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WIPO GREEN Webinar
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The power of hydrogen

Patent, bibliometric and investment analytics on critical technologies

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Presentation outline

1. Patent analytics
2. Bibliometric & investment analysis
3. The big picture

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Patent analytics

Catriona Bruce

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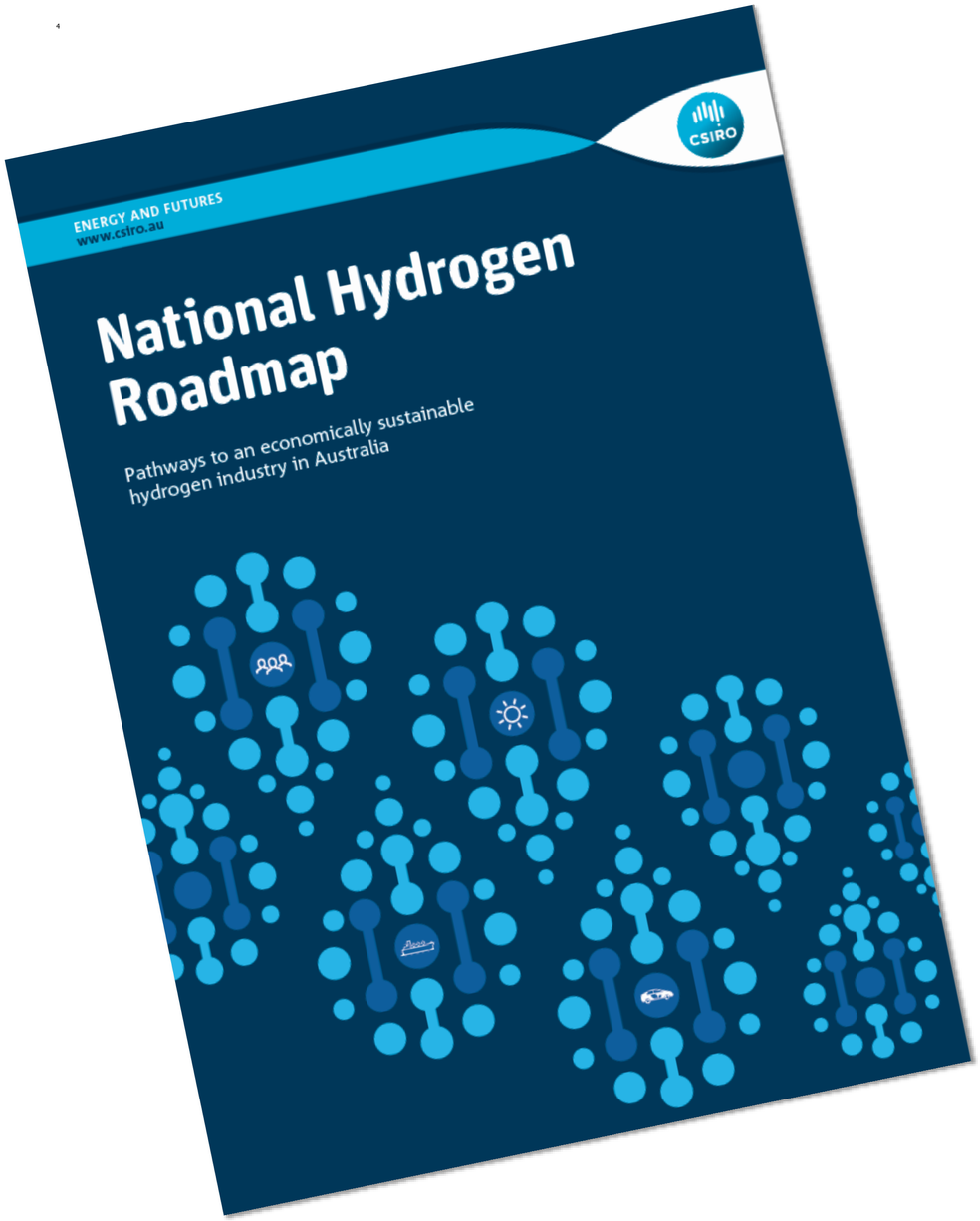

Our hydrogen customers

- Commonwealth Industrial and Scientific Research Organisation (CSIRO)
- Office of the Special Advisor on Low Emissions Technologies
- AusTrade
- Department of Industry, Science and Resources
- The Treasury
- Critical Technologies Hub

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What technologies?

Hydrogen production

- Electrolysis
- Fossil fuel conversion
- Biomass and waste conversion
- Thermal water splitting
- Biological hydrogen production
- Photochemical and photocatalytic

Hydrogen utilisation

- Gas blending
- Hydrogen-powered transport
- Electricity generation
- Industrial processes
- Export
- Heat storage

Hydrogen storage and distribution

- Compression
- Chemical carriers

What technologies?

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Possible emissions reduction?

