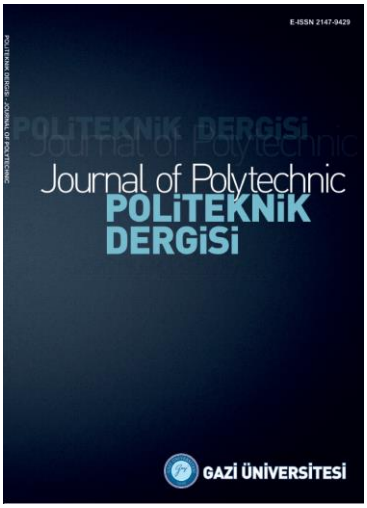

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Renewable energy incentives and future implications for Turkey: a comparative bibliometric analysis

Yenilenebilir enerji teşvikleri ve Türkiye için gelecekteki etkileri: karşılaştırmalı bibliyometrik analiz

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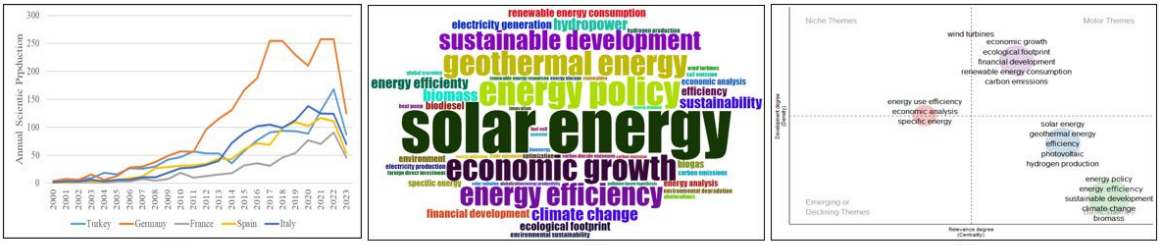
Renewable Energy Incentives and Future Implications for Turkey: A Comparative Bibliometric Analysis

Highlights

- *Renewable energy and incentives in Turkey were examined.*
- *Bibliometric analysis was used to understand relatin between renewable energy and academic production*
- *The thematic analysis shows that the maturity in RE use is reflected in scientific research*

Graphical Abstract

In this study, firstly, academic publications in Turkey and selected countries were examined. Bilbiometric analyzes were performed using these data and wordclouds were created with the prominent keywords of the countries. Likewise, the researchers performed thematic analyses for each country based on the data.



(a) (b) (c)

Figure. Graphical summary

Aim

To compare renewable energy development by bibliometric analysis of academic studies of Turkey and selected countries.

Design & Methodology

In this study, bibliometric analysis and thematic analysis were used to understand the relationship between renewables energy and academic studies.

Originality

This study is an original study comparing Turkey with other countries in terms of renewable energy sources by bibliometric methods.

Findings

As a result of the analysis, it has been seen that there is a significant relationship between the renewable energy and policy developments of the countries and their academic studies.

Conclusion

Turkey and Germany, France, Spain, and Italy compared the academic publications and installed power capacities. It finds that there is a positive correlation between the number of publications and the use of RES, and that the themes of the publications reflect the maturity and diversity of RES in each country. It suggests some research gaps and topics that can help Turkey and similar countries to increase their RES share and achieve sustainable development.

Declaration of Ethical Standards

The author(s) of this article declare that the materials and methods used in this study do not require ethical committee permission and/or legal-special permission.

Yenilenebilir Enerji Teşvikleri ve Türkiye için Gelecekteki Etkileri: Karşılaştırmalı Bibliyometrik Analiz

Araştırma Makalesi / Research Article

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ÖZ

Pek çok ülke sürdürülebilir kalkınma ve artan enerji talebini karşılamak için önemli olan yerli ve yenilenebilir enerji üretimini artırmak için teşvikler kullanır. Bu durum aynı zamanda sıfır karbon emisyonu hedeflerine ulaşılmasına yardımcı olur ve dışa bağımlılığı azaltır. Sağlanan teşviklerle ülkeler, yenilenebilir enerji kullanımı konusunda ilerleme kaydetmektedir. Politik ve ekonomik düzenlemelerin yanı sıra, bilimsel araştırma, yeniliği teşvik etmek için kamuoyu bilincini artırmada çok önemlidir. Yenilenebilir enerji ve politika üzerine akademik çalışmalar yoluyla ülkeler, sürdürülebilir bir gelecek için çevre bilincini teşvik ederken daha iyi politikalar ve yatırımlar oluşturabilir. Yeşil enerjiye yönelik teşvikler ve politikalar hakkındaki akademik çıktıların karşılaştırmalı analizi önemlidir. Yenilenebilir enerji kullanımı ile akademik üretim arasındaki bağlantıyı inceleyen bu araştırma, Türkiye, Almanya, Fransa, İspanya ve İtalya'daki bilimsel yayınların bibliyometrik analizini yaparak mevcut durumu anlamak ve gelecekteki çalışmalara rehberlik etmek için kullanılmaktadır. Web of Science veritabanında yenilenebilir enerji politikalarını ve önlemlerini belirleyen anahtar kelimelerle ulaşılan akademik çalışmalar, yenilenebilir enerji yatırımları arttıkça akademik üretimlerin niceliksel olarak arttığını ortaya koymuştur. Tematik analiz, yenilenebilir enerji kullanımındaki olgunluğun bilimsel araştırmalara da yansıdığını göstermektedir.

Anahtar Kelimeler: Yenilenebilir enerji teşvikleri, enerji politikaları, Türkiye, bibliyometrik analiz, tarife garantisi.

Renewable Energy Incentives and Future Implications for Turkey: A Comparative Bibliometric Analysis

ABSTRACT

Many countries are using incentives to increase domestic and renewable energy (RE) production, which is important for sustainable development and meeting the rising demand for energy. This also helps achieve zero-carbon emission goals and reduces dependency on foreign sources. Countries have made progress using renewable energy with provided incentives. Along with political and economic regulations, scientific research is crucial in raising public awareness to foster innovation. Through academic studies on renewable energy and policy, countries can create better policies and investments while promoting environmental awareness for a sustainable future. A comparative analysis of academic outputs on incentives and policies for green energy is important. This research examines the link between RE use and academic production. To this end, a bibliometric analysis of scientific publications from Turkey, Germany, France, Spain, and Italy was employed to understand the current state policies and suggest future studies. The academic studies that were compiled with the keywords in the RE policies and measures in the Web of Science database have revealed that academic productions increase quantitatively as RE investments increase. The thematic analysis shows that the maturity in RE use is also reflected in scientific research.

Keywords: Renewable energy incentive, energy policy, Turkey, bibliometric analysis, feed-in tariff.

