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A Case for Quad Cooperation in Biofuels

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Takshashila Discussion Document 2024-05
Version 1.0, May 2024

This document provides policy recommendations for the Quad in the biofuels sector, focusing on the aviation sector and R&D investments in third-generation biofuels, and examines larger bioeconomic implications of biofuels-investments in the four countries.

Recommended Citation:
Bharat Sharma, "A Case for Quad Cooperation in Biofuels", Takshashila Discussion Document No. 2024-05, January 2024, The Takshashila Institution.

Executive Summary

1. This policy brief argues that the Quad grouping should have a dedicated focus towards the biofuels sector, as part of its broader efforts concerning ramping up biotechnology cooperation. Advancement in the sector is also beneficial for the Quad countries' bio-economies. More importantly, aligning bioeconomic supply-chains may create certain "bubbles of trust" amongst the four countries.
2. It explores two particular areas of cooperation in this space. First, quadrilateral cooperation in the aviation space can be achieved by creating complementary standards and frameworks, along with bolstering the manufacturing capacity of sustainable aviation fuels in the four countries.
3. Second, greater collaboration between the Quad countries on third-generation biofuels research, especially through utilising Indian research and institutional capabilities, will provide a quadrilateral R&D ecosystem, which — in the long-term — will underpin the commercialisation and deployment of third-generation biofuels.

This document has been formatted to be read conveniently on screens with landscape aspect ratios. Please print only if absolutely necessary.

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Acknowledgments
The author would like to thank his colleagues Manoj Kewalramani and Shambhavi Naik for their valuable feedback and comments.

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I. Introduction

Biotechnology has become a key focus for the Quad, a strategic platform between India, the United States (US), Japan, and Australia. 'Critical and Emerging Technology' was one of the first focus areas announced at the first Quad Leaders' Summit in 2021. It involved a commitment to "monitor" advanced biotechnology,[1] especially synthetic biology, genome sequencing, and biomanufacturing.

This policy brief argues for increased Quad collaboration in the domain of biofuels' development and use. Biofuels have been identified as one of the critical biotechnologies of the 21st century in light of their capability to serve as a sustainable energy source.[2] In essence, biofuels refer to liquid fuels produced through biomass (commonly referred to as "feedstock") to meet transportation and logistics needs. Ethanol, when used in low-level blends — E10, E15 or E85[3]— can offset carbon dioxide emissions.[4] This opens up various applications for which biofuels may be used, particularly in the transportation sector.

Biofuels can be classified based on the extent of the sustainability of the production process. Fuels produced through biomass that is generally edible (sugarcane, for instance) have been termed first-generation fuels. In contrast, those produced from different feedstocks, most prominently non-edible feedstocks (municipal solid wastes, for instance), are termed second-

generation biofuels. Finally, third-generation biofuels are those that utilise algal biomass as a potential source of feedstock. However, understanding of the production process and investments in the third-generation biofuels sector are currently nascent.[5]

The IEA envisions that the role of bioenergy by 2030 — keeping in mind the 2050 Net Zero Scenario — is bound to increase. Between 2020 and 2050, bioenergy use is estimated to grow by 60%, with a shift away from conventional feedstocks like biomass to non-edible feedstock.[6] According to IEA, by 2050, the global share of biofuel in total transport fuel will likely grow from 2% to 27%.

II. Why should the Quad devote attention to biofuels cooperation?

The Quad is an appropriate grouping to steer international collaboration on decarbonisation and advancing biotechnology cooperation, given a broader focus on public goods in the Indo-Pacific region. All four countries aspire to lead the Indo-Pacific in advancing decarbonisation and meeting regional climate change challenges. A set of interconnecting commitments across infrastructure, decarbonisation, biotechnology, and climate change sectors enable the Quad to address cross-sectoral issues relating to biofuel development and deployment.

Moreover, the strategic and diplomatic significance of the Quad allows political convergence, paving the way for greater convergence on policy in these areas. That makes it a sharper group than the Global Biofuel Alliance, which consists of the US, Brazil, and India.

