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Renewable Energy Sources and Investments: setting ground for the market of the future

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Abstract

This thesis aims to show the numerous renewable energy sources in terms of their types, costs, advantages and disadvantages, as well as the laws that control them, the market circumstances in which they operate, and the possibilities for the market's growth. Is the market for renewables truly the one to watch?

Chapter 1:

Brief definition on RES, short analysis of the energy market and the role of renewables in the current European energy mix, theoretical cost analysis for such investments (onshore/offshore RES)

Chapter 2:

The state of renewable energy market historically, market energy needs and RES, onshore/offshore investments, calculation of a risk investment

Chapter 3:

Existing legal framework and proposals about the improvement of it, brief analysis of the factors that can be a setback to foreign direct investments in this sector, quick description of how this market can affect a country (positive and negative impacts), proposals on how a state can use these investments to its advantage

Chapter 4:

Conclusion. A brief resume of the meaning of the context.

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Chapter 1: Introduction

1.1 Definition and Function of the Energy Markets

Recent turmoil in the energy market has become a dominant topic in news coverage. Global energy prices are experiencing a sharp increase due to a scarcity of natural gas. This raises the question of what energy markets are and how do they function within the energy sector. Energy markets, in a nutshell, are commodity markets that deal specifically with the trade and supply of energy. An energy market can refer to the electricity market, but it can also refer to other energy sources such as natural gas and oil (Watchwire, 2021).

Energy markets are classified into two types: regulated and deregulated. It has to be mentioned that historically, regulated electricity markets existed throughout the United States, limiting customer choice. Deregulation did not become a reality until the 1970s, with the passage of the Public Utilities Regulatory Policies Act. This act marked the beginning of a period of restructuring for the energy industry. As a result, the Energy Policy Act, passed in 1992, further opened the market. The goals of the Energy Policy Act were to increase the use of clean energy and energy efficiency. It expanded utility options and established new rate-making standards. Deregulated energy markets have since spread across several states (Watchwire, 2021).

A deregulated electricity market, on the other hand, allows competitors to enter the market to buy and sell electricity by allowing market participants to invest in power plants and transmission lines. The wholesale electricity is then sold to retail suppliers by generator owners. Retail electricity suppliers set consumer prices, which are commonly referred to as the "supply" portion of the electricity bill. It frequently benefits consumers by allowing them to compare the rates and services of various third-party supply companies (ESCOs) and by offering various contract structures (e.g. fixed, indexed, hybrid). In addition, in a deregulated market, renewable energy and green pricing programs are more readily available (Watchwire, 2021).

Some states, however, have both types of markets. In that case, with many U.S. states and cities pledging to transition to renewable energy within the next 30 years or so, a deregulated energy market may appear to have more benefits. While deregulated electricity markets provide a broader range of renewable energy options, consumers in regulated states can still reap the environmental and economic benefits of green power. Deregulation was widely supported when it was introduced in the 1990s, but it has encountered some difficulties along the way. For example, the California energy crisis in 2000 caused many states to be concerned that total deregulation would result in market manipulation. However, increased consumer decision-making power drives the expansion of deregulation (Watchwire, 2021).

The energy market is basically a market handling process specifically with the trade and provision of energy, which may refer to the electrical energy market or other energy resources. Energy markets are known as a fast-growing and complicated sector considering their significant role in the global economies, the necessity of this sector in power and gas supply, and financial concerns of energy (Watchwire, 2021).

1.2. A Brief Introduction on Renewable Energy Systems

Any system or substance from which we may obtain energy to generate heat, light, or power is referred to as an energy source.

The two types of energy sources that are now available to humans are as follows:

1. <u>Non-Renewable or Conventional Energy Sources</u>

They have historically been utilized for many years to produce energy since they are based on reserves that already exist within the solid crust of the planet. This group comprises nuclear energy as well as fossil fuels (oil, natural gas, and coal). These sources' reserves are constrained and are expected to run out (Khan & Ahmad, 2008).

2. <u>Renewable or non-conventional Energy Sources</u>

Energy sources that are continually replenished are known as renewable energy sources. They can provide the energy demands of contemporary homes. Because of this, renewable energy sources provide us with a number of benefits (Panwar et al., 2011).

- These technologies are ecologically beneficial. Its usage is accompanied by a decrease in the production of gases or pollutants that heighten the greenhouse effect.
- By promoting our nation's energy independence and lowering our reliance on foreign energy imports, we take use of the nation's abundant energy resources. In this manner, both the growth of employment and the socioeconomic advantages of residents.
- They may be used to address local energy shortage issues in remote, isolated places, and they can contribute to solving the energy problem.

Greece can successfully adopt renewable energy sources primarily due to its geographic position and the local weather conditions. The amount of sunshine and the strength of solar radiation are both high throughout the year. Moreover, it has tremendous wind potential, abundant geothermal potential, and high biomass output (Khan & Ahmad, 2008).

Internationally, many renewable energy sources are used, including geothermal, hydropower, solar, and bioenergy, to mention only a plethora of renewable energy sources used. China and Canada are the two nations with the largest energy production from hydropower on a global scale. Data indicates that geothermal energy capacity and solar energy production have increased significantly internationally over the past decade (Panwar et al., 2011).

1.2.1 Types of Renewable Energy Sources (RES)

The sun serves as the primary energy source for our planet, with all other forms of energy ultimately dependent on solar energy. Solar energy is both infinite and renewable, offering no temporal or spatial limitations on its utilization. Greece, endowed with abundant sunlight, is particularly well-positioned to harness solar energy and convert it into electricity. There are two main categories for harvesting solar energy: active and passive solar systems. Active solar systems, which include a variety of solar collector types, are designed to capture and convert solar energy directly or indirectly. These systems often combine basic flat solar panels with absorption devices to heat water or generate cooling. Concentrated solar collectors can achieve higher temperatures, primarily for steam generation. Photovoltaic systems differ from these approaches by directly converting solar energy into electricity. In contrast, passive solar systems use solar energy to heat indoor spaces in buildings and rural greenhouses (Balaras, Argyriou, and Karagiannis, 2006).

Photovoltaic (PV) systems convert accessible solar energy directly into direct current (DC) electrical power using photovoltaic components. When exposed to sunlight, PV panels can convert approximately 14% of the incident solar energy into electricity, making them particularly useful in isolated locations without access to the electrical grid. These systems can utilize the generated energy immediately or store it in batteries for later use. A converter is often employed to transform the generated DC into the alternating current (AC) used by most devices (Balaras et al., 2006).

Winds are generated indirectly by solar radiation as the uneven heating of the earth's surface causes large volumes of air to flow from one region to another. It is estimated that between 1.5% and 2.5% of incoming solar radiation is converted into kinetic energy in this manner. Wind turbines are utilized to harness this wind energy, and they are typically classified into two types: horizontal-axis and vertical-axis wind turbines, with the former recently gaining popularity. Wind turbines can be employed in various settings, including large-scale wind farms that power remote locations or smaller hybrid systems (Balaras et al., 2006).

A wind turbine is a device engineered to harness the wind's kinetic energy and convert it into electricity, thereby providing power to residential areas, such as cities, towns, and villages. A collection of wind turbines forms a wind farm, wherein the energy from wind movement is converted into electrical energy. The evolution of power generation through wind turbines with horizontal or vertical blade axes has been remarkable. Since the early 20th century, the integration of electric generators with windmills has facilitated the conversion of wind energy into electricity. Today, modern technologies demonstrate that wind turbines, whether compact or large, are highly efficient and reliable. Wind turbines can be deployed individually or in clusters within wind farms. They boast impressive wingspans of 60 to 100 meters and are rated in megawatts (MW). With their advanced technical features and low cost per kilowatt-hour produced, wind energy systems represent an environmentally friendly power source. As a vital component of national energy networks, wind turbines can serve large industrial, tourism, agricultural, and animal production units, as well as systems linked to the national grid (Fragkiadakis, 2004). Additionally, wind systems are often installed in shallow coastal waters.

The installation of small-scale wind turbines in buildings represents another significant application. These turbines are designed to produce less energy due to their compact design, resulting in quieter operation. Generally, turbines with larger rotor diameters generate more energy. Notably, wind turbines can function independently to meet or supplement energy demands for remote cottages, businesses, sailing ships, caravans, and similar settings. In autonomous systems not connected to the Public Power Corporation (PPC) network, energy is stored in batteries for use as needed, addressing issues such as wind lulls or increased energy demands during specific periods. Combining wind turbines with photovoltaic components remains a viable option, resulting in hybrid systems (Felekidis, 2018).

Hydroelectric power is a significant source of renewable energy that harnesses the kinetic and potential energy of water bodies, such as rivers and lakes, to generate electricity. This process involves capturing the energy of flowing or falling water and converting it into mechanical energy, which is then transformed into electrical energy through the use of turbines and generators. The fundamental principle behind hydroelectric power is the conversion of the gravitational potential energy of water stored at higher elevations into kinetic energy as it flows downhill, turning turbines that drive electricity generators. This form of energy generation is considered one of the most environmentally friendly methods for producing high-power electrical energy. It is clean because it does not rely on burning fossil fuels, which emit harmful pollutants and contribute to global warming. Instead, hydroelectric power plants produce electricity without direct emissions, thus helping to reduce the overall carbon footprint of energy production. Furthermore, hydroelectricity is considered limitless and renewable, as it relies on the Earth's natural water cycle. As long as precipitation occurs, water will continue to flow through rivers and streams, providing a constant and reliable source of energy grid (Sims, 1991).

Hydroelectric power plants vary in size and type, from large-scale projects like the Three Gorges Dam in China, which is the largest hydroelectric power station in the world, to small-scale installations designed for local community use. These plants can be classified into several types based on their method of operation and size. The most common types include impoundment facilities, which use dams to store river water in a reservoir, and run-of-the-river systems, which use the natural flow of rivers without large storage reservoirs. Pumped storage facilities are another type, functioning as a form of energy storage, where water is pumped to a higher elevation during periods of low electricity demand and released to generate power during peak demand times. Despite its numerous advantages, hydroelectric power is not without challenges and environmental considerations. The construction of large dams and reservoirs can have significant ecological impacts, including habitat disruption, changes in water quality, and displacement of communities. Careful planning and management are essential to mitigate these impacts and ensure that hydroelectric projects are developed sustainably. The benefits, however, often outweigh the drawbacks, as hydroelectric power provides a stable and reliable energy source that can complement other renewable energy technologies, contributing to a diversified and resilient energy grid (Sims, 1991).

Biomass primarily consists of water and carbon, two elements abundantly available in nature. Plants collect solar energy during photosynthesis and store it as they grow, aided by water and minerals. Biomass serves as a moderate and renewable energy source, owing to the use of plant, animal, and forestry wastes, municipal sewage, and garbage in energy production. This stored energy can be transformed into various useful energy forms, such as heat and electricity. Biomass can be produced from any vegetable matter from agriculture or forestry used as fuel to recover its energy content, vegetable waste from these sources, and vegetable waste from the food industry. Additionally, fibrous vegetable waste from the production of virgin pulp and paper from pulp can be used as biomass, provided it is co-incinerated at the point of production (Bridgwater, 2006).

Geothermal energy is an endogenous energy source unique to each location or nation. It is based on thermal energy generated by volcanic eruptions, natural gases, or hot water heated deep within the Earth's crust. While geothermal energy is often classified as a renewable resource due to its alternative nature, it is essential to note that its supply is limited. Thorough research of the installation and surrounding area is crucial to prevent environmental harm (Balaras et al., 2006).

One primary application of geothermal energy in buildings is through ground-air exchangers for heating and cooling. These systems consist of underground pipe networks and an air circulator that propels air through the networks until it reaches the building's interior. The objective is to combine the air within the structure with air drawn through the pipe system (Mihalakakou et al., 1994). Ground-to-air heat exchanger pipes can be constructed from plastic, metal, ceramic, or even concrete. Due to the substantial thermal inertia of the soil, the conductivity and material of the pipe are less significant (Santamouris, 2006). The pipes are typically buried horizontally between one and three meters below the Earth's surface (Mihalakakou, 2012). For improved system performance, 5 cm of sand is usually placed between the pipe and the ground for better thermal contact (Santamouris, 2006).

1.3. Historical Background of the Energy Market

1.3.1 Historical Review and Description of Electricity Markets

Electricity as a good and its main characteristics:

In modern societies, the social, political and economic development of each state directly depends on electricity as a good. It is the most basic form of energy which has greatly influenced the quality of life, development and great progress in all sectors of societies worldwide.

The development of electricity and electrical systems has also contributed to the development of technology and information technology, which has been moving at a geometric pace over the last few decades. A large number of researchers support the same commercial treatment of electricity as that which governs the financial transactions of other commercial goods. However, this specific perception is wrong as electricity is by its very nature a special good that differs significantly from other commodities (Foulidis, 2018).

The characteristics that define electricity as a commodity are both unique and complex, making it a distinct element within energy markets. The transfer of electricity from one point in the network to another is facilitated by a sophisticated transmission system, with the flow of electricity governed by Kirchhoff's laws. This system is constrained by the electrical power it can transmit at any given moment, which is determined by several factors, including the thermal limits of transmission lines, voltage constraints, and stability limits. These limitations necessitate meticulous management to ensure the efficient and reliable delivery of electricity across the grid (Foulidis, 2018).

Electricity also presents a significant challenge in terms of storage. Currently, it cannot be economically stored in large quantities. While battery technology continues to advance, it has not yet reached the stage where storing electricity on a large scale is feasible or cost-effective. As a result, the most effective method of electricity storage to date remains pumped hydro storage. This technological limitation necessitates that electricity production constantly adapts to fluctuations in demand throughout the day to maintain a consistent balance between supply and demand. Furthermore, if the output of generating units does not respond quickly enough to changes in electrical load, the frequency of the network can deviate from its permitted operating limits. Such deviations pose risks to consumer electrical appliances and, if the problem escalates, can lead to a complete system collapse, commonly known as a blackout (Foulidis, 2018).

Electricity is also distinct in that it has no direct substitute. This characteristic underscores the critical importance of maintaining an uninterrupted supply, as any disruption can have far-reaching consequences for the economy, public health, and national security. The absence of viable substitutes renders the short-term demand for electricity highly inelastic. This inelasticity means that even minor interruptions in supply can lead to significant economic disruptions and pose challenges to maintaining societal functions. The irreplaceable nature of electricity emphasizes the need for robust infrastructure, reliable transmission systems, and responsive supply chains to meet the constant and ever-growing demand for this essential commodity (Foulidis, 2018).

1.3.2 Evolution of Electricity Markets

The electricity industry from the initial stages of its creation until today has passed through many stages and models of organization, which change according to the legal framework and the particularities of each country. The model of central operation was followed for most of the 20th century. This operation, i.e.through state monopolies, happened mainly because of the huge investment in production, transmission, and distribution systems that were necessary (Foulidis, 2018). On the other hand, over time the centralized operation model began to be replaced with a more competitive industry. Below follows the presentation and the main characteristics of the transition from monopolistic markets to competitive ones (Foulidis, 2018).

At the beginning of the 1990s, there is a climate of market liberalization around the world in various sectors. At that time, the electricity market is also greatly affected and it is now supported by many to abandon the monopoly model of organization of the electricity industry. This view was based on the fact that in the monopolistic organization it is not as efficient as in the competitive one, but it often obeys and is influenced to a great extent by political pursuits. In addition, with the competitive market, two main objectives of the economic operation of the system were ensured, which are the pricing close to the real cost and the provision of incentives for the minimization of this cost (Soft, 2002).

The first competitive market in Europe was implemented in 1990, in England and Wales, and a year later in Norway. The changes observed were many, starting from the privatization of a large part of the electricity supply processes to the creation of the Power Pool, a centrally organized market, and then the Power Exchange, in the case of a decentralized market (Soft, 2002).

In Norway, the first organized international electricity market (NordPool) was created in 1996, when the Norwegian and Swedish markets were joined, followed by Denmark and Finland. In Greece, market liberalization appeared with the foundation of Law 2773/99 in 1999 and became operational in 2001 In the American continent the process of transition happened earlier than the corresponding one in Europe, it started in Chile in 1982 and in the following years it spread to other countries of the continent. The United States of America adopted the relevant regulations of the transition to the deregulated energy market in 1998 with the PJM interconnection (Pennsylvania - New Jersey -Maryland Interconnection) and then with the California market (Roach & Meeus, 2020).

The most basic legislative regulation in Europe, considered as the first important step in the liberalization of the electricity market, was established in 1996 with the adoption of Directive 96/92/EC. This directive established the basic rules for a single European electricity market where everyone now had access to the market and to the transmission and distribution systems. In 2003 the first directive was replaced by 2003/54/EC which provided for full market opening. Finally, the last regulation took place in 2009, Directive 2009/72/EC aimed at improving the functionality of competitive electricity markets (Directive 96/92/EC & 2009/72/EK). With the latest directive the European Commission created two main mechanisms: the European Association of Regulators ACER and the Union of European Energy System Operators ENTSO-E, entrusting them with the practical preparation of its program for the single energy market which is called the Target Model (Target Model) (Cochran et al., 2013).

This model, through a common market architecture for each time level and a coordinated approach to the allocation of transport capacity in the interconnections, will make the European market fully functional and contribute to the development of the European economy and industry, allowing the provision of access to low-cost energy production resources to all European citizens, minimizing production costs and thereby maximizing social surplus (Meeus, 2020).

1.3.3. Short-term and Long-term Organization of Competitive Electricity Markets

The models of organization of electricity markets in Europe can be distinguished into two general types, as follows: a) the Centrally Organized Market or Power Pool and b) the Decentralized Market of Bilateral Contracts with Voluntary Power Exchange Model (Bilateral Contracts with Voluntary Power Exchange Model). In modern liberalized electricity markets, regardless of the structure and organization models, energy transactions between participants take place at various time scales, from the long-term horizon to real time (Tafreshi & Lahiji, 2015).

Depending on the regulatory framework of operation of each country the basic categories of electricity markets are the so-called forward market, bilateral OTC market, day-ahead market, intraday market, 4 Reserve market, balancing or real-time markets, imbalance settlement mechanisms (Tafreshi & Lahiji, 2015).

1.3.4 The Medium-Long Term Forward Market

Medium-long-term electricity transactions are carried out through the Forward Markets. The futures market is an auction market in which Participants buy and sell physical or financial products that expire on a specific date. These products are called derivative products. These contracts are called derivatives because their value is directly related to the value of a more basic product, which in this case is electricity (Gandolfi et al., 2018).

The most interesting feature of the futures market is that it allows the trading of physical or financial products related to the future but with a price set today (Foulidis, 2018). These peculiarities make the future values of the current quite uncertain and extremely difficult to predict accurately, especially as the forecast time horizon increases. This uncertainty is logically undesirable as it causes variability in the profit or cost of agents participating in the current market. In this way, futures markets offer derivatives that last up to a few years and allow consumers, suppliers and producers to hedge the financial risk inherent in spot market prices (Gandolfi et al., 2018).

1.3.5 Day-Ahead Market

The pre-day and intra-day electricity markets are crucial components of the broader energy landscape, as they facilitate a significant volume of transactions. These markets are centrally managed by a Market Operator, who plays a pivotal role in ensuring the smooth functioning of electricity trading. The competitive electricity markets, which have evolved over time, exhibit a lack of a unified model for organizing the day-ahead market. Despite this diversity, most markets can be categorized into two distinct organizational types, according to Foulidis (2018): the centrally organized market, often referred to as a Power Pool, and the decentralized market of bilateral contracts, which may also involve the optional operation of an energy exchange, known as the Bilateral Contracts with Voluntary Power Exchange Model.

The Power Consortium exemplifies a centrally organized market where all energy transactions occur on a short-term basis, with energy being bought and sold through the Market Operator. In this system, the Market Operator is responsible for centrally scheduling all transactions. Producers are required to submit their injection offers for electricity production, detailing quantity-price pairs, while suppliers provide their consumption offers. The Market Operator then aggregates these injection bids and ranks them in ascending order, alongside consumption bids, or in some cases, the load forecast, which are sorted in descending order. The market is subsequently cleared using a clearing algorithm. When transmission system limitations are not considered, the resultant energy price is uniform across all market participants, known as the Market Clearing Price (MCP) or Marginal Clearing Price (MCP) (Liu et al., 2015).

Conversely, if the transmission system is integrated into the market-clearing algorithm, the process yields a distinct Nodal Marginal Price, also known as Locational Marginal Price (LMP), for each node within the system. Unlike the Power Consortium, decentralized electricity markets rely on bilateral contracts between producers, suppliers, and large consumers. These contracts specify the delivery of particular quantities of energy at predetermined prices for a set future period, facilitating transactions within the Energy Exchange or Power Exchange. The principal drawback of the Bilateral Contract Markets is their medium to long-term nature, which poses challenges in ensuring the security of the electricity system through these markets alone (Tschora et al., 2022).

To address this limitation, a simple stock exchange often operates alongside the Bilateral Contracts Market. This exchange operates on a simple economic order of clearing offers and is characterized by voluntary participation. Such an arrangement enhances market liquidity and provides a mechanism for short-term adjustments, complementing the bilateral contracts. By enabling participants to engage in real-time trading and price discovery, the voluntary power exchange offers additional flexibility and resilience to the electricity market framework. This dual-market structure allows for a more dynamic and responsive electricity market, capable of accommodating fluctuations in supply and demand while maintaining system security and stability (Foulidis, 2018).

1.3.6 The Intraday or Adjustment Market

In the intraday market, participants are optionally allowed to enter into trades in order to minimize the deviation of their net position resulting from trading in all markets, from the quantities sold or bought in real time. The clearing of the intraday market takes place closer to the time of electricity delivery and covers a shorter trading time horizon. This is the only difference between this market and the pre-day market. Therefore, this feature makes intraday markets very important especially for renewable energy (RES) producers, as the best forecast of their units directly depends on how close these markets are to the actual delivery of energy (Vella & Ng, 2014).

1.3.7. Reserve Markets

The rotating and non-rotating reserve plays a crucial role in maintaining the stability and reliability of power systems. It is designed to address unforeseen disruptions in the operation of production units or transmission lines, as well as to manage significant fluctuations in electric load and the unpredictable nature of renewable energy sources. As the integration of renewable energy into the grid continues to increase, the stochastic nature of these resources necessitates a robust reserve system to ensure a seamless and uninterrupted power supply.

Rotating reserves refer to the additional capacity that can be quickly activated by increasing the output of already-running generators. This capacity is typically provided by conventional power plants, such as natural gas or coal-fired plants, that can ramp up their production rapidly in response to a sudden demand for more power. Rotating reserves are essential for covering short-term fluctuations and providing immediate backup in case of equipment failure or sudden demand spikes. This ability to quickly increase output helps maintain grid stability and prevents power outages. Non-rotating reserves, on the other hand, consist of standby power sources that are not currently online but can be brought into operation if needed. These reserves may include peaking power plants, battery storage systems, or demand response programs. Although they take longer to activate compared to rotating reserves, non-rotating reserves are invaluable for providing additional capacity over a more extended period. They are essential for addressing longer-term imbalances in supply and demand, particularly when renewable energy output is low or when there is a prolonged outage in the transmission system (Edmunds et al., 2019).

The reserve market is a critical component of the overall electricity market structure, as it provides a mechanism to ensure the availability of these essential reserves. It is intricately linked to the pre-day market, which is responsible for scheduling electricity generation and consumption for the following day. The reserve market operates either in conjunction with or immediately following the pre-day market, facilitating the procurement of necessary reserves to manage unforeseen events. By integrating reserve capacity into the pre-day market, system operators can account for potential uncertainties associated with renewable energy production. This integration enables operators to secure the necessary backup resources in advance, thereby minimizing the risk of power disruptions. In this way, the reserve market serves as a safety net, safeguarding the reliability of the electricity grid (Padmanabhan et al., 2019).

1.3.8 Balancing or Real-Time Markets

Balancing or real-time markets play an essential role in the efficient and reliable operation of electricity grids by ensuring that supply and demand are balanced on a minute-by-minute basis. These markets are integral components of modern energy systems, particularly as the share of variable renewable energy sources like wind and solar continues to grow. The balancing market is designed to handle discrepancies between predicted and actual electricity consumption and production, providing the flexibility needed to maintain grid stability and prevent disruptions. This essay will explore the fundamental concepts of balancing markets, their operational mechanics, and their significance in contemporary energy landscapes (Vlachos & Biskas, 2013).

The primary goal of balancing markets is to maintain the equilibrium between electricity supply and demand in real time. Unlike day-ahead or intra-day markets, which schedule electricity generation and consumption based on forecasts, balancing markets operate on much shorter timeframes. They address real-time deviations from planned schedules due to unexpected changes in electricity demand, unforeseen outages in generation or transmission, and inaccuracies in renewable energy forecasts (Tsaousoglou et al., 2021).

The real-time market functions as a dynamic adjustment mechanism that continuously fine-tunes the electricity system to meet actual demand. This market is vital for preventing imbalances that could lead to frequency deviations, voltage instability, or even blackouts. Balancing markets are typically managed by transmission system operators (TSOs), who are responsible for ensuring the overall reliability and security of the electricity grid (Vlachos & Biskas, 2013).

Balancing markets operate by dispatching flexible resources that can quickly ramp up or down their output to match real-time electricity needs. These resources can include a variety of assets, such as fast-responding power plants, demand response programs, energy storage systems, and grid-interconnected renewable energy sources with control capabilities (Vlachos & Biskas, 2013).

Participation in Balancing Markets

- **Balancing Service Providers (BSPs):** Entities such as power generators, storage operators, and demand response aggregators that provide balancing services. They submit bids or offers to the TSO, specifying the amount of power they can provide or reduce, along with the associated costs (Tsaousoglou et al., 2021).
- **Balancing Responsible Parties (BRPs):** Participants in the electricity market, including utilities and retailers, who are responsible for ensuring their electricity consumption or production matches their scheduled commitments. If deviations occur, BRPs must either balance their positions themselves or pay for the necessary adjustments in the balancing market (Tsaousoglou et al., 2021).

The clearing process in balancing markets is typically executed through a series of auctions that occur at short intervals, often every 5 to 15 minutes. This frequent clearing ensures that the market can react swiftly to real-time changes in the system. The TSO receives offers from BSPs, detailing the available capacity and price for either increasing or decreasing electricity production. These offers are then sorted and selected based on cost-effectiveness, with the least expensive options being dispatched first to correct any imbalances. The market-clearing price in balancing markets reflects the marginal cost of balancing energy and can vary significantly based on supply and demand conditions. This price serves as an important signal for participants, incentivizing investments in flexible technologies and encouraging efficient market behavior (Tsaousoglou et al., 2021).

1.3.9 The Imbalance Settlement Mechanisms

Maintaining a constant grid operating frequency is one of the most crucial requirements of electricity systems, as it ensures the safe and efficient operation of electrical equipment and the overall reliability of the power system. Typically, this frequency is set at 50 Hz in Europe and 60 Hz in North America. The Production-Demand Discrepancy Clearing Mechanism, commonly referred to as the balancing market, plays a vital role in achieving this requirement by continuously monitoring the load and making real-time adjustments to balance electricity production and demand. This mechanism ensures that any deviations from the standard frequency are promptly addressed, thereby preventing potential blackouts and safeguarding grid stability (Hou et al., 2019).

Grid frequency stability is essential because any deviation from the set frequency can lead to a range of problems, from inefficient power distribution to severe power outages. If the frequency drops below the required level, it indicates that demand exceeds supply, causing power plants to overwork and potentially trip offline. Conversely, if the frequency rises above the standard level, it suggests that supply exceeds demand, leading to inefficiencies and potential damage to equipment. Thus, maintaining a consistent frequency is paramount to the smooth operation of the electrical grid, necessitating a robust system for real-time monitoring and adjustment (Hou et al., 2019).

The Production-Demand Discrepancy Clearing Mechanism is designed to address these frequency stability challenges by continuously monitoring and adjusting power generation to match demand in real time. This process involves several key components. Real-time monitoring is achieved through advanced sensors and communication technologies deployed across the grid to provide continuous data on electricity consumption and generation. This data allows operators to detect discrepancies between supply and demand immediately. When a discrepancy is identified, the Automatic Generation Control (AGC) system automatically adjusts the output of power plants to restore balance. This system enables rapid responses to changes in load, ensuring that the frequency remains within the permissible range (Mendes et al., 2016).

Additionally, the mechanism activates reserve power sources, such as spinning reserves, which are generating units that are online but not operating at full capacity. These reserves can be quickly ramped up to meet sudden increases in demand or unexpected outages, providing an additional layer of security to the grid. Demand response programs also play a role in balancing supply and demand by incentivizing consumers to reduce or shift their electricity usage during peak periods, thereby alleviating stress on the grid and maintaining frequency stability (Mendes et al., 2016).

The balancing market typically clears once a day, assigning generating units to specific generation zones within which they should operate in real time. This process begins with forecasting and scheduling, where the market operator predicts electricity demand and schedules generation accordingly based on historical data, weather forecasts, and other relevant factors influencing electricity consumption. During the market-clearing process, generating units are assigned generation zones that dictate their operational parameters, specifying the range of output that each unit must maintain to respond effectively to load changes. This flexibility is crucial for maintaining the balance between production and consumption, especially in grids with a high penetration of variable renewable energy sources (Mendes et al., 2016).

The balancing market serves several essential functions. By maintaining a constant frequency, it ensures the stability and reliability of the electricity grid, preventing disruptions and potential damage to equipment. It supports the integration of renewable energy sources by providing the flexibility needed to accommodate their variability, allowing for a higher penetration of wind and solar power without compromising system stability. Furthermore, the market-clearing process optimizes resource allocation, minimizing costs and maximizing the use of available resources. By swiftly addressing supply-demand imbalances, the balancing market enhances the resilience of the power system, reducing the risk of blackouts and ensuring continuous electricity supply (Mendes et al., 2016).

1.3.10 The Participants of the Electricity Market

Following the radical changes introduced by the competitive electricity market, new participants emerged to ensure the efficient and smooth operation of this evolving landscape. The transition to a liberalized electricity market necessitated the establishment of distinct roles to manage the complexities of pricing, regulation, and system operations. The primary actors and participants in the modern liberalized electricity market each play a specific role in maintaining its functionality and competitiveness (Shafie-khah & Catalão, 2014).

The Market Operator is a critical component of the electricity market. As an independent and non-profit organization, the Market Operator is responsible for setting prices and managing the operating rules and production schedules of various generation units. Its ultimate goal is to ensure the proper management of the electricity market, facilitating the efficient allocation of resources and ensuring that supply meets demand in a balanced and equitable manner. Similarly, the System Operator is a non-profit organization tasked with the technical management of the electricity system. This entity is responsible for providing equal access to the transmission system for all participants, thus facilitating seamless transactions between energy producers and consumers. The System Operator also oversees the operation of ancillary service and regulation markets and plays a crucial role in the clearing of the balancing market, either independently or in conjunction with the Market Operator (Tanrisever et al., 2015).

The Market Regulator is a state-independent organization entrusted with overseeing the market's functioning and ensuring its proper operation and competitiveness. This body is responsible for issuing regulations that govern the market's smooth and satisfactory operation and for monitoring compliance with these regulations. By maintaining oversight, the Market Regulator ensures that the electricity market remains fair, competitive, and transparent (Shafie-khah & Catalão, 2014).

Consumers represent the final users of electricity within the market framework. They have the option to purchase energy either directly from the futures and day-ahead markets, which is primarily utilized by large consumers, or through electricity suppliers. Consumers play a passive yet essential role, as their demand ultimately drives the entire market operation and influences production and supply strategies. Suppliers, or retailers, serve as the intermediaries between the electricity market and consumers who do not directly participate in energy trading. These entities do not own generating plants but instead purchase the necessary electricity through their participation in various energy markets. Suppliers are responsible for delivering electricity to consumers, thus playing a crucial role in the distribution network (Manshadi & Khodayar, 2015).

Producers, on the other hand, own the production units within the electricity system. Their primary objective is to maximize profits from the sale of electricity. Producers have the option to sell the energy they generate by participating in various energy markets or by directly engaging in bilateral contracts with large consumers and suppliers. In addition to participating in traditional energy markets, producers may engage in reserve markets and regulation services markets. They also often participate in the balancing market to address any production or demand shortfalls or surpluses that may arise. Non-dispatchable producers differ from traditional producers in that they own non-dispatchable production units, such as wind turbines and photovoltaic systems, which are characterized by variable or intermittent power production. These producers aim to maximize profits by selling energy in the current market and are often required to participate in balancing markets to compensate for any deviations from their projected energy output, as determined by pre-day and intra-day market forecasts (Manshadi & Khodayar, 2015).

1.3.11 The Problem of Transmission System Management in a Competitive Market

The vertically integrated monopoly market controlling all processes was intended to reduce the cost of energy while ensuring the safe operation of the grid. The liberalization of the market brought to the fore new participants, each of whom now has different goals and interests. In this market, there are now suppliers, producers, non-allocating producers, and consumers, each of whom individually aims to maximize his own benefit. There is also a Market Officer whose purpose is to ensure the proper functioning of the system and maximize social welfare. The main goals for an efficient model are the liquidity of goods that will increase transactions and efficient pricing that will greatly contribute to addressing system congestion (Lu et al., 2005).

If it were possible to transfer unlimited energy through the interconnections, it would be possible to create a single price for electricity, which would also be the lowest possible price. In this way the producers with the lowest energy costs would send energy to the most expensive areas. In reality, however, this does not happen, because the transmission system has a limit to the amount of energy transfer at any time. An important function is congestion management, which is necessary when transmission lines are operating close to or even beyond their limit. Overloading a transmission line can cause many operational problems, grid strain, widespread power outages, and even the destruction of the transmission system (Hesamzadeh & Yazdani, 2013).