Patent data extraction and analysis

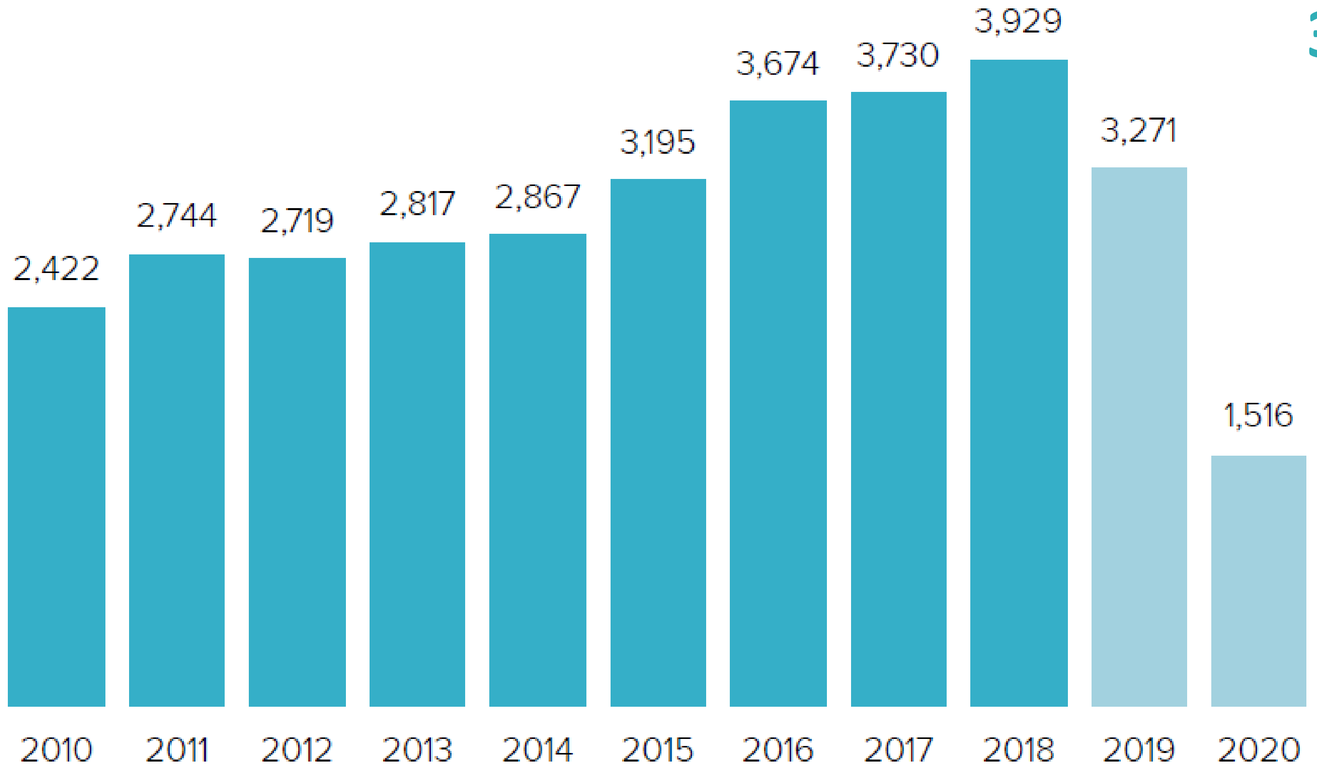
1. Develop search strategies*
2. Data mining using DWPI database
3. Patent publications extracted from PATSTAT
4. Data cleaning including name harmonisation
5. Assignment of country of origin where null (Pasimeni 2019)**
6. Data analysis and visualisation using Power BI

*Details of search strategies are given in the Glossary of each interactive visualisation, available at: https://www.ipaustralia.gov.au/tools-resources/publications-reports/patent-analytics-hydrogen-technology

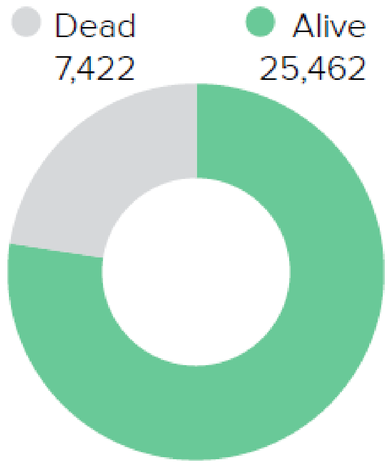
**Pasimeni, F (2019) *SQL query to increase data accuracy and completeness in PATSTAT*, World Patent Information, Vol. 57, pp 1-7

Global patent filings – hydrogen technologies

Patent families, by earliest priority year and patent statues, 2010-20
Source: PATSTAT 2021 Spring edition