Biofuel advancement is beneficial for the bio-economies of all four Quad countries. The US biofuels market size was $ 32.91 billion in 2023, and is projected to reach $56.04 billion in 2030, at a compound annual growth rate (CAGR) of 7.9% from 2023 to 2030.[7] A US government report highlights that renewable biological ingredients and fossil-free

biomanufacturing methods will reduce fossil-fuel dependency in the long-term.[8]

In India, the biofuels segment contributed $5.97 billion to the bioeconomy in 2021.[9] It was valued at $2.56 billion in 2023, and is expected to reach $10 billion by 2030, growing at a CAGR of 22%.[10] The biodiesel market is expected to reach $865.4 million by 2032, with a CAGR of 8.2% during 2024-2032.[11]

In Japan, the biofuel market is expected to expand, particularly biodiesel. The Japanese government's target to increase the share of renewable energy to 38% by 2030 implies a steady increase in the generation capacity of energy from solid biofuels and renewable waste.[12] The national biofuels market is forecasted to reach around ¥1 trillion by 2030. In Australia, the sustainable aviation fuel industry is estimated to be worth A$10 billion by 2025, and A$19 billion by 2050.[13] Australia's feedstock can supply almost five billion litres of SAF production in Australia by 2025 and up to 14 billion litres by 2050.[14]

The bioeconomic implications of investments in the biofuels sector will have vital strategic benefits for all Quad countries, and may offer the four a form of strategic cooperation consistent with their geopolitical interests. It may envelop their economies inside "bubbles of trust".[15]

The Quad can explore various aspects of biofuels cooperation. This brief recommends cooperation on biofuel usage in the aviation sector, and bolstering research capabilities in third-generation biofuels, as areas of priority. Over the next five years, biofuel demand will experience a 30%

increase from the last five-year period, and a 23% increase by 2028.[16] Half of this growth is attributable to growth in renewable diesel and biojet fuel, both different kinds of biofuels.[17]

The Quad should consider bolstering research capabilities within the third-generation biofuels segment, since future development of the market will make the production of biofuels efficient and cost-effective.[18] The Quad countries could be pioneers of a quadrilateral supply chain focused on utilising algal biofuels.[19] However, given the current capabilities, research and development is needed.

Global Biofuels Collaboration

Initiative/Organisation	Objectives
Global Biofuels Alliance	Alliance of governments and organisations focused on driving deployment and development of biofuels
Clean Energy Ministerial Biofuture Platform Initiative	Fostering consensus on biomass sustainability, availability, and governance
International Energy Agency (IEA)	Facilitate cooperation and information exchange between countries that have national programmes in bioenergy research, development and deployment
Clean Skies for Tomorrow Coalition	Industry-led coalition to accelerate the use of SAF in the international aviation sector
Global Bioenergy Partnership	International initiative to support biomass and biofuels deployment, particularly in developing countries
International Civil Aviation Organisation - Assistance, Capacity-	Aims to support knowledge exchange, development and deployment of SAF supply

building and Training for Sustainable Aviation Fuels (ACT-SAF)	and policy among its 77 participating member states and 35 aviation organisations

Source: IEA, Author's input

III. Biofuels in Aviation

There are attractive alternatives to biofuels in the medium-to-long term for road transport, such as electric vehicles, due to their sizeable market potential relative and scalability to the biofuels industry. The global market size for the biofuels sector is expected to grow from $167.4 billion in 2023 to $225.9 billion by 2028, growing at a CAGR of 6.2%. The EV market, on the other hand, is estimated to reach $951.9 billion by 2030 from $388.1 billion in 2023, growing at a CAGR of 13.7%. That being said, sectors like aviation and shipping are harder to electrify.[20]

The Quad countries are signatories to the International Civil Aviation Organisation's (ICAO) Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), a market-based measure to reduce emissions from international aviation. Countries are mandatorily required to offset C02 emissions from international flights starting in 2027.

The Quad's initiatives in this domain will aid biofuel international collaboration in two ways. First, utilising the Quad grouping to create collaborative incentive structures and lead other countries to fulfil their commitments would provide a fillip to existing international collaborations within the biofuels cooperation landscape. Collaborative incentive structures would synergise standards, which are the primary ways to engage in biofuel

(or feedstock) trade, and involve greater private-sector engagement in the sector.

Second – and connectedly – a key area where the Quad can aid existing efforts in the biofuels sector is focusing on decarbonising the international aviation sector through adopting sustainable aviation fuel (SAF). Japan's biofuel requirements are key to its goal of achieving a sustainable transportation sector. Japan aims to double the demand for bioethanol, including through sustainable aviation and on-road (bio)fuels, by 2030 to reduce dependence on imported petroleum.[21] Therefore, advanced biofuels, especially for utilisation in the aviation sector, have emerged as an attractive solution.

