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# A Comparative Analysis of Renewable Energy Use and Policies: Global and Turkish Perspectives

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**Abstract:** The utilization of renewable energy sources (RES) has become inevitable, not only due to the increasing scarcity of fossil fuels, but also to sustain life on Earth. Consequently, countries have started developing renewable energy policies individually and as part of global organizations and networks, such as the Organization for Economic Co-operation and Development (OECD), the European Union (EU) and the International Energy Agency (IEA). Turkey is a developing OECD member country and in the accession process to the EU. Thus, the renewable energy policies should be aligned with those of the EU. Moreover, despite the substantial amount and wide range of RES, it is still in a position to import more than half of its energy demand. In the light of these facts, this study aims to analyze and compare the renewable energy policies in Turkey with those adopted worldwide to lay out possible solutions regarding its energy problems.

**Keywords:** renewable energy; renewable energy policies; renewable energy use; energy policy; Turkey

## 1. Introduction

Renewables, excluding large hydro, accounted for 9.1% of world electricity generation in 2014, up from 8.5% in 2013, with a corresponding increase of 17% in global investment (\$270.2 billion invested in 2014 in renewable power and fuels excluding large hydro-electric projects) [1]. They have become the fastest growing source of world energy with their share of electric power generation increasing from 10%–15% in 2010, while the fossil fuel sources grew 3% or 4% [2]. The reason behind this is the concern for sustainability resulting from factors, including but not limited to, the depletion of natural resources, life-threatening levels of pollution, global warming, climate change and the ever-increasing worldwide energy consumption [3,4]. The Renewable Energy Working Party of the International Energy Agency (IEA) has provided the following definition [5]:

“Renewable Energy is derived from natural processes that are replenished constantly. In its various forms, it derives directly or indirectly from the sun, or from heat generated deep within the earth. Included in the definition is energy generated from solar, wind, biofuels, geothermal, hydropower and ocean resources, and biofuels and hydrogen derived from renewable resources.”

In line with the above definition and based on the related literature, renewable energy sources (RES) can be classified under seven categories [5]: (i) hydro; (ii) geothermal; (iii) solar; (iv) tide/wave/ocean; (v) wind; (vi) solid biofuels, biogases, liquid biofuels; and (vii) renewable municipal waste.

The effective utilization of RES is critical across the world, where 1.3 billion people still do not have access to modern sources of energy [6]. Moreover, in the last decade, there has been a significant shift in the world toward emerging markets and consequently energy demand; in that, while the developed world used two thirds of world oil in 2000, by 2011, this was split about evenly between developed and developing countries [6]. Thus, the energy consumption and production in developing countries have become much more critical. Turkey is one of these developing countries with a substantial amount and wide range of RES, and it is located in an advantageous geographical position that enables their effective utilization [7–9]. However, because of the rapid increase in energy consumption [10] and the inefficient use of resources, Turkey remains to be an energy importing country, with more than half of its energy being met externally [8,9,11]. Figures 1 and 2 clearly present this situation.

