle to gate lifecycle emissions – kg $CO_2$/ kg Naphtha



Carbon negative cradle to gate (-2.7 kg$CO_2$/ kg naphtha)

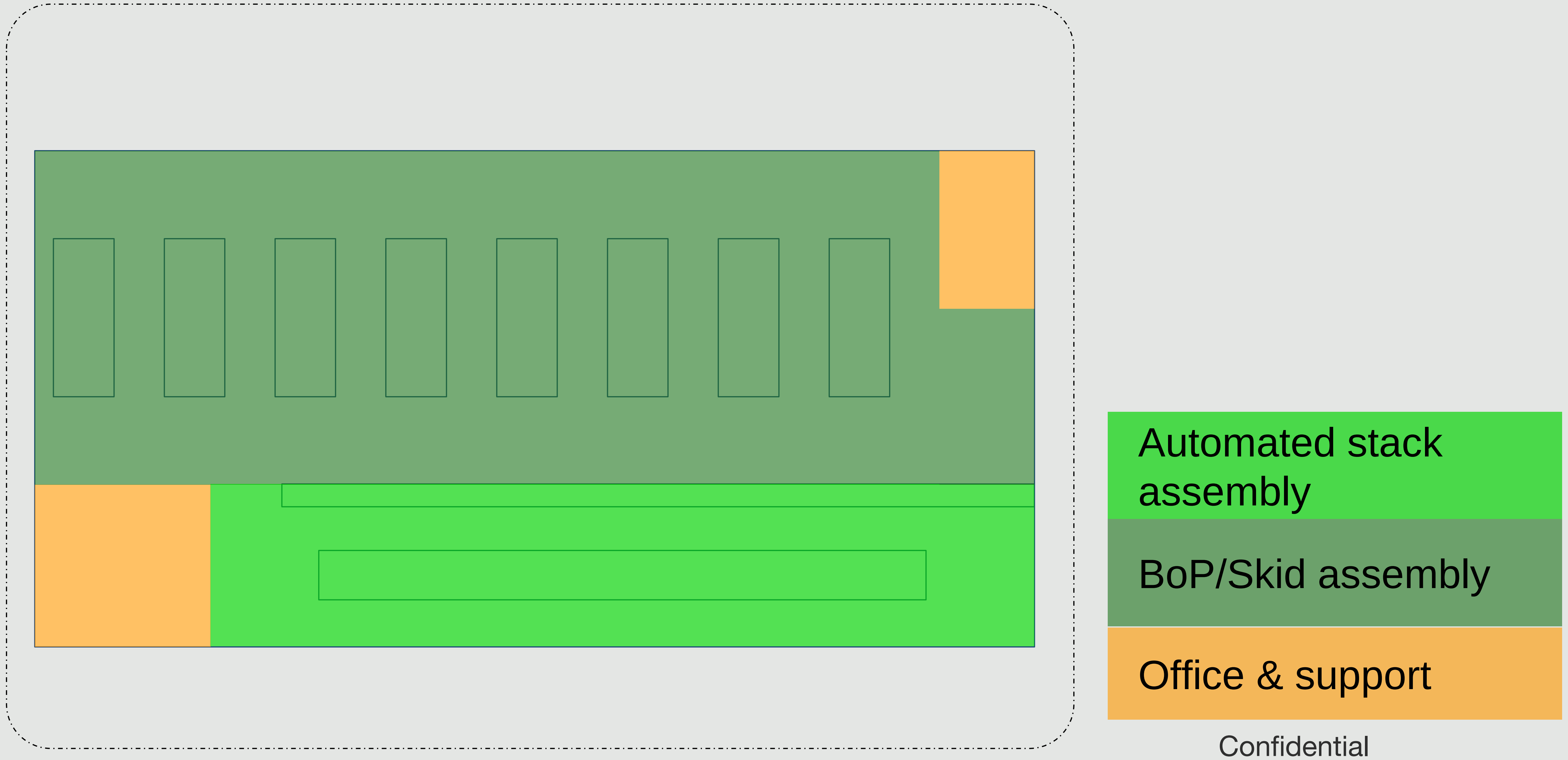
Over 3 tons of $CO_2$ transformed per ton naphtha

**Notes**

- Allocation of emissions to naphtha and e-jet based on mass
- Naphtha baseline emissions calculated using inventory from ecoinvent 3.7 and process outlined in Plastics Euro 2015 LCA on SAN and ABS
- Green hydrogen emissions adapted from NREL's LCA of Renewable Hydrogen Production via Wind/Electrolysis, 2004.
- CO2-to-CO impacts calculated using inventory from ecoinvent 3.7, and process outlined internally.
- CO2 capture impacts adapted from Advanced Post-Combustion CO2 Capture, Prepared for the Clean Air Task Force, 2009.

