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A Comparative Analytical Study of the Renewable Energy Sector in the United States and China

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Abstract :

This study aims to analyze the reality of renewable energies in both the United States and China, as pioneers in this field, by highlighting the capabilities of the two countries in this resource, and the extent of their interest in meeting the growing demand for energy, and presenting the most prominent projects planned for both countries in their quest to achieve economic gains The study concluded that the United States of America has witnessed a significant expansion in renewable energy, especially solar and wind energy, which has strengthened its role and position in this field, while China has adopted an ambitious strategy for energy transformation, which has made it lead the world in the installed capabilities of these energies. A comparison between the two experiences shows that the United States excels in research, development and performance effectiveness While China is advancing in the volume of investments and production capacity, the American and Chinese experiences are a rich source of lessons that can be used to guide the strategies of other countries, led by Algeria, that wish to develop the renewable energy sector, get out of fuel dominance, and achieve energy diversification.

Keywords: Renewable Energy; Energy Transition; United States; China.

Jel Classification Codes : Q42; Q48;O51.

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1. Introduction.

Today, the world is witnessing a radical transformation in energy production and consumption patterns, driven by increasing environmental and economic challenges, most notably climate change, environmental degradation, and the depletion of fossil resources. In this context, renewable energies have emerged as a strategic option for achieving sustainable development and ensuring long-term energy security. Investing in clean energy sources has become a priority for many countries, most notably the United States and China They are among the world's largest and most energy-consuming economies.

The United States of America has the strongest economy in the world, so that no other economy can match it, at least in terms of size. It is the first country in the world in terms of gross national product, which reached $26.95 trillion at the end of 2023. Since the beginning of the first decade of the twenty-first century, China has witnessed a noticeable increase in its economic indicators By overtaking the European Union and Japan, it has become the United States' real competitor and the number one threat to its removal from the top of the international economic pyramid. With 101,598 billion Chinese yuan (about 15,660 billion dollars), China ranks second in the world in terms of GDP in absolute terms in 2021, and its average growth is still rising by at least 5% in the coming years.

Both the United States and China have distinct characteristics in terms of natural resources, development models, and energy policies, which makes studying their experiences in the field of renewable energies of great scientific and practical importance. The United States, despite its heavy dependence on oil and gas, is witnessing a remarkable expansion in the field of solar and wind energy, supported by the dynamism of the private sector and the multiplicity of state policies. As for China, it has transformed over the past two decades into a global leader in the production of clean energy equipment With its reliance on centralized strategies and huge investments in hydroelectric and solar energy.

Research Problem

To what extent have the United States and China succeeded in developing the renewable energy sector?

Sub-questions

1. What is the current state of the renewable energy sector in both the United States and China?

2. How do the renewable energy resources available in the United States and China differ in terms of potential, diversity, and strategic utilization?

3. What are the main differences between the energy transition strategies adopted by the United States and China in developing their renewable energy sectors?

The Objective of the Study

This study aims to provide a comparative analysis of the reality of the renewable energy sector in both the United States and China, by reviewing strategies, legislative frameworks, investment volume, challenges facing each country, and results achieved in the field of energy transition.

Methodological Approach

In order to answer the problem of the study and to understand the various aspects of the subject, the descriptive analytical approach and the comparative approach were adopted. The first and second were devoted to describing the phenomenon, analyzing its components, and revealing the intertwined relationships between them. The third, i.e. the comparative approach, was devoted to conducting a comparison between the two countries of study, and identifying the differences and

similarities in terms of the diversity of natural and energy resources, the economic structure, and the strategies for managing these resources.

Structure of the study.

To cover the various aspects of the topic, the research was divided into four main axes. The first axis presents the theoretical framework based on the energy transition theory, the second axis and the third axis review the situation of the renewable energy sector in both the United States of America and China, while the fourth axis addresses a comparative analysis of the reality of the renewable energy sector in both countries.

2. Literature Review.

The first axis presents the literature review of the study, based on the theory of energy transition, which explains how countries move from dependence on fossil fuels to renewable energy sources.

In the 1980s, the concept of energy transition originated in Germany and Austria, where the ACO Institute presented it as a framework of scientific predictions and proposals to explore alternatives to oil. This concept is broader than simply shifting from energy production and consumption based on depleting sources; it emphasizes increasing the share of renewable energy in the energy mix. (Zidane, 2022)

2.1 Definition of energy transformation theory:

Energy transition means moving from an energy system based on fossil fuels to an energy system based primarily on renewable energies. (Aichaoui, 2016 , p. 13)

The International Energy Agency defined it as "moving energy production away from sources that release a lot of greenhouse gases. It shifts towards sources that emit little or no greenhouse gases, such as nuclear power, hydropower, wind energy, and solar energy". (IEA, 2024)

The energy transition is defined by the International Renewable Energy Agency as a radical reshaping of the global energy sector, aiming to move from dependence on fossil fuels to a low- or no-carbon energy system by the second half of this century. The World Energy Council (WEC) considers it a set of profound structural changes affecting the structure of the energy sector, reflecting a comprehensive transformation in production, consumption and usage patterns. (IRENA, 2024)

The Scientific Council for Energy, which brings together energy sector managers from 100 countries, has identified three dimensions of energy transition: (Lajjal, 2020, p. 162)

• Achieving energy security and providing energy for current and future generations.
• Energy justice to provide energy to all peoples of the world.
• Permanent environmental maintenance and mitigation of greenhouse gases.