1. INTRODUCTION

With the increasing population and industrial development globally, the need for energy is constantly increasing. The risk of depletion of existing energy resources and coal, oil, natural gas, etc. due to the negative effects of fossil fuels on the environment, the difference between supply and demand is increasing. The energy produced from renewable energy sources (RES) such as solar energy produced by solar panels using the rays from the sun [1], wind energy produced by wind turbines [2], hydroelectric energy produced by the movement of water in water resources such as lakes, streams, and rivers [3], organic energy produced naturally by geothermal energy produced using underground heat sources and distributed through heat pumps [4], and biomass produced by converting materials (such as wood, straw, and vegetable waste) into energy [5] is used both in houses and in industry, allowing the energy demand to be met with the country's resources. Renewable power plants can include more than one source as hybrid systems. Different energy sources can be combined in the

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same field with these systems and more benefits can be obtained from the resource potential in terms of area. Also, the electricity produced can be stored by developing batteries or derivative energy storage technologies, and this stored energy can be reused according to the energy demand. In this way, intermittent production behaviors of solar and wind energy sources can be balanced, and a continuous energy supply can be provided [6]. Using RESs is important in terms of protecting nature by reducing environmental pollution and can also help meet energy needs by providing a solution to the risk of depletion of fossil fuels [7]. Thus, many countries provide government subsidies to encourage using RESs. Among these supports, there may be various options such as incentives, tax deductions, payments, and loans [8]. The purpose of these incentives is to expand the use of RES, increase the share of RES in meeting the energy need, and reduce environmental pollution [9]. Various methods can be used to encourage the use of RES, because it is aimed to make the use of RES attractive with government incentives such as providing tax breaks for the construction of solar power plants, granting loans for the construction of hydroelectric power plants [10].

Countries can import large amounts of energy to avoid bottlenecks in energy supply. Although countries are dependent on foreign energy to some extent, reducing this is among the most important policy objectives. Ensuring energy supply security from countries' resources plays an important role in economic growth and national development. The International Energy Agency reports that Turkey's energy consumption has increased simultaneously with the country's recent rapid population and economic growth and import-dependent energy supply [11]. As can be seen in Figure 1, which shows the change in total installed power in Turkey, it has grown approximately four times since 2000 and the current installed power has been provided almost in the last ten years. The ratio of RES in the total installed power has been increasing over the years. While the RES rate was 22% in 2012, it reached 55% in 2022. At the same time, when evaluation is made according to domestic sources; the domestic resource ratio in total installed power has increased by 11.9% in the last 10 years [12].

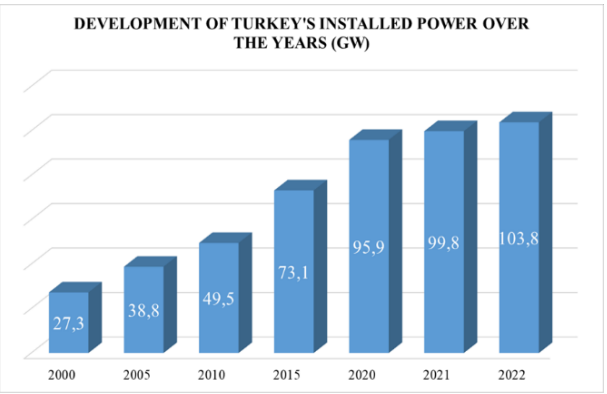

Figure 1. The development of installed power over the years

European Union (EU) countries import 58% of their total energy demands [13]. The top three energy-importing countries are Malta, Cyprus, and Luxembourg, while Turkey ranks ninth with 71%. Numerous nations, including Italy, Spain, Germany, and Turkey, rely on energy imports. This circumstance makes it difficult to ensure the continuity of energy supply, causes countries to struggle with energy shortages, particularly during times of crisis, and has multidimensional effects on the economy. The public is exposed to price fluctuations in the international market since the market determines how much customers must pay for electricity. Political unrest in countries from which a country imports energy can impact power outages and electricity supply disruptions. Dependence on foreign energy sources can lead to a lack of energy security, as any disruption in the energy supply can have devastating consequences for the economy and society. In addition, energy-exporting nations may have environmental issues associated with electricity generation. However, the increased use of RE presents Turkey and other nations with a significant opportunity to lessen their energy dependence on foreign sources. In terms of supplying local resources for economic development, nations that can utilize their energy resources have a substantial advantage. In addition to providing an input cost advantage, renewable energy also increases employment in the region where it is built [14]. RE is supported by various policies to reduce foreign dependency by meeting the increasing energy demand with environmentally sensitive sources. With the effect of these incentives, the use of RES is gradually increasing. When analysing energy investments as resource-based alternatives, wind, hydroelectric, and solar energy are the top three options in Turkey for promoting sustainable energy policies in the future [15]. According to [16] data for 2021, as can be seen in Table 1, which was prepared to show the share of electricity produced from renewable sources in Turkey and other countries, which are among the top ten countries in terms of renewable energy capacity ratio. Germany ranks fifth in the world after continental countries such as China and the USA and ranks first among EU countries.

Table 1. The percentage of electricity generated from RESs in countries.

Countries	Share of Renewable Energy in Electricity Production by Countries (%)					
	2000	**2005**	**2010**	**2015**	**2020**	**2021**
Turkey	24.9	24.5	26.4	32	41.8	35.2
Germany	6.9	11.3	17.6	30	44.8	41.5
France	13.7	10.6	14.4	16.7	24.3	22.6
Spain	16.9	15.9	33.5	35.7	44.5	47.1
Italy	20.8	18.2	26.6	39	42.4	41.4

In the last two decades, the greatest increase has been seen in Germany. There is no significant increase until 2010 in Turkey, which may be due to the large hydropower generation capacity. However, with a significant increase since 2010, other countries have

approached. Compared to other countries, France has the lowest rate and growth. The main reason for this may be the abundance of France's nuclear power generation capacity. Turkey encourages the transition to RES to reduce foreign dependency on energy, rationalize energy prices for consumers, and ensure that the country's increasing energy demand is met stably. The Turkish government provides several purchase guarantees and sizable incentives such as tax exemption, land use, and domestic component for RE [17]. Due to being both environmentally friendly and domestic resources, RE contributes to the reduction of energy and the increase in employment [18], and provides green economic growth [19]. New regulations were introduced to reduce carbon emissions as a requirement of global climate action. Turkey ratified the Paris Agreement in 2021, which is one of the critical milestones in environmental action, such as the United Nations Environment Program, which started within the scope of combating climate change, and the Kyoto Protocol for the limitation of greenhouse gas emissions. With the announcement of the net zero emission target for 2053 by the Presidency of the Republic of Turkey, an important target has been set to increase the RES. Increasing the share of RES in the electricity supply and reducing the use of fossil fuels are of great importance for Turkey to transition to a zero-carbon economy [20]. So, the Turkish government has introduced incentives such as feed-in tariffs and tax exemptions to promote their development [21]. The Aegean and Marmara areas, as well as the Black Sea coast, all have wind energy projects. To raise wind energy's proportion in the nation's electrical mix, the government is also encouraging its expansion. Turkey's energy security and environmental problems are considered as being best solved by solar and wind energy, and several large-scale power plants have recently been built or are now being developed in this regard. Especially in the last ten years, the diversity of sources used in energy production has greatly increased and the use of RES has shown extraordinary development. The ratio of domestic-sourced installed power to installed power is increasing due to the increase in the use of RE, especially wind and solar energy.