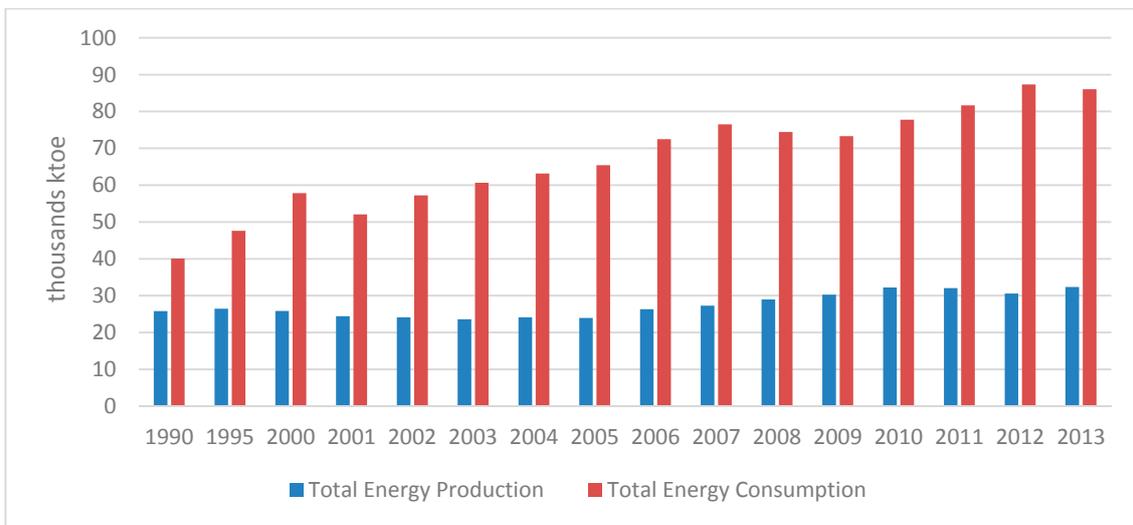


Figure 1. Total energy consumption and production in Turkey (adapted from [9]).

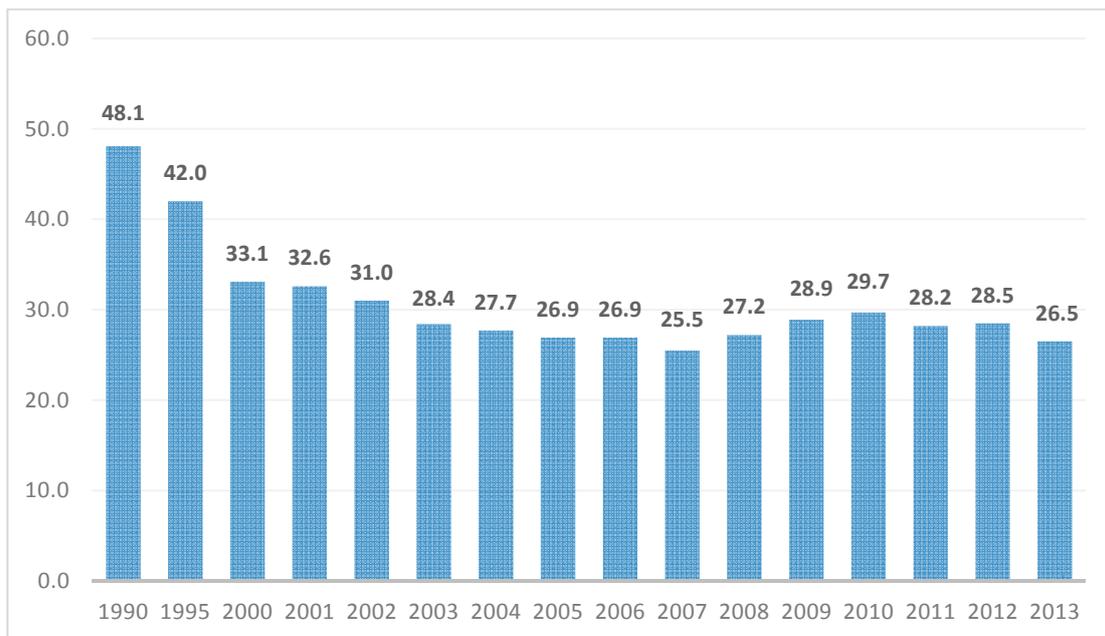


Figure 2. Percentage of energy demand met by indigenous production (adapted from [12,13]).

As can be seen in Figure 1, the total energy consumption in Turkey is increasing exponentially, while the increase in total energy production is relatively much slower. Figure 2 depicts the percentage of energy demand met by indigenous production. There was a significant decrease in 2000, and it has not been able to rise to the level of 30% after 2002. This figure is low considering the amount and range of renewables in Turkey.