For this reason, one of the most important problems in system management is the management of congestion pricing. The management of congestion pricing is a complex problem in the case of a competitive electricity market because the participants are many and there is conflict of interest. On the other hand, in the case of a monopoly system, the problem of overcrowding is more easily solved by the immediate regulation and redistribution of some production units without showing the reactions of the respective producers (Hesamzadeh & Yazdani, 2013).

1.4: Storage and Safety Capacity in Europe

The transition to a low-carbon energy system cannot be achieved without stable, flexible solutions and techniques that can manage the synchronization between renewable electricity sources and also changing consumption demands (Sarris, 2020). Of course, the transition from traditional to renewable energy sources necessitates significant expenditures in both their location and their integration with the network. (Hofmann et al., 2020).

To be more explicit, it should be noted that the energy supply from most RES-based energy systems is not continuous, as power generation is dependent on weather conditions. Wind energy, for example, is dependent on wind speed, whereas RES that harvest solar energy, like photovoltaics, are directly dependent on solar radiation and hydropower is dependent on water availability. As a result, system flexibility is critical in achieving a balance of energy, supply, and demand. At any one time, power consumption must be completely balanced with electricity output. This balance is required in all electrical systems to ensure a steady and secure supply. (European Comission, n.d.), as the Wind power's erratic and intermittent nature can have a detrimental impact on the power system (Li et al., 2019). The combination of various energy supplies and energy conversion technologies, such as renewables, green hydrogen, and conventional power plants, has resulted in a novel method to increasing system flexibility. Energy storage is another flexibility strategy that might contribute to supply and demand matching in renewable energy systems. (Daraei et al., 2020; European Comission, n.d.).

The storage of electrical energy becomes particularly important for the provision of flexible services at all levels: It helps power generation, as well as electrical transmission and distribution networks to operate more efficiently. In addition, decentralized electricity storage can provide support during unforeseen events, reducing the incidence and extent of power outages to consumers (Sarris, 2020).

Therefore it is clear that the storage of electricity gives the possibilities but also the flexibility to the electricity produced so that it does not have a direct connection with its consumption, both geographically and temporally. Storage of energy can help to stabilize changes in demand and supply by allowing excess power to be kept in huge amounts over a variety of time periods, ranging from seconds to days (European Comission, n.d.).

Considering all the aforementioned, by providing a range of systems and ancillary services, electricity storage enables the interconnection and energy participation of more renewable energy sources (RES) in an electricity system. This flexibility will be crucial when electricity systems will be powered mainly by variable RES, which means that the output will not have to be consumed immediately or even quickly adjusted to (anticipated) demand. But even in the transition period, as more and more RES will be connected to the system, electricity storage will help the system operate more safely and efficiently, while also extending the life of existing materials (e.g. grid infrastructure) (Sarris, 2020).

In general, the storage of electricity can also become important to limit the use of coal in the heating, cooling and transport sectors as well as through thermal storage and through conversion of electricity into fuel gas (Sarris, 2020).

All of the above points to electricity storage becoming the major use for future global energy linkage. Furthermore, the storage of electrical energy can also play a key role in supporting the development of infrastructure for charging electric vehicles. Finally, electricity storage can enable consumers to actively participate in the electricity market by generating, storing, and selling their own renewable electricity (Sarris, 2020). Figure 1 below depicts the construction of a power grid with energy storage capabilities (Liu, 2015).

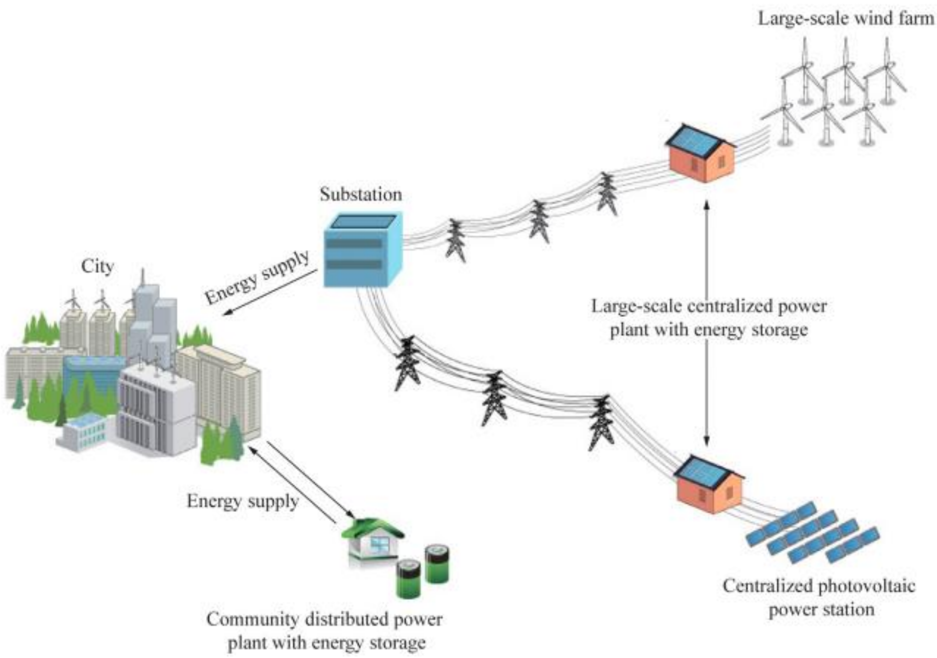


Figure 1: *The construction of a power grid with energy storage capabilities (Liu, 2015)*

Today, there is a plethora of electrical energy storage technologies, which are constantly evolving, and are now technically capable of offering many useful applications. This makes them an essential element in supporting the transition to a carbon-free energy system. The term "electricity storage" refers to a variety of technologies operating on different principles such as: Mechanical (e.g. pumped - storage, flywheels - rotating masses, compressed air system), chemical (e.g. P2G), electrochemical (e.g. batteries), thermal media (e.g. heat pump energy storage) and electrical (e.g. supercapacitors) (Sarris, 2020).

Some of these technologies provide very fast response, short-term power balancing (such as flywheels or supercapacitors) while other technologies provide longer storage and balancing over time, days or even seasons (for example, pump-storage or hydrogen storage). Each storage technology may be suitable for a specific application domain, therefore different storage technologies can be combined to form a hybrid system that can be greater than the sum of its parts (Sarris, 2020).

Europe's energy safety has become a pressing concern, especially in light of recent geopolitical tensions and the continent's ambitious climate goals. As European nations strive to reduce their dependence on fossil fuels, they face the dual challenge of ensuring a reliable energy supply while transitioning to cleaner sources. A significant step toward energy safety in Europe involves diversifying the energy mix, particularly through increased investments in renewable energy sources such as wind, solar, and hydropower. Countries like Germany and Spain have made substantial progress in this area, with Germany's Energiewende initiative leading the charge in renewable energy adoption, resulting in wind and solar power now constituting over 40% of the country's electricity production. Spain, similarly, has seen its renewable energy capacity grow exponentially, thanks to favorable policies and investments, positioning itself as a leader in solar power. However, this shift also necessitates significant infrastructure upgrades and cross-border collaborations to ensure grid stability and efficiency. The European Union has recognized this need, with initiatives like the European Green Deal and the Clean Energy for All Europeans package aiming to facilitate a more integrated energy market and promote the resilience of energy systems across member states (Sarris, 2020).

In addition to renewable energy diversification, Europe's energy safety strategy must consider the advancement of energy storage solutions and the modernization of existing infrastructure. Energy storage technologies, particularly battery storage and hydrogen fuel cells, play a crucial role in compensating for the intermittent nature of renewable sources. The European Investment Bank has increased funding for research and development in these areas, reflecting the continent's commitment to sustainable energy innovations. Furthermore, enhancing the energy infrastructure through the development of smart grids is essential to improve the efficiency and flexibility of energy distribution. The Baltic Sea region, for example, has made notable strides in this regard, with projects like the Baltic Energy Market Interconnection Plan (BEMIP) aiming to synchronize the energy systems of Baltic states with the rest of Europe, thus improving energy security and market integration. These efforts highlight the importance of a cohesive approach that combines technological innovation with policy support to fortify Europe's energy safety (Sarris, 2020).

1.4.1. The Role of Energy Storage in Decarbonising the Heating, Cooling and Transport Sectors

With electricity storage, it is possible to connect the electricity sector with the heating and cooling sector, as well as with the transport sector. Around 85% of heating demand is still met by fossil fuels, so electrifying heating is a very effective way to reduce carbon use in this sector. In addition, thermal energy storage has enormous potential to provide power system flexibility, particularly over longer time scales (Sarris, 2020).

As far as the transport sector is concerned, 94% of the energy demand is covered by fossil fuels. Storage could potentially support growth in electric vehicle charging infrastructure as it can help smooth out fluctuations in demand. In the long term, storage through natural gas supply is key to supporting clean hydrogen vehicles (Sarris, 2020).

Furthermore, as previously stated, energy storage plays a critical role in the transition to a carbon-neutral economy (European Comission, n.d.) since, with large-scale RES integration, peak-load control will become the primary scheduling and operating pressure (Li et al., 2019). At the same time, disregarding peak-load control adequacy may result in evaluation errors. For the reasons stated above, it is apparent that the advancement of energy storage technology is critical for assuring the large-scale growth of clean energy as well as the safe and cost-effective functioning of power grids. Incorporating electricity storage technology into the power system can provide an otherwise "rigid" power system that maintains balance in real time with a "flexible" touch. This will smooth out the variations caused by large-scale grid access for renewable energy, resulting in benefits in grid-level operational security, economics, and flexibility (Li et al., 2019). Energy storage, through balancing power networks and conserving surplus energy, is a tangible approach of improving energy efficiency and incorporating more renewable energy sources into electrical systems. It will also contribute to the EU's energy security and the development of a well-functioning internal market with lower consumer costs (European Comission, n.d.). The vital role of storage systems is evident from the European Commission, which published guiding documents on a proposed definition and principles in June 2016 and a staff working document on the role of electricity in energy storage in February 2017 in order to identify how to further develop energy storage technologies. These concepts were later incorporated in the Clean Energy for All Europeans package, which was accepted in 2019 (European Comission, n.d.).

1.4.2. Major Challenges for the Storage Industry in Europe

Considering that electricity storage is a relatively new player in the energy system, the biggest challenge is the legal uncertainty regarding the role of storage in the system, as it is considered in some EU member states as a production element or as a consumption element depending on its mode of operation. This results in electricity storage systems in some Member States being subject to double fees and charges (Sarris, 2020).

And it is still not clear whether the storage can be owned and managed only by the distribution network operators (for Greece, DEDDIE) for the purposes of operating the network, or whether the electricity storage devices can also be managed by the owners of the systems that it is obvious. In addition, the lack of a needs-based market and the absence of long-term agreements for energy system services hinder the security of investments in electricity storage. From a research and innovation perspective, it is necessary to develop different storage services and applications and explore ways to combine and economically exploit these services (Sarris, 2020).

1.4.3. A European Regulatory Framework and the Evolution of Energy Market Design

The EU regulatory framework must better define electricity storage and must allow interconnections of different energy sectors, such as electricity "in" and heat, natural gas or fuel "out", like electricity storage. The definition should reflect all types and applications of electricity storage and not just traditional technologies and uses such as pumped storage or batteries to allow the development of new technologies (Sarris, 2020).

Clarity is needed on the rules under which energy storage can access markets, in particular the inability of transmission system operators (TSOs) and distribution system operators (DSOs) to acquire, maintain and exploit stored electricity. Eliminating double charging and unjustified fees and taxes can help electricity storage to compete equally with other flexibility options in trading systems and offer balancing options to markets.

System services are not all provided on market-based terms in all EU Member States. This has the effect of creating higher costs for the consumer and discriminating against technologies that are not currently allowed to provide these services, even if these services will be provided more cheaply and with better reliability. It follows that it is important to ensure that the procurement of all energy resources and ancillary services is market-based and subject to cost-benefit analysis (Sarris, 2020).

Electricity storage could be identified as the fourth key element of the energy system (alongside generation, transmission/distribution, and consumption). This would prevent energy storage from being classified as generation only or consumption only or both. It could limit any ambiguity arising from historical market design stemming from a centralized energy system where everything fits into one of the three key elements mentioned. It will also enable a comprehensive and clear framework for energy storage (Sarris, 2020). Implementation of the right regulatory framework and market design is a matter of urgency for Europe, without which the development of electricity storage necessary to support the cost-effective integration of RES into the European energy system will not be achieved (Sarris, 2020).

1.4.4. Global Renewable Installation

Pumped hydro accounts for the majority (about 90%) of energy storage capacity, with 172.5 GW. Electrochemical energy storage, with an installed capacity of 14.1 GW, is the second biggest energy storage Sustainability 2022, 14, 5985 5 of 18 installed. With a total installed capacity of 13.1 GW, battery energy storage is the most advanced electrochemical storage technology (Lithium-ion type). In 2020, the global size of newly operational electrochemical energy storage projects reached 4.73 GW, while the global scale of planned and under construction projects exceeds 36 GW; the majority of these are used in wind and solar power production projects (Worku, 2022).

The top ten European markets will add 73 GWh of energy storage over the next decade, accounting for 90% of new deployments. By 2031, Europe's grid-scale energy storage capacity will have more than doubled. The United Kingdom will be the region's largest grid-scale storage market through 2031, adding 1.5GW/1.8GWh in 2022 alone. With investor confidence in the profitability of energy storage assets growing, the United Kingdom has the largest storage project pipeline in Europe, with 25 projects exceeding 100 MW. Because of the saturation of fast-response ancillary markets, UK energy storage project development will become more firmly tied to renewable energy growth, pushing for longer-duration storage assets by the middle of the decade.

The country of Ireland will be second in 2022, with new deployments totaling 0.31 GW/0.37 GWh. However, as seen in the graph above, Italy is the runner-up in the decade to 2031 overall (Darmani, 2022).

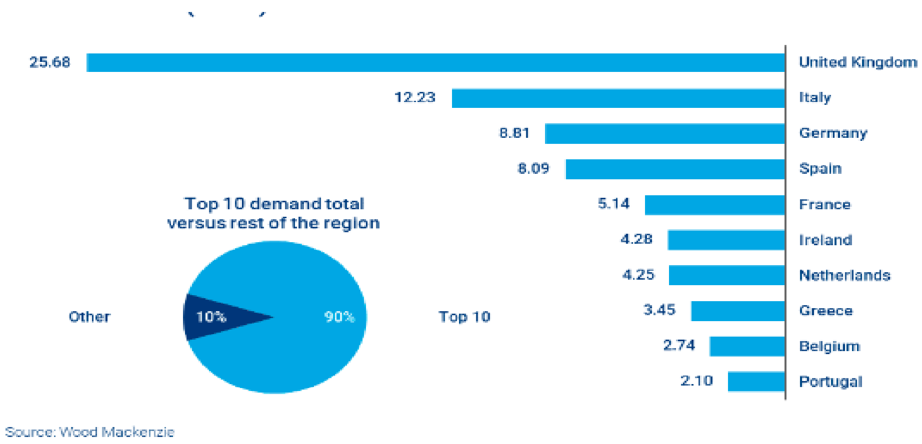


Diagram 1: *Top 10 European grid scale energy storage markets; new capacity for the time series 2022-2031 (Gwh) (Darmani, 2022)*

1.4.5. Energy Storage Necessity

The demand for energy fluctuates from peak to off-peak due to individual needs and climatic effects. Storing excess power during off-peak hours might be an urgent need as generation may surpass the total demand. The power mismatch challenge between generation and demand becomes more relevant because of the intermittency of the RES. The conventional grid reliability is affected by the large-scale integration of renewable energy sources. It is generally agreed that more than 20% penetration from intermittent renewables can greatly destabilize the grid system. Large scale ESSs can alleviate many of the inherent inefficiencies and deficiencies of the conventional grid and facilitate the full-scale integration of renewable energy sources. (Worku, 2022).

Generally, ESSs can balance supply and demand, reduce power fluctuations, decrease environmental pollution, and increase grid reliability and efficiency. Recent studies have shown that energy storage facilities, when properly scheduled, are capable of assuring firm power (up to 90% on average of their nameplate capacity) during peak loading conditions. By charging during valleys of net demand and discharging during peak hours, ESSs can make a profit from the differences in energy prices while at the same time enhancing the overall load factor, thereby reducing the need for expensive peak generators, and preventing renewable energy from being spilled. This should be supported by enhanced forecasting and control techniques and be fully coordinated with demand side flexibility. Additional markets that could enhance the business case for storage might also emerge in the near future; for example, providing advanced grid functions such as synthetic/virtual inertia/frequency regulation to support system stability (Worku, 2022).

Small-scale ESS are finding their place in households or small businesses. There might be two main reasons. On the one hand, they can store self-generated energy, typically from PV systems, for later consumption. On the other hand, if connection tariffs are in place, they might be used to decrease the network connection size, to support consumption at peak times by storing network energy at valley times, regardless of a self-generation system being installed or not (Worku, 2022).

The economics of both applications are dependent on the tariff structure. Electric vehicles (EVs), including transitional technologies such as plug-in hybrids, are expected to play a relevant role (Worku, 2022).

1.4.6. Energy Storage Systems

Electrical energy in an AC system cannot be stored electrically. However, energy can be stored by converting the AC electricity and storing it electromagnetically, electrochemically, kinetically, or as potential energy. Each energy storage technology usually includes a power conversion unit to convert the energy from one form to another. As already mentioned, energy storage systems (ESSs) make the power system more reliable and efficient by providing a wide array of solutions including spinning reserves, frequency control, load leveling and shifting, voltage regulation and VAR support, power quality improvement and relief of overloaded transmission lines (Worku, 2022).

There are several energy storage systems, some with broad use and others with more limited applications and various features. Pumped storage technique, being the most developed energy storage technology, is widely used at cheap cost. The total installed pumped-storage capacity on the globe today exceeds 100 GW. Japan, the United States, and China are the top three countries in terms of pumped storage capacity, with 26.27, 22.29, and 21.53 GW, respectively. Given the world's abundance of hydropower resources, larger-capacity pumped-storage facilities may be developed by leveraging the suitable terrain to improve supply security (Liu, 2015).

Compressed-air energy storage works on the principle of transforming electric energy into potential energy storable in compressed air by operating the air compressor and forcing the air into a large-capacity air reservoir using extra power generated during low-demand periods. In times of power outage, compressed air is coupled with oil or natural gas to power the combustion gas turbine and meet system-level peak load control requirements.

Compressed air energy storage has a high capacity, a long service life, and a low cost. However, the manufacturing process demands the use of fossil fuels, which emits pollutants and carbon dioxide. Currently, compressed-air stored energy technology is mostly being developed in laboratories or on a small scale. The kinetic energy generated by quickly spinning a rotor (flywheel) is stored. When energy is removed from the system, the rotor becomes a generator. This energy storage technology is best suited for short-term energy storage to solve power quality and impulse-type electricity consumption concerns because of its low energy density and lack of large-scale energy storage (Liu, 2015).

Big-capacity, long-term storage facilities, including pumped storage devices and compressed-air storage equipment, can help with peak load regulation on a large grid (Liu, 2015).

It should be noted that worldwide demand for batteries is fast increasing, owing to their potential to integrate further renewables into our energy systems as well as to greening the manufacturing and transportation sectors, with spillover effects on electrification in other sectors (European Commission, n.d.).

Flow batteries with significant storage capacity, many circulation periods, and a long service life, can be utilized to support energy storage devices on a grid. Furthermore, hydrogen storage may be utilized to store excess wind and solar energy for use in fuel cell cars. Large-scale power-type energy storage could be utilized to smooth out large-scale renewable energy generation variations. Supercapacitors, superconducting magnetic energy storage, flywheel energy storage, and sodium-sulfur batteries are used in conjunction with large renewable energy generation to respond quickly to wind and photovoltaic power output, smooth out fluctuations in renewable energy generation, and ensure the safety of real-time grid operations. Small batteries with stored energy can be utilized in electric cars. Stored energy technologies, like lithium batteries, new lead-acid cells, and metal-air batteries, have increased energy and power intensity but low uniformity, making large-capacity battery packs difficult to build. Instead of big power plants, this sort of energy storage is mostly employed in electric cars. Innovation in Global Energy Interconnection Technologies - ScienceDirect In the EU, pumped hydro storage is by far the most important energy storage reservoir, although battery projects are on the rise. Aside from batteries, a range of novel electrical storage technologies are rapidly evolving and becoming more market-competitive (European Commission, n.d.).

Technological progress is the root to achieving a better energy storage system. In 2020, there were advances in battery technology because of the breakthrough of the cost inflection point of lithium-iron phosphate batteries. In addition, there has been good progress in the development of non-lithium storage systems such as liquid flow batteries, CAES, and sodium ion batteries. CAES is a potential competent of PHS with the advancement of speed reduction technology (Worku, 2022).

Hydrogen storage systems are continuously evolving, and more complex hydrogen systems will soon be available on the market (Worku, 2022).

1.5. The Energy Transition of the EU Market as a Necessity

Climate change and associated dangers to ecosystems and human health necessitate a shift in the energy system away from fossil fuels and toward renewable energies, while boosting their performance is also required. Climate change and local air pollution are significant drivers of global energy transition. Rising temperatures are also a major cause of concern because of climate change (Creutzing et. al., 2014).
While end-of-pipe technology can be used to combat local air pollution, this is not the case for the majority of CO_2 emissions from energy consumption. Around two-thirds of worldwide GHG emissions are related to the supply and use of fossil fuel energy (Gielen et. al., 2019). The Paris Climate Agreement aims for far below 2°C means zero energy CO_2 emissions for the next fifty years. A more aggressive goal of merely 1.5°C suggests an even quicker reduction (Gielen et. al., 2019).

In this perspective, energy policy is the most pressing issue since it is directly tied to climate change and, more specifically, emission reductions. This is supported by EU records, which show that two of the EU's three treaties deal with the energy business. The "Green Book: European Strategy for Sustainable, Competitive, and Safe Energy" was released in 2006. The resolution's objective is to reduce greenhouse gas emissions by 20% compared to 1990 by 2020, as well as reduce energy consumption by 20% and increase the percentage of renewable energy sources by 20% by 2020. In 2016, the European Commission released a proposal that includes RES reform and a target of at least 27% renewables in power by 2030. (Press Release, European Commission, 2016). Furthermore, the Renewable Energy Directive II imposes a 7% limit for conventional biofuels in 2021, gradually decreasing to 3.8% in 2030. With a minimum contribution of 1.5 percent in 2021 and a maximum contribution of 6.8 percent by 2030, the renewable energy policy supports also the development of advanced biofuels (Borawski et al., 2019).

The Conference of Parties 21 (COP 21) accord has given this renewable energy trend further impetus, necessitating the creation of flexible, integrated energy systems. In certain locations, the key drivers for mitigating climate change are expanded combined heat and power (CHP), better efficiency, a move from coal generation to natural gas, or simple electrification (O' Malley et. al., 2016).

Simultaneously, coal power would have to be completely replaced, fossil fuel assets phased out, and infrastructure updated. Achieving the Sustainable Development Goals and providing universal access to modern energy by 2030 must continue to be a critical component of an equitable and inclusive energy transition (IRENE, 2022).

In general, and through the aforementioned, it is clear that renewables in the EU would need to be greatly scaled up across all sectors, from 14% of total energy now to about 40% in 2030 (IRENE, 2022).

The goal of energy transition is to significantly cut emissions while maintaining adequate energy for economic growth. According to the research, the world economic activity's CO2 emissions intensity must be decreased by 85% between 2015 and 2050, and CO2 emissions must be lowered by more than 70% compared to the Reference Case in 2050. As a result, yearly energy-related CO2 emissions are expected to fall by 2.6% on average, or 0.6 Gigatons (Gt) in absolute terms, culminating in 9.7 Gt of energy CO2 emissions per year in 2050. This energy shift will be made possible by technological advancements, particularly in the field of renewable energy (Gielen et. al., 2019). The aforementioned actions are feasible. The geographical periphery of Europe, particularly Southern Europe, offers significant renewable energy potential. (Gielen et. al., 2019). However, the energy storage devices discussed above will also play an essential role (IRENE, 2022).

It should be noted at this moment that renewables have already produced a fifth of all power globally since 2017. However, the transformation is taking too long. Experience has demonstrated that energy transitions take time, approximately half a century, from first market adoption to majority market share. Previous energy shifts were fueled by technology advancement, economics, resource availability, or greater energy service for customers. As a result, the transformation was centered on economic prospects, energy transition advantages, and human self-determination (Gielen et. al., 2019).

Significant societal change is unavoidable in a changing environment. Keeping the world's temperature rise below 2 degrees Celsius above pre-industrial levels will necessitate extensive and rapid social and technological transformations, including changes in the systems, structures, worldviews, and beliefs that underpin climate change and other contemporary challenges (Fazey et. al., 2018).

The European energy revolution, with a high level of renewable energy installations in the periphery, might function as an economic boost, reduce trade imbalances, and perhaps have beneficial job consequences (Creutzing et. al., 2014).

1.6. The Progress of the Technology of the RES and its Role in the Current Energy Mix

Energy systems have grown from isolated systems with few or no connections to a complex network of linked systems at customer, city, and regional sizes. Political, economic, and environmental goals have fueled this progress. Flexible energy systems are necessary to address the globally acknowledged objective of reducing carbon emissions through the deployment of substantial renewable energy capacity while simultaneously preserving dependability and competitiveness. (O' Malley et. al., 2016). In this context, particularly as a result of the obligation to implement climate mitigation measures, renewable energy sources (RES) have become more important in the power industry. As previously said, renewables provided a quarter of all power produced worldwide in 2017, and the aim is to have more RES deployed (Suna et al., 2022).

More technically focused assessments of system flexibility demands have received significant attention in scientific literature in this context and owing to the necessity to implement climate mitigation activities in the endeavor to raise the proportion of RES and to decrease any of their weak areas (Suna et al., 2022).

The two primary areas of advancement for RES are their efficiency and adaptability. In terms of flexibility, RES's non-constant output, because of its reliance on climatic conditions, contributes to diminished reliability. The coupling of RES systems with storage systems has been identified as a technical advancement that can lead to the most complete image of RES. Babatunde et al. as presented by Suna et al., (2022) characterize flexibility as the "degree to which a power system can modify the electrical demand or generation in relation to both planned and unforeseen unpredictability", as well as the capability to "sustain supply during transient and substantial imbalances". Similarly, IRENA, as presented by Suna et al., (2022) defines flexibility as "the ability of a power system to cope with the variability and uncertainty that VRES generation introduces into the system in different time scales, from the very short to the long term, avoiding curtailment of VRE and reliably supplying all the demanded energy to customers (Suna et al., 2022).

While flexibility requirements and alternatives exist at all levels of the energy system, flexibility in power systems has been described in a variety of ways, depending on the emphasis of the study and the research issue. Flexibility can be examined from a planning or operational standpoint, as well as at various geographical and temporal aggregate levels. Flexibility can be regarded at the spatial level from an overall system viewpoint (e.g., frequency control, supply security) or from a more local perspective (e.g., bus voltage maintenance, local grid stability). A difference between flexibility demands and alternatives for different timeframes, spanning from short-term to long-term, appears to be essential in matching appropriate options with respective needs (Suna et al., 2022).

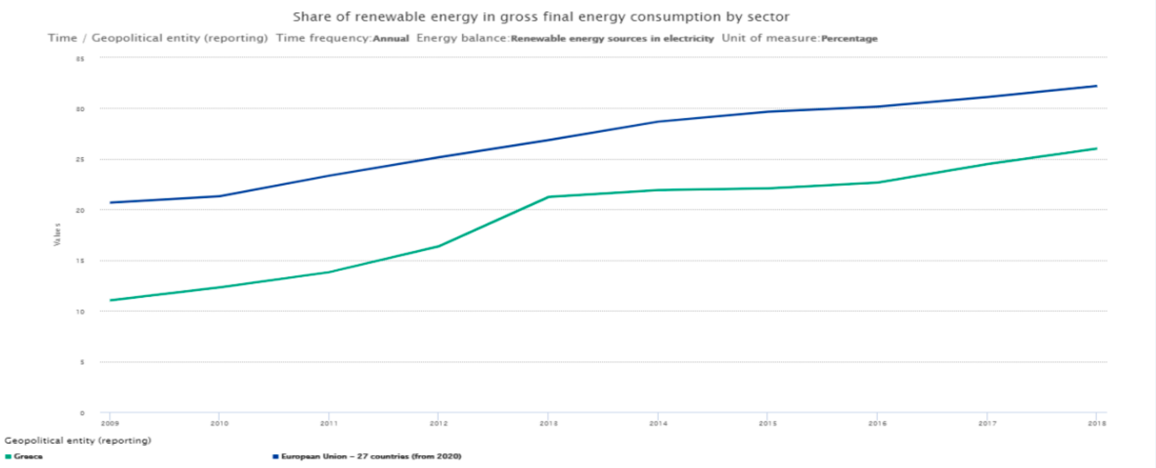


Diagram 4: *Percentage of RES Energy used for electricity for years 2009-2018 (Kosteletos, 2020)*

RES have seen significant technological progress over the years. Focused on Photovoltaic panels and wind turbines:

Photovoltaic panels at the time of their initial implementation, the power output of a single panel was relatively low, typically ranging from 5 to 20 Watts. However, with advancements in materials science and manufacturing processes, the power output of a single panel has significantly increased. Today, the largest photovoltaic panels have a power output of over 500 Watts, with some reaching as high as 700 Watts.

Wind turbines have undergone significant technological progress over the years, as well. It has to be noted that early wind turbines were much smaller in size and had a much lower power output compared to modern wind turbines. For example, the first wind turbines had a power output in the range of a few kilowatts, while today's wind turbines can have a power output of several megawatts. This improvement in power output can be attributed to several factors, including advances in materials science, improved aerodynamics, and the use of more sophisticated control systems. In addition, larger rotor diameters and longer blade lengths have also contributed to the increased power output of wind turbines.

1.7. Countries with the Biggest Percentage of RES in their Energy Mix

In the previous section, the European countries regarding the utilization of renewable energy were already briefly mentioned. In this paragraph, a more extensive reference to the countries that show significant progress regarding the participation of RES in their energy mix, are presented.

Before delving into the geographical extent of Europe, it is worth noting that the top three nations for installed renewable energy in 2021 was China, the United States, and Brazil. With a capacity of roughly 1,020 gigatons, China was the leader in renewable energy installations. In second place, the United States had a capacity of roughly 325 gigatons.

In the diagram below the countries with the biggest installation capacity of RES are presented. Below China, USA, and Brazil are India, Germany, Japan, Canada, France, Italy and Russia, as presented. We tell by the diagram that European countries are at the top list as well.

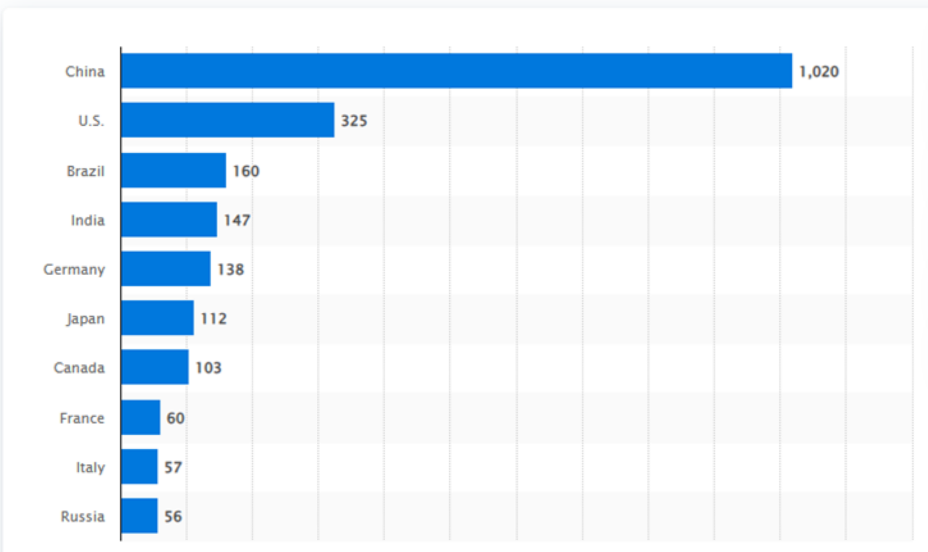


***Diagram 5**: Leading countries in installed renewable energy capacity worldwide in 2021 (Renewable energy capacity worldwide by country 2021 | Statista)*

At the European base, and for the year 2015, Denmark (7.2%), Portugal (4.3%), Ireland (4.0%), and Spain (3.5%) had the greatest percentages of wind energy in 2015. Cyprus (3.5%), Spain (2.6%), and Greece (2.2%) had the greatest percentage of solar energy in 2015. In 2015, Italy (3.5%), Portugal (0.8%), and Slovenia (0,7%) had the biggest contribution of geothermal energy. Sweden (14.2%), Austria (9.6%), and Slovenia (5.0%) had the highest hydropower share in 2015. The biggest coefficients of variation of the percentage of power from renewable energy sources were recorded in Malta (140.3%), Cyprus (101.1%), and the United Kingdom (71.9%) between 2004 and 2017. Furthermore, Malta (72.4%) had the largest coefficients of change in the percentage of renewable energy sources in heating and cooling from 2004 to 2017. Hungary (44.91%), and the United Kingdom (69.81%). Furthermore, Finland (113.78%), Malta (115.52%), and Belgium (96.53%) had the largest coefficients of variation in the percentage of renewable energy sources in transportation from 2004 to 2017 (Borawski et al., 2019).

<u>When referring to the year 2021:</u>

Denmark

Renewable energy sources will account for 67% of the country's electricity supply in 2021, with wind energy accounting for 46.8% and biomass accounting for 11.2%. The country intends to be completely fossil fuel-free by 2050 (Hope, 2022).