The issue of RE, which is of great importance for the promotion and dissemination of its use for a sustainable future, needs to be examined from a multidimensional perspective, and one of these areas is undoubtedly academic studies. It is important to support research and development studies in the field and to inform the public by increasing scientific research outputs in ensuring an increase in the use of RE. In addition, the increase in the use of RES attracts the attention of researchers in the country in this direction and causes academic publications to focus on these issues. In a bibliometric analysis that evaluated the studies on RES, it was determined that the countries that did the most research on this subject were the USA, England, Germany, China, Turkey, Spain, Italy, Canada, Australia, and Japan, respectively [22]. A paper examining studies on solar energy in Europe and other countries revealed that research on solar energy increased in parallel with the significant increase in solar energy production [22]. This mutual feeding process ensures that policymakers are well informed while making government programs and thus rational decisions can be made to protect the country's interests at the highest level. According to 2015 data, Turkey's activities in the wind power plant field were compared with seven EU countries using data envelopment analysis [23].

By examining the academic studies on the policies implemented to increase RE use and investments, the decision-making process can be realized, and the development of successful policies and investment strategies can be supported. Bibliometric analysis of scientific productions on topics such as energy investments, incentives, and policies can provide valuable information about the current state of research and help identify future research and investment opportunities in these topics. Performance and scientific mapping-based bibliographic analyzes can be used to measure the overall situation in any field of study and determine the probability of establishing a successful target for improvement. With these methods, emerging trends are determined, and results can be obtained for decision-makers and practitioners with the effect of the studies produced. To determine the distribution of academic productions in the field by countries [24–26] and to reveal commonly used terms [27-28], bibliometric analyzes conducted on academic studies on incentives. However, the evaluation of the dependent relationship between academic production and RE use and the comparative conduct of thematic analysis for different countries differentiate this study from others. This study, which examines incentive tools for RE investments in Turkey and makes a comparative bibliometric analysis of scientific studies in the field, would provide valuable information for both policymakers and researchers in determining successful strategies and good practices that can be applied to inform the public and develop effective incentives. The research questions (RQ) of this study were determined as follows:

RQ.1: *What is the relationship between the rate of adoption of renewable energy by policies and incentives implemented and the number of academic studies in the field?*

RQ.2: *How has the development of RE influenced the focus of academic studies?*

To determine the nature of the connection between RE deployment, incentive legislation, and scholarly research, bibliometric analysis was utilized in the study. Academic publications retrieved from the Web of Science (WoS) database dealing with RE incentives in Turkey, Germany, France, Spain, and Italy were analyzed with Bibliometric. In the bibliometric analysis phase, to enable comparative and in-depth evaluations

regarding Turkey, Germany, France, Spain, and Italy, which have high scientific production in the field, were included in the sample as countries with close RE usage rates. Considering the data of the last five years, the capacity ranking of these countries, which have continuously increased in renewable energy capacity, is Germany, Spain, France, and Italy. In Figure 2, the renewable energy capacities of these countries are given [29-30].

started in 2005. Legal regulations, financial support, and assistance programs are carried out within the framework of these plans [34]. With the effect of these regulations, the interest in the use of renewable energy in Spain is quite high. It is one of the countries with the highest amount of solar energy in terms of primary energy supply in the world, and it is one of the countries in the first place in terms of wind energy [35]. France is the second largest energy consumer in Europe in terms of energy

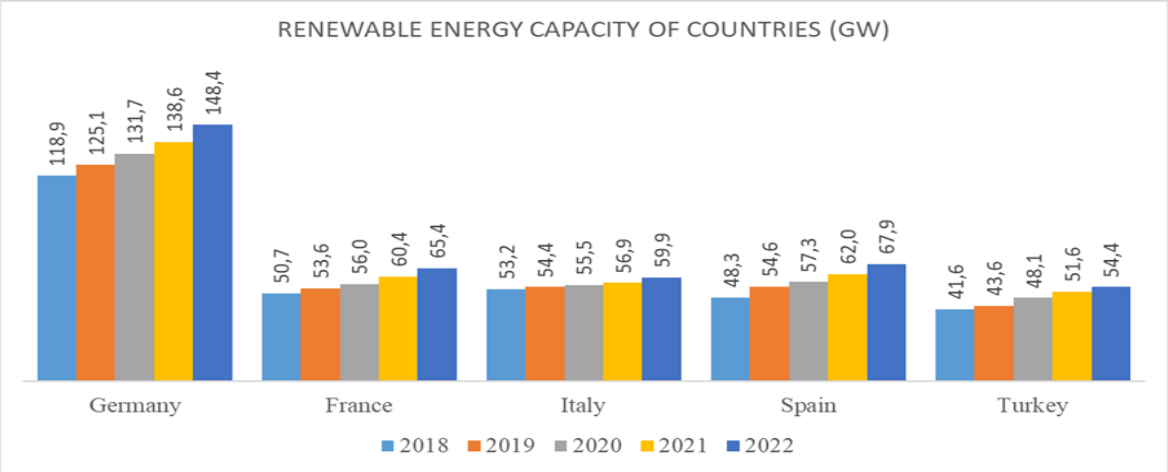

Figure 2. The development of renewable energy capacity in countries over the years

In the development of RES in EU countries, many different support and compulsory policies have been implemented from past to present. The Renewable Energy Directive, which was first enacted in 2009, obligated a 20% share of EU energy consumption must come from renewable energy sources by 2020. However, the directive has been a component of Clean Energy for All Europeans to maintain the EU's position as a global leader in renewable energy, helping it to meet its emissions reduction commitments under the Paris Agreement since 2018. In this policy, The EU applied stronger laws in March 2023 to increase its renewable energy capacity, upping for 2030 to 42.5% [31]. According to these targets, countries have implemented their own policy practices from the past to the present. Germany has aimed to increase renewable energy sources with the Renewable Energy Act since 2000. With this law, support mechanisms such as grid connection convenience and feed-in tariffs were implemented. Also, these laws have encouraged distributed generation sources such as rooftop solar applications for self-consumption [32]. Germany continues to implement different incentive mechanisms by making many changes within the framework of this law [33]. It approved changes to its energy law as of December 14, 2020, continuing the long-term expansion of renewable energy, and helping to achieve the 2030 target of producing 65% of its electricity from clean sources. In Spain, renewable energy and energy efficiency programs are maintained within the framework of the national action plans that

consumption, therefore it is of great importance for ensuring the EU's renewable energy targets. In addition, since it is the country with the highest number of interconnections in the EU, it will be more affected by the markets for renewable production [36]. With the regulation made in 2015, it was decided to reduce the nuclear energy capacity to 50% and increase the renewable energy to 50% at the same time [37]. Today, it applies incentives such as long-term purchase guarantees, public tenders, premium tariffs, corporate power purchase agreements, and self-consumption [38]. Italy has achieved significant growth thanks to the wind and solar capacity established as a result of support with different legal regulations since 2000. In this process, many different incentives such as green certificates, guarantee tariffs, and premium tariffs were applied [39]. In 2019, the so-called “FER1 Decree” was enacted to provide incentives for renewable energy sources of about €1 billion per year and ensure the development of approximately 4.8 GW of generating capacity until 2021 [40].