# gigafactory (future)

- 100,000 square feet
- Office for manufacturing technicians, supervisors, minimal G&A: employee seating, conference rooms, break room, etc.
- Manufacturing capabilities (Phase 1 and 2)
    - Automated Plate Assembly
    - Automated MEA Assembly
    - Automated Stack assembly
    - Balance of plant/electrolyzer skid assembly



# market landscape

## Low-emissions propulsion technologies

### Battery-electric propulsion

**Electric-aircraft manufacturers**

Heart Aerospace
H55
Wright
EVIATION
BYE AEROSPACE

**System elements**

ADDIONICS
H3X
Sion Power
GROUP14
magniX
Sila
StoreDot
SYLPHAERO

### Hybrid-electric propulsion

AMPAIRE
ROLLS ROYCE
PIPISTREL
HYBRIDAir Vehicles
faradair

### Hydrogen-powered propulsion

**Hydrogen-aircraft manufacturers**

APUS Zero Emission
ZEROAVIA
AIRBUS

**System elements**

POWERCELL
GTL
hypoint
Universal Hydrogen
Kubagen

## Sustainable aviation fuels

### Refinery biofuels

NESTE
world energy
bp
OMV
TotalEnergies
Renewable Energy Group

### Gasification and alcohol-to-jet

**Gasification**

Enerkem
Fulcrum BIOENERGY
INENTEC

**Alcohol-to-jet**

LanzaTech
LanzaJet
gevo
BYOGY RENEWABLES

### Power-to-liquids fuels

PROMETHEUS
twelve
SeeO2 ENERGY
Synhelion
Arcadia eFuels
NCF New CO2 Fuels
sunfire
Carbon Engineering
DIMENSIONAL ENERGY