32,885 patent families



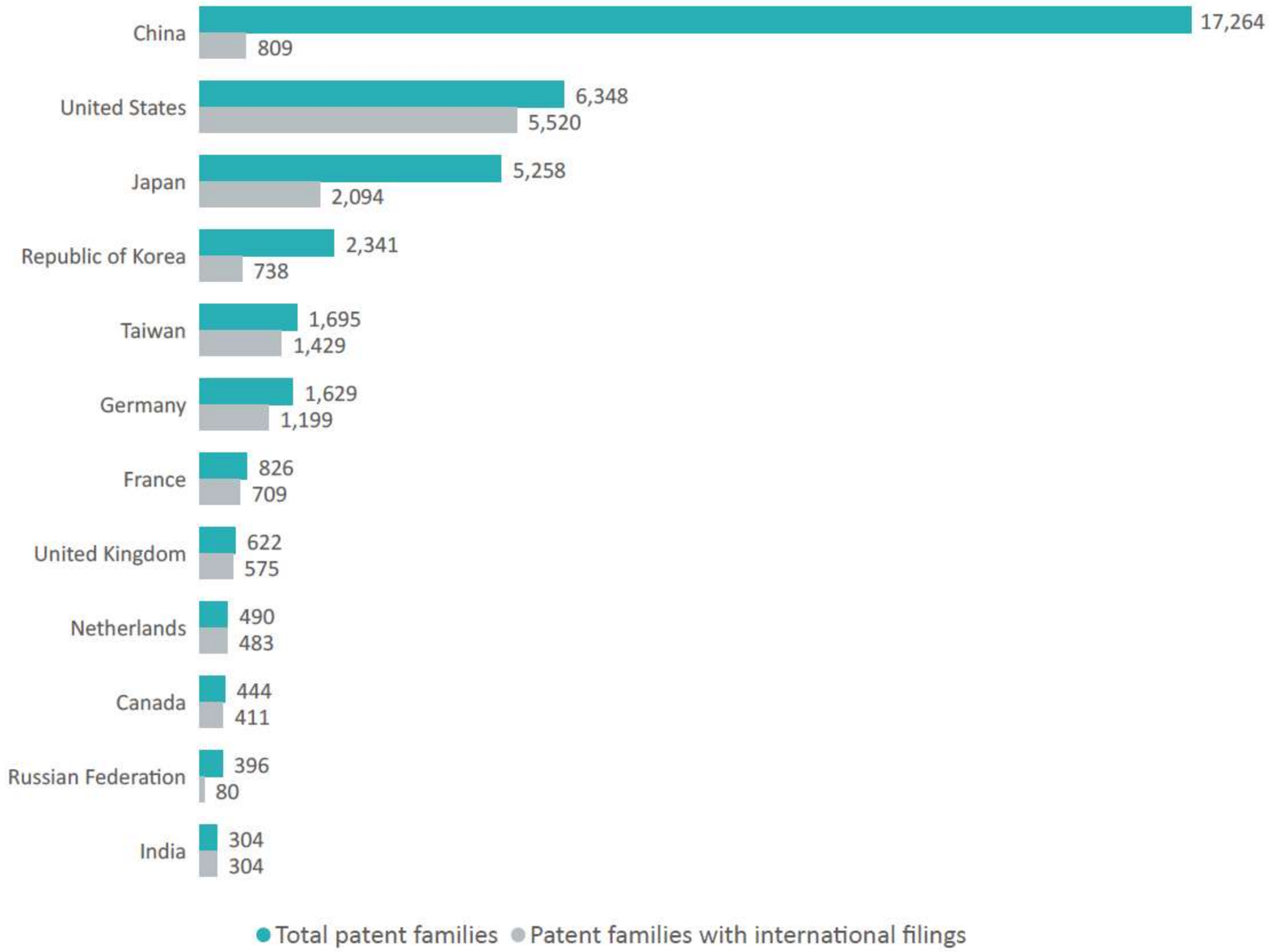
77%

Notes

1. ‘Alive’ patents are in an active state with patent protection being sought or in force for at least one family member; ‘Dead’ patent families have lapsed, expired or been withdrawn.
2. The dip in patent filings in 2019-20 reflects incomplete data due to a log in the publication of patents.

