Japan and the Netherlands as partners in *clean energy research*

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Contents

Key takeaways

High academic impact

Research into Net Zero technologies in both Japan and the Netherlands demonstrates significant academic influence. Japan's Net Zero research shows a Field-Weighted Citation Impact (FWCI) of 1.18, notably surpassing its overall national FWCI of 0.94. Similarly, the Netherlands' Net Zero research boasts an FWCI of 1.65, which, while slightly below its overall country average of 1.72, is still an impressive 65% above the global average. A particularly striking finding is the exceptional scholarly quality of collaborative research between the two nations: joint Japan-Netherlands research has an average FWCI of 3.51, indicating a remarkably high impact. However, despite this high-impact collaboration, the overall activity level for joint Net Zero research remains modest, at approximately half the world's average.

Strong contribution from international partnerships

Both Japan (with 45.1%) and the Netherlands (with 66.5%) show significantly higher international co-publication rates for Net Zero research than their overall averages, highlighting a strong commitment to global collaboration. This engagement is also notable for its shift towards a more regional focus. While the US is the number one overall research partner for both countries, it is not a primary partner in the Net Zero space. Instead, China emerges as Japan's top collaborator, while the Netherlands partners most with its close neighbors, Germany and the UK, and sees a notable increase in collaborations with China.

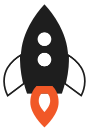
Key academic players

Leading academic institutions from both countries form the core of the bilateral research network, driving high-impact Net Zero collaborations. From the Netherlands, these include Delft University of Technology, Eindhoven University of Technology, and Utrecht University. Key Japanese institutions are the University of Tokyo, Kyoto University, and the National Institute for Environmental Studies. These major players are instrumental in the partnership's innovation and scholarly output.

High-level of academic-corporate partnerships

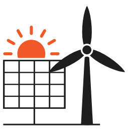
Academic-corporate collaboration in joint Japan-Netherlands Net Zero research reaches 22.7%, significantly higher than the global average (4.2%). Major corporate contributors from Japan include Toyota R&D, Hitachi, Mitsubishi Electric, and Toshiba, while the Netherlands features Shell and TenneT as leading corporate partners. These partnerships are crucial for advancing applied research and technology commercialization.

Key takeaways



Significant innovation impact

Net Zero research in both Japan and the Netherlands demonstrates a significantly higher potential for commercialization and innovation compared to their overall national research, evidenced by a higher percentage of patent citations. Japan's Net Zero research shows a notable 7% rate of patent citations (48% higher than its overall average), while the Netherlands' rate is 5.7% (32% higher than its overall average).



Common ground and complementary strength in key clean energy research areas

Analysis of clean energy areas reveals that Japan and the Netherlands share a common, highly active focus in Nuclear Energy, with both countries' Relative Activity Indexes (RAI) being well above the global average. Beyond this shared ground, they also demonstrate complementary strengths: Japan is significantly more active in Battery Technologies research (with an RAI of 1.08), while the Netherlands shows a much higher activity level in Wind Energy (an RAI of 1.06). Both countries also have similar activity levels in areas like Hydrogen Energy, Tidal Energy and Carbon Capture, clustering around the global average. These distinct yet complementary strengths in nuclear, battery, and wind research represent clear and promising opportunities for future collaboration.

In summary, the Japan-Netherlands partnership in Net Zero energy research is a strategic alliance built on complementary strengths.

The collaboration is marked by high academic excellence and robust innovation outputs, driven by extended multinational networks and strong ties between academia and industry. By leveraging their unique national strengths, this alliance is well-positioned to accelerate the clean energy transition.

Introduction

As one of the most pressing global challenges, climate change demands urgent and coordinated action. Achieving a Net Zero energy system, eliminating or offsetting greenhouse gas emissions is essential to limiting global warming to 1.5°C (Paris Agreement 2015) and safeguarding planetary health.

Since energy production and use account for over 70% of global emissions (Our World in Data), decarbonizing electricity, heat, transport, and industry lie at the heart of effective climate strategies. Beyond emissions reduction, the energy transition supports long-term sustainability by improving air quality, strengthening energy security, and fostering inclusive economic growth through clean technologies.

Nobel contributions from the Netherlands and Japan in technologies relating to Net Zero Research

The Netherlands has two Nobel Laureates with direct impact on Net Zero transition

- **Paul J. Crutzen** (1995, Chemistry)
  Research on atmospheric chemistry, especially ozone depletion — critical for understanding climate systems and environmental protection.
- **Andre Geim & Konstantin Novoselov** (Geim was Dutch at the time he received the Nobel Prize in 2010, Physics)
  Discovery of graphene, a material with potential applications in energy storage, solar cells, and efficient electronics.

Japan has been awarded with four Nobel Prizes with direct impact on Net Zero transition

- **Hideki Shirakawa** (2000, Chemistry)
  Discovery of conductive polymers, foundation for organic solar cells and flexible electronics.
- **Isamu Akasaki, Hiroshi Amano, Shuji Nakamura** (2014, Physics)
  Invention of efficient blue LEDs, enabling low-energy lighting and reducing global electricity consumption.
- **Akira Yoshino** (2019, Chemistry)
  Co-developed lithium-ion batteries, essential for electric vehicles and renewable energy storage.
- **Syukuro Manabe** (Japanese-born, U.S. citizen, 2021, Physics)
  Pioneered climate modeling, vital for Net Zero policy and climate science.

While existing solutions are being deployed at scale, they are not sufficient to meet the full scope and complexity of the Net Zero challenge. Further research and innovation are needed to address technological gaps, decarbonize particularly within sectors with high barriers to realization, enhance energy storage and grid flexibility, and develop equitable, cost-effective pathways that can be adapted across diverse regional contexts.

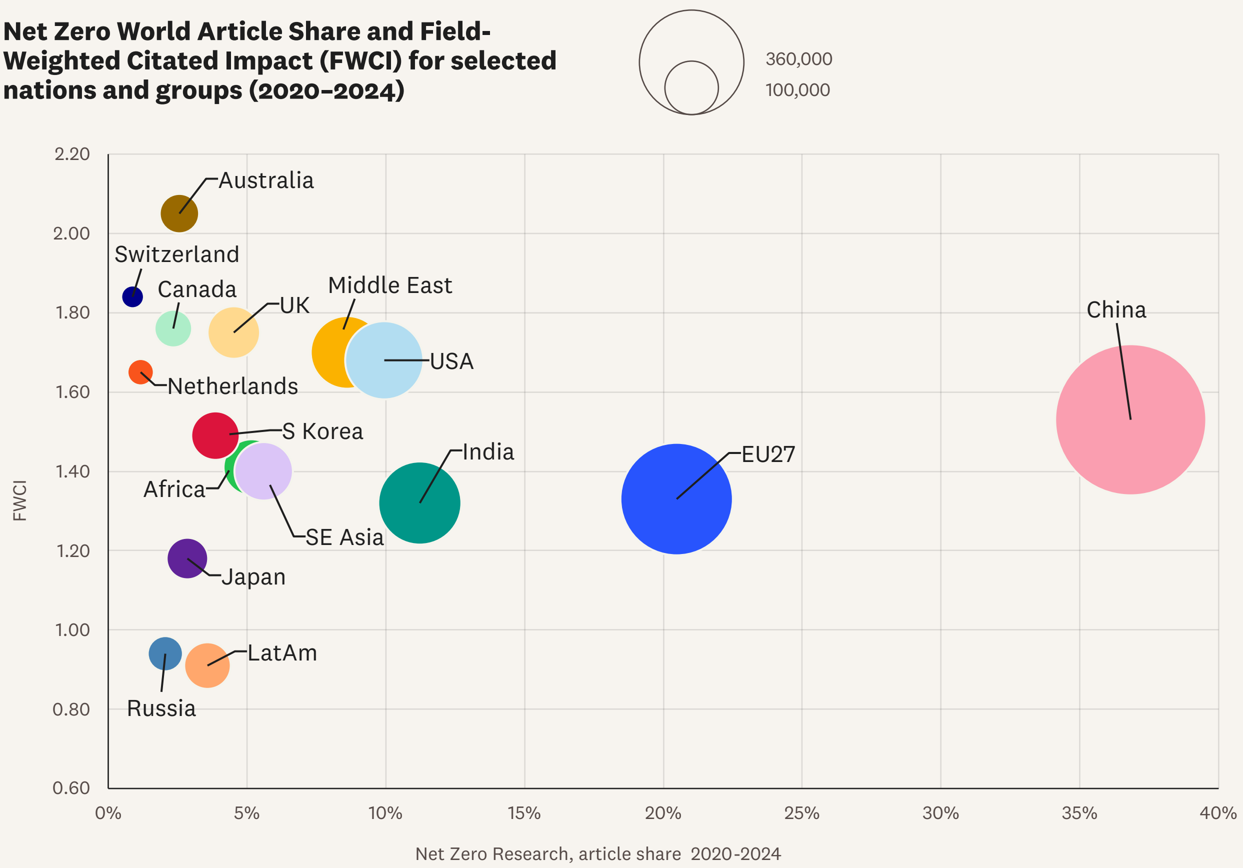
To look at Net Zero research, we use here the Net Zero dataset developed in the Elsevier 2020 report "Pathways to Net Zero: The Impact of Clean Energy Research" which is a combination of publications from SDG 7 and energy related publications from SDG 13, looking at science and innovation trends in clean energy and carbon removal. For the purpose of the report, Clean Energy is defined as an energy source that produces no climate-warming greenhouse gas emissions such as solar, wind, nuclear, hydropower, geothermal and tidal energy.