The leading role of EU countries and the increasing RE capacity in statistical data in recent years have been effective in the selection of these countries. In addition, as seen in the short review, it should be accepted that these countries have carried out renewable energy and implementation actions of these countries. Academic productions on RE of these countries which have a relatively high foreign dependency on energy, and which have implemented various successful incentives to

increase the use of RE have been analyzed. In addition, the increasing interest of researchers in RE and the increasing number of studies in this field were examined. The fact that the WoS database was chosen to collect data due to its breadth and academic quality of the publications may be considered one of the research's limitations, as bibliometric analysis performed on publications collected from different databases may reveal varied results. Meanwhile, the themes provided for future research may be revised by altering the nations used as the study sample. Furthermore, the results generated and explained by the analysis approach do not allow for a ranking of the incentive strategies as best or worst.

The direction of the relationship between the number of academic studies on RE incentives for the relevant countries and the amount of RE used by countries is questioned. In this way, it is aimed to reveal the relationship between the use of RE, the political measures implemented to increase this rate of use, and the scientific production related to the subject. It is aimed to contribute to the adoption of conscious policies by determining the prominent themes and concepts related to the increase in RE investments by examining academic studies in terms of quantity and content in comparison with sample countries. The results to be obtained by thematic analysis of publications have policy implications such as expanding RE investments and diversifying scientific output.

2. INCENTIVES FOR RENEWABLE ENERGY IN TURKEY AND SAMPLE COUNTRIES

The rise of RES in Europe has been driven by the policies of the European Union, which has been at the fore of the field in terms of RE policy [41]. The European Union has been promoting the use of RE for several years through various policies and initiatives. As part of the Clean Energy for All Europeans Package, the revised Renewable Energy Directive (Directive (EU) 2018/2001) went into effect in December 2018. This was done to maintain the EU's position as a global leader in RE and, more broadly, to assist the EU in meeting its emissions reduction commitments under the Paris Agreement. From December 2018, this regulation has been updated. It was required to become national legislation in all European Union nations by June 2021, taking effect on July 1 of that year. With a provision for a potential upward revision by 2023 and an additional 14% objective for the percentage of renewable fuels in transportation by 2030, the directive sets a new, legally binding RE target for the EU of at least 32% of final energy consumption for 2030 [42]. In addition to this policy, policies such as European Green Deal [43], Energy Efficiency Directive [44], Clean Energy for All Europeans Package [45], Connecting Europe Facility [46], 2030 Climate and Energy Framework [47], Emissions Trading System [48], Horizon Europe Program [49] are important decisions in Europe. Incentives such as feed-in tariffs, quota obligation systems, tendering systems, tax incentives, and green certificates come from these policies and regulations set by The European Union [50]. In addition to such policies, serious investments are made in the RE sector. The European Union's funding vehicle for enhancing energy, transportation, and digital infrastructure is the Connecting Europe Fund. A budget of €42.3 billion has been saved aside for the Connecting Europe Fund, which was recently extended for the years 2021-2027, to support investments in European Union energy (€8.7 billion), transportation (€30.6 billion), and digital (€3 billion) networks. The first Connecting Europe Fund call for proposals was launched on September 7, 2021, making €785 million available to finance clean energy infrastructure projects [51]. The growth and development of RES have been significantly impacted by subsidies for RE in Europe. Environmentally friendly energy systems are more expensive to use, install, and maintain than fossil fuel-based energy systems in the short term, and customers must pay more as a result of this financial issue. But, over time, the long-term costs of fossil fuels' detrimental effects on the environment and human health are substantially greater. Personal factors, socioeconomic characteristics, living circumstances, family income, size of residence, individual age, education, social status, personal experience, etc. are said to affect willingness to pay more in studies that look at people's desire to use more environmentally friendly energy sources. To prevent such difficulties, the government and institutions implement processes that encourage both the producer and the consumer. The support methods for RE are listed in Table 2 [60]

Table 2. Regulations and incentives for RE

Regulatory Policies		**Financial Incentives / Public Finance**
Fixed Price	Net Measurement	Capital Subsidy, Grant or Return
Feed-in Tariff	Mandatory Biofuel / Directive	Investment or Production Tax Reductions
Premium Payment	Mandatory Heating / Directive	Discounts on Sales, Energy, CO2, VAT, or Other Taxes
Green Certificate	Tradable Renewable Energy Licenses	Energy Production Payment
Electricity Company Quota Obligation	Tender Method	Public Investment, Loans, or Grants

Incentives and support for the use of RE should be evaluated in terms of both energy production and

consumption. The energy market, where energy is mainly provided by producers and consumers pay lower tariffs thanks to the use of RE, has now gained a different dimension thanks to regulations that allow some consumers to produce and even sell their energy. This change can lead to increased use of RE, and lower market prices, and new regulations are needed to support this shift [53]. Different types of generation activities were allowed to provide electricity generation from their resources and to reduce external dependency in Turkey. Power plant installation can be done by obtaining a license for electricity generation with the Electricity Market Law No. 6446. Also, unlicensed power plant installation was created for small-scale facilities to ensure energy supply security and reduce foreign dependency on energy use. Although the law on the use of RES in electricity generation was made at a relatively late date, it was the first legal regulation regarding RE systems in Turkey (10.05.2005 - Law No. 5346). This law aimed to encourage the widespread use of RES for reliable, economical, and high-quality electricity production, increase the diversity of sources, reduce air pollution, evaluate garbage and waste, protect the environment, and develop the manufacturing sector [54], [55]. Incentive and support programs for the use of RES have been addressed in terms of both energy production and consumption and put into practice. These incentive titles are given below [56]–[59].

