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The Role of Energy Transition in Meeting the Requirements of Sustainable Development - A Case Study of the German Experience

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Abstract:
Our study aims to present and analyze the role of the energy transition in achieving sustainable development in general. We focus on the energy transition, its goals, and the requirements for achieving it in order to balance the economic, social, and environmental aspects. The descriptive-analytical approach was used to present the aspects of the study. Ultimately, we found the significant importance that renewable energies play in achieving the dimensions of sustainable development in the environmental, economic, and social aspects by providing energy supplies for the current generations and ensuring them for future generations.
Keywords: energy transition; sustainable development; renewable energies.
JEL classifications : Q42, Q3

Introduction:

The world today requires the transition to new policies and the transformation of economies and industries due to the development we are witnessing in various fields, including the energy field, which directly affects the requirements of sustainable development (economy, society, environment), and the transition towards renewable energies is one of the global efforts to transform the energy system towards clean sustainable energies.

The energy transition is a necessary requirement due to the increasing environmental pressures and increasing challenges in the field of energy and the energy market, and this is what pushes decision-makers, policies and the international community to search for sustainable and clean solutions and alternatives that meet their energy needs and ensure future energy security, and one of the requirements of the energy transition is to increase reliance on renewable energy sources, improve energy efficiency and develop renewable energy infrastructure, while providing financial support and compatibility of international policies with the deployment of clean energies, and one of the objectives of the energy transition is to achieve Sustainable development goals and the preservation of energy and environmental resources for current and future generations, Based on this, we pose **the following problem**: To what extent does renewable energy contribute to sustainable development? How did Germany achieve this?

Study hypotheses: In this study, we will try to answer the following hypotheses:

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- Renewable energy has a role in achieving sustainable development,
Thanks to the potential of renewable energy, Germany has fulfilled the requirements for sustainable development.

Previous studies:
_ **Study (Karim Yabou 2021)**[†] **Article entitled:** The mechanism of energy transition in Algeria to achieve sustainable development: between reality and hope.
The study aimed at the importance and role of the energy transition in achieving sustainable development and energy security in Algeria, by relying on the descriptive analytical approach, describing renewable energies and presenting their most important sources and their impact on achieving energy security, and analyzing data and indicators that illustrate the reality and future of renewable energies in the world and Algeria in particular, it concluded that Algeria is a supplier of renewable energies, especially solar energy, and it must adopt projects to generate electricity from renewable energy to increase its consumption and reduce the consumption of traditional energies to achieve Energy security for future generations within the limits of sustainable development.
_study (Monica, et al., 2019) an article entitled: Renewable energy, climate change and environmental challenges in Romania, this study aims to clarify and present the capabilities of Romania and thus allocated solar and wind energy in the study, and the policies supporting the exploitation of these sources in the European Union to achieve cleaner production, and concluded that despite the cleanliness and sustainability of renewable energies, They negatively affect the environment and climate and their production processes face several challenges such as climatic conditions and current and future weather phenomena.
_The most important thing that distinguishes our study from previous studies:
Our study is distinguished by its added value from previous studies by providing different and complementary aspects at the same time, in the theoretical aspect we sought to integrate with previous studies and enhance them with new information about the energy transition, its importance and requirements and the reality of renewable energies in achieving sustainable development, while in the second part, our study was distinguished from other studies as it highlighted the problem of energy transition and its role in achieving the environmental aspect of the dimensions of sustainable development.

Objectives of the study: Through our study, we aim to:
_ Highlighting the necessity and importance of the energy transition
_Presentation of the most important requirements of the energy transition,
_The contribution of the energy transition to sustainable development,

Study Methodology: We relied in our study on the descriptive and analytical approach, by describing the energy transition and sustainable development and analyzing Germany's renewable energy potential and the extent to which it achieves sustainable development.

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I.1- Energy Transition: Requirements and Objectives

The energy transition is a comprehensive process that aims to change the global energy system from dependence on fossil fuels to reliance on renewable energy sources, and this process includes a set of requirements and objectives that must be achieved to ensure the success of the energy transition.

