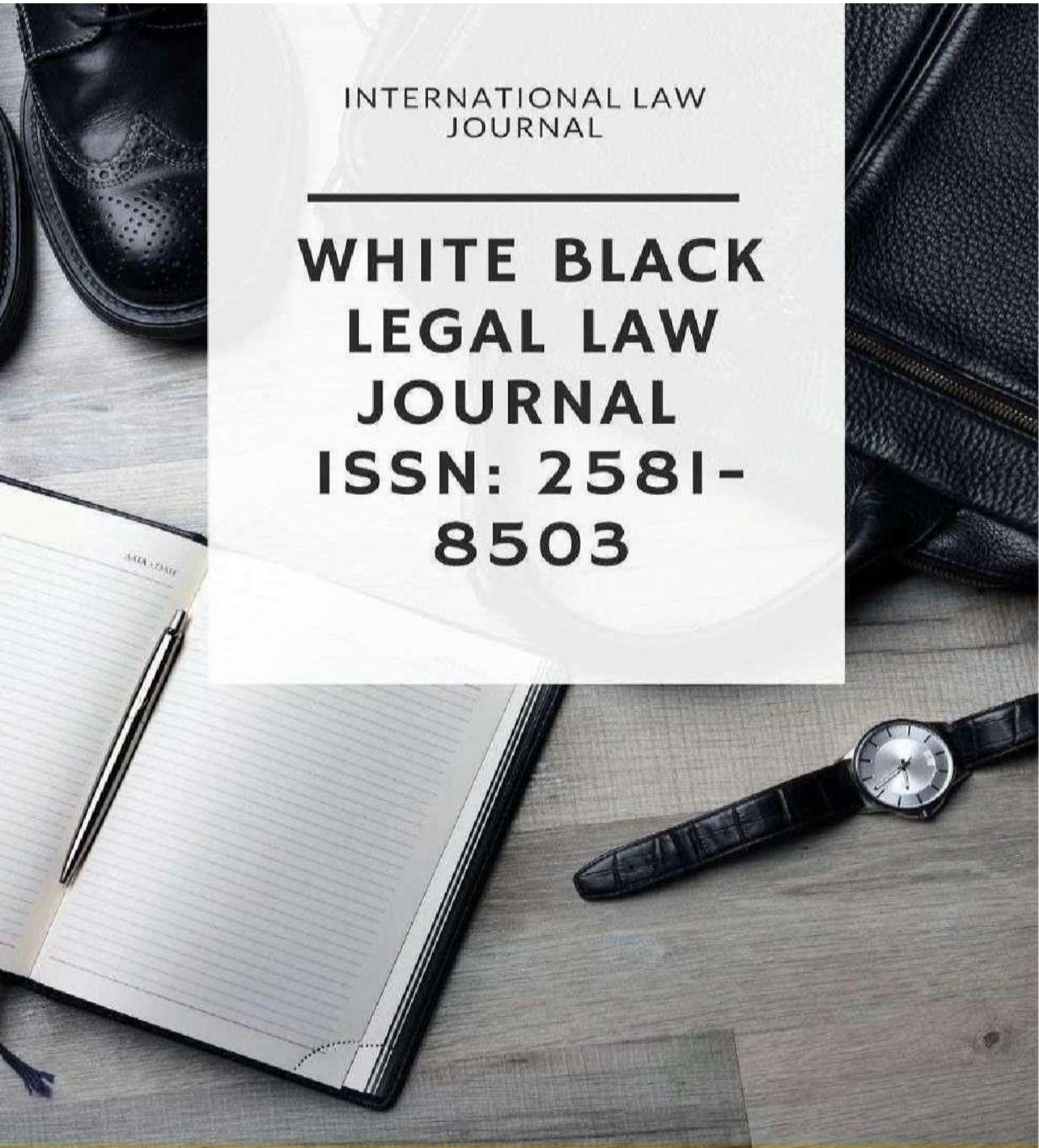

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WHITE BLACK LEGAL is an open access, peer-reviewed and refereed journal providededicated to express views on topical legal issues, thereby generating a cross current of ideas on emerging matters. This platform shall also ignite the initiative and desire of young law students to contribute in the field of law. The erudite response of legal luminaries shall be solicited to enable readers to explore challenges that lie before law makers, lawyers and the society at large, in the event of the ever changing social, economic and technological scenario.

With this thought, we hereby present to you

CCS UNPLUGGED: UNVEILING THE PATENT TECHNOLOGY IN CLIMATE CHANGE

AUTHORED BY - MAINAK GHOSH & DIVYANSHI SHARMA

Abstract

Carbon Capture and Storage (CCS) technologies have emerged as critical components of the worldwide effort to mitigate climate change by lowering greenhouse gas emissions. Patents serve a significant role in safeguarding and rewarding innovation by guaranteeing that inventors have exclusive rights to their technical advances. However, the implementation of CCS technology confronts a number of problems, including unaffordable prices, regulatory barriers, and intellectual property rights (IPR) issues. This paper looks at the relationship between patent management and Carbon Capture and Storage (CCS) systems. It stresses the role of intellectual property rights (IPRs) in stimulating innovation and supporting the deployment of CCS technologies that are critical to mitigating climate change. The essay examines patent landscapes and case studies to demonstrate how good patent strategies may overcome barriers to technology transfer and boost stakeholder engagement. The combination of patents and CCS technology provides a unique potential to enhance environmental sustainability. This essay seeks to reveal the potential of strategic intellectual property exploitation in promoting CCS technologies by reviewing the present patent environment and investigating case studies of successful patent management. The study focuses on how patent pooling, licensing agreements, and collaborative frameworks might reduce barriers to technology transfer and promote widespread adoption of CCS solutions. This paper emphasizes the importance of supporting legislation, large expenditures, and successful patent methods in achieving these goals. The study's extensive research sheds light on how intellectual property management might fuel technological developments and contribute to meeting global climate objectives.

Introduction

CCS Intellectual Property means CCS's Technologies used in the CCS Products and any other proprietary or confidential information provided to Buyer hereunder, including but not limited to reports, customized configuration, evaluation data, test data, software, documentation, compatibility, and interface information, and any other confidential information relating to CCS Products, any modifications, improvements, or derivatives of any of the foregoing, and all intellectual property.

Patents are a fundamental instrument for protecting and incentivizing inventive undertakings. Concurrently, Carbon Capture and Storage (CCS) technology has emerged as a viable method for combating climate change by lowering greenhouse gas emissions. This paper digs into the complex link between patents and CCS, analysing how the synergy between these two factors may accelerate breakthroughs in environmental sustainability and create collaboration among stakeholders. Moreover, the role of intellectual property rights (IPRs) in facilitating or hindering technology transfer, particularly in the context of CCS, is a subject of ongoing debate.[1]

The importance of patents in stimulating innovation cannot be emphasized. Patents are critical instruments for protecting intellectual property rights, giving innovators exclusive ownership over their work. This exclusivity encourages investment in R&D since individuals and companies are certain of enjoying the advantages of their ideas. The urgency of climate change mitigation demands rapid dissemination and deployment of CCS Technologies, which can be important by stringent Intellectual Property Regimes.[2] Furthermore, patents stimulate knowledge sharing and cooperation by compelling inventors to divulge specific details about their innovations in return for patent protection. This disclosure not only adds to the communal pool of information, but it also encourages future creativity by allowing others to expand on current ideas.