-Financial, tax, and fixed-price guarantee incentives

-Unlicensed electricity generation

-Premium warranty and tender method

-Quota obligation and renewable portfolio standard

-Local components and land use incentives

-Incentives for producers and consumer

One of the most widely used support and incentive mechanisms in the world and in Turkey is the fixed price guarantee. In this system, a fixed price guaranteed strategy is introduced for each RE resource. It is based on the fact that real and legal persons who own a renewable power plant receive a fixed price guarantee if they send the electrical energy, they produce more than their needs to the distribution system [60]. At the same time, the fiscal incentive is the event that the government provides incentives by providing low-interest and long-term loans to businesses in the RE supply and demand stage, and by providing many financial supports with tools such as environmental tax exemptions, value-added tax exemptions, and accelerated depreciation As a financial incentive tool, investment incentives are usually given as a percentage of the investment cost at the start-up phase or supported by low-interest long-term loans per kWh installed for the development of RE projects. A government-backed loan is when the government or international organization provides loans to support RE investments on more attractive terms than regular commercial loans. Tax incentives, exemptions, and discounts that can be applied in the form of tax deductions, tax credits, and tax exemptions are provided [61]. Regarding unlicensed energy production in Turkey, the policy of using the electricity produced by the producer for self-consumption was adopted. Premium warranty and tender methods, RE portfolio, local components, and land use incentives are other incentive methods in Turkey. When the support given by the Turkish Government is examined, it is seen that in terms of the use, installation, and maintenance of environmentally friendly energy systems, it is not financially advantageous in the short term compared to fossil fuels and consumers are provided with tax and financial support due to this financial problem. In addition, local components and land use incentives were also considered important to support domestic products and manufacturers.

3. MATERIALS AND METHODS

In this study, scientific publications in Turkey, Germany, France, Spain, and Italy which deal with the issue of RE within the framework of political, legal, and economic developments, were examined. WoS Core Collection, which provides access to multiple databases containing comprehensive citation data for various academic fields, provides the opportunity to search among rich information. The academic publication data analyzed in the study were accessed as a result of the search carried out with country names and related keywords in WoS, which includes scientific research that shapes the literature. The analysis was performed to cover all relevant studies containing the keyword combinations shown in the Table 3. Keywords were chosen from those most used in the literature involving incentives, policy, or similar topics. The same search method was used, replacing “Turkey” with “Germany”, “France”, “Spain”, and “Italy”, and in turn, to perform the same scan. Table 4 shows the quantitative data of the publications by countries obtained from the WoS database using the keywords given.

Table 3. Keyword combinations

Main words	Keywords
renewable energy * AND Turkey*	AND support*, AND incentives*, AND feed-in tariff *, AND policy *, AND legislation*, AND tax*, AND loan*, AND subsidy *, AND tender*, AND auction*, AND interest*

Retrieved studies were analyzed using the Bibliometrix tool developed in the R-studio environment. Within the scope of bibliometric analysis, which includes several methods used to analyze the literature, keyword analysis was applied to identify and analyze common words or expressions in documents to understand patterns and trends in research. In addition, thematic analysis was carried out by determining and coding the themes that emerged from the data and then allowing these themes to be interpreted according to the research questions, giving direction to further studies

Table 4. Main information about the data

DESCRIPTION	**RESULTS**				
MAIN INFORMATION ABOUT THE DATA	**Turkey**	**Germany**	**France**	**Spain**	**Italy**
Sources (Journals, Books, etc.)	387	824	288	401	470
Documents	1318	2624	598	1078	1247
Annual Growth Rate %	17.99	13.79	12.31	11.38	14.69
Document Average Age	6.78	6.34	5.24	6.1	5.89
Average Citations per Doc	28.45	26.51	22.24	23.02	20.3
References	42678	98538	26695	42066	45579
DOCUMENT CONTENTS					
Keywords Plus (ID)	1847	2883	1267	1869	1973
Author's Keywords (DE)	3034	6210	1955	3102	3656
AUTHORS					
Authors	2650	6853	2053	3156	3667
Authors of Single-Authored Docs	214	366	83	80	81
AUTHORS COLLABORATION					
Single-Authored Docs	285	418	88	90	84
Co-Authors per Doc	2.77	3.39	3.82	3.77	4.11
International Co-Authorships %	18.97	26.56	36.12	30.06	24.22
DOCUMENT TYPES					
Article	212	1915	437	788	883

4. RESULTS AND DISCUSSION

As a result of the scanning carried out to obtain the data to be used in the research, 1318 publications from Turkey, 2624 publications from Germany, 598 publications from France, 1078 publications from Spain, and 1247 publications from Italy were reached. Figure 3 presents the numerical graph of the scientific research articles produced in Germany, France, Spain, and Italy on the use of RESs and their incentives, which were determined to be analyzed comparatively with Turkey by years. While it is seen that the number of research on this subject has increased rapidly in the last ten years when ranking according to the number of academic productions, at this point, it would be useful to consider the total installed capacity of renewable energy by countries graph to see the parallel development in the number of academic studies with the increased use of RES with the support of incentive mechanisms (Figure 2). When Figures 2 and 3 confirming RQ1 are examined together, it is striking that the rankings in both are as Germany, France, Spain, Italy, and Turkey. The ranking of nations according to the total installed capacity of RE in the sample countries and the ranking of countries according to the number of scholarly papers on RE policies and incentives are identical. This is one of the most noteworthy findings of the research.

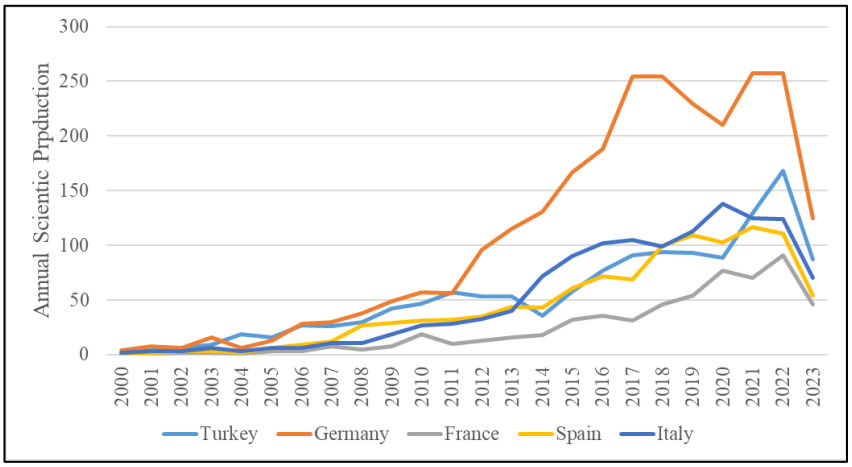

Figure 3. The change in studies on incentives for RESs over the years according to countries

Bibliometric analyses of scientific publications on low-carbon energy technology investments of countries confirm the finding of a parallel relationship between RE use and academic production. Studies reveal that while the USA ranks first in the publication rankings in the field, it is followed by countries such as China, Germany, Spain, Italy, England, Canada, and Denmark, and Turkey is among the first 15 countries on the list [23]. Similarly, it was determined that Germany and Spain, the two EU countries with the highest installed photovoltaic capacity account for 51% of the total solar energy-related scientific production in the EU-27 [26].Used in bibliometric studies to identify and analyse the most frequently used words or phrases in the literature for interpretation, keyword analysis allows us to understand patterns and trends in research by counting how many times certain keywords or keyword combinations appear in documents. The word cloud figure obtained for Turkey with the analysis carried out is presented in Figure 4. According to this figure, it has been determined that important concepts, respectively, such as solar energy, economic growth, sustainable development, and energy policy come to the fore in Turkey

