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KNOWLEDGE IN ACTION

Faculty of Business Economics

Master of Management

Master's thesis

Systematic review of the effect of renewable energy policies on innovation in China

Zander Rectem

Thesis presented in fulfillment of the requirements for the degree of Master of Management, specialization Strategy and Innovation Management

SUPERVISOR :

Prof. dr. Stephan BRUNS

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This master thesis was written during the COVID-19 crisis in 2020-2021. This global health crisis might have had an impact on the (writing) process, the research activities and the research results that are at the basis of this thesis.

Preface

This master thesis is the final challenge of my study Master of Management with a major in Strategy & Innovation at the University of Hasselt. The research topic, "Systematic review of the effect of renewable energy policies on innovation in China ", was not my first choice, and since this topic and the methodology was completely new to me it demanded a lot of effort and determination. I learned a lot about policies in China and got rid of a lot of prejudice along the way. I had the opportunity to learn how to systematically find and assess a lot of studies which can be a handy skill for my further career development.

I am grateful for all the help from my supervisor, Stephan Bruns, who was always willing to answer all my questions and give constructive feedback when needed. Next to that, I'm thankful for my friends, family, and my girlfriend. I want to stress that my studies were all made possible due to the support of my widow mother, I will be forever in your debt.

The pandemic had a big impact on everyone, and for me personally, it completely ruined my business where I have put 3 years of my life and soul into. This resulted in a lot of time issues, stress and other unpleasantries related to this master thesis. Without the support of everyone, I could not have achieved finishing this master thesis during the pandemic.

Abstract

Introduction

The main pollution source in China is fossil fuel combustion, this has a significant impact on climate change, the local environment, and human health. A suitable solution is to convert current energy systems to renewable energy sources, this way it is possible to create electricity without producing CO2. The change requires a lot of technical innovation. Therefore, research needs to be done regarding the innovation drivers. The scope of this thesis is limited to policy intervention on innovation. This master thesis presents a systematic review of the effects of renewable energy policies on innovation. The outcome of the intervention method is measured in patents. The research question is the following: What is the effect of renewable energy policies on innovation in China?

Method

This systematic review uses reporting standards for systematic evidence syntheses for environmental standards (ROSES), to ensure the highest possible reporting standards. ROSES follows a sequential pattern. The first step is creating a search string and choosing databases, I chose the "Web of Science" database. Second, inclusion and exclusion criteria for the articles need to be defined. This is followed up by text screening; first a title and abstract screening, and next a full-text screening. While doing this, every article that has been included or excluded needs to be saved in a list, so the study is replicable.

Findings

The first search gave 293 articles, after removing duplicates, removing articles with an unretrievable text, and excluding non-relevant articles according to the inclusion criteria, 20 relevant articles remained. Then I conducted a data synthesis on the remaining articles. The data synthesis method I used is narrative synthesis. I extracted certain variables such as article title, author, policies, type of research, and innovation outcome in the form of patent measurement. The outcome was then classified into separate renewable energy technology groups, this way it is easier to see if there are contradictory values in the remaining articles. The technology groups consist out of alternative energy, waste management, energy conservation, other green technologies, and others.

Important findings show that China is a latecomer to the renewable energy market, but China has booked significant innovation progress. China booked significant innovation progress in every renewable energy technology identified in this thesis. In 2018, China filed the most renewable energy patents globally. The results show that renewable energy policies in China have a significant positive effect on innovation. China has become the world's biggest manufacturer in wind energy and solar energy technology, but mainly through international in-licensing.

While analyzing, a couple of policies reoccurred or were mentioned as a driver of innovation. The "Renewable Energy Law "(2006) was mentioned multiple times as a significant positive effect on

innovation. The Five-year development plans were also mentioned several times as important factors for innovation in multiple different energy technology groups. These Five-Year guidelines are very important because they can prioritize certain renewable energies, and thus are a strong policy instrument.

The results also show that subsidies have a significant positive effect on innovation and play an important role in new-energy firms, namely innovation subsidies. Multiple studies also mention that China uses a lot of push, pull, and environmental policies, which all show to have a significant positive effect on innovation, with an important one being feed-in tariffs. This shows a correlation with significant innovations in mature and novel technologies.

One of the most polluting industries is the vehicle industry, China has invested a lot in the new energy vehicle industry and owns a high patent share. China has enacted multiple policies to stimulate innovation in this industry, an important one is the 12th Year with a focus on manufacturing and deploying 500000 vehicles. China is the world's biggest automobile manufacturer, and they invest heavily in this sector because China wants foreign oil independence and it wants to reduce emissions (Gao et al., 2017).

Despite the great innovation leaps, China still has not caught up with leading countries in innovation in a lot of areas. China shows to only have two percent of solar energy patents grants worldwide between 2002 and 2015 and only one percent in wind energy but is an emerging player in the renewable energy market.

Value of the study

The contribution of this research is that it highlights possible advantageous policies for innovation in renewable energies, this can be of interest for policymakers in emerging countries to shape the renewable energy landscape in the future. The findings can be used by the policymakers that plan to improve innovation. The results show a broad overview of policies and their effects. The research also shows the significant role that policies play in developing renewable energy technology.

Limitations

Creating a systematic review with ROSES is normally made by multiple people, this systematic review is done by one person. Therefore, consistency checks with multiple people have not been performed in the article screening process. There was only one database used in this screening process. Next to that, this paper was written with certain deadlines and time restrictions. The data gathered is dependent on the correctness of existing papers, therefore it is not sure if all data is reliable data. In this study, innovation is measured in the patent count or with a correlation with papers, which sometimes fail to grasp the full amount of innovation. Not every invention is patented, and the value of each patent is not clear. Lastly, English is my second language, and this can be a deficiency because a lot of these studies were very technical, and sometimes it was difficult to interpret everything.

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1. Introduction

China is the most polluting country in the world regarding CO_2 emissions (World Resources Institute, 2021). China has a very high amount of air pollution, ozone pollution, and fine particles (PM2.5) in the air and these have a significant impact on the local environment, climate change, and human health (Gao et al., 2017; Jia et al., 2017; Yihui, 2006). The main pollution source is fossil fuel combustion in diverse sectors (Lei et al., 2011; Zhai et al., 2012). The other big problem is that fossil fuels are not a sustainable energy source. Research from Kuo (2019) shows that there is a limited amount of these exhaustive resources. The research predicts that by 2090 coal, oil and gas will be depleted. This means that countries must look into alternative energy sources.

Renewable energy is considered an alternative to fossil fuels. It produces minimum emissions and is a sustainable energy source (Panwar et al., 2011). It is becoming a prominent factor in the fulfillment of energy demand (Bull, 2001). There are multiple sources of renewable energy such as solar energy, wind energy, hydropower, geothermal energy, tidal energy, and ocean thermal energy (Twidell & Weir, 2015). Switching to alternative energy is not an easy task and a lot of strategies will be involved. Lund (2007) says that converting all present energy systems to renewable energy systems is possible, but a lot of technological innovation is needed to realize this goal. This implies that investment for innovation in renewable energy sources is very much needed. Consequently, policies should offer an incentive to innovate in this area.

Policies, innovation, and patent laws go hand in hand (Archibugi, 1992). When looking at the innovation side, it is considered that patent count is an indicator for innovation (Archibugi, 1992). But there are some issues with patents in China; Hall (2018) says that China is a controversial country regarding patent laws because it is known to duplicate a lot of items from existing brands. They are liable for over 86 % of counterfeit goods globally. But in the latest years, they have strengthened their patents laws, and the government has started a war on fake items (Hall, 2018; Zhao, 2015).

Zhang et al (2013) say that the current renewable energy market in China is very diverse, in some areas China is becoming a world leader, but in others, it is still lagging. Next to that, China appears to be the manufacturing leader in wind and solar energy technologies, but under-deployment in the domestic country has occurred (Heggelund, 2021). In 2012 the energy mix of China existed out of 66.2% coal as primary energy consumption, it was a trade-off between fast economic growth and sustainable development (Clark & Cooke, para. 73).

China has issued several initiatives for renewable energies in the infamous five-year plans. Five Year-plans are important guidelines for social and economic development, they map strategies and set growth targets and contain detailed guidelines for all its regions (Kennedy & Johnson, 2016). These plans are already shaping China’s economic market since 1953.

In 2018 China has filled the greatest number of patents for renewable energy technologies, 7544 patents (Statista, 2019). This shows that the innovation rate is growing. Therefore, it is important to check what the existing policies are and how they affect innovation. This can offer interesting insights for policymakers in emerging economies. To do this the method of systematic review has been chosen, because it gives a broad look into the materials, it is repeatable, and it minimizes bias. This systematic review tries to provide a look into policies for renewable energy in China and what kind of effect they have on innovation. Throughout the thesis **the research question**: "What is the effect of renewable energy policies on innovation in China?" will be discussed and answered.

2. Objective of the review

The general objective is to identify the relationship between renewable energy policies and innovation in China. The measurement of innovation will be patent count. The scope of the analysis will be limited to renewable energy sources. These mainly include solar energy, wind energy, hydropower, and geothermal energy (Twidell & Weir, 2015). To reach the objective studies will be identified, summarized, and analyzed in a systematic approach. After doing this the thesis can provide an answer to the research question: What is the effect of renewable energy policies on innovation in China?

3. Methods

Systematic reviews try to identify studies and findings, summarize them, and analyze them (Tutt Library Colorado College, 2021). This methodology was chosen because with this method I can identify and synthesize all relevant data to answer my research question (Poklepović & Tanveer, 2019). The methodology minimizes bias and makes research replicable. The field of renewable energy offers a lot of existing literature, and the research question is clearly defined with PIO (Teesside University, 2019). This approach implies that the research question can be answered and that a systematic review is a suitable method for this study.

This systematic review is conducted based on the protocol for reporting standards for systematic evidence syntheses (ROSES) (Haddaway et al., 2017). ROSES aims to improve the standards of reporting for fields related to environmental research. This standard ensures that systematic reviews are qualitative and replicable.

3.1 Creating the research question

Before looking for articles and other materials in a field, one must result to creating a research question. For this master thesis, the forming of the research question was done by using the PIO framework (Teesside University, 2019). PI(C)O is a framework that tries to help with constructing a clear and good research question.

Population	China
Intervention	Renewable energy policy
Outcome	Innovation

Table 1: PIO method used to form the research question

After doing the method the following research question was created.
What is the effect of renewable energy policies on innovation in China?

3.2 Search strategy

This systematic review was conducted with the database of the "Web of Science" between October 2020 till July 2021. Access was granted through the institution of UHasselt. First, keywords and synonyms were identified and then combined to create a search string. This search string was then entered on the advanced search option on the Web of Science. Next, the results were screened, and data were extracted.

3.2.1 Search string

A search thing is a group of text or words that can be inserted into a search engine to find corresponding results. Multiple search strings were tested and can be found in 'Appendix A'. In this research, the search string in Table 2 was created for the advanced search option of the "Web of Science".

China is included in the search string since it is the population I am researching. Renewable energy policy on its own excludes a lot of articles that do not tag themselves as renewable energy policies, therefore wind, solar energy, and hydropower are included. Geothermal energy is another energy source but adding it to the search string shows no impact on the number of results. The outcome of this review is to check the effect on innovation. Soete and Wyatt (1983) say that innovation is often measured using patent count; therefore, a lot of studies mention only innovation in the metadata but nothing about patents. Energy consumption is not something useful for this study.

TS= (chin* AND (renewable energ* polic* OR wind energ* polic* OR solar energ* polic* OR hydro* energ* polic*) AND (innovation* OR patent *) NOT (energ* consum*))	293

Table 2: Search string used in this thesis

3.2.2 Screening

The screening of articles was divided into two main parts. First a title and abstract screening followed up by a full-text screening. Normally a screening for unretrievable text is done in the full-text screening, but in this case, it has been performed with the title and abstract screening because a lot of articles didn't appear to have an access link from my institution, or the abstract was completely missing. This has no influence on the outcome. The inclusion and exclusion criteria used can be found in Table 3. A full list of all articles and exclusion criteria can be found in 'Appendix B', and the outcome is shown in Figure 1.

Inclusion	**Exclusion**
The studied population is China	The studied population is not China
Articles that analyze the effect of renewable energy policies on innovation	Papers that propose policy options but show no research on existing ones
Renewable energy	Nonrenewable energy or nuclear energy
English language	Non-English papers
Domestic policies	Foreign policies, or no clear mention of renewable energy policies
Papers that measure innovation through patents or R&D in and output	Papers without any measurement of innovation
	Papers about energy consumption

Table 3: Inclusion and exclusion criteria

3.2.3 Critical appraisal

The remaining articles were subjected to a critical appraisal. The critical appraisal method will not exclude articles, rather show what kind of research has been done in every article. This way it can be distinguished if articles are empirical or theoretical. Empirical studies are studies with a lot of charts, tables and graphs, contain more than 5 pages with a clear structure, and are peer-reviewed (Tutt Library Colorado College, 2021). Theoretical papers make connections between multiple empirical studies or define a theoretical position (Tutt Library Colorado College, 2021).

3.2.4 Data extraction

For each search result the following data will be extracted: Author, date of publication, title, and possible reason for exclusion. This table can be found in 'Appendix B'.

Every selected article after full-text screening is summarized with some background information and then the variables "policy" and "outcome" are extracted in the 'Data analysis' section. Next to that, the research type is extracted and put in the 'Literature study' section.

4. Results

4.1 Flow diagram for systematic reviews

The Web of Sience Core collection returned 293 articles, with one duplicate.
After an abstract and title screening, and removing all unretrievable texts, 46 articles remained. Normally, checking if all full texts are accessible is done after abstract and title screening, but quite a lot of articles did not have an abstract. Therefore, I decided to incorporate this procedure with title and abstract screening. After the full-text screening, 20 articles remained. These 20 articles will now be summarized and analyzed in the following sections.

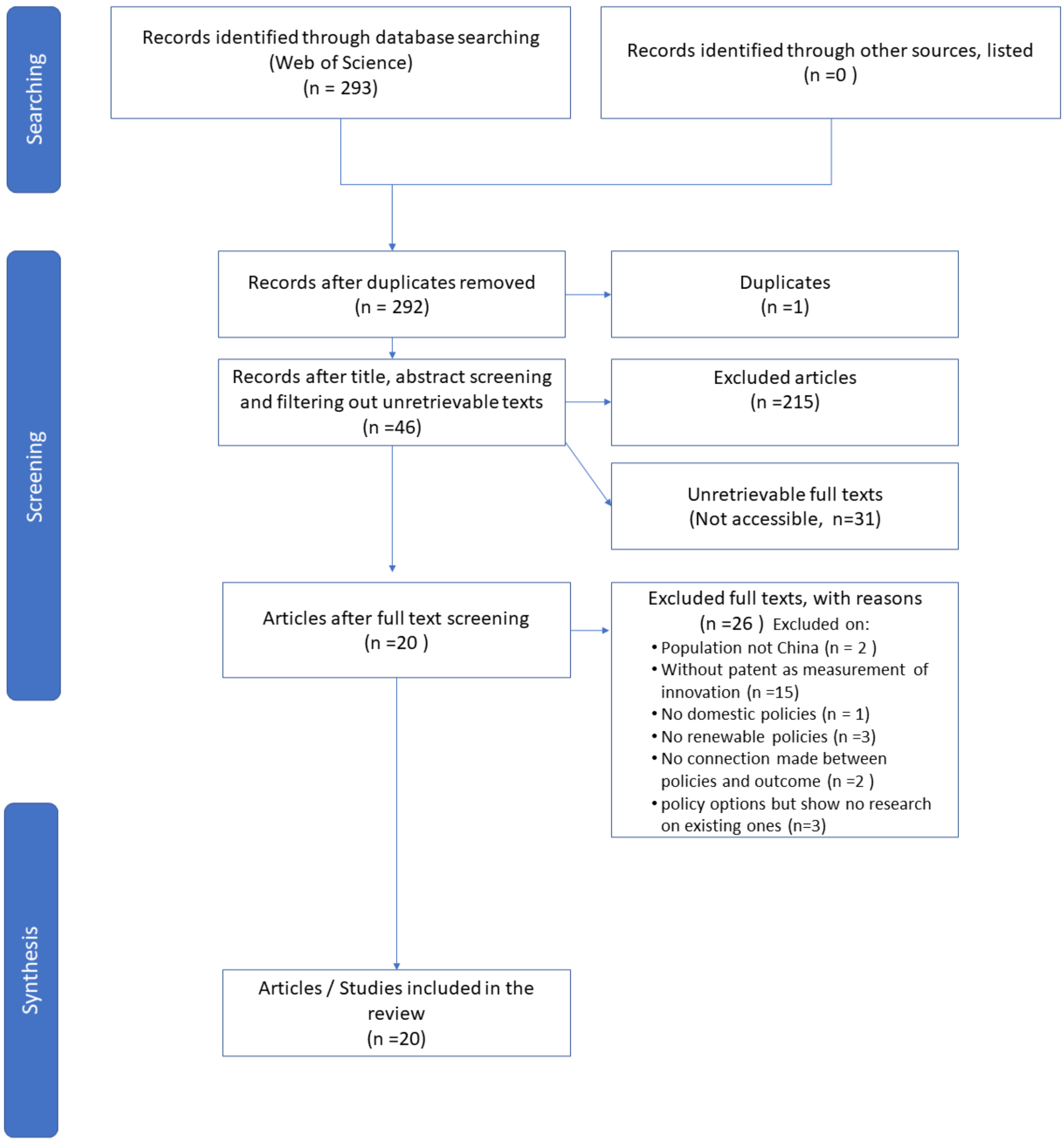

Figure 1: ROSES flow diagram for systematic review

4.2 Literature study

The literature study offers a brief summary of the selected articles. Next to that, they contain data about policies and their impact on innovation. Lastly, they show the type of research that has been done, as seen in the critical appraisal section.