Turkey is Europe's sixth largest energy market, and projected annual growth of the electricity demand until 2020 is around 7% [12]. Between 2000 and 2010, Turkey's primary energy production has grown from 81.2 Mtoe–109.3 Mtoe with an increase of 34.6%, and in the period up to 2020, the annual average of Turkey's primary energy production is expected to increase by 4% [12]. Between 2000 and 2013, Turkey's installed capacity of electricity has grown from 27,264 MW–64,044 MW with an increase of 134.9%. During the same period, electricity production has grown from 124.9 billion kWh–239.3 billion kWh with an increase of 91.55% [12]. In 2008, imported primary energy supply was 73%, and in 2009, the energy generated from fossil fuels was 81% [14]. In terms of electricity generation, 19% was from renewable energy in 2009, and hydropower constitutes 98% of the renewable energy in Turkey [14].

The above-mentioned facts also prove that although there has been an increase in Turkey's primary energy production, it is far from meeting the accelerating demand. Thus, there is an urgent need to increase the quality, quantity and diversity of the RES. This is only possible by effective renewable energy policies, which constitute a "highly complex policy subsystem that lies at the intersection between environmental policy, economic policy and energy policy" [15]. The concern for energy security, climate change mitigation and sustainable development [16] has prompted many countries to develop government policies and adopt respective regulations to ensure the production and use of renewable energy and promote the respective new investments. Moreover, they have come to consensus regarding the development of RES in electricity production [17]. Consequently, an extensive literature review has been conducted in this study on the renewable energy projects, binding laws and regulations, incentives and pricing mechanisms, together with the respective energy statistics, to analyze the renewable energy policies and strategies in Turkey and compare them to those adopted worldwide. A comparative analysis using descriptive statistics has also been carried out to provide a general perspective on the current and projected renewable energy use in Turkey and around the world (based on the geographical coverage given in Section 2). Ultimately, the goal is to make suggestions and lay out possible solutions regarding Turkey's energy problems. To this end, the second part of the study provides a descriptive statistical analysis to compare renewable energy use throughout the world. The third section summarizes the global energy policies of the Organisation for Economic Co-operation and Development (OECD) countries, non-OECD countries and European Union (EU) Member countries. A detailed perspective on the current renewable energy status, respective legislation, international commitments and renewable energy policies and strategies in Turkey has been provided in the fourth section. Finally, the possible solutions and promising areas for future research are elaborated in the conclusions part. This study is a modified version of the one conducted by Arioglu Akan *et al.* [18].

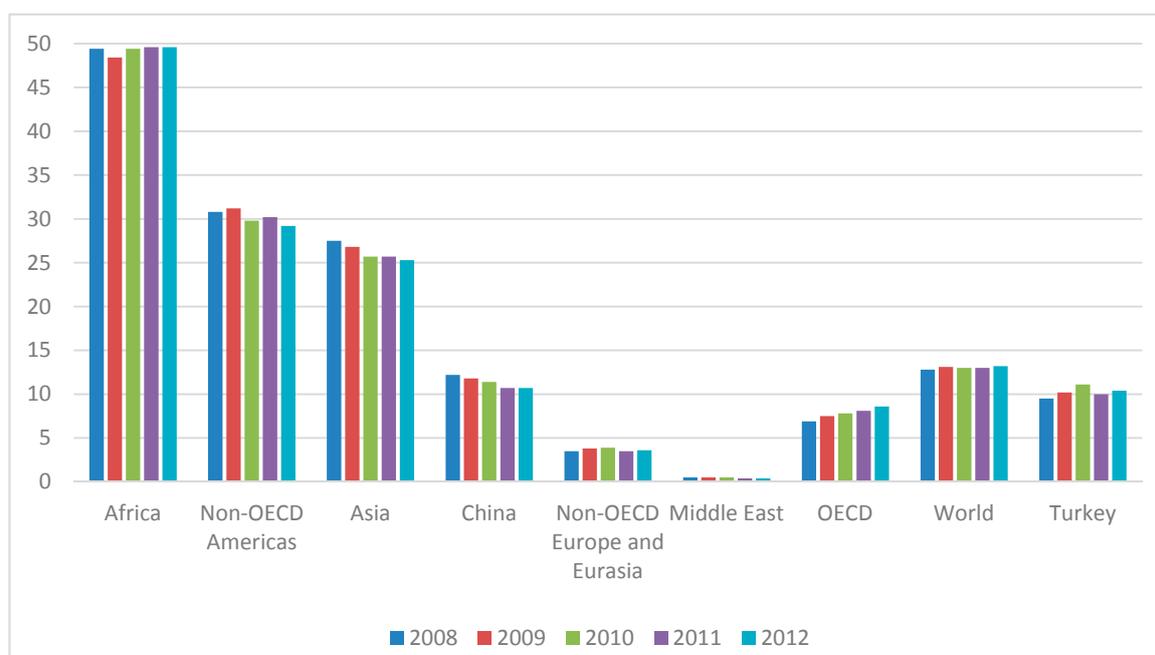
## 2. A Comparison of Renewable Energy Use around the World