2.2 Energy transition strategies and requirements:

The strategies can be summarized in three main ones: (Abou & Tayeb, 2018, pp. 38-39)

- **Optimal energy consumption**: can be achieved by reducing heating energy consumption, through better building insulation and improving heating media. It also involves selecting vehicles that meet sustainability requirements, and minimising the use of fossil fuels, in addition to working to reduce the use of electricity in all sectors, industrial, domestic, electronic office technology and information.
- **Planning for energy transition**: can be achieved by integrating all energy stakeholders, according to programs and plans that seek to meet energy needs while ensuring the rights of future generations and preserving the environment.

Considering energy transition as the primary driver of the development process: This is what makes major economic institutions producing energy materials move towards optimal exploitation of energy resources, which enables them to use renewable resources in addition to improving their image and providing new job positions.

The most important requirements are: (Maleki & Mouadhin, 2020, p. 223)

- High-level political will requires a clear commitment from national leadership to gradually phase out fossil fuels and adopt renewable energy.

-Securing the necessary financing: This requires providing the necessary financial liquidity for renewable energy projects by involving the private sector and encouraging foreign direct investment in this field.

-Creating new and emerging markets: New markets must be provided for the energy produced from this transition, characterized by flexibility and transparency in transactions.

-Strengthening international partnerships: This includes concluding international agreements and partnership contracts to develop renewable energy generation and manufacturing and transfer knowledge.

-Supporting research and development: This includes encouraging continuous scientific and technological research in the renewable energy sector to drive innovation and reduce costs

2.3 The importance of energy transformation

The world today has witnessed radical transformations in energy production and consumption patterns, driven by a number of environmental, economic and technological challenges. At the heart of these transformations is the concept of energy transition as a strategic option imposed by the urgent need to reduce over-reliance on traditional energy sources, especially fossil fuels, with their negative impacts on the environment and resource sustainability. This transformation is not limited to the technological aspect only, but also includes economic, social and institutional dimensions .This requires the adoption of integrated public policies and effective national strategies that take into account local specificities and take into account the requirements of a just and comprehensive transition towards cleaner and more efficient energy models.

The transformation of the energy system is considered an essential factor in achieving the sustainable development goals, as it contributes to enhancing energy security, opens the way for diversifying energy sources, in addition to reducing carbon emissions that lead to global warming. It is also an effective means of enhancing countries' energy independence and increasing their ability to confront international fluctuations in fuel markets. (Maleki & Mouadhin, 2020, p. 40)

Thus, energy transition theory provides a comprehensive framework for understanding the transition from fossil fuel-based energy systems to low- or carbon-free energy systems. Its principles include energy security, sustainability, and institutional planning, and will form the basis for analyzing the experiences of the United States and China in accelerating their energy transition and relying more on renewable energy.

3.Current status of the renewable energy sector in the United States of America

The economic scale and diversification of the United States of America provide structural advantages, making it unmatched in size and strength, supported by a market economy based on free investment and trade competition.(Ali, 2009, p. 155) The United States of America is the first country in the world in terms of gross national product, which reached $26.95 trillion at the end of 2023, with a per capita share of $80,410 thousand (the largest in the world), and an annual output growth rate of 1.6% It also has a large consumer market and promotes the spirit of innovation and

entrepreneurship (Hisham, 2023; IMF, 2023), in addition to having a flexible infrastructure and good working conditions. The US economy ranks second in terms of GDP based on purchasing power parity.(IMF, 2021) In 2021, the US economy ranked fifth in terms of nominal GDP per capita, and seventh in terms of GDP based on purchasing power parity per capita The United States has the most technologically powerful and innovative economy in the world. The strength of the economy is evident in the fields of artificial intelligence, computers, pharmaceuticals, medicine, aerospace, and military technology in particular. The US dollar is the most widely used currency in international trade and the main currency in the currency reserves held by banks and countries, supported by the US economy and armed forces, petrodollar recycling, and dollar forward deposits outside US banks and the US Treasury Department The US dollar is an official currency in several other countries, and an actual currency in other countries.(Mdkhana Hicham, 2023; IMF, 2023)

3.1. Renewable energy resources in the United States of America

The total installed capacity of clean energy in the United States of America in 2021 reached 15,317 megawatts(American Clean Power, 2021, p. 6), and the following are renewable energy resources:

a. Solar Energy

Of all renewable energy resources, solar energy has the greatest potential for electricity production and generation in the United States and has expanded significantly due to the low cost of solar panels. There are three solar energy technologies: utility-scale photovoltaic, concentrated solar, and distributed photovoltaic. (US Department of Energy, 2022, pp. 9-11-16-17)