1. Do government subsidies promote new-energy firms' innovation? Evidence from dynamic and threshold models (Li et al, 2021).

This paper focusses on the impact of government subsidies on new energy firms.
The research consists out of patent and R&D data from nine provinces located at the Chinese eastern coastal area and 18 provinces located in noncoastal area. During the research they divided the data from the noncoastal area and coastal area because the coastal area is relatively more developed and there is a more mature innovation environment. The methodology is innovation measured from the aspects of inputs and innovation outputs in a period of 5 years (2012-2016). When looking at the regression result of linear models for regional samples, the main findings are that government innovation subsidies have a greater effect than non-innovation subsidies in regards of innovation outcome. The effect of non-innovation subsidies is not significant.

Its main findings are that government subsidies have a great importance on firm's innovation, but since there are many factors to consider; it's not possible to predict the outcome of government subsidies a priori. Next to that, there exists a complicated nonlinear relationship between the effects of the subsidies and only when subsidies are within certain intervals, they can create an impact on a firm's innovation in- and output. Secondly, innovative inertia in the short term can be a great motivator for firm's innovation practices; Lastly, regional differences are important when creating policies.

The limitations of this study show that they don't show how they defined what is a non-innovation and an innovation subsidy. They also mention themselves that the classification was not optimal. Also, when doing the data analysis, it says they distinguish between the coastal and noncoastal area due to development reasons, but this is without citations and not substantiated; as an outsider you don't know if coastal areas are less developed or not.

Type of research: Empirical research

2. China's climate and energy policy: at a turning point (Heggelund, 2021)?

This article talks about 30 years of development in energy and climate policies in China. It maps the transition of fossil fuels to gaining traction in the renewable energy market. China utilizes FYPs (Five years plans) and Nationally Determined Contribution (NDC) objectives to conserve energy and control emissions. The 11th (2006–2010) FYP focused on energy efficiency to reduce consumption, but it came short in reaching the goals. The 12th FYP (2011–2015) green development and market approaches were deployed for renewable energy but coal was still favorited. The 13th FYP (2016-2020) put on goals for energy development to reduce coal, China has reached this objective. It also wants to control emissions with the air pollution action plan (2013–2017).

After the climate convention of 2015 in Paris, China developed objectives aimed at peaking emissions around 2030. Since then, coal consumption went down, and they have put in place air pollution control to bring back blue skies and improvements. Beijing opted for a national emission trading system as a policy tool to reduce emissions. Currently, China is the 'largest manufacturer, exporter, and deployer of solar panels, wind turbines, and electric vehicles, placing it as the world leader in renewable energy.

This success is thanks to subsidies and other advantageous policies such as the renewable energy law (2005). By 2017, China's renewable energy investment was more than 45 percent of the global total. In 2018, 13160 global patents were filed in the field of renewable energy, and 7544 were from China. But there is also a lot of curtailment in this field since thermal power plants still have priority over solar and wind plants. Economic growth has been the most important driver by far.

To address certain issues the government has issued some policies. In 2018, NEA gave the ' Clean Energy Consumption Action Plan' (2018–2020). This plan sets in motion that there must be a minimum number of hours purchases from renewable energy from photovoltaic, wind, and hydropower.

The vehicle industry has also seen a lot of innovation; a recent study found that motor vehicles give the greatest proportion of local atmospheric PM2.5. The article says that there are numerous policies that have been adopted to enhance the new energy vehicle market, like the 'Made in China 2025' strategy and policies for new-energy vehicles. China is building new infrastructure to lead in the rollout of freely available chargers and a fully electric bus fleet of 16000 vehicles is coming. There is no mention of patents in the vehicle industry in this article.

This article has not been cited a lot and has no strict framework on how to gather information.

Type of research: Theoretical overarching view, but not in a systematic approach.

3. Is China's industrial policy effective? An empirical study of the new energy vehicles industry (Liu et al., 2020).

China has imposed several policies to become competitive in the new energy vehicle (NEV) market. They analyze the overtaking on the curve strategy, a strategy designed to lead technological development in the NEV sector. It says that innovation can be measured in three ways; R&D in and out puts, patents, and direct measures of innovation output. They used data from 71 policies in the NEV sector launched by the government between 2006 and 2018. Since China was late on the market, they adopted a "overtaking on the curve" strategy. The strategy is meant to catch up with the global automobile industry by investing heavily into NEV and gaining core domestic technologies instead of a specialization in manufacturing. The article also concludes that the policies that have been used are giving a significant positive impact on innovation. These policies include policies for Research and development, taxation and finance. These have a good effect on growth Of NEV patents but the overtaking on the curve strategy did not meet expectations since they are still behind Japan. China shows significant patent share in NEV technology. Figure 2 shows the number of patents in the NEV industry.

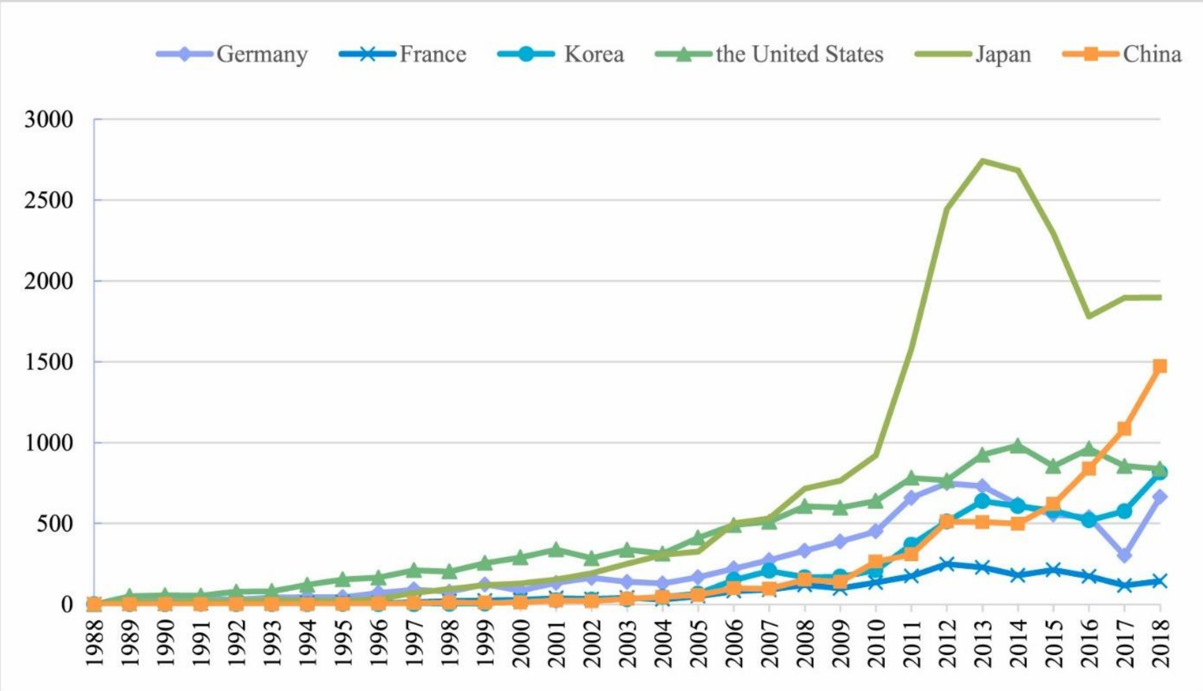

Figure 2: patent numbers in NEV for six countries (1988-2018)

Type of research: empirical study

4. Does the focus of renewable energy policy impact the nature of innovation? Evidence from emerging economies (Samant, 2020).

This paper talks about how policies impact innovation. The research shows that the implementation of certain policies has different impacts on the nature of innovation. China's government is known for using a lot of push-pull policies. China employed 92 new renewable energy policies between 2000 and 2013; 24 pull policies, 26 push policies, and nine general policies. The most used policy instrument is feed-in tariffs, this is a pull policy. The technology focus of policies is solar energy and exploring tidal energy. The objective is that China wants to be self-sufficient and builds capacity. China employs the following pull instruments in its policy mix: mandatory RE targets, feed-in tariffs, quality certification, financial and tax benefits to consumers, and government procurement. China employs the following push instruments in its policy mix: financial and tax benefits to local manufacturers, R&D funding, State-owned enterprises doing R&D, direct capital subsidies, capacity auctions, and R&D demonstrations.

Between 2002-2015 China had 159210 patents in renewable energy and 5163 novel technology patents. When comparing it with Brazil, India, and Turkey; China had the highest number of novel patents. The data analysis shows that countries with higher supply push policies have more novel technologies. Based on the research they created a matrix framework to classify innovations in four categories.

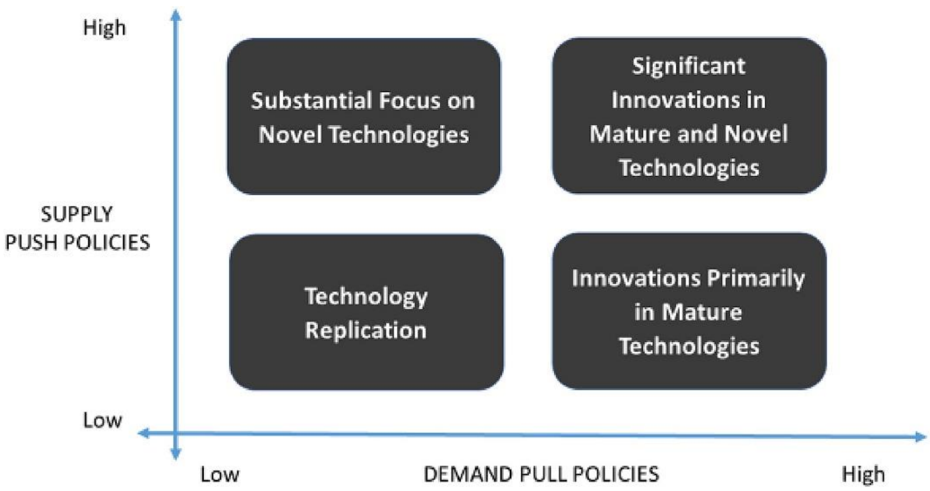

Figure 3: innovation matrix of emerging economies

Figure 3 shows an innovation matrix, this innovation matrix can be defined in four categories. Technology replication: pull and push policies are weak, with little incentive for innovation. Innovations primarily in mature technologies: policy focuses on domestic demand with some government support and also a focus on local market demand. Substantial focus on novel technologies: focus on supply push policies, support goes to innovation that helps industrial development. Significant innovations in mature and novel technologies with high demand-pull and supply push policies: policy motivates demand through pull policies but also encourages manufacturing and research and development through these policies. China can be placed in this quadrant. It is the most mature way in the matrix.

The limitation of this study is that they use data from other past research and it's difficult to categorize renewable energy technologies as novel or mature. The sample size is also limited, and the research can be improved by quantitative statistical analysis.

Type of research: Empirical research

5) Green technology innovation development in China in 1990–2015 (Wang et al,2015).

This paper researches the development of green technology in China from 1990-2015 using patent counts. The innovation in green technology made significant progress in areas of water and waste management and the solar photovoltaic sector. The growth trend of research and development expenditure is linear with the growing trend of the GDP per capita. After economic development reaches a certain level, a shift towards more innovation and green technology happens. Innovation in the field of climate change is currently more than environmental management and water-related technologies. However, the sector is not big enough to become reliant on soon.

The innovation activities of China and environment-related technologies are a growing trend, and the growth rate is one of the highest globally. Figure 4 shows the growth of selected green technology patents among different countries. This growth has a correlation with "China's National Climate Change Program" which controls the export of pollution-intensive products and counter the expansion of polluting firms. Although there is a positive shift in green development, China needs to improve more seen from the perspective of the Environmentally Adjusted Multifactor Productivity indicator. China relies too much on production capital and natural capital instead of productivity improvement and this is a gap that needs to be filled.

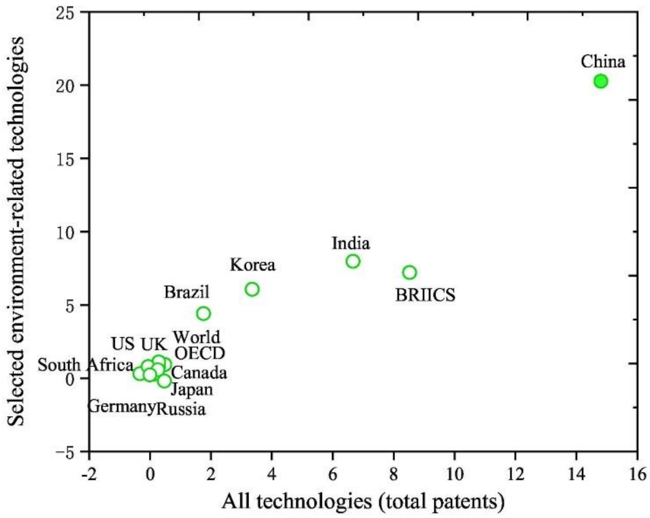

Figure 4: environmentally related technology patents between 2000-2015

Type of research: empirical research

6) How will different types of industry policies and their mixes affect the innovation performance of wind power enterprises? Based on dual perspectives of regional innovation environment and enterprise ownership (Wang et al, 2019).

This article talks about wind power industry policies issued by departments above the ministerial level. This study reaches from 2001 to 2016 and incorporates 241 policies about policy mixes on the innovation performance of WPEs. The study finds that policy mixes offer the best performance in areas with weak innovation environments. However, there is little gain from implementing policies in areas with strong innovation environments and government-managed companies in areas with weak innovation environments. Supply-side policies dominate China's wind power policy framework.

The development plan from the Five-years plans seem to set China's wind power goals and effectively promote innovation. There are a couple more important development plans mentioned that have effectively promoted innovation for wind energy enterprises: "the Medium and Long-Term Development Plan of Renewable Energy" (2007)," the Twelfth Five-Year National Strategic Emerging Industry Development Plan "(2011–2015), and the "Twelfth Five-Year Wind Power Development Plan" (2012).

The study finds that the innovative performance of single demand-side policies (DSP) and environmental side policies (ESP) gives negative effects on wind power enterprises. Single supply-side policy (SSP) shows a positive, significant effect on innovation performance. The regression outcome of finds that mixes of SSP and ESP, mixes of SSP and DSP, as well as mixing them all have significantly promoted the innovation performance of WPEs. ESP and DSP mixes show a negative effect on innovation. This means that SSP can compensate for the negative impact of ESP and DSP on innovation performance.

Type of research: empirical research

7) Impacts of policies on innovation in wind power technologies in China (Lin, 2019).

This study researches the effect of feed-in tariffs, research and development spending, and their connection and interaction. Policies play an important role in innovation in wind energy, this research shows the impact of Chinese policies on wind power energy. The data used is from 2006 to 2016.

The results show that demand-pull policies by the means of feed-in tariffs have a significant positive effect on wind power technologies. If prices for feed-in tariffs are higher, the number of patents in wind energy will grow. Deploying more wind power results in more patent growth. By making electricity prices higher power manufacturers will need to innovate to reduce costs. R&D funding in companies (feed-in tariff policy) can stimulate greater patent growth because the wind power industry enterprises are gainers for feed-in tariff policy. This means that that there is an interaction effect.

Type of research: empirical research: negative binomial fixed effect regression model

8) Local demand-pull policy and energy innovation: Evidence from the solar photovoltaic market in China (Gao, 2019).