Japan aims to make it compulsory that 10% of aviation fuel for international flights using Japanese airports be composed of SAF by 2030. Boosting domestic production of SAF is Japan's primary focus in expanding biofuel consumption.[22] A draft report released in 2022 called for Japanese SAF suppliers to establish optimum SAF manufacturing capacity and ensure that the raw materials required to produce SAF are available and priced competitively.[23]

In this vein, the Ministry of Economy, Trade and Industry (METI) plans to set a new target volume for SAF by 2030.[24] Separately, Japan's target for ethanol production is 500 million litres of crude oil equivalent for the transportation sector. The Ministry of Land, Infrastructure, Transport, and Tourism (MLTT) estimates that a 10% SAF addition to jet fuel by 2030 will stimulate demand to reach 1.7 billion litres a year. Projections by METI

indicate that Japan will be able to produce 1.9 billion litres by 2030.[25] Japan aims to achieve this by subsidising, granting specific exemptions for imported SAF from the fossil fuel import tariff, and supporting research, development, operation, and certification acquisition.[26]

In India, the National Biofuel Coordination Committee (NBCC) recently set indicative targets for SAF blending with Aviation Turbine Fuel (ATF). By 2027, India aims to mandate a 1% blending of SAF for all international flights.[27]

In the US, current targets dictate the production of 3 billion gallons of SAF by 2030 and then increase production tenfold to 35 billion gallons over the next two decades (by 2050).[28] These estimations are, however, uncertain given that feedstock supply for biofuels may lead to the revision of targets across the four countries.[29] While clear targets do not exist for the Australian case, Australia aims to support efforts to increase SAF adoption in the aviation sector.[30]

Recommendations

In the short term, the focus should be on an initiative clarifying biofuels as one of the priorities within the Quad's larger cooperation efforts in the biotechnology space. The Quad countries can aid each other's efforts to meet targets by creating complementary standards and frameworks, including synergising low-carbon fuel standards in the aviation industry. A focus on biofuels within the Quad's Critical and Emerging Technology Working Group may help create complementary standards, given its purpose in the coordination of technology standards, design, development, and use. This will help align policy incentives and lead to firmer industry linkages. This is also an initiative possible under the broader umbrella of initiatives catered to supporting a clean energy transition in the Indo-Pacific.

The Quad's principles regarding this initiative focus on aiming to expand manufacturing of clean energy technologies alongside increasing demand and enabling commercial-scale production capabilities of key components in the transition. Another facet is interoperability in technical standards, policies and measures.

In the *medium* term, the Quad can focus on providing a fillip to existing efforts to enhance the consumption and supply of SAF in the international aviation sector. First, the Quad should undertake studies to explore how each Quad country can sustainably expand its feedstock supply to meet its SAF targets, particularly harnessing the domestic feedstock capabilities of the United States and India. The four should also work

together to assess how a network of countries (a Quad+ grouping) can be created focusing on deepening collaboration in this domain.

The Quad should also utilise the Quad Investors' Network (QUIN) to bolster biofuel production across each country, especially in India, given its relatively affordable manufacturing costs. The QUIN is a body through which the Quad seeks to foster co-investment in critical and emerging technologies across the Quad countries. The body could be harnessed to attract capital for setting up biofuel industries across the four countries and creating industry consensus regarding biofuel standards across national industries.

For instance, in February 2023, the US-based sustainable fuels technology company, LanzaJet, signed a Memorandum of Understanding (MoU) with Indian Oil Corporation Ltd. to lead the development of Alcohol-to-jet production in India.[31] A sustained focus on the development of the SAF industry will allow enhanced production, which the Quad countries may utilise to trade with each other. This would also help drive down costs, given that SAF is estimated to be 300-500% more expensive than ATF. In the early stages, easier SAF adoption requires subsidisation and policy support, and in the medium-term stage, private-sector engagement can spur innovation and bring down costs.