## Optimizing operations and aircraft

### Airport and operations

**Flight operations**

SKYGRID
signol
AIRSPACE INTELLIGENCE

**Ground operations**

CARGOMETER
AIREXPERT
Moonware
i6 GROUP

### Aircraft design and manufacturing

**Aircraft**

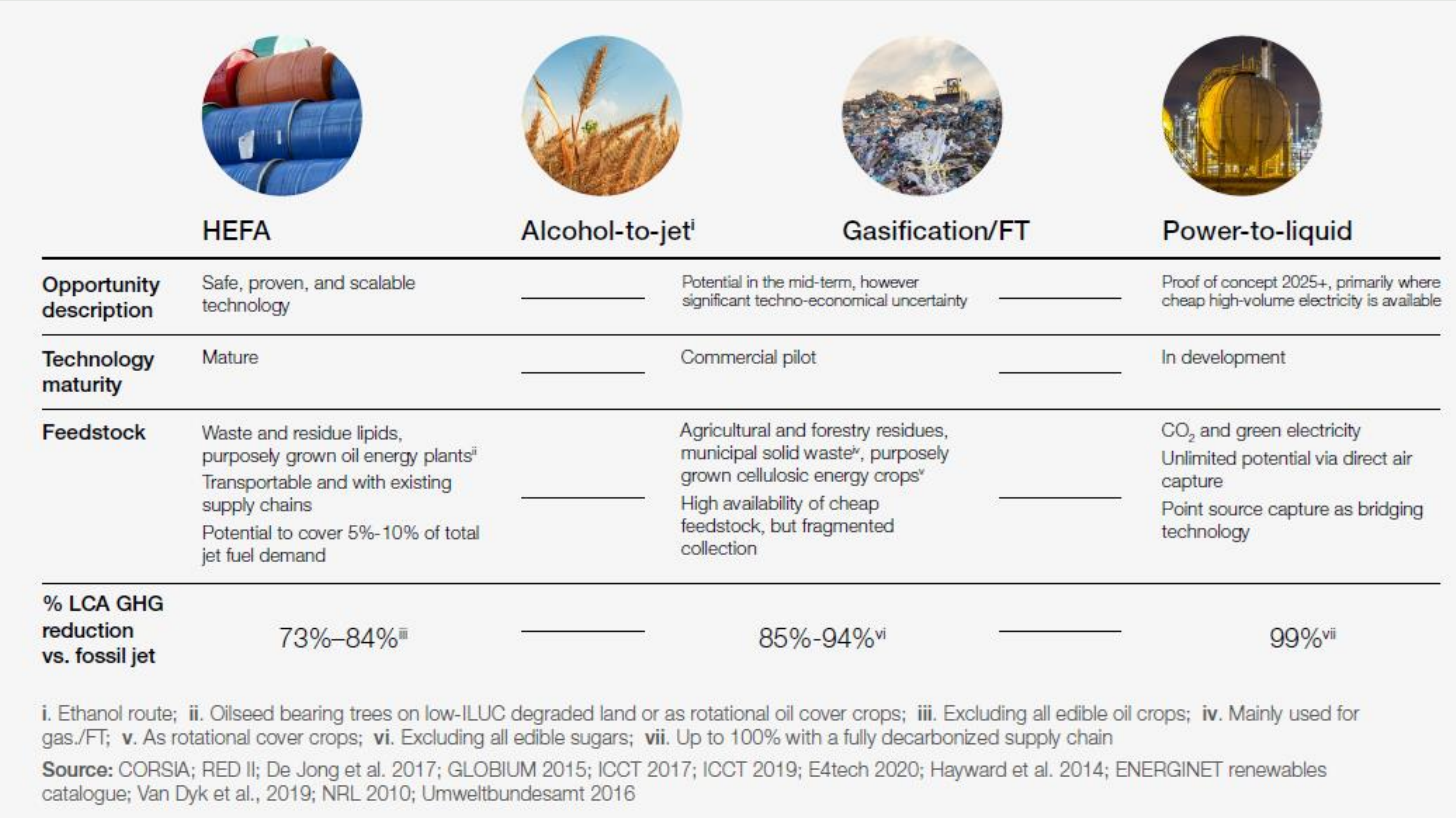
BASF We create chemistry
cfm
ROLLS ROYCE
Pratt & Whitney
Lufthansa
GE