Local demand-pull and supply policy are important factors for innovation. This research talks about Local demand-pull policies in the photovoltaic (PV) market in China and correlates them with related balance-of-system patents. These patents include all components of the PV system other than the photovoltaic panels. The solar photovoltaic balance of system market has seen significant growth from 2005 till 2014, with patent count increasing up from two to 567. A big leap happened in 2011, the patent count went up from 155 to 326 in 2012. This is a result of a policy that changed large-scale photovoltaic to distributed PV rollout. Thanks to the Chinese government's policies, installations of distributed PV in China increased 1.7 GW, starting if from 0.6 GW in 2011 to 2.3 GW in 2012.

The outcomes recommend that local demand-pull approaches for the PV market in China have essentially molded local innovation. In any case, the significant job of local demand-pull strategy in initiating advancement has been tested by the way that China has started to lead the pack in the PV module manufacturing industry even without an enormous PV market demand when PV production in China took off. The conclusion of the study is that only local demand significantly increases local innovation, with non-local demand not having a significant effect on local innovation.

Type of research: empirical research

9) Scientific linkage and technological innovation capabilities: international comparisons of patenting in the solar energy industry (Fan et al, 2017).

This study measures scientific linkage and technological innovation capabilities, existing out of Japan, the US, the EU, South Korea, and China. The study chose these countries because the amount of patent applications is very high in each one in the EPO database. It uses measurements in technological innovation capabilities and scientific linkage to analyze international competitiveness in the solar energy industry. The findings are that China was a latecomer and had a focus on technology-based innovation. China focused on certain technology portfolios to improve its technological innovation capabilities, increasing the R&D ventures and enhancing the R&D effectiveness of solar thermal technologies and other supportive policies of renewable energy development. When data is compared with the other countries, China comes out really strong in all three categories: relative growth rate, relative patent position, and revealed technological advancement. China has a high number of patents granted between 1973 and 2014: 80 011 patents in solar energy technologies. But a weak scientific linkage in comparison with early strong entrants like the USA.

Type of research: empirical research

10) Trends in patents for solar thermal utilization in China (Zhao, 2015)

This research focuses on technologies of solar thermal utilization (STU) and analyzes the relation between policy and patents with a database consisting out of 7373 patents. The STU sector has made successful progress regarding market development and patent applications, with the main driver being renewable energy policies. Eight laws, four development plans, and three technology standards are listed as the important policies related to patent growth in the STU sector between 1984 and 2006. Since 2006, the "Energy Saving Law" was set up and China started to zero in on the vital innovations of energy-saving and new energy. Accordingly, the creation of the tenth Five-year research project, the eleventh Five-year research project, and the twelfth Five-year research project effectively grew new energy advancement designs. Since the mid-90s, numerous spots across China have effectively executed a few approaches about environmentally friendly power steadily, for instance, tax reductions and subsidies, … The advancement of STU would get fiery help from all the levels of the government.

The STU sector consists of products that use solar radiation conversion to an alternative application. In this paper, they analyze the following representative technologies: solar water heating (SWH), solar cookers (SC), and solar space heating (SSH).

SWH patents started rapid growth after the "Renewable Energy Law" and the Eleventh Five-Year plan. SSH had a remarkable growth since "the energy conservation law" (1998) and "Renewable Energy Law", but SHH is still in an early stage. SC grew significant since 2005 thanks to the Eleventh Five-year Energy Development Plan and R&D-funded solar warm engineering projects.

Type of research: Analysis between patents and policies, empirical

11) The development of wind power in China, Europe and the USA: how have policies and innovation system activities co-evolved? (McDowall et al.,2013).

This paper shows how wind power developed in China, Europe and the USA.
Since the early 2000's China's wind power has started to grow significant. China was a latecomer to (mature) wind power. China took policies to catch up with other countries, three areas are important: Funding research and universities in and wind energy manufacturers though the Key technology program. The second one is support join ventures and other technology transfer mechanisms through the "Ride the wind" program. Thirdly, increasing licensing and other IP projects so that they have intellectual property of their own.

In China, the achievement of wind energy is better clarified because of Chinese government strategy than because of worldwide innovation move measures, for example, the CDM. The vital component for wind energy growth in China has been thanks seeing wind energy as a significant opportunity.

Another interesting finding of the study is that huge political and institutional work should go close by endeavors to give value backing and R&D subsidizing and that the constructions through which value supports and R&D financing are coordinated influence the elements of the development framework.

Patent data shows that the share of global wind energy patents in China between 1978-2007 is low compared to Germany, US, UK and Denmark and that China mostly manufacturers. In 2009, more than 450 million dollars flowed to other countries in the form of royalties, licenses, and technical consulting.

Type of study: Theoretical

12) Demand-side policy for emergence and diffusion of eco-innovation: The mediating role of production (Lee et al., 2020).

This article explains that the role of how exactly demand-side policy affects eco-innovation is unclear, but the study analyzes if demand-side policy affects production activities and if these production activities facilitate innovation in solar photovoltaics. The panel data used contains 14 countries from 1999 to 2016: Australia, Austria, Canada, China, France, Germany, Italy, Japan, South Korea, Netherlands, Spain, Switzerland, the United Kingdom, and the United States. Limitations are that data from China is less complete than other countries. To overcome this, the study analyzes data with and without data from China and checks the differences.

The research shows that production has a significant positive impact on environmental innovation. Next to that, there is also a positive relationship between production and demand side policy. Therefore, there is a positive indirect effect from demand-side policy on innovation. But there is an insignificant effect on direct innovation from demand-side policy on innovation. So, production is a mediator between their relationships. Public R&D is taken as a supply-side policy also shows a positive relationship regarding innovation. Electricity generation shows a negative impact on innovation due to patent proportion. The literature links this to the policies that started in 1980 to fund R&D for eco-innovation and reached around 1.8 billion dollars in 2015. China also started to use Feed In tariffs since 2009 which expanded onto national level in 2011 to stimulate the photovoltaic market.

Type of research: Empirical research: 3SLS regression technique

13) The technological system of production and innovation: The case of photovoltaic technology in China (Shubbak, 2019).

This paper uses 3 levels of analysis to study the innovation and the technological system of production in photovoltaics. The analysis is about the market dynamics of production and deployment, the institutional framework, and innovation-related activities. The results show the role of government policy instruments in developing domestic situations. The government domestic policy mix is divided into four main periods ranging from 1993 to 2017. The first period (1995 - 1999) focused on building a knowledge base for scientific reasons and regulations. The position of China was still relatively small. The second period (2000-2004) focused on rural electrification programs and establishment of solar panel production and strengthening innovation and R&D. This resulted in a growth of priority patents. The third period (2005-2009) was more market-oriented and focused on production and export. Thanks to the success of panel production, international expansion, and industry policies stimulated patent growth thanks to several laws and subsidies. Priority patents and transnational patents have experienced a lot of growth since 2007. The fourth period (2010-2014) policies stimulate the domestic market by creating grid infrastructure and subsidizing PV panels. The policies are divided into four types of institutional instruments: targets from the government, supply-push policies, demand-pull policies, and regulatory instruments such as laws. It mainlined the growth of both patenting activities.

The patent indicators use priority patent filings to capture the complete landscape of licensing activities and transnational patents that are applications filed at the European patent office and international applications which are expected to be of higher technological and economical value.

When we look at priority patent filings, we notice that China has accumulated notable growth since 2005, overtaking the traditional leader in priority patents, Japan, in 2011. But China is lagging in transnational patent applications with being only involved in 3% of the accumulated transnational patents during 1977-2012.

The connections between the PV production system of production and innovation conclude different findings. The institutions, market and innovation are completely connected, the results show a different pattern for environment. Direct influence of environmental aspects was found neither on market nor on innovation. Environment influenced them indirectly through institutions. There also couldn't be found a direct influence of institutions on environment. Nonetheless, there is indirect influence via the market dynamics or innovation.

When looking into detail, the positive effects of local institutions on innovation are thanks to collaborations in scientific programs, attracting foreign experts, supporting research and development activities, and strengthening intellectual property rights. There are no negative effects from local institutions found in this paper. Positive innovation effects from the market are merger & acquisition deals that provide foreign intellectual property, financial support for patenting, and stimulating R&D when there is an industrial success, and the emergence of a domestic photovoltaic market. The market has one negative effect on innovation namely down-cycling that reduces R&D for some companies.

Market-wise China has become the leader of PV installations, with a global share up to 60% in 2013. The patent stock of China has grown a lot in priority patents, but they are lagging in transnational patents. This shows that high-income, leading countries use patents as a market instrument.

Type of research: empirical research

14) Exploring the patent collaboration network of China's wind energy industry: A study based on patent data from CNIPA (Liu et al., 2021).

This study investigates the collaboration network of the wind energy industry in China. It shows that China's State Grid Corporation plays an important actor in this network. To do this, the research uses social network analysis and complex network theory. It also shows an important look into the network's spatial distribution, relationship types, competitiveness, and network structures.

The number of collaborative patents applications grew from 6 to 564 from 2000 till 2018, the proportion of collaborative patents grew from 3% to 5%, with some variances over the year. This is thanks to the twelfth Five-year Plan and the "Renewable Energy Law" (2006). The "Renewable

Energy Law" made the first big growth possible on the number of patent applications. Then the Five-Year plan (2012) had policies to promote the development and application of wind energy technology. These two policies have a positive impact on the collaboration patent growth of China's wind energy industry. The paper uses these dates to create three phases, namely the budding phase (1985-2005), the growth phase (2006-2012), and the maturity phase (2013-2019).

Type of research: empirical research: Complex network theory and social network analysis

15) China's wind industry: Leading in deployment, lagging in innovation (Lam et al., 2017).

This study focusses on the question whether the wind industry in China has become an important element of innovation of clean technology. The growth of wind capacity is enormous, but in terms of innovation and cost competitiveness it is still lagging behind; domestic manufacturers have not secured a lot of transnational patents and have low learning rates in comparison to other global players. China has embraced wind capacity at an impressive rate from coming from a country with no wind power capacity in 2000. By 2012 its wind capacity went a little over 75000 MW, coming from 400MW in 2000. There are multiple policies to promote wind energy in recent years and the "Renewable Energy Law" (2006) is the most notable one. Figure 5.a and 5.b show that China has round 5% overall share, but more than half of them are only granted by the Chinese Patent Office.

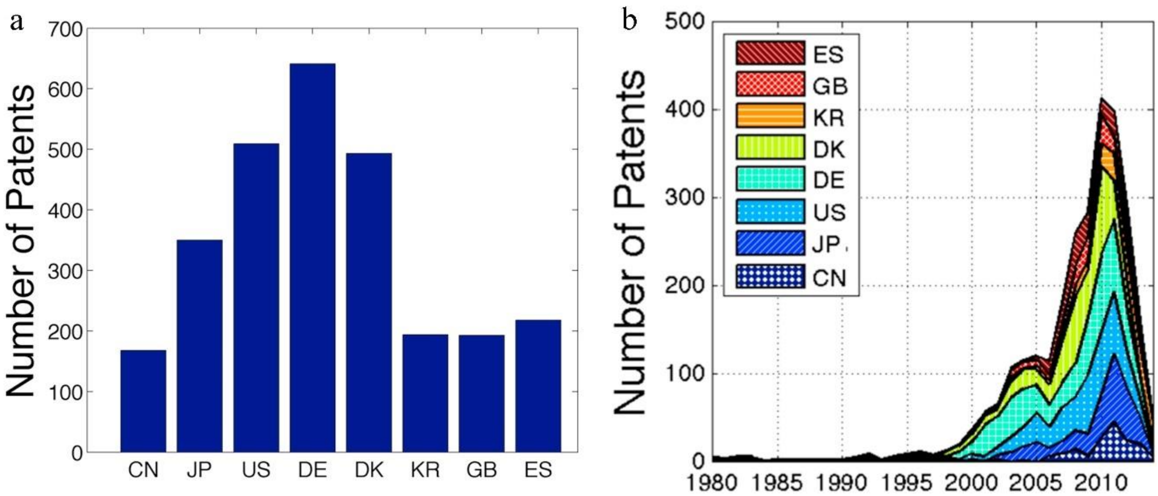

Figure 5.a and 5.b: (a) Cumulative patent count from China (CN), Japan (JP), United States (US), Germany (DE), Denmark (DK), France (FR), Great Britain (GB), and Spain (ES) (2015), (b) Wind patents over time by country

Type of research: Empirical

16) Decomposition analysis of sustainable green technology inventions in China (Fujii & Managi, 2019).

This paper examines the factors of inventions in green technology. The focus lies on policy results from each five-year period between 1996-2015 and uses patent data to create a decomposition framework. It is found that green patent publications are increased due to efficiency improvement, prioritization the five-year plans, and increased R&D mainly due to economic welfare. The priority shifts from each five-years plan in different green technology areas.

The priority factor in the 12th year plan for renewable energy policies declines, and more priority was given to other green technology. As such, green patents in waste overtake the renewable energy patents in each period. Next to that, patents in conservation are also close, which indicates the shift from renewable energy to other green technology. Table 4 shows that there is significant growth thanks to issued policies from the Five-Year plans. Compared to the total average value in each period, renewable energy patents are growing percentage-wise at a higher rate/ The paper concludes that economic development and increasing R&D activities are effective stimulators to develop green technology in China.

Data variable	1996-2000 9th Five-Year plan	2001-2005 10th Five-Year plan	2006-2010 11th Five-Year plan	2011-2015 12^{th} Five-Year plan
Renewable energy patents	1249	2734	7774	27387
Total patents	80747	188270	488849	1271679

Table 4: Green patent data from China provided by WIPO, numbers are the average value in each period

Type of research: Empirical research: patent decomposition framework.

17) Trends and driving forces of low-carbon energy technology innovation in China's industrial sectors from 1998 to 2017: from a regional perspective (Zhang et al., 2021)

This research uses data from 30 provinces in China to look for trends that drive low-carbon technology innovation. These 30 provinces are then divided into four economic zones. The patent data is derived from China's Intellectual Property Office combined with data from the World Intellectual Property Organization. Then an LMDI decomposition model is made. The results show that total Low carbon patent applications in China's industrial sectors increased by 36209 items from 1998 to 2017, with a growth rate of over 97% after 2005.

The number of alternative energy patents is higher than the number of energy conversion technology. This is a result of renewable energy policies that promote renewable energy sources. This paper argues that the Medium- and Long-term Program for Renewable Energy Development is an important driving force. But the gap between both is closing because patent applications have increased from 12.9% to 73.8%. This is due to a series of energy-saving policies like the, Top-1000 Energy-Consuming Enterprises Program, Buildings Energy Efficiency, Structural Adjustment like small Plant Closures, Ten Key Projects, and Appliance Standards and Energy-Efficiency Labels. The total amount of low carbon patents grew with a yearly average rate of 36.7%. Total patent applications (1998-2017) of low-carbon energy increased by 36209 items with a growth of 97% from 2005 to 2017.

Type of research: Empirical

18) Employee incentives and energy firms' innovation: Evidence from China (Si et al.,, 2020).

This study researches the causal relationship between non-executive stock ownership (ESOP) and innovation using the State Intellectual Property Office database from 2006 to 2018. 248 enterprises are covered, and a significant positive link has been found. Non-executive stock ownership fosters innovation due to risk-taking from employees. This effect has mainly been found by non-state-owned companies with high research and development intensity. This ESOPs concept was started in the 1980s, but due to weak laws and unregulated processes, it was not found a successful practice. Finally, in 2005 the Regulation of Equity Incentive Plans was introduced with more success, but the biggest improvement was in 2014 named the Guiding Opinions on the Pilot Program of Employee Stock Ownership Plans Implemented by Listed Companies. It introduces flexibility and manages finances. The result shows a significant positive effect from ESOP on patent applications, with an increase of 15.2% of the market value of per-employee ESOPs in the number of patent applications. The study does not directly target renewable energy, but it is said to improve energy technologies for conventional and renewable energy.

Type of research: Empirical

19) Do government subsidies promote efficiency in technological innovation of China’s photovoltaic enterprises? (Lin & Luan, 2020).

This article takes a closer look into the relationship between subsidies and innovation performance. To do this, it uses data from Chinese photovoltaic companies from 2012 to 2016. To analyze the relationship, they investigate four factors of innovation: government subsidy, financial leverage, ownership concentration, and firm size. The descriptive statistics show that there is no correlation between the influencing factors. The data analysis shows that government subsidy has a significant positive effect on the innovation of photovoltaic enterprises. Secondly, firm size has a negative impact on innovation due to bureaucratic difficulties, and lastly, a higher asset-liability ratio enhances innovation performance. The limitation of this study is that it cannot quite capture how exactly effective government subsidies are in promoting innovation.