IV. R&D in Biofuels

In the long term, the Quad should prioritise building research and development (R&D) capacity. Third-generation biofuels and their production process remain understudied,[32] as is the case for second-generation biofuels broadly. Strong industrial and research linkages should underpin the deployment and commercialisation of third-generation biofuels.[33] Encouraging greater public and private investment and collaboration in clean energy research, development, and demonstration and innovation is also a key facet of the Clean Energy Initiative.[34]

India is a leading producer of R&D in the biofuels space, which the Quad should utilise to spur existing efforts towards research and development of third-generation biofuels. The Australian Strategic Policy Institute's Critical Technology Tracker lists India as 2nd in research contribution, calculated across two metrics, 'H-index' (figure 1) and '10% of most highly cited papers' (figure 2).[35]

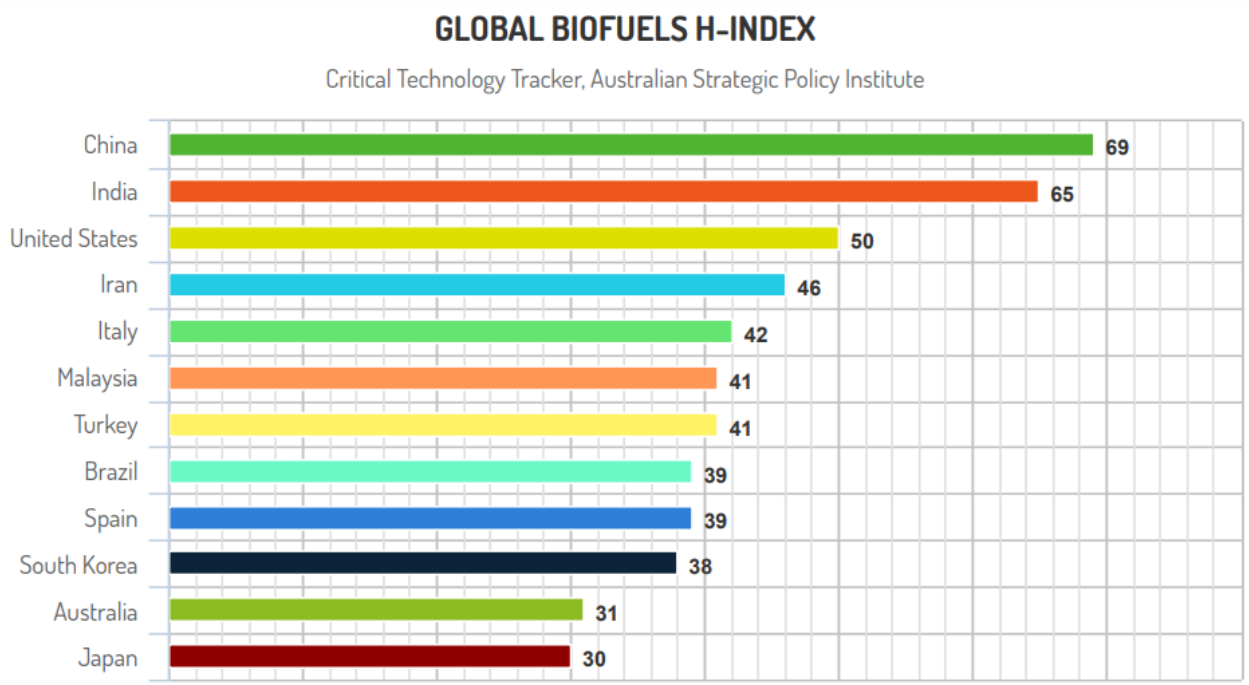

Figure 1: The H-index (Hirsch index) is an established performance metric used for analysing the impact of scholarly output

In the first metric, the Quad countries — India, United States, Australia, and Japan — stand at 2nd (65%), 3rd (50%), 14th (31%) and 17th (30%), respectively. In the second metric — the proportion of publications in the top 10% – India stands at 15.5%, the US at 5.5%, Australia at 1.8%, and Japan at 1.1%. Collectively, the Quad countries represent 21.8% of total biofuels research (China is at 17.7%).[36]