Subchapter I: The Concept of Energy Transition

First: Definition of Energy Transition

The energy transition is defined as the concept of abandoning the use of traditional energy sources such as: oil, coal and natural gas that are the most consumed, which cause the release of greenhouse gases that cause global warming, and replace them with clean sources that include solar, wind and hydro energy in addition to other non-polluting sources (Careem, 2021, p. 244), and according to the report of the International Renewable Energy Agency, "The transformation of the energy system, while technically feasible and economically beneficial, will not happen on its own and there is a need to take urgent policy action to steer the global energy system towards a sustainable path" (IRENA, International Renewable Energy Agency Report: Transforming the Global Energy System, Roadmap 2050, 2021, p. 11)The transformation of the energy system is an essential element of the transition in the ecosystem, and means the transition from the use of traditional energies to the exploitation of renewable energies, i.e. the development of existing energy alternatives and their partial change towards renewable sources (Maliki and Muezzin, 2020, p. 223).

The concept of energy transition also refers to the shift from the use of fossil energies in industries and productions and daily consumption to the use of new and renewable energy resources in energy supplies, and this concept has emerged as a result of emergency climate changes in the world and its impact on living organisms on the one hand, and on the other hand the limited traditional sources and the decline in their reserve rates and the increase in global demand for energy, the energy transition represents an important shift in the use and production of energy with the aim of achieving environmental, economic and social sustainability, Investment in renewable energies, the development of clean technology and the adoption of supportive policies in this field are among the most important steps of the energy transition, and therefore strategies and systems must be developed that apply the employment of the renewable energy mix in the current energy field to ensure energy security and the continuity of future energy resource supplies.

Second: The importance of the energy transition

As we mentioned earlier, energy transition is a process of transformation in the use and generation of energy with the aim of moving from traditional energy sources to clean and sustainable renewable energy sources, and its importance is represented in:

_ **Environmental conservation:** The use of fossil fuels leads to greenhouse gas emissions and air pollution, while renewable energy sources rely on renewable and clean sources such as sun, wind and water, which reduces negative impacts on the environment and climate change,

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_Economic growth and elimination of unemployment: Renewable energy provides new economic opportunities by providing jobs in the renewable energy sector and stimulating technological innovation, in addition, dependence on fossil fuels reduces the dependence of countries on the global market and reduces energy price volatility,

_ Moving towards sustainability: The energy transition is part of the global trend towards sustainability and the preservation of natural resources for future generations, and encourages the use of alternative and renewable sources and the development of clean and energy-efficient technology.

_Energy security: While many countries face challenges in securing their energy needs through heavy reliance on fossil fuels, the energy transition can enhance energy independence and improve energy security by diversifying energy sources and leveraging domestic energy resources.

Therefore, the energy transition represents an important transformation in the use and production of energy aimed at achieving environmental, economic and social sustainability, and investment in renewable energy, clean technology development and the adoption of supportive policies are the most important steps in the energy transition.

I.2 Requirements and objectives of the energy transition:

First: Energy Transition Requirements

The energy transition calls for a set of measures and initiatives aimed at transforming the global energy system towards sustainability, these measures include multiple requirements that represent the basis for achieving the desired goals behind the energy transition, the economic and social footprint is a concept that must be applied in order for the energy transition to be achieved, and by economic and social footprint we mean everything related to GDP, social welfare and employment, the energy transition can only be by improving the ratios in the economic and social system and in the long term in 2050 will provide The energy transition increases social welfare rates by 15%, GDP peaks to 1% and jobs by 0.1% (IRENA, 2021, p. 7), and this results in environmental and social benefits, as the higher the percentage of social welfare, the lower the rate of epidemics, diseases, social backwardness, and low unemployment rates,

It also requires the transformation of the energy system to achieve a set of foundations:

_Policy orientation: The energy transition requires strong political support from local governments, there must be a strong commitment to adopt policies and strategies that promote the use of renewable energy and reduce the region's dependence on fossil fuels (Maleki and Muezzin, 2020, p. 223),

_ Infrastructure: Appropriate infrastructure must be developed to provide renewable energy, including the installation of renewable energy plants and advanced electrical grids that allow efficient energy transmission,

_ Financing: Financing is a major challenge in the energy transition process, huge investments must be made to develop renewable energy projects and improve energy efficiency, and there

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may be a need to attract international investments and develop innovative financing mechanisms (Aisha and Siham, 2021, p. 208).