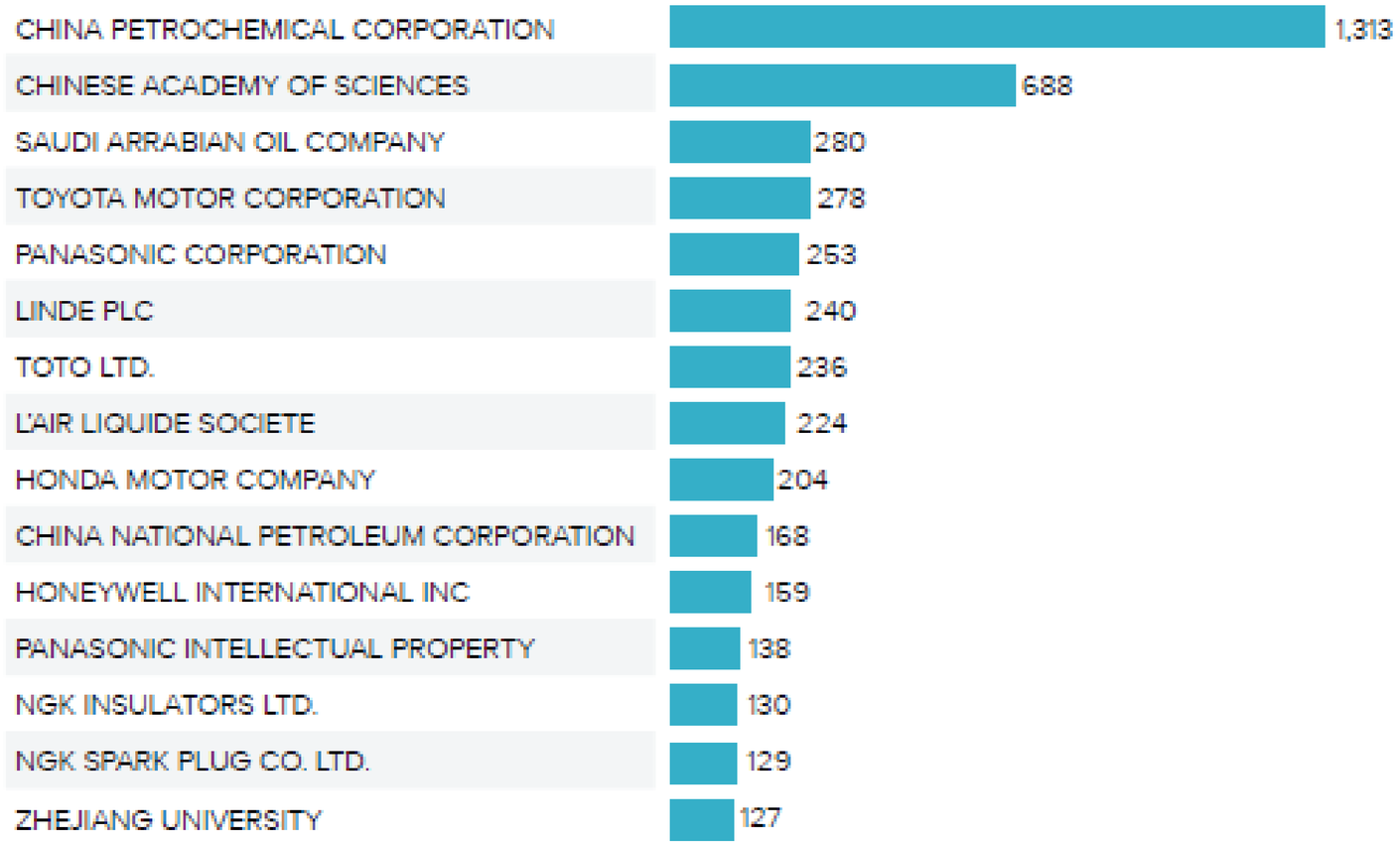
Country of origin

Hydrogen technologies,
global patent families, 2010-20
Source: PATSTAT 2021 Spring edition



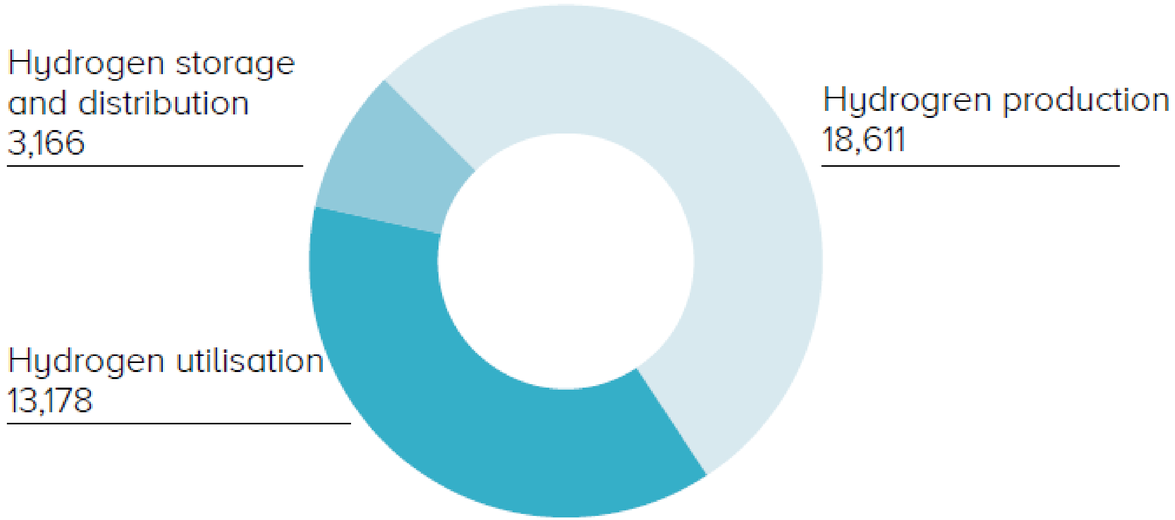
Top global applicants

Hydrogen technologies, patent families, by applicant, 2010-20
Source: PATSTAT 2021 Spring edition



Main technology category

Hydrogen technologies, patent families, 2010-20
Source: PATSTAT 2021 Spring edition