Type of research: DEA -Tobit model: Empirical research

20) Assessing fuel cell vehicle innovation and the role of policy in Japan, Korea, and China (Gareth et al., 2012).

In 2010, China became the biggest automobile manufacturer on the market. This has encouraged Chinese policymakers to act on the associated issues of pollution and foreign oil independence. In response, the government has issued policies to promote alternative energy vehicles; fuel cell vehicles have received funding from the "National Basic Research Program" and the "Ministry of Science and Technology's High Technology Development Program". In the 12th year plan (2011-2015) it was planned to manufacture and deploy a minimum of 500 000 "green" vehicles. More than 7.6 billion dollars has been invested in research and development and industrial development for all alternative vehicles. Prior to 1995, China had virtually no fuel cell patents. Contrary to Japan who already had a broad portfolio. But the 10th five-year plan (2001) has started with R&D support for fuel cells, but the patent growth was still quite small compared to Japan. In 2008 the financial crisis had a severe impact on innovation, China had a patent decrease of 96%. Then after 2009 China got and keeps increasing a lead over Japan and Korea regarding patent applications.

Globally there are different kind of innovation strategies; significant innovators for fuel cells in China are universities and government research institutes, while in Japan only around 1% of patents are coming from universities. There is no known data of collaboration on patents in China between industry and academic institutes. The data from this research shows that the 5-Year Plans and other innovation policies had a significant positive effect on stimulating innovation. The private sector in China still has huge growth potential, since 51% of patents filed are from universities. China grew from zero fuel cell patents to over 1600 patents between 1995 and 2011***.***

Type of research: Empirical

5. Data analysis

In this section, the data is extracted and put into Table 5.
Table 5 shows the title, author(s), policy and the outcome. The result of this analysis is discussed in the discussion section.

Title	Author(s)	Policy	Outcome
Do government subsidies promote new-energy firms' innovation? Evidence from dynamic and threshold models.	(Li et al, 2021)	Innovation and non-innovation government subsidies.	Innovation subsidies have a significant positive effect on innovation in new energy-firms. Non-innovation subsidies have not a significant effect on innovation.
China's climate and energy policy: at a turning point?	(Heggelund, 2021).	The 11th,12th, 13th Five-year plan. The Renewable Energy Law (2005), subsidies, and other advantageous policies. The air pollution plans (2013-2017) Clean Energy Consumption Action Plan' (2018–2020)	The 12th and 13th Five-Year plans made clear improvements regarding innovation, the 11th fell a bit short in reaching its goals. But thanks to the Renewable Energy Law and other advantageous policies listed in the policy section, China became the largest producer, exporter and installer of solar panels, wind turbines, batteries, and electric vehicles, placing it at the top of the global energy transition. China became frontrunner in renewable energy patents, with 7544 patents from the 13160 globally patents filed from China in 2018.
Is China's industrial policy	(Liu et al,. 2020).	71 policies in the NEV sector between 2006 and	A significant positive effect on NEV patents. China has a

effective? An empirical study of the new energy vehicles industry		2018; policies for taxation, finance, research and development and in the new energy vehicles industry (NEV).	significant patent share amongst the world's major countries. It shows that China its policies for the NEV are effective.
Does the focus of renewable energy policy impact the nature of innovation? Evidence from emerging economies	(Samant, 2020)	China uses a lot of push and pull policies. Between 2000 and 2013 China issued 92 new renewable energy policies: 24 pull policies, 26 push policies, and 9 general policies. China employs the following pull instruments in its policy mix: mandatory RE targets, feed-in tariffs, quality certification, financial and tax benefits to consumers, and government procurement. China employs the following push instruments in its policy mix: financial and tax benefits to local manufac-turers, R&D funding, State-owned enterprises doing R&D, direct capital subsidies, capacity auctions, and R&D demonstrations. The most used policy instrument is feed-in tariffs, this is a pull policy.	These push and pull policies had significant positive effects on innovation. China had significant innovations in mature and novel technologies. Between 2002-2015 China had 159210 patents in renewable energy and 5163 novel technology patents. Novel technology patents have risen from 1.3% to 4.3% patents in that period. When comparing it with Brazil, India, and Turkey China had highest number of novel patents.
Green technology innovation development in China in 1990–2015	(Wang et al,2015)	Environmental-related policies such as "China's National Climate Change Program": Controlling export of heavy polluting products and counter	Significant innovation in green technology patents in waste technology and photovoltaics. Innovation in the field of climate change is currently

		growth of polluting firms.	more than innovation in environmental management and water related technologies. China has one of the highest growth rates but needs to improve more seen from the perspective from the Environmentally Adjusted Multifactor Productivity indicator.
How will different types of industry policies and their mixes affect the innovation performance of wind power enterprises? Based on dual perspectives of regional innovation environment and enterprise ownership	(Wang et al, 2019)	241 policies about policy mixes on the innovation performance of Wind powered enterprises. Supply side policies dominate China's wind power policy. Five-year plans and "the Medium and Long-Term Development Plan of Renewable Energy" (2007), "the Twelfth Five-Year National Strategic Emerging Industry Development Plan" (2011–2015), and the "Twelfth Five-Year Wind Power Development Plan" (2012).	The developments show to effectively promote innovation in wind powered enterprises. Single demand-side policies and environmental-side policies give significant negative effect, but single supply-side policy shows a positive, significant effect on the innovation performance. The regression outcome finds that mixes of SSP and ESP, mixes of SSP and DSP, as well as mixing them all have significantly promoted the innovation performance of Wind power enterprises.
Impacts of policies on innovation in wind power technologies in China	(Lin, 2019)	The effect of demand-pull policies (2002-2016): feed-in tariff policy, research and development spending, and their connection and interaction.	Feed-in tariffs have had a significant positive effect on wind power technologies. If tariffs are higher, they induce greater patent stock. R&D funding though feed-in tariffs stimulate patent growth. Policies also induce innovation by making electricity prices higher, since power manufacturers

			need to try to reduce costs to obtain more profit.
Local demand-pull policy and energy innovation: Evidence from the solar photovoltaic market in China	(Gao, 2019)	Local demand-pull policies in the photovoltaic (PV) sector.	The balance-of-system patents have seen significant improvements, going from two to 567. China has become the leader of PV module manufacturing. Local demand-pull policies give only a significant positive effect on local innovation. Probably due to local knowledge. Non-local demand-pull policy is insignificant effect for local innovation.
Scientific linkage and technological innovation capabilities: international comparisons of patenting in the solar energy industry	(Fan et al, 2017).	Policies that affect technology-based innovation: R&D investment and improving R&D efficiency and other advantageous renewable energy policies.	The patent stock of China in the solar energy industry has grown significantly. Between 1973 and 2014, 80 011 patents were granted in solar energy technologies. China also shows a strong growth in solar technology-related patent grants between 1985-2014. The policies show a significant positive effect on innovation, but China is not the market leader in wind patents and has a focus on technology-based innovation.
Trends in patents for solar thermal utilization in	(Zhao, 2015)	This article says that there are eight laws, four development plans (Five-year plans) and three	The main driver of patent growth in STU comes from energy policies, and the Solar thermal utilization has

China		technology standards that are important for patent growth in solar thermal utilization (STU). The most prominent being the 11th and 12th Five-Year plan, the Renewable Energy Law, and the energy conservation law.	made a lot of progress in regard of patent applications. 85.8 % came from solar water heater patents alone. Solar water heating patent growth is correlated significantly from the Renewable Energy Law (2006). Solar space heating patents grew a lot since 1998 thanks to the energy conservation law and the renewable energy law (2006) Solar cookers patent counts have a positive correlation with the Eleventh Five-year Energy Development Plan.
The development of wind power in China, Europe and the USA: how have policies and innovation system activities co-evolved?	(McDowall et al.,2013).	China has setup Catch up polies since the early 2000's. They have funded research and universities in and wind energy manufacturers though the "Key technology program". Another important policy is support join ventures and other technology transfer mechanisms through the "Ride the wind" program. Thirdly, increasing licensing and other IP projects so that they have intellectual property of their own.	Since the early 2000's the share of wind energy patents grew significantly, but they are still lagging behind countries like Germany, US, UK and Denmark (1978-2007). It notes that China is a strong manufacturer for wind energy technology.
Demand-side policy for emergence and diffusion of eco-	(Lee et al., 2020).	Demand side policies on production.	Demand side policies on production of eco-innovation show a significant positive

innovation: The mediating role of production (Lee et al., 2020).			effect on innovation.
The technological system of production and innovation: The case of photovoltaic technology in China	(Shubbak, 2019)	The policies are divided in into multiple periods, these correspond with the Five-Year plans. 1995-1999: focus on building a knowledge base for scientific reasons and regulations. 2000-2004: focus on rural electrification, R&D support and manufacturing solar panels. 2005-2009: market oriented and focused on production and export. 2010-2014: creating grid infrastructure and subsidizing PV panels.	Market-wise China has become the leader of PV installations, with a global share up to 60% in 2013. The patent stock of China has grown a lot in priority patents (2000-2004). In 2005, China overtook the leader Japan in priority patents. The third period marks a good growth in patent growth. But they are lagging behind in transnational patents, with being only involved in 3% of the accumulated transnational patents during 1977-2012. This shows that high-income, leading countries use patents as a market instrument.
Exploring the patent collaboration network of China's wind energy industry: A study based on patent data from CNIPA.	(Liu et al., 2021)	the Renewable Energy Law (2006) and 12th Five-year plan (2011-2015)	Collaborative patent applications grew from 6 to 564 from 2000 till 2018. This is a significant positive impact. The proportion of collaborative patents grew from 3% to 5%.
China's wind industry:	(Lam et al., 2017).	There are multiple policies in recent years and the	The growth of innovation is apparent, but it’s still

Leading in deployment, lagging in innovation.		"Renewable Energy Law" (2006) is the most notable one.	lagging. China has a low number of international patents and even together with the patents that are only granted in China, it is still behind in numbers of patents in comparison with Japan, United States, Germany, Denmark , France, Great Britain , and Spain (2015).
Decomposition analysis of sustainable green technology inventions in China	(Fujii & Managi, 2019)	Policies issued by the 9th Five-year plan (1996-2000), 10th Five-year plan (2001-2005), 11th Five-year plan (2006-2010) and 12th Five-year plan (2011-2015).	There is a significant positive patent growth in green patents and renewable energy patents due to the policies issued in the Five-year plans and increased R&D thanks to economic welfare. The average value number of patents grew from 1249 to 27387 between 1996 to 2015 in periods of five years. This growth is percentage wise higher than the total nonrenewable patent growth. The highest growth rate happens between 2006 and 2015; the patents grew from 7774 to 27387.
Trends and driving forces of low-carbon energy technology innovation in China's industrial sectors from	(Zhang et al., 2021)	The Renewable Energy Law (2006) and multiple development plans and energy-saving policies.	Total patent applications (1998-2017) of low-carbon energy increased by 36209 items with growth of 97% from 2005 to 2017. The number of alternative energy patents is higher than the number of energy conservation patents, but

1998 to 2017: from a regional perspective.			this gap is closing due to said policies. Policies play an important role in innovation rate for low-carbon technologies.
Employee incentives and energy firms' innovation: Evidence from China.	(Si et al., 2020).	Non-executive stock ownership permission made possible through the Regulation of Equity Incentive Plans (2005) and Guiding Opinions on the Pilot Program of Employee Stock Ownership Plans (2014).	A significant positive relationship with innovation in (renewable) energy companies.
Do government subsidies promote efficiency in technological innovation of China's photovoltaic enterprises?	(Lin & Luan, 2020)	The effect from Government subsidies for photovoltaic enterprises.	Research shows that there is a significant positive effect on innovation from government subsidies.
Assessing fuel cell vehicle innovation and the role of policy in Japan, Korea, and China	(Gareth et al., 2012)	Fuel cell vehicles have received funding from the "National Basic Research Program" and the "Ministry of Science and Technology's High Technology Development Program. In the 12th Five-Year plan (2011-2015) it was planned to manufacture and deploy a minimum of 500 000 "green" vehicles. More than 7.6 billion dollars has been invested for research and development and industrial development for all alternative vehicles.	The policies had a significant positive effect on innovation. China grew from zero fuel cell patents to over 1600 patents between 1995 and 2011.

Table 5: data synthesis

5.1 Distribution of articles

This section describes in what type of subgroup the analyzed articles fall. The distribution happens in four different groups: Waste management, alternative energy, energy conservation and other green technologies (Fujii & Managi, 2019). The technology group and subgroup categories can be found in 'Appendix C'. I created the other category for articles that talk about certain policy effects on new energy firms. These are effects that can apply to all new energy firms.

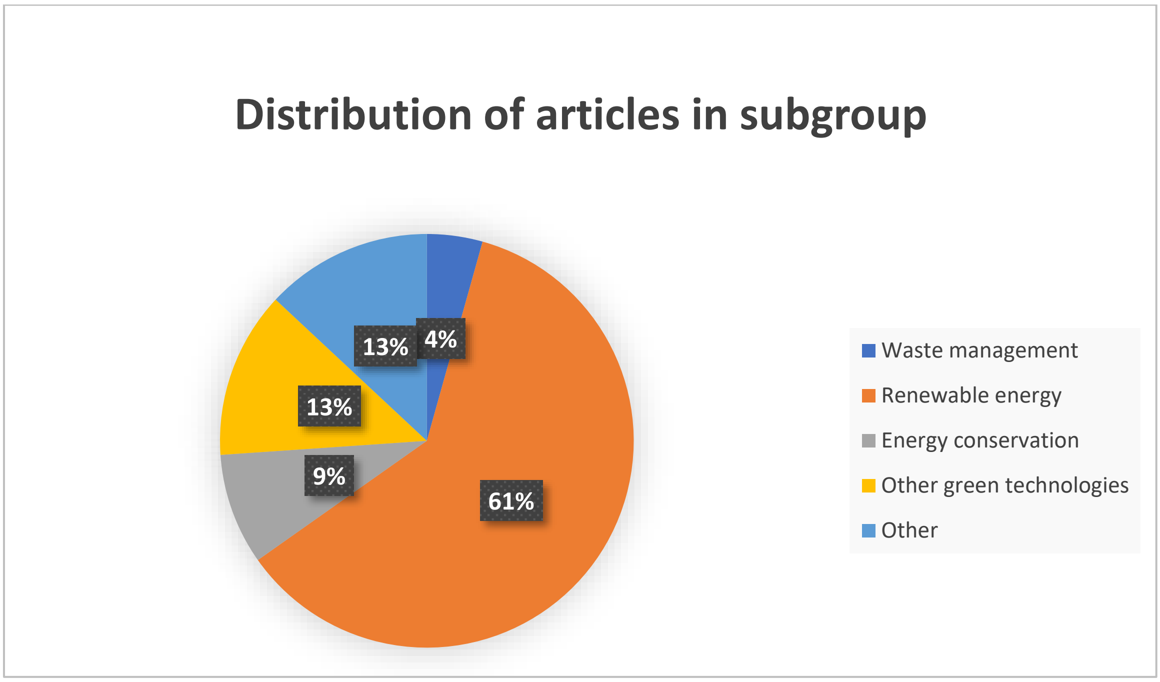

Figure 6: Distribution of renewable energy group talked about in the sample size

14 articles fall into the group "renewable energy", three mention innovation in "other green technologies", one is about innovation in waste management and three articles fall in the other category. An article can cover multiple subgroups.

Figure 7 shows the distribution of types or research. Theoretical research uses theoretical data, while empirical data uses evidence-based data (Corbetta, 2003).