_Technical and technological challenges: Achieving the energy transition requires the development and adoption of the technologies and knowledge necessary to generate, store and use renewable energy effectively and sustainably (Careem, 2021, page 245), especially the most prevalent topic currently which is the use of artificial intelligence in all fields In our topic the energy sector**,** the energy and renewable energy sector is a growing economic force and an effective strategy to improve environmental sustainability, and artificial intelligence in the field of energy is increasingly being used to manage Renewable energy, dealing with energy fluctuations and improving its storage, as well as monitoring artificial intelligence, collecting information, controlling, evaluating and managing energy consumption in buildings and factories, which helps control energy use during peak hours, identifies problems and detects equipment malfunctions before they occur Artificial intelligence in the renewable energy sector is characterized in several points (Majed, 2023):

_Energy forecasting: Artificial intelligence has the ability to analyze big data accessed from local satellite reports, weather stations and wind farms in the surrounding area, to predict weather conditions, helping to improve the stability of networks in power plants, by programming them with previous data about energy fluctuations and weaknesses on the network, and creating autonomous networks capable of responding more smoothly to any changes,

_Optimize energy consumption: Smart energy devices that measure, predict and control heating and cooling systems based on actual need help to optimize energy consumption, by integrating data received from smart meters and the Internet of Things, to predict energy demand, and machine learning techniques can be used to manufacture materials with greater efficiency and capacity in producing and storing energy,

_Reducing energy production expenditures: The use of artificial intelligence technologies has helped reduce the costs of producing conventional and renewable energy, as capital expenditures for oil extraction as well as the construction of solar, wind and bioenergy plants have witnessed a significant decline in recent years.

_Awareness and education: It is important to raise awareness and encourage the community to adopt sustainable energy behaviors and improve energy efficiency.

_Economic challenges: The energy transition required a change in the economic models adopted in the region, may have an impact on specific sectors such as the oil and gas sector, and requires the creation of alternative economic opportunities to ensure sustainable development.

Therefore, we conclude that the energy transition requires strong regional cooperation to promote the joint exchange of experiences and knowledge, and to enhance cooperation in the field of research and technological development. To achieve these goals, training and qualification of cadres working in the energy sector must be strengthened, and national capacities in the field of renewable energy projects must be strengthened.

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3.1-: The role of the energy transition in achieving sustainable development

The goal behind the energy transition lies in meeting a set of dimensions: energy security, environmental security and economic and social security, and here we seek the dimensions on which sustainable development is built,

First: Definition of sustainable development

Economically, sustainable development is one of the objectives of the United Nations for the map of environmental, social and economic development, and it means providing social welfare for all members of societies while developing production and improving its management so that natural resources are not run out now and in the future (Agriculture, 2024), and according to the famous definition of sustainable development, which first appeared in 1980 by the "International Federation for Medical Conservation". As part of the Global Survival Strategy, the term was folded in 1991 at the United Nations Environment and Development Programme and in 2002 the term returned at the Johannesburg Summit (Massoud and Nabila, 2019, p. 142), where it is defined as "a process of developing and folding the current situation without affecting the capacities and resources of future generations" (Boughali, 2013, p. 56)., as defined by the World Commission on Environment and Sustainable Development, as "that development that meets the needs of the present without prejudice to the ability of future generations to meet their needs" (Anne E, 2012, p. 83),

A definition of sustainable development can be provided as a development approach aimed at meeting the needs of the current generation without compromising the ability of future generations to meet their needs, including a balance between the economic, environmental and social dimension, which ensures the sustainability of economic growth and the use of resources in a balanced manner, sustainable development depends on a set of indicators and varies according to each country and its needs and classification of priorities, namely:

Table 01: Sustainable Development Indicators

Economic indicators	**Social Indicators**	**Environmental indicators**
–GDP per capita index, –Domestic investment index as a percentage of GDP, - Savings to GDP ratio index, - Export-import index to GDP, –inflation index, –indicator of the ratio of employment to the total working-age population, - Annual per capita energy consumption index.	**–population growth index,** **–fertility rate,** **–infant mortality rate,** **-under-five mortality rate,** **–population per doctor,** **- Primary school enrolment index,** **–telephone line index per 1,000 population,** **–Internet user index per 100 people,** **–the proportion of the population with access to sanitation,** **- Indicator of the ratio of city population to the total number.**	**–carbon dioxide emission index,** **–Protected Wilderness Areas Index,** **–waste treatment and sanitation index,** **–the proportion of the population with access to drinking water,**