The global landscape of Net Zero research looks significantly different from the overall research landscape (as we have seen in our first report) or the landscape of medical research (reported in our second analysis) where in both cases we see three strong, leading players of not too dissimilar similar size and impact: China, EU27 and US.

For Net Zero it is fundamentally different, as shown in the figure below. There is clearly one leading player, China, which is almost double the next one in line (EU27), and four times the US, while India has emerged in third place as a larger contributor than the US. For the Middle East it is also worth noticing that, while in recent years it is emerging fast in research output in general, in Net Zero this is even more apparent with an output close to the US (and even higher citation levels than the US). In the area of citation levels, Australia, Switzerland, Canada and the UK are in the lead.

Figure 1

Net Zero World Article Share and Field-Weighted Citated Impact (FWCI) for selected nations and groups (2020–2024)



We can also study the share of research articles per country which are linked to Net Zero research, compared to their total research output, which are then normalized to 1 for the world: the relative activity index or RAI. The RAI for Japan is 0.82, for the Netherlands 0.65, and for Dutch Japanese Net Zero research it is 0.53 – all well below the world's average, indicating that for these two nations and their collaboration the Net Zero activity level is modest. This is also the case for the USA at 0.54, and the UK and France, both at 0.75. Far more active countries are China with an RAI of 1.49 and India at 1.60. Clearly the approach to secure energy security and a sustainable future has been tackled in very different ways by different regions and the reshuffling has only just begun.

As the report will show in more detail, the Netherlands and Japan offer complementary Net Zero research strengths. Both countries are committed to Net Zero by 2050 and are investing in public-private partnerships, international collaboration, and cutting-edge research to accelerate the transition. Early energy-related research and technology collaborations between Japan and the Netherlands were relatively modest but began gaining traction in the 2000s through broader science and technology agreements. These early efforts focused on renewable energy, hydrogen, and smart grid technologies, often embedded within larger bilateral frameworks such as the Japan–EU Science and Technology Cooperation Agreement (effective since 2011) and OECD-led initiatives.

In more recent activity, Japan and the Netherlands are deepening their Net Zero partnership through the 2025 Action Plan for Sustainable Peace and Prosperity, which outlines joint efforts in clean energy, innovation, and climate resilience. A revised Memorandum of Cooperation on Hydrogen, signed in 2019 and updated in 2024, commits both countries to building a global hydrogen and ammonia supply chain through shared infrastructure, technology development, and regulatory alignment, notably with the port of Rotterdam as a hub. The Net Zero collaboration is actively supported by high-level trade missions, such as the 2023 Dutch delegation to Japan, which brought over 30 companies to co-develop offshore wind, hydrogen, and battery solutions, and in September 2025 a large Energy and Circular Economy trade mission in conjunction to the Osaka World Expo 2025.

This report is the third and final of three reports from Elsevier as a proud sponsor of the Dutch pavilion at the 2025 World Expo in Osaka. All analysis is based on data and analytics from Elsevier's comprehensive tools Scopus and SciVal. Typically, the most recent five-year period in Scopus and SciVal (2020–2024) is utilized for analysis for this report, unless otherwise indicated. The first report examined overall scientific collaboration between Japan and the Netherlands, highlighting key contributions in academic and corporate sectors, as well as key technologies where photonics and quantum technology were identified as areas with strong potential for expanded bilateral collaboration. The second report showed that Dutch Japanese collaboration in medical science demonstrates exceptional academic, innovation, and policy impact, driven by strong academic–corporate alliances and opportunities for further collaboration in regenerative medicine and digital health. Japan's strengths in stem cell biology and tissue engineering complement the Netherlands' expertise in clinical and digital technologies, creating a synergistic partnership that advances high-quality, globally influential research.

The full first and second reports can be found here including the information on the databases and search parameters used. This third and final report will also be available from the same website.

Chapter 1

Japan and the Netherlands

A comparative view

Japan overview

Japan's Net Zero energy transition is shaped by its industrial strength, policy ambition, and untapped renewable energy potential.

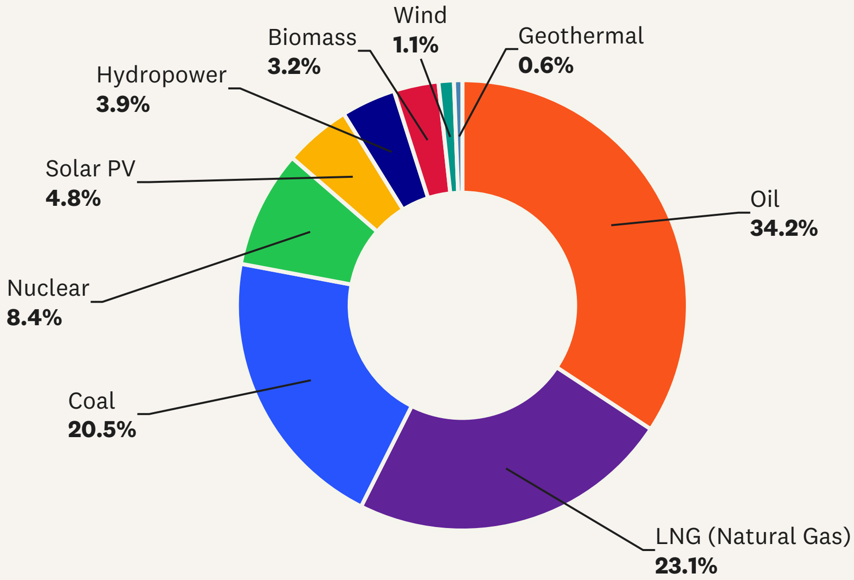
Being the fifth largest energy consumer in the world after China, the United States, India and Russia, its energy system remains deeply reliant on fossil fuels, with over 99.7% of oil, 97.7% of Liquified Natural Gas (LNG), and 99.6% of coal imported.[1 2] This dependence exposes Japan to geopolitical risks and price volatility, making the diversification of the energy portfolio a priority.

In terms of energy supply mix[3]:

- Oil remains the largest contributor at 34.2%, mainly for transport and industrial use.
- LNG and Coal together make up 43.6%, powering much of Japan's electricity.
- Nuclear is slowly recovering, now at 8.4%. (note: from 54 nuclear reactors before the Fukushima disaster 2011, 24 are decommissioned, or under decommission, with only 14 reactors operating in 2025).

Figure 2

Japan's total primary energy supply breakdown (FY2023)



1 Ministry of Foreign Affairs of Japan (2021). Achieving Net Zero GHG Emissions by 2050 in Japan: Policies and Measures Update. https://www.mofa.go.jp/files/100153687.pdf

2 EU-Japan Centre for Industrial Cooperation (2021). Japan's Energy Transition toward Carbon Neutrality by 2050. https://www.eu-japan.eu/sites/default/files/publications/docs/Japanese-Energy-Transition-toward-Carbon-Neutrality-by-2050.pdf

3 Japan Energy Profile 2024 – ideas, energy, Government confirmation: Energy White Paper 2024 – JAIF. Additional policy context: METI Cabinet Decision on Strategic Energy Plan (2025) https://www.enecho.meti.go.jp/en/category/whitepaper/pdf/2024_outline.pdf

Japan committed to carbon neutrality by 2050 with a 46% emissions reduction target by 2030 (measured against a 2013 baseline, 35% if measured against a 1990 baseline), supported by its Green Transformation (GX) strategy. At COP28, Japan pledged to triple renewable energy and double energy efficiency by 2030.[4] Its hydrogen strategy, updated in 2023, focuses on international supply chains, cost reduction, and deployment across sectors.[5] [6] The offshore wind target is to reach 10 GW by 2030 and up to 45 GW by 2040, while nuclear is expected to supply 20–22% of electricity, requiring a significant reactor restart.[7] Though Japan has vast geothermal potential, development remains limited due to regulatory and cultural barriers, with reforms aiming to triple capacity by 2030.[8]

To meet its Net Zero goals, Japan must accelerate renewable research and deployment, reduce fossil fuel reliance, and leverage its industrial and research capabilities. Let us therefore look deeper into Japan's research strengths in Net Zero focusing on the recent five-year time-period of 2020 to 2024.