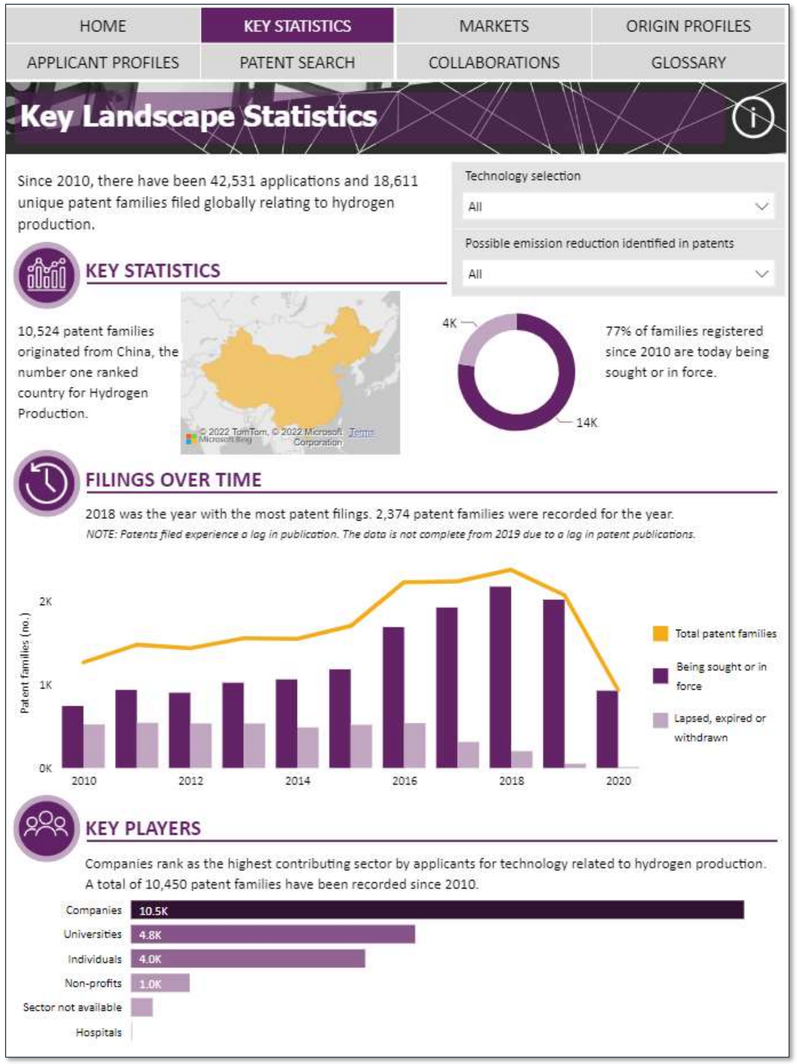


Hydrogen production country of origin

Patent families, by technology subsector, 2010-20
Source: PATSTAT 2021 Spring edition

Country	Biological	Biomass and waste conversion	Electrolysis	Fossil fuel conversion	Photochemical and photocatalytic	Thermal water splitting
China	1,543	1,274	4,253	3,666	1,215	402
United States	565	806	1,128	1,744	356	183
Japan	174	332	1,134	300	236	34
Republic of Korea	137	200	829	322	113	32
Taiwan	134	128	607	264	95	45
Germany	78	215	344	282	57	65
France	39	101	146	237	15	5
Netherlands	21	115	55	195	49	26
United Kingdom	61	70	115	169	24	10
Canada	51	76	88	138	21	14

Interactive visualisations



Interactive visualisations are available at: https://www.ipaustralia.gov.au/tools-and-research/professional-resources/data-research-and-reports/publications-and-reports/2022/09/30/hydrogen-technology-patent-analytics

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Bibliometric & investment analysis

Marcus McDonald

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Keeping pace with technology

The problem

Keeping pace with threats and opportunities to Australia’s national interests requires the Australian Government to make more informed and strategic decisions on critical technologies.

The solution

Develop tailored and broadly accessible information about critical technologies.

Technology analytics

News

Bibliometrics

Investments

Intellectual Property

What are Australia’s strengths and weaknesses?

Bibliometrics

Metric: **Research impact**

The research impact is intended to indicate the productivity of a country or institution. It is not necessarily an indication of the quality of the research, e.g. a publication may be cited for the purpose of a negative review.

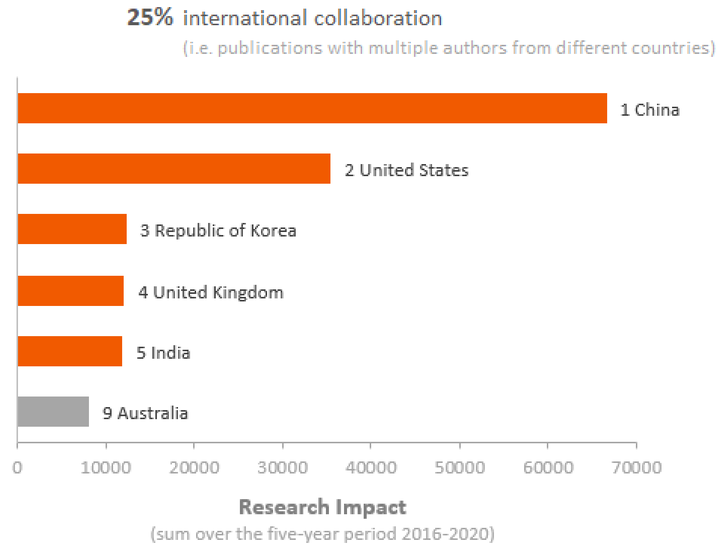
Research impact * = Scholarly_output x (0.05 x Views + 0.5 x Citations)