CCS technology has enormous promise for increasing environmental sustainability by collecting carbon dioxide emissions from industrial processes and power plants, reducing their influence on the climate. The advantages of CCS are numerous, ranging from lowering influence on the climate. The advantages of CCS are numerous, ranging from lowering greenhouse gas emissions to facilitating carbon-neutral energy generation. The relationship between the patent system and Carbon Capture Storage (CCS) technology is a nuanced one.

On one hand, the patent system is designed to incentivize innovation by granting inventors exclusive rights to their inventions for a time.[3] However, the global deployment of CCS is hampered by a number of obstacles, including soaring prices, regulatory impediments, and public image concerns. Despite these limitations, the urgent need to tackle climate change requires the continuous development and implementation of CCS technology as part of a

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1. *Huang, Can, and Naubahar Sharif, 'Intellectual Property Rights Protection', in Xiaolan Fu, Bruce McKern, and Jin Chen (eds),* The Oxford Handbook of China Innovation *(2021; online edn, Oxford Academic, 10 Nov. 2021),*

2. *Hirdan Katarina de Medeiros Costa, Carolina Arlota, Carbon Capture and Storage in International Energy Policy and Law, Elsevier, 2021, Pages 181-203,*

comprehensive carbon-reduction plan.

On one hand, the patent system is designed to incentivize innovation by granting inventors exclusive rights to their inventions for a time.[3] However, the global deployment of CCS is hampered by a number of obstacles, including soaring prices, regulatory impediments, and public image concerns. Despite these limitations, the urgent need to tackle climate change requires the continuous development and implementation of CCS technology as part of a comprehensive carbon-reduction plan.

Exploring the relationship between patents and CCS reveals a plethora of opportunities for encouraging innovation in environmental sustainability. Patents can help to advance CCS technology by motivating innovators to create unique ways for collecting and storing carbon emissions. Furthermore, using patents can promote collaboration among researchers, companies, and policymakers, allowing the pooled expertise to be used to overcome the problems connected with CCS implementation. However, conflicts between patent rights and the requirement for broad CCS deployment must be resolved through procedures that balance the need for innovation with access to critical technology for meeting climate targets. To successfully tackle climate change, a compromise must be struck between safeguarding investors and ensuring that CCS technologies can be accessed and applied internationally. The literature indicates that policy frameworks and business models that facilitate technology transfer and address IPR Challenges could be a key to achieving this balance.

Past Prospects

In June 2019, the United Kingdom became the first large economy to declare a legally binding objective of achieving net zero greenhouse gas emissions by 2050. In November 2020, the UK Government announced a ten-point strategy for a green industrial revolution. Innovation can assist in attaining carbon-net-zero emissions, and it may be reflected in worldwide patenting patterns.

CCS is a substantial field of patenting activity, with a large growth in patent applications over recent years. Globally, this activity is spearheaded by US Businesses such as Exxon Mobil.

Owners of CCS Patents are pursuing protection in the United States, China, and other jurisdictions, including many European Countries.

3. Arho Suominen, Matthias Deschryvere, Rumy Narayan, Uncovering value through exploration of barriers - A perspective on intellectual property rights in a national innovation system, Technovation, Volume 123, 2023, 102719, Looking at the UK landscape, there seems to be a surge in patenting activity between 2010 and 2014. The majority of this activity is conducted by proprietors headquartered outside of the United Kingdom, most notably Mitsubishi Heavy. Annual patent filings by UK-based companies appeared to peak in 2010 and have stayed stable in subsequent years.

When looking at CCUS, it is obvious that the patterns exhibited both globally and, in the UK, follow the same tendencies as seen with CCS in general. This implies that innovation in CCS in general is linked to innovation in CCUS. The subject of CCS is quickly evolving, and the government is investing in the construction of CCU facilities in the UK. As a result, the patterns of patenting activity in this field may shift in the next years.

Current Status of CCS Development

Carbon Capture and Storage is expected to play a key role in meeting the global warming targets set by the IPCC [4] and at COP21.[5] A number of methods are being explored for the capture, transportation, storage, and use of CO_2. Typically, technological development proceeds in a succession of scale-up steps:

i. Bench or Lab Scale

ii. Pilot Scale

iii. Demonstration Scale

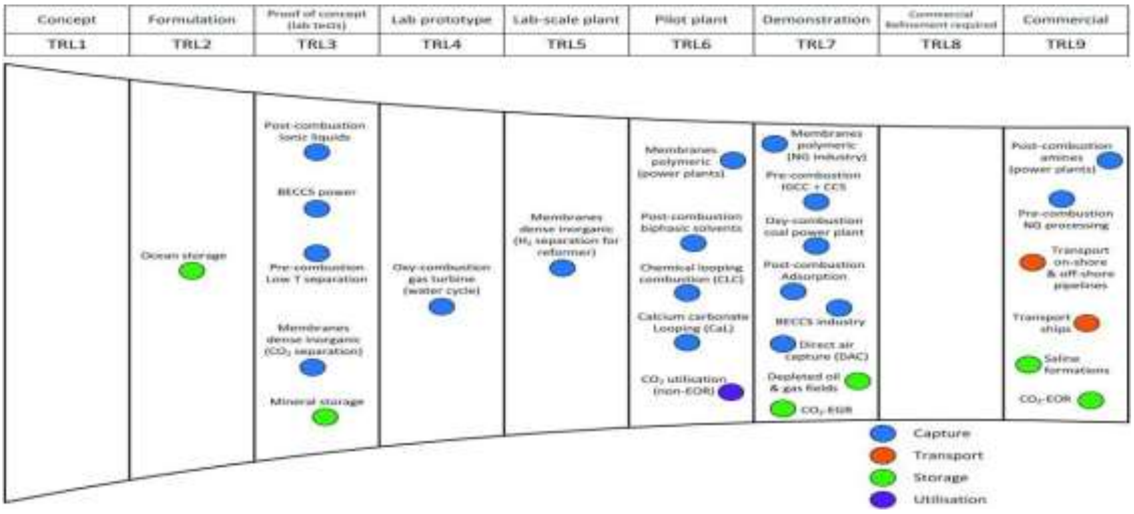
iv. Commercial Scale

This summarizes the current development progress of different CCS Technologies in TRL [6] Scale. According to the Global CCS Institute's 2023 report, the CO_2 capture capacity of CCS plants under development has increased by 48% from the previous year to 361 million tonnes per annum (Mtpa). Additionally, 198 additional facilities have been added to the development pipeline, bringing the total to 392 projects, with 41 in operation and 26 under construction.

4. IPCC, Climate Change 2014: Mitigation of Climate Change. Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2014

5. International Negotiations Agreement signed by Paris, published by climate.ec.europa.eu.

6. The “technology readiness level” (TRL) system provides a means of tracking the status of technologies during their progression through distinct stages of research and development (R&D). It is a nine-point scaling system used to qualitatively evaluate the maturity level of a technology.