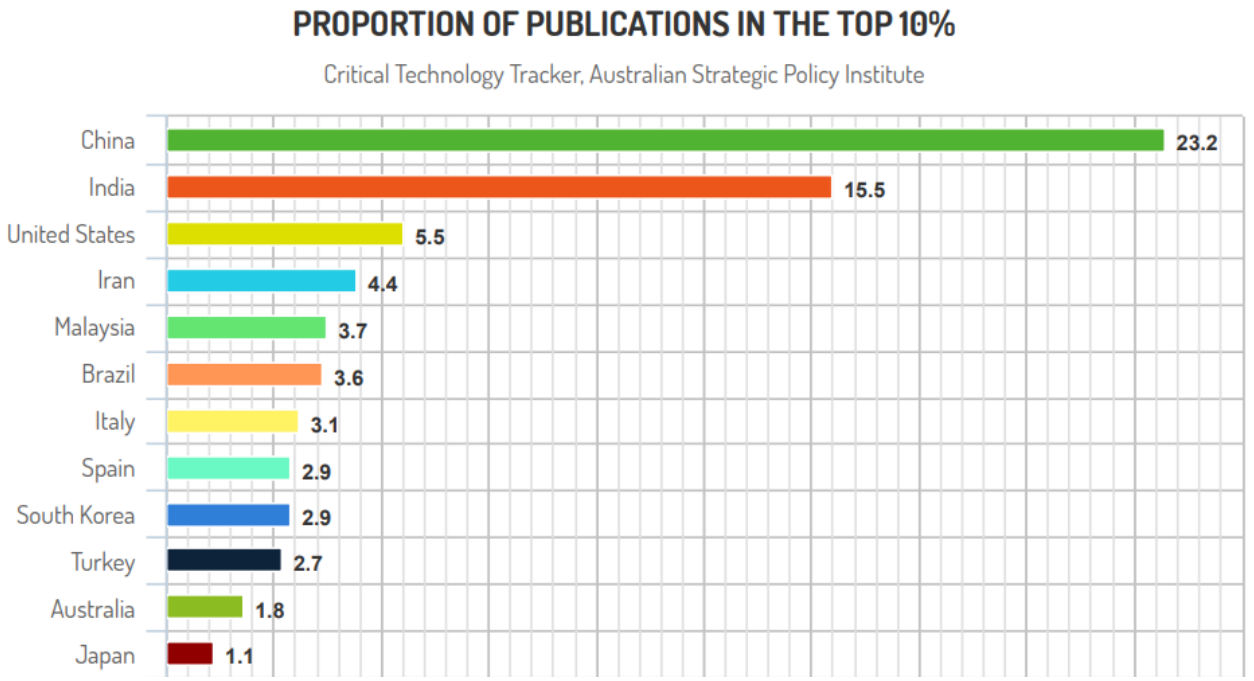

Figure 2: Provides insights into which countries are publishing the greatest share of high-quality, innovative and high-impact research

Recommendations

First, the Quad's STEM Fellowship should identify biofuels as a priority sector under consideration towards graduate study funding. The Quad STEM Fellowship focuses on growing a network of science and technology experts committed to advancing innovation and collaboration in their own nations' private, public and academic sectors and amongst the Quad countries. In particular, the fellowship aims to bring 100 students each year — 25 from each Quad country — to pursue Master's and Doctoral degrees in STEM fields in the United States. Clarifying sub-domains will highlight the network of experts that the Quad ultimately builds.[37]

Second, as researchers van der Kley and Pavlich write in the context of Quad biotechnology collaboration, the Quad countries are uniquely positioned to utilise each other's research capabilities in the biotechnology space.[38] The fellowship also lacks an institutionalised research element. An analogous research component to the education component would help create sectoral research opportunities, and provide an overall fillip to research capabilities, particularly the number of research grants available and researchers working within this space.

The fellowship should assume a particular *research* focus on biofuels, aimed at producing experts by harnessing Indian talent and expertise, especially through exploring arrangements where Indian universities can host researchers from other Quad countries for research collaboration in the biofuels space. This could take the form of an establishment of research and

education training centres at Indian universities like the Indian Institute of Technologies across India and NIT India, which currently lead the flow of talent and research in the world.[39] To begin with, this would require working on a host of existing barriers to lowering research collaboration amongst the Quad countries.[40]

V. Conclusion

This brief has argued that the Quad is a viable grouping that can undertake biofuels collaboration. The Quad's focus on biotechnology and market potential within the biofuels industry incentivises the Quad countries to bolster each of their bio-economies. First, the Quad can do so through quadrilateral cooperation in the aviation space by creating complementary standards and frameworks, along with bolstering the manufacturing capacity of sustainable aviation fuels. Second, greater collaboration between the Quad countries on third-generation biofuels research, especially through utilising Indian research and institutional capabilities, will provide a quadrilateral R&D ecosystem, which — in the long-term — will underpin the commercialisation and deployment of third-generation biofuels.

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