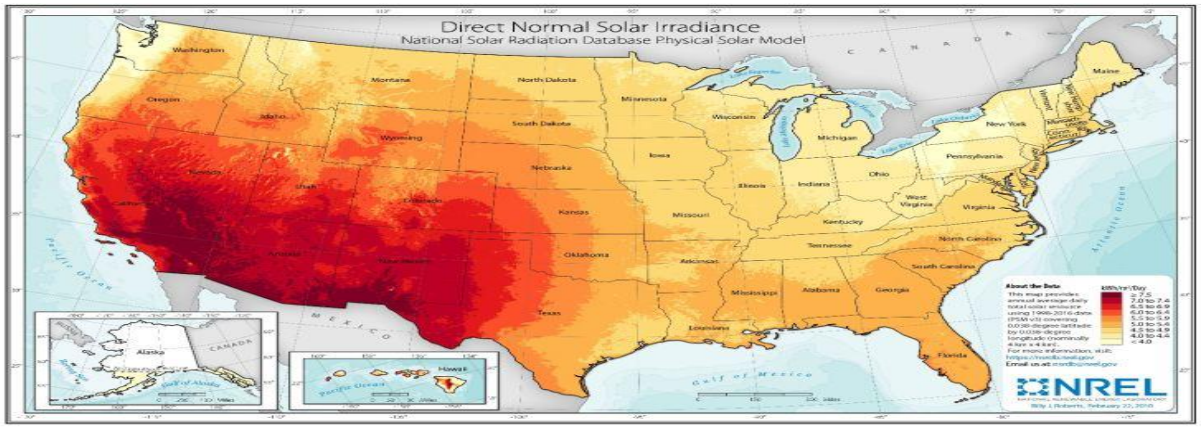
Table 1.Technical potential for solar power generation in the United States 2020

Renewable sources	Potential capacity (GW)	Potential production capacity (TWh/year)	Potential capacity for production near tribal lands	Total production capacity
Utility-scale photovoltaic energy	157.765	297.486	22.736	88
-Concentrated Solar Power (CSP)	16.691	87.728	14.703	3
Distributed photovoltaic energy	1.118	1.432	416	42

Source: (US Department of Energy, 2022, p. 9).

We note that photovoltaic technology has the greatest technical potential of any renewable energy resource in the United States, with a total technical potential estimated at 157.8 terawatts. At the end of 2023, installed capacity exceeded 160 gigawatts.

Figure 1.Average annual solar energy resources of the USA



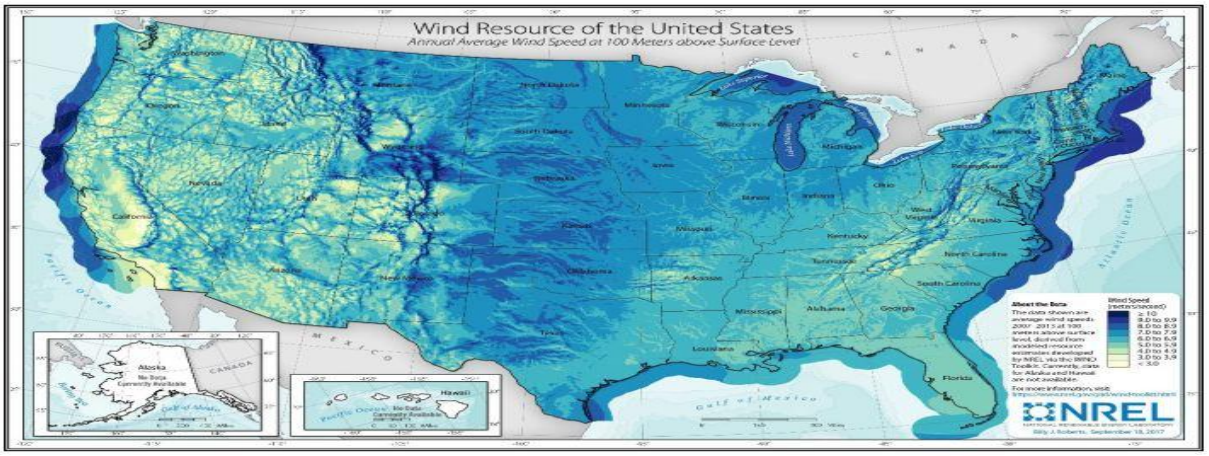
Source: (US Department of Energy, 2022, p. 12).

As can be seen on the map, large areas in the southwestern states have a higher insolation rate, exceeding 6.8 kilowatts/m2/hour, while areas surrounding the Great Lakes and Washington state do not exceed 4 kilowatts/m2/hour.

b. Wind Power

There is great potential for wind energy production in the United States, especially in the Central Plains and beyond, and the coasts of the Northeast and Northwest. Seasonal patterns of wind resources vary greatly between different types of regions of the United States, and even within a region or state. Onshore wind plants are located in 41 states and have created more than 10,000 jobs. (US Department of Energy, 2022, pp. 21-26)

Figure 2.Average annual wind resources at 100 meters in the USA



Source: (US Department of Energy, 2022, p. 22).

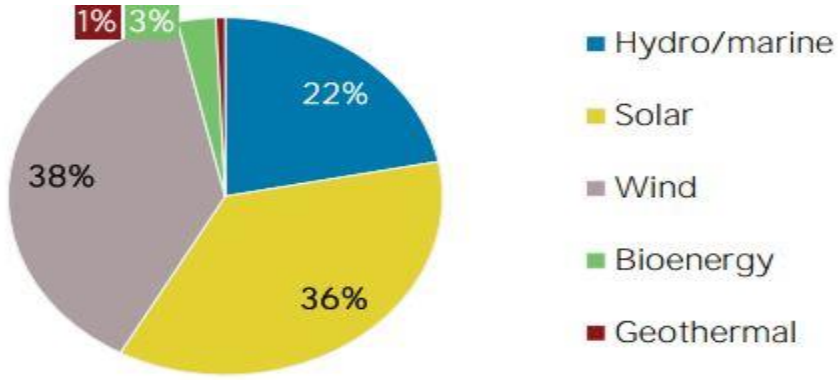
We notice from the figure the variation in onshore wind speeds in the United States of America. The greatest source of wind is found in the central plains between the Rocky Mountains and the Mississippi River, where the average wind speed ranges from 6-8 m/s, while wind speeds are higher and less variable at sea in the Great Lakes region, the Gulf Coast, the Atlantic Ocean and the Pacific Ocean (more than 10 m/s).

c. Hydropower

Hydropower in the United States uses running water to produce electricity, without any greenhouse gas emissions or reduced water consumption. Hydropower technology costs much less

than many other energy sources, so almost all US states use it for electricity. The total hydropower potential in the United States is 661 terawatt-hours.