Germany

Germany has long been a leader in green energy use. Renewables were already contributing 45.3% of its power usage by 2020. The present administration earlier stated plans to lower its emissions further and then made another declaration that they rejected the European Union's ambitions to name nuclear energy "green" since it is "hazardous". The government is on track to close its three remaining nuclear power reactors by the end of this year (Hope, 2022).

Scotland

Wind power provided 98% of Scotland's energy output in 2018. In 2019, Scotland used 90.1% of its power needs from renewable sources. Although the aim was 100%, Scotland's renewable energy production fell slightly to 97.4%. Wind power accounts for the majority of renewable energy generation (Hope, 2022).

Sweden

The Swedish government pledged in 2015 to phase out fossil fuels from the country's electrical generation by 2040. Sweden has continued to invest in solar, wind, energy storage, smart grids, and sustainable transportation since then. Sweden aspires to be the world's first fossil-fuel-free country. According to the country's official website, hydropower (45%) and nuclear (30%) power generate around 75% of Sweden's electricity. The nation now operates three nuclear stations with six nuclear reactors. Wind power accounts for 17% of total energy output, while combined heat and power (CHP) facilities account for 8% (Hope, 2022).

1.8. States that Rely on R.E.S. in Practice

The disadvantages of RES have already been presented in the current thesis. Their unstable energy generation, which is weather dependent, makes it extremely difficult for a country to become independent of fossil fuels. While more stable kinds of RES, such as geothermal and hydro, may provide more assurance, they are not always adequate. Even if numerous nations have installed a substantial number of RES systems, the foregoing drawbacks, as well as those related to space availability, make it difficult to transition away from fossil fuels. The cases of California, Austria, and Ireland, which are pioneers in RES concerns, will be analyzed briefly below.

1.8.1 The Case of California

Even when California's RES installation record was broken, natural gas power plants continued to operate. This is due to a difficult time of day: when the sun sets and solar farms cease production. California must rapidly and seamlessly replace that power with other sources such as hydropower and natural gas. In California, spring is an excellent time of year for renewable energy. As the days lengthen, so does the need for solar energy (Sommer, 2022). Wind and hydropower are humming away, and the mild temperatures mean that air conditioners aren't turned up, thus electricity usage remains low. On April 30th, grid operators at the California Independent System Operator (ISO), which serves around 80% of the state, had enough electricity from solar, wind, geothermal, and small hydropower dams to meet all demand in their area for approximately an hour. Because more power was produced than was needed at the time, some were exported to other Western nations (Sommer, 2022).

Nonetheless, at the time the record was broken, natural gas power plants generated around 10% of the electricity on the California system, including power exported out of state. This is due to the fact that such power plants are still critical to keeping the lights on later in the day. When the sun sets, solar power quickly evaporates from the system, forcing grid controllers to ramp up other sources of electricity, so that the entire system does not fail, supply and demand must be properly managed (Sommer, 2022).

California often utilizes hydropower, imports from other states, and natural gas power facilities to replace sunlight at sunset. However, most big natural gas plants are gigantic industrial complexes that are not meant to be turned on rapidly. Many take 4 to 8 hours to turn on, so they must be running during the day to be used at nightfall (Sommer, 2022).

This implies that even though there is lots of solar power available during the day, natural gas generation remains a component of the energy mix. In fact, solar farms are often instructed to shut down because there is just too much energy on the grid. California is attempting to store excess renewable energy created throughout the day so that it may be used later in the evening. Large battery installations are springing up across the state, and energy storage has risen 20-fold in California in the last two and half years.

Still, batteries provide just a small proportion of the electricity required when the sun goes down, at most a few percent. So, despite the state's aggressive climate change targets, the natural gas sector isn't planning to leave anytime soon (Sommer, 2022).

1.8.2 The Case of Iceland

Iceland ranks among the top nations in terms of renewable power output per capita. In 2020, over 100% of the power generated in the nation was generated from renewable sources, with hydropower accounting for 68.8% and geothermal power accounting for 31.2% [2]. Over 80% of Iceland's total energy use is renewable. Iceland's reliance on renewable energy sources is set to grow further, as the country's Climate Action Plan [4] addresses the low percentage of renewables in the transportation sector, among other things, by supporting the purchase and usage of electric automobiles and other green power vehicles. Iceland has used hydro and geothermal energy for decades, and various wind farm ideas are being considered (Tverijonaite et. al., 2022).

However, because Renewable Energy Infrastructure (REI) has limited geographical flexibility, renewable energy resources must be exploited where they are accessible. In the context of

Iceland, such resources are mostly available in relatively unspoiled natural regions that are becoming increasingly valuable for tourists and recreation, potentially leading to resource competition. Since 2010, the tourism industry has been the greatest contributor to the Icelandic economy in terms of export income and regional growth, with nature and scenery drawing the most tourists. High-quality natural areas are an important resource for the tourism industry. As a result, Iceland is a fantastic case study for studying the impacts of REI on nature-based tourism. In terms of renewable energy generation per capita, Iceland is among the top countries (Tverijonaite et. al., 2022).

1.8.3 The Case of Austria

Austria has so far achieved a high portion of RES, more specifically 78% by 2020, but neither the national strategy nor the corresponding law restricts the utilization of natural gas (or other fossil fuels). These fuels are mostly utilized in CHP plants to supplement the supply of electricity, as well as to produce heat for district heating systems and industrial steam delivery. In contrast to the scale of RES expansion, ensuring stable operation and supply security are key concerns that must be addressed in the next years. The large share of fluctuating renewable energy sources (VRES) such as hydro, wind power, and photovoltaics (PV) is predicted to cause enormous weather-related changes in electrical supply. System flexibility is required to adjust for generation and consumption disparities both in the near term (e.g., hourly swings in both demand and supply) and in the long run (i.e., seasonal differences driven by high demand during the winter period, and an oversupply during summer months) (Suna et al., 2022).

Following all the above, obtaining sole energy supply from RES systems remains a very challenging task. Energy storage systems, hydrogen, and the integration of multiple energy sources can increase system efficiency; nonetheless, traditional energy sources are still required for the time being. Exclusive usage of RES will become more viable as technology progresses and awareness about storage concerns grows. In the case of spatial constraints (for example, Ireland), technical breakthroughs, increased system efficiency, and merging storage units are likely to be viable options.

1.9 Theoretical Cost Analysis of an Offshore/Onshore RES Investment

The theoretical cost analysis of an offshore or onshore RES investment is a complex and multifaceted endeavor that requires careful consideration of numerous factors, including initial capital expenditures, operational and maintenance costs, grid connection fees, and economic incentives or subsidies. This analysis plays a crucial role in determining the financial viability and attractiveness of potential RES projects. As the global energy landscape shifts towards cleaner and more sustainable energy sources, understanding the cost dynamics of offshore and onshore RES investments becomes imperative for investors, policymakers, and stakeholders. At the outset, the capital expenditures associated with offshore and onshore RES projects represent a significant portion of the total investment cost. For offshore wind farms, these costs typically encompass the procurement and installation of wind turbines, the construction of subsea foundations and support structures, and the laying of undersea cables for power transmission. The harsh marine environment necessitates specialized equipment and technology, which can drive up costs. Onshore wind farms, while generally less expensive to construct, still require substantial investments in land acquisition, turbine procurement, and grid connection infrastructure. Solar photovoltaic (PV) installations, whether offshore or onshore, involve similar considerations, with the added complexity of selecting appropriate sites with optimal sunlight exposure (Hevia-Koch & Jacobsen, 2019).

Additionally, operational and maintenance costs constitute a critical component of the cost structure for both offshore and onshore RES projects. Offshore installations, particularly those located far from the coast, face unique challenges such as harsh weather conditions, corrosion, and accessibility issues, which can lead to increased maintenance expenses. Regular inspections, repairs, and component replacements are essential to ensure the continuous operation and longevity of the infrastructure. Onshore RES projects, while less susceptible to severe weather, also require ongoing maintenance to optimize performance and address technical issues that may arise. The implementation of advanced monitoring and predictive maintenance technologies can help mitigate these costs, but they represent additional financial consideration (Laura & Vicente, 2014).

Grid connection costs are another significant factor in the theoretical cost analysis of RES investments. The process of connecting a RES project to the electrical grid involves complex technical and regulatory considerations. Offshore projects may require extensive undersea cabling and substations to facilitate the transmission of electricity to the mainland grid. These costs can vary depending on the distance from the shore, the capacity of the project, and the existing grid infrastructure. Onshore projects may benefit from proximity to existing transmission lines, reducing the need for extensive grid upgrades. However, both types of projects must comply with grid connection standards and regulations, which can influence overall costs (Herding et al., 2021).

Economic incentives and subsidies play a pivotal role in shaping the cost dynamics of RES investments. Many governments offer financial incentives, such as feed-in tariffs, tax credits, and grants, to encourage the development of renewable energy projects. These incentives can significantly offset the initial capital expenditure and operational costs, enhancing the financial attractiveness of RES investments. For example, feed-in tariffs provide a guaranteed payment for electricity generated from renewable sources, while investment tax credits can reduce the tax liability for project developers. However, the availability and magnitude of these incentives can vary significantly between jurisdictions and are subject to policy changes, adding a layer of uncertainty to the cost analysis. Beyond immediate financial considerations, RES investments offer a range of economic and environmental benefits that should be incorporated into the cost analysis. The deployment of renewable energy projects can stimulate local economies by creating jobs, fostering innovation, and attracting ancillary industries. Additionally, the environmental advantages of RES investments, such as reduced greenhouse gas emissions and decreased reliance on fossil fuels, contribute to broader societal benefits. These positive externalities, while not directly quantifiable in monetary terms, can enhance the overall value proposition of RES projects and justify the initial investment (Herding et al., 2021).

Risk assessment is an integral part of the theoretical cost analysis for RES investments. Factors such as fluctuating energy prices, technological advancements, regulatory changes, and environmental impacts must be considered when evaluating the potential risks associated with a project. Offshore projects may face additional risks, such as maritime disputes and potential impacts on marine ecosystems, which necessitate comprehensive environmental assessments and stakeholder engagement. Onshore projects, meanwhile, may encounter challenges related to land use, community opposition, and potential impacts on local ecosystems. Effective risk management strategies, including diversifying the project portfolio and securing long-term power purchase agreements, can mitigate these risks and enhance project viability (Hevia-Koch & Jacobsen, 2019).

The integration of innovative technologies and approaches can further influence the cost analysis of RES investments. For instance, advancements in wind turbine design, solar panel efficiency, and energy storage solutions can improve the performance and cost-effectiveness of RES projects. The adoption of smart grid technologies and digitalization can enhance grid integration and enable more efficient energy management. Additionally, hybrid RES projects that combine multiple energy sources, such as wind and solar, can optimize energy production and reduce costs associated with intermittency (Laura & Vicente, 2014).

Chapter 2: The State of the Market

2.1. Current State of the Energy Market

The utilization of more renewable energy sources is now a strategic imperative for many countries, especially in the European Union, as a result of the Russian invasion of Ukraine, which has increased the urgency to accelerate clean energy transitions in order to reduce the dependence on imported fossil fuels from Russia.

The deployment of solar, wind and other renewable energy sources has been delayed due to the global energy crisis, and some EU member states have stated efforts to speed up this process. Solar and wind power have the greatest potential to reduce the EU's reliance on Russian energy by 2023.

The Russian-Ukrainian war and the global energy crisis have led energy markets to a new state of play, characterized by high raw material prices and even higher fossil fuel and electricity prices (World Economic Forum, 2022).

In 2022, solar energy was projected to account for 60% of the global increase in renewable energy capacity, pushing the total to over 300 gigawatts. This remarkable growth underscores the pivotal role that solar energy plays in the transition towards a sustainable and resilient energy future. The surge in solar capacity reflects several underlying trends, including technological advancements, cost reductions, supportive policy frameworks, and increased demand for clean energy. As countries strive to meet ambitious climate targets and reduce their carbon footprints, solar energy has emerged as a cornerstone of global renewable energy strategies. The anticipated growth in solar energy capacity in 2022 can be attributed to several factors that have contributed to its widespread adoption. One of the most significant drivers has been the dramatic decline in the cost of solar photovoltaic (PV) technology over the past decade. Advances in manufacturing processes, economies of scale, and improvements in solar panel efficiency have collectively reduced the cost of solar installations, making them increasingly competitive with traditional fossil fuels. In many regions, solar energy has achieved grid parity, meaning it can be generated at a cost equal to or lower than that of conventional energy sources. This economic viability has spurred investments in solar projects, leading to rapid capacity expansion (Maka & Alabid, 2022).

Policy frameworks and government incentives have also played a crucial role in accelerating the growth of solar energy. Many countries have implemented policies to support renewable energy deployment, including feed-in tariffs, tax credits, and renewable portfolio standards. These incentives provide financial benefits to solar project developers and encourage the integration of solar energy into national grids. Additionally, international agreements such as the Paris Agreement have prompted nations to commit to reducing greenhouse gas emissions, further driving the adoption of clean energy technologies. As a result, solar energy has become a key component of national energy strategies, with governments recognizing its potential to deliver both environmental and economic benefits (Kabir et al., 2018).

The projected increase in solar capacity also reflects the growing demand for clean energy from consumers and businesses. As awareness of climate change and environmental sustainability increases, there is a heightened demand for energy sources that have a minimal environmental impact. Solar energy, with zero emissions during operation, aligns perfectly with these demands. Moreover, businesses are increasingly seeking to enhance their sustainability credentials by adopting solar energy solutions to power their operations. This shift is further driven by corporate social responsibility goals and consumer preferences for environmentally friendly products and services. As such, solar energy is becoming an integral part of the business landscape, with companies investing in solar installations to meet their energy needs and sustainability objectives (Maka & Alabid, 2022).

Since the start of 2021, the cost of several raw commodities and freight has been on the rise. PV-grade polysilicon prices more than tripled by March 2022, while costs for steel, copper and aluminum soared by 50%, 70%, and roughly fivefold, respectively. As manufacturers pass on increasing equipment costs, the long-term trend of falling costs has reversed, as seen by the rising pricing of wind turbines and PV modules (International Energy Agency, 2022).

The expected cost of overall investment in new utility-scale photovoltaic (PV) and onshore wind projects in 2022 was estimated to be 15% to 25% higher than it was in 2020. The primary factor contributing to the increase in costs for onshore wind projects is the rise in freight expenses. For solar PV, the cost increase is more evenly attributed to several factors, including higher freight costs, rising polysilicon prices, and increased metal prices, as noted by the International Energy Agency (2022).

Since the last quarter of 2021, the price of fossil fuels and electricity has risen at a much faster pace than the increase in renewable energy costs, even though these renewable costs are significant in absolute terms. In many parts of the world, particularly in regions where natural gas is the marginal technology that determines the final hourly or daily pricing in wholesale electricity markets, power prices have reached unprecedented levels. This trend is especially prevalent in the European Union, where wholesale electricity prices in countries such as Germany, France, Italy, and Spain have increased by more than sixfold compared to the average values from 2016 to 2020 (Australian Energy Regulator, 2023).

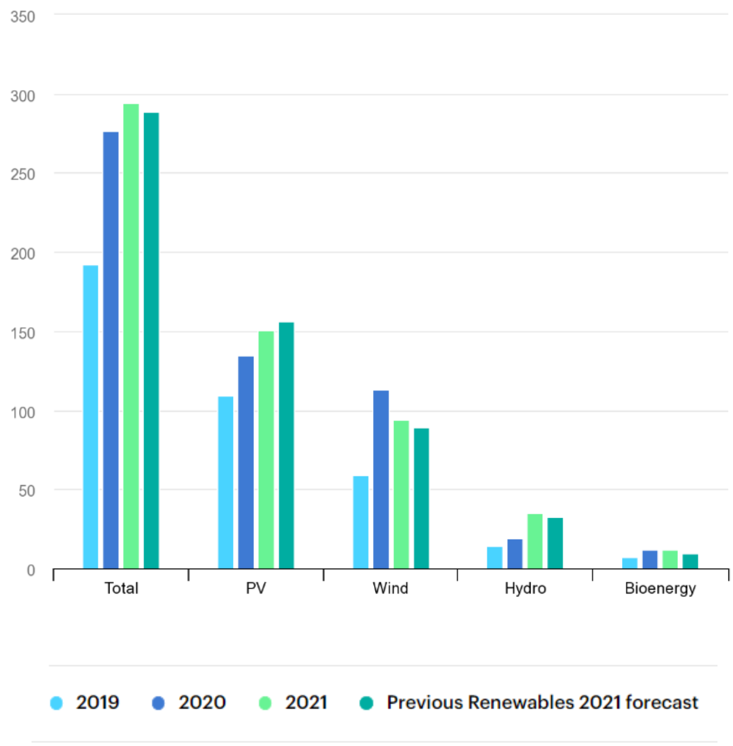


Diagram 6: Renewable net capacity additions, 2019-2021 (IEA, 2022a)

In the diagram above is depicted the renewable net capacity additions in MWh (PV, wind, hydro, bioenergy) and their total installed capacity for the years 2019-2021. According to the diagram, solar is the dominant force in the market, followed by wind power, hydropower on a smaller scale, and bioenergy/biomass in last position. Except for PV, installations in wind, hydro, and bioenergy surpassed the 2021 installations forecast of the IEA (IEA, 2022a).

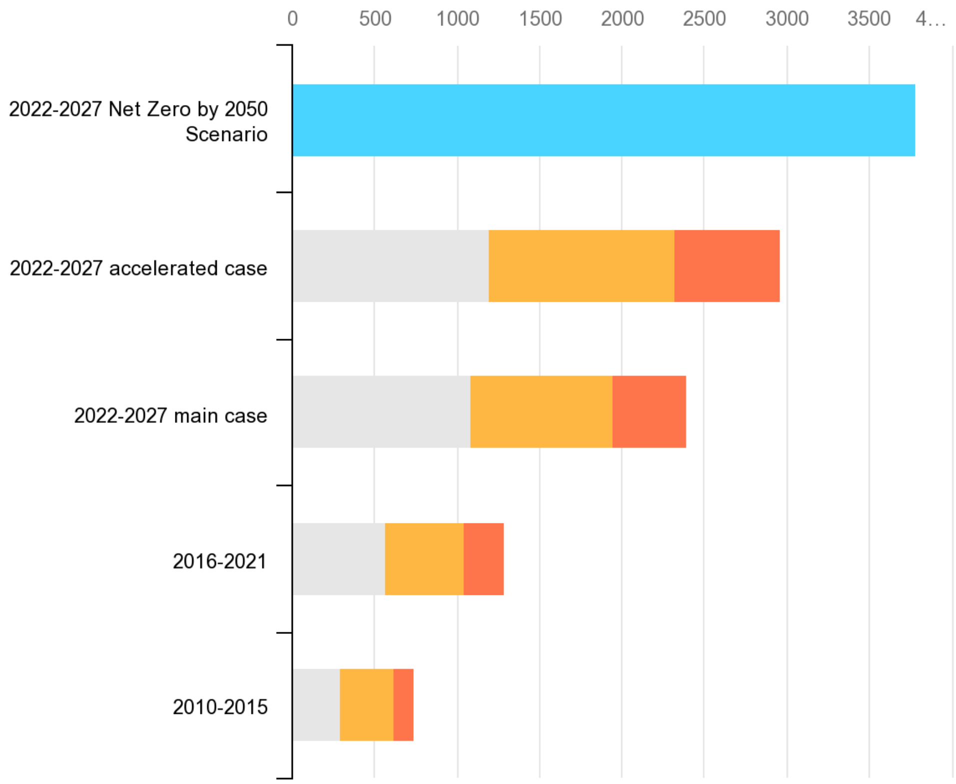
Faster adoption of dispatchable renewable power production is being held back by higher investment costs than for wind and solar PV, a lack of governmental support, and a lack of proper acknowledgement of the flexibility value of hydropower, bioenergy, CSP, geothermal, and ocean technologies. By 2027, solar PV will have more installed electricity capacity than coal, natural gas, and hydropower combined (IEA, 2022a).

With the commissioning of about 45 GW in 2013, hydropower additions peaked annually, but deployment over the predicted period is unpredictable, ranging from 17 GW to 33 GW depending on the commissioning deadlines of sizable reservoir projects in China, India, and Turkey. Our main prediction of 141 GW during the years 2022 to 2027, which is a little less than the deployment accomplished in the previous five years, is based on these three sizable markets. The upside potential for hydropower is still just 40 GW, according to the expedited scenario, because of the lengthy environmental approval and construction processes (IEA, 2022a).

Due to continued legislative support at the provincial level for waste-to-energy projects, China now accounts for over 60% of the increase of the world's bioenergy capacity. Brazil has instituted auctions, while Turkey uses feed-in tariffs to encourage the spread of bioenergy outside of China. The huge resource potential of geothermal energy is hindered by the absence of legislation to handle the hazards associated with pre-development and resource exploration, with an expected increase of fewer than 6 GW over the years 2022–2027 mostly focused on Africa and Southeast Asia. For CSP, the rise is almost 5 GW throughout the projection period because of relatively high investment costs and insufficient assistance for the development of storage capacity (IEA, 2022a).

In any event, the total number of renewable energy installations and their proportion to the global energy mix is sharply rising. The expansion of RES is being driven in the European Union by the quick execution of previously declared, high policy objectives and already awarded auctions, together with ongoing subsidies for distributed solar PV. Numerous nations in the European Union declared intentions to speed up the deployment of renewable energy sources in reaction to Russia's invasion of Ukraine in an effort to lessen their reliance on Russian natural gas supplies. Germany, the Netherlands, and Portugal either upped their goals for renewable energy or pushed back their original deadlines (IEA, 2022b).

The projection for most advanced economies is based on the high goals and policy incentives of these nations, but there are still difficulties with execution, particularly when it comes to obtaining permits and expanding grid infrastructure. The main obstacles to a more rapid spread of renewable energy in emerging economies continue to be policy and regulatory uncertainty, as well as difficulties with implementation. Finally, the IEA main-case scenario is that insufficient grid infrastructure and a lack of cheap finance in underdeveloped nations slow down the commissioning of numerous projects more quickly (IEA, 2022b).



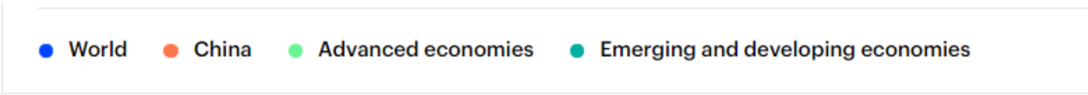


Diagram 7: Renewable capacity growth in the main and accelerated cases, 2010-2027 (IEA, 2022c)

In the previous five years compared to 2010–2015, the European Union, the second-largest growing market after China, has had steady growth in renewable capacity, but its rate of increase is anticipated to more than double between 2022 and 2027. Prior to Russia's invasion of Ukraine, several EU member states had already introduced aggressive targets and measures to speed up the deployment of renewable energy. However, since then, the European Union has proposed even more aggressive goals under the Repower EU package to end imports of Russian fossil fuels by 2027, renewable capacity additions are expected to hit new highs, with solar PV and wind to be taking the lead (IEA, 2022b).

About 45% of the gas that the European Union buys for use in industry, residences, and energy generation comes from Russia. International Energy Agency estimates that between 100 TWh and 200 TWh of the European Union's natural gas-based energy is supplied by Russia when taking into account country-level supply dependencies (IEA, 2022b).

Expanding wind and solar PV power generation is still one of the best solutions to minimize natural gas use in the EU electrical industry. Utility-scale renewable energy continues to be more cost-competitive with fossil fuel-based alternatives because of steep power rates brought on by record-high natural gas prices. In reality, the average contract costs for long-term wind and solar PV projects were 77% less than wholesale market prices from December 2021 to October 2022. Distributed solar PV applications are also becoming more popular since they can lower industrial and residential customers' power costs, which have increased dramatically since 2022's first day (IEA, 2022b).

On the other hand, IEA predictions show a gradual increase in renewable power output up to 180 TWh from 2021–2023, which is nearly equivalent to the peak amount of gas-fired generation dependent on Russia. With current deployment patterns, the expansion of wind and solar PV in the European Union has the potential to dramatically lessen the reliance on Russian gas consumption for power, and their competitiveness won't be affected by the rising costs of solar PV and wind energy installations. Their main forecast on renewable electricity indicates an increase by 2027 in onshore wind additions to 109 GWh, from just 74 GWh in 2021 (IEA, 2022b).

To address the energy problem, China (with the 14th five-year plan and the market reforms), Europe (with the REPowerEU plan), the US (Inflation Reduction Act-IRA), and India are moving forward with new policies, regulatory changes, and market reforms more swiftly than anticipated. However, policies on energy efficiency measures restricting demand as well as the phase-out or phase-down plans for coal and nuclear energy in certain member states will also affect the contribution of variable renewables (IEA, 2022b).

2.1.1. Energy Market Players

As for the market players, in 2021, China continued to hold the lion's share of the deployment market, contributing 46% of the growth in renewable energy capacity globally. The European Union, which surpassed the all-time record in 2011, was the second-largest market outside of China in terms of added capacity. In India, record highs for the growth of renewable capacity are anticipated in 2022 and 2023 as a result of the commissioning of stalled projects from earlier competitive auctions, particularly for solar PV (IEA, 2022a).

Over 2023, it is anticipated that yearly capacity increases in the United States would decelerate. Two major obstacles must be overcome in the short term to achieve quicker growth in the wind and solar PV industries. First, the project pipeline for onshore wind initiatives has shrunk due to the absence of long-term visibility on potential incentive plans, decreasing their economic allure (IEA, 2022a).

Second, prospective trade restrictions on solar PV against Southeast Asian nations in addition to China are decreasing the short-term supply of solar modules and driving up costs, which were already high owing to high commodity prices. There are just a few manufacturers outside of Viet Nam, Indonesia, Cambodia, Malaysia, and China that can supply PV materials to the US market, and current module manufacturing in the US can only match less than 20% of the yearly demand from last year (IEA, 2022a).

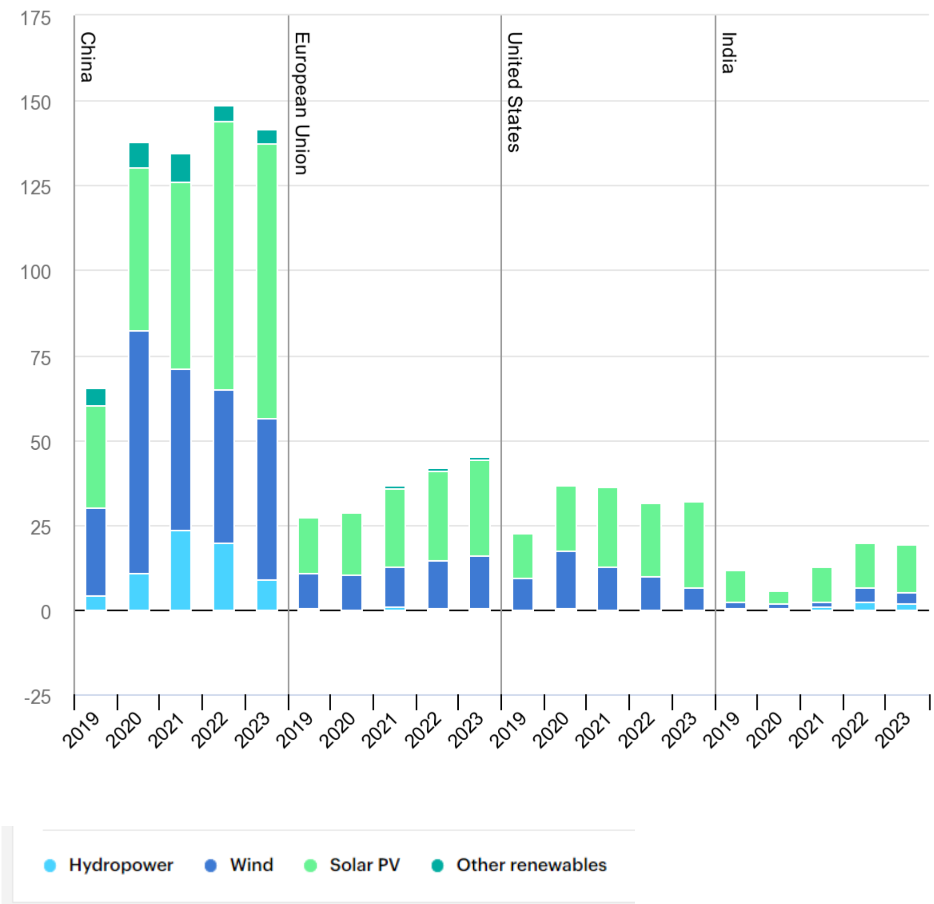


Diagram 8: Capacity additions in hydropower, wind, solar PV and other renewables in China, EU, US, India (IEA, 2022d).

Even if they are smaller in absolute terms, other parts of the world, particularly Latin America, the Middle East, and North Africa, are seeing tremendous growth. Brazil's net metering incentives start to diminish in 2023, which will cause a modest decrease in capacity increases that year (IEA, 2022d).

Utility-scale wind and PV capacity additions in the Association of South-East Asian Nations (ASEAN) may fluctuate because of the various commissioning dates of competitive auctions and bilateral contracts. In comparison to 2020, capacity additions in Viet Nam have been drastically reduced due to the country's policy boom and bust cycles. Following the onshore wind and solar PV booms in 2020 and 2021, Viet Nam's additions to renewable capacity are predicted to fall from 17 GW for 2020–2021 to barely 6 GW for 2022–2023 (IEA, 2022d).

Annual capacity additions are driven by the demand for solar PV in the Middle East and Africa. Solar PV projects in the Middle East are economically appealing due to declining system costs, strong resource potential, favorable financing circumstances, and economies of scale. Government guarantees or funding from development banks for utility-scale solar PV, wind, and hydropower projects are promoting expansion in sub-Saharan Africa (IEA, 2022d).

2.1.2. Most Frequent Misconceptions about RES

Renewable energy systems have proven not only feasible but increasingly profitable as well. Despite this progress, misunderstandings regarding renewable energy technologies persist within both technical and policy communities. These misunderstandings often revolve around the feasibility, dependability, and economic viability of renewable energy systems, leading to ongoing debates about their potential to meet energy needs while addressing significant challenges. A key aspect of this debate is the phenomenon known as NIMBYism ("Not In My Backyard"), which explores how communities interact with renewable energy facilities and research initiatives. This essay seeks to clarify some of the most prevalent misconceptions about Renewable Energy Sources and Technologies (RES & RET), addressing these myths with evidence-based insights.

One common misconception is that the transition to renewable energy will lead to increased residential energy costs. In reality, the opposite is true. As government investments in renewable energy grow, the cost of clean energy becomes increasingly competitive with fossil fuels. When renewable energy sources become less expensive than traditional energy options, their prices begin to fall rapidly. Already, wind and solar power have emerged as the least expensive sources of electricity. This transition has the potential to generate global savings of up to 12 trillion dollars. The initial perception of high costs fails to account for the long-term economic benefits and cost reductions associated with widespread adoption of renewable energy technologies.

Another frequently cited myth is that renewable energy sources require massive subsidies to be viable. However, it is fossil fuels that receive the bulk of governmental financial support. In recent years, governments have spent nearly 70 billion dollars on fossil fuel subsidies, which represents more than three times the amount spent on clean energy investments. This financial imbalance highlights the entrenched support for fossil fuels, despite their environmental impact. In the United Kingdom, for example, new wind turbine installations no longer require subsidies, underscoring the growing cost competitiveness of renewable energy technologies without the need for excessive governmental support.

A third myth concerns the impact of renewable energy on employment, with some suggesting that a shift to renewable energy will result in higher unemployment rates. In fact, transitioning from fossil fuels to renewable energy is projected to generate a net increase in employment opportunities. While an estimated 3 million jobs may be lost in fossil fuel industries, the renewable energy sector is expected to create approximately 12 million new jobs. These new positions span a variety of roles, from engineering and manufacturing to maintenance and installation. To facilitate this transition, governments must invest in retraining programs and education initiatives that equip workers with the skills needed to thrive in the burgeoning green economy.

Despite their growing prominence, renewable energy technologies are not universally embraced by the energy sector. Contrary to the myth that the energy sector fully supports renewables as the future of the market, conventional energy sectors wield significant communication power to protect their interests. These sectors often downplay the potential of renewable energy and may even incite public hostility toward it. Research indicates that vested interests frequently disseminate misleading information about renewable energy through media channels, shaping public perception and policy decisions in favor of traditional energy sources.

The notion that mass media actively promote the use and benefits of renewable energy sources to the average consumer is also a misconception. Renewable energy receives limited attention in mainstream media. Most programs aimed at raising awareness or addressing public concerns tend to be one-way informational provisions rather than engaging, interactive dialogues. To effectively inform public opinion, it is essential to engage in proactive discussions, briefings, and collaborations with opinion leaders and media outlets about the advantages and successes of renewable energy. A reactive strategy should be reserved for exceptional circumstances where myths about renewable energy are hotly contested on a global scale, thereby preventing the propagation of misconceptions and misinformation.

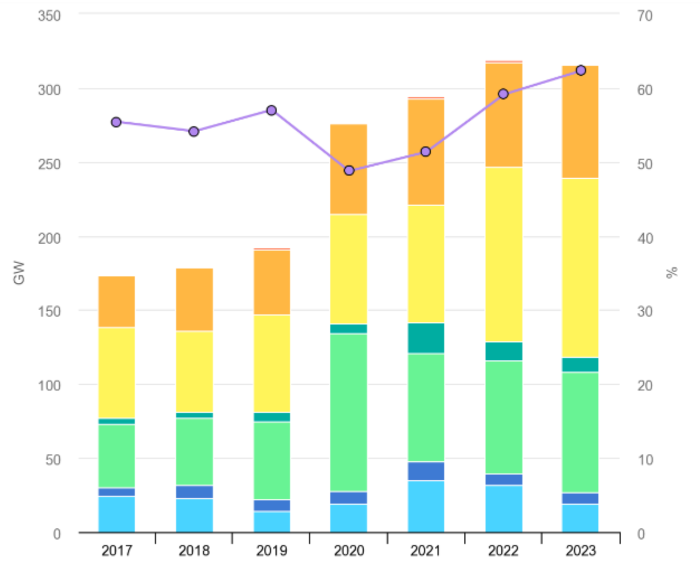


Diagram 9: Renewable net capacity additions, 2019-2021 (IEA, 2022a).