This section provides a brief analysis of the comparison of renewable energy use in Turkey with Africa, the non-OECD Americas, Asia, China, non-OECD Europe and Eurasia, the Middle East, OECD and world total (world marine and aviation bunkers have not been included in the analysis because of the lack of data). The purpose is to lay out the current situation of renewable energy use in Turkey on a general basis and also by source. To this end, Table 1 presents the overall renewable energy share in total primary energy supply (TPES) in addition to the individual shares of hydro, geothermal/solar/wind/wave and biofuel/renewable waste. The figures are the averages of the respective data corresponding to the years between 2008 and 2012, which have been gathered from IEA yearly "Renewables Information" reports (2010–2014 Editions) [19–23]. Figure 3 depicts

the worldwide renewable energy shares in TPES between 2008 and 2012, and the five-year average individual shares of the above-mentioned sources can be viewed in Figure 4. The geographical coverage provided in Table 1, Figures 3 and 4 and throughout the current section is provided from IEA [19–23].

**Table 1.** Five-year (2008–2012) average share of renewable energy in total primary energy supply (TPES) (general and by source) (data source: [19–23]).

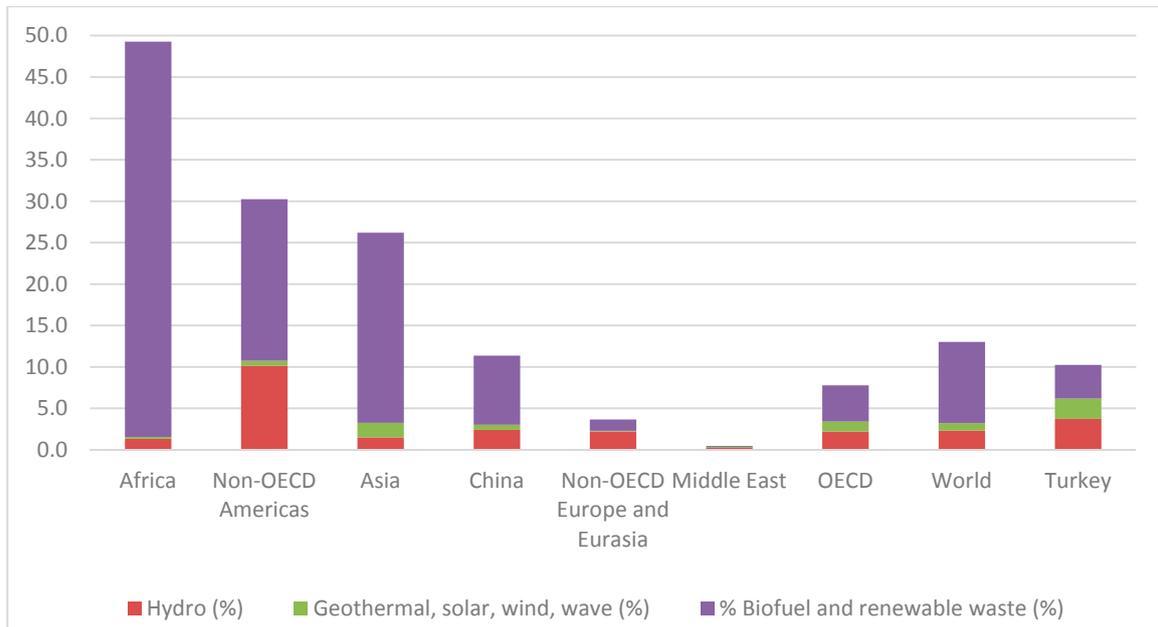
Region	Renewables in TPES (%)	Hydro (%)	Geothermal, Solar, Wind and Wave (%)	Biofuel and Renewable Waste (%)
Africa	49.3	1.3	0.2	47.7
Non-OECD Americas	30.2	10.1	0.6	19.5
Asia	26.2	1.5	1.8	22.9
China	11.4	2.4	0.6	8.3
Non-OECD Europe and Eurasia	3.7	2.2	0.1	1.4
Middle East	0.5	0.2	0.1	0.1
OECD	7.8	2.2	1.2	4.4
World	13.0	2.3	0.9	9.8
Turkey	10.2	3.7	2.4	4.1