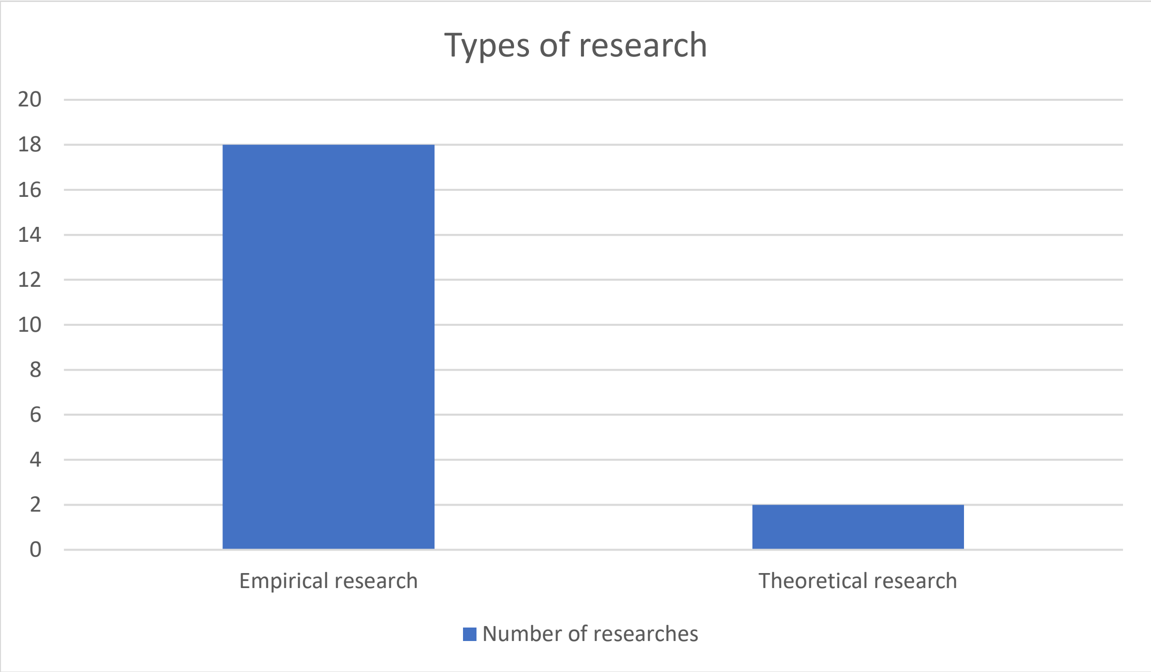

Figure 7: The distribution of research types

6. Discussion

The results show that China has made significant innovation progress in renewable energy and that policies seem to have a significant connection with innovation results. China was a latecomer in the renewable energy market but is making substantial gains since the 2000s. China is still lagging behind the global leaders in innovation in wind energy and solar energy, but data shows that China is one of the biggest emerging forces (Samant, 2020; Statista, 2016; Statista, 2016). Between 2002-2015 China had 159210 patents in renewable energy and 5163 novel technology patents. When comparing this with Brazil, India, and Turkey; China had the highest number of novel patents (Samant, 2020). More recent data shows that China is becoming a frontrunner in renewable energy patents, with 7544 patents from the 13160 global patents filed from China in 2018 (Heggelund, 2021). The Five-Year development plans contribute significantly to innovation in renewable energy. 7 studies acknowledge that they played a significant role in fostering innovation. The biggest patent growth seems to be in the 11th and 12th Five-year plans (2006 to 2015) (Fujii & Managi, 2019). China used a lot of push-pull policies between 2000 and 2013 which show to have given significant innovations in mature and novel technologies (Samant, 2020). An important push policy is (innovation) subsidies, they have a significant positive effect on innovation in new-energy firms. Next to those, public research and development policies also seem to have a positive relationship with innovation.

The solar energy sector has also made positive gains in multiple areas. Solar thermal utilization (STU) has made a lot of positive progress regarding patent applications. The "Renewable Energy Law" is mentioned as an important driver for STU. The patent stock in the solar energy industry grew significantly between 1973 and 2014, 80 011 patents were granted in solar energy technologies. This growth is possible thanks to advantageous policies such as R&D support, feed-in tariffs, creating grid infrastructure, and subsidizing PV panels. China has gained a lot of priority patents since 2005, but they are lagging in important transnational patents. China has become a leader in PV installations and manufacturing.

The wind energy sector seems to be similar. China came late onto the wind energy market and had to introduce catch-up policies like the "Ride the wind program", which had a positive innovation effect. Thanks to innovation mixes of demand, environmental and supply-side policies the patent stock grew. A significant positive policy regarding innovation outcome is feed-in tariffs, they often involve long-term contracts of support towards the development of renewable energy sources, by guaranteeing a high price for producing companies. Despite the progress, data also show that China is still behind other countries like Germany, the US, UK, and Denmark in 2007 (McDowall et al.,2013). In 2015 China was still behind in numbers of wind energy patents in comparison with Japan, United States, Germany, Denmark, France, Great Britain, and Spain (Lam et al., 2017). But China has a lot of international licensing deals and is a strong manufacturer in this sector.

The new energy vehicle industry is another story. China has invested a lot in the new energy vehicle industry and has a high patent share. China enacted multiple policies to stimulate innovation in this industry, an important one is the 12th Year with a focus on manufacturing and deploying 500000 vehicles. China is the world's biggest automobile manufacture, and they invest heavily in this sector because they want foreign oil independence and this is sector pollutes a lot (Gao et al., 2017).

Further, Figure 7 shows the classification between theoretical and empirical research articles. Theoretical data relies more on logical assumptions, while empirical data tests these assumptions (Corbetta, 2003). Corbetta (2003) implies that the validity of the empirical data is often more accurate since it has been tested for validity. The articles reviewed are mainly empirical research. From the 20 articles, only two seem to be theoretical research. This shows that the gathered data has an appropriate amount of validity and reliability. Additionally, Figure 6 shows that there are multiple articles in the same green patent category, this is used to spot similarities in policies in the same energy groups.

Lastly, the results show multiple studies in renewable energy fields, but some renewable energy sources are not incorporated into this study. There is no mention of hydropower energy and tidal energy. Other research shows that hydro energy plays a significant role in the energy industry of China (Li et al., 2020). Liu et al., (2011) say that tidal energy has been neglected by the government due to the prices of tidal power plants. Next to that, there are some other factors that limit this research. A systematic review done with the ROSES method is normally executed by two or more people, this systematic review is done by one person. Therefore, there can be some bias in areas such as article screening. Next to that, this paper was written with certain deadlines and time restrictions. The data gathered is dependent on the correctness of existing papers, therefore it is not sure if all data is reliable data. There was only one database used due to time restrictions. Also, 31/281 articles were not accessible, meaning that more than 10 % of articles were automatically excluded. Some papers also mention that data from China was not complete or not completely reliable. In this study, innovation is measured in the patent count or with a correlation with papers, which sometimes fail to grasp the full amount of innovation. Not every invention is patented. The final limitation is that English is my second language, and this can be a deficiency because a lot of these studies were very technical, and sometimes it was difficult to interpret everything.

7. Conclusion and policy implications

This thesis analyzes literature about renewable energy policies and their effect on innovation. Following the systematic protocol of ROSES, the paper highlights innovation outcomes related to renewable energy policies. The results show that renewable energy policies play an important positive role in the effect of innovation in China. Government policies are effective in stimulating innovation. In every retrieved article, China has shown remarkable growth patent-wise. Data from Statista (2019) shows that China has filed the highest number of patents worldwide for renewable energy in 2018.

Solar energy, wind energy, solar, solar thermal utilization, new energy vehicles, fuel cells, and other new-energy firms have seen a lot of innovation after the millennium. The Five-Year Plan is one of the biggest innovation drivers. Next to that, mixes of demand, environmental and supply-side policies have played an important factor in fostering innovation. The "Renewable Energy Law" in 2006 marks an important step for innovation, as every major renewable energy source has seen patent growth after 2006. This was at the start of the 11th Five-year plan. During the 11th, 12th and 13th Five-year plan (2006-2020) renewable energy patents have seen a lot of growth. This is very important because China is one of the most polluting countries in the world regarding CO2 and other pollution (Gao et al., 2017; Jia et al., 2017; World Resources Institute, 2021). The main source of pollution comes from fossil fuel combustion in diverse processes and sectors (Lei et al., 2011; Zhai et al., 2012). Despite the great innovation leaps, China still has not caught up with leading countries in innovation in a lot of areas. China shows to only have two percent of solar energy patents grants worldwide between 2002 and 2015 and only one percent in wind energy (Statista, 2016; Statista, 2016).

Garrett-Peltier (2017) says that the efficiency and use of renewable energies is one of the main strategies to reduce emissions. The major contribution of this research is that it highlights possible advantageous policies for multiple renewable energies, this can be of interest for policymakers in shaping the renewable energy landscape in the future. That is why this thesis has significant policy implications. The findings can be used by the policymakers that plan to improve innovation. The results show a broad overview of policies and the result of those policies. The research shows the significant role that policies play in developing renewable energy technology, thus the paper can also contribute to other emerging countries. China can improve policies to gain more transnational patents and that China is still lagging behind the patent leaders. China is especially a strong manufacturing market player. The reviews show that push and pull policies and innovation subsidies had a positive influence on innovation in every instance, this can be interesting for new emerging markets in renewable energy.

Lastly, the main limitation is that this systematic review has been done in a short period of time by only one person. Therefore, there has been no consistency checking done for articles screening and some articles were not accessible through the university. Only one database has been used due to the time limitations. Next to that, English is not my native language, which could be a deficiency while identifying and interpreting.

8. Stakeholder engagement

There is no role of stakeholders in this systematic review.

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10. Appendix

10.1 Appendix A: Search string results from Web of Science Core Collection

Search string	Results
TS= (Patent* and China and Renewable energ* and Polic*)	35
TS= (chin* AND (renewable energ* polic*) AND (patent) NOT (energ* consum*))	26
TS= (chin* AND (renewable energ* polic*) AND (innovation* OR patent*) NOT (energ* consum*))	196
TS= (chin* AND (renewable energ* polic* OR wind energ* polic* OR solar energ* polic* or geothermal energ* polic*) AND (innovation* OR patent *) NOT (energ* consum*))	281
TS= (chin* AND (renewable energ* polic* OR wind energ* polic* OR solar energ* Polic* AND (innovation* OR patent *) NOT (energ* consum*))	281
TS= (chin* AND (renewable energ* polic* OR wind energ* polic* OR solar energ* polic* OR hydro* energ* polic*) AND (innovation* OR patent *) NOT (energ* consum*))	293

10.2 Appendix B: Inclusion and exclusion list

Title	Author(s)	Publication Year	Reason for exclusion (No value= no exclusion)
Analysis of the Technical Competitive Strategy of Main Competitors in the Field of Wind Power	Duan Liping	2009	Unretrievable text
Competitive advantage in the renewable energy industry: Evidence from a gravity model	Kuik, Onno; Branger, Frederic; Quirion, Philippe	2019	Innovation measurement not in patents
Renewable energy technologies: patent counts and considerations for energy and climate policy in Brazil	de Melo, Conrado Augustus; da Silva, Manuella Pereira; Benedito, Ricardo da Silva	2020	Population not China
Chinese Renewable Energy Technology Exports: The Role of Policy, Innovation and Markets	Groba, Felix; Cao, Jing	2015	Innovation measurement not in patents
The emergence of China's wind and solar industries	Korsnes, Marius	2020	Unretrievable text

Comparing the International Knowledge Flow of China's Wind and Solar Photovoltaic (PV) Industries: Patent Analysis and Implications for Sustainable Development	Zhou, Yuan; Pan, Meijuan; Urban, Frauke	2018	No clear link between policy and result
Which Subsidy Mode Improves the Financial Performance of Renewable Energy Firms? A Panel Data Analysis of Wind and Solar Energy Companies between 2009 and 2014	Zhang, Huiming; Zheng, Yu; Zhou, Dequn; Zhu, Peifeng	2015	Innovation measurement not in patents
Geothermal power in China: Development and performance evaluation	Zhang, L. X.; Pang, M. Y.; Han, J.; Li, Y. Y.; Wang, C. B.	2019	Innovation measurement not in patents
The profitability of onshore wind and solar PV power projects in China - A comparative study	Tu, Qiang; Betz, Regina; Mo, Jianlei; Fan, Ying	2019	Innovation measurement not in patents
The economics of renewable energy power in China	Xu, Yan; Yang, Zhijie; Yuan, Jiahai	2021	Innovation measurement not in patents
Wind energy and green economy in Europe: Measuring policy-induced innovation using patent data	Lindman, Asa; Soderholm, Patrik	2016	Population not China
Review on the costs and benefits of renewable energy power subsidy in China	Zhao, Hui-ru; Guo, Sen; Fu, Li-wen	2014	Innovation measurement not in patents
The role of the complementary sector and its relationship with network formation and government policies in emerging sectors: The case of solar photovoltaics between 2001 and 2009	Choi, Hyundo; Anadon, Laura Diaz	2014	Population not China
Technological Progress in Developing Renewable Energies	Jiang, Kejun	2017	Innovation measurement not in patents
Global patterns of renewable energy innovation, 1990-2009	Bayer, Patrick; Dolan, Lindsay; Urpelainen, Johannes	2013	Foreign policy/Data not from China
Interactions between renewable energy policy and renewable energy industrial policy: A critical analysis of China's policy approach to renewable energies	Zhang, Sufang; Andrews-Speed, Philip; Zhao, Xiaoli; He, Yongxiu	2013	Innovation measurement not in patents
Impacts of policies on innovation in wind	Lin, Boqiang; Chen, Yufang	2019	

power technologies in China			
SWITCH-China: A Systems Approach to Decarbonizing China's Power System	He, Gang; Avrin, Anne-Perrine; Nelson, James H.; Johnston, Josiah; Mileva, Ana; Tian, Jianwei; Kammen, Daniel M.	2016	Innovation measurement not in patents
Exploiting the Implementation Gap: Policy Divergence and Industrial Upgrading in China's Wind and Solar Sectors	Nahm, Jonas	2017	Innovation measurement not in patents
Protecting Solar: Global Supply Chains and Business Power	Meckling, Jonas; Hughes, Llewelyn	2018	Foreign policies
Building an internationally competitive concentrating solar power industry in China: lessons from wind power and photovoltaics	Gilmanova, Alina; Wang, Zhifeng; Gosens, Jorrit; Lilliestam, Johan	2021	Unretrievable text
Selection of key technology policies for Chinese offshore wind power: A perspective on patent maps	Zhang, Huiming; Zheng, Yu; Zhou, Dequn; Long, Xingle	2018	Innovation measurement not in patents
The Management Innovation and Research Systematic Strategies of Wind Electric Power Development in China	Pang, Nan-sheng; Ma, Shuai	2016	Outcome
The short-term costs of local content requirements in the Indian solar auctions	Probst, Benedict; Anatolitis, Vasilios; Kontoleon, Andreas; Anadon, Laura Diaz	2020	Population not China
Renewable energies: Worldwide trends in research, funding and international collaboration	Luis Aleixandre-Tudo, Jose; Castello-Cogollos, Lourdes; Luis Aleixandre, Jose; Aleixandre-Benavent, Rafael	2019	No policies
What drives investment in wind energy? A comparative study of China and the European Union	Ydersbond, Inga Margrete; Korsnes, Marius Stoylen	2016	Innovation measurement not in patents
Toward Technology-Sensitive Catching-Up Policies: Insights from Renewable Energy in China	Binz, Christian; Gosens, Jorrit; Hansen, Teis; Hansen, Ulrich Elmer	2017	Papers that propose policy options but show no research on existing ones
Is the supply chain ready for the green transformation? The case of offshore wind logistics	Poulsen, Thomas; Lema, Rasmus	2017	Innovation measurement not in patents
Evolutionary Patterns	Oh, Yoonhwan;	2016	No mention of policies

of Renewable Energy Technology Development in East Asia (1990-2010)	Yoon, Jungsub; Lee, Jeong-Dong		
Fragmented authorities, institutional misalignments, and challenges to renewable energy transition: A case study of wind power curtailment in China	Cai, Yifan; Aoyama, Yuko	2018	Innovation measurement not in patents
The production of scientific knowledge on renewable energies: Worldwide trends, dynamics and challenges and implications for management	Rizzi, Francesco; van Eck, Nees Jan; Frey, Marco	2014	No domestic policies
Green Industrial Policy in Emerging Markets	Harrison, Ann; Martin, Leslie A.; Nataraj, Shanthi	2017	Innovation measurement not in patents
The politics of late late development in renewable energy sectors: Dependency and contradictory tensions in India's National Solar Mission	Behuria, Pritish	2020	Population not China
Beyond Technology Push vs. Demand Pull: The Evolution of Solar Policy in the US, Germany and China	Hansen, Erik G.; Luedeke-Freund, Florian; Quan, Xiaohong (Iris); West, Joel	2017	Innovation measurement not in patents
Development trajectories in China's wind and solar energy industries: How technology-related differences shape the dynamics of industry localization and catching up	Quitzow, Rainer; Huenteler, Joern; Asmussen, Hanna	2017	No mention of policies
Projecting the Price of Lithium-Ion NMC Battery Packs Using a Multifactor Learning Curve Model	Penisa, Xaviery N.; Castro, Michael T.; Pascasio, Jethro Daniel A.; Esparcia, Eugene A.; Schmidt, Oliver; Ocon, Joey D.	2020	no policies
Antidumping and Feed-In Tariffs as Good Buddies? Modeling the EU-China Solar Panel Dispute	Bougette, Patrice; Charlier, Christophe	2018	No deomestic policies
Low-carbon technologies, national innovation systems, and global production networks: the state of play	Hughes, Llewelyn; Quitzow, Rainer	2018	Unretrievable text
Renewable Energy Transformation or	Moe, E.	2015	Unretrievable text