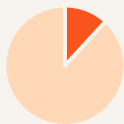
As can be seen from the output in top 10 % citation percentiles (11.8%, 8% for all areas of science), top 10% journal percentiles (36.4% compared to 23.5% for all areas of science) and Field-Weighted Citation Impact — FWCI, 1.18 for Net Zero compared to 0.94 for Japan overall, the academic impact of Japanese research in Net Zero is substantial. Furthermore, 9.2% of publications are academic-corporate co-publications, compared to 7.2% for all Japanese research and a global average of 3%.

Overview of Net Zero research published in Japan (2020–2024)

Scholarly Output
28,410

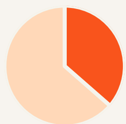
Field-Weighted Citation Impact
1.18

Outputs in top citation percentiles
Publications in top 10% most cited worldwide



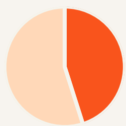
11.8%

Publications in top journal percentiles
Publications in top 10% journals by CiteScore



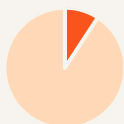
36.4%

International collaboration
Publications co-authored with institutions in other countries/regions



45.1%

Academic-Corporate collaboration
Publications with both academic and corporate affiliations

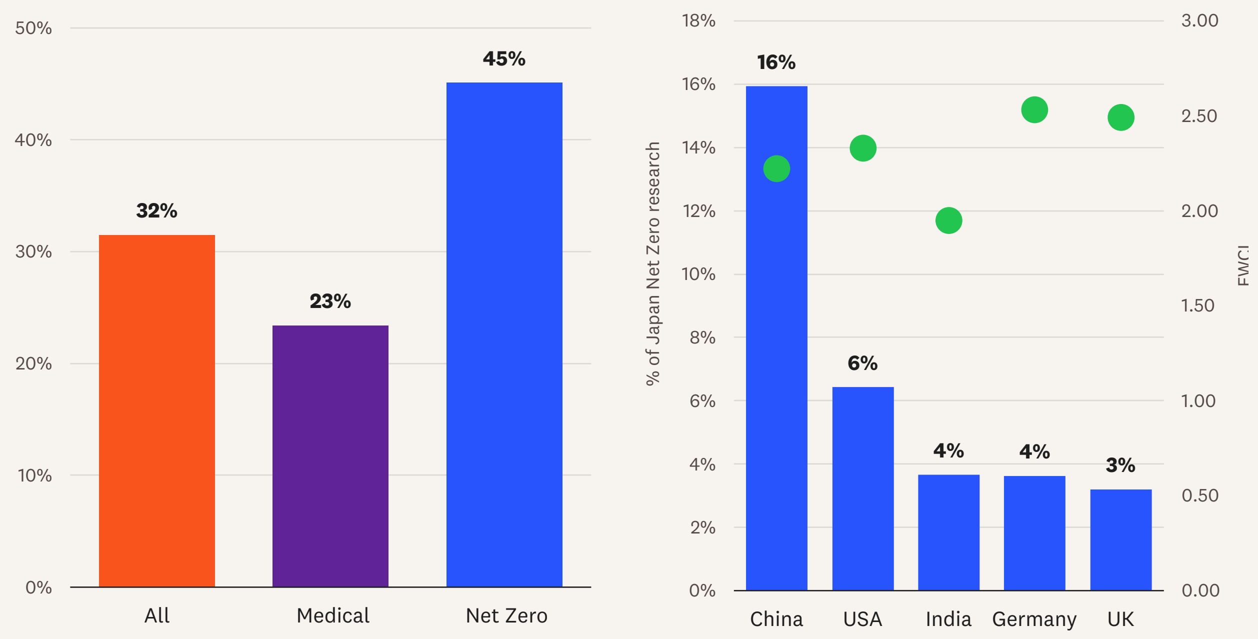


9.2%

4 Institute for Global Environmental Strategies (IGES, 2025). Energy Security and Energy Transition in Japan. https://www.iges.or.jp/sites/default/files/2025-03/S3-1_20250318%20Takizawa%20Climate%20Security_EF.pdf
5 Oxford Institute for Energy Studies (2025). Japan's Energy Transition: The Interplay of Renewables, Gas and Energy Security. https://www.oxfordenergy.org/wpcms/wp-content/uploads/2025/02/Insight-163-Japans-Energy-Transition.pdf
6 National Bureau of Asian Research (NBR). Japan's Transition Toward a Renewable Energy Future. https://www.nbr.org/publication/japans-transition-toward-a-renewable-energy-future/
7 The British Academy (2023). Just Transitions in Japan. https://www.thebritishacademy.ac.uk/publications/just-transitions-in-japan/
8 EIS Network (2023). Geothermal Energy: A Key to Sustainable Development. https://insight.eisnetwork.co/en/20230817-geothermal/.

Figure 3

Japan Net Zero international collaborations levels and top 5 partners (2020–2024)



In Net Zero-related research, as shown above, Japan demonstrates a significantly higher level of international collaboration (45.1%) compared to its overall average across all research fields (31.5%). This contrasts with medical research (23.4%), which shows less international collaboration than the national average. A notable difference in Japan's Net Zero research partnerships is that China is its primary international collaborator, accounting for 16% of co-authored papers. This is a significant deviation from Japan's overall research partnerships, where the USA is typically the main partner. In Net Zero research, the USA ranks much lower at 6%. India also emerges as a strong partner, holding the third position, while the Netherlands is a modest partner for Japan on Net Zero, coming in around a twentieth position. Our analysis revealed that Japan's Net Zero research partnerships show a stronger prevalence of collaborators within the Asia-Pacific (APAC) area, which differs from its overall research collaboration patterns.

To understand further around recent research trends in Japan, we applied our earlier methodology, explained in detail in our second report around Medicine and Health Research to examine topic clusters of current research interest and then apply artificial intelligence to extract key trends.

Key areas of expanded focus include:

1. **Next-generation energy conversion and storage**

   In this research cluster there are three distinct focus areas: solar cells, lithium batteries and electrocatalysis.

   - The leading focus areas is on Perovskite and Dye-Sensitized Solar Cells: Japanese researchers are heavily invested in overcoming challenges related to stability and durability of flexible perovskite solar cells, especially under harsh environmental conditions (such as heat and humidity). The goal is to move these highly efficient, low-cost solar technologies from lab to large-scale fabrication for diverse applications like building integration and mobile platforms.
   - High-Performance Lithium Batteries is a top priority as reflected as by the 2019 Nobel prize. Research is focused on developing safer, higher energy density, and longer-lasting batteries. The emphasis on recycling lithium-ion batteries also reflects a move towards a circular economy in this critical sector.
   - Electrocatalysis for Energy Conversion: This signifies a strong drive for efficient chemical reactions in energy systems. Japanese researchers are exploring novel electrocatalysts for applications like hydrogen production, CO2 reduction, and fuel cell reactions.

2. **Advanced materials for energy applications**

   Beyond just batteries and solar cells, there is a broad materials science effort. This includes e.g. Titanium Dioxide structures, Tungsten applications, and other materials, that are being investigated for various energy conversion, storage, and environmental applications.

3. **Future Energy systems and infrastructure:**

   - More long-term there is a focus on Fusion Energy that will require crucial research into Plasma Control. This points to Japan's significant long-term investment in fusion energy research, particularly with the JT-60SA tokamak and contributions to ITER and DEMO reactors.
   - Also more future focused are the Hydrogen Economy Components: Beyond production and storage, there's research on catalytic innovations for hydrogen and ammonia production, indicating a comprehensive approach to a hydrogen-based energy infrastructure.