The diagram illustrates the annual increase in global renewable energy capacity from 2017 to 2023, measured in gigawatts (GW). Each stacked bar represents the total capacity added each year and is color-coded to show the contributions of different renewable energy sources. While the colors are not explicitly labeled, they typically represent key energy types such as solar, wind, hydro, and bioenergy. The data reveals a clear upward trend, with significant growth in renewable capacity additions, particularly in 2021 and 2022. The purple line graph overlay indicates the percentage growth of renewable energy capacity relative to previous years, showing a general upward trajectory, though with some fluctuations. Notably, the graph demonstrates that solar energy is a major contributor to the increase, particularly from 2020 onward, reflecting its growing importance in the global energy mix. This growth trend underscores the accelerating shift towards renewable energy sources as part of global efforts to reduce reliance on fossil fuels and combat climate change.

In conclusion, the misconceptions surrounding renewable energy sources and technologies hinder their adoption and integration into mainstream energy systems. By addressing these myths and providing clear, evidence-based information, policymakers, industry leaders, and media outlets can foster a more informed public discourse about the benefits and viability of renewable energy. Understanding that renewable energy systems are economically viable, job-creating, and environmentally sustainable is crucial for driving the transition toward a cleaner and more resilient energy future. As the global community continues to face pressing environmental challenges, the adoption of renewable energy technologies represents a critical step toward achieving sustainable development and energy security.

2.2 Forecasts Regarding the Ability of RES to Cover Today's Market Energy Needs

Many individuals are attempting to forecast which power production technology will predominate by 2050. The only thing that is definite is that a variety of technologies with specialized applications that address certain demands in particular situations will replace the current dominating technology in the mix used to generate power.

Promoting low-carbon energy technology is a top priority for governments all around the world and is also seen to be the most effective way to ensure a dependable, sustainable, and efficient future energy system. Geopolitical and economic issues make estimates for renewable power beyond 2023 more questionable. The lowest first-quarter auction volumes globally in 2022 since 2016 were caused by higher wind and solar PV investment costs brought on by rising commodity prices following Russia's invasion and permission delays. Additionally, especially in the European Union, contract negotiations for corporate power purchase agreements (PPA) have become more difficult due to the volatility in the electricity markets brought on by sharply higher gas prices. At the same time, rising interest rates are making it more difficult for developers of renewable energy sources (Jaganmohan, 2021).

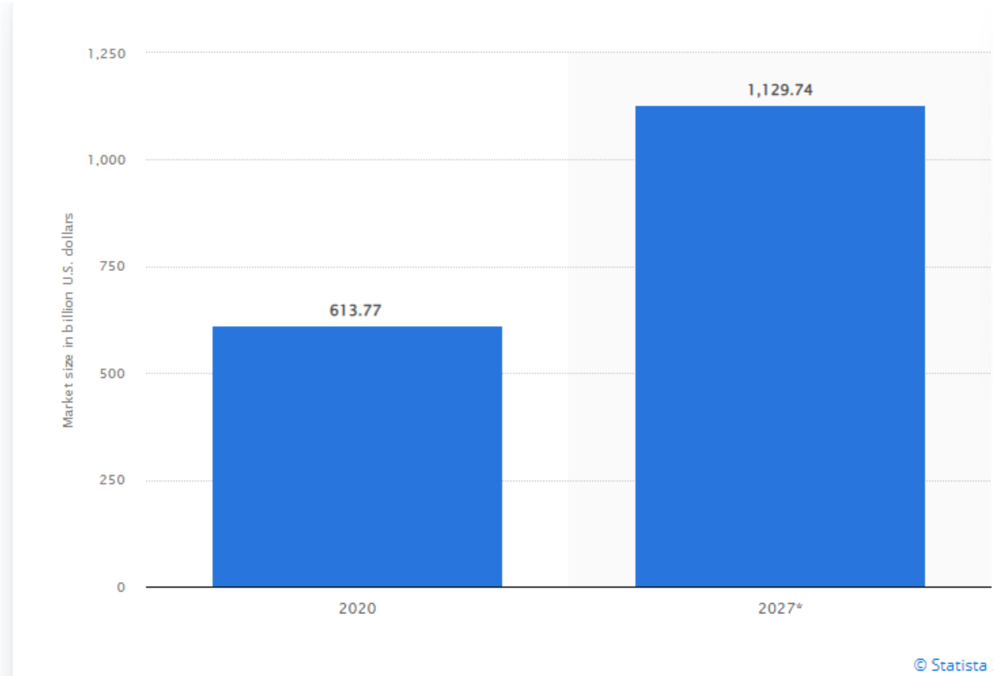


Diagram 10: Renewable energy market size worldwide in 2021, with a forecast for 2022 to 2030 (Jaganmohan, 2021).

The diagram presents a bar chart comparing the global market size of renewable energy in 2020 with projections for 2027. In 2020, the renewable energy market was valued at approximately 613.77 billion U.S. dollars. By 2027, this market is projected to grow substantially, reaching an estimated value of 1,129.74 billion U.S. dollars. This indicates a nearly twofold increase over seven years, underscoring the anticipated rapid expansion and investment in the renewable energy sector. The significant growth reflects increasing global efforts to transition to sustainable energy sources, driven by technological advancements, policy incentives, and heightened awareness of climate change. The chart highlights the pivotal role renewable energy is expected to play in the global energy landscape, showcasing its potential to dominate future energy investments.

As depicted in the diagram above, the energy market by 2027 will have almost doubled along with the need to cover its energy requirements. This indicates that growing and diversifying the energy mix is required to ensure energy stability. In order to prevent energy crises like the one that happened worldwide during the Russian-Ukrainian war, it would be beneficial if RES made up the majority of the mix (Jaganmohan, 2021).

A study-case in the Italian electricity market indicates that the cost of wholesale power decreases as non-programmable RES electricity generation rises. The expense of the RES assistance programs, however, has been directly carried through to the final power bill, suggesting a rise in the retail electricity price and an economic shift from the final energy users to the renewable energy producers. This has raised widespread concerns about the redistributive impact of RES assistance schemes (Rundle-Thiele et al., 2008).

More aggressive expansion strategies in important markets, partially in reaction to the present energy crisis, are driving the rise of renewable energy. Two causes are principally responsible for the 85% increase in expansion rate over the previous five years. To begin with, the high costs of electricity and fossil fuels brought on by the global energy crisis have made renewable power technologies much more economically appealing. Second, the Russian invasion of Ukraine has made fossil fuel importers, particularly in Europe, value the advantages of renewable energy's contribution to energy security more and more (Jaganmohan, 2021).

RES contribution in the energy market can be characterized as multifaceted, as greater RES generation can decrease energy reliance, lower the energy deficit, lessen the impact of sudden and abrupt changes in the price of fossil fuels on economic activity, and lastly encourage green growth and employment. In the upcoming future, the market for renewable energy is projected to keep expanding, reaching 1.1 trillion dollars by 2027. Urban development, rapid population growth, environmental concerns related to fossil fuels, and economic development in growing economies are all significant drivers of the anticipated market expansion (Jaganmohan, 2021).

2.3. Criteria an Investor Should Take Under Consideration Before Proceeding in RES Market

The utilization of renewable energy can significantly enhance economic output, improve the quality of life, and provide substantial environmental benefits. However, before proceeding with an investment in renewable energy sources (RES), several crucial factors must be carefully considered by prospective investors. This section examines the attractiveness of such investments, analyzing them in the context of foreign direct investment (FDI) and highlighting key criteria that influence decision-making.

A primary factor influencing investment decisions is the state-investor relationship. This relationship encompasses the entire tax system of the host country, as tax concessions are often regarded as the most significant factor in attracting FDIs. The tax obligations imposed on investors may cover various aspects, including the installation of energy plants, corporate profits, the final product (in this case, the production per kilowatt-hour), storage facilities, transportation, and distribution systems. A favorable tax environment can greatly enhance the attractiveness of a country for renewable energy investments by reducing financial burdens and providing incentives for development (IEA, 2022b).

The existing legal framework in the host country also plays a critical role, serving as a multifaceted safety net for investors, consumers, and the nation itself. The national legal system is pivotal in regulating the relationship between the state and investors, as well as interactions between investors and local market competitors, the workforce, and the end consumers. Despite the potential of RES, a stable regulatory environment offering long-term income certainty and streamlined licensing processes is essential to accelerating the growth of renewable capacity. Regulatory stability ensures that investors have confidence in the consistency and predictability of the legal and business environment, which is crucial for long-term planning and investment (IEA, 2022b).

Human capital availability is another important consideration for investors in renewable energy. The skills and knowledge possessed by the local workforce enable them to maximize their potential as productive members of society. A well-educated and skilled workforce is essential for the successful implementation and operation of renewable energy projects, as it ensures that there is a sufficient pool of talent to support various stages of project development, from design and construction to maintenance and operation. Political and economic stability are also of paramount importance when considering investments in renewable energy. Stable political environments, favorable diplomatic relations with neighboring nations, adherence to international trade treaties, low inflation rates, low unemployment rates, and currency stability all contribute to a conducive investment climate. These factors reduce the risk of disruptions and provide a secure environment for the operation and growth of renewable energy projects, attracting investors seeking reliable returns on their investments (Lucas et al., 2021).

Foreign direct investments are a vital component of a country's economic growth and are directly linked to its inflation rates. As noted by Nobel laureate Milton Friedman, "inflation is taxation without legislation." Therefore, a stable economic environment that fosters foreign investments can lead to reduced inflationary pressures and enhance economic growth. Investors are more likely to commit resources to countries that offer a stable and predictable economic climate, thus fostering sustainable development in the renewable energy sector. Market considerations, such as market size, availability of resources, the percentage of RES in the country’s energy mix, globalization, and cost factors, also play a crucial role in investment decisions. A large market with high demand and an established energy infrastructure provides opportunities for investors to achieve economies of scale and maximize returns. Additionally, understanding the local market dynamics, including supply and demand fluctuations and energy pricing, is essential for making informed investment choices (Virlics, 2013).

The infrastructure for energy transportation and distribution is a critical factor that investors must consider. The host country's energy network must be capable of efficiently distributing electricity generated by RES to households and businesses. An established and properly functioning grid, along with adequate storage capacity, is vital for ensuring that renewable energy can be seamlessly integrated into the national energy system and distributed to end users. Openness to trade is positively correlated with FDI, particularly in the manufacturing sector. Countries that offer an open trade policy environment are more likely to attract efficiency-seeking investments in renewable energy manufacturing. This openness facilitates the exchange of goods, services, and technologies, fostering innovation and growth within the renewable energy sector (Virlics, 2013).

Geographical conditions, including geographic sustainability and meteorological or climatological assessments, are critical criteria for RES investments. The availability of natural resources, such as sunlight, wind, and water, as well as the geographical characteristics of onshore and offshore sites, significantly influence the feasibility and profitability of renewable energy projects. Investors must assess these factors to determine the potential for energy generation and the suitability of locations for project development. The ease of initiating a business is also an important consideration. The bureaucratic requirements and regulatory steps necessary to establish and operate a renewable energy project can significantly impact the investment decision-making process. Streamlined processes and clear guidelines for project initiation can enhance the attractiveness of a country for renewable energy investments (Meike et al., 2015).

Tax incentives, such as the Production Tax Credit (PTC), play a significant role in encouraging renewable energy investments. The PTC allows developers and owners of wind energy installations to claim a federal income tax credit for each kilowatt-hour of power generated and sold to an unaffiliated party. These tax credits reduce the financial burden on investors, making projects more financially viable and attractive. The availability of tax credits and other financial incentives can transform projects with negative net present value (NPV) into profitable ventures, thus encouraging investment in renewable energy. Lastly, the availability of raw materials is a crucial consideration in the energy markets, particularly for renewables. The presence of natural resources, such as sunlight, wind, and suitable land or offshore sites, determines the potential for renewable energy generation. Investors must assess the availability of these resources to ensure that the chosen location can support sustainable and efficient energy production (Meike et al., 2015).

Competitive government-led auctions for wind and solar photovoltaic (PV) projects are expected to continue driving renewable energy growth through 2023, according to the International Energy Agency (IEA). Although auction volumes have declined in some regions, such as China and India, they have increased in the European Union and Latin America, highlighting the continued importance of auctions in the renewable energy sector. Public attitudes toward renewable energy also play a significant role in the adoption of these technologies. Low levels of knowledge and persistent misunderstandings about renewable energy can hinder its growth. Societal decisions are often based on the information available, making it essential to address misinformation and educate the public about the benefits and potential of renewable energy sources (Meike et al., 2015).

In conclusion, investors considering entering the renewable energy market must evaluate a wide range of criteria, including state-investor relations, legal frameworks, human resources, political and economic stability, market conditions, infrastructure, and geographic factors. These considerations, along with tax incentives, raw material availability, and public attitudes, are critical in determining the attractiveness and viability of renewable energy investments. By carefully assessing these factors, investors can make informed decisions that contribute to the growth of sustainable energy and the transition toward a cleaner and more resilient energy future.

2.4.: Choosing Between Onshore and Offshore Investments

Concerns about the environmental impact of traditional fossil fuels, along with rising populations, urbanization, and decreasing costs of green technologies, are driving the increasing adoption of renewable energy sources. The emphasis on energy security has also encouraged the use of distributed energy generation and renewable energy within electric power distribution systems. Despite higher costs due to elevated commodity and freight prices, the construction costs of solar PV and wind facilities are expected to remain higher than pre-pandemic levels throughout 2022 and 2023. However, these renewable technologies remain competitive, as the prices of natural gas and other fossil fuels have risen even more sharply.

Nevertheless, the wind sector is not expanding as rapidly as it could, primarily due to policy uncertainty and lengthy regulatory requirements. After a 32% decline in 2021, following a surge of installations in 2020, there is a projected moderate increase in the capacity of new onshore wind additions in the coming years. Despite this slower growth, China was anticipated to surpass Europe by the end of 2022, becoming the market leader with the most offshore wind capacity globally (IEA, 2022c).

Currently, two main types of floating renewable energy systems exist: floating photovoltaics and wind turbines. This chapter provides an analysis of the advantages and disadvantages of both onshore and offshore renewable energy systems, specifically focusing on photovoltaic plants and wind turbine installations (IEA, 2022c).

Floating photovoltaics are mounted on the water's surface using a floating system that stabilizes them and prevents rotation. These solar installations are connected to the electrical grid through specialized wiring and efficiently convert solar radiation into electricity. This innovative approach offers significant benefits without requiring land for installation (IEA, 2022c).

The decision between floating (offshore) and fixed (onshore) renewable energy systems is multifaceted, involving various advantages and disadvantages that investors must consider carefully. Each system offers unique benefits and poses specific challenges, particularly when comparing photovoltaic (PV) installations to wind turbine systems. A comprehensive understanding of these factors is essential for determining the most suitable approach for energy generation in any given context (Clò et al., 2015).

Floating renewable energy systems, particularly solar photovoltaics, present several compelling advantages. One of the primary benefits is the ease of construction, as these systems do not require extensive foundation placement or land acquisition. This simplification is unique to photovoltaics, as wind turbines necessitate a solid foundation and are typically situated near the shore. Additionally, the aquatic environment provides natural advantages, such as easy access to water, which facilitates the cleaning of solar installations when needed. The shading effect of floating solar panels can also contribute to reduced algae growth in the underlying water, which can be beneficial in maintaining water quality. Furthermore, the cooling effect of water on solar panels can enhance energy production efficiency by reducing overheating, leading to improved performance. Moreover, floating installations help reduce evaporation from water bodies, conserving energy and potentially benefiting water management. Unlike terrestrial installations, floating systems are not limited by land availability, offering flexibility in placement that can optimize space utilization (Fernández, 2024).

However, floating renewable energy systems also face significant challenges that must be addressed. Pollution from bird droppings is a common issue that can affect the efficiency and cleanliness of the installations. The stabilization of floating systems requires complex mooring and anchoring solutions, which vary depending on the water body's characteristics and can increase installation costs. Large-scale floating installations may impede sunlight penetration into aquatic ecosystems, potentially affecting biodiversity and disrupting marine habitats. Maintenance poses another challenge, as specialized equipment, such as boats and divers, is required to access and service the installations. Furthermore, offshore installations often have shorter equipment lifespans and present greater electrical safety concerns than onshore systems. Visual pollution is another consideration, as both onshore and offshore installations can impact the aesthetic value of natural landscapes. Lastly, solar energy production is limited to daylight hours, imposing daily and seasonal constraints on productivity, which can be a significant drawback in regions with limited sunlight exposure (Fernández, 2024).

On the other hand, fixed onshore renewable energy systems have distinct advantages that make them an attractive option for investors. Onshore systems benefit from a well-established history of successful application, with mature technologies and market-tested solutions that provide a high degree of reliability and predictability. This maturity attracts investor interest, as the perceived risks are lower and the potential returns more predictable. The installation process for onshore systems is generally straightforward, as they do not require specialized aquatic equipment, simplifying logistics and reducing costs. Onshore systems also tend to have longer equipment lifespans and offer enhanced electrical safety, which can lower operational risks. Additionally, maintenance activities for onshore installations are typically more straightforward and cost-effective, as access is easier and does not require specialized equipment (Fernández, 2024).

Despite these advantages, onshore renewable energy systems also present several disadvantages. Regular cleaning is necessary to maintain optimal performance, especially for solar panels, which can incur significant costs, particularly in remote locations without access to water resources. Similar to offshore systems, onshore solar installations are subject to daily and seasonal limitations on energy generation, as they rely on sunlight availability. Visual pollution is a concern, particularly in scenic landscapes where onshore installations may detract from the natural beauty and impact tourism or local aesthetics. The requirement for significant land areas for large-scale onshore installations can lead to land-use conflicts, as the competition for land resources may increase tensions with agricultural, residential, or conservation interests (Clò et al., 2015).

Countries with stable regulatory environments that offer long-term income certainty, efficient permitting processes, and strategies for timely grid expansion are experiencing the fastest growth in onshore wind installations. In China, annual offshore wind capacity additions are projected to decrease by more than 30% in 2022 compared to 2021 due to reduced expansion following the previous year's record growth and the end of subsidies. Nevertheless, government support in the European Union, the United States, and China is expected to drive a 50% increase in annual offshore wind deployments, reaching over 30 GW by 2027. Although there is potential for further growth, factors such as long lead times, ongoing auctions, and lease schedules may limit the speed of expansion. Consequently, the accelerated scenario forecasts a 20% increase in offshore wind capacity, with China accounting for a significant portion of this growth (Fernández, 2024).

Despite the promising potential of decentralized energy systems, existing technical limitations and outdated infrastructure may hinder their full adoption in many regions. Large-scale renewable energy projects have the potential to provide reliable electricity supply to remote communities and underdeveloped countries, where electricity access is often unstable and inadequate.

In the transition to a low-carbon economy, increasing the percentage of renewable energy (RE) in the global energy mix is critical. While the promise of onshore renewable energy resources is widely known, offshore renewable energy is still a relatively young sector that faces some distinct hurdles is to be noted that offshore wind turbines are more popular than the offshore PV systems. Generally, offshore renewable energy costs more than onshore renewable energy because of greater technology, installation, and maintenance expenses (Ram et al., 2018).

The cost of offshore renewable energy investment is determined by several factors, including technological complexity, installation, maintenance, and other related expenditures. Offshore wind turbines, for example, are more complicated, necessitating more advanced technology, greater installation costs, and more regular maintenance than onshore wind turbines. Furthermore, the cost of offshore renewable energy is impacted by distance from shore, as well as weather and ocean conditions. Onshore RE investment is often less expensive due to simpler technology, reduced installation costs, and more regular maintenance. Furthermore, weather and ocean conditions, as well as distance from shore, have less of an impact on the cost of onshore RE. However, land availability and other constraints such as zoning might limit onshore RE projects (Ram et al., 2018).

On general, utility-scale solar PV has the lowest LCOE values, varying from 16 to 117 €/MWh, whereas onshore wind has an LCOE range of 16 to 90 €/MWh. Rooftop solar PV has the lowest LCOE, varying from 31 to 126 €/Mwh. Offshore wind power has an LCOE varying from

64 to 135 €/MWh. Solar PV and battery systems are very competitive in terms of LCOE, with utility-scale expenses varying from 21 to 165 €/MWh and residential expenses varying from 40 to 204 €/MWh (Ram et al., 2018).

More specifically, as mentioned by Hevia-Koch and Jacobsen (2019) In comparison to onshore wind farms, offshore wind farms construction is a far more costly and capital-intensive endeavor. Additionally, expenses vary substantially according to the location, because of water depth, distance to the shore, sea conditions, and other factors. Often, overall investment expenses are divided down into multiple cost components. Offshore cost components are distributed differently than onshore wind. Foundation, construction, and electrical/connection expenses are higher than for onshore, although turbine costs are lower. Operation and maintenance costs (O&M) or OPEX are represented as yearly costs following the farm's commissioning and tend to rise during the farm's lifetime.

The operating and maintenance expenditures are either expressed as a variable cost per MWh generated or as a fixed cost per MW installed capacity. This is due to the fact that certain OPEX components are variable, such as repair costs and, to a lesser extent, spare parts and service (which are likely to be correlated to production level), while others are fixed, such as insurance fees, administration, and routine maintenance (which are most likely connected to fixed installed capacity). According to Energinet.dk and the Danish Energy Agency (2017), fixed O&M costs are 57,300 EUR/MWh in 2015, while variable costs are 4.3 EUR/MWh.

To calculate the entire OPEX cost, add the variable cost based on the amount of energy generated and the leftover fixed cost. The variable component of offshore wind OPEX is projected to represent half of the overall OPEX (Voormolen et al., 2015, as cited by Hevia-Koch and Jacobsen (2019)). It is estimated in the literature to be between 15 and 49 EUR/MWh (Kitzing and Morthorst, 2015 as mentioned by Hevia-Koch and Jacobsen (2019) in variable terms and 2.2-4% in fixed terms as a percentage of CAPEX (DECC Department of Energy and Climate Change, 2013; Heptonstall et al., 2012; Prässler and Schaechtele, 2012 as mentioned by Hevia-Koch and Jacobsen (2019)).

Globally, onshore investment expenses have been falling and are presently in the range of 1000 EUR/kW to 1950 EUR/kW. Over the period 2015-2030, the Technology Catalogue (Energinet.dk and Danish Energy Agency, 2017) forecasts a drop from 1070 EUR/kW to 910 EUR/kW. According to recent indications from manufacturers, turbine prices have already reduced to slightly about 800 EUR/kW. The yearly operating and maintenance expenses are estimated to be 8-10 EUR/MWh, proportionate to generation. In contrast, (The Danish Wind Turbine Owners' Association, 2014, as cited by Hevia-Koch and Jacobsen (2019)) forecasts a lifespan O&M cost of roughly 11 EUR/MWh for Danish onshore generators.

Expenses may be decreased in the future by longer turbine lifetimes due to slower technological advancement (replacement with equivalent turbine) and a greater portion of payment from market revenue. Greater revenues from generation later in life may necessitate more maintenance work than if support is solely generated in the first 8-10 years. Because of this, as well as the relatively consistent turbine size, only a slight reduction in maintenance costs is to be expected. As mentioned by Hevia-Koch and Jacobsen (2019), Energinet.dk (2016) estimates that current land wind requires a market price of around 13-16 EUR/MWh to stay profitable after the subsidy expires, which is consistent with slightly higher O&M costs (more than 10-11 EUR/MWh) at the end of turbine lifetime (Hevia-Koch and Jacobsen, 2019).

Throughout the farm's lifespan, OPEX can account for 25-30% of overall project costs (Kitzing and Morthorst, 2015, as cited by Hevia-Koch and Jacobsen (2019)). Among the aforementioned geographical expenses, the distance to the nearest servicing port has the greatest direct impact on OPEX, due to the cost associated with the servicing vessel's travel time and potentially rougher weather patterns at sites further offshore, which limit the operation time on site. After estimating the investment, operating, and maintenance expenses of a wind farm project over its lifetime, the LCOE may be calculated by anticipating the farm's energy output over its whole lifetime. Both variables will have an impact on technical costs: as water depth grows, it becomes more expensive to erect wind turbines, and at certain water depths, more costly foundation technologies must be employed. Similarly, as the distance to shore grows, so do the expenses for cabling throughout installation, as well as the expenses involved to port availability and installation time.

Offshore wind energy expenses curves will rise when more sites are developed that are less expensive, either because they have better wind conditions or because they have lower investment costs (water depth). Offshore cost predictions for Denmark and elsewhere have recently reduced dramatically, as indicated by the Kriegers Flak project, which received a winning offer of 4.9 EUR cent/kWh. Surprisingly, this development offers a level that is lower than any of the previous LCOE estimations (Hevia-Koch and Jacobsen, 2019).

As previously stated, the LCOE of offshore wind energy has decreased dramatically in recent years, particularly when compared to onshore, and if this trend continues, the economic advantage of onshore vs offshore will be lowered even further. Offshore costs have decreased, but it is anticipated that significant savings may be realized by generating more onshore capacity than offshore. The precise proportion of onshore to offshore wind that needs to be placed is unknown and will be determined by future cost reductions in offshore development, in addition to the determination of the population range to be deemed impacted and so included in the aggregate (Hevia-Koch and Jacobsen, 2019).

Regarding PV systems, and while there is currently limited publicly available data on the capital costs or maintenance and operation (O&M) expenses of FPV systems (Wang and Lund, 2022), studies show that offshore PV solar has higher values of Levelized Cost of Energy than onshore PV solar, despite the latter's higher efficiency (Costoya et al., 2022).

More specifically, construction at sea necessitates more considerations than installation on land, which increases the overall cost (Wang and Lund, 2022). For example, panels must be developed to be water resistant, and in order to float, their weight must be planned to be lightweight, which necessitates the use of high-cost equipment. According to Ramasamy and Margolis (2021), the levelized cost of electricity (LCOE) from FPV systems is approximately 20% more than the LCOE from ground-mounted PV systems (excluding the solar Investment Tax Credit).

More precisely, in their study (Ramasamy and Margolis, 2021), they compared the installation costs in the United States of a benchmark ground-mounted PV system to our base-case FPV system, using system capacities of 10 MWDC. The installed cost of the FPV system is $0.26/WDC (25%) more than the cost per WDC of the ground-mounted PV system, owing to substantially higher structural expenses (about 300%) connected to the floats and anchoring mechanism. Optimizing the quantity of floats to fit expected environmental demands may assist in lowering float expenses. As compared to the expenses of land systems with standardized designs, adapting FPV system designs to installation sites may raise upfront engineering and feasibility study expenditures. Due to the FPV system's relative newness and an additional shipping and handling cost of 5% for the floats and anchoring system, the cost model anticipates a higher contingency rate (5% against 3% for the ground-mounted system). Because high-power installation equipment is utilized less and float assembly is relatively straightforward and quick, installation labor and equipment expenses are 50% cheaper for the FPV system, which partially balances the FPV system cost premium. For ground mount systems, site staging expenses are included in the electrical balance of system cost category. Site staging comprises road access and parking, and security fencing that are not part of floating PV system cost estimates. As a result, the electrical BOS for floating PV systems is somewhat lower (Ramasamy and Margolis, 2021).

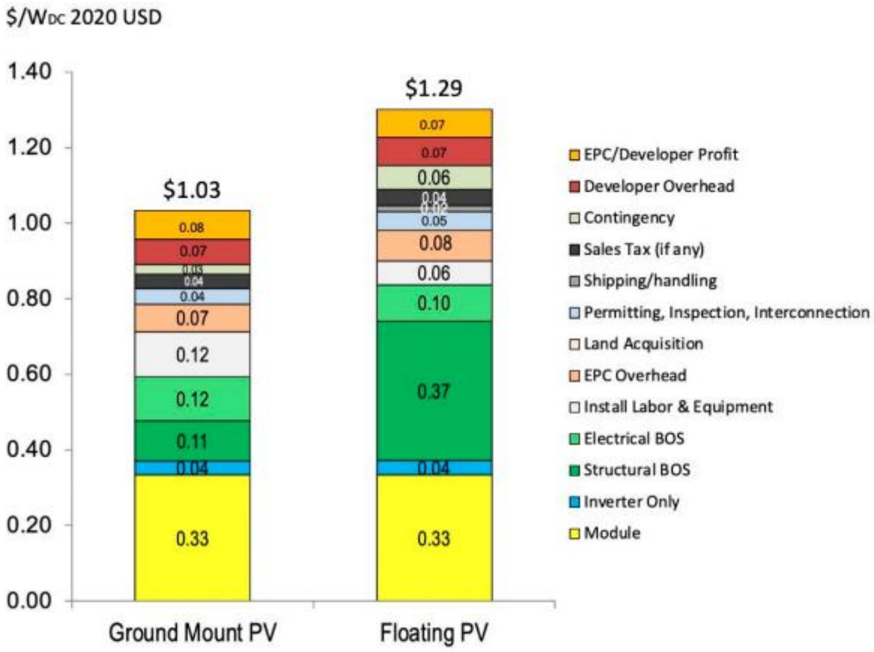


Figure 2: Installed expenses of 10 Mwdc based scenario offshore and onshore system (Ramasamy and Margolis, 2021)

The above graph depicts the lowering per-watt cost of the base-scenario FPV system as system size increases. SBOS expenses contribute 25%-30% of overall cost, depending on system size, driving the economies of scale. Float expenses account for around 75%-85% of SBOS expenditures. The typical cost of floats manufactured in the United States is $0.20-$0.40/WDC, whereas the average cost of floats made in Europe, including transportation to the United States, is projected to range between $0.22/WDC and $0.90/WDC, relying on the kind of HDPE floating structure and quantity ordered. The cost of floats per unit decreases as the amount of floats ordered increases.

For example, a 2-MW FPV system costs $0.40/WDC, a 5-MW FPV system costs $0.36/WDC, a 10-MW FPV system costs $0.30/WDC, and a 50-MW FPV system costs $0.20/WDC. The float cost for a particular system size implies that the installer orders floats for just one system at a time (Ramasamy and Margolis, 2021).

The LCOE results are shown in Figure 8. More specifically, as shown in the figure, the LCOE for FPV systems is roughly $57/MWh even without investment tax credit (ITC) and $38/MWh with the investment tax credit (ITC). The LCOE for ground-mounted PV systems is around $47/MWh without the ITC and $32/MWh with the ITC. Despite greater energy production owing to cooling effects of FPV systems and cheaper O&M estimates, their LCOE is still 20% larger without the ITC and 17% higher with the ITC when compared to ground-mounted systems (Ramasamy and Margolis, 2021).

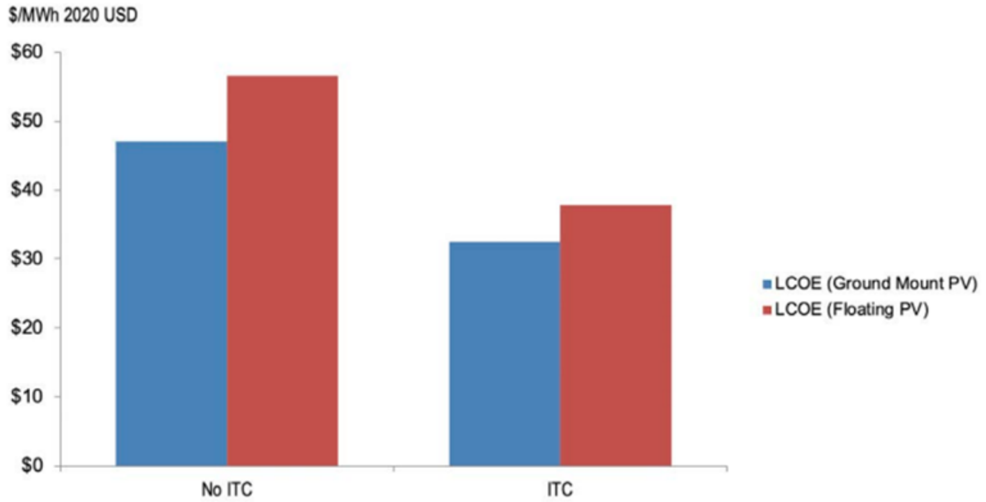


Figure 3*: LCOE comparison of onshore and offshore PV systems (Ramasamy and Margolis, 2021)*

To summarize, it is evident that, as of currently, offshore renewable investments are more expensive than onshore ones.

2.5. Calculation of the Investment's Risk

In the business sector, the topic of financial planning with an emphasis on investment finance is quite current. The business sector is regarded as requiring investment due to its rapid and dynamic expansion over the past several decades, and the main issue is how to reduce the risks in this sector. The results of poor financial planning and investment decisions result in significant losses that negatively affect not only the businesses as a whole but also the whole industry.

To answer this question, we should first give a definition regarding what an investment is. There are two methods to incur investment costs to make a profit. Fix investments, like machinery, plants, or structures, as well as financial investments, such as stocks and bonds, are also examples of investments. Both types of funding may help a business expand. From a different angle, investments might be net investments when new assets are added to the existing ones or replacement investments when a physical item is replaced. Whether to invest or not relies on the investor's expected return, the asset's cost, the amount of available financing, and the method of financing that (Virlics, 2013).

Another definition that needs to be presented is one of the risks. As risk we identify the potential for suffering losses. The assessment of risk is based on extensive knowledge and data that permits the calculation of likelihood and consequence (Virlics, 2013).