Data source: **Scopus**

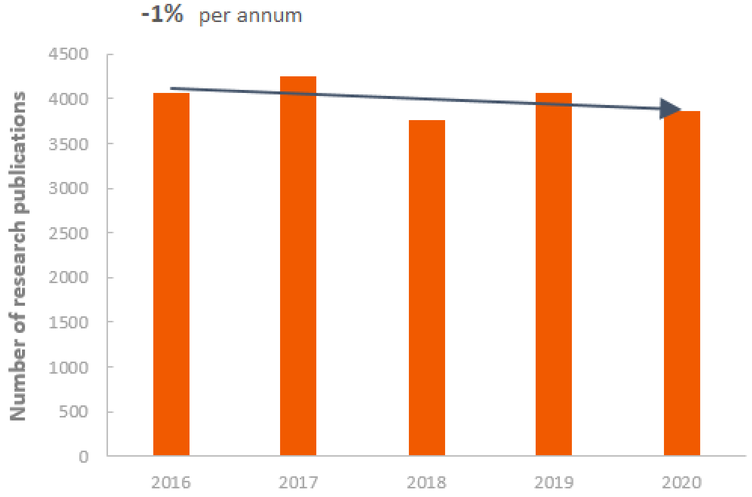
Scopus is the largest abstract and citation database of peer reviewed literature and includes over 21,000 titles from 5,000 publishers.

* *ResearchGate, How Research Interest scores are calculated, https://www.researchgate.net/application.researchInterest.ResearchInterestHelp.html last accessed August 2021.*

International Ranking



Five Year Trend



Investments

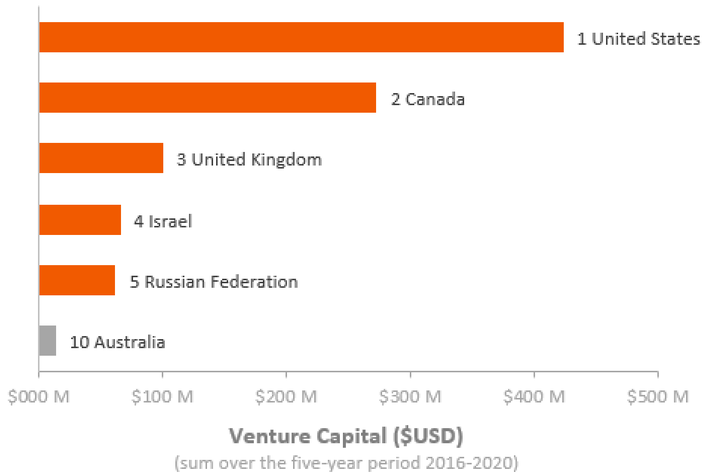
Metric: **Venture Capital**

Venture capital investment is mainly related to early-stage businesses that may not yet be on profit, but have a disruptive business offering with the potential of very strong growth.

Data source: **Crunchbase**

Crunchbase maintains data of approximately 1.6 million companies and approximately 800,000 investment rounds, with global coverage.

International Ranking



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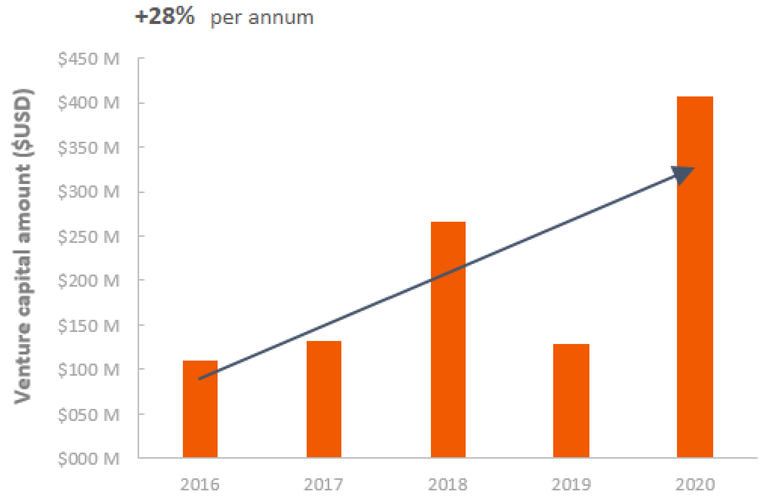
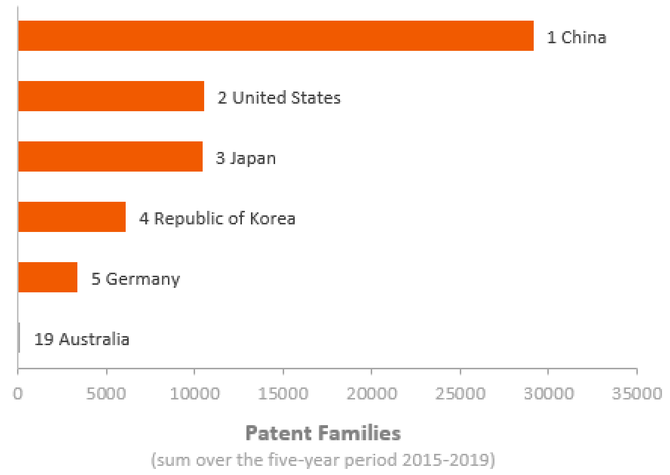