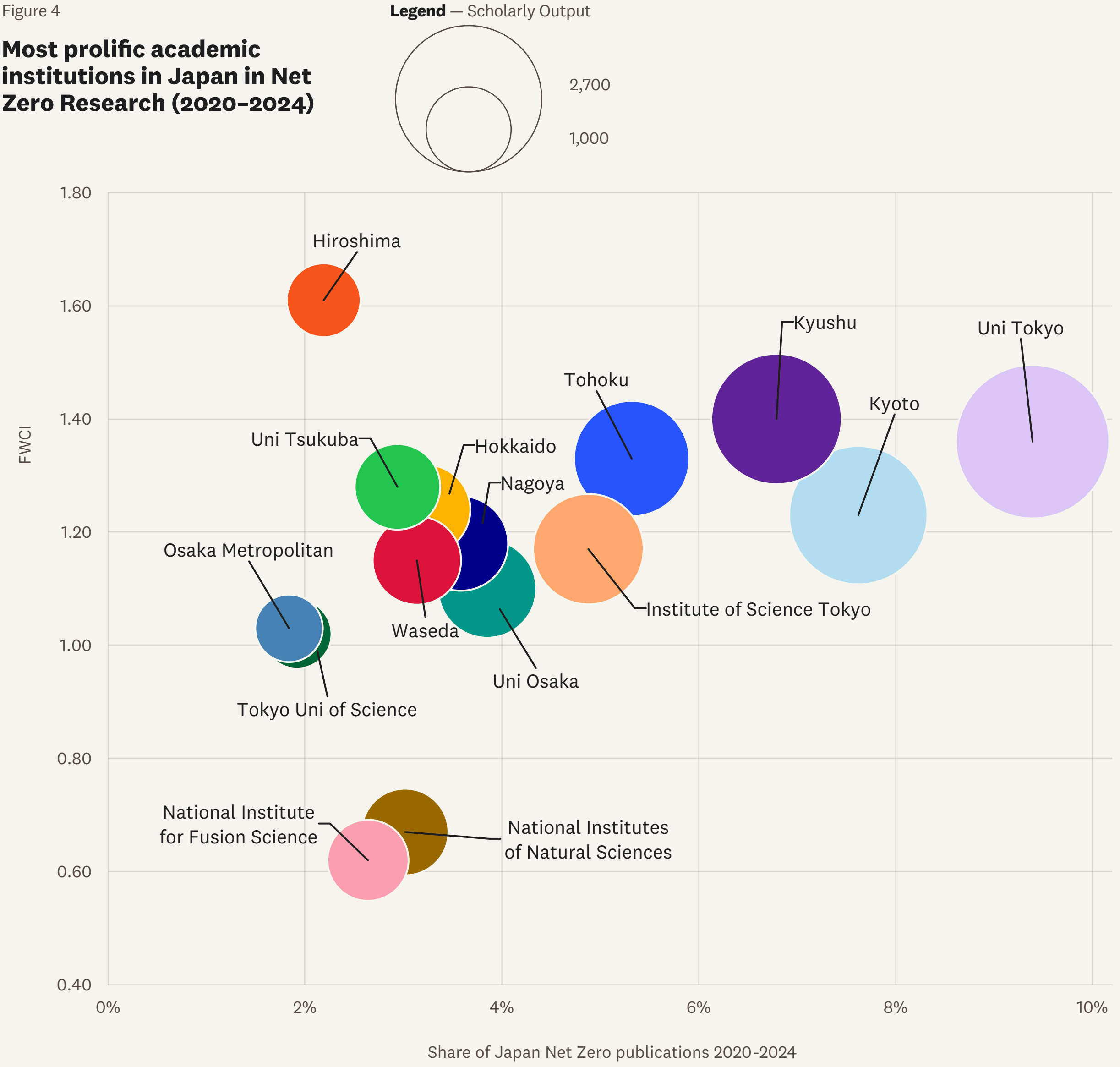
4. **Decarbonization beyond energy production**

   Research on Climate Policy and Carbon Emission Dynamics shows interest in the socio-economic and policy aspects of achieving Net Zero. It is further related to another focus area: Sustainable Resource Management and Circular Economy as well as Urban and Building Decarbonization. The latter highlight efforts to reduce energy consumption in the building environment, a crucial part of Japan's Net Zero strategy.

Looking at the performance of the academic institutions, we see not surprisingly the University of Tokyo followed by Kyoto University, Kyushu University, Tohoku University and the newly formed Institute of Science Tokyo, formed by the merger of Tokyo Institute of Technology and Tokyo Medical and Dental University. Also noted is the citation impact of Hiroshima University, which has strong research on solar cells, fusion research, and a very active network NERPS, on Education and Research on Peace and Sustainability. To be noted is that in this graph, the Advanced Institute of Industrial Science and Technology – AIST, as a government research institute, is not included. AIST is the fifth largest in Net Zero publications in Japan, with strong activity in photovoltaic and battery technology research.

Figure 4

Most prolific academic institutions in Japan in Net Zero Research (2020–2024)



Looking next at the research contributions of corporate institutions, we find not surprisingly the strong role of Toyota R&D and Toyota Motors, but also the strong contribution of large corporate conglomerates such as Hitachi, Mitsubishi and Toshiba, basically doing research across several Net Zero technologies. All three, Hitachi, Mitsubishi Electric, and Toshiba aim for Net Zero by 2050, or earlier, through deep emissions cuts and pioneering energy technologies.

Figure 5

Ten most prolific corporates co-authoring with JP Net Zero Research (2020–2024)

Institutions in Japan	Scholarly Output	Field-Weighted Citation Impact
Toyota Central R&D Labs., Inc.	241	0.97
Toyota Motor	208	1.41
Hitachi, Ltd.	183	0.64
Mitsubishi Electric Corporation	174	0.71
Toshiba Corporation	174	0.76
Nissan Motor Co., Ltd.	110	1.25
Fuji Electric Co., Ltd.	107	0.79
Nippon Telegraph & Telephone	92	1.31
Panasonic Holdings Corporation	86	1.07
Tokyo Electric Power Company Holdings, Incorporated	85	0.59

In conclusion, Japan’s Net Zero research portfolio from 2020–2024 is comprised of cutting-edge material science and engineering for a future powered by advanced solar, battery, and potential fusion energy, all underpinned by smart grid integration and emphasis on reducing emissions across various sectors.

The Netherlands overview

The Netherlands' energy mix is undergoing a rapid transition toward renewables (today at 14% of all energy use), with significant growth in offshore wind, solar, and biomass, while fossil fuels — particularly natural gas (36%), oil (42%) and coal (6%) — still account for a large share of primary energy use.

Electricity generation is increasingly decarbonized, though gas-fired power remains prominent, and emission intensity is projected to decline as renewable capacity expands. Nuclear energy plays a minor role, and geothermal and hydrogen are emerging but not yet mainstream. The country remains heavily reliant on energy imports, especially for oil and gas, but policy efforts are focused on reducing this dependency through domestic clean energy production and circular economy strategies.

In terms of policies, the Netherlands' Net Zero transition is guided by a comprehensive policy framework that includes the Dutch Climate Law, which legally commits the country to climate neutrality by 2050 and sets interim targets of a 55–60% reduction in greenhouse gas emissions by 2030 (measured against a 1990 baseline), alongside a CO_2- free electricity sector by 2035.[9] The National Climate Agreement outlines sectoral decarbonization strategies across electricity, industry, buildings, mobility, and agriculture, with updates in 2024 aligning with EU Fit for 55 and REPowerEU goals.[10] The Net-Zero Government Initiative targets climate-neutral public operations by 2030, including zero-emission fleets and sustainable procurement.

Complementing this is the Circular Economy Strategy, which aims for a fully circular economy by 2050 and a 50% reduction in primary resource use by 2030.[11] The broader energy transition emphasizes offshore wind, solar, nuclear and carbon capture, with growing support for green hydrogen and geothermal technologies. In a recent progress report[12] on international climate policy the Dutch government stressed feasibility, affordability and societal support, as well as innovation and international collaboration, especially in the areas of hydrogen and carbon capture. A separate government report[13] on nuclear energy reaffirmed commitment to nuclear energy as necessary in the clean energy mix together with wind and solar energy.

9 European Parliament (2024). Briefing: The Netherlands' climate action strategy https://www.europarl.europa.eu/RegData/etudes/BRIE/2024/767176/EPRS_BRI(2024)767176_EN.pdf.

10 RVO (2020). National Climate Agreement: The Netherlands. https://english.rvo.nl/sites/default/files/2020/07/National%20Climate%20Agreement%20The%20Netherlands%20-%20English.pdf.

11 Government of the Netherlands (n.d.). Circular Dutch Economy by 2050. https://www.government.nl/topics/circular-economy/circular-dutch-economy-by-2050#:~:text=The%20government-wide%20programme%20for%20a%20Circular%20Dutch%20Economy,into%20a%20sustainable%2C%20fully%20circular%20economy%20by%202050.

12 Rijksoverheid (2025). Kamerbrief inzake voortgang internationale klimaatstrategie. https://www.rijksoverheid.nl/documenten/kamerstukken/2025/05/09/kamerbrief-inzake-voortgang-internationale-klimaatstrategie.

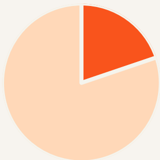
13 Tweede Kamer der Staten-Generaal (2025). Brief van de Minister voor Buitenlandse Handel en Ontwikkelingssamenwerking https://www.tweedekamer.nl/kamerstukken/brieven_regering/detail?id=2025Z09636&did=2025D22012.