**Manufacturing**

iCOMAT
Supercool Metals
9T LABS
Productive Machines
veelo TECHNOLOGIES

*Source: BloombergNEF*

# SAF product landscape

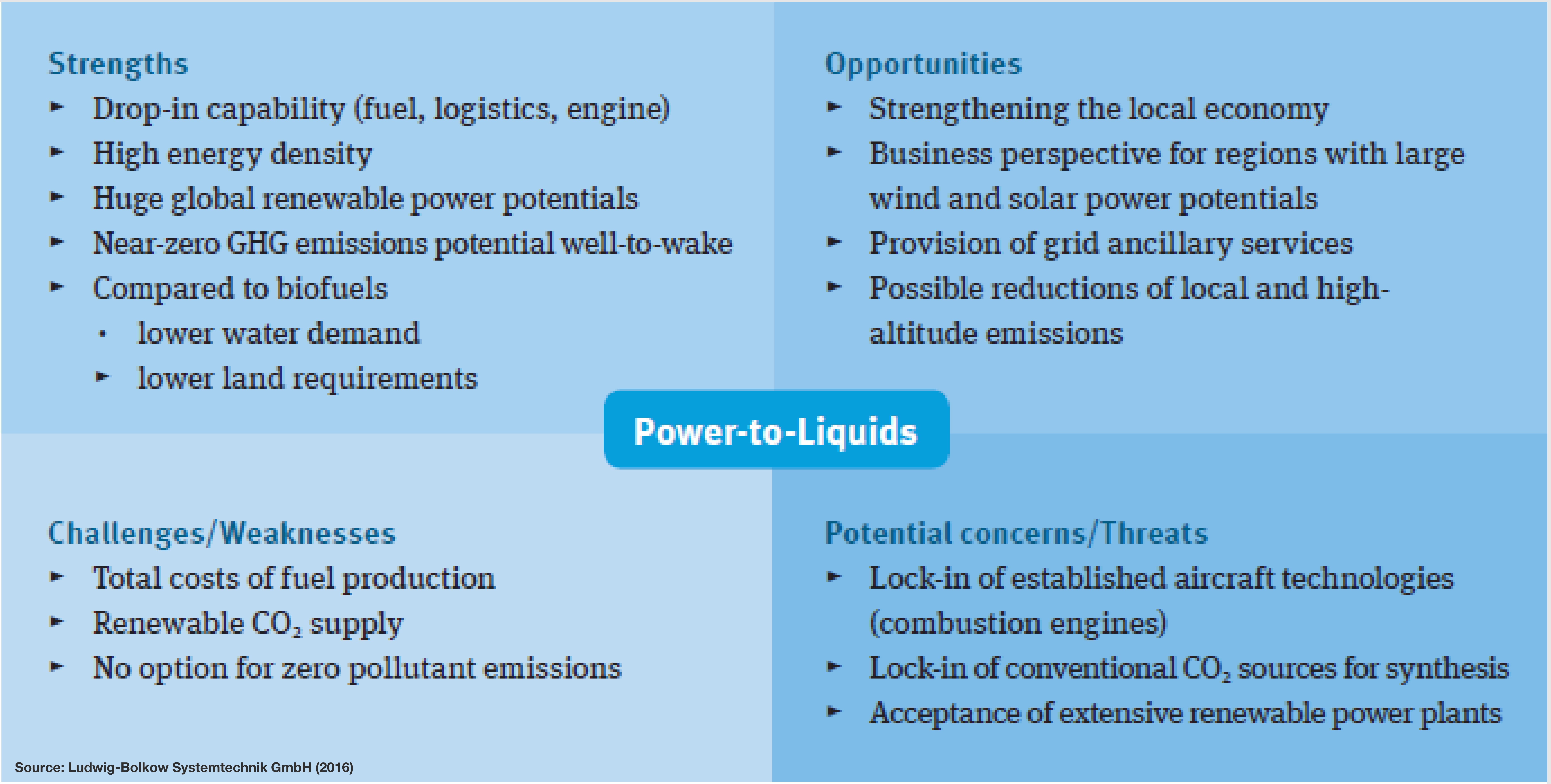


| | HEFA | Alcohol-to-jet[i] | Gasification/FT | Power-to-liquid |
|---|---|---|---|---|
| **Opportunity description** | Safe, proven, and scalable technology | | Potential in the mid-term, however significant techno-economical uncertainty | Proof of concept 2025+, primarily where cheap high-volume electricity is available |
| **Technology maturity** | Mature | | Commercial pilot | In development |
| **Feedstock** | Waste and residue lipids, purposely grown oil energy plants[ii]<br>Transportable and with existing supply chains<br>Potential to cover 5%-10% of total jet fuel demand | | Agricultural and forestry residues, municipal solid waste[iv], purposely grown cellulosic energy crops[v]<br>High availability of cheap feedstock, but fragmented collection | CO$_2$ and green electricity<br>Unlimited potential via direct air capture<br>Point source capture as bridging technology |
| **% LCA GHG reduction vs. fossil jet** | 73%–84%[iii] | | 85%-94%[vi] | 99%[vii] |

**i**. Ethanol route; **ii**. Oilseed bearing trees on low-ILUC degraded land or as rotational oil cover crops; **iii**. Excluding all edible oil crops; **iv**. Mainly used for gas./FT; **v**. As rotational cover crops; **vi**. Excluding all edible sugars; **vii**. Up to 100% with a fully decarbonized supply chain

**Source:** CORSIA; RED II; De Jong et al. 2017; GLOBIUM 2015; ICCT 2017; ICCT 2019; E4tech 2020; Hayward et al. 2014; ENERGINET renewables catalogue; Van Dyk et al., 2019; NRL 2010; Umweltbundesamt 2016

# swot analysis



**Strengths**

- Drop-in capability (fuel, logistics, engine)
- High energy density
- Huge global renewable power potentials
- Near-zero GHG emissions potential well-to-wake
- Compared to biofuels
  - lower water demand
  - lower land requirements

**Opportunities**

- Strengthening the local economy
- Business perspective for regions with large wind and solar power potentials
- Provision of grid ancillary services
- Possible reductions of local and high-altitude emissions