Fossil Fuel Backlash: Vested Interests in the Political Economy			
Demand-side policy for emergence and diffusion of eco-innovation: The mediating role of production	Lee, Hoyoon; Shin, Kiyoon; Lee, Jeong-Dong	2020	
China's climate and energy policy: at a turning point?	Heggelund, Gorild M.	2021	
Market and Non-market Policies for Renewable Energy Diffusion: A Unifying Framework and Empirical Evidence from China's Wind Power Sector	Liu, Yang; Wei, Taoyuan	2016	Innovation measurement not in patents
The technological system of production and innovation: The case of photovoltaic technology in China	Shubbak, Mahmood H.	2019	
Barriers to onshore wind energy implementation: A systematic review	Farkat Diogenes, Jamil Ramsi; Claro, Joao; Rodrigues, Jose Coelho; Loureiro, Manuel Valentim	2020	Population not China
Scientific linkage and technological innovation capabilities: international comparisons of patenting in the solar energy industry	Fan, Xia; Liu, Wenjie; Zhu, Guilong	2017	
International Diffusion of Renewable Energy Innovations: Lessons from the Lead Markets for Wind Power in China, Germany and USA	Subtil Lacerda, Juliana; van den Bergh, Jeroen C. J. M.	2014	Innovation measurement not in patents
Global Innovation Systems-A conceptual framework for innovation dynamics in transnational contexts	Binz, Christian; Truffer, Bernhard	2017	Unretrievable text
Exploring the patent collaboration network of China's wind energy industry: A study based on patent data from CNIPA	Liu, Weiwei; Song, Yifan; Bi, Kexin	2021	
Frugal innovation strategies and global competition in wind power	Gerybadze, Alexander; Klein, Malte	2020	Population not China
Resource misallocation in the Chinese wind power industry: The	Yu, Chin-Hsien; Wu, Xiuqin; Lee, Wen-Chieh; Zhao,	2021	Innovation measurement not in patents

role of feed-in tariff policy	Jinsong		
The Evolution of Renewable Energy Price Policies Based on Improved Bass Model: A System Dynamics (SD) Analysis	Zhao, Xin-gang; Zhang, Yu-zhuo; Li, Yan-bin	2018	Innovation measurement not in patents
The effectiveness of domestic content criteria in India's Solar Mission	Sahoo, Anshuman; Shrimali, Gireesh	2013	Population not China
Allocating subsidies to R&D or to market applications of renewable energy? Balance and geographical relevance	Koseoglu, Nazli M.; van den Bergh, Jeroen C. J. M.; Subtil Lacerda, Juliana	2013	Innovation measurement not in patents
Trends in patents for solar thermal utilization in China	Zhao, Ruikai; Zhao, Li; Deng, Shuai; Zheng, Nan	2015	
China's wind power industry: Policy support, technological achievements, and emerging challenges	Wang, Zhongying; Qin, Haiyan; Lewis, Joanna I.	2012	Innovation measurement not in patents
Exuberance in China's renewable energy investment: Rationality, capital structure and implications with firm level evidence	Zhang, Dayong; Cao, Hong; Zou, Peijiang	2016	Innovation measurement not in patents
China's wind industry: Leading in deployment, lagging in innovation	Lam, Long T.; Branstetter, Lee; Azevedo, Ines M. L.	2017	
Policymaking challenges in complex systems: The political and socio-technical dynamics of solar photovoltaic technology deployment in China	Gao, Xue; Yuan, Jiaha	2020	Innovation measurement not in patents
Development of photovoltaic power generation in China: A transition perspective	Liu, Dawei; Shiroyama, Hideaki	2013	Innovation measurement not in patents
A comprehensive review of state-of-the-art concentrating solar power (CSP) technologies: Current status and research trends	Islam, Md Tasbirul; Huda, Nazmul; Abdullah, A. B.; Saidur, R.	2018	Innovation measurement not in patents
The greening of South-South trade: Levels, growth, and specialization of trade in clean energy technologies between countries in the global South	Gosens, Jorrit	2020	Population not China
Gone with the wind: A learning curve analysis of China's wind power	Hayashi, Daisuke; Huenteler, Joern; Lewis, Joanna, I	2018	No mention of policies

industry			
Social acceptance of solar energy technologies in China-End users' perspective	Yuan, Xueliang; Zuo, Jian; Ma, Chunyuan	2011	No mention of policies
Technology transfer and cooperation for low carbon energy technology: Analysing 30 years of scholarship and proposing a research agenda	Kirchherr, Julian; Urban, Frauke	2018	No mention of policies
What hinder the further development of wind power in China? A socio-technical barrier study	Zhao, Zhen-Yu; Chang, Rui-Dong; Chen, Yu-Long	2016	Innovation measurement not in patents
Piloting Away - State-Signaling and Confidence-building in China's Renewable Energy Sector	Tseng, Sheng-Wen; Habich-Sobiegalla, Sabrina	2020	Unretrievable text
Decomposition analysis of sustainable green technology inventions in China	Fujii, Hidemichi; Managi, Shunsuke	2019	
Can value-added tax incentives of new energy industry increase firm's profitability? Evidence from financial data of China's listed companies	Sun, Chuanwang; Zhan, Yanhong; Du, Gang	2020	Innovation measurement not in patents
The role of technology transfer for the development of a local wind component industry in Chile	Pueyo, Ana; Garcia, Rodrigo; Mendiluce, Maria; Morales, Dario	2011	Population not China
The verticality of policy mixes for sustainability transitions: A case study of solar water heating in China	Huang, Ping	2019	Innovation measurement not in patents
Large-scale PV power generation in China: A grid parity and techno-economic analysis	Zou, Hongyang; Du, Huibin; Brown, Marilyn A.; Mao, Guozhu	2017	Innovation measurement not in patents
Green fiscal policy and firms' investment efficiency: New insights into firm-level panel data from the renewable energy industry in China	Chang, Kai; Wan, Qiong; Lou, Qichun; Chen, Yili; Wang, Weihong	2020	Innovation measurement not in patents
Analysis of Russia's biofuel knowledge base: A comparison with Germany and China	Kang, Jin-Su; Kholod, Tetyana; Downing, Stephen	2015	No renewable policies
Literature review on renewable energy development and China's roadmap	Zhou, Dequn; Ding, Hao; Wang, Qunwei; Su, Bin	2021	Unretrievable text

Handling financial resource mobilisation in technological innovation systems-The case of chinese wind power	Karltorp, Kersti; Guo, Siping; Sanden, Bjorn A.	2017	Innovation measurement not in patents
Optimal policy supports for renewable energy technology development: A dynamic programming model	Ding, Hao; Zhou, Dequn; Zhou, P.	2020	Innovation measurement not in patents
Localisation Strategies of Firms in Wind Energy Technology Development	Perrot, Radhika; Filippov, Sergey	2010	Innovation measurement not in patents
Trends and driving forces of low-carbon energy technology innovation in China's industrial sectors from 1998 to 2017: from a regional perspective	Zhang, Xi; Geng, Yong; Tong, Yen Wah; Kua, Harn Wei; Dong, Huijuan; Pan, Hengyu	2021	
An analysis of the wind power development factors by Generalized Bass Model: A case study of China's eight bases	She, Zhen-Yu; Cao, Rui; Xie, Bai-Chen; Ma, Jia-Jun; Lan, Sheng	2019	No review on existing policies
The development of wind power in China, Europe and the USA: how have policies and innovation system activities co-evolved?	McDowall, Will; Ekins, Paul; Radosevic, Slavo; Zhang, Le-yin	2013	
Effect of innovation policy mix on innovation efficiency: Evidence from Chinese wind power industry chain	Wang, Xiaozhen; Jiang, Zihao; Zheng, Ying	2020	Unretrievable text
Cross-National Complementarity of Technology Push, Demand Pull, and Manufacturing Push Policies: The Case of Photovoltaics	Hansen, Erik G.; Luedeke-Freund, Florian; Quan, Xiaohong Iris; West, Joel	2019	Innovation measurement not in patents
Public policy and financial resource mobilization for wind energy in developing countries: A comparison of approaches and outcomes in China and India	Surana, Kavita; Anadon, Laura Diaz	2015	Innovation measurement not in patents
Accelerating renewable energy electrification and rural economic development with an innovative business model: A case study in China	Li, Changsheng; Shen, Bo	2019	Innovation measurement not in patents
Application of a fuzzy	Huang, Shih-Chieh;	2013	Innovation measurement not in

cognitive map based on a structural equation model for the identification of limitations to the development of wind power	Lo, Shang-Lien; Lin, Yen-Ching		patents
What makes renewable energy successful in China? The case of the Shandong province solar water heater innovation system	Goess, Simon; de Jong, Martin; Ravesteijn, Wim	2015	Innovation measurement not in patents
Sustainability transitions and leapfrogging in latecomer cities: the development of solar thermal energy in Dezhou, China	Yu, Zhen; Gibbs, David	2018	Innovation measurement not in patents
DEVELOPMENT OF LOW-CARBON TECHNOLOGIES DURING THE 11TH FYP	Leibo, Steven A.; Yang, Li	2013	Innovation measurement not in patents
Driving forces of solar energy technology innovation and evolution	Luan, Chunjuan; Sun, Xiaoming; Wang, Yalan	2021	Innovation measurement not in patents
Inter-sector network and clean energy innovation: Evidence from the wind power sector	Zhang, Fang; Tang, Tian; Su, Jun; Huang, Keman	2020	No renewable policies
Spatial characteristics and its driving factors of low-carbon energy technology innovation in China: A gravity movement and exploratory spatial data analysis	Zhang, Xi; Geng, Yong; Tong, Yen Wah; Kua, Harn Wei; Tian, Xu; Wu, Rui; Zhao, Xingrong; Chiu, Anthony S. F.	2021	policy options but show no research on existing ones
Status and future strategies for Concentrating Solar Power in China	Wang, Jun; Yang, Song; Jiang, Chuan; Zhang, Yaoming; Lund, Peter D.	2017	No renewable policies
The persistence of flexible coal in a deeply decarbonizing energy system	Ding, Yongbin; Li, Mingquan; Abdulla, Ahmed; Shan, Rui; Gao, Shuo; Jia, Guozhu	2021	Not renewable energy
From collapsed coal mines to floating solar farms, why China's new power tor stations matter	Pouran, Hamid M.	2018	Innovation measurement not in patents
Accelerating diffusion of climate-friendly technologies: A network perspective	Halleck-Vega, Solmaria; Mandel, Antoine; Millock, Katrin	2018	Innovation measurement not in patents
Technology transfer in the clean development mechanism: Insights from wind power	Lema, Adrian; Lema, Rasmus	2013	Innovation measurement not in patents
From lagging to lead-	Gosens, Jorrit; Lu,	2013	Innovation measurement not in

ing? Technological innovation systems in emerging economies and the case of Chinese wind power	Yonglong		patents
The near- to mid-term outlook for concentrating solar power: mostly cloudy, chance of sun	Lilliestam, Johan; Ollier, Lana; Labordena, Merce; Pfenninger, Stefan; Thonig, Richard	2021	Innovation measurement not in patents
Collaborative governance for technological innovation: a comparative case study of wind energy in Xinjiang, Shanghai, and Guangdong	Mah, Daphne Ngar-yin; Hills, Peter	2014	Innovation measurement not in patents
The institutional evolution process of the global solar industry: The role of public and private actors in creating institutional shifts	Bohnsack, Rene; Pinkse, Jonatan; Waelpoel, Anneloes	2016	Innovation measurement not in patents
Green technology innovation development in China in 1990-2015	Wang, Qinhua; Qu, Jiansheng; Wang, Bao; Wang, Penglong; Yang, Taibao	2019	
THE ROLE OF INDUSTRIAL POLICIES IN THE DEVELOPMENT OF A COMPETITIVE WIND ENERGY INDUSTRY: THE DANISH AND CHINESE SECTORAL INNOVATION SYSTEMS	Botta, Enrico	2016	Unretrievable text
Is the photovoltaic poverty alleviation project the best way for the poor to escape poverty?-A DEA and GRA analysis of different projects in rural China	Wang, Zihan; Li, Jiaxin; Liu, Jing; Shuai, Chuanmin	2020	Innovation measurement not in patents
Has solar PV achieved the national poverty alleviation goals? Empirical evidence from the performances of 52 villages in rural China	Li, Jiaxin; Wang, Zihan; Cheng, Xin; Shuai, Jing; Shuai, Chuanmin; Liu, Jing	2020	Innovation measurement not in patents
Differences in CO2 emissions of solar PV production among technologies and regions: Application to China, EU and USA	Liu, Feng; van den Bergh, Jeroen C. J. M.	2020	about energy consumption or co2 reduction
Local demand-pull policy and energy innovation: Evidence from the solar photovoltaic market in China	Gao, Xue; Rai, Varun	2019	

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Co-benefits, contradictions, and multi-level governance of low-carbon experimentation: Leveraging solar energy for sustainable development in China	Lo, Kevin; Broto, Vanesa Castan	2019	Innovation measurement not in patents
Spatial lifecycles of cleantech industries - The global development history of solar photovoltaics	Binz, Christian; Tang, Tian; Huenteler, Joern	2017	No renewable policies
Demonstration projects for diffusion of clean technological innovation: a review	Bossink, Bart A. G.	2015	Innovation measurement not in patents
Market dynamics, innovation, and transition in China's solar photovoltaic (PV) industry: A critical review	Zou, Hongyang; Du, Huibin; Ren, Jingzheng; Sovacool, Benjamin K.; Zhang, Yongjie; Mao, Guozhu	2017	Innovation measurement not in patents
Financing Indian Urban Rail through Land Development: Case Studies and Implications for the Accelerated Reduction in Oil Associated with 1.5 degrees C	Sharma, Rohit	2018	Population: Not China
Cost reduction or electricity penetration: Government R&D-induced PV development and future policy schemes	Ding, H.; Zhou, D. Q.; Liu, G. Q.; Zhou, P.	2020	Innovation measurement not in patents
Knowledge spillover efficiency of carbon capture, utilization, and storage technology: A comparison among countries	Bae, Junhee; Chung, Yanghon; Lee, Jaewook; Seo, Hangyeol	2020	No renewable energy policies from China
Opportunities and challenges for renewable energy policy in China	Zhang Peidong; Yang Yanli; Shi Jin; Zheng Yonghong; Wang Lisheng; Li Xinrong	2009	Innovation measurement not in patents
The Impact of International Oil Prices on the Stock Price Fluctuations of China's Renewable Energy Enterprises	Hsiao, Cody Yu-Ling; Lin, Weishun; Wei, Xinyang; Yan, Gaoyun; Li, Siqi; Sheng, Ni	2019	No renewable energy policies
Carbon intensity reduction assessment of renewable energy technology innovation	Cheng, Yuanyuan; Yao, Xin	2021	about energy consumption or co2 reduction