Source: (Bouhla, 2015, pp. 77-78)

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Second: Energy Transition and Sustainable Development

In a report issued by the United Nations regarding the pace of achieving the sustainable development goals and in the seventh goal "clean energy at affordable prices", statistics indicate that the energy transition is not going enough, and the transport sector lacks the consumption of renewable energy sources and its dependence on fossil fuels significantly, as renewable energies include only 30% of global energy consumption, and this shows that the path towards renewable energies and the transition to the use of clean energies is still far from achieving energy security, and in the medium term in 2030 there will be 660 million people lack electricity and continue to consume conventional energies for domestic use (Unstats, 2023, p. 26).

Environmentally: According to the Paris Climate Agreement in 2015, which provides for limiting temperature rise to two degrees, the energy transition aims to achieve this item and rely on low-carbon renewable energies in electricity production, and according to the long-term scenario, the rate of progress in production from renewable sources will move by about 25% in 2017 to 85% in 2050 (IRENA, International Renewable Energy Agency report>: : The Transformation of the Global Energy System, Roadmap for 2050, 2021, p. 4), According to the Synthesis Report of the Nationally Determined Contributions (NDCs) of the United Nations Convention on Climate Change, the climate pledge issued in the Paris Agreement will achieve a 0.3% reduction in global warming by 2030, but this percentage is very small and will not meet the requirements of the agreement to reduce global warming rates to 1.5 °C, which indicates a possible warming of 2.5 °C. Celsius at the end of the century (Unstats, 2023, p. 38)

Economically: The energy transition promotes the achievement of the economic dimension of sustainable development, by transforming economies towards clean and sustainable energy sources, and provides multiple opportunities for long-term economic growth, and the energy transition helps to enhance the energy independence of countries and achieve a balance in energy resources, which contributes to enhancing energy security and reducing price fluctuations and the energy market (Massoud and Nabila, 2019, p. 149), in addition, the energy transition opens new horizons for innovation and investments New renewable energy and clean technology industries, which creates new jobs and promotes economic growth, as well as contributes to reducing energy costs in the long run and enhancing the competitiveness of companies and countries, therefore, the energy transition represents an important role in the economy and achieving sustainable development by directing investments towards clean and sustainable energy sources.

Socially: Society is the focus of the economy, so countries seek to provide social welfare for a developed and developing economy, and the energy transition aims to achieve a set of social requirements:

Social justice through job creation and creation of new jobs in renewable energies including maintenance, installation of solar panels, electricity generation and connection equipment and improvement of technology, which in turn improve the living conditions of the population and reduce poverty and unemployment,

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- Providing energy, delivering electricity to remote areas, and developing the countryside that contributes to improving the quality of life of the population, establishing investment projects, thus achieving the social justice to which we mentioned earlier,
Improving infrastructure such as hospitals, schools and administrations, and increasing the consumption of clean energies reduces diseases from environmental pollutants, especially carbon dioxide produced by fossil fuels.

Third: Germany's experience in the energy transition

The expansion of renewable energies has become a strategic choice for Germany to reduce its dependence on fossil fuels, and is a key part of the country's plan to eliminate energy imports, whether from Russia or others, this expansion is the core of the energy transition adopted by the German government more than 10 years ago and a key pillar of its strategy to achieve zero greenhouse gas emissions by 2045, however, this expansion requires significant financial resources and intensive investment, along with fundamental changes in policies and laws, which He faces significant challenges.
Despite the multiplicity of renewable energy sources such as wind, solar, hydroelectric and geothermal energy, wind and solar energy are the most exploitable and expandable in Germany, and the effects of this expansion are clearly visible in the electricity sector, where more than half of the country's electricity production in 2022 came from renewable energies, an increase of 50.3% compared to the previous year, according to the German Energy and Water Economy Association (BDEW) and the Stuttgart Research Institute (ZSW).).
Solar energy plays an important role in achieving the desired energy transition in Germany, driven by significant technological advances in solar energy cells that have become more efficient and easier to use, with the low costs of electricity produced, the sun as an energy source is permanently available and free, which enhances the attractiveness of investment in this field. In 2022, solar energy accounted for about 10.9% of the total electricity generated in Germany, a significant increase compared to 9% In 2021, the production of photovoltaic systems reached about 58 terawatt hours, which contributed to reducing greenhouse gas emissions by about 41.7 million tons of carbon dioxide, during the first half of 2023, solar energy accounted for 13.4% of total electricity generation, a new record.
The high demand for solar power plants was noticeable in 2023, as 159,000 photovoltaic systems were commissioned for private homes in the first quarter of the year, an increase of 146% over the same period of the previous year, this growth also includes the use of solar systems by farmers and investors.
However, the solar industry faces challenges, including rising systems and financing costs, although some expectations of lower prices, a return to pre-energy crisis levels is not expected, rising interest rates are a major obstacle, prolonging the payback period and slowing down the implementation of new projects.
In contrast, the global expansion of solar energy systems continues, with experts at Rystad Energy expecting a 13% increase this year, driven by an improved policy framework in several countries, including Germany.