**Power-to-Liquids**

**Challenges/Weaknesses**

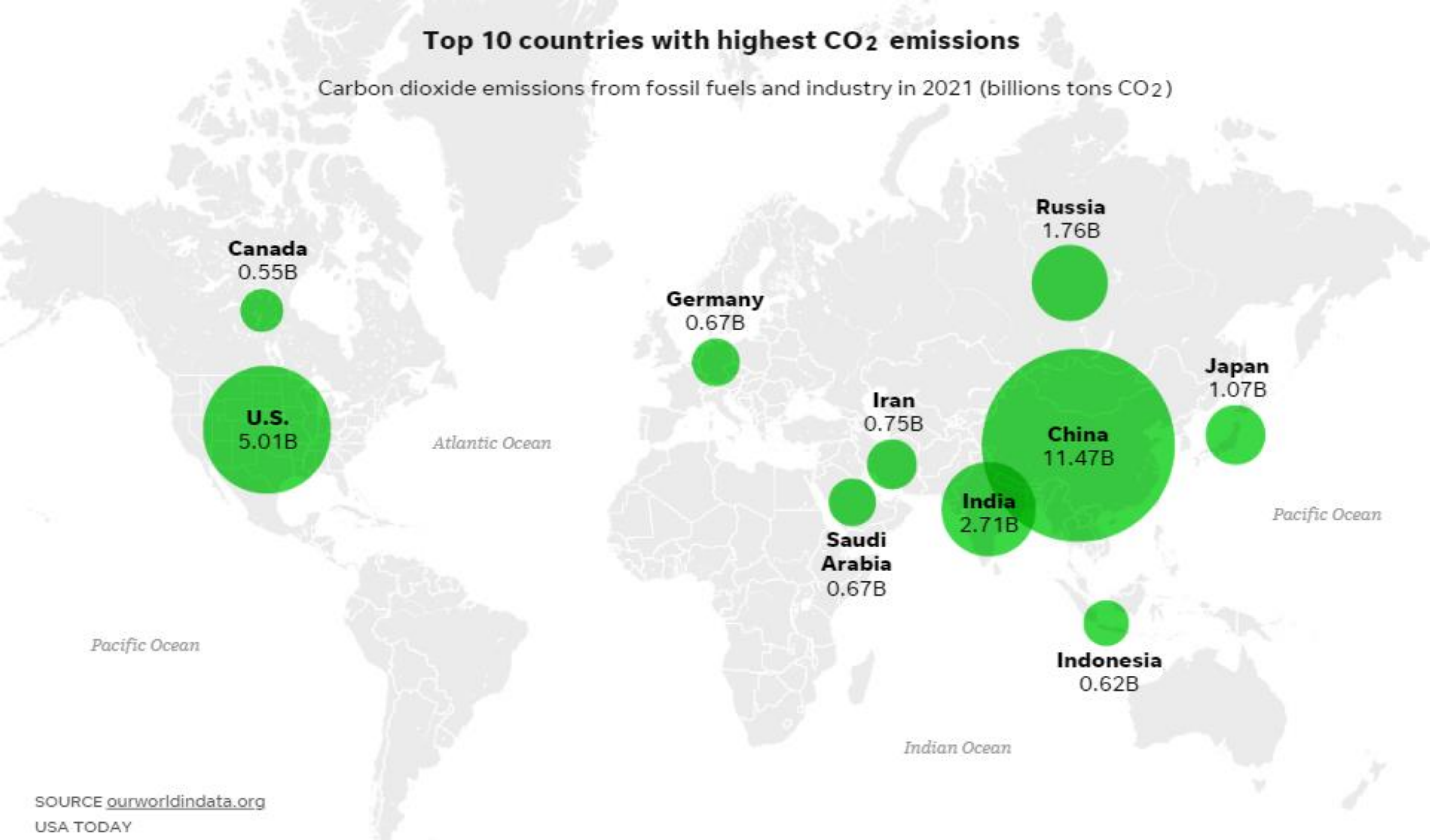
- Total costs of fuel production
- Renewable $CO_2$ supply
- No option for zero pollutant emissions

**Potential concerns/Threats**

- Lock-in of established aircraft technologies (combustion engines)
- Lock-in of conventional $CO_2$ sources for synthesis
- Acceptance of extensive renewable power plants

Source: Ludwig-Bolkow Systemtechnik GmbH (2016)

# global emissions footprint



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