in China: A panel data model with cross-section dependence and slope heterogeneity			
Renewable energy investment risk evaluation model based on system dynamics	Liu, Ximei; Zeng, Ming	2017	Innovation measurement not in patents& Review
China's New Energy Industrial Development: Position, Contradictions and Policies in the Post-crisis Era	Jin Yue-qin	2010	Unretrievable text
Do renewable energy technology innovations promote China's green productivity growth? Fresh evidence from partially linear functional-coefficient models	Yan, Zheming; Zou, Baoling; Du, Kerui; Li, Ke	2020	policy options but show no research on existing ones
A review of photovoltaic poverty alleviation projects in China: Current status, challenge and policy recommendations	Li, Yan; Zhang, Qi; Wang, Ge; McLellan, Benjamin; Liu, Xue Fei; Wang, Le	2018	Innovation measurement not in patents
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The limits of academic entrepreneurship: Conflicting expectations about commercialization and innovation in China's nascent sector for advanced bio-energy technologies	Gosens, Jorrit; Hellsmark, Hans; Kaberger, Tomas; Liu, Li; Sanden, Bjorn A.; Wang, Shurong; Zhao, Lei	2018	Unretrievable text
A Functional Analysis of Technological Innovation Systems in Developing Countries: An Evaluation of Iran's Photovoltaic Innovation System	Esmailzadeh, Mohammad; Noori, Siamak; Aliahmadi, Alireza; Nouralizadeh, Hamidreza; Bogeys, Marcel	2020	Population not China
The Kyoto mechanisms and the diffusion of renewable energy technologies in the BRICS	Freitas, Isabel Maria Bodas; Dantas, Eva; Iizuka, Michiko	2012	Innovation measurement not in patents
Toward just energy transitions in authoritarian regimes: indirect participation and adaptive governance	Huang, Ping; Liu, Ying	2021	No renewable policies
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Does the focus of renewable energy policy impact the nature of innovation? Evidence from emerging economies	Samant, Shantala; Thakur-Wernz, Pooja; Hatfieldc, Donald E.	2020	
Energy System Transitions in the Eastern Coastal Metropolitan Regions of ChinaThe Role of Regional Policy Plans	Xiao, Mengzhu; Simon, Sonja; Pregger, Thomas	2019	Innovation measurement not in patents
Challenges Presented in the Implementation of Sustainable Energy Management via ISO 50001:2011	Rampasso, Izabela Simon; Melo Filho, Geraldo Pereira; Anholon, Rosley; de Araujo, Robson Amarante; Alves Lima, Gilson Brito; Perez Zotes, Luis; Leal Filho, Walter	2019	Innovation measurement not in patents
Effectiveness evaluation of photovoltaic poverty alleviation project in China: From a capital perspective	Bai, Bo; Xiong, Siqin; Ma, Xiaoming; Tian, Yushen	2021	Innovation measurement not in patents
Employee incentives and energy firms' innovation: Evidence from China	Si, Deng-Kui; Wang, Yanan; Kong, Dongmin	2020	
Not in my backyard, but not far away from me: Local acceptance of wind power in China	Guo, Yue; Ru, Peng; Su, Jun; Anadon, Laura Diaz	2015	Innovation measurement not in patents
Constructing China's wind energy innovation system	Klagge, Britta; Liu, Zhigao; Silva, Pedro Campos	2012	No renewable energy policies
The Learning Process and Technological Change in Wind Power: Evidence from China's CDM Wind Projects	Tang, Tian; Popp, David	2016	Innovation measurement not in patents
Overview of the development of the Chinese Jiangsu coastal wind-power industry cluster	He, Zhengxia; Xu, Shichun; Shen, Wenxing; Long, Ruyin; Yang, He	2016	Innovation measurement not in patents
Using Backcasting Methodology in Decision-making of Biomass Energy Development	Li, Jun; Ding, Wenbin; Jing Sijiang	2013	Innovation measurement not in patents
The price of wind power in China during its expansion: Technology adoption, learning-by-doing, economies of scale, and manufacturing localization	Qiu, Yueming; Anadon, Laura D.	2012	Innovation measurement not in patents

Comparing the Evolution of Crystalline Silicon Photovoltaic Cells: Technological Route and National Specialization	Tan, Long; Sun, Honghang; Ye, Xuanting; Liu, Yun; Su, Jun	2014	Innovation measurement not in patents
Is China's industrial policy effective? An empirical study of the new energy vehicles industry	Liu, Lanjian; Zhang, Tian; Avrin, Anne-Perrine; Wang, Xianwen	2020	
Do favorable land price policy affect renewable energy industry? Evidence from photovoltaics	Geng, Bin; Zhang, Xiaoling; Liang, Ying; Bao, Haijun	2016	Innovation measurement not in patents
OFF-GRID:: FARM. Multifuncional landscapes and sustainable systems for Mediterranean rural areas.	Rocca, Valentina	2014	No renewable policies
How Expensive Is Expensive Enough? Opportunities for Cost Reductions in Offshore Wind Energy Logistics	Poulsen, Thomas; Hasager, Charlotte Bay	2016	Innovation measurement not in patents
INSTITUTIONAL INNOVATION OF LOW-CARBON DEVELOPMENT	Leibo, Steven A.; Yang, Li	2013	Innovation measurement not in patents
Are government subsidies effective in improving innovation efficiency? Based on the research of China's wind power industry	Lin, Boqiang; Luan, Ranran	2020	Innovation measurement not in patents
Do government subsidies promote new-energy firms' innovation? Evidence from dynamic and threshold models	Li, Qing; Wang, Maoqiong; Xiangli, Liuxu	2021	
Notions on learning applied to wind turbine development in the Netherlands and Denmark	Kamp, LM; Smits, REHM; Andriesse, CD	2004	Population
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The Evaluation of Innovation Policy Efficiency for the Emerging Energy Industry in China: Wind Industry	Lu, Ming-Jie; Chen, Song; Liu, Xin; Lou, Yong	2012	Unretrievable text
A Critical Review of Sustainable Energy Policies for the Promotion of Renewable Energy Sources	Lu, Yuehong; Khan, Zafar A.; Alvarez-Alvarado, Manuel S.; Zhang, Yang; Huang, Zhijia; Im-	2020	Innovation measurement not in patents

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Assessing the renewable energy investment risk factors for sustainable development in Turkey	Kul, Cansu; Zhang, Ling; Solangi, Yasir Ahmed	2020	Population not China
Learning and technological capability building in emerging economies: The case of the biomass power equipment industry in Malaysia	Hansen, Ulrich Elmer; Ockwell, David	2014	Population not China
How does international trade network affect multinational diffusion of wind power technology?	Zhang, Gupeng; Duan, Hongbo	2020	Innovation measurement not in patents
Prospects for global market expansion of China's wind turbine manufacturing industry	Gosens, Jorrit; Lu, Yonglong	2014	No renewable energy policy link with innovation
Integrated technological paradigm-based soft paths towards sustainable development of small hydropower	Xu, Jiuping; Ni, Ting	2017	Innovation measurement not in patents
The (R)evolution of China: Offshore Wind Diffusion	Poulsen, Thomas; Hasager, Charlotte Bay	2017	Innovation measurement not in patents
Destined for decline? Examining nuclear energy from a technological innovation systems perspective	Markard, Jochen; Bento, Nuno; Kittner, Noah; Nunez-Jimenez, Alejandro	2020	Not renewable energy
The Evolution of the Wind Industry and the Rise of Chinese Firms: From Industrial Policies to Global Innovation Networks	Silva, Pedro Campos; Klagge, Britta	2013	Unretrievable text
Does politics matter? Explaining swings in wind power installations	Moe, Espen	2017	No renewable energy policies
Influencing factors of energy technical innovation in China: Evidence from fossil energy and renewable energy	Yang, Fang; Cheng, Yuanyuan; Yao, Xin	2019	No renewable energy policies
Potential usage, vertical value chain and challenge of biomass resource: Evidence from China's crop residues	Yang, Jun; Wang, Xiaobing; Ma, Hengyun; Bai, Junfei; Jiang, Ye; Yu, Hai	2014	Innovation measurement not in patents
Industrial life cycle: relevance of national markets in the development of new indus-	O'Sullivan, Marlene	2020	Innovation measurement not in patents

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Innovation Nirvana or Innovation Wasteland? Identifying commercialization strategies for small and medium renewable energy enterprises	Walsh, Philip R.	2012	Innovation measurement not in patents
Causal Dynamic Relationships between Political-Economic Factors and Export Performance in the Renewable Energy Technologies Market	Sung, Bongsuk; Wen, Cui	2018	Innovation measurement not in patents
Development of smart microgrid powered by renewable energy in China: current status and challenges	Xu, Cong; Lu, Wu	2019	Unretrievable text
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Behind the development of technology: The transition of innovation modes in China's wind turbine manufacturing industry	Ru, Peng; Zhi, Qiang; Zhang, Fang; Zhong, Xiaotian; Li, Jianqiang; Su, Jun	2012	Innovation measurement not in patents
Wind turbine cost reduction: A detailed bottom-up analysis of innovation drivers	Elia, A.; Taylor, M.; OGallachoir, B.; Rogan, F.	2020	Innovation measurement not in patents
China's policy initiatives for the development of wind energy technology	Dai, Yixin; Xue, Lan	2015	Unretrievable text
The price evolution of wind turbines in China: A study based on the modified multi-factor learning curve	Yu, Yang; Li, Hong; Che, Yuyuan; Zheng, Qiongjie	2017	No renewable energy policies
Solar energy innovation and Silicon Valley	Kammen, Daniel M.	2014	Population not China
A Comparative Assessment of Wind Turbine Innovation and Diffusion Policies	Neij, Lena; Andersen, Per Dannemand	2014	Unretrievable text
Solar Energy Innovation and Silicon Valley	Kammen, Daniel M.	2015	Population not China
Evolution of collaborative networks of solar energy applied technologies	de Paulo, Alex Fabianne; Porto, Geciane Silveira	2018	No renewable energy policies
Low-Carbon Electricity Technology, Innovation, Manufacturing		2019	Innovation measurement not in patents

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Examining the impact of factor price distortions and social welfare on innovation efficiency from the microdata of Chinese renewable energy industry	Qiao, Sen; Chen, Hsing Hung; Zhang, Rong Rong	2021	Innovation measurement not in patents
How will different types of industry policies and their mixes affect the innovation performance of wind power enterprises? Based on dual perspectives of regional innovation environment and enterprise ownership	Wang, Xiaozhen; Zou, Honghui; Zheng, Ying; Jiang, Zihao	2019	
Vested Interests, Energy Policy and Renewables in Japan, China, Norway and Denmark	Moe, Espen	2014	Unretrievable text
Ambition and ambiguity: Expectations and imaginaries developing offshore wind in China	Korsnes, Marius	2016	Innovation measurement not in patents
Government funded renewable energy innovation in China	Huang, Cui; Su, Jun; Zhao, Xiaoyuan; Sui, Jigang; Ru, Peng; Zhang, Hanwei; Wang, Xin	2012	Innovation measurement not in patents
From transitions in cities to transitions of cities: The diffusion and adoption of solar hot water systems in urban China	Huang, Ping; Broto, Vanesa Castan; Liu, Ying	2018	Innovation measurement not in patents
Profiling Innovation System for Solar Photovoltaics in China	Guo, Ying; Zhu, Donghua; Wang, Xuefeng	2009	Unretrievable text
Are we seeing clearly? The need for aligned vision and supporting strategies to deliver net-zero electricity systems	Ford, Rebecca; Hardy, Jeffrey	2020	Innovation measurement not in patents
The impact of government subsidies and enterprises' R&D investment: A panel data study from renewable energy in China	Yu, Feifei; Guo, Yue; Le-Nguyen, Khuong; Barnes, Stuart J.; Zhang, Weiting	2016	Innovation measurement not in patents
Comparison of technology efficiency for CO2 emissions reduction among European countries based on	Kwon, Deuk Sin; Cho, Joon Hyung; Sohn, So Young	2017	Population not China

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Current Status of PV in China and Its Future Forecast	Wang, Sicheng	2020	Unretrievable text
Innovation policies and industry subsidies: China and the global solar energy industry	Sarathy, Ravi	2013	Unretrievable text
Scientific relatedness in solar energy: a comparative study between the USA and China	Zhang, Jingjing; Yan, Yan; Guan, Jiancheng	2015	No renewable energy policies
Diffusion and Adoption Behavior of Environmentally Friendly Innovation: Sharing from Chinese Society	Sereenonchai, Sukanya; Arunrat, Noppol; Xu Peixi; Yu Xue	2017	Unretrievable text
Evaluating green innovation and performance of financial development: mediating concerns of environmental regulation	Hsu, Ching-Chi; Ngo Quang-Thanh; Chien, FengSheng; Li, Li; Mohsin, Muhammad		No renewable energy policies, so no link with innovation
Seven steps to curb global warming	Mathews, John	2007	Papers about energy consumption or co2 reduction
EFFECTS OF COLLABORATION NETWORKS ON TECHNOLOGY INNOVATION IN THE SOLAR PHOTOVOLTAIC (PV) SECTOR: A CASE STUDY OF CHINA	Liang, Xinning; Lu, Weisheng; Wu, Zezhou	2020	Unretrievable text
Technology Diffusion and Climate Policy: A Network Approach and its Application to Wind Energy	Vega, Solmaria Halleck; Mandel, Antoine	2018	Innovation measurement not in patents
Green investment: Trends and determinants	Eyraud, Luc; Clements, Benedict; Wane, Abdoul	2013	Innovation measurement not in patents
Public financing of innovation: new questions	Mazzucato, Mariana; Semieniuk, Gregor	2017	Innovation measurement not in patents
Patterns of technological accumulation: The comparative advantage and relative impact of Asian emerging economies in low carbon energy technological systems	Wong, Chan-Yuan; Keng, Zi-Xiang; Mohamad, Zeeda Fatimah; Azizan, Suzana Ariff	2016	No domestic policies
Electricity portfolio innovation for energy security: The case of carbon constrained China	Chalvatzis, Konstantinos J.; Rubel, Keagan	2015	Innovation measurement not in patents
Managing tradeoffs in green industrial policies: The role of re-	Matsuo, Tyeler; Schmidt, Tobias S.	2019	Population not China

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Integrating bibliometrics and roadmapping methods: A case of dye-sensitized solar cell technology-based industry in China	Li, Xin; Zhou, Yuan; Xue, Lan; Huang, Lucheng	2015	No renewable energy policies
Attaining a sustainable competitive advantage in the smart grid industry of China using suitable open innovation intermediaries	Chen, Hsing Hung; Chen, Silu; Lan, Yong	2016	Innovation measurement not in patents
Strategic policy to select suitable intermediaries for innovation to promote PV solar energy industry in China	Chen, Hsing Hung; Lee, Amy H. I.; Chen, Silu	2014	Innovation measurement not in patents
Dynamics of a policy-driven market: The co-evolution of technological innovation systems for solar photovoltaics in China and Germany	Quitzow, Rainer	2015	Innovation measurement not in patents
Natural gas: A transition fuel for sustainable energy system transformation?	Safari, Amir; Das, Nandini; Langhelle, Oluf; Roy, Joyashree; Assadi, Mohsen	2019	Not renewable energy
Conceptualizing Niche-Regime Dynamics of Energy Transitions from a Political Economic Perspective: Insights from Community-Led Urban Solar in Seoul	Mah, Daphne Ngar-yin; Cheung, Darren Man-wai	2020	Innovation measurement not in patents
Policy Decision Model on Innovation Stimulus and Industrial Regulation: A Case Study of Chinese Solar Energy Industry	Yan Hailin; Dai Sheng; Hou Jiangzhou; Jiang Hongyun	2009	Unretrievable text
Comparing Solar Water Heater Popularization Policies in China, Israel and Australia: The Roles of Governments in Adopting Green Innovations	Li, Wei; Rubin, Tzameret H.; Onyina, Paul A.	2013	Innovation measurement not in patents
The research profiling method applied to nano-enhanced, thin-film solar cells	Guo, Ying; Huang, Lu; Porter, Alan L.	2010	No renewable energy policies
Political conflict and climate policy: the European emissions trading system as a Trojan Horse for the low-carbon transition?	Markard, Jochen; Rosenbloom, Daniel	2020	Population not China

Community solar energy initiatives in urban energy transitions: A comparative study of Foshan, China and Seoul, South Korea	Mah, Daphne Ngar-yin	2019	Innovation measurement not in patents
A Policy Dimension Required for Technology Roadmapping: Learning from the Development of Emerging Wind Energy Industry in China	Zhou, Yuan; Xu, Guannan; Minshall, Tim; Su, Jun; Zhang, Fang; Zhi, Qiang	2011	Unretrievable text
The Effects of Neoliberalism and Trade Liberalization on China's Environment Over Time: A Macromarketing Perspective	Xu, Zhenning; Ramirez, Edward; Xu, Juanjuan; Liu, Yu	2015	Innovation measurement not in patents
Assessing the potential of low-carbon technologies in the German energy system	Kumar, Subhash; Loosen, Maximilian; Madlener, Reinhard	2020	Population not China
Environmental Policy Integration in the Energy Sector of China: The Roles of the Institutional Context	Ruan, Xiang; Sheng, Rong; Lin, Tuo	2020	Innovation measurement not in patents
Electric power substitution for coal in China: Status quo and SWOT analysis	Niu, Dong-xiao; Song, Zong-yun; Xiao, Xin-li	2017	Innovation measurement not in patents
Scaling up concentrating solar thermal technology in China	Li, Jun	2009	Unretrievable text
Plenary lecture III - Worldwide energy demand and environmental safeguard	Muzi, Francesco	2008	Not domestic policies
The governance of urban energy transitions: A comparative study of solar water heating systems in two Chinese cities	Huang, Ping; Broto, Vanesa Castan; Liu, Ying; Ma, Huizi	2018	Innovation measurement not in patents
How China became a leader in solar PV: An innovation system analysis	Huang, Ping; Negro, Simona O.; Hekkert, Marko P.; Bi, Kexin	2016	Innovation measurement not in patents
Comparison study of tidal stream and wave energy technology development between China and some Western Countries	Liu, Yijin; Li, Ye; He, Fenglan; Wang, Haifeng	2017	Innovation measurement not in patents
Towards the achievement of SDG 7 in sub-Saharan Africa: Creating synergies between Power Africa, Sustainable Energy for All and	Chirambo, Dumisani	2018	Population not China