Intellectual property

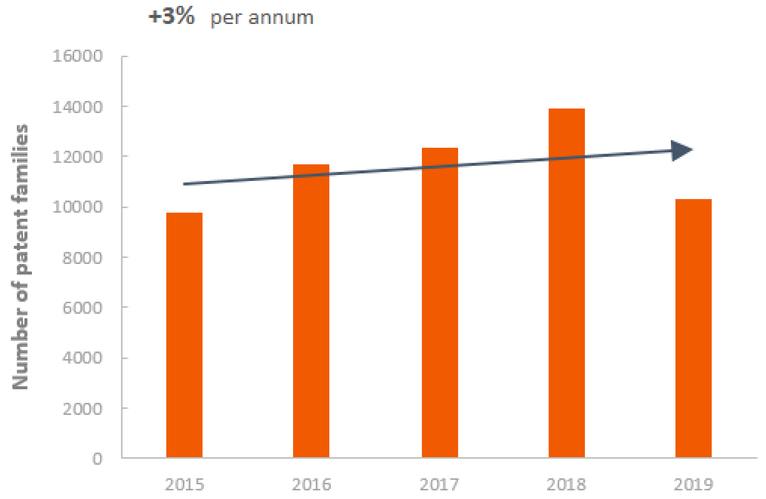
Metric: **Patent Families**

Data source: **PATSTAT 2021 (Spring edition)**

International Ranking



Five Year Trend



Critical technologies

Advanced materials and manufacturing	AI, computing and communications	Biotechnology, gene technology and vaccines	Energy and environment	Quantum	Sensing, timing and navigation	Transportation, robotics and space
Additive manufacturing (incl. 3D printing)	Advanced data analytics	Biological manufacturing	Biofuels	Post-quantum cryptography	Advanced imaging systems	Advanced aircraft engines (incl. hypersonics)
Advanced composite materials	Advanced integrated circuit design and fabrication	Biomaterials	Directed energy technologies	Quantum communications (incl. quantum key distribution)	Atomic clocks	Advanced robotics
Advanced explosives and energetic materials	Advanced optical communications	Genetic engineering	Electric batteries	Quantum computing	Gravitational-force sensors	Autonomous systems operation technology
Advanced magnets and superconductors	Advanced radiofrequency communications (incl. 5G and 6G)	Genome and genetic sequencing and analysis (Next Gen Sequencing)	Hydrogen and ammonia for power	Quantum sensors	Inertial navigation systems	Drones, swarming and collaborative robots
Advanced protection	Artificial intelligence (AI) algorithms and hardware accelerators	Nanobiotechnology	Nuclear energy		Magnetic field sensors	Small satellites
Continuous flow chemical synthesis	Distributed ledgers	Nanoscale robotics	Nuclear waste management and recycling		Miniature sensors	Space launch systems (incl. launch vehicles and supporting infrastructure)
Coatings	High performance computing	Neural engineering	Photovoltaics		Multispectral and hyperspectral imaging sensors	
Critical minerals extraction and processing	Machine learning	Novel antibiotics and antivirals	Supercapacitors		Photonic sensors	
High-specification machining processes	Natural language processing	Nuclear medicine and radiotherapy			Radar	
Nanoscale materials and manufacturing	Protective cyber security technologies	Synthetic biology			Satellite positioning and navigation	
Novel metamaterials		Vaccines and medical countermeasures			Scalable and sustainable sensor networks	
Smart materials					Sonar and acoustic sensors	

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The big picture

Rebecca Doolan

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CTPCO
CRITICAL TECHNOLOGIES POLICY COORDINATION OFFICE

Hydrogen and ammonia for power

Sustainable production, storage, distribution and use of hydrogen (H_2) and ammonia (NH_3) for heat and electricity generation. Hydrogen and ammonia are potential low or zero emission, zero-carbon alternatives to fossil fuels and electric batteries. Applications for hydrogen and ammonia as a fuel source include aviation and marine transport, long distance road transport and heating.

Key Sectors

- Agriculture
- Energy & Environment
- Construction
- Defence & Defence Industry
- Manufacturing
- Mining & Resources
- Transport & Logistics

Estimated impact on national interest	Low	Med	High
Economic Prosperity			X
National Security			X

Key Australian Government Actions

Initiatives

- National Hydrogen Strategy
- National Hydrogen Roadmap
- Australian Renewable Energy Agency (ARENA) – projects
- Modern Manufacturing Strategy – clean energy priority
- Clean Hydrogen Industrial Hubs Program
- Clean Energy Finance Corporation (CEFC)
- Low emissions partnerships with Germany, Singapore, Japan and the United Kingdom
- Quad clean energy partnership

Regulations

- Australian Energy Market Act 2004 (Cth)
- Renewable Energy (Electricity) Act 2000 (Cth)
- Road Vehicle Standards Act 2018 (Cth)
- Australian Energy Market Agreement

Australia's place in the world

China has the highest research impact in this field, significantly ahead of the second-ranked United States. Australia ranks 9th for research impact, led by the University of New South Wales and Curtin University which both feature in the top 50 international institutes.