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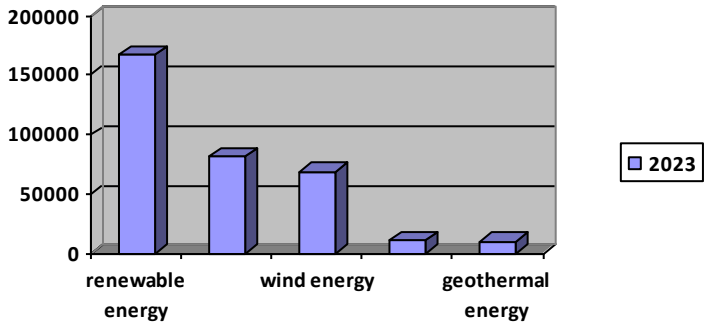
On the industry front, the German solar industry has seen a strong comeback, supported by technological innovations and growing demand, startups and new investors are boosting the sector, while global companies such as China's Longi are planning to build factories in Germany, reflecting the attractiveness of the German market despite the challenges.
Experts confirm that many Chinese and Asian companies are currently discussing plans to build production facilities in Europe, as EU initiatives aim to resettle the solar industry, with a main target that 40% of photovoltaic systems used in Europe by 2030 will be made in Europe (Ghorfa, 2024).

Germany's renewable energy potential:
Germany is one of the leading countries in the field of renewable energies, especially the solar panel manufacturing sector, which is one of the most popular areas in the country, as it becomes its products of solar panels, which are of the finest types after the panels produced in Saudi Arabia, in 2023 its renewable energy potential reached about 166939 megawatts and is divided into 11,164 megawatts of hydropower, 69,459 megawatts of wind energy, 81,739 megawatts of solar energy, and about 9,950 megawatts of underground energy,

Figure 01: Installed capacity of renewable energy in Germany in 2023 (MW)



Source: Prepared by researchers based on IRENA_RE_Capacity_Statistics_2024 data

Renewable energies in Germany have contributed to sustainable development such as the creation of jobs, especially in solar panel manufacturing enterprises, technical work, installation and maintenance operations

Renewable energy has been mixed into the electricity generation in Germany since 2000 and the consumption of renewable energy sources continued to increase until 2022, according to the data, and wind energy was one of the most developed sources in the country due to its strategic location characterized by strong wind speed.
As mentioned earlier, Germany is one of the world's leading countries in the consumption of renewable energy, as it has made significant progress in relying on clean and renewable energy sources as part of its energy transition strategy, in 2022 the share of renewable energy in electricity production exceeded 50%, a percentage that reflects Germany's commitment to reducing dependence on fossil fuels and reducing greenhouse gas emissions. Wind and solar