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Identifying the underpin of green and low carbon technology innovation research: A literature review from 1994 to 2010	Shi, Qian; Lai, Xiaodong	2013	Innovation measurement not in patents
Management Innovation and Policy Diffusion through Leadership Transfer Networks: An Agent Network Diffusion Model	Yi, Hongtao; Berry, Frances Stokes; Chen, Wenna	2018	Innovation measurement not in patents
Examining the asymmetric effects of Pakistan's fiscal decentralization on economic growth and environmental quality	Li, Xiaolong; Younas, Muhammad Zeeshan; Andlib, Zubaria; Ullah, Sana; Sohail, Sidra; Hafeez, Muhammad	2021	Population not CHina
Vehicle emission and atmospheric pollution in China: problems, progress, and prospects	Wang, Jin; Wu, Qiuxia; Liu, Juan; Yang, Hong; Yin, Meiling; Chen, Shili; Guo, Peiyu; Ren, Jiamin; Luo, Xuwen; Linghu, Wensheng; Huang, Qiong	2019	Innovation measurement not in patents
Interdependence between Urban Processes and Energy Transitions: The Urban Energy Transitions (DUET) Framework	Huang, Ping; Broto, Vanesa Castan	2018	Innovation measurement not in patents
Government subsidies, R&D investment and innovation performance: analysis from pharmaceutical sector in China	Xu, Jian; Wang, Xiuhua; Liu, Feng	2021	Not renewable energy
Towards a typology of pilots: the Shanghai emissions-trading scheme pilot	Stensdal, Iselin	2020	Unretrievable text
Innovation orientations, external partnerships, and start-ups' performance of low-carbon ventures	Gu, Yuandong; Su, Dejin	2018	Innovation measurement not in patents
Mandating better buildings: a global review of building codes and prospects for improvement in the United States	Sun, Xiaojing; Brown, Marilyn A.; Cox, Matt; Jackson, Roderick	2016	Population not China
The Impact of Green Credit Guidelines on the Technological Innovation of Heavily Polluting Enterprises:	Hao, Fangjing; Xie, Yuantao; Liu, Xiaojiao	2020	not about renewable energy

A Quasi-Natural Experiment from China			
Clean distributed generation in China: Policy options and international experience	Dong, Jun; Feng, Tian-tian; Sun, Hong-xing; Cai, Hong-xin; Li, Rong; Yang, Yisheng	2016	Innovation measurement not in patents
The importance of open and closed styles of energy research	Sovacool, Benjamin K.	2010	Innovation measurement not in patents
Towards Smart Cities by Internet of Things (IoT)-a Silent Revolution in China	Song, Tao; Cai, Jianming; Chahine, Teresa; Li, Le	2021	Innovation measurement not in patents
Potentials and opportunities towards the low carbon technologies - From literature review to new classification	Metta, Julie; An, Yao; Zheng, Huanhuan; Zhang, Lin	2020	Innovation measurement not in patents
The Impact of Government Subsidies on Private R&D and Firm Performance: Does Ownership Matter in China's Manufacturing Industry?	Jin, Zhenji; Shang, Yue; Xu, Jian	2018	Not renewable energy
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Multi-level Reinforcement in European Climate and Energy Governance: Mobilizing economic interests at the sub-national levels	Jaenicke, Martin; Quitzow, Rainer	2017	population not China
The impression of technological innovations and natural resources in energy-growth-environment nexus: A new look into BRICS economies	Khan, Anwar; Muhammad, Faqir; Chenggang, Yang; Hussain, Jamal; Bano, Sadia; Khan, Muhammad Awais	2020	Papers about energy consumption or co2 reduction
A comparison of innovation policy in the smart grid industry across the pacific: China and the USA	Lin, Chen-Chun; Yang, Chia-Han; Shyua, Joseph Z.	2013	Innovation measurement not in patents
A Cross-Strait Comparison of Innovation Policy under Industry 4.0 and Sustainability Development Transition	Lin, Kuan Chung; Shyu, Joseph Z.; Ding, Kun	2017	Innovation measurement not in patents
Green transition, industrial policy, and economic development	Kemp, Rene; Never, Babette	2017	Unretrievable text
How do Public Demonstration Projects Promote Green-Manufacturing Tech-	Zhou, Yuan; Xu, Guannan; Minshall, Tim; Liu, Peng	2015	No renewable energy policies

nologies? A Case Study from China			
How public demonstration projects affect the emergence of new industries: an empirical study of electric vehicles in China	Zhou, Yuan; Zhang, Hanwei; Ding, Mengyu	2015	No renewable energy policies
Conceptual design of a municipal energy and environmental system as an efficient basis for advanced energy planning	Kostevsek, Anja; Petek, Janez; Cucek, Lidija; Pivec, Aleksandra	2013	Population not China
Differences in the effects of China's new energy vehicle industry policies on market growth from the perspective of policy mix	Xiong, Yongqing; Qin, Shufeng	2021	Innovation measurement not in patents
Carbon-Free Energy and Sustainable Environment: The Role of Human Capital and Technological Revolutions in Attaining SDGs	Shen, Hebin; Ali, Syed Ahtsham; Alharthi, Majed; Shah, Ali Shan; Basit Khan, Abdul; Abbas, Qaiser; ur Rahman, Saeed	2021	Innovation measurement not in patents
The energy policy outlets for community acceptance of ecological investment in China	Wang, Zhan; Deng, Xiangzheng	2017	Innovation measurement not in patents
How do technological innovation and fiscal decentralization affect the environment? A story of the fourth industrial revolution and sustainable growth	Cheng, Ya; Awan, Usama; Ahmad, Shabbir; Tan, Zhixiong	2021	propose policy options but show no research on existing ones
Moving from subsidy stimulation to endogenous development: A system dynamics analysis of China's NEVs in the post-subsidy era	Ye, Rui-Ke; Gao, Zhuang-Fei; Fang, Kai; Liu, Kang-Li; Chen, Jia-Wei	2021	Innovation measurement not in patents
Economic performance of photovoltaic water pumping systems with business model innovation in China	Zhang, Chi; Campana, Pietro Elia; Yang, Jin; Yan, Jinyue	2017	Innovation measurement not in patents
Factors influencing the application of prefabricated construction in China: From perspectives of technology promotion and cleaner production	Wu, Guobin; Yang, Ru; Li, Ling; Bi, Xing; Liu, Bingsheng; Li, Shaoyan; Zhou, Shixiang	2019	Innovation measurement not in patents
Unfolding the convergence process of scientific knowledge for the early identification	Zhou, Yuan; Dong, Fang; Kong, Dejing; Liu, Yufei	2019	No renewable energy policies

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Examining the patterns of innovation in low carbon energy science and technology: Publications and patents of Asian emerging economies	Wong, Chan-Yuan; Mohamad, Zeeda Fatimah; Keng, Zi-Xiang; Azizan, Suzana Ariff	2014	No renewable energy policies
Promotion policies for third party financing in Photovoltaic Poverty Alleviation projects considering social reputation	Li, Yan; Zhang, Qi; Wang, Ge; Liu, Xuefei; Mclellan, Benjamin	2019	Innovation measurement not in patents
Assessing the regional sustainability performance in China using the global Malmquist-Luenberger productivity index	Liu, Kai-di; Yang, Duo-Gui; Yang, Guoliang; Zhou, Zhi-Tian		Unretrievable text
Facilitating the transition to sustainable construction: China's policies	Chang, Rui-dong; Soebarto, Veronica; Zhao, Zhen-yu; Zillante, George	2016	Innovation measurement not in patents
How Do Configuration Shifts in Fragmented Energy Governance Affect Policy Output? A Case Study of Changing Biogas Regimes in Indonesia	Budiman, Ibnu; Smits, Mattijs	2020	Population not China
The politics of technology bans: Industrial policy competition and green goals for the auto industry	Meckling, Jonas; Nahm, Jonas	2019	No renewable energy policies
Green energy futures: Responsible mining on Minnesota's Iron Range	Phadke, Roopali	2018	Population not China
Multinational firms and the internationalization of green R&D: A review of the evidence and policy implications	Noailly, Joelle; Ryfisch, David	2015	propose policy options but show no research on existing ones
National innovation systems and the intermediary role of industry associations in building institutional capacities for innovation in developing countries: A critical review of the literature	Watkins, Andrew; Papaioannou, Theo; Mugwagwa, Julius; Kale, Dinar	2015	Innovation measurement not in patents
Impact of Political Connection Strength on the Internationalization Outcome of Chinese Firms: Perspectives from Market Exploration and Technology Acquisition	Zhang, Gupeng; Zhang, Qianlong; Huang, Dujuan	2020	not about renewable energy

Empirical analysis and strategy suggestions on the value-added capacity of photovoltaic industry value chain in China	Liu, Jicheng; Lin, Xiangmin	2019	Innovation measurement not in patents
China's role in attaining the global 2 degrees C target	Jiang, Kejun; Zhuang, Xing; Miao, Ren; He, Chenmin	2013	Papers about energy consumption or co2 reduction
Prospects for Clean-Tech Venture Capital Investment in China: A Third Wave?	Chen, Bei	2009	Unretrievable text
Innovation and technology transfer through global value chains: Evidence from China's PV industry	Zhang, Fang; Gallagher, Kelly Sims	2016	No domestic policies
The optimal research and development portfolio of low-carbon energy technologies: A study of China	Wang, Kaiming; Mao, Yong; Chen, Jiangtao; Yu, Shiwei	2018	No renewable energy policies
Second Use Value of China's New Energy Vehicle Battery: A View Based on Multi-Scenario Simulation	Zhang, Lei; Liu, Yingqi; Pang, Beibei; Sun, Bingxiang; Kokko, Ari	2020	Innovation measurement not in patents
Co-evolution entropy as a new index to explore power system transition: A case study of China's electricity domain	Nie, Yan; Lv, Tao; Gao, Jian	2017	Innovation measurement not in patents
Business innovation and government regulation for the promotion of electric vehicle use: lessons from Shenzhen, China	Li, Ying; Zhan, Changjie; de Jong, Martin; Lukszo, Zofia	2016	Innovation measurement not in patents
Can an island economy be more sustainable? A comparative study of Indonesia, Malaysia, and the Philippines	Yang, Lan; Wang, Chengdong; Yu, Huajun; Yang, Meijie; Wang, Shoubing; Chiu, Anthony S. F.; Wang, Yutao	2020	Population not China
Global sustainability, innovation and governance dynamics of national smart electricity meter transitions	Sovacool, Benjamin K.; Hook, Andrew; Sareen, Siddharth; Geels, Frank W.	2021	Population not China
Conceptualising government-market dynamics in socio-technical energy transitions: A comparative case study of smart grid developments in China and Japan	Mah, Daphne Ngar-yin	2020	Innovation measurement not in patents
Research on the policy route of China's dis-	Li, Hanfang; Lin, Hongyu; Tan, Qing-	2020	Innovation measurement not in patents

tributed photovoltaic power generation	kun; Wu, Peng; Wang, Chengjie; De, Gejirifu; Huang, Liling		
An innovation-focused roadmap for a sustainable global photovoltaic industry	Zheng, Cheng; Kammen, Daniel M.	2014	Innovation measurement not in patents
The dynamics of advancing climate policy in federal political systems	Jordaan, Sarah M.; Davidson, Adrienne; Nazari, Jamal A.; Herremans, Irene M.	2019	Population not China
Do government subsidies promote efficiency in technological innovation of China's photovoltaic enterprises?	Lin, Boqiang; Luan, Ranran	2020	
Evaluating the transition towards cleaner production in the construction and demolition sector of China: A review	Ghisellini, Patrizia; Ji, Xi; Liu, Gengyuan; Ulgiati, Sergio	2018	Innovation measurement not in patents
Implementation of agrophotovoltaics: Techno-economic analysis of the price-performance ratio and its policy implications	Schindele, Stephan; Trommsdorff, Maximilian; Schlaak, Albert; Obergfell, Tabea; Bopp, Georg; Reise, Christian; Braun, Christian; Weselek, Axel; Bauerle, Andrea; Hoegy, Petra; Goetzberger, Adolf; Weber, Eicke	2020	Innovation measurement not in patents
Role of technologies in energy-related CO2 mitigation in China within a climate-protection world: A scenarios analysis using REMIND	Zhang, Shuwei; Bauer, Nico; Luderer, Gunnar; Kriegler, Elmar	2014	Innovation measurement not in patents
The Hangzhou Consensus: Legacy for China, G20 and the World	Larionova, Marina; Kolmar, Olga	2017	Innovation measurement not in patents
Patent analysis to identify shale gas development in China and the United States	Lee, Woo Jin; Sohn, So Young	2014	Not renewable energy
Assessing fuel cell vehicle innovation and the role of policy in Japan, Korea, and China	Haslam, Gareth E.; Jupesta, Joni; Parayil, Govindan	2020	
Charging Chinese future: the roadmap of China's policy for new energy automotive	Li, Jianzhong	2020	Innovation measurement not in patents

industry			
Challenges and Policy Suggestions on the Development of Hydrogen Economy in China	Shan, Wei; Wang, Fang-Fang	2020	Innovation measurement not in patents
Parallel chance-constrained dynamic programming for cascade hydropower system operation	Liu, Benxi; Cheng, Chuntian; Wang, Sen; Liao, Shengli; Chau, Kwok-Wing; Wu, Xinyu; Li, Weidong	2018	Innovation measurement not in patents
Technology transfer in the hydropower industry: An analysis of Chinese dam developers' undertakings in Europe and Latin America	Kirchherr, Julian; Matthews, Nathanial	2018	Innovation measurement not in patents
When do states disrupt industries? Electric cars and the politics of innovation	Meckling, Jonas; Nahm, Jonas	2018	Unretrievable text
Influencing factors on hydrogen energy R&D projects: An ex-post performance evaluation	Chun, Dongphil; Hong, Sungjun; Chung, Yanghon; Woo, Chungwon; Seo, Hangyeol	2016	Population not China
Progress in China's Unconventional Oil & Gas Exploration and Development and Theoretical Technologies	Zou Caineng; Yang Zhi; Zhu Rukai; Zhang Guosheng; Hou Lianhua; Wu Songtao; Tao Shizhen; Yuan Xuanjun; Dong Dazhong; Wang Yuman; Wang Lan; Huang Jinliang; Wang Shufang	2015	Not renewable energy
Policy Implications of Shale Gas Research in Collaboration Network Analysis	Liu, Jie; Ma, Tieju	2015	Not renewable energy
Review of Low-Carbon Vehicle Technologies in China	Ou, Xunmin; Zhang, Xiliang	2010	Unretrievable text
Alternative fuel buses currently in use in China: Life-cycle fossil energy use, GHG emissions and policy recommendations	Ou, Xunmin; Zhang, Xiliang; Chang, Shiyan	2010	Innovation measurement not in patents

10.3 Appendix C: Classification of green patent groups (Fujii & Managi, 2019)

Technology group (code)	Technology subgroup
Waste management (WASTE)	(1) Waste disposal, (2) treatment of waste, (3) consuming waste by combustion, (4) reuse of waste materials, (5) pollution control
Alternative energy production (RENEWABLE)	(1) Biofuels, (2) integrated gasification combined-cycle fuel cells, (3) pyrolysis or gasification of biomass, (4) harnessing energy from manmade waste, (5) hydroenergy, (6) ocean thermal energy conversion, (7) wind energy, (8) solar energy, (9) geothermal energy, (10) other production or use of heat not derived from combustion, (11) using waste heat, (12) devices for producing mechanical power from muscle energy
Energy conservation (CONSERVATION)	(1) Storage of electrical energy, (2) power supply circuitry, (3) measurement of electricity consumption, (4) storage of thermal energy, (5) low-energy lighting, (6) thermal building insulation, in general, (7) recovering mechanical energy
Other green technology (OTHER)	(1) Vehicles, in general, (2) vehicles other than rail vehicles, (3) rail vehicles, (4) marine vessel propulsion, (5) cosmonautic vehicles using solar energy, (6) forestry techniques, (7) alternative irrigation techniques, (8) pesticide alternatives, (9) soil improvement, (10) commuting, (11) Carbon/emissions trading, (12) static structure design, (13) nuclear engineering, (14) gas turbine power plants using heat sources of nuclear origin