Overview of Net Zero research published in the Netherlands (2020–2024)

Scholarly Output
11,634

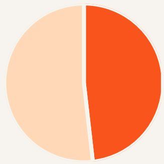
Field-Weighted Citation Impact
1.65

Outputs in top citation percentiles
Publications in top 10% most cited worldwide



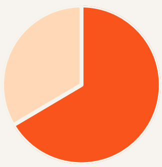
19.8%

Publications in top journal percentiles
Publications in top 10% journals by CiteScore



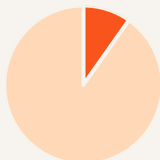
48.2%

International collaboration
Publications co-authored with institutions in other countries/regions



66.5%

Academic-Corporate collaboration
Publications with both academic and corporate affiliations

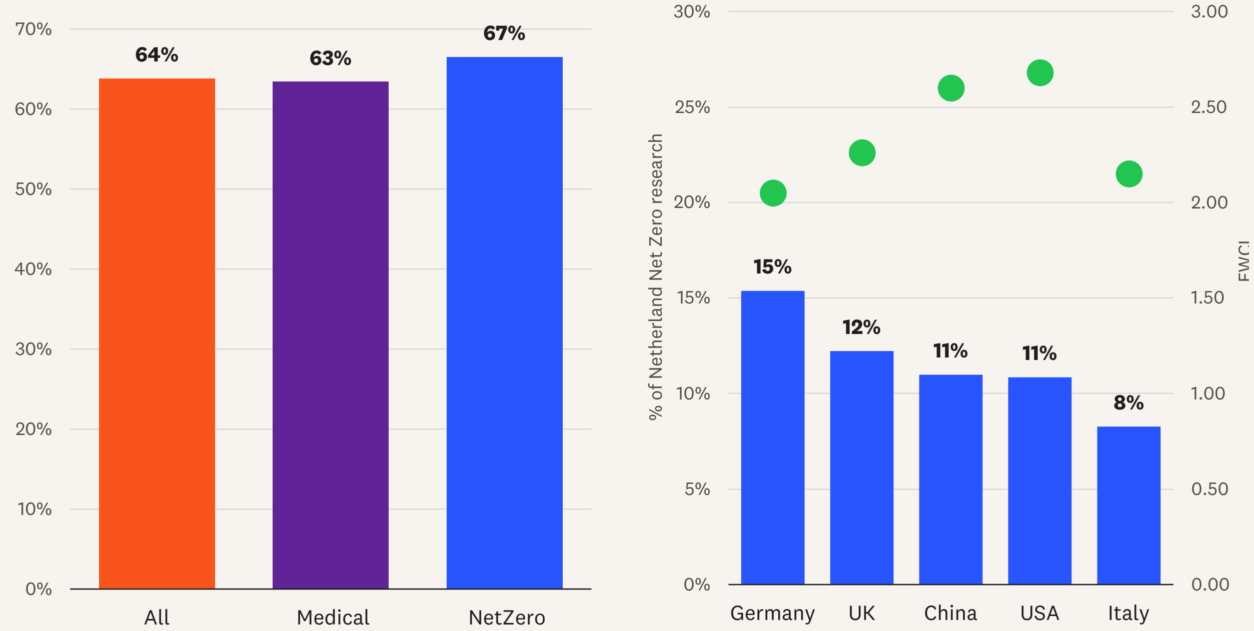


9.8%

Let us now take a closer look at the Netherlands within the context of research on Net Zero. The Dutch publications linked to Net Zero have a citation impact as measured by the FWCI of 1.65, just below 1.72 for all Dutch research, but 65% above the world average. The share in the 10% most cited articles and in the 10% most cited journals is higher for Net Zero compared to all Dutch science: 19.8% vs. 17.9% and 48.2% vs. 40.6%. Finally, Net Zero research has an even higher contribution from academic-corporate collaboration compared to all Dutch research: 9.8% vs. 7.1% (the global average is 3%). In conclusion Dutch Net Zero research is impactful on science globally and has a strong contribution from university-industry partnerships.

Figure 6

Netherlands Net Zero international collaborations levels and top 5 partners (2020-2024)



The Netherlands has consistently shown a high level of international research collaboration, a trend we highlighted in our previous two reports. This collaborative spirit is even more pronounced in Net Zero research, with 66.5% of papers being international, compared to the overall average of 63.8% for all research fields. However, the specific partners in Net Zero research differ significantly from the Netherlands' general collaborations. While the US is typically the top partner for overall research, it falls to fourth place for Net Zero.

Instead, the Netherlands' top two collaborators in this field are its close neighbours: Germany and the UK. China also plays a more prominent role, ranking third in Net Zero collaborations, a notable jump from its eighth-place position in overall co-authorship. Beyond these top partners, the most frequent country collaborations for the Netherlands in Net Zero research are predominantly with other European nations, highlighting a clear preference for regional networking. Japan is only a modest collaborator for the Netherlands in Net Zero research, coming in around a 16th position.

We studied the research themes in the Dutch Net Zero dataset that are most prominent, through an AI-supported review of the Topics collection. Unlike Japan's predominant focus on specific materials science for solar and battery innovations, the Dutch research portfolio shows a broader, more integrated approach, with significant investment in system-level solutions and resource efficiency.

Six clusters of research areas

1. **Offshore Wind, Tidal, and Marine Energy Leadership**

   This is by far the leading topic, underscoring the Netherlands' strategic focus on its vast North Sea potential. Research here includes advanced wind turbine design and aerodynamics; it focuses on efficiency, large-scale offshore wind farms, and reducing environmental impact.

2. **System-Level Energy Integration and Smart Grids**

   This significant cluster highlights the Netherlands' commitment to electromobility and its seamless integration into a flexible energy system. There is also a focus on grid stability, demand-side management, and energy forecasting. This is linked to an integrated approach to energy systems that takes market dynamics into consideration. Finally foundational research is included that is needed to modernize the grid, enabling efficient power conversion and distribution, crucial for integrating distributed renewables and EVs.

3. **Hydrogen Economy and Decarbonized Fuels**

   This indicates research across the entire hydrogen (and ammonia) value chain, from production to safe and efficient storage and end-use applications.

4. **Circular Economy and Bio-based Solutions**

   Circular economy and life cycle assessment integration is a hallmark of Dutch research, demonstrating a strong commitment to resource efficiency, waste reduction, and sustainable product design across industries. Significant investment also in bio-based energy and materials research, seeking to valorise organic waste streams and agricultural residues for fuels, chemicals, and energy, reducing reliance on fossil resources.

5. **Climate Policy, Societal Engagement, and Adaptation**

   There is a strong interdisciplinary focus on the governance, economic, and societal aspects of climate change. This includes analysing policy effectiveness, modelling emission pathways, and understanding the behavioural and economic implications of the energy transition.

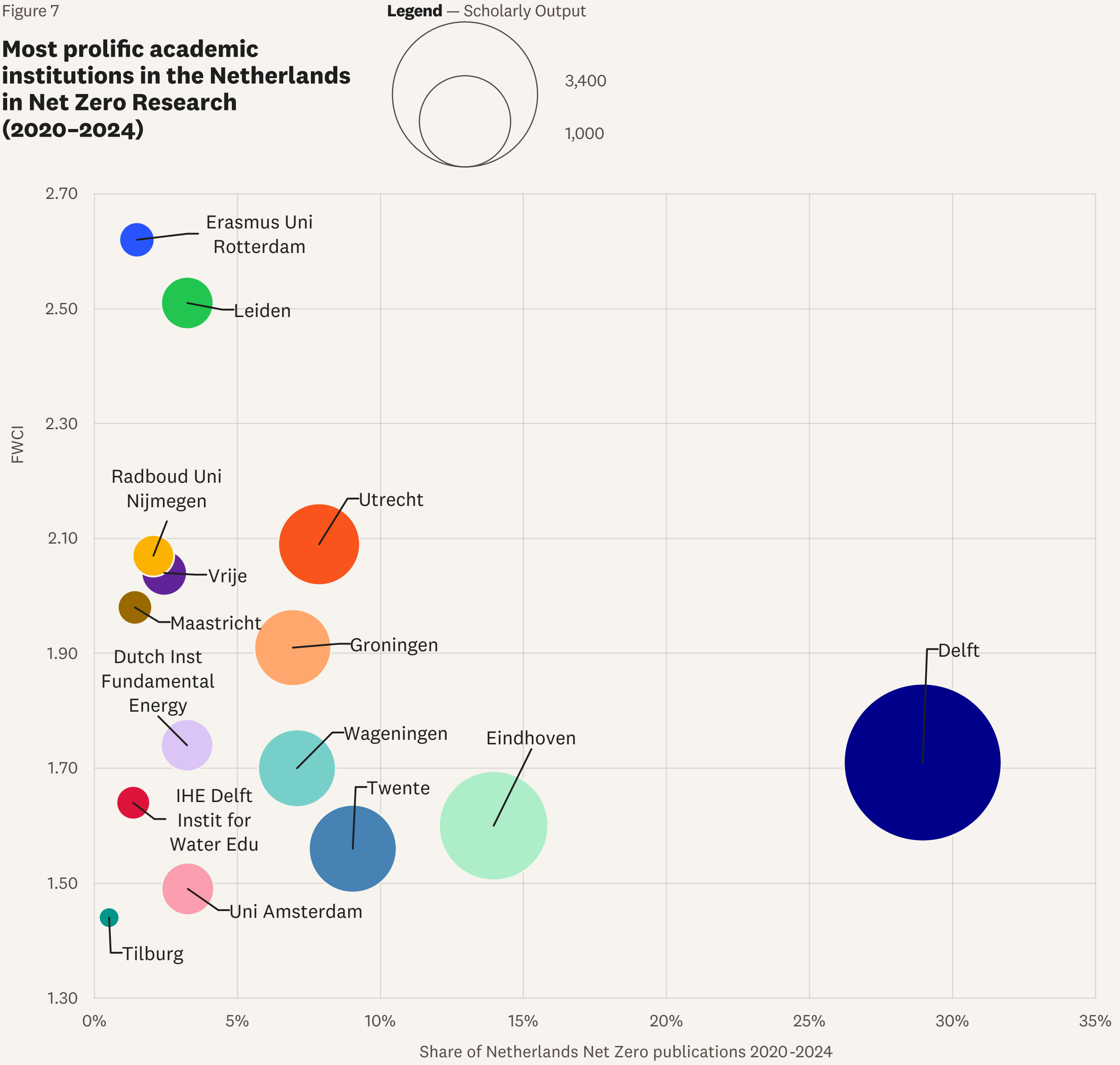
6. **Solar Energy**

   The Dutch solar research appears to be more broadly distributed across different solar technologies and their integration, reflecting a focus on diverse applications and system optimization rather than solely material breakthroughs

In conclusion, the Netherlands' Net Zero research portfolio leverages the nation's expertise in offshore engineering and water management to accelerate wind and marine energy. Concurrently, there is a substantial investment in system-level integration, smart grid technologies, and the burgeoning hydrogen economy. Crucially, the Dutch research also demonstrates a strong commitment to circular economy principles, bio-based solutions, and understanding the socio-economic and policy dimensions necessary to ensure a just and effective energy transition. This balanced portfolio aims not just for technological advancements but for their successful deployment and societal adoption.