Figure 3.Renewable energy sources in the U.S.A in 2023



Source : (IRENA, 2024, p. 2)

Wind energy dominates the largest percentage of renewable energy sources in the United States of America, at a rate of 38%, followed by solar energy by a small margin and at a rate of 36%, with hydroelectric energy occupying third place with a rate of 22%, while living energy and geothermal energy, their percentage is 3% and 1% respectively, as these two energies are still at a somewhat late stage in terms of technology and cost, as well as completed and future projects.

3.2 The United States' strategy for investing in renewable energies

The US government has adopted an integrated system that includes a set of strategies and mechanisms to secure energy from renewable sources, as follows:(Al-Saeedi, 2011, pp. 61-65)

a. Political measures

Encouraging investment in alternative energies, such as the US government's issuance of a program to expand the use of nuclear energy and encourage the construction of new plants in the near future, as well as the development of more economical, safe and sustainable reactors, in addition to the Advanced Fuel Cycle Initiative, to recycle used nuclear fuel and extract much more energy from uranium resources.

b. Legislative procedures

The most important of these is the "Energy Act" passed by Congress, which included the following points:

- Granting tax incentives to alternative energy producers, with the aim of increasing US production and increasing research in the field of technology.
- Providing hazard insurance to encourage the construction of nuclear power plants.
- Providing tax exemptions to producers of energy sources derived from wind and live masses, to consumers of hybrid cars, and to producers of electronic and electrical devices that comply with standards for optimal energy use.

c. Scientific and research procedures

It is related to activating and reviving the use of alternative and renewable energy sources, by adopting a principle that encourages the use and innovation of technology to generate environmentally friendly energy, such as wind energy, solar energy, and biofuels.

d. Economic and investment measures

It was represented as follows:

- Reducing gasoline consumption by increasing alternative energy sources, such as cellulosic ethanol.
- Encouraging investment in renewable energy projects and encouraging investors to invest in them, with the aim of reducing dependence on oil sources of energy.

e. Awareness and technological measures

By spreading the concept of energy economy, making individuals consume less in carrying out their daily activities, with the aim of saving energy consumption, providing methods that encourage energy economy, spreading new energy policies by adopting them commercially by creating markets for what is called clean energy technology, and creating incentives that support such goods for producers and consumers, through programs to liberalize and reshape the market.

The United States of America also seeks, through the technologies, systems and practices it has developed in the field of renewable energy, to achieve the following goals:

- Fairly convert the United States to net zero economy-wide greenhouse gas emissions in 2050.
- Installing 30 gigawatts of solar energy per year, until 2025 and 60 gigawatts annually from 2025 to 2030, deploying 30 gigawatts, opening more than 110 gigawatts of offshore wind energy by 2050, and saving 60 gigawatts by strengthening geothermal energy systems in 2050, which represents 8% of power generation in the United States.
- Reduce the cost of solar energy facilities by 60%, making them the least expensive option for generating electricity everywhere in the United States.
- Prioritize energy and environmental justice and remove barriers to citizens' access to renewable sources.
- Providing at least 300,000 new jobs in the solar energy sector, and providing 44,000 workers by 2030 and 77,000 workers in 2050 in the field of wind energy .
- Achieving a carbon-free electricity sector by 2035, which in turn achieves the following points :

1. Achieving health and economic benefits, the most important of which is reducing damage resulting from climate change, such as extreme weather, heat-related diseases and deaths, decreased agricultural productivity, and others.
2. Ensuring energy security by reducing fluctuations in oil and natural gas prices.
3. Improving social justice and supporting well-paying jobs in new and emerging industries.

The United States' experience in renewable energy is unique, as it has been able - without a doubt - to achieve the largest number of successful experiences, especially in solar energy, the southern parts of which are densely covered most days of the year. This is due to many factors, the most prominent of which is the US Department of Energy's support for research in this field to achieve the goals of the strategy followed.