Expected outcomes of the risk calculation are unpredictable because of how the financial and economic environments affect investments. The investment risk level is one of the fundamental elements affecting the choice. This risk occurs since it's not known if the investment's initial outlay will be recouped, and a profit will be made. Risk is a complicated topic, thus it's crucial that investment procedures study, comprehend and identify it and it is important to not proceed in any type of investment choice without first doing a risk analysis (Virlics, 2013).

The following three methods to be presented—general analytical techniques like P.E.S.T. and S.W.O.T., or computational techniques like the Monte Carlo method in conjunction with the Python programming language—are frequently used to estimate investment risk (Virlics, 2013).

2.5.1. Calculations Using S.W.O.T. Analysis

In contemporary theory and practice, company management is often approached through two distinct methodologies. The first is the constructivist method, which primarily relies on rational management principles. This approach emphasizes the optimization of inputs and outputs to resolve issues through analytical thinking. Within this framework, one of the most commonly utilized tools in the corporate world is the S.W.O.T. analysis. This method succinctly encapsulates the Strengths, Weaknesses, Opportunities, and Threats relevant to a business or project.

The S.W.O.T. analysis offers several notable advantages. Its straightforward nature, devoid of complex mathematics, makes it easily understandable through a simple graphic representation. This accessibility allows for its application at various organizational levels, including individual employees, teams, business units, or entire corporations. Additionally, S.W.O.T. analysis can be adapted to different levels of complexity, from quick and simple evaluations to more detailed and intricate assessments. When properly applied, it can be closely aligned with business objectives and strategy implementation, serving as a highly visual tool that facilitates clear communication (Tobisova et al., 2022).

Strengths:

- Capabilities
- Competitive advantages
- Resources, assets, people
- Experience, knowledge, and data
- Financial reserves, returns
- Marketing, Reach
- Innovative aspects
- Geographical location
- Price, value, quality
- Communications, IT systems, and processes
- Advantages of the proposition

Weaknesses:

- Lack of capabilities
- Gap in competitive strengths
- Reputation, presence, and reach
- Pressures (deadlines, timescales)
- Financials
- Cash flow, cash drain
- Continuity, supply chain
- Effects on core activities
- Reliability of data, plan, and project
- Management cover & succession

Opportunities:

- Market developments
- Industry or lifestyle trends
- Innovation & technology development
- Global influences
- Market dimensions (horizontal, vertical)
- Target markets
- Geographical import & export
- Major contracts, tactics, surprises
- Business/product development

Threats:

- Political & economic effects
- Legislative effects
- Environmental effects
- Competitiveness
- Market demand
- Innovation (in services, technologies, ideas)
- New partners & contracts
- Loss of resources
- Obstacles to be faced (in any sector and every aspect)
- Poor management strategies
- Economic conditions (in host country & mother country)

However, despite its widespread use and these advantages, S.W.O.T. analysis also presents several drawbacks. One of the primary criticisms is the tendency to rely on qualitative or subjective information, rather than quantitative data. This reliance can lead to general descriptions of issues rather than detailed analyses. Furthermore, the outcomes of a S.W.O.T. analysis can be heavily influenced by individual preferences, personality traits, and perceptions. The processes of data collection, analysis, and decision-making are often conflated, leading to potential inaccuracies. Additionally, the method can be misapplied, especially when the fundamental principles are ignored, resulting in a flawed analysis. There is also a tendency to overlook the broader methodological context, or worse, a failure to recognize its existence altogether (Tobisova et al., 2022).

Because of these drawbacks, S.W.O.T. analysis is sometimes disparagingly referred to as "Significant Waste Of Time," particularly when conducted by inexperienced facilitators. However, when applied correctly, S.W.O.T. analysis remains a valuable tool for strategic thinking. It focuses attention on critical elements that might otherwise be overlooked, providing a structured approach to identifying and analyzing key factors influencing a business or project (Tobisova et al., 2022).

In the context of renewable energy investments, particularly when comparing photovoltaics and wind turbines, S.W.O.T. analysis can be especially useful. For photovoltaics, strengths might include the decreasing cost of solar panels and the abundance of sunlight in many regions. Weaknesses could encompass the need for large land areas and the variability of solar energy production. Opportunities may lie in technological advancements and government incentives, while threats might involve competition from other renewable energy sources and regulatory changes. For wind turbines, strengths could include the high energy yield of wind farms and their ability to operate in various locations. Weaknesses might involve the visual and noise impact on surrounding areas and the initial high capital costs. Opportunities may be found in offshore wind developments and improving turbine technology, while threats could include fluctuating policy support and environmental concerns related to wildlife impacts (Tobisova et al., 2022).

By employing S.W.O.T. analysis, investors can gain a nuanced understanding of the strategic landscape for renewable energy projects. This understanding can inform decision-making processes, helping to identify potential risks and opportunities and align investments with broader strategic goals. Despite its limitations, S.W.O.T. analysis, when executed with precision and insight, can contribute significantly to the strategic planning and execution of renewable energy investments, ensuring a more informed and effective approach to fostering sustainable energy development.

2.5.2. Calculations Using Monte Carlo x Python

The system-evolutionary approach offers an alternative strategy for understanding and managing businesses by treating them as complex systems that cannot be precisely described or controlled through traditional methods. This approach emphasizes the primary objective of securing the enterprise's viability and sustainability, which is regarded as the aim of any business. In this context, the use of Monte Carlo methods becomes highly relevant. Monte Carlo methods, also known as Monte Carlo experiments, are a comprehensive family of computational techniques that utilize repetitive random sampling to derive numerical results. These methods leverage randomness to find solutions to problems that, while theoretically deterministic, may be difficult to solve using other methods. They are especially valuable in calculating investment risks, evaluating investments, and assessing depreciation rates over time.

Monte Carlo methods are frequently applied to mathematical and physical problems and are particularly useful when other strategies are impractical or impossible. This technique is versatile and can be implemented in Python, Crystal Ball Software, and other computational tools. Users can select the factors, or uncertainty parameters, that they are most concerned with, and which pose potential risks to an investment, such as raw material costs, market pricing, seasonal and annual weather patterns, and more. Although the specific techniques within the Monte Carlo family may vary, they often share a common structure: establishing a range of possible inputs, generating random inputs from a probability distribution across the domain, performing a deterministic calculation using these inputs, and aggregating the results (Mallieswari et al., 2024).

Despite its conceptual and technical simplicity, the computational cost of a Monte Carlo simulation can be extremely high. The method often requires a large number of samples to provide a reliable estimate, which can result in lengthy total runtimes, especially if processing each sample is time-consuming. However, the parallel nature of the Monte Carlo algorithm allows for the use of parallel computation techniques on local processors, clusters, cloud computing, GPUs, and FPGAs, which can significantly reduce the cost, potentially bringing it to a manageable level (Shenyin & Caballero, 2022).

Research on energy communities has become increasingly common in recent years, driven by the growing interest in sustainable energy solutions. While numerous studies have focused on the economic viability of energy communities, there is a surprising lack of developed and published methods for evaluating the economic risks associated with them. This gap in the literature is notable given the importance of understanding these risks for making informed decisions regarding investments, operational plans, and financing options for potential energy communities before they are established (Mallieswari et al., 2024).

Python, as a versatile programming language, allows for the assessment of various uncertainties that define the risks to the profitability of energy communities. Monte Carlo simulations, conducted through Python, offer a robust framework for risk assessment, providing a reliable depiction of how uncertainties behave and their implications for economic risk within energy communities. Furthermore, the chosen technique enables the exposure of a wide range of outcomes related to specific parameters during the implementation of an energy community, thereby enhancing the decision-making process (Mallieswari et al., 2024).

The model offers several benefits, including insights into CO2 emissions for each option, which aids in identifying the least carbon-intensive operational model for the energy community. Additionally, the model provides a well-founded assessment of real behavior and allows for an understanding of how profitability, risk level, and environmental impact are interrelated within different operational models of energy communities. Investors can leverage this model for strategic planning, as it enables the use of multiple and varied variables that the algorithm provides. It is instrumental in estimating investment risks, evaluating investment potential, and assessing depreciation over time. Users can select variables of interest, known as uncertainty parameters, which contribute to investment uncertainty (Mallieswari et al., 2024).

The most modeled economic uncertainties include raw material prices, market prices, seasonal and annual weather conditions, policy changes, electricity prices, technological costs, discount rates, investment costs, technical factors, energy prices, regulatory considerations, and subsidies. This comprehensive modeling makes it possible to assess the impact of these uncertainties on economic performance. Renewable energy systems also face challenges in energy management, system design, and expansion planning, which are critical considerations in investment strategies (Shenyin & Caballero, 2022).

On the other hand, this technique integrates computer simulation options into the decision-making processes of businesses within the industry sector. Despite the advantages of computer simulations, it is important to acknowledge the potential risks associated with their use. The quality of the output is not guaranteed solely by the user's software management skills or adherence to methodological rigor. Thus, while the Monte Carlo method provides valuable insights and strategic advantages, it requires careful application and consideration of potential limitations to ensure accurate and reliable results in the context of renewable energy investments (Shenyin & Caballero, 2022).

2.5.3. Calculations Using the P.E.S.T. Model

In the business world, the P.E.S.T. (Political, Economic, Socio-cultural, and Technological) model is an invaluable tool for market analysis and assessing the conditions that impact strategic decision-making. This model facilitates a comprehensive examination of the market environment by considering a multitude of factors, including political, regulatory, economic, social, demographic, cultural, and technological elements. These components provide a framework for understanding how various external influences affect a company's operations and strategic planning.

Political factors encompass the regulatory and governmental aspects that can have both direct and indirect impacts on a company's strategic decisions. These include tax laws, environmental protection regulations, political stability, global trade conditions, labor laws, and local government regulations. These factors set the framework for business creation and operations, influencing decisions on where and how to conduct business. For instance, favorable tax laws and political stability can encourage investment, while stringent environmental regulations may require companies to adapt their strategies to comply with new standards (Yumei, 2023).

Economic factors pertain to the broader market in which a company operates, including the specific industry and the interconnected conditions of the overall economy. This includes considerations such as business cycles, energy prices, interest rates, GDP trends, unemployment rates, and per-capita disposable income. Economic conditions can significantly affect a company's profitability and growth potential. For example, rising energy prices might increase operational costs for manufacturing firms, whereas favorable interest rates could reduce the cost of financing for new investments (Yumei, 2023).

Socio-cultural factors include prevailing social institutions, trends, and perceptions that shape consumption patterns and ultimately influence a company's strategic choices. Variables such as population distribution, mobility, income distribution, spending habits, educational levels, community impressions, local customs, traditions, and religious beliefs all play a role in shaping consumer behavior. Companies must understand these factors to effectively tailor their products and marketing strategies to meet the needs and preferences of their target demographics. Technological factors encompass the technological environment that impacts the development and introduction of innovative products, manufacturing processes, and distribution methods. This includes spending on research and development, technological discoveries, the pace of technology transfer, technical infrastructure, and the emergence of new products. A dynamic technological environment can create opportunities for innovation and competitive advantage, while also posing challenges as companies must keep pace with rapid technological changes (Yumei, 2023).

The benefits and drawbacks of the P.E.S.T. model is often comparable to those of S.W.O.T. analysis due to their similarities. While the P.E.S.T. approach is straightforward and easy to communicate when analyzing a problem, it relies heavily on subjective data and often describes issues in broad terms rather than with depth. This method is also susceptible to the biases of individual preferences, personality traits, and beliefs, which can skew the analysis. Furthermore, the processes of data collection, interpretation, and decision-making may become conflated, especially when fundamental principles are overlooked, leading to incorrect conclusions and negatively impacting the final outcomes. To achieve enterprise viability, early identification of risk factors, anticipation of market changes, implementation of preventive and corrective measures, and the creation of new development opportunities are essential. It is critical to analyze investment risks not solely as objective factors but also from the perspective of behavioral economics. Understanding risk perception is vital, as it ultimately influences decision-making processes. There is a need for further research into the risks associated with investment decisions and how these risks are perceived, as risk perception significantly impacts decision outcomes (Yumei, 2023).

By effectively employing tools such as the P.E.S.T. model, companies can enhance their stability and safeguard against unforeseen circumstances that could disrupt operations. Decision-makers must carefully evaluate whether to act immediately or delay action, all while considering the possibility of acquiring additional information that could clarify the level of risk associated with investment decisions. In summary, the P.E.S.T. model offers a structured approach to understanding the complex external factors that shape business environments, providing valuable insights that inform strategic planning and decision-making in the renewable energy sector and beyond.

2.6. The Expansion of the Energy Market Affecting Energy Prices

We are getting closer to the energy transition with each passing year. The turn in RES, like solar and wind, helped Europe avoid 10 billion euros in gas costs and the return to coal power. Empirical research demonstrates that the supply of low-margin renewable energy sources like wind and solar energy can lower electricity market prices. The integration of renewable energy and market performance in an oligopolistic energy market, like the one in Europe, are also related, according to recent theoretical studies and simulations.

Policymakers have recently begun to take the global climate change problem brought on by fossil fuel use of global climate change brought on using fossil fuels seriously, particularly in the power generating industry. As a result, energy regulations that aim to combat climate change have taken over the European power sector. Particularly, many nations have put policies into place for a shift to a low-carbon economy through the promotion of renewable energy sources (RESs, hereinafter), supported by large subsidies and priority dispatch requirements in the power balance (Energy, Climate Change, Environment, 2024).

Among other recent developments is the effect of the events after Russia's unjustified invasion of Ukraine, high energy commodity prices (mostly gas, but also coal), restricted pipeline gas flows, and market anxiety over European security of supply all stood out during the second quarter of 2022 when the European Power Benchmark averaged 191 €/MWh, an increase of 181% comparatively to the second quarter of 2021 (Energy, Climate Change, Environment, 2024).

Gas specifically, which is frequently used in power plants to generate electricity and sets the marginal wholesale price has been at high levels, supporting sustained price volatility. The EU member states with the highest price rises over the previous year were France (+254%), Greece (238%), and Italy (+234%). The highest quarterly average price was reported by Malta and Italy (252 and 249 €/MWh, respectively), up 211% and 234% from the second quarter of 2021. In the second quarter of 2022, the percentage of renewable energy grew to 43%, surpassing the share of fossil fuels (36%). The production of renewable power increased year over year by 2% (+5 TWh). This came about as a consequence of rises in the solar output of 24% (+13 TWh), the onshore wind of 10% (+7 TWh), and offshore wind of 11% (+1 TWh). Despite high energy commodity costs, reduced output levels of nuclear and hydropower energy enabled for an increase in fossil fuel generation of 6% (+12 TWh) year over year (Energy, Climate Change, Environment, 2024).

Household consumer bills have increased as a result of high wholesale power rates, which has an effect on the industrial sector as well. In addition, government actions in EU nations are assisting in lowering consumer costs. Mid-sized industrial consumers would face retail power costs that were predicted and proved to be 32% higher year over year in the second quarter of 2022 (Pham, 2019).

Due to the difficulty in defining the market power parameter, it is more difficult to empirically quantify the influence of RESs on market power level than it is to do so for wholesale prices because of the exogeneity of RES data. The findings emphasize how crucial it is for integrated European power markets to coordinate energy policy via cooperative renewable energy assistance programs. Renewable production has an influence on spot market pricing even if renewable generators are compensated at a fixed rate and are not actively involved (Pham, 2019).

The ongoing transition to renewable energy sources is gaining momentum and presents significant economic and environmental benefits. The shift towards solar and wind power has not only helped Europe avoid substantial gas costs but also prevented a resurgence of coal power usage. Empirical studies highlight that renewable energy sources like wind and solar can effectively lower electricity market prices, especially in oligopolistic markets such as Europe. Policymakers are increasingly acknowledging the impact of fossil fuels on climate change and are implementing policies to promote a low-carbon economy, supported by significant subsidies and priority dispatch for renewables. Recent events, such as the geopolitical tensions following Russia's invasion of Ukraine, have further underscored the importance of energy security, as evidenced by the soaring energy prices in 2022. The percentage of renewable energy in the European power mix surpassed fossil fuels for the first time, indicating a positive trend towards sustainability. However, the volatility in gas prices has led to increased household bills and impacted on the industrial sector. This underscores the need for integrated European power markets to coordinate energy policies and cooperative renewable energy support programs. The influence of renewable energy on market prices and energy security continues to grow, highlighting its crucial role in shaping the future of global energy markets. Despite challenges, the path towards a more sustainable and resilient energy future is clear, with renewable energy sources at the forefront of this transformation.

2.7. Bureaucracy, State and Other Restrictions

The transition to renewable energy is a crucial component of the global effort to mitigate climate change and create a sustainable energy future. However, the bureaucratic and regulatory environment significantly influences the pace and success of renewable energy investments. The role of bureaucracy and state-imposed restrictions in the energy sector is multifaceted, involving both positive and negative aspects. Understanding these elements is essential to identifying areas for improvement and fostering an environment conducive to renewable energy investments.

Bureaucracy often represents a significant hurdle for investors looking to enter the renewable energy market. The complexity and length of bureaucratic processes can deter investment by creating delays, increasing costs, and introducing uncertainties. For example, in many countries, obtaining the necessary permits and licenses for renewable energy projects involves navigating a maze of administrative procedures that can take years to complete. This is especially true in regions where market structures are not fully liberalized, leading to further difficulties in market entry. The case of Greece serves as a notable example, where bureaucratic inefficiencies have historically hindered foreign investment. Streamlining and simplifying licensing procedures could make these markets more attractive to investors by reducing the time and cost required to launch projects (European Council, 2022).

In addition to bureaucratic challenges, state restrictions can also include the absence of support policies for renewable energy. These policies encompass grid access regulations, financial support schemes, and incentives necessary for integrating renewables into the energy mix. Without supportive policies, renewable energy projects may struggle to secure financing or gain access to the grid, limiting their feasibility and competitiveness compared to established fossil fuel sources. Furthermore, resistance from incumbent actors in the fossil fuel industry can influence policymaking, resulting in insufficient support for renewables and hindering the transition to a sustainable energy system. This resistance can manifest in lobbying against renewable subsidies or in efforts to delay the implementation of supportive regulations (Cunha et al., 2017).

Another critical restriction is the insufficient know-how and experience in the renewable energy sector, particularly in developing countries. A lack of skilled engineers and technicians familiar with renewable technologies can impede the deployment and operation of renewable energy projects. Educational initiatives and training programs are necessary to build local expertise and ensure that renewable energy systems can be effectively integrated and maintained. Such capacity-building efforts are essential for fostering a knowledgeable workforce capable of supporting the growth of the renewable energy industry (Felsmann et al., 2018).

The technical challenge of integrating intermittent renewable sources, such as wind and solar photovoltaic (PV) generation, into existing electricity systems is another significant barrier. The variability of these energy sources requires advanced grid management and storage solutions to maintain a reliable power supply. Investments in grid modernization and energy storage technologies are crucial for overcoming these challenges and facilitating the smooth integration of renewables. Governments can play a pivotal role by providing incentives and support for the development and deployment of such technologies, thereby enhancing the resilience and flexibility of the power grid (Cunha et al., 2017).

Despite these challenges, state-imposed restrictions also have positive aspects that can benefit renewable energy investments. For instance, regulations that enforce environmental standards and promote sustainability can drive innovation and encourage the adoption of clean energy technologies. Such positive restrictions can ensure that renewable energy projects adhere to high standards of environmental performance, contributing to broader sustainability goals. Additionally, states can implement policies that incentivize research and development in renewable technologies, fostering innovation and driving down costs. These measures can create a more favorable environment for investment and stimulate the growth of the renewable energy sector (Felsmann et al., 2018).

To improve the investment climate for renewable energy, several recommendations can be made. First, governments should focus on streamlining bureaucratic processes to reduce administrative burdens and accelerate project timelines. Simplifying the licensing and permitting process can make markets more accessible and attractive to investors. Second, implementing supportive policies for renewables, including grid access regulations and financial incentives, can enhance the competitiveness of renewable energy projects. Governments should also prioritize capacity-building initiatives to develop a skilled workforce capable of supporting the deployment and maintenance of renewable energy systems. Third, investment in grid modernization and energy storage solutions is essential to address the challenges of integrating intermittent renewables. By providing incentives and support for these technologies, states can enhance the reliability and flexibility of the power grid, facilitating the transition to a sustainable energy system (European Council, 2022).

In conclusion, bureaucracy and state-imposed restrictions play a critical role in shaping the renewable energy investment landscape. While these factors can pose significant challenges, they also present opportunities for positive change and innovation. By addressing the negative aspects of bureaucracy and implementing supportive policies, governments can create an environment that encourages renewable energy investments and supports the transition to a sustainable energy future. Through targeted efforts to streamline processes, enhance grid infrastructure, and build local expertise, states can overcome barriers and foster a thriving renewable energy sector that meets the needs of the future.

2.8. Positive and Negative Impacts of Foreign Direct Investments

Foreign Direct Investments (FDIs) have the potential to significantly influence the economic and social landscapes of host countries. While FDIs are often heralded for their ability to stimulate economic growth, enhance technological development, and create employment opportunities, they can also introduce challenges and complexities. Analyzing both the positive and negative impacts of FDIs can provide a comprehensive understanding of their role in shaping a nation’s development, especially in the context of renewable energy investments.

On the positive side, FDIs can act as a catalyst for economic development by injecting much-needed capital into the host country. This infusion of capital can lead to the establishment and expansion of industries, which in turn can enhance the country's GDP and economic stability. In the renewable energy sector, FDIs can accelerate the transition to sustainable energy sources by financing large-scale projects such as wind farms, solar parks, and other renewable energy installations. Such investments not only contribute to energy security but also reduce reliance on fossil fuels, thereby supporting environmental sustainability (Žilinskė, 2010).

The growth of renewable energy sources driven by FDIs can also stimulate employment in various sectors. As new projects are initiated, they create a demand for a skilled workforce, leading to job creation in ‘green’ technologies. This demand extends beyond the construction phase, encompassing ongoing operations, maintenance, and technological innovation. In the European Union, for instance, the renewable energy sector is poised to create numerous job opportunities, fostering a transition to a low-carbon economy while simultaneously addressing unemployment issues. FDIs can also facilitate the transfer of technology and knowledge between countries. When multinational corporations invest in a foreign country, they often bring with them advanced technologies and management practices that can be adapted and implemented locally. This technology transfer can enhance the productivity and competitiveness of domestic firms, fostering innovation and efficiency in various industries. Moreover, FDIs can improve the availability of local skills, as the presence of international companies often necessitates training programs and knowledge-sharing initiatives that elevate the skill set of the local workforce (Kurtishi-Kastrati, 2013).

Despite these positive impacts, FDIs can also have adverse effects on host countries, particularly if not managed carefully. One significant concern is the potential for non-compliance with existing national legislation. Foreign companies may prioritize profit over local regulations, leading to environmental degradation, labor exploitation, or disregard for community welfare. This non-compliance can erode public trust and result in social tensions, undermining the intended benefits of FDIs. For instance, if a foreign company bypasses environmental regulations to expedite project completion, it may cause long-term ecological harm, contradicting the goals of sustainable development (Tülüce & Doğan, 2014).

Furthermore, FDIs can lead to economic disparities within the host country. While foreign investments may create jobs and stimulate economic growth, they can also exacerbate income inequality if the benefits are not equitably distributed. In some cases, foreign companies may import their own labor force or focus their activities on specific regions, neglecting local communities and contributing to regional imbalances. Additionally, the dominance of multinational corporations can overshadow domestic firms, limiting their market share and competitiveness. This can stifle local entrepreneurship and innovation, hindering the growth of small and medium-sized enterprises (SMEs) that are vital to a robust economy. Another potential drawback of FDIs is the risk of capital flight and economic instability. Foreign investors may withdraw their investments abruptly in response to economic or political uncertainties, leaving the host country vulnerable to financial crises. This volatility can disrupt local economies and result in significant job losses, negating the initial benefits of the investment. Therefore, it is crucial for host countries to establish regulatory frameworks that mitigate these risks and ensure that FDIs contribute to long-term economic resilience (Tülüce & Doğan, 2014).

To maximize the benefits of FDIs while minimizing their negative impacts, several strategies can be implemented. Policymakers should focus on creating a transparent and stable regulatory environment that encourages responsible investment practices. This includes enforcing compliance with national laws and regulations, promoting corporate social responsibility, and ensuring that environmental and labor standards are upheld. Additionally, host countries can implement policies that support the development of local industries and SMEs, fostering a balanced economic landscape that benefits all stakeholders (Kurtishi-Kastrati, 2013).

Moreover, governments should prioritize skill development and education to equip the local workforce with the necessary skills to thrive in an increasingly competitive market. By investing in education and training programs, countries can enhance their human capital, making them more attractive to foreign investors and ensuring that the benefits of FDIs are widely shared across society. Finally, fostering strong partnerships between public and private sectors can facilitate the successful integration of FDIs into national development strategies, aligning foreign investments with the country's long-term goals and priorities (Kurtishi-Kastrati, 2013).

2.9. Energy Systems Integration (ESI)

Energy Systems Integration (ESI) represents a transformative approach to managing the complex demands of modern energy systems. It involves the coordinated development and operation of various energy sources and infrastructures across multiple geographic regions and channels. This integration aims to provide reliable, affordable energy services while minimizing environmental impacts, making it a cornerstone of contemporary energy policy and practice. The integration of energy systems is particularly relevant in the European

Union (EU), where the establishment of a unified energy market is seen as the most cost-effective way to ensure a stable and affordable energy supply for all citizens. Through standardized regulations and cross-border infrastructure, energy can be generated in one EU nation and delivered to consumers in another, exemplifying the benefits of a connected and cooperative energy framework.

The evolution of energy markets is driven by current environmental, political, and economic goals. The transition to renewable energy sources, the need to reduce greenhouse gas emissions, and the desire for energy independence are central motivations behind these changes. Energy Systems Integration plays a critical role in achieving these objectives by increasing the adaptability of the energy system, enabling the efficient integration of renewable energy sources, and reducing carbon emissions. The ESI approach is inherently flexible and can be tailored to the specific needs and characteristics of each system. Depending on the complexity and scope of the integration, it may require knowledge from multiple disciplines or focus on a single area, impacting various stakeholders differently based on the system's configuration (O'Malley et al., 2016).

One of the primary benefits of Energy Systems Integration is its ability to enhance the flexibility of energy systems, allowing for the seamless incorporation of renewable energy sources. Renewable energy, such as wind, solar, and hydroelectric power, is inherently variable and requires a flexible system to accommodate fluctuations in supply and demand. ESI enables energy systems to adapt to these variations by optimizing the use of available resources and facilitating the balancing of supply and demand across different regions and sectors. This flexibility is essential for maximizing the potential of renewable energy sources and ensuring a stable and reliable energy supply. Moreover, ESI contributes to the diversification of energy supplies, reducing reliance on foreign fuels and enhancing energy security. By integrating multiple energy sources, including renewables, nuclear, and fossil fuels, into a cohesive system, ESI minimizes the risks associated with supply disruptions and price volatility. This diversity also supports the EU's goal of energy independence, allowing member states to leverage their unique resources and capabilities to contribute to a shared energy market. As a result, ESI fosters cooperation and collaboration among EU nations, promoting a more resilient and interconnected energy landscape (O'Malley et al., 2016).

Energy Systems Integration also plays a pivotal role in reducing carbon emissions and addressing climate change. By facilitating the integration of low-carbon energy sources and improving the efficiency of energy use, ESI helps to lower greenhouse gas emissions associated with electricity generation. This transition from fossil fuels to cleaner energy alternatives not only mitigates the impacts of climate change but also reduces air pollution, contributing to improved public health and environmental quality. The environmental benefits of ESI are significant, as it supports the global effort to transition to a sustainable energy future and aligns with international commitments to reduce carbon emissions (Cambini et al., 2020a).

Economically, ESI drives growth and job creation in various sectors, including manufacturing, installation, and maintenance of energy systems. The integration of energy systems necessitates the development and deployment of advanced technologies and infrastructure, creating opportunities for innovation and investment. As the demand for integrated energy solutions grows, so too does the need for skilled professionals and experts in the field. This demand stimulates economic activity and supports job creation, particularly in the renewable energy sector, which is characterized by its potential for rapid growth and development (Cambini et al., 2020a).

To fully realize the benefits of Energy Systems Integration, it is essential to articulate and communicate its value proposition to energy professionals, policymakers, and the public. Understanding the advantages of ESI, such as increased efficiency, enhanced reliability, and reduced environmental impact, is crucial for fostering knowledge generation and transfer. By promoting awareness and education about ESI, stakeholders can better appreciate its potential and contribute to its successful implementation. However, the implementation of Energy Systems Integration is not without challenges. The complexity of integrating diverse energy sources and systems requires careful planning, coordination, and investment. Technical, regulatory, and economic barriers must be addressed to facilitate the seamless operation of integrated energy systems. Policymakers must work collaboratively with industry stakeholders to develop supportive policies and frameworks that encourage innovation and investment in ESI. Additionally, investments in research and development are necessary to advance the technologies and processes that underpin successful integration (Cambini et al., 2020b).

2.10. The Role of Energy Exchanges

Since the liberalization of energy markets in the late 1990s, energy exchanges have become a vital component of the European energy landscape. These exchanges have played a crucial role in shaping how energy is traded, establishing themselves as an essential part of both current and future energy markets. By focusing on efficient, environmentally friendly, and economically viable methods of developing, managing, and integrating resources from both public and private sectors, energy exchanges offer a transparent and competitive platform for energy trading.

Energy exchanges operate by pooling bids to buy energy and offers to sell energy, subsequently determining a purchase price known as the market clearing price based on these bids and offers. This mechanism ensures that the market operates efficiently, facilitating the trade of electricity at the lowest possible cost to meet demand. The wholesale energy market is characterized by daily trading, with transactions occurring every day of the year for power generation scheduled for the following day. The spot price, which reflects the real-time market conditions, fluctuates hourly based on the dynamic interplay of supply and demand. This system allows energy exchanges to respond swiftly to changes in market conditions, ensuring a stable and reliable energy supply (Diallo et al., 2017).

Understanding the functioning of energy exchanges is crucial for comprehending their impact on the energy market. An energy exchange is essentially an automated trading platform that enables both the physical supply of power and the trading of two types of certifications: Renewable Energy Certificates (RECs) and Energy Saving Certificates (ESCs). These certifications play a significant role in promoting sustainable energy practices by providing market-based incentives for the adoption of renewable energy and energy efficiency measures. By facilitating the trading of these certificates, energy exchanges contribute to the broader goal of reducing carbon emissions and promoting the transition to a low-carbon economy (Diallo et al., 2017).

Energy exchanges are instrumental in providing a transparent and equitable method for determining electricity prices. They offer a level playing field for all market participants, from large-scale power producers to individual consumers, allowing for fair competition and efficient price discovery. The ability of energy exchanges to motivate businesses to adopt green energy is particularly noteworthy. By enabling the trade of RECs, they create a financial incentive for companies to invest in renewable energy projects, thereby accelerating the transition to sustainable energy sources. This not only benefits the environment by reducing greenhouse gas emissions but also supports the economy by fostering innovation and creating new business opportunities (Girish & Vijayalakshmi, 2015).

The Indian Energy Exchange (IEX), for example, is a prominent energy exchange that facilitates the trade of electricity across 29 states and 5 union territories. With more than 6,600 participants, IEX enables the buying and selling of electricity through an efficient and transparent platform. On average, the market trades over 6,000 MW of power per day, highlighting the significant volume of energy transactions facilitated by the exchange. The IEX is listed on both the National Stock Exchange (NSE) and the Bombay Stock Exchange (BSE), underscoring its importance in the energy sector and its role in driving market efficiency (Girish & Vijayalakshmi, 2015).

Energy exchanges also contribute to enhancing grid stability and reliability by providing mechanisms for balancing supply and demand. Through sophisticated forecasting and trading algorithms, energy exchanges can anticipate fluctuations in demand and adjust supply, accordingly, minimizing the risk of blackouts and ensuring a continuous flow of electricity. This capability is particularly important in the context of integrating renewable energy sources, which are inherently variable and require flexible grid management solutions. Moreover, energy exchanges facilitate cross-border energy trading, enabling countries to leverage their unique resources and optimize their energy mix. In Europe, the interconnected nature of the energy grid allows for the seamless exchange of electricity between countries, enhancing energy security and promoting regional cooperation. This cross-border trading capability is a testament to the power of energy exchanges to break down barriers and create a unified energy market that benefits all participants (Diallo et al., 2017).

Despite their many advantages, energy exchanges face challenges that must be addressed to fully realize their potential. One such challenge is ensuring that the regulatory framework keeps pace with the rapid evolution of the energy market. Policymakers must work collaboratively with industry stakeholders to develop regulations that support innovation and facilitate the integration of new technologies into the energy exchange platform. Additionally, there is a need to enhance the infrastructure that supports energy trading, including the development of advanced communication networks and data analytics tools that enable real-time monitoring and decision-making. Another challenge is the need to educate market participants about the benefits and opportunities presented by energy exchanges. By raising awareness and providing training programs, energy exchanges can empower stakeholders to make informed decisions and participate actively in the market. This will not only increase market liquidity but also drive greater adoption of renewable energy and energy efficiency measures (Diallo et al., 2017).

2.11. The Market of the Future

The future of the global energy market is increasingly defined by the need for sustainable and resilient energy systems. As countries strive to reduce their carbon footprints and transition away from fossil fuels, renewable energy sources (RES) such as solar and wind have become central to this evolution. Despite significant progress, the current state of the renewable energy market reveals several challenges that must be addressed to fully realize its potential. These include infrastructure limitations, storage capabilities, and the resilience of energy systems in the face of global disruptions such as the COVID-19 pandemic and geopolitical conflicts like the Russia-Ukraine war. The European Union's ambitious climate goals, embodied in initiatives such as Fit for 55 and RepowerEU, highlight the region's commitment to increasing RES penetration. These projects aim to enhance renewable energy's share in the European energy sector significantly by 2030. A critical component of this strategy is the dramatic increase in the installed capacity of photovoltaic (PV) systems within distribution networks. However, the success of these initiatives depends on overcoming the limitations that currently hinder the full integration of RES into energy markets (Lin & Wang, 2022).