Figure 7

Most prolific academic institutions in the Netherlands in Net Zero Research (2020–2024)



Who are the key players in Net Zero research in the Netherlands? As shown in Figure 7 the technical universities are the most prolific with Delft in the lead contributing almost 30%, followed by Eindhoven and Twente.

We saw that 9.8% of the Dutch Net Zero research comes from corporate-academic collaborations — which are the largest corporate contributors? As we can see Shell is in the lead as the most prolific contributor. The Norwegian headquartered SINTEF, an independent research organization focused on contract research, is in second place with a high citation impact (FWCI is 2.43). TenneT, the predominantly Dutch electricity grid operator, comes in at third place. Not surprisingly as the level of international collaboration is very high for the Netherlands we also see several non-Dutch companies listed here.

Figure 8

Ten most prolific corporates co-authoring with the Netherlands in Net Zero research (2020–2024)

Corporates	Country	Scholarly Output	FWCI
Royal Dutch Shell PLC	The Netherlands	167	1.95
SINTEF	Norway	69	2.43
Tennet TSB B.V.	The Netherlands	65	0.58
Stellantis	The Netherlands	55	6.13
BTG Biomass Technology Group BV	The Netherlands	44	0.67
NXP Semiconductors	The Netherlands	33	1.47
Qualcomm Inc	United States	33	1.47
DNV GL Group	Norway	30	2.12
General Atomics	United States	30	2.77
DSM Food Specialties	The Netherlands	28	1.28

Chapter 2

Japanese-Dutch collaboration

Exploring common ground

After establishing an understanding of the individual contributions from Japan and the Netherlands in this chapter we explore the joint contributions along with the global landscape of clean energy research.

What kind of Net Zero research is most prominent between Japan and the Netherlands?

Through an AI assisted assessment of topic clusters, specifically focusing on co-authored research between Japan and the Netherlands, we were able to highlight the advantage the two nations have as collaborators by utilizing their unique research strengths. Three main areas of common ground can be identified through the topic clusters of the co-authored papers.

1. Fusion Energy Research

Co-authored papers see a strong presence of fusion energy research, which includes topics of Turbulence and Transport in Tokamak Plasmas, Tungsten Materials in Fusion Reactor Applications and Machine Learning Applications in Tokamak Disruption Prediction. Although fusion energy research is not a top theme in Net Zero research for the Netherlands, their expertise in plasma physics – crucial for fusion development – results in a strategic partnership with Japan's deep and long-standing investment in the field.

2. Hydrogen and Advanced Energy Storage

Both nations' individual Net Zero strategies feature hydrogen as a future energy carrier and the need for efficient storage solutions. Co-authored research particularly highlights topics such as like Borohydride Systems for Enhanced Hydrogen Storage and Hydrogen Storage Innovations in Magnesium Alloys. Japan's expertise in materials science for hydrogen storage, combined with the Netherlands' focus on developing hydrogen infrastructure and diverse storage technologies, creates a powerful collaborative synergy.

3. Global Climate Strategies and Policies

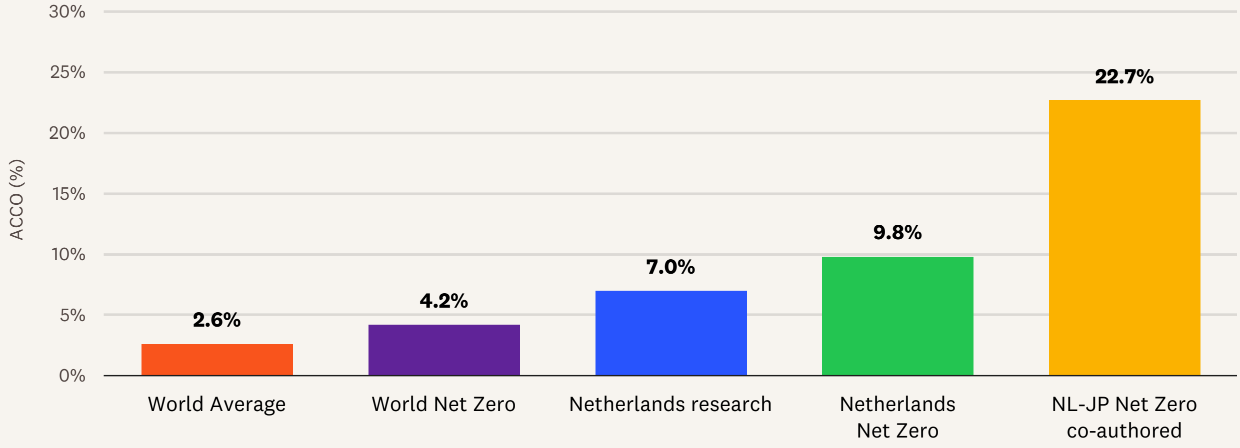
Global carbon management is another place for common ground, highlighting a shared commitment to influence broader policy and strategic dimensions of climate action. Given the Netherlands' strong emphasis on topics of Climate Policy and Carbon Emission Dynamics and Japan's interest in setting global standards and long-term emission reduction pathways, this collaboration leverages Dutch expertise in policy and societal aspects with Japanese leadership in advanced technological implementation and international frameworks.

The role of Academic-Corporate partnerships in Net Zero research

Amongst such key topics, the role of corporate institutions for co-authored papers is significant, as seen in the figure below. The graph shows the proportion of research including academic-corporate collaboration on global averages, for the Netherlands and Japanese Dutch co-authored papers. Net Zero research already globally sees a higher level of academic-corporate collaboration; however, Japanese Dutch co-authored papers are unparalleled, seeing 22.7% of papers with such collaboration. Compared to the 4.2% of academic-corporate collaboration seen globally for Net Zero research and 9.8% for Dutch research, the strength of the Japan-Netherlands partnership is also apparent in the corporate institutions which are willing and able to contribute to the field.

Figure 9

Level of Academic-Corporate collaboration in the Netherlands and in Net Zero Research (2020–2024)



Japanese Dutch co-authored papers include contributions from other nations as well, with the most frequent partners including Germany, the USA, the UK, Italy, France, Spain, China, Austria, South Korea and Australia.

The strength of Japanese Dutch collaboration, as well as their global partners allows for the collaboration of top international institutions in Net Zero research. Figure 10 shows the top academic and government institutions involved in Japanese Dutch co-authored research. From the Netherlands, Delft University of Technology, Eindhoven University of Technology and Utrecht University are in the lead. Japan follows with Kyoto University, The University of Tokyo and the National Institute for Environmental Studies of Japan. Internationally, the United States Department of Energy, CNRS and the Commissariat à l'énergie atomique et aux énergies alternatives (French Alternative Energies and Atomic Energy Commission — CEA) are the top three contributors. This contribution from a wide range of institutes, with their output seeing an average FWCI of 3.51 demonstrates the impact of not just bilateral collaborations between Japan and the Netherlands, but across the international research landscape as well.