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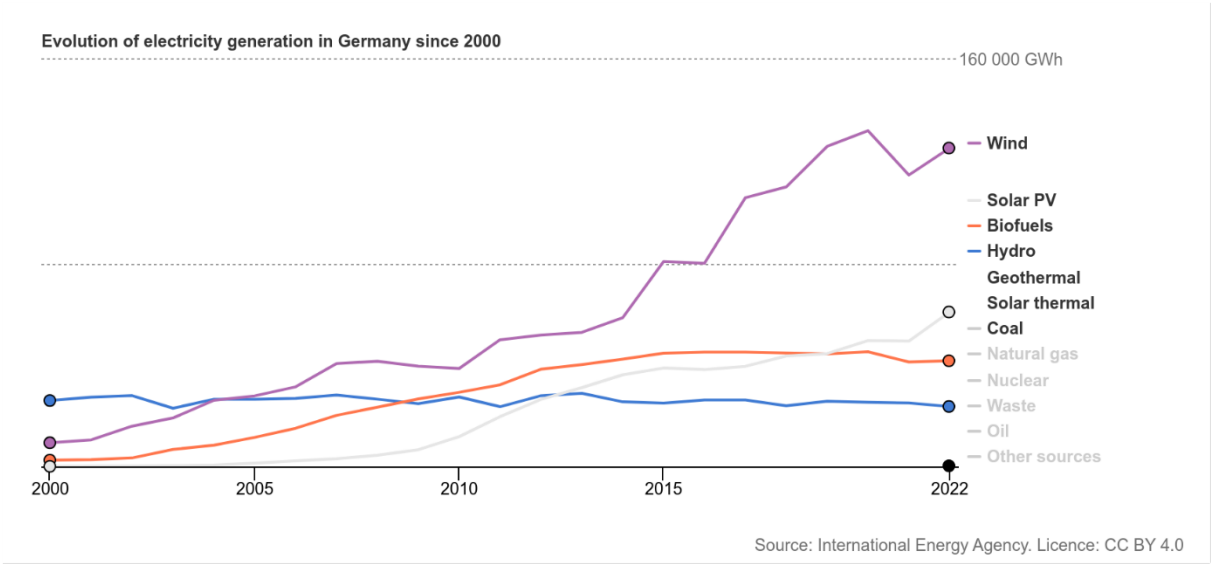
energy in particular contribute to meeting the country's growing energy needs, where solar energy has formed alone about 10.9% of total electricity production in the same year The continued growth in renewable energy consumption in Germany depends on technological advancement, government support, and increased environmental awareness among individuals and businesses, however, Germany faces challenges in expanding renewable energy infrastructure, especially in winter periods when the hours of sunshine decrease.

Figure 02: Electricity generation from renewable energy sources in Germany



Source: https://www.iea.org/countries/germany/energy-mix

Sustainable development in Germany:

Germany is one of the leading countries in the field of achieving sustainable development, as it has developed a comprehensive strategy that combines economic growth, social justice, and environmental protection, Germany works to achieve the Sustainable Development Goals (SDGs) by promoting innovation in various sectors and adopting policies that ensure the sustainable use of natural resources,

On the environmental side, Germany attaches great importance to renewable energy as part of its energy transition strategy, with the aim of reducing greenhouse gas emissions and reaching carbon neutrality by 2045, by investing in wind, solar energy, and hydropower, which is one of the German efforts to reduce climate change and preserve biodiversity.

On the economic front, Germany seeks to promote the green economy through innovation and technology, which has led to the creation of new jobs in the renewable energy sector, and the German government encourages companies to adopt sustainable production practices that contribute to reducing the environmental footprint and promoting a circular economy, while in the social dimension, German policies focus on achieving social justice and well-being for all, Germany seeks to improve the quality of life for its citizens by developing infrastructure, ensuring quality education, and universal health care, in addition to reducing Germany is

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demonstrating its commitment to international cooperation to achieve sustainable development worldwide through its participation in global initiatives and financing development projects in developing countries.

Conclusion:

In conclusion, the energy transition, which means the transition from the exploitation of traditional energy to the exploitation of renewable energy, is necessary due to the problem of the depletion of traditional energies, which can lead to a shortage of energy supplies in the future, and with the increase in demand for energy resources, countries, especially Germany, resort to introducing renewable energy into the energy mix to achieve the continuity of energy supply, and this is in line with the requirements of sustainable development that call for ensuring current and future energy supplies,

Through our study, we reached some of the following results: The energy transition has an effective role in achieving sustainable development, sustainable development is not limited to energy supplies only, but also branches to economic, social and environmental requirements, and this is what renewable energies provide.

Recommendations and suggestions:

- The necessity of international cooperation for a green, clean and carbon-free world,
- Continuous encouragement of the installation of solar panels in private institutions and homes,
- The imposition of a law in each country that provides for the use of renewable energy sources in electricity generation,
- Expanding the use of renewable energy in cooking and heating water,
- Establishing universities and opening specializations in the field of energy transition in all its branches,
- Benefiting from the German experience.

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