<u>Current Development progress of Carbon Capture, storage, and utilisation technologies in terms of Technology Readiness Level</u>

There is a congestion of technologies at the TRL 3, TRL 6 and TRL 7 development phases. The progression beyond TRL 5 and TRL 7 needs significant financial investment and/or commercial interest.

Technology	Description
Direct Air Capture (DAC)	Chemicals (e.g., Animes or Sodium Hydroxide) are used to absorb CO_2, which is then mineralised for solid storage, or is stored in geological formation
Soil Carbon Sequestration (SCS)	Carbon Soil Sequestration is enhanced by increasing inputs or reducing losses. [7]
Biochar	Through Pyrolysis, biomass is made more resistant to decomposition and then added to the soil to store embedded carbon. [8]
Ocean Fertilisation (OF)	Iron can be used to make ocean phytoplankton absorb more CO_2 through photosynthesis, and then sink to the deep ocean and sequester carbon after their death.

7. *P. Smith, Global Change Biol., 2016, 22, 1315–1324*
8. *P. Smith, Global Change Biol., 2016, 22, 1315–1324*

Indirect Ocean Capture	Ocean Carbon uptake represents the largest sink for anthropogenic CO_2 absorbing about 40% of CO_2 emissions from the atmosphere since the start of the industrial era.[9] The use of an efficient method for the extraction of CO_2 from seawater provides a method of CO_2 removal from the atmosphere, e.g. using a pH swing with Bipolar Membrane Electrodialysis[10] or electrolytic cation exchange units [11]

The number of global patents registered for carbon capture and storage (CCS) increased by 22% between 2020 and 2021, marking the sixth consecutive year increase. BDO, an accountancy and business advisory firm, recorded 203 registrations, an increase from 167 the previous year. This number also represents a massive 227% increase over the 62 CCS patents registered five years ago. China has the largest interest, accounting for 81% of all patents registered. China, the world's greatest carbon dioxide emitter and the source of more than half of worldwide coal power output, has just launched its first offshore carbon capture project, confirming its commitment to decreasing emissions.

The United Studies is second in Patent Registrations, accounting for 9% of the total. The United States Government's $1.75 Trillion infrastructure initiative includes $12 Billion for carbon capture activities.

The United Kingdom accounts for 1% of all patent registrations. In its 2020 budget, the UK government allocated £1 billion to carbon capture infrastructure. CCS is the process of collecting and storing CO_2 from industrial emissions, often in depleted oil and gas reservoirs or coalbeds. In certain cases, captured CO_2 may be recycled to make commercial products, thereby removing it from the carbon cycle.

9. T. DeVries, M. Holzer and F. Primeau, Nature, 2017, 542, 215–218

10. M. D. Eisaman, K. Parajuly, A. Tuganov, C. Eldershaw, N. Chang and K. A. Littau, Energy Environ. Sci., 2012, 5, 7346–7352

11. H. D. Willauer, F. DiMascio, D. R. Hardy and F. W. Williams, Ind. Eng. Chem. Res., 2014, 53, 12192–12200

The energy industry is leading the way in CCS technology adoption, accounting for 32% of CCS patents registered in 2020-2021 and 16% of all patents. Aside from oil and gas companies, other sectors that use this approach include cement, sewage and waste treatment, mining, agriculture, steel, and construction. The increased interest in CCS across industries reflects a growing respect for its ability to cut carbon emissions and contribute to a more sustainable future.

The main CCS Research priorities in IAMs include:

- More within-model studies to understand better the interactions between CCS characteristics and Modelled deployment/cumulative storage, which are difficult to discern in model intercomparisons. [12]
- Update parameterization based on CCS research and demonstration results.
- Perform within-model investigations to better understand system dynamics.
- Complement with geographically explicit techno-economic engineering approaches and geological suitability analysis to identify key areas for deployment and more realistic potentials. [13]
- Consider technological choices based on institutional obstacles and societal acceptance.
- Include additional negative emission options to reduce competition for storage capacity and biomass.

Clearly, as goals rise and action is delayed, CCS will play a more essential role in mitigation strategies. Broadening the portfolio of energy options to include CCS would improve the affordability of a near-zero emissions energy system. [14]

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12. B. S. Koelbl, M. A. van den Broek, A. P. C. Faaij and D. P. van Vuuren, Clim. Change, 2014, 123, 461–476

13. F. Kraxner, S. Fuss, V. Krey, D. Best, S. Leduc, G. Kindermann, Y. Yamagata, D. Schepaschenko, A. Shvidenko, K. Aoki and J. Yan, The role of bioenergy with carbon capture and storage (BECCS) for climate policy, John Wiley & Sons, Ltd, UK, 2015, vol. 3, pp. 1465

14. [C. T. M. Clack, S. A. Qvist, J. Apt, M. Bazilian, A. R. Brandt, K. Caldeira, S. J. Davis, V. Diakov, M. A. Handschy, P. D. H. Hines, P. Jaramillo, D. M. Kammen, J. C. S. Long, M. G. Morgan, A. Reed, V. Sivaram, J. Sweeney, G. R. Tynan, D. G. Victor, J. P. Weyant and J. F. Whitacre, Proc. Natl. Acad. Sci. U. S. A., 2017, 114, 6722–6727

Commercial-Scale CCS Projects

In particular, the IPCC scenarios associated with a more than even chance of achieving the 2^0C target are characterised by average capture rates of 10 $GtCO_2$, per year in 2050 and 25 $GtCo_2$ per year in 2100 and cumulative storage of 800-3000 $GtCo_2$ by the end of the century.[15] The proportion of BECCS in the models' CCS fuel mix grows as the objective becomes more stringent. This is mostly due to the replacement of coal and natural gas throughout time. In response to concerns about large-scale biomass production for BECCS and doubts about CCS, the EMF Models developed a variety of scenarios that limited the use of both biomass and CCS. Although scarious achieve the same target, they are constantly characterised by higher costs, which is consistent with earlier findings and later confirmed by the results of the IPCC's AR5 [16] In absence of CCS, the total cost of climate change mitigation increased by 138%, whereas limited bioenergy availability increased cost by 64%. The integration of CCS into an energy system provides a significantly greater reduction in Co_2 emissions compared to wind technology. [17] With limited CCS and Biomass Availability, the development of nuclear, intermittent solar/wind, interconnection and gas-fired power needs to increase, consequently leading to higher total system cost.[18] The increase in mitigation cost is associated with the delay in technology development, use of more expensive technologies, and maintaining grid stability. Furthermore, the AR5 scenarios have been scrutinized for their use of CCS in combination with bioenergy. The 101 out of 116 scenarios that result in concentrations of 430-480 ppm CO_2-equivalent need worldwide net negative emissions between 2050 and 2100. About half of the scenarios have BECCS surpassing 5% of primary energy supply. [20]

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15. D. van Vuuren, E. Kriegler, K. Riahi, M. Tavoni, B. S. Koelbl and M. van Sluisveld, The use of carbon capture and storage in mitigation scenarios—An integrated assessment modelling perspective. Our Common Future Under Climate Change, International Scientific Conference, Paris, France, 2015