4. Current status of renewable energies in China

China's tremendous economic rise is one of the most important features of the current international system, and it is expected to be the fastest growing economy in the world in the foreseeable future(Shiping, 2006 , p. 31). Since the beginning of the first decade of the twenty-first century, China has witnessed a noticeable increase in its economic indicators, as it has surpassed the European Union and Japan and has become the real competitor to the United States of America and the first threat to remove it from the top of the international economic pyramid.(IMF, 2021)

With 101,598 billion Chinese yuan (about 15,660 billion dollars), In 2021, China ranks second in the world in terms of GDP in absolute terms, and its average growth is still rising by at least 5% in the coming years.(Meglio, 2021, p. 67)

The People's Republic of China is located in the northern part of the Eastern Hemisphere, extending over an area of 9.6 million km2, or about 1/15 of the world's land area, and occupies the eastern part of the Asian continent(Guang, 1987, p. 1). It consists of more than 22 provinces, 5 autonomous regions, and 4 directly administered municipalities. The Chinese economy is the second largest economy in the world in terms of GDP after the United States of America It is the largest economy in the world since 2016 according to neutral purchasing power. It is also the largest industrial economy and the largest exporter of goods, the fastest growing consumer market and the second largest importer of goods in the world. China is the largest trading country and the largest recipient of foreign direct investment in the world, surpassing the European Union. In 2022, China participated with 18.6% in the global economy Historically, China was one of the world's leading economic powers for about 2,000 years, from the first millennium until the nineteenth century. The Chinese economy consists of public sector institutions, state-owned enterprises and mixed-ownership companies, as well as a large domestic private sector and openness to foreign companies.(World Bank, 2023)

4.1The reality of investment in renewable energy in China

The Chinese government has been rapidly encouraging investment in renewable energy. Between 2003 and 2014, investment increased by an average of 42% per year. Even as global investment declined in 2012, it rose by 22% in China, but fell by 6% in 2013(Tayeb, 2019, p. 29).

a. Wind Power

China's entry into the wind energy market came late compared to other countries such as the United States, Germany and Sweden, but it was able to rise in this field to the top of the global industry, thanks to the support and incentive measures provided by the Chinese government for such projects, in addition to a large and growing internal market, which made these projects find a place in the world China's vast area also offers many sites for establishing wind energy fields. The construction of these fields initially began in Inner Mongolia, and their construction later expanded to other sites in the northern provinces of China. Before 2005, wind energy did not exist in China, but it exceeded 10 gigawatts in 2008. (Tayeb, 2019, pp. 30-31) The year 2020 witnessed record wind energy installations with more than 72 gigawatts of facilities, including 3 gigawatts of offshore wind energy (Hove, Qian, Zhao, Philipp, & Liu, 2021, pp. 7-8), while the installed capacity of wind energy reached 467 terawatt hours compared to 406 in 2019 with a growth rate of 15%, and the share of wind in electricity production in China reached 6.1% compared to 5.5% in 2019. (Hove, Qian, Zhao, Philipp, & Liu, 2021, p. 34)

Table 2.Evolution of installed wind turbine capacity in China 2016 – 2021(GW)

years	2016	2017	2018	2019	2020	2021
capacity	148.5	164.4	184.7	209.6	282.1	329.0

Source : (bp, 2022, pp. 43-44).

From the table, the installed capacity of wind turbines in China reached 329 gigawatts, after it was 148.5 gigawatts in 2016, an increase of 121.54% compared to 2011, which reflects the interest that the Chinese government attaches to this renewable source.

b. Solar Energy

China leads the world in solar photovoltaic energy, surpassing both the United States and Germany. It has shown a significant increase in solar energy, which represents about 31% of global photovoltaic additions(bp, 2022, p. 44). China has rich solar resources in most of its territories. More than 96% of its territory receives about 1,050 kilowatt-hours of solar radiation annually per square meter, and two-thirds of it receives 2,200 hours of sunlight annually.(Pencea, 2011, p. 107)

Table 3.Solar photovoltaic energy installed in China 2016 – 2021(GW)

years	2016	2017	2018	2019	2020	2021
Solar photovoltaic	77.8	130.8	175.0	204.6	253.4	306.4

Source :(bp, 2022, p. 46)

Solar energy production in China continued to rise strongly, reaching 261 terawatt-hours in 2020 compared to 224 gigawatt-hours in 2019, with a growth rate of 19%. The share of photovoltaic electricity in China rose to 3.4% compared to 3.1% in 2019.

c. Hydropower and biofuel energy

Hydropower is the largest renewable energy source in China, and this is because it has great potential in this energy, as the total water resources amount to 2.8 trillion cubic meters, which made it lead the world in hydropower with a capacity of 370 gigawatts, generating about 18% of the total electricity in China. This capacity is concentrated in Sichuan Province, which has the highest hydropower generation capacity at 78.9 gigawatts in 2020 It is followed by Yunnan Province with 75.6 GW, then Hubei Province with 37.6 GW. The Three Gorges Dam in China is considered the largest hydroelectric power station in the world, generating about 100 terawatt-hours of electricity annually. (Hove, Qian, Zhao, Philipp, & Liu, 2021, p. 31) China represents approximately 80% of the global increase in hydroelectric power,(bp, 2022, p. 46) and its consumption of hydroelectric power in 2021 amounted to 12.25 exajoules, which represents 30.4% of the global consumption of this energy While its consumption of biofuels for the same year amounted to the equivalent of 48 thousand barrels of oil per day, or 2.6% of global consumption, according to BP's report for the year 2022, which is shown in the following table:

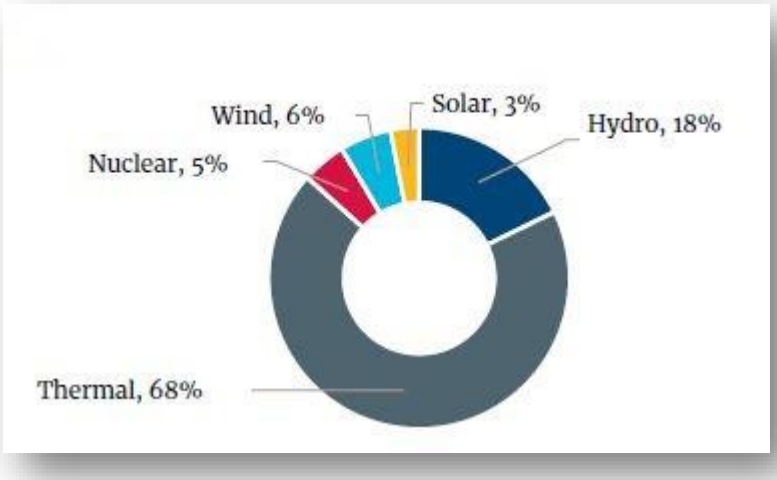
Table 4.Evolution of biofuel and hydropower consumption in China 2016 – 2021(GW)

years	2016	2017	2018	2019	2020	2021
Hydropower consumption(Exajoule)	11.11	11.16	11.42	12.08	12.50	12.25
Biofuel consumption (thousand (Barrels of oil per day	46	42	55	49	38	48

Source : (bp, 2022, pp. 42-49)

China's energy consumption from hydroelectric sources and biofuel sources gradually developed during the years 2016 – 2021, and this is at almost constant rates.

Figure 4.Electricity generation in China by source in 2020



Source : (Hove, Qian, Zhao, Philipp, & Liu, 2021, p. 17)

The share of renewable energy in primary energy consumption has reached 15.9%, achieving the 2014 target of 15% in 2020. Wind and solar combined provide 9.4% of electricity, having set an 11% target for 2021. China then expects to reach 16.5% by 2025.

4.2 China's Renewable Energy Investment Program

With the aim of expanding its renewable energy capacity, China has developed a set of policies and regulations that encourage energy efficiency and the deployment of domestic renewable energy. The Renewable Energy Law passed in 2005 (amended in 2009) provided a comprehensive framework for regulating renewable energy in China, and set a goal of obtaining 11.4% of its primary energy from renewable sources by 2015 and 15% by 2020 The renewable energy target was further strengthened by the 12th Five-Year Plan target of reducing energy intensity by 16% and carbon intensity by 17%, while the Chinese president announced in 2014 that China was doing its utmost to reduce its emissions and increase the share of non-fossil fuels in primary energy consumption to about 20% by 2030 China has also followed a renewable energy quota system, under which each province is responsible for ensuring that a certain percentage of its electricity consumption comes from renewable sources (other than hydropower). The quotas vary according to the energy resources of each province, and provinces unable to meet their quotas are forced to suspend or reduce fossil fuel power generation projects This strategy (quota system) has encouraged the country's electric utility companies State Grid Corporation of China and China Southern Power Grid Corporation to improve the rate at which wind and solar power connect to their electricity (Chu, 2015, pp. 3-4). In 2016, China's National Development and Reform Commission, which is responsible for combating climate change, said that 27 out of 31 regions had achieved greenhouse gas emission reduction targets Among the areas that received excellent ratings were the cities of Beijing and Shanghai, Zhejiang provinces in the east, and Guangdong on the southeast coast.(Bousis, 2021, p. 49)

In general, China's five-year plans for investing in renewable energy are :(Belajin, Saji, & Abderrahim, 2020, pp. 114-115)

- The Tenth Five-Year Plan: China has developed a ten-year plan aimed at increasing its installation capacity in several renewable energy sectors. These goals, set for 2003, were to increase the water heating capacity using solar energy to 1.1 million cubic meters, and to increase the cumulative production capacity of solar cells to 5.3 megawatts. The plan succeeded in promoting renewable energy by increasing the installation capacity to about 25% during the specified period.
- The Twelfth Five-Year Plan: The rapid growth of renewable energy was a result of the 2005 Renewable Energy Law, which came into effect in 2006, and laid solid foundations for achieving the goal of increasing the capacity of renewable energy to supply 15% of energy needs in 2020, through adopting a set of measures, including the establishment of large wind stations with a capacity ranging from 5 to 10 megawatts in the northeastern and northwestern regions Developing offshore wind production capacity, building new renewable energy cities, and constructing solar power plants in desert areas.

China's national policies and measures for developing alternative sources are as follows : (Meddahi, 2015, pp. 156-157)

-Increasing tax and financial incentives: Local financing bodies –including the Ministry of Finance – are committed to managing the resources necessary to establish new and renewable energy projects, in accordance with national plans and development requirements that they specify, and also in accordance with the New and Renewable Energy Law.

-Improving the market environment: Electricity produced from renewable sources in China is compulsorily sold to electric power transmission companies and petroleum product distribution companies, and the same applies to biofuels produced from agricultural sources. Energy

management bodies are also responsible for setting and following up on the laws necessary for the production, transmission, distribution and management of energy from renewable sources.

-Establishing a stable and sustainable energy market: This is done by identifying the contributions of conventional energy to the energy basket and identifying its potential capabilities, providing diverse and high-quality energy resources, as well as developing and strengthening the expansion of the energy supply sector on the basis of high quality, reasonable price, and availability of supplies.

-Accelerating the development of technologies: China intends to establish a new renewable energy and manufacturing services system, which will create a manufacturing base that relies primarily on the Chinese market to meet the requirements of various alternative energy systems.