Figure 10

Institutions in Japan co-authoring with the Netherlands in Net Zero Research (2020–2024)

Institution	Sector	Scholarly Output	FWCI
Kyoto University	Academic	52	2.63
The University of Tokyo	Academic	37	2.06
National Institute for Environmental Studies of Japan	Government	35	2.77
National Institutes of Natural Sciences	Academic	34	2.75
National Institutes of Natural Sciences — National Institute for Fusion Science	Academic	32	2.89
National Institutes for Quantum and Radiological Science and Technology	Government	25	2.19
National Institute of Advanced Industrial Science and Technology	Government	19	1.62
Kyushu University	Academic	15	5.2
The University of Osaka	Academic	14	1.45
University of Tsukuba	Academic	14	1.19
Tohoku University	Academic	13	7.55
Hokkaido University	Academic	11	3.28
Nagoya University	Academic	11	1.23
Hiroshima University	Academic	10	14.5

Institutions in the Netherlands co-authoring with Japan in Net Zero Research (2020–2024)

Institution	Sector	Scholarly Output	FWCI
Delft University of Technology	Academic	59	2.06
Eindhoven University of Technology	Academic	47	2.33
Utrecht University	Academic	42	3.71
Dutch Institute for Fundamental Energy Research	Academic	36	2.61
University of Groningen	Academic	22	5.85
PBL Netherlands Environmental Assessment Agency	Government	20	3.44
University of Twente	Academic	16	3.56
Wageningen University & Research	Academic	14	3.98
Radboud University Nijmegen	Academic	11	3.11

Figure 11

Institutions of other countries partnering in Japan-Netherlands co-authorship in Net Zero Research (2020–2024)

Institution	Sector	Country	Scholarly Output	FWCI
United States Department of Energy	Government	USA	48	4.50
CNRS	Government	France	46	5.09
Commissariat à l'énergie atomique et aux énergies alternatives	Government	France	26	4.53
European Commission	Academic	Belgium	26	4.06
Technical University of Denmark	Academic	Denmark	26	6.04
Max Planck Institute for Plasma Physics	Government	Germany	25	3.21
Jülich Research Centre	Government	Germany	24	3.79
Karlsruhe Institute of Technology	Academic	Germany	23	4.02
National Research Council of Italy	Government	Italy	21	4.73
European Commission Joint Research Centre Institute	Government	Belgium	20	3.47
International Institute for Applied Systems Analysis, Laxenburg	Academic	Austria	20	3.41
Université Paris-Saclay	Academic	France	20	3.87
University of Lisbon	Academic	Portugal	20	3.50
Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile	Government	Italy	19	4.04
CIEMAT	Government	Spain	19	4.18
Potsdam Institute for Climate Impact Research	Government	Germany	19	2.50
Aix-Marseille Université	Academic	France	18	3.84
Chinese Academy of Sciences	Government	China	18	4.85
Massachusetts Institute of Technology	Academic	USA	18	4.02
Oak Ridge National Laboratory	Government	USA	18	4.00

In addition to academic and government institutions, global Net Zero research is spearheaded by global corporations, with China being very well represented in the Top 10 (also with an exceptionally high number of research papers), e.g. the State Grid Corporation of China and SINOPEC. SINTEF from Norway is the only European entry in the Top 10, which also includes General Atomics from the US and Samsung from South Korea.

Figure 12

World Net Zero Research, most prolific corporates globally (2020–2024)

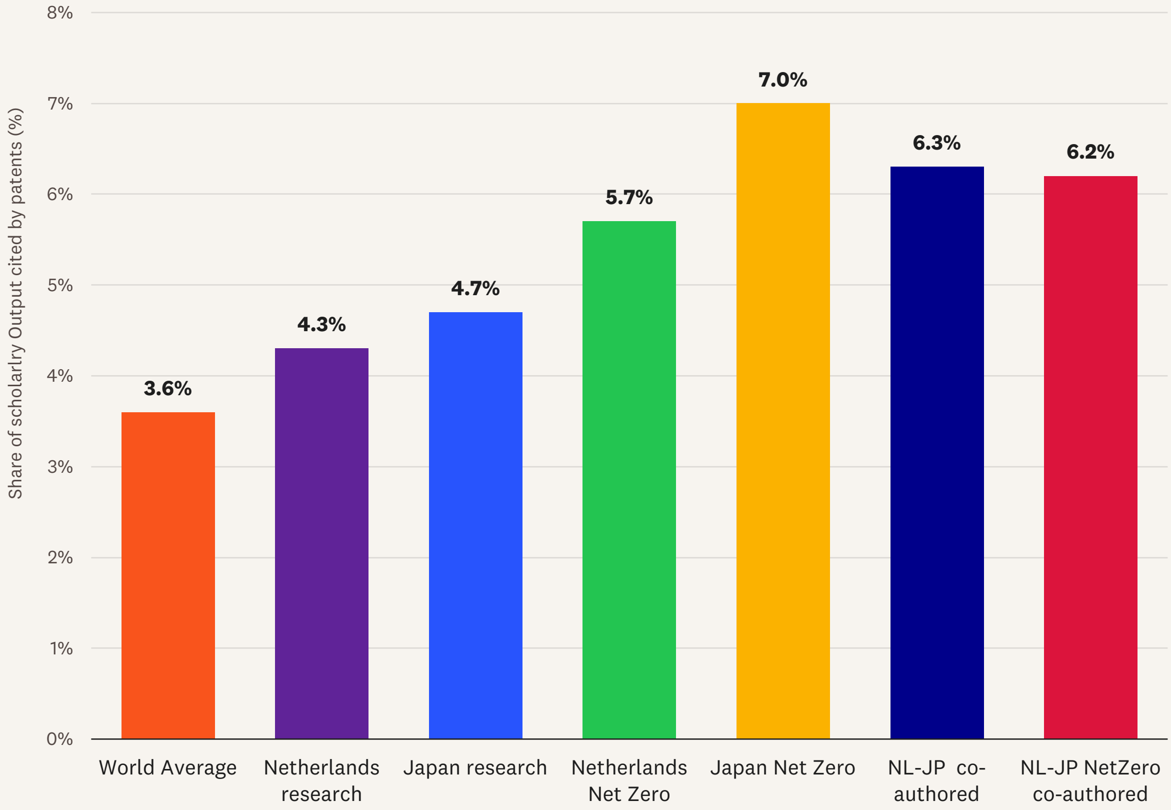
Corporates	Country	Scholarly Output	FWCI
State Grid Corporation of China	China	10,152	0.77
China Southern Power Grid	China	2,875	0.65
SINOPEC	China	1,536	1.06
SINTEF	Norway	1,361	1.45
China National Petroleum Corporation	China	1,270	1.34
General Atomics	USA	891	1.38
PowerChina Huadong Engineering Corporation Limited	China	864	0.74
NARI Technology Co., Ltd.	China	704	0.56
Samsung	South Korea	655	2.09
Research Institute of Petroleum Exploration and Development	China	579	1.74
Total S.A.	France	517	1.03
Électricité de France S.A.	France	512	1.06
Siemens	Germany	499	1.13
Saudi Arabian Oil Company	Saudi Arabia	432	1.71
General Electric	USA	399	1.42
Hyundai Motor Group	South Korea	361	1.27
Petronas	Malaysia	353	1.26
Hydro-Quebec	Canada	343	1.67
China National Offshore Oil Corp	China	341	1.01
E.ON	Germany	1	1.01

The impact of Net Zero research on patents

Another angle to assess the impact of Japanese Dutch co-authored Net Zero research is through the level of patent citations, this being a proxy of knowledge transfer supporting innovation. As demonstrated in the figure below, both Dutch and Japanese research on average is cited more frequently than the global average (details of which can be found in our first report). Looking at Net Zero specifically, Japanese and Dutch research individually get higher citations in patents than overall research, with Japan having up to 7% cited in patents, compared to 4.7% for all research – the same pattern is seen for the Netherlands: 5.7% vs 4.3% compared patent citations from Net Zero research to overall research. For the joint Japanese-Dutch collaboration, the level of scholarly output that is cited in patent is very similar between the overall research and Net Zero research (6.3% vs 6.2%). With respect to patents, in our 2020 Global report *Pathways to Net Zero: The Impact Of Clean Energy Research*, looking at global patent share, dominated by corporates, Japan was second only to China in patents.

Figure 13

Share of Research Cited by patents (2015–2024)



Conclusions on Japanese-Dutch Net Zero Research

Even amongst these differences, a common thread woven through both nations' research is a strong dedication to the hydrogen economy, with both exploring innovative pathways for hydrogen and ammonia production, storage, and utilization. Both also acknowledge the role of carbon capture and storage for residual emissions in sectors in which such efforts are particularly challenging. Net Zero research strongly resonates with the sustainable development goals, as also seen in the fact that Japanese and Dutch research for SDG 13, Climate Action, shows a higher FWCI than the world average, with the Netherlands at 2.24 and Japan at 1.61.

However, where Japan seeks to push the boundaries of materials science and pursue ambitious, long-term energy sources like fusion, the Netherlands focuses on optimizing existing and near-term renewables for broad deployment, fostering systemic integration, and addressing the societal and circular economy aspects crucial for a holistic energy transition. In essence, Japan is heavily invested in inventing the future energy components, while the Netherlands is more focused on architecting and socially enabling the integrated clean energy system. By understanding the differences and strengths of Japanese-Dutch Net Zero research in detail, academic and government institutions along with corporates should be able to further leverage the partnership between the two nations for great impact, particularly as climate action and Net Zero research is more crucial than ever before.