**Figure 3.** Worldwide renewable energy shares in TPES (2008–2012) (data source: [19–23]).

It can clearly be seen in Table 1 and Figure 3 that the percentage of renewable energy use in Africa is around 50%, which is significantly above the world average. This is due to the fact that mostly organic non-fossil fuels are used in African countries. The Middle East, which is the center of crude oil production, is, as expected, where renewable energy has the lowest share. As for the OECD countries, the renewable energy use is close to the world average with a slight increase throughout the years subject to study. China has also caught up with the world average in terms of renewable energy use. The non-OECD Americas and Asia are the second and third, respectively, both well above the world average. Non-OECD Europe and Eurasia are fairly below the OECD and world averages. Turkey approaches the world average in renewable energy use and is in a slightly better position than the OECD total. Selam *et al.* [24] have compared renewable energy use in Turkey with that of OECD and concluded that it is slightly above the OECD total, OECD Americas and OECD Asia Oceania and slightly below OECD Europe between 2006 and 2010. However, the renewable energy

use excluding hydro is below the general average, which indicates that a significant amount of the energy production in Turkey is from hydroelectric sources.



**Figure 4.** Worldwide renewable energy use (five-year averages for the years 2008–2012 by source) (data source: [19–23]).

While Africa, non-OECD Americas, the Middle East and the world show a steady behavior with regard to renewable energy share in TPES, a slight decrease has been observed in Asia and China starting from 2009 (see Figure 3). The OECD countries exhibit an increasing trend of renewable energy share in TPES, while Turkey has experienced minor deviations around 10%, except for 2011, when the share of renewables in TPES had reached 11.1% (see Figure 3).

The analysis of the individual shares of hydro, geothermal/solar/wind/wave and biofuel/renewable waste in Table 1 and Figure 4 indicates that except for non-OECD Europe and Eurasia and the Middle East, biofuels and renewable wastes constitute the highest percentage of renewables throughout the world. This is especially significant for Africa, Asia and the world total. The relative utilization percentage of hydro is the highest in non-OECD Europe and Eurasia (60%) followed by the Middle East, Turkey, the non-OECD Americas, OECD and China, respectively. As for geothermal, solar, wind and wave energies combined, the most significant utilization (as a percentage of the TPES) is observed in the Middle East (27%), followed by Turkey (24%). The most uniform distribution of the individual shares is in Turkey, where the total 10.2% of renewables is divided as 3.7%, 2.4% and 4.1% among hydro, geothermal/solar/wind/wave and biofuel/renewable waste, respectively.