One of the primary challenges facing the renewable energy sector is the intermittent nature of solar and wind power. Solar radiation and wind, the primary energy sources for PVs and wind turbines, are not consistently available. Solar power generation is constrained by daylight hours, and wind power is highly variable, dependent on geographic and atmospheric conditions. This intermittency presents a significant barrier to relying solely on RES for energy independence, making it difficult for any nation to achieve complete self-sufficiency based on renewables alone. This challenge is compounded by the lack of robust infrastructure and storage systems, which are essential for balancing supply and demand and ensuring a reliable energy supply (United Nation, 2023).

Energy storage is a critical component in addressing the intermittency of renewable energy. Without effective storage solutions, excess energy generated during peak production periods cannot be stored for use during times of low production. The current state of energy storage technology, however, is not yet advanced enough to fully support the transition to a renewable-dominated energy market. Battery technologies, while improving, remain expensive and limited in capacity. Pumped hydro storage, the most established form of large-scale energy storage, requires specific geographical conditions that are not always available. As a result, significant investment in research and development is necessary to advance storage technologies and make them more economically viable (Lynch et al., 2019).

The current market dynamics further complicate the integration of RES into the energy mix. Renewable energy sources have a high fixed-to-marginal cost ratio compared to conventional energy technologies. This means that while the initial investment in RES infrastructure is significant, the marginal cost of producing electricity is relatively low.

Conversely, fossil fuel-based technologies have lower fixed costs but higher marginal costs, primarily due to fuel expenses. This cost structure raises questions about whether transitioning from fossil fuels to renewables genuinely reduces overall production costs (Lynch et al., 2019).

Moreover, the penetration of RES can impact electricity prices and revenue streams for various energy technologies in complex ways. During periods of high-RES generation, such as midday for solar power, electricity prices tend to decrease, which can reduce the revenues of traditional energy producers. However, when RES are in short supply, conventional power plants often set higher market prices, compensating for some of the revenue loss experienced during low-price periods. This creates a market environment where conventional sources can engage in strategic pricing behavior, while RES producers are more constrained in their ability to influence market prices. Considering these market dynamics, it is essential to consider how the penetration of RES affects price competition, the merit-order function, and supply elasticity. The degree of market competition plays a crucial role in determining the impact of RES on prices. In highly competitive markets, increased RES penetration can drive down prices more significantly, benefiting consumers but potentially squeezing profit margins for all producers. Conversely, in less competitive markets, the impact on prices may be more muted, allowing traditional energy producers to maintain higher revenue levels despite increased RES penetration (Lin & Wang, 2022).

Investors in the renewable energy sector must navigate these complexities when assessing potential returns. The influence of RES on market prices can create both opportunities and challenges, depending on the specific market context and the level of competition. While RES can drive down electricity prices during peak production periods, traditional energy sources may offset these reductions by capitalizing on periods of lower RES availability. As a result, a balanced approach that considers both the potential revenue impacts and the broader market dynamics is essential for successful investment in the renewable energy sector.

The market of the future must address these challenges to fully harness the potential of renewable energy. This includes investing in advanced storage technologies, enhancing grid infrastructure, and developing regulatory frameworks that support the integration of RES. Additionally, policymakers must prioritize the development of a more resilient energy system capable of withstanding global disruptions. Events such as the COVID-19 pandemic and the Russia-Ukraine war have underscored the vulnerability of energy systems to external shocks. Ensuring energy security and stability in such contexts requires a diversified energy portfolio that combines renewables with other energy sources, as well as strategic investments in infrastructure and technology (Pollitt, 2021).

Chapter 3: RES Market, Investments and Legal Framework

3.1. European Energy Market and Existing Legal Framework

Since 1996, steps have been introduced to address market access, transparency and regulation, consumer protection, enabling interconnectivity, and appropriate levels of supply to harmonize and liberalize the EU's internal energy market. These policies seek to create a more competitive, customer-focused, flexible, and non-discriminatory EU power system with market-based supply pricing. In doing so, they strengthen and expand individual customers' and energy communities' rights, address energy poverty, clarify the roles and responsibilities of market participants and regulators, and address the security of electricity, gas, and oil supply, as well as the development of trans-European networks for transporting electricity and gas. Since Russia's invasion of Ukraine and the ensuing energy crisis, the EU energy market structure has undergone substantial structural changes.

In the energy sector, the completion of the EU's internal market necessitates the removal of multiple hurdles and trade barriers, the convergence of tax and pricing policies, norms and standards, and environmental and safety legislation. The goal is to have a working market with equitable market access and a high degree of consumer protection, as well as acceptable levels of interconnection and generation capacity. It is of major importance to also mention that regarding the energy market, Europe is a pioneer in g*as and electricity market liberalization*, as during the 1990s, when most national electricity and natural gas markets remained monopolies, the European Union and its member countries agreed to progressively open these markets to competition. The initial liberalization directives (initial Energy Package) were enacted in 1996 (electricity) and 1998 (gas) and were to be incorporated into the legal systems of Member States by 1998 (electricity) and 2000 (gas). The second energy package was introduced in 2003, the third in April 2009, the fourth in June 2019, and the fifth (also known as "Fit for 55") on 14 July 2021, with the goal of aligning the EU's energy targets with the new European climate ambitions for 2030 and 2050 (Ciucci, 2024).

Europe is the first that has set the ground for the application of advanced renewable energy, having built the first offshore wind farm and been the first continent to implement renewable policy plans. With the European Union aiming to achieve carbon neutrality by 2050, renewable energy investments will remain critical in the future. However, with renewables accounting for only 18% of total power consumption in 2018, the EU is still a long way from meeting its aim (Ciucci, 2024).

Generally, the European policy is concentrated on decarbonization that is cost-effective and the adoption of broad objectives to combat climate change while balancing ever-tougher regulations (policy importance). On this context, there are efforts made to create a democratic system that allows customers to participate in supply, storage and DSM (Demand-Side-Management), and at the same time exhaust full creativity for flexibility of all market participants (Ciucci, 2024).

The existing legal framework governing renewable energy in Europe and Greece plays a crucial role in shaping the landscape for investments in this sector. The European Union's legal framework includes both binding legislation and non-binding instruments, collectively known as "soft law." Soft law, such as guidelines, recommendations, and best practices, often provides flexibility and adaptability in the rapidly evolving field of renewable energy. However, its non-binding nature can lead to inconsistencies in implementation across member states. This flexibility can be advantageous, allowing countries to tailor their approaches to specific national circumstances. Still, it can also create regulatory uncertainty, which may deter large-scale investments if investors perceive these instruments as lacking enforceability or clarity (Inês et al., 2020).

In the realm of internal legislation, European directives and regulations form the backbone of the EU's energy policy. The Renewable Energy Directive (RED II) sets ambitious targets for member states to increase the share of renewable energy in their energy mix. This directive mandates binding national targets and introduces measures to simplify administrative procedures and remove barriers to investment. However, despite these efforts, there are notable gaps in the legal framework that need addressing. One such gap is the lack of a harmonized approach to permitting processes across member states, which can lead to delays and increased costs for investors. Furthermore, the absence of a unified grid infrastructure strategy can hinder the integration of renewable energy into the European energy system, limiting its potential impact (Newbery et al., 2018).

Greek legislation on renewable energy aligns closely with European directives but also presents unique challenges and opportunities. Greece has made significant strides in promoting renewable energy, particularly in wind and solar power, through a range of incentives and supportive policies. The Greek government has implemented feed-in tariffs, net metering, and tax incentives to encourage investment. However, bureaucratic hurdles and complex permitting procedures remain significant barriers to attracting large-scale investments. Streamlining these processes and enhancing transparency would improve the investment climate significantly. Additionally, Greece's energy infrastructure requires modernization to accommodate the increasing share of renewables in the energy mix. Upgrading grid capacity and implementing smart grid technologies are essential steps in ensuring the efficient integration of renewable energy sources (Lowitzsch et al., 2019).

The attractiveness of European and Greek legislation for large investments in renewable energy depends on several factors, including regulatory stability, financial incentives, and market accessibility. While the European Union has made commendable progress in creating a favorable legal environment, further improvements are needed to fully capitalize on the potential of renewable energy. Enhancing cross-border cooperation and harmonizing regulatory frameworks could provide investors with the certainty and predictability they require. Furthermore, addressing the existing gaps in grid infrastructure and permitting processes would significantly boost investor confidence. In Greece, reducing bureaucratic obstacles and ensuring policy continuity are vital for attracting large-scale investments and positioning the country as a leader in renewable energy in the region (Lowitzsch et al., 2019).

Overall, the existing legal framework in Europe and Greece demonstrates a commitment to advancing renewable energy, but there is room for improvement. Strengthening the enforcement of soft law instruments, harmonizing internal legislation, and addressing infrastructure gaps are key areas that require attention. By doing so, Europe and Greece can create a more attractive investment environment, facilitating the transition to a sustainable and resilient energy future. With targeted improvements in these areas, the legal framework can become a powerful tool in driving the growth of renewable energy investments and setting the ground for the market of the future (Inês et al., 2020).

The European energy market is governed by a complex legal framework designed to ensure a secure, sustainable, and competitive energy supply for all European Union (EU) citizens. This framework is outlined in key strategic documents such as the Energy Union strategy and the "Clean Energy for All Europeans" package. The latter, introduced in November 2016, focuses on energy efficiency, renewable energy, electricity market architecture, power supply security, and governance. It underscores the EU's commitment to transitioning towards a more integrated and decarbonized energy system.

The internal electricity market regulation, established under Regulation (EU) 2019/943, revises the rules governing the electricity market to promote efficiency and competitiveness while aligning with the Paris Agreement's decarbonization goals. This regulation emphasizes market-based principles, such as price determination through demand and supply, consumer empowerment, and incentives for clean energy generation. Additionally, it seeks to reduce barriers to cross-border energy flows, holding producers accountable for their power sales, and establishing new prerequisites for capacity mechanisms among Member States (Ciucci, 2024).

Directive (EU) 2019/944 outlines uniform rules for the internal electricity market, placing consumers at the center of the clean energy transition. It allows suppliers to set their own prices while ensuring market-based competition and protecting vulnerable consumers. The directive also grants consumers the right to request smart electricity meters at no extra cost and to access at least one tool comparing supplier offers. Furthermore, it enables consumers to switch suppliers for free and participate in collective switching schemes, promoting active consumer engagement in the energy market. The Risk-Readiness Regulation, Regulation (EU) 2019/941, enhances collaboration among transmission system operators across the EU and neighboring countries to improve risk readiness and manage power networks during electrical crises. This regulation introduces regional operating centers to simplify cross-border management, ensuring a more resilient electricity grid. The European Network of Transmission System Operators for Electricity (ENTSO-E), in partnership with the Agency for the Cooperation of Energy Regulators (ACER) and the Coordination Group for Electricity, has been tasked with developing a unified methodology for risk identification, aimed at enhancing supply security across the continent (Ciucci, 2024).

The fifth energy package discussions commenced amid high energy costs spurred by post-pandemic recovery. The European Commission released the first component of the "Fit For 55" package in July 2021, aiming for a 55% reduction in greenhouse gas emissions by 2030 and achieving climate neutrality by 2050. This package includes measures to support the development of renewable energy sources and transition the EU towards a low-carbon economy. However, the geopolitical tensions following Russia's invasion of Ukraine in 2022 and the ensuing energy crisis have shifted the focus, highlighting the EU's vulnerability to external energy supply disruptions. In response to these challenges, the EU proposed several structural adjustments to its energy markets. The REPowerEU communication outlined a plan to reduce dependence on Russian fossil fuels, emphasizing energy conservation, diversification of supplies, and acceleration of renewable energy deployment. Subsequent proposals included coordinated demand reduction measures for gas and initiatives to lower energy costs for consumers and businesses, reflecting the EU's commitment to energy security and sustainability (Ciucci, 2024).

The establishment of ACER in March 2011 under Regulation (EC) No 713/2009 marked a significant step towards fostering regional and European collaboration among national regulatory bodies. ACER's mandate includes overseeing the internal electricity and gas markets, investigating market abuses, and coordinating fines with Member States. The ACER Regulation (2019/942/EU), adopted in June 2019, reformed ACER's role, enhancing its authority in wholesale market supervision and cross-border infrastructure development. This regulation also introduced fees to cover the costs of ACER's activities, including data collection and analysis. Two regulations established cooperative structures for European Network Transmission System Operators (ENTSOs): Regulation (EC) No 714/2009 for electricity and Regulation (EC) No 715/2009 for gas. These regulations, amended by Commission Decision 2010/685/EU, aim to improve transparency and coordination in the energy sector. Furthermore, Regulation (EU) 2016/1952 requires Member States to report gas and electricity prices to Eurostat, ensuring transparency and fair-trading practices in European energy markets. The EU's commitment to ensuring the security of energy supply is reflected in Regulation (EU) No 2019/941, which establishes measures to maintain a balanced electricity market. This includes ensuring adequate interconnection between Member States, generation capacity, and supply-demand balance. Additionally, Regulation (EU) 2017/1938, updated in response to the Russian-Ukrainian gas crisis, focuses on crisis prevention and response, highlighting the critical role of gas in the EU's energy supply (Ciucci, 2024).

The EU's energy security strategy, issued in 2014, aims to secure a stable energy supply by enhancing energy efficiency, supporting domestic energy production, and completing infrastructure connections to transport energy where needed during crises. This strategy aligns with Directive 2009/119/EC, which mandates Member States to maintain minimum oil inventories, ensuring preparedness for supply disruptions. In May 2019, the Commission introduced amendments to the 2009 Natural Gas Directive, extending its provisions to cross-border pipelines with third countries. This amendment aims to prevent distortions in the EU's energy market and ensure supply security. The proposed changes in December 2021 to Gas Directive 2009/73/EC and Gas Regulation (EC) No 715/2009 further reinforce the legal framework for competitive decarbonized gas markets, supporting the development of an EU hydrogen market and reducing methane emissions. The recent geopolitical tensions following Russia's invasion of Ukraine have underscored the importance of gas storage regulations. The new gas storage regulation, adopted in 2022, mandates EU countries to fill their gas storage facilities to 80% capacity by November 1, 2022, and 90% in subsequent years, ensuring energy security during supply disruptions (Ciucci, 2024).

The Trans-European Networks for Energy (TEN-E) policy aims to connect Member States' energy infrastructure, prioritizing nine corridors and three thematic areas. The new TEN-E

Regulation, enacted in April 2022, promotes the upgrading of Europe's cross-border energy infrastructure, supporting the goals of the European Green Deal. Regulation (EU) No 347/2013 outlines the standards for trans-European energy networks, identifying projects of common interest (PCIs) and priority projects, funded by the Connecting Europe Facility for Energy (CEF-E) (Ciucci, 2024).

The European energy market, supported by a comprehensive legal framework, continues to evolve in response to environmental, economic, and geopolitical challenges. The EU's commitment to transitioning towards a sustainable energy system is reflected in its regulatory measures, promoting energy security, decarbonization, and market integration. As the energy landscape shifts, the EU remains focused on enhancing its energy infrastructure, ensuring a reliable supply, and achieving its climate goals.

3.2. International Legal Framework and Investments

International investment law forms a comprehensive body of legal principles and agreements that regulate the entry and treatment of foreign investments. The foundation of this legal framework lies in investment treaties, which are negotiated between states to encourage investment flows by establishing clear obligations regarding the protection and treatment of investments by citizens of one state within the territory of another. Most of these treaties are bilateral, focusing solely on investment-related issues. However, there is a growing trend toward regional and bilateral trade agreements that include investment chapters. Due to the dominance of bilateral and regional treaties in international investment law, the legal framework applicable to specific investments may vary depending on the host and home governments involved. Although many treaties share broadly similar language and underlying principles, variations in precise wording can result in significant differences in the standards of treatment investors are entitled to.

A key aspect of these treaties includes "national treatment" and "most-favored-nation" clauses, which require states to treat foreign investors or investments no less favorably than they treat their own nationals or those of other states in similar circumstances. Additionally, "full protection and security" provisions often mandate that nations preserve the physical integrity of foreign investments, although these provisions can sometimes be interpreted more liberally to include legal protection. "Fair and equitable treatment" clauses require states to treat international investments fairly, regardless of the standards applied to domestic investments under national law. Furthermore, many treaties contain clauses that limit the authority of governments to expropriate foreign investments, typically stipulating that any expropriation must serve a public purpose, be non-discriminatory, and comply with due process while providing compensation based on established standards tied to market value (Cotula, 2015).

Investment treaties often include provisions that ensure currency convertibility and allow investors to repatriate profits, facilitating the free movement of capital. Beyond establishing substantive norms of treatment, these treaties frequently provide for investor-state arbitration as a mechanism for resolving disputes between investors and host states. This arbitration process allows investors to bypass domestic courts and seek recourse in international arbitration centers, each with its own set of rules. The International Centre for the Settlement of Investment Disputes (ICSID), hosted by the World Bank, is a prominent institution in this field, hearing hundreds of arbitrations annually. Arbitrations may also be conducted outside established institutions, often following standards set by the United Nations Commission on International Trade Law (UNCITRAL) (Seatzu & Vargiu, 2015).

In investor-state arbitration, investors typically allege treaty violations and seek monetary compensation. Once a tribunal rules on a case, it issues a binding award, akin to a legal verdict. If the tribunal finds that a treaty has been violated, the host state is generally ordered to compensate the investor. The enforcement of these awards is facilitated by multilateral accords that most countries have ratified, allowing investors to pursue enforcement in any signatory nation where the host state holds assets. Given the globalized nature of today's economy, almost all governments possess assets abroad, making this form of legal action effective. Furthermore, governments are often compelled to comply with arbitral awards to maintain their attractiveness to foreign investors. Despite these enforcement mechanisms, some countries have recently refused to honor arbitral decisions, raising concerns about the efficacy of investment treaties and arbitration (Seatzu & Vargiu, 2015).

Investment treaties and arbitration offer a platform for international scrutiny of state behavior, granting arbitral tribunals, typically composed of three private individuals, the authority to evaluate actions taken by governments, legislatures, or national courts based on broadly defined treaty norms. This scrutiny has led investors to challenge various government actions, including environmental permit refusals, smoking legislation, incentives for local research and development activities, contract terminations, affirmative action measures, and environmental regulations. Arbitral tribunals have awarded substantial compensation to investors for treaty violations, raising concerns that the prospect of significant awards and costly arbitration hearings may deter governments from pursuing socially beneficial public actions. This is particularly concerning in low-income countries with limited public funds. Studies indicate that even high-income nations consider potential liabilities in their policymaking processes, suggesting that investment treaties may constrain regulatory space. Moreover, debates persist about the appropriate distribution of costs for socially desirable public actions between public and private actors (Coyle & Drahozal, 2019).

In addition to actions initiated by public authorities, large-scale investments can generate grassroots contestation due to perceived or actual negative social or environmental impacts, such as land expropriations, soil degradation, and water pollution. Investors have sometimes resorted to investor-state arbitration to challenge civil society-initiated court procedures or government responses to grassroots actions. This highlights the complexities of regulatory space, which encompasses not only government action but also contestation and negotiation involving a range of public and private stakeholders seeking to influence national decision-making (Cotula, 2015).

International investment treaties and bilateral investment treaties are often promoted as tools to attract foreign direct investment by providing robust protections for investors, liberalizing investment regimes, and reducing regulatory burdens. Each country typically has a defined investment strategy to safeguard its rights, borders, and natural resources. A country retains the sovereign right to determine the extent of protection offered to investors, either broadening it to encompass as many investors as possible or restricting it to a select few. One mechanism for addressing the asymmetric legal position created by foreign investment agreements is the use of counterclaims by the host state. Counterclaims allow the state to bring claims on behalf of affected individuals, organizations, or indigenous communities harmed by investor actions. This approach centralizes legal proceedings, potentially preventing inconsistent outcomes in different forums and enhancing the credibility of arbitral institutions. Counterclaims have the potential to equalize access to arbitration for disputing parties and enhance the accountability of investors, potentially raising corporate governance standards (Coyle & Drahozal, 2019).

The introduction of counterclaims holds significance for both states and investors. For states, it offers a means of addressing grievances arising from investor actions, while for investors, it introduces considerations of nuisance value and deterrent effects that may influence arbitration and litigation strategies. Furthermore, counterclaims shift the tribunal's focus from solely evaluating state actions to considering investor conduct, potentially affecting the tribunal's perception of primary allegations (Coyle & Drahozal, 2019).

Contractual dispute resolution clauses represent another avenue for pursuing counterclaims. International transactions often present unique legal challenges, particularly when multiple countries are involved. To mitigate these risks, parties commonly include dispute resolution clauses in contracts, such as arbitration agreements and forum selection provisions, to reduce forum uncertainty. Choice-of-law provisions clarify applicable legal standards. However, a notable percentage of new cases registered with ICSID in recent years are contract-based, underscoring the complexity of resolving disputes through contractual mechanisms (Seatzu & Vargiu, 2015).

While domestic courts offer an alternative avenue for dispute resolution, they may not always be reliable due to issues such as political pressure and corruption. Additionally, an investor's local courts may be reluctant to handle extraterritorial matters, further complicating the resolution process. Thus, the international legal framework governing investments remains a critical factor in shaping the global investment landscape, balancing the rights and obligations of states and investors within a complex web of legal agreements and dispute resolution mechanisms.

3.3. Counterclaims and Umbrella Clauses

The international legal landscape governing foreign investments includes several mechanisms designed to balance the interests of investors and host states. Among these mechanisms are counterclaims and umbrella clauses, both of which play crucial roles in shaping the legal dynamics between investors and states. Counterclaims serve as a defense mechanism for states, allowing them to address grievances related to foreign investment agreements. In contrast, umbrella clauses provide a distinct basis for claims, often extending the scope of obligations under international treaties. Together, these elements contribute to a complex legal framework that influences the behavior and responsibilities of both investors and host states.

Counterclaims are legal instruments that enable states to address the imbalance often perceived in foreign investment agreements. These claims allow states to bring petitions on behalf of individuals, organizations, or indigenous communities who have been harmed by the actions of investors. In essence, counterclaims provide a mechanism for the state to hold investors accountable for their actions, thereby restoring some balance to the investor-state relationship. The state's ability to pursue counterclaims ensures that private entities are held accountable for violations on state property, emphasizing the importance of due diligence. This centralized approach to resolving disputes can enhance efficiency, avoid repetitive litigation, and prevent conflicting outcomes across different forums, thereby maintaining the legitimacy of the international arbitration system. Counterclaims have been recognized for their potential to level the playing field in investor-state dispute settlement. They enhance the effectiveness of arbitration by allowing both parties to present their grievances, promoting a more balanced approach to resolving disputes. Furthermore, the international enforcement mechanisms available in investment arbitration are often more robust than those in domestic courts, offering better protection for victims in cases where investor liability is established. This increased accountability can lead to improved corporate governance, as investors are held to higher standards of responsibility in their dealings with host states (Kryvoi, 2012).

Investment agreements between investors and host states are designed to establish specific regulations that differ from the host state's general legislation. These agreements aim to create a stable legal framework that governs the relationship between the parties throughout their collaboration. Investors, particularly those engaging with states prone to political or judicial instability, often seek stability provisions to protect their investments. Host states may accept these provisions to attract international investment. A stability clause, in its strictest form, would require the host state to maintain its existing legal framework for the subject matter of the clause. Typically, investors are concerned with the durability of their specific arrangements with the host state. Stability is achieved through intangibility provisions that shield investment contracts from changes in host state law (Bjorklund, 2013).

Contractual dispute resolution clauses present alternative avenues for advancing state claims. These clauses can be incorporated into contracts to address disputes, as evidenced by the fact that 14% of new cases registered with the International Centre for Settlement of Investment Disputes (ICSID) in 2018 were contract-based. However, challenges arise when relying on domestic courts, as the host state's courts may be subject to political pressure or corruption, and the investor's local courts may be unwilling to handle extraterritorial matters (Bjorklund, 2013).

The success rate of counterclaims brought by host countries against investors has been limited, primarily due to constraints imposed by Article 46 of the ICSID Convention. This article requires jurisdictional claims to be based on bilateral investment treaties (BITs), which often limit dispute resolution provisions to claims brought by investors, excluding counterclaims by the state. According to Article 46, unless otherwise agreed by the parties, the tribunal must address any incidental or additional claims arising directly from the dispute, provided they fall within the parties' consent and the jurisdiction of the Centre. For a counterclaim to be valid under Article 46, three conditions must be met: the counterclaim must be directly related to the subject matter of the dispute, there must be agreement from both parties to arbitrate the counterclaim, and the ICSID panel must have jurisdiction to hear the claim (Kryvoi, 2012).

Umbrella clauses, on the other hand, provide a legal basis for claims rooted in violations of domestic law obligations by the state, exercised through its sovereign authority. These clauses are said to "internationalize" domestic law obligations by creating a separate cause of action under BIT. However, the interpretation and application of umbrella clauses can vary significantly, depending on several factors. The function of an umbrella clause relates to its intended impact. It may serve as an aspirational statement, rather than an operational treaty clause, or it could establish a new cause of action by internationalizing domestic law obligations. The scope of an umbrella clause defines the specific responsibilities to which it applies, ranging from covering all obligations arising from contracts to including unilateral commitments. Jurisdictional precedence involves the weight given to contractual forum selection provisions when an umbrella clause claim is based on a contractual duty. Privity concerns the relationship between the parties involved in the umbrella clause claim, including whether the claimant or respondent is a party to the contract (Douglas, 2023).

Umbrella clauses present interpretational challenges in investor-state arbitration. The function of an umbrella clause can range from serving as an aspirational statement to providing a distinct cause of action under the BIT. This function influences how the clause is applied and interpreted in specific cases. The scope of an umbrella clause determines the specific obligations it covers, including contractual and unilateral commitments. Jurisdictional precedence refers to the consideration given to contractual forum selection provisions, while privity examines the relationship between the parties involved in the umbrella clause claim. The varied interpretations of these factors contribute to the complexity of umbrella clauses and their application in international investment law (Douglas, 2023).

From the state's perspective, it may not be held liable for actions taken by separate legal entities, even if they are state-owned or performing public functions. However, there is an alternative view that such entities can be held accountable for commercial activities, depending on applicable international law. When investors pursue claims under an umbrella clause provided in the relevant BIT, rather than directly as contractual claims, the situation becomes more challenging (Aceris Law, 2018).

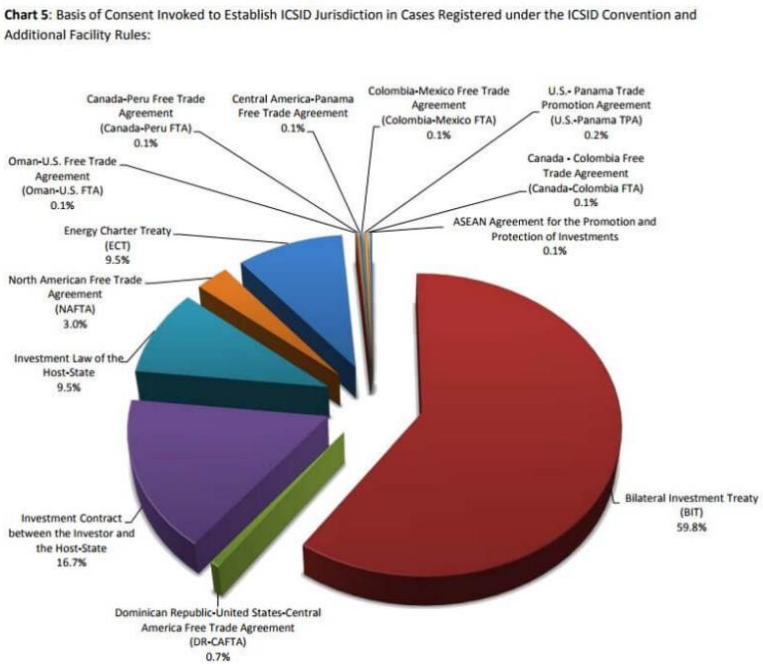


Diagram 11: Basis of Consent Invoked to Establish ICSID Jurisdiction in Cases Registered under the ICSID Convention and Additional Facility Rules (Aceris Law, 2018).

The diagram provides a breakdown of the bases of consent used to establish jurisdiction under the ICSID (International Centre for Settlement of Investment Disputes) Convention and Additional Facility Rules in various cases. It reveals that most cases, 59.8%, are grounded in Bilateral Investment Treaties (BITs), underscoring the prominence of BITs as a foundational legal framework for resolving international investment disputes. The Investment Law of the Host State accounts for 13.9% of the cases, highlighting the importance of national legislation in some disputes. The Investment Contract between the Investor and the Host State represents 16.7% of cases, indicating that specific contractual agreements also play a significant role in arbitration. Various Free Trade Agreements (FTAs) contribute smaller percentages, with the Dominican Republic-United States-Central America Free Trade Agreement (DR-CAFTA) at 0.7%, and several other FTAs, such as the ASEAN Agreement and the North American Free Trade Agreement (NAFTA), comprising minor shares. This distribution underscores the diverse legal instruments available for investors and states to establish jurisdiction in ICSID proceedings, emphasizing the central role of BITs while also recognizing the relevance of national laws and specific contractual agreements.

In conclusion, counterclaims and umbrella clauses play significant roles in shaping the legal framework for international investment. Counterclaims offer a mechanism for states to hold investors accountable, promoting a more balanced approach to investor-state relations. Meanwhile, umbrella clauses provide an avenue for addressing violations of domestic law obligations by states, contributing to the complex legal landscape of international investment law. Understanding the nuances and implications of these mechanisms is crucial for navigating the intricate dynamics of foreign investment and ensuring a fair and equitable resolution of disputes.

3.4. BITs: Investor and Investments

Bilateral investment treaties (BITs) are agreements made between two States wherein one party commits to operating in a specific manner and refraining from engaging in certain conduct that is harmful to investors who are citizens of the other contracting party. These international agreements are interstate in nature, but they are meant to help non-signatory investors who are private people. These investors also directly benefit from international arbitration since BITs provide them with direct access to it. This indicates that individuals have the authority to file a claim against the State receiving their investment on the grounds that the State has disregarded its BIT responsibilities. The unique feature of BITs is that only investors may use the international arbitration procedure. The investors are granted the exceptional right to assert their rights before a panel for international arbitration.

The investors who profit from BITs are not identified by name; they are only recognizable. This implies that the treaties contain a criterion that will enable the identification of those investors who may benefit from a treaty's protection, as appropriate and on a case-by-case basis. The nationality connection between an investor and a signatory State is the criteria in dispute. The site of incorporation, the head office, and the control are the three basic factors used in BITs to identify nationality. It is important to say that a BIT is in fact designed to safeguard the interests of citizens of one contracting party who invest in that party's territory (Yackee, 2008).

Positively, this indicates that only investors who are citizens of a contractual State can file a claim against another contracting State that is hosting their assets. In a negative sense, it also implies that investors who are citizens of a state that is not a party to the BIT and investors who are citizens of the contracting State in which their investment is made are ineligible to use the treaty's provisions for international arbitration against that State. As a result, determining an investor's nationality is essentially the only way to determine if that investment is covered by a BIT. An important factor in assessing the extent of the protection provided by an investment treaty is the nationality connection (Yackee, 2008).

However, it does not, in general, intend for investors of non-party States or its own nationals to be able to profit from a BIT particularly negotiated with another State in a particular situation and for specific purposes by signing a bilateral and reciprocal agreement. In any event, making protection widely available to investors has substantial/practical ramifications. To attract foreign money, regardless of its origin, it is certainly fine to give rights and assurances to as many investors as possible. But permitting any investor to sue the host State in international arbitration is another story. It should be noted that there have been about 400 investor-state arbitrations initiated under investment treaties so far. The International Centre for Settlement of Investment Disputes is where the majority of them have been started during the past ten years (ICSID). 4 Moreover, access to international arbitration is a common feature of the rights and assurances provided by existing BITs. Thus, it is crucial to determine who is eligible to use the BITs' built-in international arbitration process (Yackee, 2008).

Generally, in Bilateral Investment Treaties (BITs), with respect to a contracting party, an "investor" can be either a natural person having the citizenship or nationality of who is permanently residing in that contracting party with its applicable law, or legal persons (companies/businesses). Depending on whether people or businesses are engaged, the problems vary. ECT's definition of 'investor' includes a company or other organization organized in accordance with the law applicable in that Contracting Party. Investors who are covered by investment treaties are required to be citizens of one of the States parties, not the host State or a third-party State (Nikièma, 2012).

Cases of dual nationality are more challenging for natural people than for legal people in the context of investor-State arbitration. This is largely explained by the fact that it is uncommon for businesses to be able to equally claim both nationalities based on the same standard. Yet, it does happen with joint venture firms where two partners have equal control. They can be seen as possessing the nationality of each partner in this situation. The fact that businesses themselves, together with their individual owners, are typically regarded by BITs as investors provides a secondary justification. On this basis, any shareholder can assert their individual right to a treaty benefit in cases where the company's nationality poses a challenge. There are two possible dual nationality possibilities for natural beings (Nikièma, 2012).

Two major difficulties are spotted when using BITs among states. The first is the fundamental principle of reciprocity, in which investors from State B are granted access to international arbitration when State A agrees to do so in exchange for granting its own citizens the same benefit. However, when a State C investor unfairly profits from that BIT, State A is forced to defend those investors rather than allowing its own investors to seek the same treatment in States C with whom it does not have a BIT (Legum, 2006).