- Implementing a cost-sharing policy and setting an energy tariff: The excess cost of producing renewable energy in China, compared to other traditional sources, is divided by the electricity bills of all subscribers. As for the selling prices of energy produced from renewable sources, Chinese energy administrative bodies are working to set a tariff that takes into account improving these prices, while working to set competitive tenders for the spread of wind farms and the expansion of alternative energy production.

China's objectives for renewable energy development policies are mainly as follows: (Boufench, 2018, pp. 99-100)

-Achieving sustainable economic growth.

-Taking advantage of the economic opportunities available in global markets for energy and low-carbon technology, and ensuring the largest share in them.

-The current and future impacts of greenhouse gas emissions and climate change, which have led to a decline in agricultural production and a sharp deterioration in ecosystems as a result of sea level rise, reduced flow in northern rivers and floods, which according to official reports caused direct economic losses estimated at $50 billion in 2011 It is expected to reach $748 billion annually by 2030, so the Chinese government is working to mitigate the effects of climate change and fulfill its international obligations to combat it, by relying on various energy sources, which is the best way to reduce dependence on fossil energy resources that pollute the environment.

-International challenges and opportunities.

-Regional economic development.

- Achieving energy security.

Overall, China has led the global markets for bioenergy, hydropower, solar PV and wind energy. Out of 8 renewable energy sources, China ranks first in 6 of them, representing 75% of the world's renewable energy generation capacity. These include bioenergy, hydropower, solar PV, wind energy, solar water heating complex and geothermal heat output It also outperformed in terms of total renewable energy capacity, whether including hydropower or not, displacing the United States of America to second place in both. Therefore(REN21, 2021, p. 51), China is considered a leading country in the production of renewable energy from wind, solar energy and biofuels worldwide. The growth of these sectors has increased as a result of the correct policies pursued by the Chinese government However, China faces major challenges, as it ranks first in greenhouse gas emissions globally, and it still relies on fossil fuels (coal and petroleum) for its energy mix, which makes its path to increasing investment in renewable energies long and continuous (Belajin, Saji, & Abderrahim, 2020, p. 112).

5. An analytical comparison of the reality of renewable energies in the United States and China

The United States and China are among the leading international players in renewable energy development, but they differ in terms of approaches, levels of achievement, and energy strategies. This can be highlighted in the two tables below:

Table 5.Differences in the renewable energy sector between the United States and China

item	The U.S.A	China
Resources	It is characterized by great geographical diversity that allows it to benefit from solar energy (especially in the south and west) and wind energy (especially in plains states such as Texas.	It has huge resources, especially in the field of solar energy in the northwest, and hydroelectric energy in the southwest (Yangtze River dams such as (the Three Gorges Dam)
Policy model	Decentralization –central federal and local initiatives	Government planning within the five-year plan
Annual investments	High but lower than China,	The world's highest
Solar energy	Major technical development - focus on efficiency	The largest production and installation capacity in the world
Wind energy	Leadership in offshore wind energy	Leadership in onshore wind energy
Future focus	Green hydrogen and advanced batteries expand	Production capabilities and localize technology
Challenges	Policy variation between states Internal political pressure	Industrial pollution Development and environmental balance

Source: Prepared by the student based on data sourced from:

(Hove, Qian, Zhao, Philipp, & Liu, 2021)

(US Department of Energy, 2022)

This table shows that China is particularly focused on rapid expansion and massive infrastructure, while the United States is focused on advanced technology and decentralized policies. China's massive investments reflect a strategic shift toward renewable energy, going beyond environmental considerations toward global industrial and economic leadership. The United States faces challenges related to disparities between state policies.

Table 6.Comparing renewable energy indicators between the two countries in 2023

indicator	The U.S.A	China
Total installed capacity of renewable energies	About 411 GW	More than 1300 GW
Composite solar energies	About 160 GW	More than 500 GW
Composite wind energy	About 145 GW	More than 430 GW
Percentage of renewable energies in the total electricity mix	About 22%	More than 30%
Annual investments in renewable energies	About 55 billion $	More than 120 billion$
Jobs in the renewable energy sector	More than 800 thousand jobs	More than 5 million jobs
Annual carbon emissions	About 5.2 billion tons (second largest exporter)	About 10.5 billion tons (first in the world
Future goal	Carbon neutrality by 2050	Carbon neutrality by 2050

Source: Prepared by the student based on data sourced from: (IRENA, 2024)

The table reflects China's quantitative superiority over renewable states in most renewable energy indicators. China has installed capacity of more than 1,300 gigawatts, more than three times that of the United States, with global leadership in solar and wind energy. Its investments are more than double, and it provides more than 5 million job opportunities in this sector, compared to about 800,000 in the United States.

Table 7. Key performance indicators for energy transition in the United States and China 2023

Indicators	The U.S.A	China
Renewable energy share of electricity (%)	20	27
Annual installed power additions (GW)	35	120
Carbon density (g CO_2/k.W.S)	350	450
Investments in renewable energy (billion dollars)	36 in the first half of 2023	890
Employment in the renewable energy sector	1.060.000	7.390.000

Source: Prepared by the student based on data sourced from: (IRENA, 2024, pp. 39- 45)

The table above presents a comprehensive comparison of key performance indicators for the energy transition in the United States and China. We note China's superiority in the volume of annual additions to installed capacity and employment in the renewable energy sector, while the United States shows higher efficiency in electricity production and lower carbon emissions.