The distribution of the individual shares (expressed as percentages of total renewables) over time has also been studied, between 2008 and 2012 (see Figures 5–9). In terms of the share of hydro in total renewables, non-OECD Europe and Eurasia have the highest percentage until 2011. In 2011 and 2012, it was replaced by the Middle East. The respective listing is the Middle East, non-OECD Europe and Eurasia, Turkey, the non-OECD Americas, OECD, China, world total, Asia and Africa in decreasing order for 2011 and 2012. In 2010, the only difference in this order is that non-OECD Europe and Eurasia and the Middle East have changed places. As for 2009, the top four geographical groupings have been listed as non-OECD Europe and Eurasia, the Middle East, non-OECD Americas and Turkey, respectively. 2008 is the only year significantly different from the others in that non-OECD Europe and Eurasia have been followed by the non-OECD Americas, Turkey, OECD, the Middle East, China, world total, Asia and Africa, respectively.

It has been observed that, for biofuels and renewable wastes, the first two positions are Africa followed by Asia for all of the years. China was listed as third in 2008 and 2009, then for the following three years, it was replaced by world total and positioned in the fourth spot. The non-OECD Americas and OECD are listed as fifth and sixth, respectively for all of the years subject to study. Turkey was in the seventh position for 2008, 2009 and 2010, then it was replaced by non-OECD Europe and Eurasia. As for the Middle East, it has the least percentage of biofuels and renewable waste (in total renewables) among all of the geographical groupings, except for 2008.

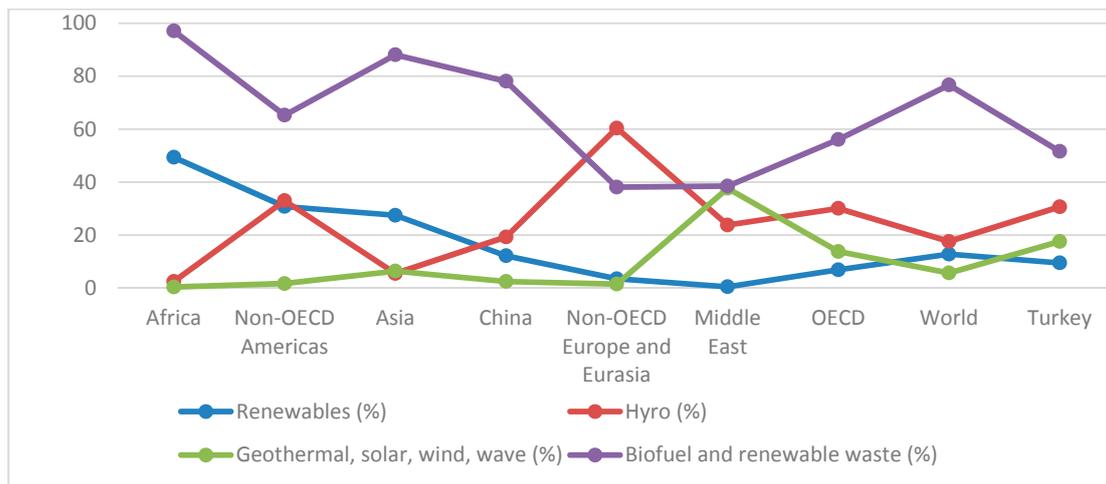


Figure 5. Worldwide renewable energy use in 2008 (data source: [19]).