16. C. Azar, K. Lindgren, M. Obersteiner, K. Riahi, D. P. van Vuuren, K. M. G. J. den Elzen, K. Möllersten and E. D. Larson, Clim. Change, 2010, 100, 195–202

17. C. F. Heuberger, I. Staffell, N. Shah and N. Mac Dowell, Energy Environ. Sci., 2016, 9, 2497–2510

18. C. F. Heuberger, I. Staffell, N. Shah and N. Mac Dowell, Comput. Chem. Eng., 2017, 107, 247–256

19. [S. Fuss, J. G. Canadell, G. P. Peters, M. Tavoni, R. M. Andrew, P. Ciais, R. B. Jackson, C. D. Jones, F. Kraxner, N. Nakicenovic, C. Le Quere, M. R. Raupach, A. Sharifi, P. Smith and Y. Yamagata, Nat. Clim. Change, 2014, 4, 850–853

IP Consideration

Given the significant government investment in carbon capture technologies under the IIJA, companies who are now operating or intend to operate in this clean technology industry require a clear IP strategy more than before. If companies wish to share control over the intellectual property developed as a result of a carbon capture cooperation, they should consider establishing a contract defining their expected rights and duties, such as a joint development or co-development agreement. Any such contract may outline the parties' respective ownership rights, obligations, and development needs as part of the partnership.

If the parties fail to properly identify such rights and obligations, they may find themselves with unanticipated IP ownership - or no ownership at all - under applicable IP rules, possibly leading to future conflicts and costly litigation over carbon capture technology. To establish the companies' respective ownership rights, the contract should include appropriate IP assignment provisions in the present tense, as well as confirmation that each company has appropriate agreements in place with its employees who will be involved in the collaboration to ensure that such employees do not unintentionally retain any intellectual property rights to carbon capture technology.

This can be accomplished by executing a confidential information and innovation assignment agreement between the business and the employee. The enterprises may come to an agreement on a range of ownership structures based on what is best for the partnership and the parties' individual contributions to the technology.

For example, the parties may agree that the company providing funds for the development of the new carbon capture technology will own the associated intellectual property, but that the funding company will grant the developing company a perpetual, nonexclusive license to manufacture, use, sell, and commercialize the technology. Furthermore, if the companies intend to provide licenses to other parties as part of their commercialization strategy, they should consider stating their distinct rights to royalties from such licenses.

However, if the company developing carbon capture technology obtains federal funding, the intellectual property issues may become more complicated, depending on the conditions of the financing. The large amount of federal funding available to corporations under the IIJA may result in disproportionate innovation in clean technology and carbon capture, making it vital for businesses to appropriately safeguard their intellectual property rights.

Furthermore, if other companies begin to develop in the same industry, they will naturally fight to create the best product. As a result, obtaining strong intellectual property rights might be the difference between having a large competitive advantage in the marketplace and being unable to compete with other companies at all. To avoid being engaged in a litigation over intellectual property owned by third parties, firms should consider reviewing the landscape of already accessible carbon capture technologies, particularly because this technology has been available since the 2000s.

Such research may include a "freedom to operate" search, which involves doing legal analysis to determine if a technology integrates — and potentially infringes on — another person's intellectual property, particularly a third party's patent claims. If such a study determines that the firms are in danger of infringing on a third party's intellectual property rights as a result of developing and commercializing their carbon capture technology, the companies may choose to approach the third party about entering into a license agreement to avoid future.

Clarifying the businesses' ownership of the carbon capture technology is also likely to result in increased value. Purchasing and investing firms do due diligence to determine whether the target company has legal ownership of its intellectual property (IP), which is typically the company's most valuable asset. If the target company lacks clear rights to its intellectual property because to contractual issues or other factors, it may be forced to sell at a lower price. As a result, establishing each company's ownership rights to the carbon capture IP at the outset of the collaboration is crucial to avoiding disputes and achieving the highest market price possible in the future.

Carbon Capture Utilization and Storage in India

CO_2 Emissions: According to Niti Aayog’s Carbon Capture Utilization and Storage (CCUS) Report 2022, India is the world’s third-largest CO_2 emitter, after only China and the United States, with estimated annual emissions of 2.6 gigatonnes per year.

Carbon Capture Utilization and Storage: It is vital to ensuring India’s long-term growth and advancement, particularly in the production of clean products and energy, which will lead to an Aatmanirbhar Bharat.

Estimated CO_2 Storage Capacity in India

EOR	Well established in North America; oil recovery possible to the extent of 30-60%	**3.4 Gt**
ECBMR	CO_2 injected in unmineable coal seams; further R&D required before commercial deployment	**3.5 - 3.7 Gt**
Saline acquifers	No economic benefit - but potential of large scale CO_2 storage	**291 Gt**
Basaltic formations	More recent developments vis-à-vis saline aquifers	**97 - 315 Gt**
Total		**400 - 600 Gt**

(Image Source: https://pwonlyias.com/current-affairs/carbon-capture-utilization-and-storage/)

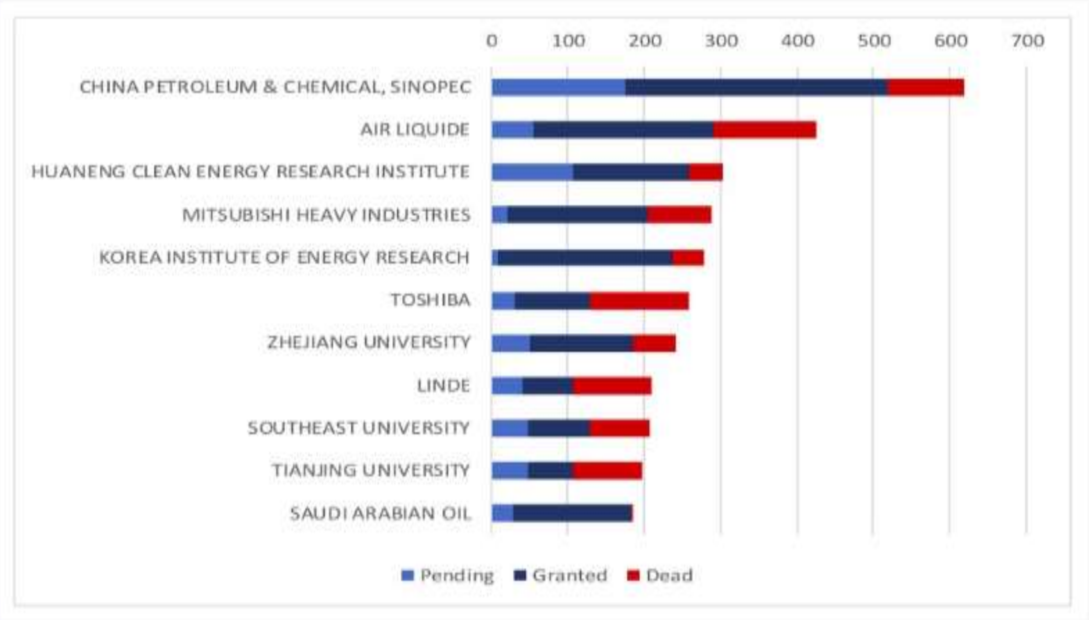
Carbon Capture Utilization and Storage Centers in India: The National Centre of Excellence in Carbon Capture and Utilization (NCoE-CCU) in Mumbai and the National Centre in Carbon Capture and Utilization (NCCCU) in Bengaluru are being established with funding from the Department of Science and Technology.