Venture capital (VC) investment has increased at around 28% p.a. from 2016–2020, with the United States having the highest amounts of VC investment. Canada, the United Kingdom, Israel and the Russian Federation make up the top 5 countries for VC investment. Australia has the 10th highest amount of VC investment globally.

Patents in this area have been increasing by around 3% p.a. since 2015. China dominates the number of patents in this area, with almost 3 times the amount of the second-placed United States. Australia ranks 19th.

As articulated in the 2019 National Hydrogen Strategy, the Australian Government recognises the importance of hydrogen in the country's energy mix as an emerging power source. Australia has the opportunity to be world leading in its use of hydrogen and ammonia for power, both in terms of its research and potential export to overseas markets. Continual research and investment to more effectively extract and store hydrogen, as well as its safe export, could place Australia as a key export partner for countries with energy needs.

Example Outcomes

- Reduced carbon and methane emissions from increased utilisation of alternative fuels
- Improved stability of the electricity grid
- Diversified and stabilised energy supply
- Improved supply chain resilience of fuel supply from increased local production of alternative fuels
- Reduced transportation and logistics costs from locally produced fuels
- Diversified export resources

Opportunities and Risks

The growth of technologies to extract hydrogen and ammonia as power sources presents not only opportunities for exports to existing and emerging markets, but for promoting Australia as a reliable source of hydrogen. Hydrogen is increasingly being considered in other countries' energy mixes as a clean source of energy that can contribute to green energy targets. For example, Japan has set an ambitious target of 800,000 hydrogen fuel cell vehicles by 2030, with South Korea committing to 630,000 hydrogen fuel cell vehicles by 2030. Australia currently has 16 hydrogen projects underway, with a further 10 projects at an advanced stage of development planning. These investments could generate more than 8000 jobs, many in regional Australia, and contribute $11 billion to GDP by 2050.

Diversifying our export mix to include hydrogen and ammonia as a source of fuel and power for current and emerging markets may help reduce Australia's reliance on traditional natural resources, such as coal. This could build Australia's economic resilience to price fluctuations and geopolitical actions which may not be in Australia's economic interests. Production of hydrogen and ammonia as clean, alternative sources of power may adversely affect other Australia exports, most notably coal. It may also affect other exports such as liquefied natural gas, which is a current source of (non-clean) hydrogen fuel.

Domestic commercialisation of hydrogen and ammonia is dependent on the competitiveness of energy pricing, especially as non-renewable power sources currently provide lower electricity generation costs. Furthermore, Australia's electricity grid has not yet been adapted to generate power from hydrogen or ammonia. Further investment in our capabilities, as well as adaption of the electricity grid, is required to lower costs, encourage domestic consumption and increase the competitiveness of Australian-sourced hydrogen. There is also further opportunity to alleviate national security and energy risks through the decentralisation of power production and increased source diversity.

As alternative fuels are increasingly adopted as sources for heat and electricity, countries may use hydrogen, for example, as a strategic, geopolitical asset. Attempts to undermine the use or export of hydrogen may create both an economic and strategic risk for Australia – particularly if Australia seeks to position itself as a key regional supplier of hydrogen. However, this risk can be mitigated through the reinforcement and facilitation of free trade, as well as export to a variety of trading partners and markets.

Underpinning Science

ANZ Standard Research Classification Category

- Analytical chemistry
- Inorganic chemistry
- Macromolecular and materials chemistry
- Physical chemistry
- Automotive engineering
- Chemical engineering
- Electrical engineering
- Electronics, sensors and digital hardware
- Fluid mechanics and thermal engineering
- Materials engineering
- Mechanical engineering
- Resources engineering and extractive metallurgy
- Atomic, molecular and optical physics
- Classical physics
- Condensed matter physics

Example Applications

Readiness Level – Now

- Some electric vehicles, including cars, buses, fork lifts, construction vehicles, through the use of hydrogen fuel cells
- Dual-powered (hydrogen/diesel) farming equipment
- Diesel-electric submarines, such as the German Type 212
- Industrial chemical feedstock
- Hydrogen-fuelled gas turbines for power production
- Hydrogen rocket fuel for space travel

Readiness Level – 2–5 years

- Blending hydrogen in the gas network
- Hydrogen internal combustion engines
- Ammonia as a carrier for hydrogen
- Ammonia-fuel blends for combustion engines
- Large-scale hydrogen fuel cells for factories
- Green ammonia production

Readiness Level – Beyond 5 years

- Conversion of the gas network to using hydrogen
- Fuel for mining vehicles, long distance trucks, trains
- Fuel for cargo and container ship
- Ammonia internal combustion engines
- All-ammonia fuel cells

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Thank you

Q&A

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