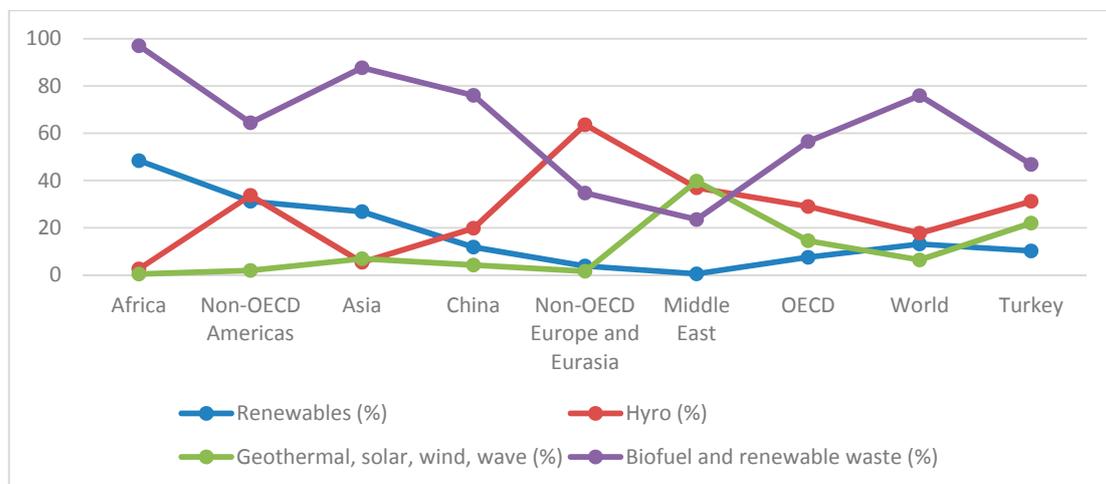


Figure 6. Worldwide renewable energy use in 2009 (data source: [20]).

The investigation of the share of geothermal, solar, wind and wave energies combined in total renewables reveals that the Middle East, which was the first in this category in 2008, 2009 and 2010, was replaced by Turkey in the years 2011 and 2012. The reason for this change is that starting from 2010, hydro constitutes a higher percentage in total renewables than geothermal, solar, wind and wave energies combined. The decreasing ordering of the geographical groupings with respect to the share of geothermal, solar, wind and wave energies combined in total renewables has been the Middle East, Turkey, OECD, Asia, world total, China, non-OECD Americas, non-OECD Europe and Eurasia and Africa for the years 2008, 2009 and 2010. This has changed to Turkey, OECD, world total, China, Asia, the Middle East, non-OECD Europe and Eurasia, non-OECD Americas and Africa in 2011. As for 2012, the only difference from the previous year is that world total and China have changed places.

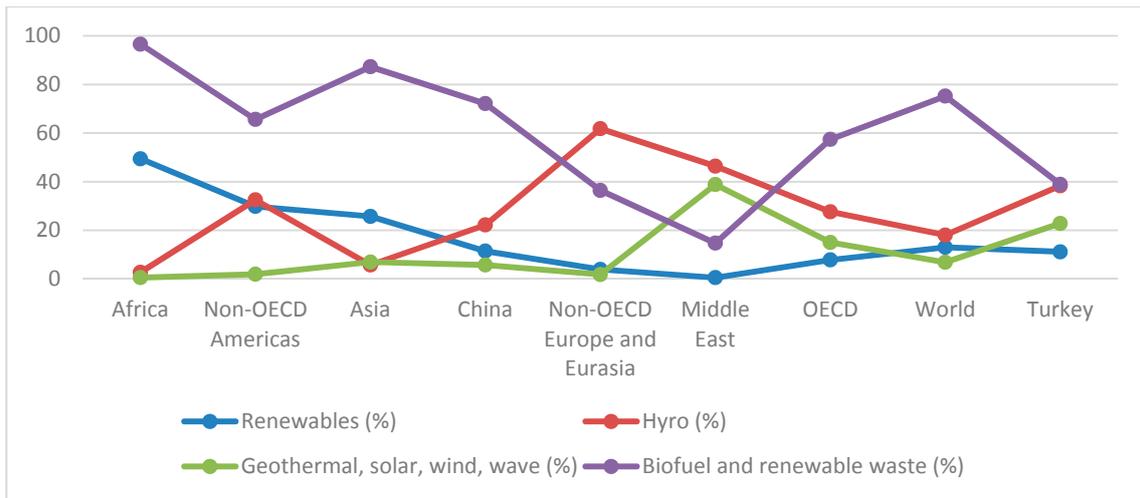


Figure 7. Worldwide renewable energy use in 2010 (data source: [21]).