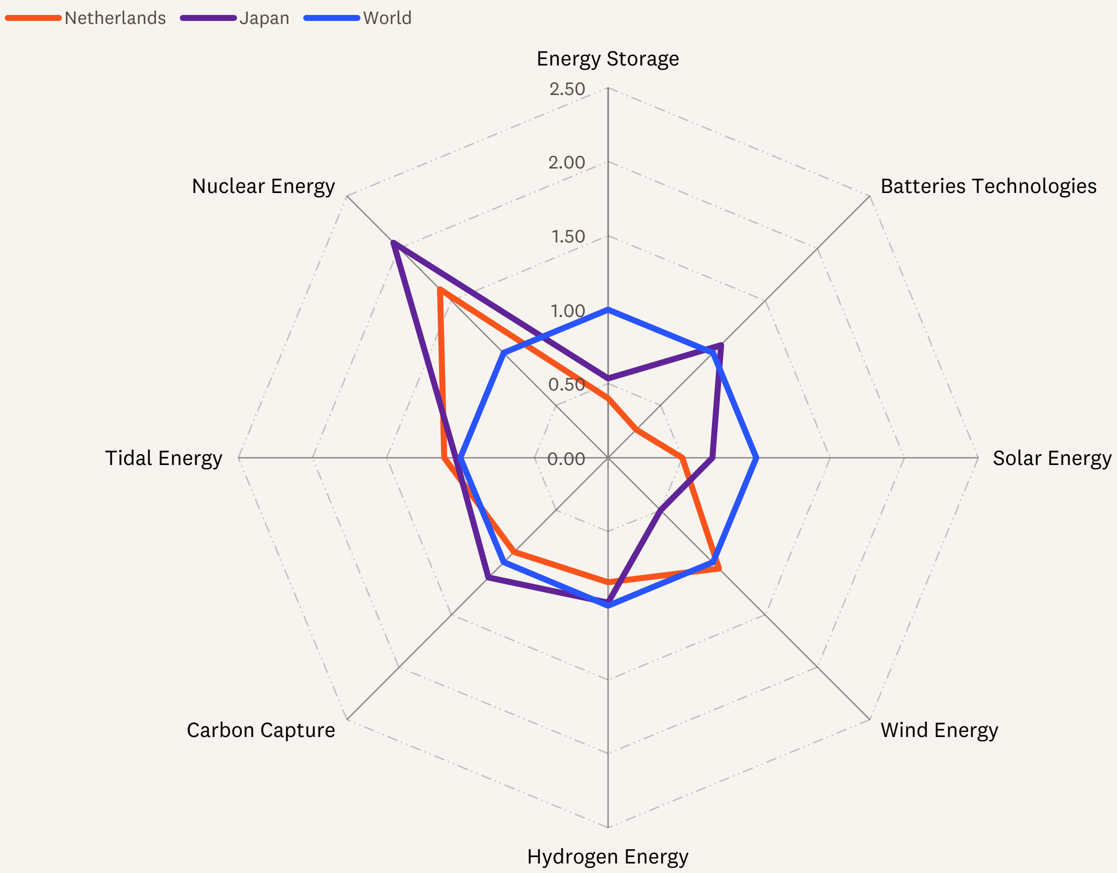
Comparison of research activity in selected clean energy types

In this section we take a different approach to analyze energy research than the Net Zero research shown previously. Here we explore research in different clean energy types and establish the activity levels for Japan and the Netherlands in order to understand the similarities and differences between Japan and the Netherlands in their approach to clean energy (the search parameters are defined in the Appendix). To this end we use the relative activity index. The Relative Activity Index (RAI) is calculated in relation to global activity in each of the areas noted in the figure below (the world's average is here defined at 1; RAI values above 1 indicate activity levels above the world's average, etc.).

The figure below shows areas of similar research activity for Japan and the Netherlands in Hydrogen Energy, Carbon Capture and Tidal Energy. Japan shows significant activity above the Netherlands in Battery Technologies (a RAI of 1.08 vs. 0.27), with the Netherlands leading instead in Wind Energy (a RAI of 1.06 vs. 0.50). Both have significant activity above the world average in Nuclear Energy (the RAI for the Netherlands is 1.61 and for Japan 2.05), which is also a leading area of collaborative Japanese-Dutch research. All three energy types, nuclear, batteries and wind, are prime opportunities for further Japanese-Dutch collaboration.

Figure 14

Research Relative Activity in selected energy types (2020–2024)



Conclusion

The collaboration between Japan and the Netherlands in clean energy research presents a compelling model of complementary national strengths converging to advance the global Net Zero agenda.

Japan's leadership in advanced materials science, hydrogen technologies, next-generation batteries, and long-term fusion energy research pairs effectively with the Netherlands' expertise in offshore wind, circular economy innovation, smart grids, and systemic integration of renewable energy solutions. This synergy is further amplified by a high level of academic-corporate partnerships in both countries, with joint research exhibiting citation impacts and patent citations well above global averages, underscoring the innovative and practical significance of their work.

Both nations share ambitious climate goals aligned with the 2050 carbon neutrality target, reinforced by robust policy frameworks and substantial public-private investments. Yet, the common global climate challenge calls for even stronger collaborations in research and technology deployment to achieve the deeper emission cuts and societal transformation needed.

The analysis in the report suggests several common grounds to explore closer collaboration in areas such as clean energy research, including hydrogen, fusion, nuclear and smart systems. There is further potential in combining complementary expertise — like offshore wind and port infrastructure from the Netherlands with Japan's work in hydrogen and batteries — to develop integrated energy solutions. Societal and policy research might be considered to support public understanding and inclusive transition strategies. Broader international cooperation, such as within the European framework, could further be explored to align research, standards and share insights.

Global collaboration catalysts

Given their unique positions, Japan and the Netherlands are very well-suited to serve as a bridge between the Asia-Pacific (APAC) and European regions. As global challenges like climate change require cooperative solutions rather than competition, their partnership can act as a powerful catalyst. By strengthening this collaboration, these two nations can pull other countries in their regions into a more unified effort to find solutions that benefit all. This strategic alliance highlights how even countries with smaller research outputs can play a pivotal role in shaping a collaborative, global response to the urgent need for a sustainable future.

Appendix 1

External sources

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Appendix 2

Data sources

Energy types	**Dataset used (2020–2024)**	**How dataset was obtained**
Net Zero	Research Area in SciVal from Elsevier 2019 Report methodology	Based on the dataset of SDG 7: Affordable and Clean Energy and a small section of the data set of SDG13: Climate Action
Energy Storage	string based on selected keyword(s)	"energy storage" OR "gravity-based" OR "flow batter*" OR "thermal storage" OR "cryogenic storage" OR "compressed air storage" OR *capacitator OR edlc
Batteries Technologies	string based on selected keyword(s)	("lead acid batteries") OR ("Nickel-Cadmium") OR ("NiCd") OR ("Nickel-Metal Hydride") OR ("Lithium-Ion") OR ("Li-ion") OR ("Sodium-Sulfur") OR ("Vanadium-Redox Flow") OR ("Lithium-Air") OR ("Solid-State Batteries")
Solar Energy	string based on selected keyword(s)	"solar energy" OR "solar power" OR "solar panel*"
Wind Energy	string based on selected keyword(s)	"wind energy" OR "wind power" OR "wind turbin*" OR "wind farm*"
Hydrogen Energy	string based on selected keyword(s)	"hydrogen power" OR "hydrogen energy" OR "hydrogen fuel" OR "hydrogen economy" OR "Hydrogen batter*" OR "green hydrogen" OR "blue hydrogen" OR "clean hydrogen" OR "hydrogen storage"
Carbon Capture	string based on selected keyword(s)	"carbon capture" OR "direct air capture" OR "pre-combustion ca*" OR "post-combustion ca*" OR "oxyfuel" OR ccs AND NOT (coronary)
Tidal Energy	string based on selected keyword(s)	"tidal energy" OR "tidal power" OR "power of waves" OR "tidal range" OR "tidal stream" OR "underwater kite*" OR "floating stream turbine*"
Nuclear Energy	string based on selected keyword(s)	"nuclear energy" OR "nuclear fusion" OR "nuclear fission" OR "nuclear waste" OR "nuclear power" OR "nuclear fuel" OR "nuclear reactor" OR "nuclear industry" OR "radioactive waste" OR "nuclear engineering" OR "nuclear physics" OR "pressurized water reactors" OR "reactor core" OR "fusion reaction" OR "fission reaction" OR "tokamak" OR "nuclear safety" OR "thermonuclear" OR "plasma physics" OR "plasma stability" OR "plasma confinement" OR "stellarator" OR "inertial confinement" OR "advanced reactor" OR "generation IV reactor" OR "small modular reactor" OR "molten salt reactor" OR "fast neutron reactor" OR "gas cooled reactor" OR "liquid metal reactor" OR "heavy water reactor" OR "light water reactor" OR "supercritical water reactor" OR "used nuclear fuel" OR "thorium fuel" OR "transuranic waste" OR "deep geological disposal" OR "neutron poison" OR "control rod" OR "International Thermonuclear Experimental Reactor" OR "DEMO reactor" OR "fusion reactor design" OR "tritium breeding"