Table 8. The five leading countries in the field of renewable energies 2021

rank	1	2	3	4	5
Renewable energy capacity ((including hydropower	China	U.S.A	Brazil	India	Germany
Renewable energy capacity (not including (hydropower	China.	U.S.A	Germany	India	Japan
Renewable energy per capita (not including (hydropower	Iceland	Denmark	Germany	Sweden	Australia
Bioenergy capacity	China	Brazil	U.S.A	India	Germany
Subterranean bioenergy capacity	U.S.A	Indonesia	Philippines	Turkey	New Zealand
Hydropower capacity	China	Brazil	Canada	U.S.A	Russia
Solar photovoltaic energy	China	U.S.A	Japan	India	Germany
Concentrated solar thermal energy	Spain	U.S.A	China	Morocco	South Africa

Wind energy	China	U.S.A	Germany	India	Spain
Solar water heating complex	China	U.S.A	Turkey	Germany	Brazil
Ground heat output	China	Turkey	Iceland	Japan	New Zealand

Source: (REN21, 2022, p. 51)

The table clearly shows that China ranks first in most renewable energy production capacity indicators, with or without hydropower. It leads the world in solar photovoltaic energy, wind energy, hydropower, and solar water heating systems, reflecting a long-term strategic direction towards expanding production capacity and ensuring energy security .

On the other hand, the United States of America comes in second place in most of these indicators, especially in solar photovoltaic energy and wind energy, but it is unique in the global leadership in the field of geothermal energy thanks to its geographical diversity and advanced infrastructure. However, per capita renewable energy remains weak compared to some small European countries such as Iceland and Denmark .

Overall, China dominates in terms of large-scale installed capacity, while the United States focuses on technological diversification, especially in areas such as geothermal and concentrated solar power. This reflects different national strategies: China relies on massive quantitative expansion to meet growing domestic demand, while the United States prioritizes innovation and diversity of energy sources.

6. Results and discussion.

The following results can be presented:

- China leads the world in installed solar and wind power capacity, while the United States stands out in energy innovation and technology.
- China tends to implement large-scale projects thanks to state support and its five-year plans, while the United States relies on market dynamics and the role of the private sector.
- The two countries share challenges related to energy storage, network integration, and geographical distribution of projects.
- The institutional and legislative structure differs between the two countries, which is reflected in the effectiveness of performance and the flexibility to adapt to transformations.
- Both experiences show that renewable energy development requires a long-term vision, political will, and sustainable investment in infrastructure and scientific research.

7. Conclusion and Recommendations

This study concluded that both the United States and China have succeeded, each in their own way, in achieving advanced steps in developing the renewable energy sector, making them leaders on the global scene in this field. While the United States relied on a model based on innovation, private initiatives, and economic incentives, China focused on central planning, large-scale industrialization, and organized government support. Although approaches varied, both experiences provided successful models that other countries could benefit from. The comparison also highlighted that the shift towards renewable energy is no longer a luxury option, but rather a strategic necessity to ensure energy security, protect the environment, and enhance economic independence.

In Algeria, fossil fuels still dominate the energy sector, contributing about 40% of GDP and more than 95% of the country's total export revenues(IEA, 2023). Electricity generation in Algeria relies mainly on natural gas, compared to a very modest contribution from renewable energies

(contributing only about 3% with a production of 600 MW in 2024) (IRENA, 2024, pp. 2-84). With the aim of raising this percentage, the country has adopted an ambitious strategy through the 2011 National Renewable Energy Development and Energy Efficiency Program, to reach 22,000 MW of installed renewable energy by 2030, which would cover about 27% of domestic electricity demand. (Ministry of Renewable Energy and Energy Transition, 2021, p. 17) In addition, Algeria plans to deploy 3,200 MW of solar energy by late 2025–2026 as part of the first phase of its national renewable energy program.

To benefit from the experiences of the two countries under study, the following recommendations are particularly relevant for Algeria:

-The need to adopt a clear national strategy for energy transition, combining strong central planning with effective private sector participation.

-Increasing investment in research and development, along with enhanced international cooperation for technology transfer and localization, is crucial given the country's limited domestic manufacturing and technological capabilities in renewable systems.

-Diversifying energy sources and reducing dependence on fuels, by exploiting renewable natural potential Algeria possesses one of the highest solar potentials in the world—particularly in the Sahara—yet its effective contribution to electricity production remains far below its potential.

-Improving the legislative and institutional framework to attract foreign investments in the field of renewable energy is crucial for Algeria, as regulatory instability and complex administrative procedures continue to discourage many international investors.

-Supporting renewable energy projects not only environmentally, but also as a long-term economic option with global renewable costs declining, Algeria could reduce domestic gas consumption for electricity generation and redirect more gas exports to international markets.

-Develop energy storage solutions to ensure network stability, this is particularly relevant for Algeria, where solar-based electricity will require storage systems to compensate for variability and ensure reliable supply.

- Strengthening international cooperation in the field of energy innovation, through research platforms and co-financing, Algeria's growing partnerships with countries such as China, USA, and members of the European Union could serve as key channels for knowledge transfer and technological integration.

Overall, the combined lessons from the U.S. and Chinese models suggest that Algeria can accelerate its energy transition by integrating strong institutional planning with market-based incentives, while leveraging its exceptional natural potential—particularly solar resources.

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