World Perspective

Several research papers and resources have been published on CO2 capture utilizing biological systems. However, the research and evaluation of patent state of art has received less attention, providing only a basic overview of the leading applicants in the CCS industry based on their geographical distribution and the type of technology developed. Carbon Capture and Storage (CCS) technology is an effective technique for fighting climate change. Patent records relating to CCS Technology filed in China and the United States (U.S.) were retrieved from INNOGRAPGHY, a commercial database of intellectual property and technological advances in CCS Technology.

In the 2000s, Chesbrough's work popularized the open innovation paradigm. It contends that a creative firm is intrinsically related to resources outside of itself, which may be developed in a variety of ways (acquisition, R&D contract, licensing, joint ventures, etc.).

For Chesbrough (2003) open innovation *"is a paradigm that assumes that firms can and should use external ideas and internal and external paths to market… Open innovation combines internal and external ideas into architectures and systems whose requirements are defined by a business model."* [20]



Although the database contains around 50,000 innovations, none of the top players have more than 1,000 patent families, demonstrating the market's variety and the number of firms working on developing ideas in the carbon capture technology sector. [21]

- SINOPEC, an oil, and gas company, has the most patents, with 600 families, 83% of which are active and 342 granted. The bulk of patent families are protected in China, with only a few extended. This demonstrates the company's commitment to decreasing carbon emissions. Its environmental and low-carbon activities have been acknowledged as the 'China Low-Carbon Model'. One of its projects, the Qilu-Shengli Oilfield million-

20. *Revue Journal of Innovation Economics, 2012(2); Page-107*
21. *Carbon Capture Technology: Catalysing Sustainability through Innovation- a Patent Landscape Report*

tonne carbon capture, utilization, and storage (CCUS) demonstration project, was completed and made operational in August. SINOPEC filed steadily during the previous decade, peaking in 2021 (78 patent families).

- Air Liquide, a gas supplier with substantial experience in carbon capture, has over 400 patent families, with 234 issued and more than 60% currently active. Despite filing fewer patent families than SINOPEC in the previous decade, it increased dramatically in 2020 to 39 patent families, and Air Liquide created solutions for CO2 collection and liquefaction.
- The Huaneng Clean Energy Research Institute (CERI), part of the Huaneng Group (CHNG), is a leading Chinese public power corporation with around 300 patent families (85% active and 151 granted). Its filing trend has been growing since 2013, with a considerable increase between 2020 and 2021 (18 and 68 patent families, respectively), indicating China's efforts to reduce its carbon impact.

In Australia, for the last decade or more, a series of conservative governments have continued to invest in carbon sequestration projects, frequently at the expense of investment and/or policies that promote the use of renewable energies. Despite this, the penetration of renewable energies into the Australian economy has been remarkable, owing mostly to technological advancements and cost reductions produced overseas. Recently, numerous large-scale carbon sequestration trials have begun across the world. For example, the world's first commercial direct air capture plant in Iceland [22] This argument's intricacy stems from a range of circumstances. For example, environmentally friendly technology has primarily been developed in industrialized nations, despite the fact that they are urgently required to cut GHG emissions in rapidly rising emerging economies. Ensuring the worldwide dissemination of these technologies therefore presents enormous regulatory and economic issues, since poor nations are reluctant to shoulder all of the financial expenses involved with their adoption, while corporations in affluent countries are anxious to hand over important intellectual assets. The role of intellectual property rights is particularly contested. Developing Countries have argued for the creation of different IPR Regime for climate-friendly technologies in order to encourage diffusion, whereas industrialized countries claim that the incentives provided by existing IPR Regimes reinforce diffusion incentives by ensuring patent holders the benefits that result from their invention. [23]

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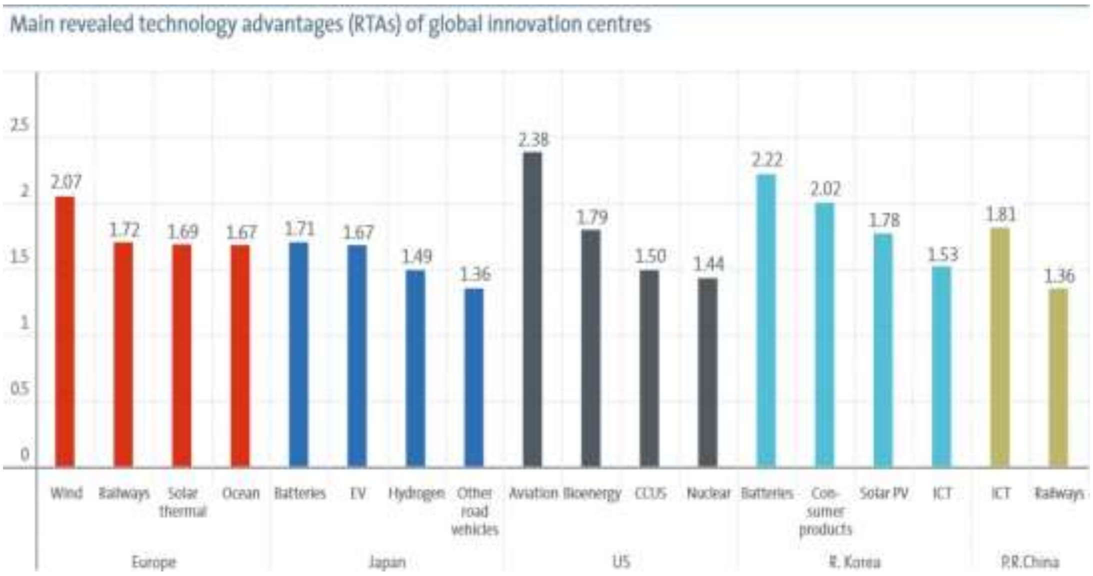
22. Orca Plant, Vision to Reality Online Report, conducted by Climeworks.
23. Makus 2010 Discussion



(Image Source: European Patent Office)

Since 2000, Europe has dominated patenting in LCE, accounting for 28% of all IPFs from 2010 to 2019. It leads in most renewable energy categories. Since 2010, Japan has responsible for 25% of all IPFs, followed by the United States (20%). Japan's competence in batteries and hydrogen provides a competitive advantage in the EV industry. In addition to its knowledge of fossil fuel technology, the United States has a technological advantage in low-carbon combustion and related businesses, such as aviation. Korea (10%) and the People's Republic of China (8% of all IPFs) are tiny hubs of invention in LCE technology, although patenting has increased over the past decade.

Future of Patent with Carbon Capture Storage System

Patent applications for carbon capture, utilization, and storage solutions, like those for novel technology, should be broad enough to encompass significant commercial features while being narrow enough to clearly distinguish differences from prior art.
To increase the scope of patent protection, technical companies may consider asserting many individual components of their technology. Examples of potential patentable breakthroughs in the field of carbon capture and storage include:

Materials for collecting CO_2 from certain sources.