The second difficulty arises from the proliferation of intermediary investors protected by a single investment. This is the risk of multiple claims. The host State risks being brought to multiple arbitration procedures over a single investment and a single dispute. Numerous foreign investors may claim the protection of numerous BITs. These include a company subject to local law and created for the purpose of investment under foreign control, the intermediary subsidiaries, the parent company, the majority shareholders in each of these companies, and even the minority shareholders in each of these companies. The probability of several claims for a single investment and a single dispute increases with the number of BITs the host State has signed with countries in which these firms or shareholders are citizens. It will also be required to take into account any venues for dispute resolution outlined in any contract between the intermediary investor and the host State. All these problems are amenable to resolution through various national and international channels. In this approach, the State could be required to react to many judicial cases concurrently, with all the associated expenses. Conflicting arbitral judgments and court rulings are also a genuine possibility. There are already cases of this kind in case law (Simmons, 2014).

The Article 46 of the ICSID Rules granting ICSID courts first competence to consider counterclaims (Reisman, Goetz vs Burundi). If this is the case, then existing BIT constraints, such as relevant legislation, are withdrawn and permission is presumptively given. These constraints were imposed on host states by limiting their regulatory autonomy, as they require states to adhere to specific standards of treatment for foreign investors, such as fair and equitable treatment, protection from expropriation without compensation, and non-discriminatory practices, potentially restricting a state's ability to implement domestic policies that might conflict with these obligations. This presumption extends beyond the admission of counterclaims. According to Professor Douglas, who appears to support this strategy, the host State's counterclaim may have a contractual requirement, domestic regulatory obligation, or another legal foundation as long as it closely connects to the parties' disagreement over the investment in question. Consequently, the constraint that has thus far been the biggest barrier to enabling counterclaims made under domestic laws would be removed by Professor Douglas' "factual nexus" approach, which would permit counterclaims that are not always based on the law specified by the BIT as relevant (Jandhyala et al., 2011).

The setback of the applicable law is that whether national law or a contract, in addition to the BIT, is the relevant law before the international court, there is a strong argument in favor of allowing counterclaims. Such an example is Netherlands -Czech and Slovak Federal Republic BIT (1991) Art. 8(6): "The arbitral tribunal shall decide on the basis of the law, taking into account in particular though not exclusively: the law in force of the Contracting Party concerned; the provisions of this Agreement, and other relevant Agreements between the Contracting Parties; the provisions of special agreements relating to the investment; the general principles of international law" (Nikièma, 2012).

In contrast, since BITs exclusively give rights to investors, a condition that exhausts the court's jurisdiction in petitions based on BIT is presumably insufficient to be lodged as a counterclaim. An exception to the theory is that even in the presence of a restricted provision, the state may nevertheless file a complaint for abuse of process since the investor's decision to start arbitration gives rise to this claim. This could be a possibility if the investment arbitration is initiated, for instance, to impede on domestic criminal or other legal processes, causing the respondent state delays, annoyance, and financial losses (Simmons, 2014).

Despite their investor-centric focus, BITs do not typically grant states the same level of legal standing, or locus standi, to initiate claims against investors. The legal standing, or locus standi, is primarily conferred upon investors, allowing them to bring claims against host states for alleged breaches of the treaty's provisions. This asymmetry is deliberate, reflecting the underlying objective of BITs to protect investors and their investments from potential arbitrary or unfair treatment by host states. As a result, the host state's role in these treaties is generally confined to that of a respondent in disputes initiated by investors, rather than as an active claimant (Sprenger & Boersma, 2014).

The limited capacity of states to bring claims against investors under BITs does not imply a total absence of legal recourse. One avenue available to host states is the use of counterclaims within the arbitration process. If the BIT or the specific arbitration rules permit, a host state can file counterclaims against an investor. This mechanism allows the state to respond to claims made by investors, potentially offsetting any liability or even securing remedies for breaches of domestic laws or contractual obligations by investors. However, it is important to note that counterclaims are reactive rather than proactive, meaning they can only be pursued in response to an investor's-initiated claim (Sprenger & Boersma, 2014).

Another potential avenue for states under certain BITs is the state-to-state dispute resolution mechanism. These provisions allow states to engage in arbitration or negotiation concerning the interpretation or application of the treaty itself, rather than addressing specific grievances against individual investors. This mechanism is generally reserved for disputes about the overarching principles and clauses of the treaty, and not for adjudicating claims directly against foreign investors. The design of BITs reflects a broader international investment law architecture that prioritizes the protection of investments over host state interests in initiating claims. This focus aligns with the fundamental purpose of BITs, which is to create a stable and predictable legal environment that encourages cross-border investments by safeguarding investors against potential risks posed by host state actions. However, this framework has drawn criticism for potentially constraining host states' regulatory autonomy and for creating an imbalance in the rights and responsibilities between states and investors (Simmons, 2014).

Finally, it must be emphasized that the majority of BITs do not forbid abusive activities, notwithstanding these dangers of extensive and unanticipated exposure to investor claims and their detrimental effects on the host State (Sprenger & Boersma, 2014).

3.5. Definition of Investor

An investor is identified as any individual or other entity (such as a business or mutual fund) who invests money with the aim of making a profit. Stocks, bonds, mutual funds, derivatives, commodities, and real estate are examples of investment securities. Investors depend on a variety of financial instruments to generate a rate of return and achieve crucial financial goals like saving for retirement, paying for a child's school, or just collecting more wealth over time. Investors all share the tendency to seek to minimize risk while maximizing profits as a shared characteristic. As they commit capital, investors take on risk and strike a balance between controlling risk and reward.

Investors vary from traders by taking long-term strategic positions in businesses or projects, by building portfolios with either an active or passive approach that strives to outperform the benchmark index, and by being inclined toward either growth or value strategies. Investors frequently concentrate on a company's core principles while being more focused on its long-term prospects and they base their investment choices on the possibility that the price of a stock will increase (Nikièma, 2012).

In the business world, investors play a critical role in providing the financial resources necessary for businesses to grow and thrive. They are generally categorized into five distinct types, each with their own characteristics, goals, and investment strategies. These types include angel investors, venture capitalists, peer-to-peer lenders, personal investors, and institutional investors. Each category of investors contributes uniquely to the financial ecosystem and supports different stages of business' development (Di Pietro & Cheung, 2020).

Angel investors are typically high-net-worth individuals who provide capital to startups or entrepreneurs, often in exchange for equity in the company. These investors are known for taking significant risks by investing in early-stage ventures where the potential for failure is high. Angel investors usually step in at the earliest stages of a startup's life cycle when traditional sources of funding, such as banks, are not accessible due to the high-risk nature of the business. They offer a critical financial lifeline that allows nascent companies to develop their products, refine their business models, and reach a point where they can attract further investment. The investments made by angel investors are not limited to monetary support; they often bring their own experience, networks, and mentorship to the businesses they invest in, contributing to the overall growth and success of the startup (Di Pietro & Cheung, 2020).

Venture capitalists, on the other hand, are private equity investors who focus on funding startups and small businesses that demonstrate strong growth potential. Unlike angel investors, venture capitalists usually represent firms rather than individuals and are interested in businesses that have moved beyond the initial startup phase. They seek out companies that are in the early stages of development but have already shown promise through their products or services. Venture capitalists provide the capital needed for these businesses to scale their operations and enter new markets. In exchange for their investment, venture capitalists acquire an ownership stake in the company, with the goal of selling this stake at a profit once the company has achieved substantial growth. This investment approach not only provides businesses with the necessary funds to expand but also brings in strategic support and industry expertise that can drive further development and success (Nikièma, 2012).

Peer-to-peer lending, or P2P lending, offers an alternative to traditional bank financing by facilitating loans directly between individuals. This form of lending eliminates the need for a conventional financial intermediary, such as a bank, and instead allows borrowers to connect directly with individual lenders through online platforms. One popular example of this model is crowdsourcing, where businesses seek to raise funds from multiple investors online in exchange for rewards or other benefits. P2P lending has gained popularity due to its accessibility and flexibility, enabling borrowers to obtain funding that might otherwise be difficult to secure through traditional financial institutions. Investors participating in P2P lending are often attracted by the potential for higher returns compared to conventional savings accounts or fixed-income securities (Lin, 2012).

Personal investors are individuals who invest their own money across various financial instruments, such as stocks, bonds, mutual funds, and exchange-traded funds (ETFs). Unlike institutional investors, personal investors typically operate independently and are motivated by the desire to achieve higher returns on their investments. These investors often have specific financial goals, such as building wealth for retirement or generating passive income, and they make investment decisions based on their own research and risk tolerance. Personal investors may employ a range of strategies, from conservative approaches focused on preserving capital to more aggressive tactics aimed at maximizing returns. Despite the challenges posed by market volatility and the need for a sound understanding of investment principles, personal investors continue to play a significant role in the financial markets, contributing to overall market liquidity and diversity (Lin, 2012).

Institutional investors represent organizations that manage substantial pools of capital on behalf of others. These entities include mutual funds, exchange-traded funds, hedge funds, and pension funds. Due to the significant amount of capital they control, institutional investors have considerable influence over asset prices and market dynamics. They can purchase large quantities of securities, such as substantial blocks of stocks, which can have a notable impact on the markets. Institutional investors benefit from economies of scale, allowing them to access resources, technology, and expertise that individual investors may not possess. Their sophisticated investment strategies, informed by in-depth research and analysis, enable them to make informed decisions that can drive market trends and shape the investment landscape (Lin, 2012).

Investors receive a return on their investment. The money gained or lost on an investment over time is referred to as a return, often known as a financial return. The nominal change in the dollar value of an investment over time can be used to describe a return. The ratio of profit to investment can be used to calculate a return as a percentage. Returns can either be shown as net results (after costs, taxes, and inflation) or as gross returns, which just take the price change into account. When it comes to payment of the (positive) return, common stock and debt holders often receive repayment after investors or preferred shareholders. In venture capital contracts, the liquidation preference is widely employed (Hussain, 2024).

Investing is often done by people to achieve a variety of financial goals, including wealth creation, early retirement, tax savings, and staying ahead of inflation. To succeed as an investor, a specific set of abilities are necessary, which consist of perseverance, knowledge acquisition, risk management, discipline, optimism, and goal setting (Hussain, 2024).

3.6. Investment Arbitration, State & Investor Consent

Foreign investors and host countries can resolve their differences through investment arbitration. Investment protection agreements are meant to have the effect of promoting investment and, in turn, the economic growth of the contractual parties. Three methods exist for parties to enter the arbitration process: judicial arbitration, contractual arbitration, or via stipulation.

The establishment and competence of arbitration tribunals are determined by consent. As a result, it is a cornerstone of the investor-state arbitration system. Arbitration requires consent, whether between private parties in commercial transactions or between a foreign investor and its host state. Furthermore, the host State and foreign investors may grant their permission to arbitration at various periods. It is common for the host State to provide approval initially, which is considered as a standing offer. The investor's acceptance of this offer, and therefore its consent, can be performed by submitting a request for arbitration or by direct notice to the respondent State. Due to the multiplicity of treaties and contracts between foreign investors and host countries, whether a host country has consented or not to arbitration and the breadth of that permission is frequently contested (Blyschak, 2009).

In terms of the type of permission, most arbitration rules do not specify what constitutes valid consent. The Convention on the Settlement of Investment Disputes between States and Nationals of Other States ('ICSID Convention'), for example, requires written permission to arbitration. It does not, however, go on to specify the writing requirements. In such cases, conflicting parties are allowed to express their consent in whatever way they see fit. In the circumstances, investment arbitration tribunals have considerable leeway in evaluating whether consent has been provided, its legality, and its breadth (Ataman-Figanmeşe, 2011).

As in commercial arbitrations, party autonomy, particularly the assent of the parties to arbitration—is a fundamental characteristic of investor-State arbitration. However, permission for investment arbitration differs from that for commercial arbitration. In most circumstances, consent is not granted in an agreement signed by both conflicting parties. Host countries frequently express their approval through local laws, bilateral investment treaties (BITs) and free trade agreements (FTAs) to which they are parties, or multilateral treaties such as the Energy Charter Treaty or the North American Free Trade Agreement (NAFTA), and each of these is regarded as a standing offer that investors can accept. Foreign investors are not party to international treaties or unilateral statements in such instances. This is known as "international arbitration without privity," since it "allows the true complainant to face the true defendant." This has the enormous benefit of clarity and reality; these values, rather than flowery proclamations, are the foundations for trust in the legal process. The tendency is that privity is no longer an issue in investor-state arbitration. Even those who disagree with the above argument must recognize that the practice favors arbitration without privity (Wang, 2014).

In addition to privity, there are several additional elements to consider when deciding whether the disputing parties have accepted to arbitration, which is a requirement for the jurisdiction of arbitration courts (Ataman-Figanmeşe, 2011).

Truth be told, the significance of consent cannot be overstated. State Parties to the ICSID Convention may express consent by, for example, negotiating BITs or passing domestic laws that include a commitment to refer conflicts with foreign investors to the International Centre for Settlement of Investment conflicts (ICSID). According to the ICSID Convention, once permission to arbitration is provided, no party may unilaterally withdraw such consent. Furthermore, unless otherwise specified, any acceptance to ICSID arbitration is assumed to constitute a waiver of any alternative recourse. At the same time, agreement to arbitration may be subject to limitations under local laws and BITs. Given the nature of investor-State arbitration, any decision of the presence of consent requires interpretation of the applicable international treaties and arbitration procedures. As a result, arbitral tribunals must interpret consent clauses in line with the real meaning of the treaty provisions (Wang, 2014).

Because investor-State arbitration includes sovereign states, courts must exercise extreme caution when the respondent State raises an argument to jurisdiction based on a lack of consent. Sometimes, in investor-State arbitration, the respondent State disputes whether permission to arbitration was provided. If the answer is affirmative, the question is whether consent is effective when the dispute occurs. In other circumstances, the responding State even claims that no consent was granted (Wang, 2014).

In the context of international investment, states frequently join into a BIT years before an investment dispute is brought to arbitration. It is also uncommon for an entity to be founded long after a State has entered into a BIT with another State—the moment at which it is assumed to have granted its agreement to arbitration—and to invest in the State. As a result, it is usually acknowledged that the date of granting approval for the investor/claimant is the date of filing a request for arbitration. Modern BITs always include provisions for investor-State arbitration, which signifies the host State's agreement to it. When an investor initiates arbitration procedures, such conduct is interpreted as acceptance of the BIT's offer. Estoppel is unlikely to emerge in such situations (Blanchard, 2011).

In the modern world, states may proclaim their readiness to have conflicts with foreign investors settled through international arbitration in their own national legislation in order to attract foreign investment. This might be seen as an offer of assent to arbitration. Host countries often make unilateral pledges to attract FDIs for the same reason. However, expressing acceptance to arbitration in a unilateral commitment is unusual in practice. Unilateral commitment raises the issue that, if affirmed, the norm of substantive treatment must be set in line with national legislation and customary international law. With an increasing number of BITs in place, unilateral arbitration consent is no longer the primary form of expressing arbitration consent. To use a certain approach in reading unilateral declarations and national legislation is one thing; whether such interpretation represents the intent of the states involved is quite another. This is especially relevant given that most, if not all, nations have norms for interpreting their own laws, which may differ from the legislation used by investment tribunals (Ataman-Figanmeşe, 2011).

A request for arbitration is, by definition, permission to arbitrate since a legal procedure cannot be sought by a party who does not participate in the proceeding. To desire legal procedure is to submit to it. The consent that completes the arbitration agreement and establishes the arbitral tribunal's jurisdiction is an unconditional request to commence arbitration submitted by another. Foreign investors could not be said to have been notified of the consent requirements. Second, in practice, participation in arbitration is often seen as an indication of agreement to arbitration, with no more action required to prove such consent. In any case, arbitration practice demonstrates that the formality of consent is not stressed. Tribunals are willing to acknowledge the presence of consent once it has been proven without questioning if every ceremonial detail has been followed (Wang, 2014).

The determination of the presence of consent is equally critical in investor-state arbitration. However, it is also necessary to consider the time when such consent becomes effective. A legal prescription should not have retroactive effect in any system controlled by the rule of law. The same idea applies to bilateral and multilateral treaties and international agreements. Since the goal of BITs is to attract foreign investment, the protection afforded to foreign investors under the terms of a newly negotiated BIT may be extended to investors of the other Contracting Party even before the relevant BIT goes into force. Even so, when it comes to dispute resolution, particularly international arbitration of such disputes, states are hesitant to apply the BIT retroactively to disagreements that arose before to the BIT's effective date (Blyschak, 2009).

Finally, consent in investor-State arbitration is comparable to consent in commercial arbitration. At the same time, permission to arbitration cannot be conveyed in the same instrument to which the foreign investor is a party. In most circumstances, the host State is the first to accede to arbitration, as stated in its BITs and FTAs or its own national legislation. In reality, such consent is viewed as an offer that investors may accept in formal writing form or through the establishment of arbitration procedures. Because all investor-State arbitration involves international duties of the host State, whether there is valid consent must be read in line with treaty interpretation standards of international law. However, practice in this area is insufficient (Wang, 2014).

Investment tribunals are frequently regarded as favoring assertive jurisdictions. Arbitrators have an inevitable conflict of interest when it comes to jurisdiction since they are paid by the opposing parties. In these instances, tribunals' claim of jurisdiction without justification may be seen as gaining business and revenue for the arbitrators themselves. Given these facts, tribunals should use extreme caution when interpreting treaty provisions, especially those pertaining to consent (Blanchard, 2011).

3.7. Markets and Regulation: EU Market Coupling

The various policies implemented to encourage renewable energy systems, as detailed in numerous publications, are explored in this section. While an uncertainty analysis is not mandatory for the inclusion of these regulatory frameworks, it is crucial to understand that the parameters subject to ambiguity can vary significantly depending on the framework applied. This makes it essential to clarify these policies beforehand, as the regulatory environment plays a pivotal role in shaping the renewable energy landscape. In energy markets, several regulatory frameworks are particularly noteworthy for their roles in promoting renewable energy.

Feed-in Tariff (FiT) and Feed-in Premium (FiP) are two of the most frequently employed frameworks in research. These systems are named for their mechanism of compensating energy that is fed into the grid, thereby incentivizing renewable energy production by offering either a set tariff over the market price (FiT) or providing a premium (FiP). Three key characteristics define feed-in systems: preferential grid access for renewable energy producers, the obligation to absorb all renewable energy supplied into the electrical system, and a government-mandated minimum price or premium for selling renewable power. The level and type of subsidy depend on several factors, including the energy source, plant size, location, and political objectives. To drive technological progress, FiT and FiP should decrease over time, as less subsidy is needed as technology advances. Low tariffs, however, can deter investment in renewable energy, highlighting the need for authorities to address regulatory uncertainty actively. Tariffs and premiums often fluctuate unpredictably over the lifespan of a facility, necessitating a stable regulatory framework to encourage investment in renewable energy technology (Alonso-Travesset et al., 2023).

Net Metering (NM) and Net Billing (NB) are designed to target prosumers, allowing them to pay only for their net consumption (NM) or net monetary balance at the end of the billing period (NB). In this system, the difference between energy consumed and energy fed into the grid is calculated at a predetermined rate. Although NM and NB systems support small-scale renewable energy sources without imposing excessive government spending, they can disadvantage passive consumers by necessitating self-consumption to cover distribution costs, which other prosumers may bypass. Renewable Portfolio Standards (RPS) require a minimum percentage of power generation to come from renewable sources. The Renewable Energy Certificate (REC) system verifies that utilities meet these environmental targets by assigning a certificate for each MWh of renewable power produced. These certificates are tradable, allowing utilities exceeding their requirements to sell excess RECs to those who do not meet the minimum renewable energy share. However, research suggests that certificate markets pose high risks to investors due to the variability of support levels, unlike the more predictable Feed-in Tariff. The market price of certificates can fluctuate significantly in response to regulatory changes, creating an unstable investment environment (Finck, 2021).

Investment aid is employed when market conditions are favorable enough to support renewable energy without the need for feed-in systems. Although high initial costs can deter some investors when designing a power plant, renewable energy typically has low operational expenses. Direct subsidization of capital expenditures (CAPEX) has been shown to encourage earlier or larger investments. Unlike methods that extend over time, direct subsidies provide investors with confidence about available funds at the facility's commissioning. However, direct subsidies must be funded upfront with public resources, which can be a significant burden for governments. Tax credits offer an alternative approach to reduce investors' burdens while promoting facility development. For instance, the United States offers both Production Tax Credit (PTC) and Investment Tax Credit (ITC) programs. The ITC provides credits based on investment amounts, while the PTC offers credits per unit of energy generated. These credits can help offset taxes such as value-added, property, and income taxes. Tax benefits have proven effective in transforming projects with negative net present value (NPV) into profitable ventures (Alonso-Travesset et al., 2023).

In feed-in systems, risk is often borne by either the investor or the policymaker. The fixed rate of the Feed-in Tariff shields investors from market volatility, placing all the risk on policymakers. Conversely, Feed-in Pricing fully exposes the investment to market price risks. To balance risks between stakeholders, a market price guarantee or floor may be introduced. Additionally, a cap can be implemented to offset the policymaker's risk in setting the guarantee. Variations of this concept include a FiT where the tariff depends on the average market price, allowing for shared gains between investors and policymakers. Capacity payments compensate power plants for being available to supply energy when needed. Traditionally, renewable power plants were excluded from these systems due to their intermittent nature, but successful capacity methods have emerged to promote renewable energy. Once the target energy output per unit of capacity is reached, a ceiling on payments is imposed, with capital costs compensated by a performance coefficient. This approach protects investors from market risk, akin to FiT, and decisions about capacity are based on factors such as local demand, grid access, and generation potential, rather than subsidy size (Alonso-Travesset et al., 2023).

As renewable energy technologies mature, the reliance on Feed-in Tariffs is waning in favor of other regulatory frameworks, particularly renewable energy certificates and Feed-in Pricing. These plans pose less risk to policymakers and rely on market dynamics to support renewable energy. However, the best framework for fostering renewable energy development remains unclear, as each approach has distinct advantages and disadvantages. Although Feed-in Tariffs are better suited for emerging technologies, given that they place the entire risk burden on policymakers, consideration should be given to phasing them out. Certificate systems, Feed-in Pricing, and minor market interventions, such as price floors and capacity rewards, are proving to be more effective in promoting renewable energy systems (Metaxas et al., 2018).

3.8. Neighboring Countries: Relationships, Rights and Investments

Governments compete for foreign investment in international 'location tournaments' by offering tax breaks and other short-term incentives. Short-run incentives, however, have no apparent influence on site choice. We find that high-cost tournament participation is unnecessary in nations with developed infrastructure, specialized input providers, and rising domestic markets. Some location theorists emphasize the significance of agglomeration economies in industrial areas. Others, however, argue that traditional sources of comparative advantage, such as relative salaries, market size, and transportation costs, dominate site decisions. Some argue that overseas investors may overlook the benefits of agglomeration, preferring many sites as a risk buffer (Wheeler & Mody, 1992).

The European Neighborhood Policy (ENP), first implemented in 2004, is a single European Union (EU) policy framework aimed at the EU's bordering nations. The ENP's goal is to increase the EU's economy, stability, and security by forming a 'ring of friends' around the EU's political borders. Other EU projects in this area, such as the Eastern Partnership (launched in Prague in 2009), the Euro-Mediterranean Partnership or Union for the Mediterranean (re-launched in Paris in 2008), and the Black Sea Synergy (launched in Kiev in 2008), are synergistic with the ENP. Armenia, Azerbaijan, Belarus, Georgia, Moldova, and Ukraine ('ENP East') and Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, Palestine, Syria, and Tunisia ('ENP South') are covered under the ENP framework (Pierce, 2011).

Among the benefits of the ENP is that it stimulates economic, political, and institutional growth at the same time by offering not just political incentives but also financial resources. A closer relationship with the EU has a few domestic political and economic benefits, including strengthening domestic policies and facilitating political reforms that consolidate the process of political transition, democratization, and, in some cases, conflict resolution and normalization of external relations (Monastiriotis et al., 2010). On the other hand, however, economic integration diminishes the importance of national boundaries as obstacles to factor mobility, which is strengthened by lower trade costs. Borders that are 'closed' distort market size effects, but removing economic barriers causes a range of spatial dynamics related to increased access to foreign markets and import competition (Brülhart et al., 2004). In other words, in the expanding economic space in the EU and its neighbors, the space of flows (i.e. integration) has a significant impact on the space of locations, i.e. economic development (Petrakos, 2012).

To examine the current co-evolution of the EU and ENP economies, trade patterns between the EU and its neighboring countries, as well as their potential effects on growth, structural change, and cohesion in both areas, location choices of EU foreign investment, the direction and drivers of capital mobility, and their effects in EU neighboring countries, should be looked into. Following on, the efforts of domestic and foreign firms to invest in technological and organizational capacities, thereby contributing to the co-evolution of local institutional environments, as well as the spatial sub-national effects of increased trade and investment flows in both the EU and its neighboring countries, must be investigated. Further research into these issues is required to inform the debate of policy alternatives at the EU level and maximize the potential advantages of the integration process on both sides of the EU's external borders (Foster, 2013).

The relationship that two adjacent nations have with each other may have a significant impact on commerce, tourism, FDI attractiveness, and, on a wider scale, their whole economy (Pierce, 2011).

Cooperation between neighboring countries on energy transmission networks is vital for enhancing energy security, diversifying supply sources, and achieving sustainable energy goals. The Greece-Turkey relationship presents a complex yet crucial dynamic in this regard. The two countries share a geographically strategic location, serving as a bridge between Europe and Asia. However, their relationship is often marked by political tensions, particularly concerning maritime boundaries and exclusive economic zones (EEZs) in the Aegean and Eastern Mediterranean seas. These disputes pose challenges to energy cooperation, as unresolved issues related to EEZs can hinder the development of shared resources and energy infrastructure projects. The rules of law and transparency are fundamental principles that must be upheld to foster mutual trust and facilitate cross-border energy investments. Establishing clear legal frameworks and adhering to international maritime laws can pave the way for more effective cooperation between Greece and Turkey in energy transmission networks (Crescenzi & Petrakos, 2016).

The relationship between Greece and Turkey significantly impacts the attraction of foreign investment in the region. Political instability and territorial disputes can deter investors who seek certainty and stability. In contrast, a cooperative relationship can enhance the region's appeal to investors by promising a more stable and predictable business environment. Investment in energy infrastructure, such as interconnectors and pipelines, can serve as a catalyst for improving bilateral relations. Such projects necessitate collaboration, thereby fostering dialogue and cooperation between the two countries. Furthermore, investments in the energy sector can lead to economic benefits for both nations, creating jobs and stimulating economic growth. By sharing resources and expertise, Greece and Turkey can optimize energy transmission networks, reduce costs, and increase energy efficiency, ultimately benefiting consumers and industries across the region (Crescenzi & Petrakos, 2016).

Historical examples demonstrate how strained relationships between neighboring countries can hinder investment opportunities. For instance, the ongoing conflict between Armenia and Azerbaijan over the Nagorno-Karabakh region has severely limited their ability to attract foreign investment, particularly in the energy sector. The potential for energy cooperation and development of resources remains largely untapped due to geopolitical tensions. Similarly, the longstanding dispute between India and Pakistan over Kashmir has impeded the development of transnational energy projects that could have bolstered economic growth and improved energy access in South Asia. In contrast, the successful collaboration between Norway and Russia in the Barents Sea serves as a model for how countries can overcome historical disputes to jointly develop energy resources, demonstrating the potential for mutual benefits through cooperation (Foster, 2013).

Investments in the energy sector can act as a driving force for improving relationships between neighboring countries. By focusing on shared economic interests and regional development, countries can transcend political differences and work towards common goals. In the case of Greece and Turkey, energy investments have the potential to transform their bilateral relationship by emphasizing the economic benefits of cooperation and the importance of stability for sustained growth. A collaborative approach to energy transmission networks can also enhance regional energy security, reducing dependence on external sources and promoting the integration of renewable energy into the grid. Such developments not only contribute to the economic prosperity of Greece and Turkey but also reinforce the stability and resilience of the broader European and Eastern Mediterranean energy markets (Pierce, 2011).

In conclusion, the cooperation between Greece and Turkey on energy transmission networks exemplifies the intricate interplay between geopolitics and economic interests. By fostering a cooperative relationship based on the rule of law and transparency, both countries can attract significant foreign investments, enhancing their energy infrastructure and economic resilience. Historical examples underscore the importance of stable relationships for attracting investments and highlight the potential benefits of collaboration in the energy sector. With a focus on shared goals and mutual benefits, Greece and Turkey can pave the way for a more stable and prosperous future, setting a precedent for other nations facing similar challenges (Crescenzi & Petrakos, 2016).

3.9. Joint Developments

Joint development agreements (JDAs) play a significant role in international relations by establishing cooperative frameworks for states to explore and exploit hydrocarbon resources in regions where maritime boundaries overlap. These agreements are particularly relevant in the context of international law, which imposes certain rights and obligations on states regarding the use of resources in disputed maritime areas. The UN Convention on the Law of the Sea (UNCLOS), along with general international law, emphasizes the necessity for states to cooperate in managing resources located in overlapping claim regions. This cooperation can be achieved through JDAs or other provisional arrangements until the resolution of maritime boundaries. Joint development agreements are legal contracts that define the terms of collaboration between two or more parties, particularly concerning the exploration and exploitation of resources and the potential development of patentable intellectual property (Xue, 2019).

Part V of the 1982 United Nations Convention on the Law of the Sea (UNCLOS) is instrumental in shaping the legal framework for joint developments. It grants coastal states exclusive rights to explore and exploit the natural resources of the seabed and its subsoil, including both living and non-living resources such as minerals and hydrocarbons. These rights extend to activities related to the economic exploitation of the zone, and the Exclusive Economic Zone (EEZ) can extend up to 200 nautical miles from the territorial sea baseline. When the EEZ regime was established by the Third United Nations Conference on the Law of the Sea, it placed approximately 87 percent of the world's known offshore petroleum reserves under the jurisdiction of coastal states, significantly influencing the global management of these resources (MacLaren & James, 2013).

A prominent example of cooperation through joint development agreements can be seen in the collaboration between Greece and Egypt. This partnership illustrates how JDAs can facilitate mutual benefits and enhance economic development while adhering to international legal obligations. The Greece-Egypt collaboration has emerged as a strategic alliance aimed at capitalizing on the potential of hydrocarbon resources in the Eastern Mediterranean. This region is characterized by complex maritime boundaries and overlapping claims, making it a prime candidate for joint development initiatives. The Greece-Egypt partnership involves the exploration and exploitation of hydrocarbon resources in their respective EEZs. By entering into a joint development agreement, both nations aim to navigate the challenges posed by overlapping claims and maximize the economic potential of their shared resources. This collaboration underscores the importance of diplomatic engagement and negotiation in resolving disputes and promoting economic cooperation. Through joint efforts, Greece and Egypt have established a framework for resource management that aligns with the principles outlined in UNCLOS and other international legal instruments (Xue, 2019).

One of the key aspects of the Greece-Egypt partnership is the emphasis on transparency and mutual benefit. The joint development agreement outlines the responsibilities and rights of each party, ensuring that the exploration and exploitation activities are conducted in a manner that respects the sovereignty and interests of both nations. This approach not only fosters economic growth but also strengthens bilateral relations and regional stability (MacLaren & James, 2013).

The Greece-Egypt collaboration serves as a model for other nations facing similar challenges in regions with overlapping maritime claims. By prioritizing cooperation and adhering to international legal standards, states can effectively manage their shared resources and avoid conflicts that could arise from unilateral actions. Joint development agreements offer a practical solution for harnessing the potential of hydrocarbon resources while minimizing the risk of disputes and fostering positive international relations (Cameron & Nowinski, 2013).

In addition to the economic benefits, joint development agreements have significant geopolitical implications. The Greece-Egypt partnership enhances energy security in the region by diversifying energy sources and reducing dependence on external suppliers. This strategic alliance contributes to the stability of the Eastern Mediterranean, which is a critical area for global energy markets. By collaborating on resource management, Greece and Egypt demonstrate the potential for regional cooperation to address complex geopolitical challenges and promote sustainable development (Cameron & Nowinski, 2013).

3.10. "Not In My Backyard" Phenomenon

The "Not In My Backyard" (NIMBY) phenomenon presents a significant challenge to the development and implementation of renewable energy projects. While many countries and communities express strong support for transitioning to renewable energy sources, they often oppose projects in their vicinity due to concerns about visual and environmental impacts. This paradox reflects a broader societal tension where the desire for clean energy is tempered by apprehensions about its potential local consequences. Aesthetic concerns, fears of decreased property values, and disruption of natural landscapes are common reasons for opposition. This resistance can stall or even derail projects, posing a substantial barrier to the widespread adoption of renewable energy technologies, which are essential for achieving global climate goals (Kinder, 2013).

The word NIMBY has two separate meanings and user groups. In certain cases, it denotes individuals' refusal to tolerate the development of large-scale projects by companies or governmental agencies nearby, which may have an impact on their quality of life and the value of their property. Project proponents (often the sponsoring business, construction worker unions, and contractors, among others) tend to use the word in this way. Social service and environmental justice campaigners use the word to signify a lack of social conscience exhibited by a class-, race-, or disability-based resistance to the placement of social-service institutions in communities (Kinder, 2013).

Several notable examples illustrate how the NIMBY phenomenon has impeded renewable energy projects. In the United States, the Cape Wind project, which proposed installing 130 wind turbines off the coast of Cape Cod, Massachusetts, faced significant local opposition due to fears of visual pollution and potential harm to the local tourism industry. Despite its potential to provide clean energy for thousands of homes, the project was ultimately abandoned after a protracted legal battle spanning nearly two decades. Similarly, in the United Kingdom, plans to develop onshore wind farms have often met with resistance from local communities concerned about the impact on picturesque landscapes and wildlife habitats. In Germany, a country known for its commitment to renewable energy, opposition from locals has led to delays and cancellations of several wind farm projects, highlighting the pervasive nature of this issue even in environmentally progressive regions (Weng-Wai et al., 2023).

