State of the Art – A Patent-centric Outlook on e-Fuels

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Background

- Transport sector accounted for 21% global CO_2 emissions in 2018 & sector emissions grew at an annualized average rate of 1.7% from 1990-2022
- Road-based passenger transport is responsible for 45.1% emissions, road-based freight accounts for 29.4% emissions followed by aviation at 11.6% and shipping at 10.6%
- IEA Net-Zero Emissions by 2050 scenario requires sales of roughly 60 million EVs in 2030, up from 10 million in 2022 but economic, inflationary and consumer behaviour patterns seem to be indicating a slowdown in the pace of growth of passenger EV market
- Electrification approaches seem ill-suited to decarbonize hard to abate sectors - aviation and shipping, heavy-duty electrification barriers include infrastructure and technology limitations in the near term

Research Question

Does patent filing activity (number of patents filed) serve as an indicator of industry interest in the development and propagation of e-Fuels technology?

Research Methodology

Patent Data Collection

Combination of patent classifications and keywords used to extract a patent master set from the Lens database

Search cut-off date covers filed & published patents with earliest priority date of January 01, 2000

Patent Refining

Lens patent relevancy sort was used to rank patents in decreasing order of relevance

Relevancy criteria based on extent of patent disclosure in the Title, Abstract, Claims and Specification was developed

Top-2000 patent families subject to manual screening of relevancy criteria to shortlist documents for study

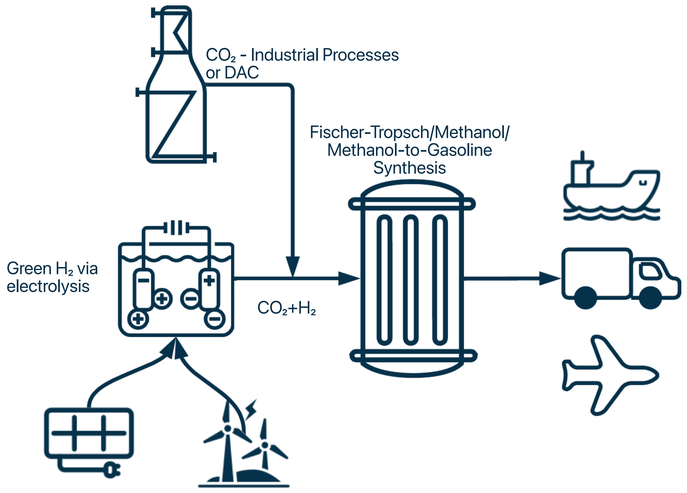
Forward and backward citations of relevant patents subjected to same relevancy criteria to yield final patent set (n=97)

Patent Analysis

Patent bibliographic and specification data analyzed to plot industry trends - fuel specific disclosures, carbon capture processes and types of patent claims

Family data used for plotting geographic scope of coverage and Assignee/Applicant data used for identifying key players

e-Fuel Process



Key Findings

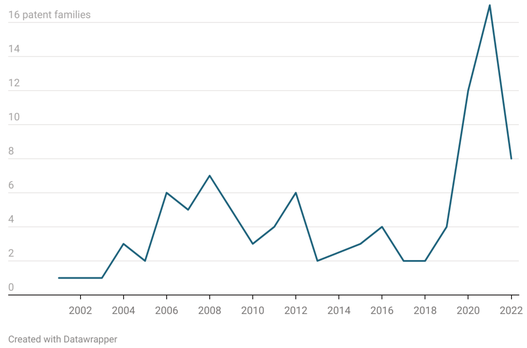


Fig - Patent Family Count – Priority Year Earliest

- Fairly consistent patenting activity from the mid-2000s to late 2010s
- Interest in patenting in the e-Fuel sector gained traction around 2019
- Patent publications reached a maximum of 17 families in 2021
- Visible decrease in filing activity around 2022 however, it is understood to stem from the lag between patent filing and publication

- Methanol as the final product was reported in the largest number of patents, 66 of the 97 patent families
- 13 patent families disclose the sole synthesis of methanol
- The only patent publication for OME (Oxymethylene ether), a diesel alternative was filed in 2018

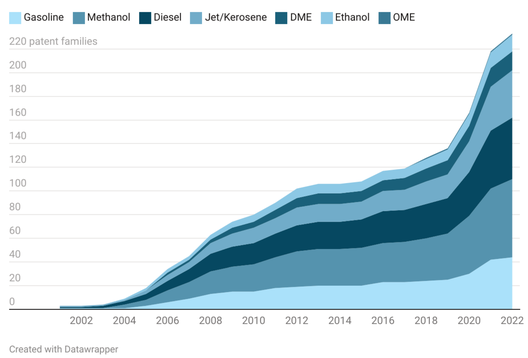


Fig - Cumulative Patent Family Count – Fuel Type

- Maximum e-Fuel specific disclosures are observed in 2021, with 12 filings for diesel and gasoline each and 11 filings for methanol and jet/kerosene each

Key Findings & Discussion

- Patent data clearly indicates an increased interest in e-Fuel technology commencing in 2019
- Industry interest seems to stem from global climate action commitments (Paris Agreement) and emission related regulations - ReFuelEU aviation and FuelEU maritime regulations
- e-Fuel patents have been filed across multiple jurisdictions, with filings led by USA (131 patents) and China (42 patents) [WIPO & EP excluded]
- Patent publications cover all primary transport fuels with a majority of patents focusing on methanol synthesis (main application in shipping)
- Patenting activity in the industry is led by Infinium (already commenced commercial operations) with 12 patent families, other primary assignees include Siemens (7 patent families), Obrist Technologies (5 patent families), Stratos Fuels (4 patent families), Topsoe (3 patent families) and Sunfire, Nordic Electrofuel and Climeworks (2 patent families each)
- Co-patenting observed between Climeworks (direct air capture) and Sunfire (electrolyzer) - US10421913B2 - patent filed in 2016, the organizations collectively established Norsk e-Fuel in 2019 with plans for full scale-production targeted for after 2026
- Patent data suggests both core and non-core firms are interested in e-Fuels with patents serving as an indicator for commercialization however not all active firms have opted for patent protection

Industry Outlook & Challenges

- Drop in capabilities of specific e-Fuels with existing infrastructure make them potential candidates to decarbonize hard to abate sectors
- Cost disadvantage and process scalability relative to fossil derived fuels act as commercialization barriers for widespread e-Fuel deployment
- Overall energy use efficiency for electrification centric approaches is roughly 4-6 times higher compared to e-Fuels
- Further developments needed in Solid Oxide Electrolysis to enable higher electrolysis efficiencies and co-electrolysis of H_2O and CO_2
- No precise quantification of GHG savings for e-Fuels application, reductions are dependent on energy source, system boundaries of life-cycle assessment studies, choice of modelling CO_2 flows, land-use changes etc.

Key References

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