- Solvents are liquid carriers that absorb CO_2 through chemical or physical processes. Durable, low-cost, non-corrosive solvent that can successfully collect CO_2 with minimal energy input.

- Sorbents use physical absorption to collect CO_2. Develop highly effective CO_2 capture sorbents with cheap raw material prices, excellent thermal and chemical properties, and low sorbent loss rates over time.
- Improved membrane properties include permeability, selectivity, thermal and physical stability, and pollutant tolerance.

Components of CO_2 capture systems:

- Combining technologies may significantly enhance production by eliminating limitations, lowering costs, and increasing performance.
- Improved gas and liquid flow systems, heat control, and solid waste disposal.
- Designing systems to decrease complexity and risk of failure, save energy, and increase scalability.

Captured CO_2 may be a valuable source for producing chemicals and fuels through processes such as CO_2 hydrogeneration, CO_2 cycloaddition to epoxides, and CO_2 carbonylation of amines and alcohols. Examples of carbon conversion and utilization technology that may be claimed in a patent application include:

- Systems for disposing, converting, and using collected or concentrated CO_2.
- Effective methods for reducing leakage and extending CO_2 storage duration.
- Reduce transportation demands for important operations.
- Use collected CO_2 for specialized uses, such as increased oil recovery.
- Methods for reducing waste and environmental impact.

To get a patent, the claimed innovation must be non-obvious in comparison to the previous art. To establish that the invention is novel, the patent application should explicitly state how it improves or gives an advantage over previous technology. Carbon capture, utilization, and storage methods may give the following advantages:

- Improved selectivity for CO_2 capture and removal
- Improved efficiency in storing captured CO_2.
- Increased CO_2 capture rates from air, seawater, or other sources
- Improved CO_2 chemical conversion rates to valuable products
- Higher efficiency (e.g., low energy consumption, high faradic efficiency, and high carbon capture efficiency)
- Reduced environmental effect and physical footprint.

- Improved CO_2 usage in industrial, energy conversion, and storage applications

The outlook for the carbon capture, utilization, and storage (CCUS) market appears optimistic, fueled by ongoing technological advancements, favorable policies, and growing investments. It is projected that by 2030, the global annual CO2 capture capacity could approach approximately 800 million tons, making a substantial impact on global climate change mitigation efforts. The integration of CCUS with renewable energy sources and the advancement of new materials and capture techniques will be pivotal for the market's advancement and success.

Below are some of the latest innovations and future trends shaping this crucial industry:

1. Advancement in Direct Air Capture- Direct Air Capture (DAC) is emerging as a promising technology for extracting CO2 directly from the atmosphere. Companies such as Climeworks are leading the way, building facilities that dramatically enhance carbon removal capabilities. For example, Climeworks' Mammoth plant in Iceland is designed to capture up to 36,000 tons of CO2 annually, marking a tenfold increase compared to its predecessor, Orca. This progress underscores the potential for rapid expansion and the establishment of gigaton-scale facilities by 2050, which could significantly contribute to lowering atmospheric CO2 levels.
2. Integrated Capture and Conversion Technologies- Advancements in integrated capture and conversion technologies are transforming the CO2 capture field. Researchers are pioneering systems that not only capture CO2 but also convert it into valuable products like methanol and polyurethanes. This integration simplifies operations and decreases expenses, enhancing the economic feasibility of carbon capture. For instance, novel solvent-based systems can capture over 90% of CO2 efficiently and convert it into methanol through a single, continuous process, which substantially reduces costs compared to conventional approaches.
3. Diverse Carbon Capture Methods- The expansion of carbon capture methods is reducing risks and broadening the scope of applications for these technologies. Researchers are investigating a range of techniques, such as capturing carbon in biomass, utilizing minerals, and employing engineered synthetic methods. This diversification enables the creation of customized solutions that can address diverse industries and emission sources. For example, capturing CO2 from cement kilns and

transforming it into sustainable building materials represents a promising area of research and development.

4. Scalability and Cost Reduction- A prominent trend in CO2 capture technology involves emphasizing scalability and cost-effectiveness. Innovations are geared towards making these technologies more economically viable and capable of widespread implementation. Key strategies include the advancement of cheaper solvents and integrated systems that streamline the process steps. For instance, recent breakthroughs have led to CO2 capture systems operating at approximately 75% of the cost of conventional technologies, thereby expanding their applicability across a broader array of industries.

Challenges Faced in protection of Patents and other Intellectual Property Rights for CCS

India, as a member of the World Trade Organization and party to the accord on Trade-Related Aspects of Intellectual Property Rights (TRIPS), is required to align its intellectual property rights legislation with the TRIPS accord. The issue stems not only from the creation of laws, but also from their execution since the Indian government must find a balance between the demands of the country's population and the rights of patent holders. Given that foreign corporations file the vast majority of patent applications in India, the issue has become very contentious. For example, the Indian IP office's annual report for 2017-2018 reveals that foreign applicants filed more than twice as many applications (32,304) as Indians.

In the previous five years, the present administration, led by Prime Minister Narendra Modi, has worked hard to bring about visible change in the IP environment. Begin with implementing National Intellectual Property Rights policy and creating a Cell for IPR Promotion and Management (CIPAM) to work toward IP policy objectives. In addition to clearing the backlog of patent and trademark applications, the government has embarked on a vast digitisation project, employing a sizeable number of examiners, resulting in an exponential growth in patent examination and award.

Facilitators have been hired to encourage start-ups to preserve their intellectual property and file patent applications. Despite government efforts, global firms continue to advocate for stronger intellectual property protection. The expectations are summarized in a Special 301 Report produced by the Office of the United States Trade Representative (USTR), which places India on the "priority watch list". According to the study, "India has taken initiatives over the last year to address intellectual property (IP) concerns and improve IP protection and enforcement.

Moreover, protecting patents for Carbon Capture and Storage (CCS) systems presents various issues due to the technology's complexity and novelty, the interdisciplinary character of the sector, and the changing legal and commercial situations. Implementing carbon capture and Storage (CCS) Technologies is crucial for mitigating the harmful effects of climate change caused by rising global temperatures. Despite its significant potential benefits, the adoption of

CCS has been slow. [24] The successful implementation of CCS technologies relies on several crucial factors, such as economic feasibility, public acceptance, technological advancement, and environmental impact. [25] Therefore, it can be concluded that CCS is a complex system encompassing not only the technical aspects of capture, transport, and storage but also an organizational framework that involves a diverse group of people, including workers, managers, and all other stakeholders.[26]

<u>Main challenges faced in carbon capture and storage:</u>

Key challenges in carbon capture and storage (CCS) encompass cost, technical difficulties, safety concerns, storage capacity, and regulatory requirements. Public perception also poses a challenge, as critics question its safety and effectiveness. Furthermore, CCS is sometimes viewed as a diversion from efforts to reduce emissions through renewable energy and improved energy efficiency. [27]

a. Commercial Challenges-

As a new and costly technology, CCS encounters numerous commercial challenges that have hindered its widespread adoption. The current expenses associated with capturing and storing CO2 are often prohibitively high, especially for smaller industrial facilities or power plants. Consequently, many companies are hesitant to