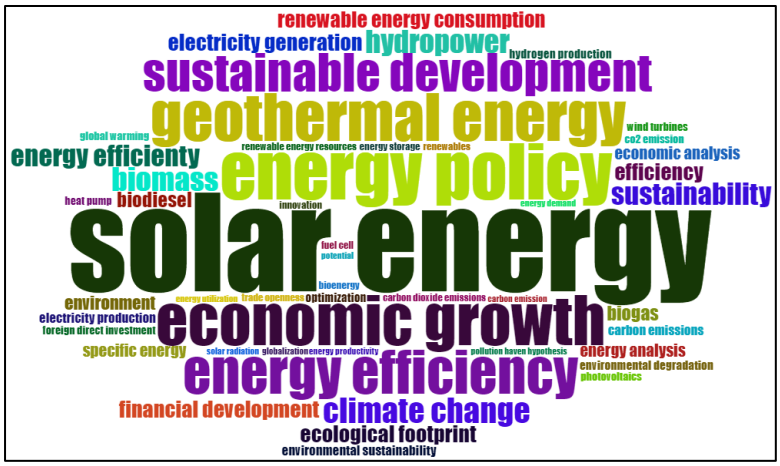

Figure 4. Word cloud of keywords for Turkey

These terms show a strong interest in the intersection of economic and environmental concerns, as well as the role of energy policy in achieving sustainable development goals. While a focus on economic growth may indicate a desire to balance economic progress with environmental sustainability, an emphasis on sustainable development suggests a long-term approach to economic and environmental planning. It can be evaluated that energy policy is seen as a key tool for promoting sustainable development and balancing energy needs with environmental protection. Overall, these findings suggest that Turkey takes a proactive approach to address the challenges of economic and environmental sustainability and actively seeks to balance economic growth with the need to conserve natural resources for future generations. The word cloud figure obtained from the bibliometric analysis of the studies conducted for Germany, France, Spain, and Italy is presented in Figure 5. The prominence of the feed-in tariff, energy policy, energy efficiency, and storage systems in Germany, France, Spain, and Italy suggests a common focus on advancing RES and integrating them into national energy systems. Feed-in tariff policies, which incentivize RE production and ensure fair compensation for energy producers, have been particularly successful in Germany and Spain, which are global leaders in RE adoption. Italy has also been expanding its use of feed-in tariffs, as well as implementing policies to increase energy efficiency and promote the use of energy storage systems. Overall, these countries appear to be working to develop comprehensive energy policies that prioritize sustainability and RES, reflecting a global trend towards a more environmentally conscious approach to energy production and consumption. Considering the climate change and efficiency targets, it is seen that the words energy efficiency, energy policies, and renewable energy stand out in four countries. For Turkey and other countries, it is seen that the issues of climate change, renewable energy sources, and sustainable development are studied significantly. As in the rest of the world, the most common renewable energy resource used in the countries studied is solar energy. In Germany and Spain, which are ahead of the others in terms of RES capacity, energy policy, and feed-in tariff are ahead, and accordingly, giving the necessary importance to support policies is an indicator of its contribution to RES investment. However, as it is known, RES capacity increase causes some unbalance problems in the electricity grid. For this reason, new applications such as energy storage, demand response, and self-consumption are emerging to increase the RES capacity in Germany and Spain. Economic growth is ahead in Turkey and France. Since the energy issue in Turkey is one of the most important factors in terms of the economy, academic studies primarily focus on this area.

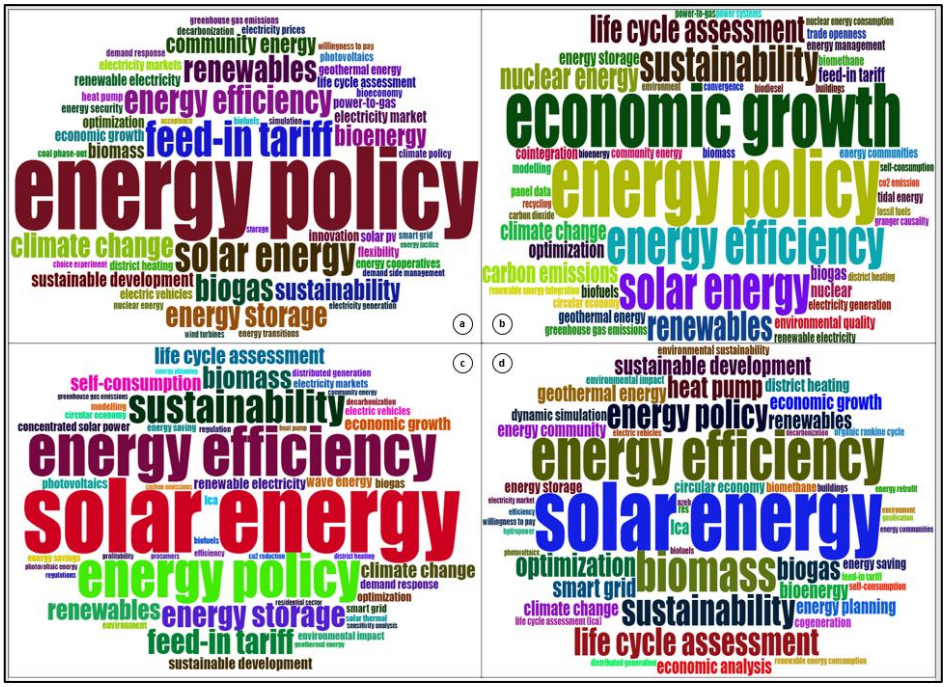

Figure 5. Word cloud of keywords for countries: a) Germany, b) France, c) Spain, d) Italy

When the prominent words in the word clouds examined in the studies in the countries compared are analyzed, it is seen that Germany, France, Spain, and Italy attach more importance to price policies such as energy policies, efficiency, investment, and tariff guarantees than Turkey (Table 5). The results of a study in which a bibliometric analysis of different types of RE financing was carried out similarly determined that the terms most strongly represented in the literature were "energy policy" and "feed-in tariffs" [27]. With the bibliometric analysis carried out to show the development of studies carried out by countries on RES between 1998 and 2019, it has been determined that the concepts used in academic studies are generally solar and wind energy, optimization, investment, incentives, and energy storage technology [28]. In this context, it can be said that these issues should be brought to the fore, and policies aimed at encouraging both producers and consumers should be implemented to expand Turkey's RE resources throughout the country. In addition to promoting the use of RES, Turkey must invest in research and development to increase the efficiency of these technologies. This will not only increase the adoption of RES but will also stimulate technological advances and innovation in the country. In recent years, thanks to government incentives, Turkey has made significant progress in the use of RESs and, in parallel, an increase in academic studies, but by implementing these measures, Turkey can take important steps toward a more sustainable future and contribute to global efforts to combat climate change.