Addressing the NIMBY phenomenon requires a multifaceted approach that balances the need for renewable energy development with the legitimate concerns of local communities. One strategy involves enhancing community engagement and participation in the planning and decision-making processes. By involving residents early in the development process and addressing their concerns transparently, developers can build trust and foster a sense of ownership among local stakeholders. Offering financial incentives or benefits to communities hosting renewable energy projects, such as reduced energy costs or community development funds, can also help mitigate opposition. Additionally, advances in technology can play a role in reducing the visual impact of renewable energy infrastructure. For instance, offshore wind farms can be located further from the coast, minimizing visual disturbance, while innovations in turbine design can reduce noise and enhance aesthetic appeal (Weng-Wai et al., 2023).

Furthermore, governments and policymakers can implement regulatory frameworks that encourage harmonious coexistence between renewable energy projects and local communities. Zoning laws and land-use planning can be optimized to identify suitable locations for renewable energy installations that minimize conflict with residential areas and sensitive ecosystems. Public awareness campaigns can also help shift perceptions by emphasizing the broader environmental and economic benefits of renewable energy, thereby reducing resistance based on misconceptions or lack of information. Ultimately, overcoming the NIMBY phenomenon requires a concerted effort from all stakeholders—governments, developers, and communities alike—to recognize and address the complex interplay of local and global interests in the pursuit of a sustainable energy future (Franklin, 2018).

The NIMBY phenomenon represents a significant barrier to the development of renewable energy projects, reflecting broader societal tensions between local interests and global environmental goals. By examining specific examples of projects hindered by local opposition, it becomes clear that strategic interventions are necessary to address these challenges. Enhancing community engagement, providing incentives, leveraging technology, and implementing supportive regulatory frameworks are critical steps toward reconciling local concerns with the urgent need for renewable energy expansion. Through these efforts, the path can be paved for a more sustainable energy landscape that aligns with both community values and environmental imperatives (Rauck, 2020).

Some environmentalists have attempted to capitalize on NIMBY. They have suggested that caring about what occurs in one's own “neighborhood” is the foundation of environmental consciousness. They have also highlighted the logical inconsistency of a firm using social class to win a project. While this is undeniably true, the "NIMBY as positive" thesis has received little momentum since, in the 1990s, environmental justice advocates and other social justice campaigners mainly used the word negatively, reinforcing its class-based connotation (Rauck, 2020).

The common thread running across the public's worries about renewable energy is landscape change and the disruption it causes to established ways of life for people who live nearby. It also indicates that the emphasis of renewable energy projects should be shifted away from the usual technical focus that dominates development planning. The most appropriate and practical approach would be to see developmental obstacles as primarily social issues with technological components, rather than the other way around. Accepting this viewpoint opens the way to renewable energy. Opposition to landscape changes and the attendant repercussions on local communities' quality of life are creating hurdles to a renewable energy future. Despite the numerous benefits that renewable energy sources provide, they also have several drawbacks. Regardless of geography, geothermal energy, for example, must be exploited very near to where it is located (development, building, and power plant operation). When generated, it emits a rotten-egg odor, spills out into the environment, and more, just enough to cause negative publicity (Weng-Wai et al., 2023).

3.11 Energy as a Pressure Lever Among Countries: The Strategic Aspect of Energy

Energy has always played a pivotal role in international relations, serving as both a resource and a tool of strategic leverage among nations. As countries strive to secure their energy needs, they inevitably find themselves interdependent, leading to a complex web of geopolitical dynamics. This interdependence provides an opportunity for energy-rich nations to wield power over energy-importing countries, often using energy resources as a means to exert political and economic influence. The strategic manipulation of energy supplies can lead to shifts in alliances, economic dependencies, and even conflicts, as nations use energy as a pressure lever to achieve their geopolitical objectives. In an era where energy security is paramount, understanding the strategic aspect of energy becomes crucial for assessing global power structures.

The strategic role of energy is underscored by the reliance of countries on external sources of oil, natural gas, and other critical fuels. Nations that control vast energy resources can exert significant influence over those that depend on them. This influence is often manifested in the form of pricing strategies, supply cuts, and contractual terms that can sway the political and economic decisions of dependent countries. The Organization of the Petroleum Exporting Countries (OPEC), for example, has historically wielded considerable power by coordinating oil production among its member states to influence global oil prices. Such actions demonstrate how energy-exporting countries can impact global markets and the economies of energy-importing nations, highlighting the intrinsic power dynamics associated with energy control (Sornette et al., 2019).

Modern geopolitical conflicts have further exemplified energy's strategic importance. The Russian-Ukrainian war serves as a poignant illustration of how energy can be leveraged as a weapon in international disputes. Russia, one of the world's largest energy exporters, has used its vast natural gas resources as a tool of influence over Europe, which relies heavily on Russian gas imports. The conflict in Ukraine has heightened Europe's energy vulnerability, prompting Russia to use gas supplies as leverage to exert pressure on European countries. By manipulating gas flows through Ukraine and other routes, Russia aims to achieve geopolitical goals while exposing Europe's reliance on its energy exports. This situation has prompted European nations to reassess their energy policies, diversify their energy sources, and seek alternatives to reduce dependency on Russian gas (Sornette et al., 2019).

The strategic use of energy as a pressure lever is not confined to Europe and Russia; it is a global phenomenon with far-reaching implications. In the Middle East, countries with significant oil reserves have historically wielded substantial influence over global energy markets, impacting everything from economic policies to military strategies. In the Asia-Pacific region, China's growing energy demands have led to strategic partnerships and investments in energy-rich regions, reflecting a broader trend of energy-driven geopolitics.

These dynamics illustrate how energy resources can shape international relations, prompting countries to form alliances or engage in conflicts based on their energy interests (Wen et al., 2021).

Addressing the strategic aspect of energy requires a multifaceted approach that considers energy security, technological advancements, and geopolitical strategies. As countries strive to enhance their energy security, they must navigate complex international relationships while investing in renewable energy sources and technologies to reduce their reliance on external resources. The transition to renewable energy presents both challenges and opportunities, as nations seek to balance their energy needs with environmental sustainability. By investing in renewable energy infrastructure and diversifying energy sources, countries can mitigate the risks associated with energy dependency and leverage energy as a tool for diplomacy and cooperation rather than conflict (Svobodova et al., 2020).

In conclusion, energy's strategic role as a pressure lever among countries underscores its significance in shaping global power dynamics. Through the lens of modern examples like the Russian-Ukrainian conflict, it becomes evident that energy resources can be wielded as tools of influence, impacting international relations in profound ways. By recognizing energy's strategic importance, countries can develop more resilient energy policies that prioritize security, sustainability, and cooperation. As the global energy landscape continues to evolve, understanding the interplay between energy and geopolitics will be crucial for navigating the challenges and opportunities of the future.

Chapter 4: Conclusion

The pressing challenges of climate change and the pursuit of energy security necessitate a profound transformation in global energy systems. Renewable Energy Sources (RES) have emerged as a pivotal solution in this endeavor, offering the potential to reduce carbon emissions, enhance energy independence, and contribute to a sustainable future. This conclusion aims to address whether RES can support energy autonomy and security, and if there remains a necessity to resort to other energy sources such as nuclear power to meet the ever-increasing energy demand.

The deployment of renewable energy is imperative in the global effort to mitigate the adverse effects of climate change. Renewable energy sources, such as solar, wind, hydroelectric, and geothermal, provide cleaner alternatives to fossil fuels, significantly reducing greenhouse gas emissions. The transition to RES is not merely an environmental imperative; it is an economic and social necessity. In the context of Europe, the transition to renewable energy has been bolstered by policy initiatives that aim to enhance energy security, reduce dependence on imported fossil fuels, and stimulate economic growth through green technology investments. The transformation of the energy landscape requires a strategic approach that integrates RES into national energy policies, ensuring that local authorities prioritize renewable energy deployment to achieve long-term sustainability goals.

The choice of specific renewable energy sources is less critical than the overarching commitment to the renewable transition. Various RES technologies, each with distinct advantages and limitations, can be integrated into the energy mix based on regional characteristics and resource availability. For instance, solar energy is particularly viable in regions with high solar irradiance, while wind energy may be more suitable in areas with consistent wind patterns. The diversification of energy sources ensures resilience against resource variability and enhances the overall stability of the energy supply. The expansion potential for RES remains significant, contingent upon the ability of nations to overcome deployment barriers. This includes the simplification of permitting processes, modernization of transmission and distribution networks, and the establishment of robust policy frameworks that provide long-term support for both utility-scale and distributed renewable projects.

In the pursuit of energy autonomy and security, minimizing carbon footprints is paramount. The transition to renewable energy not only addresses the urgent need to reduce emissions but also ensures the provision of clean, sustainable energy for future generations. The integration of RES into energy systems must be complemented by efforts to improve energy efficiency across all sectors. Energy efficiency is a critical component of the renewable transition, as it reduces overall energy demand and optimizes the use of available resources. This dual approach of expanding renewable energy capacity and enhancing energy efficiency is vital for achieving energy security and reducing environmental impacts.

Despite the inherent challenges in transitioning to renewable energy, recent developments, particularly in the European Union, have highlighted a renewed commitment to energy security and sustainability. The geopolitical tensions resulting from conflicts, such as the

Russia-Ukraine war, have underscored the vulnerabilities of reliance on fossil fuel imports. This has prompted policymakers to accelerate the adoption of renewable energy and strengthen energy infrastructure. The shift towards RES is accompanied by unprecedented policy momentum, aimed at advancing energy efficiency and promoting the deployment of renewable technologies. The trajectory of renewable markets for 2023 and beyond will largely depend on the implementation of new and strengthened policies in the coming months. This period represents a critical juncture for the global energy transition, with significant implications for future energy security and climate goals.

The transition to renewable energy is not solely the responsibility of governments and large corporations; individuals and communities play a fundamental role in this transformation. Citizens have the power to drive change by choosing renewable energy technologies for residential buildings, purchasing renewable electricity from green markets, and even becoming producers of renewable energy themselves. This grassroots involvement is essential in achieving 100% renewable energy targets. Public awareness and education about energy consumption and conservation are crucial for fostering a culture of energy efficiency and sustainability. By reducing energy waste and optimizing energy use, individuals and communities contribute to the broader goal of energy autonomy and environmental stewardship.

The expansion of RES also necessitates addressing specific challenges related to permitting, policy uncertainty, and grid infrastructure. The growth of renewable energy systems hinges on streamlined regulatory processes that facilitate timely project approvals and minimize bureaucratic delays. Additionally, policy certainty is essential for attracting investments in renewable energy projects, as investors seek stable and predictable regulatory environments. The development of resilient and flexible grid infrastructure is another critical factor in supporting the integration of renewable energy. Modernizing grids to accommodate variable energy sources, such as wind and solar, is imperative for ensuring a reliable energy supply and maximizing the potential of RES.

In the commercial and industrial sectors, solar applications are increasingly recognized for their dual economic and environmental benefits. Solar panels installed on commercial and industrial buildings can significantly reduce carbon emissions, contributing to a more sustainable future. Moreover, solar energy offers long-term cost savings for businesses, providing a hedge against rising energy prices. The ability to generate electricity on-site enhances energy security, reducing reliance on traditional energy sources and contributing to the resilience of business operations.

However, the question remains whether renewable energy alone can meet the ever-growing global energy demand or if alternative sources, such as nuclear power, will be necessary. Renewable energy systems face inherent limitations, particularly in terms of intermittency and resource availability. Solar and wind power, for example, are dependent on weather conditions and time of day, leading to variability in energy production. This necessitates the development of advanced energy storage solutions and grid management systems to ensure a stable energy supply. While RES can play a significant role in the energy mix, the transition may require complementary energy sources to achieve a balanced and reliable energy system.

Nuclear power, with its ability to provide a stable and continuous energy supply, presents a viable alternative or complement to renewable energy sources. The debate over nuclear energy's role in the future energy mix centers on concerns related to safety, waste management, and public acceptance. However, advances in nuclear technology, such as small modular reactors and improved safety protocols, offer promising prospects for integrating nuclear energy into a sustainable energy strategy. The decision to incorporate nuclear power alongside renewables ultimately depends on balancing energy security, environmental considerations, and societal acceptance.

In conclusion, renewable energy sources are poised to play a central role in achieving energy autonomy and security. The transition to RES offers substantial environmental and economic benefits, contributing to a sustainable future. However, the journey toward energy independence is complex, requiring strategic integration of various energy sources and overcoming significant challenges related to infrastructure, policy, and public engagement. While renewable energy has the potential to transform global energy systems, a comprehensive approach that includes diverse energy solutions, such as nuclear power, may be necessary to meet the ever-increasing global energy demand. The path forward demands collaboration, innovation, and a commitment to building a resilient and sustainable energy future.

Chapter 5: Bibliography

Aceris Law. (2018). Consent in Investment Arbitration. https://www.acerislaw.com/consent-investment-arbitration/

Alonso-Travesset, À., Coppitters, D., Martín, H., & de la Hoz, J. (2023). Economic and regulatory uncertainty in renewable energy system design: A review. *Energies*, *16*(2), 882.

Ataman-Figanmeşe, İ. (2011). Manufacturing Consent to Investment Treaty Arbitration By Means of the Notion of 'Arbitration Without Privity'. *Annales de la Faculté de Droit d'Istanbul, C*, *43*, 60.

Australian Energy Regulator. (2023). State of the energy market 2023. https://apo.org.au/sites/default/files/resource-files/2023-10/apo-nid324577.pdf

Bjorklund, A. K. (2013). The role of counterclaims in rebalancing investment law. *Lewis & Clark L. Rev.*, *17*, 461.

Blanchard, S. (2011). State consent, temporal jurisdiction, and the importation of continuing circumstances analysis into international investment arbitration. *WaSh. u. Global Stud. l. rev.*, *10*, 419.

Blyschak, P. M. (2009). State consent, investor interests and the future of investment arbitration: Reanalyzing the jurisdiction of investor-state tribunals in hard cases. *Asper Rev. Int'l Bus. & Trade L.*, *9*, 99.

Bridgwater, T. (2006). Biomass for energy. *Journal of the Science of Food and Agriculture*, *86*(12), 1755-1768.

Brülhart, M., Crozet, M., & Koenig, P. (2004). Enlargement and the EU periphery: the impact of changing market potential. *World Economy*, *27*(6), 853-875.

Cambini, C., Congiu, R., & Soroush, G. (2020a). Regulation, innovation, and systems integration: evidence from the EU. *Energies*, *13*(7), 1670.

Cambini, C., Congiu, R., Jamasb, T., Llorca, M., & Soroush, G. (2020b). Energy systems integration: Implications for public policy. *Energy policy*, *143*, 111609.

Cameron, P., & Nowinski, R. (2013). Joint development agreements: legal structure and key issues. In *Beyond Territorial Disputes in the South China Sea* (pp. 152-178). Edward Elgar Publishing.

Ciucci, M. (2024). "Internal energy market", fact sheets on the European Union. *European Parliament*. https://www.europarl.europa.eu/factsheets/en/sheet/45/internal-energy-market

Clò, S., Cataldi, A., & Zoppoli, P. (2015). The merit-order effect in the Italian power market: The impact of solar and wind generation on national wholesale electricity prices. *Energy Policy*, *77*, 79-88.

Cochran, J., Miller, M., Milligan, M., Ela, E., Arent, D., Bloom, A., ... & Sandholt, K. (2013). Market evolution: Wholesale electricity market design for 21st century power systems.

Cotula, L. (2015). *Democratising international investment law: Recent trends and lessons from experience*. International Institute for Environment and Development..

Coyle, J. F., & Drahozal, C. R. (2019). An empirical study of dispute resolution clauses in international supply contracts. *Vand. J. Transnat'l L.*, *52*, 323.

Crescenzi, R., & Petrakos, G. (2016). The European Union and its neighboring countries: The economic geography of trade, Foreign Direct Investment and development. *Environment and Planning C: Government and Policy*, *34*(4), 581-591.

Cunha, B. Q., Pereira, A. K., & de Ávila Gomide, A. (2017). State capacity and utilities regulation in Brazil: exploring bureaucracy. *Utilities Policy*, *49*, 116-126.

Di Pietro, D., & Cheung, K. (2020). The Definition of Investor in Investment Treaty Arbitration: Overview of Common Issues in the Context of the ICSID Convention. *Handbook of International Investment Law and Policy*, 1-26.

Diallo, A., Banerjee, S., Zweben, S. J., & Stoltzfus-Dueck, T. (2017). Energy exchange dynamics across L–H transitions in NSTX. *Nuclear Fusion*, *57*(6), 066050.

Douglas, Z. (2023). The Umbrella Clause Revisited. *ICSID Review-Foreign Investment Law Journal*, *38*(2), 472-483.

Edmunds, C., Martín-Martínez, S., Browell, J., Gómez-Lázaro, E., & Galloway, S. (2019). On the participation of wind energy in response and reserve markets in Great Britain and Spain. *Renewable and Sustainable Energy Reviews*, *115*, 109360.

Energy, Climate Change, Environment. (2024). Market Analysis: The Commission produces quarterly reports on EU gas and electricity markets. EU. https://energy.ec.europa.eu/data-and-analysis/market-analysis_en#energy-data-centre

European Council. (2022). EU to speed up permitting process for renewable energy projects. https://www.consilium.europa.eu/en/press/press-releases/2022/11/24/eu-to-speed-up-permitting-process-for-renewable-energy-projects/

Felekidis, N. (2018). *Effects of Energetic Disorder on the Optoelectronic Properties of Organic Solar Cells* (Vol. 1943). Linköping University Electronic Press.

Felsmann, B., Mezősi, A., & Szabó, L. (2018). Market versus bureaucracy–Price regulation in the electricity retail sector.

Fernández, L. (2024). Global renewable energy industry - statistics & facts. *Statista*. https://www.statista.com/topics/2608/global-renewable-energy-industry/#topicOverview

Finck, R. (2021, June). Impact of flow based market coupling on the European electricity markets. In *Sustainability Management Forum| NachhaltigkeitsManagementForum* (Vol. 29, No. 2, pp. 173-186). Berlin/Heidelberg: Springer Berlin Heidelberg.

Foster, G. K. (2013). Investors, states, and stakeholders: Power asymmetries in international investment and the stabilizing potential of investment treaties. *Lewis & Clark L. Rev.*, *17*, 361.

Franklin, J. (2018). Not in my backyard. *Fourth Genre: Explorations in Nonfiction*, *20*(1), 61-76.

Gandolfi, G., Regalli, M., Soana, M. G., & Arcuri, M. C. (2018). Underpricing and Long-Term Performance of Ipos: Evidence From European Intermediary-Oriented Markets. *Economics, Management & Financial Markets*, *13*(3).

Girish, G. P., & Vijayalakshmi, S. (2015). Role of energy exchanges for power trading in India. *International Journal of Energy Economics and Policy*, *5*(3), 673-676.

Herding, L., Cossent, R., Rivier, M., Chaves-Ávila, J. P., & Gómez, T. (2021). Assessment of electricity network investment for the integration of high RES shares: A Spanish-like case study. *Sustainable Energy, Grids and Networks*, *28*, 100561.

Hesamzadeh, M. R., & Yazdani, M. (2013). Transmission capacity expansion in imperfectly competitive power markets. *IEEE Transactions on Power Systems*, *29*(1), 62-71.

Hevia-Koch, P., & Jacobsen, H. K. (2019). Comparing offshore and onshore wind development considering acceptance costs. *Energy policy*, *125*, 9-19.

Hou, J., Zhang, Z., Lin, Z., Yang, L., Liu, X., Jiang, Y., ... & Wen, F. (2019). An energy imbalance settlement mechanism considering decision-making strategy of retailers under renewable portfolio standard. *Ieee Access*, *7*, 118146-118161.

Hussain, A. (2024). What Does an Investor Do? What Are the Different Types?. *Investopedia*. https://www.investopedia.com/terms/i/investor.asp

IEA, (2022a). Renewable net capacity additions, 2019-2021, IEA, Paris https://www.iea.org/data-and-statistics/charts/renewable-net-capacity-additions-2019-2021.

IEA. (2022b). Renewable Energy Market Update Outlook for 2022 and 2023. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://iea.blob.core.windows.net/assets/d6a7300d-7919-4136-b73a-3541c33f8bd7/RenewableEnergyMarketUpdate2022.pdf

IEA. (2022c). Renewable capacity growth in the main and accelerated cases, 2010-2027, IEA, Paris. https://www.iea.org/data-and-statistics/charts/renewable-capacity-growth-in-the-main-and-accelerated-cases-2010-2027.

IEA. (2022d). Renewable capacity additions in China, European Union, the United States and India, 2019-2023, IEA, Paris. https://www.iea.org/data-and-statistics/charts/renewable-capacity-additions-in-china-european-union-the-united-states-and-india-2019-2023.

Inês, C., Guilherme, P. L., Esther, M. G., Swantje, G., Stephen, H., & Lars, H. (2020). Regulatory challenges and opportunities for collective renewable energy prosumers in the EU. *Energy policy*, *138*, 111212.

Jaganmohan, M. (2021). Renewable energy market size worldwide in 2021, with a forecast for 2022 to 2030. *Statista*. https://www.statista.com/statistics/1094309/renewable-energy-market-size-global/#statisticContainer

Jandhyala, S., Henisz, W. J., & Mansfield, E. D. (2011). Three waves of BITs: The global diffusion of foreign investment policy. *Journal of Conflict Resolution*, *55*(6), 1047-1073.

Kabir, E., Kumar, P., Kumar, S., Adelodun, A. A., & Kim, K. H. (2018). Solar energy: Potential and future prospects. *Renewable and Sustainable Energy Reviews*, *82*, 894-900.

Khan, M. A., & Ahmad, U. (2008). Energy demand in Pakistan: a disaggregate analysis. *The Pakistan Development Review*, 437-455.

Kinder, P. D. (2013). "NIMBY." *Encyclopedia Britannica*. https://www.britannica.com/topic/NIMBY.

Kryvoi, Y. (2012). Counterclaims in investor-state arbitration. *Minn. J. Int'l L.*, *21*, 216.

Kurtishi-Kastrati, S. (2013). The Effects of Foreign Direct Investments for Host Country's Economy. *European Journal of Interdisciplinary Studies*, *5*(1).

Laura, C. S., & Vicente, D. C. (2014). Life-cycle cost analysis of floating offshore wind farms. *Renewable Energy*, *66*, 41-48.

Legum, B. (2006). Defining investment and investor: who is entitled to claim?. *Arbitration International*, *22*(4), 521-526.

Lin, T. C. (2012). The new investor. *UCLA L. Rev.*, *60*, 678.

Lin, Y., & Wang, J. (2022). Realizing the transactive energy future with local energy market: an overview. *Current Sustainable/Renewable Energy Reports*, *9*(1), 1-14**.**

Liu, G., Xu, Y., & Tomsovic, K. (2015). Bidding strategy for microgrid in day-ahead market based on hybrid stochastic/robust optimization. *IEEE Transactions on Smart Grid*, *7*(1), 227-237.

Lowitzsch, J., Hoicka, C. E., & van Tulder, F. J. (2020). Renewable energy communities under the 2019 European Clean Energy Package–Governance model for the energy clusters of the future?. *Renewable and Sustainable Energy Reviews*, *122*, 109489.

Lu, M., Dong, Z. Y., & Saha, T. K. (2005, August). A framework for transmission planning in a competitive electricity market. In *2005 IEEE/PES Transmission & Distribution Conference & Exposition: Asia and Pacific* (pp. 1-6). IEEE.

Lucas, H., Carbajo, R., Machiba, T., Zhukov, E., Cabeza, L.F. (2021) Improving Public Attitude towards Renewable Energy. Energies **2021**, 14, 4521. https://doi.org/10.3390/en14154521

Lynch, M., Devine, M. T., & Bertsch, V. (2019). The role of power-to-gas in the future energy system: Market and portfolio effects. *Energy*, *185*, 1197-1209.

MacLaren, G., & James, R. (2013). Negotiating joint development agreements. In *Beyond Territorial Disputes in the South China Sea* (pp. 139-151). Edward Elgar Publishing.

Maggauer, K., & Fina, B. (2022). Monte Carlo Simulation-based Economic Risk Assessment in Energy Communities. *Available at SSRN 4699586*.

Maka, A. O., & Alabid, J. M. (2022). Solar energy technology and its roles in sustainable development. *Clean Energy*, *6*(3), 476-483.

Mallieswari, R., Palanisamy, V., Senthilnathan, A. T., Gurumurthy, S., Selvakumar, J. J., & Pachiyappan, S. (2024). A Stochastic Method for Optimizing Portfolios Using a Combined Monte Carlo and Markowitz Model: Approach on Python. *ECONOMICS*.

Manshadi, S. D., & Khodayar, M. E. (2015). A hierarchical electricity market structure for the smart grid paradigm. *IEEE Transactions on Smart Grid*, *7*(4), 1866-1875.

Meeus, L. (2020). *The evolution of electricity markets in Europe*. Edward Elgar Publishing.

Meike A. S. Bradbury, Thorsten Hens, Stefan Zeisberger. (2015). Improving Investment Decisions with Simulated Experience, *Review of Finance*, vol. 19, n. 3, 1019–1052, https://doi.org/10.1093/rof/rfu021

Mendes, A. L. S., de Castro, N., Brandão, R., Câmara, L., & Moszkowicz, M. (2016, June). The role of imbalance settlement mechanisms in electricity markets: A comparative analysis between UK and Brazil. In *2016 13th International Conference on the European Energy Market (EEM)* (pp. 1-6). IEEE.

Metaxas, A., Mathioulakis, M., & Lykidi, M. (2018). Implementation of the target model: regulatory reforms and obstacles for the regional market coupling. *EEJ*, *8*, 28.

Mihalakakou, G., Santamouris, M., & Asimakopoulos, D. (1994). Use of the ground for heat dissipation. *Energy*, *19*(1), 17-25.

Monastiriotis, V., & Jordaan, J. A. (2010). Does FDI promote regional development? Evidence from local and regional productivity spillovers in Greece. *Eastern Journal of European Studies*, *1*(2), 139.

Newbery, D., Pollitt, M. G., Ritz, R. A., & Strielkowski, W. (2018). Market design for a high-renewables European electricity system. *Renewable and Sustainable Energy Reviews*, *91*, 695-707.

Nikièma, S. H. (2012). Best Practices Definition of Investor. *International Institute for Sustainable Development*. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.iisd.org/system/files/publications/best_practices_definition_of_investor.pdf

O'Malley, M., Kroposki, B., Hannegan, B., Madsen, H., Andersson, M., D'haeseleer, W., ... & Rinker, M. (2016). *Energy systems integration. Defining and describing the value proposition* (No. NREL/TP-5D00-66616). National Renewable Energy Lab.(NREL), Golden, CO (United States).

Padmanabhan, N., Ahmed, M., & Bhattacharya, K. (2019). Battery energy storage systems in energy and reserve markets. *IEEE Transactions on Power Systems*, *35*(1), 215-226.

Panwar, N. L., Kaushik, S. C., & Kothari, S. (2011). Solar greenhouse an option for renewable and sustainable farming. *Renewable and Sustainable Energy Reviews*, *15*(8), 3934-3945.

Petrakos, G. (2012). Integration, spatial dynamics and regional policy dilemmas in the European Union. *University of Thessaly Discussion Paper Series*, *18*(2), 27-40.

Pham, T. (2019). Do German renewable energy resources affect prices and mitigate market power in the French electricity market ? *Applied Economics*, *51*(54), 5829–5842. https://doi.org/10.1080/00036846.2019.1624919

Pierce, J. (2011). A South American Energy treaty: how the region might attract foreign investment in a wake of resource nationalism. *Cornell Int'l LJ*, *44*, 417.

Pollitt, M. G. (2021). The future design of the electricity market. In *Handbook on electricity markets* (pp. 428-442). Edward Elgar Publishing.

Rauck, K. K. (2020). *" Not in My Backyard!": The 2015 Refugee Crisis in Germany*. Otto-von-Guericke-Universität Magdeburg, Fakultät für Wirtschaftswissenschaft.

Roach, M., & Meeus, L. (2020). The welfare and price effects of sector coupling with power-to-gas. *Energy Economics*, *86*, 104708.

Rundle-Thiele, S., Paladino, A., Apostol. Sergio, A. G. (2008). Lessons learned from renewable electricity marketing attempts: A case study, Business Horizons, Volume 51, Issue 3, 2008, Pages 181-190, ISSN 0007-6813.

Santamouris, M. (2006). Ventilation for comfort and cooling: the state of the art. *Building Ventilation*, 235-264.

Seatzu, F., & Vargiu, P. (2015). Africanizing Bilateral Investment Treaties ('Bits'): Some Case Studies and Future Prospects Of A Pro-Active African Approach To International Investment. *Connecticut Journal of International Law*, *30*(2).

Shafie-khah, M., & Catalão, J. P. (2014). A stochastic multi-layer agent-based model to study electricity market participants behavior. *IEEE Transactions on Power Systems*, *30*(2), 867-881.

Shenyin, P., & Caballero, J. (2022, December). Research on Monte Carlo financial index simulation method based on Python Technology. In *Proceedings of the 2022 10th International Conference on Information Technology: IoT and Smart City* (pp. 337-344).

Simmons, B. A. (2014). Bargaining over BITs, arbitrating awards: The regime for protection and promotion of international investment. *World Politics*, *66*(1), 12-46.

Sims, G. P. (1991). Hydroelectric energy. *Energy Policy*, *19*(8), 776-786.

Sornette, D., Kröger, W., Wheatley, S., Sornette, D., Kröger, W., & Wheatley, S. (2019). Strategic Aspects of Energy. *New Ways and Needs for Exploiting Nuclear Energy*, 1-56.

Sprenger, H., & Boersma, B. (2014). The importance of Bilateral Investment Treaties (BITs) when investing in emerging markets. *Bus. L. Today*, 1.

Svobodova, K., Owen, J. R., Harris, J., & Worden, S. (2020). Complexities and contradictions in the global energy transition: A re-evaluation of country-level factors and dependencies. *Applied energy*, *265*, 114778.

Tafreshi, S. M. M., & Lahiji, A. S. (2015). Long-term market equilibrium in smart grid paradigm with introducing demand response provider in competition. *IEEE Transactions on Smart Grid*, *6*(6), 2794-2806.

Tanrisever, F., Derinkuyu, K., & Jongen, G. (2015). Organization and functioning of liberalized electricity markets: An overview of the Dutch market. *Renewable and Sustainable Energy Reviews*, *51*, 1363-1374.

Tobisova, A., Senova, A., & Rozenberg, R. (2022). Model for sustainable financial planning and investment financing using Monte Carlo method. *sustainability*, *14*(14), 8785.

Tsaousoglou, G., Sartzetakis, I., Makris, P., Efthymiopoulos, N., Varvarigos, E., & Paterakis, N. G. (2021). Flexibility aggregation of temporally coupled resources in real-time balancing markets using machine learning. *IEEE Transactions on Industrial Informatics*, *18*(7), 4342-4351.

Tschora, L., Pierre, E., Plantevit, M., & Robardet, C. (2022). Electricity price forecasting on the day-ahead market using machine learning. *Applied Energy*, *313*, 118752.

Tülüce, N. S., & Doğan, İ. (2014). The impact of foreign direct investments on SMEs' development. *Procedia-Social and Behavioral Sciences*, *150*, 107-115.

United Nation. (2023). Renewable energy – powering a safer future. https://www.un.org/en/climatechange/raising-ambition/renewable-energy

Vella, V., & Ng, W. L. (2014). Enhancing risk-adjusted performance of stock market intraday trading with neuro-fuzzy systems. *Neurocomputing*, *141*, 170-187.

Virlics, A. (2013). Investment decision making and risk. *Procedia Economics and Finance*, *6*, 169-177.

Vlachos, A. G., & Biskas, P. N. (2013). Demand response in a real-time balancing market clearing with pay-as-bid pricing. *IEEE Transactions on Smart Grid*, *4*(4), 1966-1975.

Wang, G. (2014). Consent in Investor–State Arbitration: A Critical Analysis. *Chinese Journal of International Law*, *13*(2), 335-361.

Watchwire. (2021). What Are Energy Markets? The Nitty Gritty, Explained. https://watchwire.ai/what-are-energy-markets/

Wen, H., Li, N., & Lee, C. C. (2021). Energy intensity of manufacturing enterprises under competitive pressure from the informal sector: evidence from developing and emerging countries. *Energy Economics*, *104*, 105613.

Weng-Wai, C., Siaw-Chui, W., Sheau-Ting, L., Hon-Choong, C., & Izhar, A. I. (2023). Community acceptance towards migrant settlements in a sustainable city: What contributes to the not in my backyard social phenomenon?. *Journal of International Migration and Integration*, *24*(2), 611-636.

Wheeler, D., & Mody, A. (1992). International investment location decisions: The case of US firms. *Journal of international economics*, *33*(1-2), 57-76.

World Economic Forum. (2022). These 4 charts show the state of renewable energy in 2022. https://www.weforum.org/agenda/2022/06/state-of-renewable-energy-2022/

Xue, S. (2019). Why Joint Development Agreements Fail. *Contemporary Southeast Asia*, *41*(3), 418-446.

Yackee, J. W. (2008). Bilateral investment treaties, credible commitment, and the rule of (international) law: Do BITs promote foreign direct investment?. *Law & Society Review*, *42*(4), 805-832.

Yumei, L. (2023). *Real Estate Enterprise Risk-Resistant Ability Based on Pest Model-A Case Study of Yunnan City Real Estate Company* (Doctoral Dissertation, Siam University).

Žilinskė, A. (2010). Negative and Positive Effects of Foreign Direct Investment. *Economics & Management*.