24. IJCOE Volume8, Issue4; Pages 18-30

25. Karayannis, V., Charalampides, G., & Lakioti, E. (2014). Socio-economic aspects of CCS Technologies. Procedia Economics and Finance, 14, 295–302. https://doi.org/10.1016/s2212- 5671(14)00716-3

26. Samadi, J., & Garbolino, E. (2012). Development of a Systemic Risk Management Approach for CO2 Capture, Transport and Storage Projects (thesis). Sciences et génie des activités à risques, Paris

27. Challenges of CCS, Clean Energy/Carbon-Capture, published by Solartronisa invest in CCS technology due to doubts about its economic viability. Although some governments have funded CCS projects, many companies contend that further incentives, such as tax credits or subsidies, are necessary [28]

b. Human and Structural Challenges-

Socio-political acceptance refers to the widespread approval of policies and technologies by key social actors, including policymakers and the general public. In contrast, market acceptance is more specific, focusing on the adoption of innovations by consumers and the investment decisions made by those operating in national and multinational markets. Based on a survey, the main challenges attributed to social acceptance revolve around human and organizational behaviours. These obstacles can be summarized as follow:[29]

1. The cost and recovery of expenses,
2. The absence of a financial incentive,
3. The presence of risks of long-term liability, and
4. The lack of an all-encompassing regulatory framework

The primary challenge to the widespread adoption of CCS technology is "the expense related to its deployment" [30]. Reducing the cost of CO_2 capture is essential for lowering the overall cost of CCS, as it constitutes approximately 70% of the total cost. The operating expenses of CCS are significantly higher than the capital costs due to the commercial prices of fuel and electricity. Utilizing the energy generated by the facility could reduce these operating expenses. [31]

c. Investment Challenges-

- Lack of financial incentives for investing in carbon dioxide capture and storage.
- Cross-chain risk is a potential issue. The government can mitigate this risk by either directly investing in shared transport and storage infrastructure or by creating a regulatory framework that facilitates cost-effective network development.

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28. Challenges of CCS, Clean Energy/Carbon-Capture, published by Solartronisa

29. Davies, L. L., Uchitel, K., & Ruple, J. (2013). Understanding barriers to commercial-scale carbon capture and sequestration in the United States: empirical assessment. Energy Policy, 59, 745–761. https://doi.org/10.1016/j.enpol.2013.04.033

30. Budinis, S., Krevor, S., Dowell, N. M., Brandon, N., & Hawkes, A. (2018). An assessment of CCS costs, barriers, and potential. Energy Strategy Reviews, 22, 61–81.

31. Kimura, S. A. S., Shinchi, K., Coulmas, U., & Saimura, A. (Eds.). (2022). (rep.). Study on the Potential for Promoting Carbon Dioxide Capture, Utilisation, and Storage (CCUS) in ASEAN Countries Vol. II. Jakarta: ERIA.

- The absence of a clearly defined legal and regulatory framework outlining the liabilities of carbon dioxide storage operators may create long-term liability risks, deterring private sector investment.
- Insufficient financial support through grants, concessional loans, accelerated depreciation, or other mechanisms to attract private investment in carbon capture and storage projects.
- Inadequate identification and evaluation of additional policy measures to mitigate specific financial risks.
- Lack of research data and information to assess the impact of various risk categories on the cost of debt, discouraging private sector investments.

d. Technical Challenges-

From a technical standpoint, the performance or quality of one component in a system can influence other components. For example, the quality of the capture stage can determine the level of impurities in the system. This can result in issues such as corrosion during transport and injection, as well as affecting the long-term geochemistry of the storage. [32] Regarding CO2 utilization, there are two main goals for increasing urea yield. First, the fluctuating prices and demand for urea and NH3 make long-term assessments challenging. Second, there is the potential issue of high capital costs associated with implementing CO2 capture infrastructure. [33]

Due to the additional energy required for the capture process, there will be an increase in emissions during transportation within the CCS life cycle because of the fuel. Due to the additional energy required for the capture process, there will be an increase in emissions during transportation within the CCS life cycle because of the fuel penalty.[34] For example, a significant increase in direct emissions of ammonia (NH3), a poisonous and toxic gas, is predicted compared to the non-CCS scenario.[35] "This can be a potential barrier, as energy system transition models aiming to limit global

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32. Paltrinieri, N., Wilday, J., Farret, R., Hebrard, J., & Breedveld, L. (2011). 22nd Institution of Chemical Engineers. In Carbon Capture and Storage: A Case Study of Emerging Risk Issues in the iNTeg-Risk Project (Ser. Symposium Series No. 156). Liverpool; Hazards XXII

33. Hong, W. Y. (2022). A techno-economic review on carbon capture, utilisation and storage systems for achieving a net-zero CO2 emissions future. Carbon Capture Science & Technology, 3, 100044.

34. European Environment Agency. (2011). (tech.). Air pollution impacts from carbon capture and storage (CCS). Copenhagen.

35. European Environment Agency. (2011). (tech.). Air pollution impacts from carbon capture and storage (CCS). Copenhagen.

warming to below 2°C estimate that without CCS technology, 26% of fossil fuel reserves will be consumed by 2050. However, with CCS technology, the estimated consumption of fossil fuel reserves by 2050 rises to 37%"[36]

e. Infrastructural Challenges-

Suitable storage sites can be remote, necessitating the transportation of captured CO_2 over long distances via a network of pipelines. Constructing and maintaining these pipelines can be costly, and public resistance to their construction is possible. Similar cost concerns apply to the storage infrastructure, as even existing geological sites may require adaptation for safe CO2 storage and monitoring to prevent leakage. Furthermore, integrating CCS infrastructure with existing facilities, such as power plants or industrial sites, can be complex and expensive.[37]

Main challenges faced in Patent with respect to CCS:

The patent landscape in the CO2 capture industry is dynamic and constantly evolving, showcasing substantial innovation and investment in this crucial field.

Analysing data from various patent records offers valuable insights into the leading players, geographic distribution, and types of patents that are shaping the future of carbon capture technologies.

There has been debate over whether CCS technologies should be classified as clean technologies for purposes of patent law and mechanisms like green fast-tracks. This technology has raised concerns regarding patent validity, infringement, licensing, and bankruptcy. Additionally, discussions have emerged about the role of patent exceptions, including technology transfer, public sector licensing, patent pools, compulsory licensing, and competition oversight.

Few of the challenges are as follows-

a. Complex Patent Landscape- The CCS technology space is crowded with numerous patents, leading to "patent thickets" where multiple patents cover similar technologies or aspects of a process. Innovators may face difficulties in navigating overlapping patents, which can complicate the development and commercialization of innovative technologies.

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36. Havercroft, I. (2019). (rep.). Lessons and Perceptions: Adopting a Commercial Approach to CCS Liability. Global CCS Institute.