Table 5. Word Cloud Density*

	Turkey		Germany		France		Spain		Italy	
	Word	**Total**	**Word**	**Total**	**Word**	**Total**	**Word**	**Total**	**Word**	**Total**
Economic Growth	58	4.64	25	2	30	2.4	14	1.12	20	1.6
Sustainable	45	3.6	31	2.48	12	0.96	13	1.04	24	1.92
Energy Policy	65	5.2	167	13.36	32	2.56	48	3.84	37	2.96
Energy Efficiency	51	4.08	58	4.64	21	1.68	54	4.32	63	5.04
Feed-In Tariff	0	0	73	5.84	7	0.56	27	2.16	10	0.8
Energy	10	0.8	2	0.16	3	0.24	1	0.08	0	0
Sustainable	26	2.08	31	2.48	17	1.36	36	2.88	39	3.12

** Some words in this table may not appear in Figures 4 and 5 due to word limitations*

In the second stage of the bibliometric analysis, a thematic analysis was made using the obtained studies. With this analysis, thematic maps that visually represent how certain themes and issues are distributed in the data and how they change over time are created. Thematic maps were divided into four sections: Motor Themes, Niche Themes, Emerging or Declining Themes, and Basic Themes. The Motor Themes section contains the most central and dense word groups, while the Niche Themes represent less analyzed topics. The Emerging or Declining Themes section includes newly emerging or less important word groups, and the Basic Themes section contains commonly analyzed word groups. The thematic map shows how keyword trends have changed over time, highlighting which topics have received more attention in the past and which are more important today. It also shows the relationship between word groups in the data, with Motor Themes being more central and important than Niche Themes. The thematic analysis of the studies conducted for Turkey is shown in Figure 6. According to the results, it is seen that the primary driving motivation for academic studies in Turkey is economic growth and increasing the use of RES. In addition, the main motivation is energy policy, energy efficiency and sustainability.

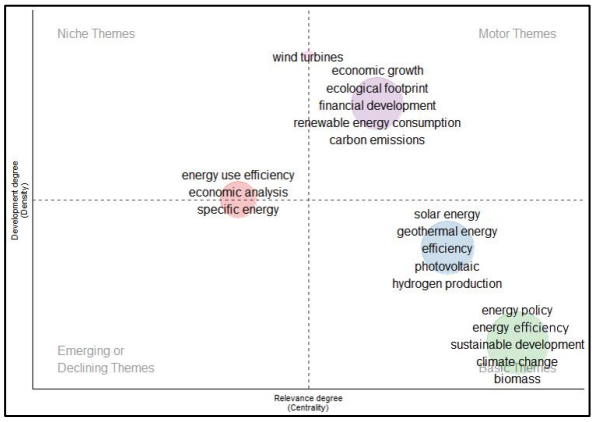

Figure 6. Thematic analysis of the abstract sections of articles for Turkey

On the other hand, the thematic analysis of studies conducted for Germany, France, Spain, and Italy are shown in Figures 7-10, respectively. According to these analyses, the focus of these countries' studies also includes the same terms. However, unlike Turkey, these countries have different focal points with important keywords such as feed-in tariffs, energy storage, flexibility, energy community, self-consumption and green certificate. Based on these analyses, it would be said that these keywords will start to gain importance in Turkey and come into the agenda soon. The reason for this is the increase in state incentives and the development that Turkey has shown both in project-based and academic-based RES in recent years. In addition, while any RES does not come to the fore in the thematic analysis for Turkey, it is seen that the themes related to solar and wind energy in other countries often form clusters with other concepts. This finding is consistent with other studies in the field which suggest that the literature is focused on RES and technologies [27].

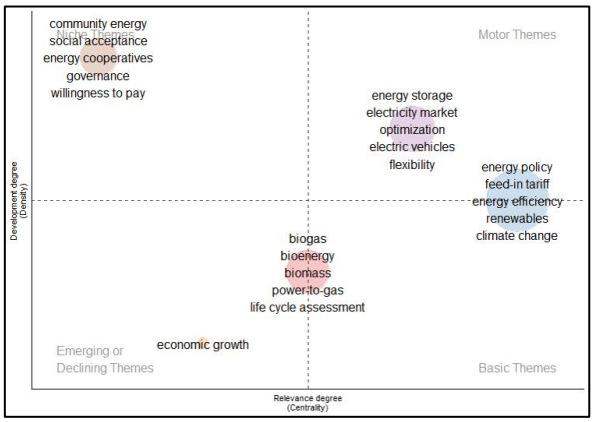

Figure 7. The thematic analysis of the abstract sections of articles for Germany

While studies on solar and wind energy are intensified among RES, it is observed that technical themes such as battery storage, RE integration, and load management, offshore floating power plants, support systems come to the fore. In the solar energy framework, support policies such as subsidies, feed-in tariffs, tradable green

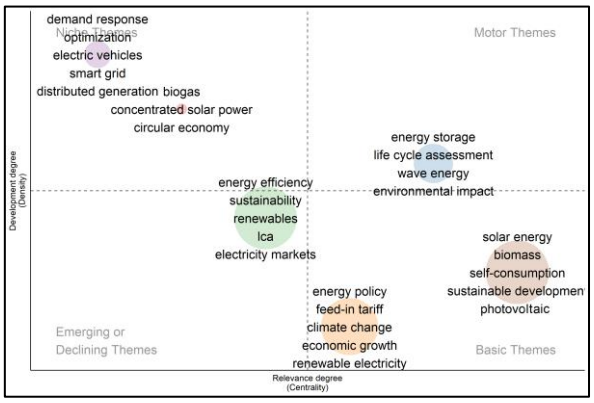

Figure 8. The thematic analysis of the abstract sections of articles for Spain

certificates, and self-consumption are discussed. The Non-Fossil Fuel Liability (NFFO), which means a set of instructions that require electricity distribution grid operators to purchase electricity from the nuclear power and RE sectors, has been analyzed in academic studies as an incentive method studied to promote RES. The concept of circular economy, which aims to protect the environment by recycling resources in the industrial, supports the energy potential, energy efficiency, and public perceptions in the energy transition, considering RE as a political, economic, technical, and social multidimensional issue by researchers. And it emphasizes the necessary regulations with a holistic approach to policymakers.