37. Challenges of CCS, Clean Energy/Carbon Capture, published by Solartronisa.

b. Patent Blocking- Key patents held by competitors can block other companies from entering the market or developing similar technologies without risking infringement. Negotiating cross- licensing agreements can be time-consuming and expensive, potentially hindering innovation and collaboration.

c. Cost of Filing and Maintenance- Filing and maintaining patents, especially across multiple jurisdictions, can be prohibitively expensive for small and medium-sized enterprises (SMEs) and startups. The costs associated with defending patents or negotiating licenses can be significant.

d. Regulatory Hurdles- Differences in patent laws and regulations across countries can create challenges for global deployment of CCS technologies. Ensuring compliance with diverse regulatory requirements can increase the costs and complexity of patent management.

e. Open Innovation Models- Traditional IP models may resist open innovation approaches that could accelerate CCS technology development. Finding the right balance between protecting IP and fostering collaboration is challenging but crucial for rapid advancement.

Dissemination of Knowledge of Patents and Technology for CCS

Environmental Sustainability, defined as meeting the needs of current and future generations without compromising ecosystem health, is always a significant issue for the public, policymakers, and researchers. In the U.S., CCS technology has been developed as a key technology in the fossil fuel R&D programs of the U.S. for over a decade, there were 150 projects related to CCS technology carried out in the U.S. between 2000 and 2008, the total investments doubled from USD 20 million per year in the beginning of the millennium to USD 40 million in 2005, after that, investments in CCS rose to nearly USD 140 million in 2008 [38]. Therefore, as one of the countries, who has demonstrated the strongest interest and highest level of investment in CCS technology [39], the U.S. also takes a leadership role in the patent activities of CCS technology. In China, as the largest emitter of CO_2 in the world, it is necessary to deploy the CCS technology, actually, China is promoting the demonstration projects of CCS.

38. Alphen, K.V.; Noothout, P.M.; Hekkert, M.P.; Turkenburg, W.C. Evaluating the development of carbon capture and storage technologies in the United States. Renew. Sustain. Energy Rev. 2010, 14, 971–986.

39. Chaudhry, R.; Fischlein, M.; Larson, J.; Hall, D.M.; Peterson, T.R.; Wilson, E.J.; Stephens, J.C. Policy Stakeholders' Perceptions of Carbon Capture and Storage: A Comparison of Four U.S. States. J. Clean. Prod. 2013, 52, 21–32

technology in recent years [40]. As a result, in the field of CCS technology, the technological innovation and its patent protection are strengthened in both countries. It also can be seen from the figure that, although the annual trend of patent counts for CCS technology between the United States and China are similar, the patent activities of CCS technology in China is slower than that in the U.S.

In addition, the development of CCS technology will depend on both internal and external conditions, the former includes the performance effectiveness and economics, and the latter includes the emission-reduction target, unit price of emission allowance and economics of technology [41]. Therefore, the fluctuation of patent number after 2010 may to some extent reflect the attitude and its changes toward the acceptance and investment of CCS technology.

It is to be noted here that a patent document is published 18 months from the date of its filing. In other words, a patent document is held as a confidential document and cannot be searched by the public within 18 months of filing, the patent numbers of CCS technology in both 2016 and 2017 are incomplete. Therefore, the patent information in these years would not be treated in this study.

Case Study: GreenTech Solutions and the CCS Patent Ecosystem

Background

GreenTech Solutions is a technology business that specializes on environmental technologies. They are continuously studying and developing Carbon Capture and Storage (CCS) Systems, with the goal of making them more efficient and cost-effective. Their ultimate objective is to assist industry in lowering their carbon footprint while strengthening their position in the CCS Market.

Patent Strategy

GreenTech's R&D Department has created a new CCS process that combines chemical and mechanical ways to collect carbon dioxide with more efficiency and less energy usage. They recognize the significance of intellectual property and submit patents for their innovative

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40. Jaccard, M.; Tu, J.J. Show some enthusiasm but not too much: Carbon capture and storage development prospects in China. Glob. Environ. Chang. 2011, 21, 402–412

41. Koo, J.; Han, K.; Yoon, E.S. Integration of CCS, emissions trading, and volatilities of fuel prices into sustainable energy planning and its robust optimization. Renew. Sustain. Energy Rev. 2011, 15, 665– 672.

technology in numerous important locations, including the United States, Europe, and Asia. GreenTech attempts to get patents to protect its Intellectual Property, obtain exclusive rights to technology, and attract investment for future development and commercialization. Position yourselves as a market-leading vendor of CCS Technology.

Challenges

Despite having patents, GreenTech faces various hurdles. They are:

- Patent Fragmentation: The CCS Industry is complicated, with several business owning patents for different components of the technology. This fragmentation makes it difficult for GreenTech to traverse the Patent environment without infringing on other people's patents.
- Licensing Fees and Legal Concerns: As GreenTech attempts to market its invention, they face significant licensing fees and legal concerns owing to potential patent infringement. This may discourage investors and hinder the acceptance of their technology.
- Collaboration Barriers: Because patents are private, they might make it difficult to collaborate with other corporations or academic institutions, slowing CCS development in general.

Collaborations and Solutions

To solve these difficulties, GreenTech considers a numerous strategy:

- Patent Pooling and Licensing Agreements: GreenTech has formed a patent tool with other CCS Technology vendors. This enables them to exchange patents, lowering the risk of infringement while encouraging joint innovation. GreenTech has an open innovation strategy, enabling other firms and researchers to utilize parts of its patented technologies under certain conditions. This strategy encourages wider CCCS usage while preserving control over essential technology.
- Government Collaboration and Policy: GreenTech collaborates with government agencies to establish policies that promote CCS adoption. They advocate for incentives and legislation that encourage collaboration and ensure unrestricted access to vital CCS Technology.

Outcome

GreenTech delivers a number of results through coordinated efforts and effective patent management:

- Increased Innovation: By participating in a patent pool and adopting open innovation, GreenTech encourages a collaborative atmosphere that leads to greater advances in CCS.
- Wider CCS Adoption: The removal of Patent-related restrictions and government backing for CCS encourages widespread adoption across sectors.
- Industry Leadership: GreenTech established itself as a CCS Industry leader, illustrating how a well-balanced patent strategy can promote corporate success and environmental benefit.

This case study demonstrates how CCS firms may use the patent system to foster innovation while overcoming fragmentation and cooperation problems. It also emphasizes the need of legislation and collaboration in increasing CCS implementations for a more sustainable future.

Conclusion

The CO_2 capture technology landscape is dynamic and evolving swiftly, marked by significant advancements and promising trends that point toward a sustainable future. Innovations in direct air capture, integrated capture and conversion systems, and diverse methods for carbon capture are paving the way for more efficient and economically viable solutions. Supportive policies and substantial investments are pivotal drivers of this progress, creating an environment conducive to the flourishing of cutting-edge technologies.

Looking ahead, the scalability and cost-effectiveness of these technologies will be crucial for their widespread adoption. The ongoing integration of carbon capture with renewable energy sources and other low-carbon technologies will be essential in achieving global climate objectives. Continued commitment to research and development, underpinned by robust policy frameworks, will ensure that CO_2 capture remains a cornerstone of our efforts to combat climate change and transition toward a sustainable energy future.