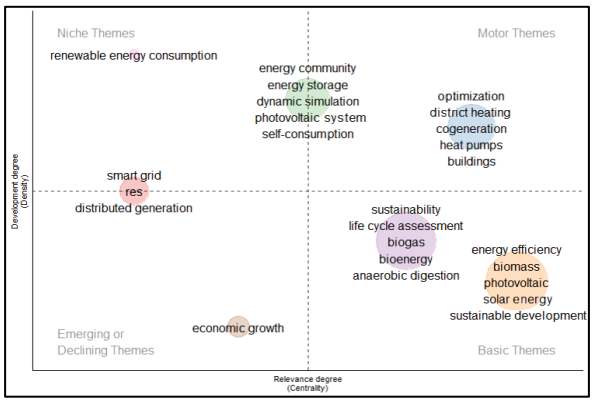

Figure 9. The thematic analysis of the abstract sections of articles for Italy

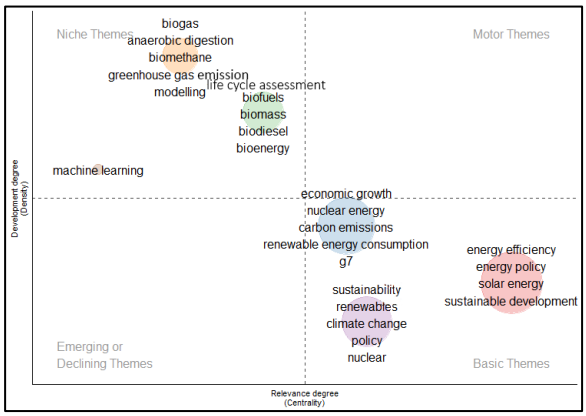

Figure 10. The thematic analysis of the abstract sections of articles for France

5. CONCLUSIONS

With the crises produced by the political turbulence in the energy supply, it has become clearer that the world's and Turkey's ever-increasing energy demand cannot be met by foreign-dependent economic models. Globally, the usage of RES is growing in importance as one of the primary components of constructing a self-sufficient economic development order in a sustainable environment. The growth of these resources is ensured by government policies designed to promote the use of renewable energy sources in Turkey, the rest of the globe, and especially EU member states. To support economic growth and development with local resources and ensure sustainability by reducing carbon emissions, renewable energy (RE), fixed price, tariff guarantee, premium payment, the green certificate, electricity company quota obligation or capital subsidies, tax reductions, public investments, loans, grants, and public financing instruments supported by financial incentives. In addition to its existing benefits, other incentive measures, which differ by nation, are implemented to remove reluctance towards RE.

However, while some countries can elevate the amount of clean energy in their energy production to 100 percent, green energy is not adopted at the same rate in all countries, investments are not growing at the expected rate, and installed power capacity cannot meet local demand. Although the demographics of the countries shape the technical elements of RE investments, the willingness to pay for this energy, the level of adoption, and the awareness of green consumption vary between nations and cultures. For renewable energy incentives to be effective and to increase the use of self-renewing domestic energy supplies that are sensitive to the environment and public health, academics must take a holistic approach to the issue. In addition to the necessary legal regulations, academic studies have great importance in the adoption of the use of these energy resources by both industry and households. To identify the proper resources for the country and to suggest appropriate regulations and incentives to policymakers, there is a need for academic research that analyses the topic extensively and discusses their findings in public.

Recognizing the major challenges or themes in the field of academic research on RE policies and incentives, comparing the relative importance of diverse concepts or ideas, and monitoring the evolution of research through time are deemed valuable to the policy-making process in this area. This analysis stated academic study themes and incentive themes for countries where RE investments are considerably lagging by analyzing their publications on incentives. In this manner, extensions for policies and academic studies have been recommended to Turkey and similar nations where investments in RE are still in their developmental stages. This study, which questions the relationship between RE and academic studies with the bibliometric analysis of academic productions on RE policies and incentives of Turkey, Germany, France, Spain, and Italy, was carried out to shed light on the orientation of scientific studies and political decisions through the thematic examination of the field. As a result of the search carried out with the keywords determined in the WoS database to analyze scientific publications on RE policies and incentives, 1318 publications from Turkey, 2624 publications from Germany, 598 publications from France, 1078 publications from Spain, and 1247 publications from Italy were reached. As an answer to the first research question, which brought into question the increase in the number of academic research papers on the subject as the use of RE increases as a result of policies and incentives in the countries, a comparison was made between the academic publications and the countries' established RE capacities. Observably, the number of scientific works addressing incentives for RE investments has expanded in tandem with the expansion of RE use. A notable conclusion of the study is that the ranking of total RE installed power in the sample nations and the number of publications on RE incentives increase together. As with RE investments, the number of publications is highest in Germany, followed by Italy, Spain, Turkey, and France. This similarity between academic production and RE production demonstrates the significance of funding academic studies in this area for Turkey, which seeks to expand its RE share. The

surge in academic research on RE incentives parallels the strong commitment to sustainability shown by governments that promote the usage of RES.

The goal of the thematic analysis of these papers, which reveals connections between academia and RE production, is to enable new initiatives to be reflected in both scientific studies and energy policy by emphasizing the themes that these countries address. In this study, thematic analysis was employed to answer the second research question, which was devised to discover how academic studies are oriented due to the evolution of RE use. By disclosing the topics that these countries address, a thematic analysis of these publications has been undertaken, and new avenues for scientific research and energy policy have been provided. It has been concluded that the academic studies of nations that enhance their investments in RE have matured, that the diversity of issues has increased, that the breadth has expanded, and that specialty studies have also been done. It is believed that investigating topics such as battery storage, load management, offshore floating power plants, RE integration support systems, subsidies, guaranteed tariffs, self-consumption, circular economy, energy efficiency, and exchangeable green certificates will help to close the research gaps. These research findings can facilitate the adoption and social acceptance of the appropriate legalization and incentives. All these efforts will be extremely important in establishing a sustainable society for future generations.

RE, which is the most significant opportunity to reduce foreign dependence on energy, which is the engine of national development, while simultaneously reducing carbon emissions and achieving the net-zero target, provides countries with a significant competitive advantage in ensuring sustainable economic growth from domestic sources. With this knowledge, countries support the deployment of significant incentives to raise the proportion of renewable energy (RE) in energy production and to encourage sector investments. Within the context of the study's findings, it is possible to assert that storage, load management, demand response, and self-consumption are evolving. In the scientific community, addressing consumer-oriented and grid-supported RE applications can significantly contribute to the policy creation and commercialization process. Owing to the decline in grid flexibility under conditions of fluctuating RE generation, the requirement for grid flexibility to be fulfilled by new activities rises in tandem with the increasing RE potential. In the coming years, these challenges will acquire importance in nations such as Turkey that intend to increase RE investments. Considering Turkey's coastline, studies on offshore wind turbines and solar plants should consider the power grid, energy markets, and incentive applications. In addition, the incorporation of significant concerns such as self-consumption, load management, demand response, energy transition, green economy, and offshore energy plants into academic research can present significant potential for both academics and policymakers. Also, new ideas such as energy villages and energy cooperatives can be investigated. These challenges are production- and consumer-oriented. Policy and incentive examples can be studied by identifying potential sector/user-oriented applications. On this basis, the outcomes of legalization and commercialization can be uncovered.

CONFLICT OF INTEREST

There is no conflict of interest in this study.

AUTHORS' CONTRIBUTIONS

Hafize Nurgül Durmuş Şenyapar: She carried out literature research, methodology, analysis of results and writing of the study.

Ümit Çetinkaya: He carried out literature research, methodology, analysis of results and writing of the study.

Ramazan Bayındır: He made comments and evaluations after the analysis.

DECLARATION OF ETHICAL STANDARDS

The author(s) of this article declare that the materials and methods used in this study do not require ethical committee permission and/or legal-special permission.

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