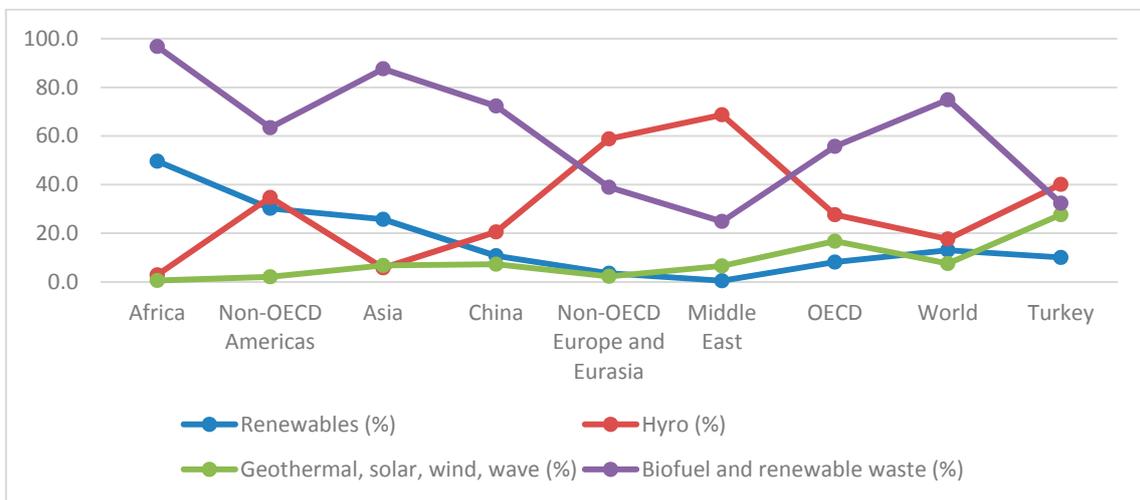


Figure 8. Worldwide renewable energy use in 2011 (data source: [22]).

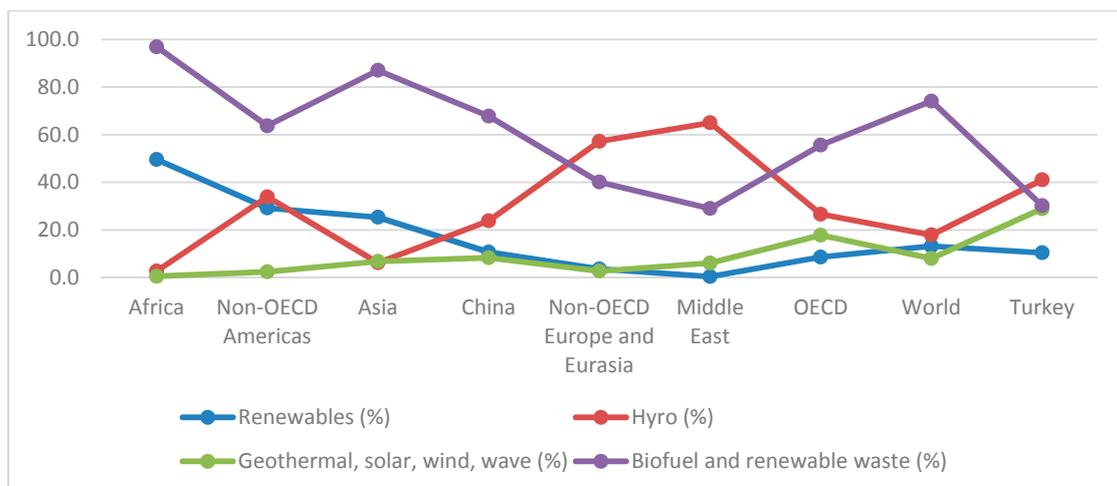


Figure 9. Worldwide renewable energy use in 2012 (data source: [23]).

When the geographical groupings are examined within themselves throughout the years subject to study, it can be concluded that there have been no changes in the distribution of the individual renewable sources. The only exceptions are the Middle East and Turkey. In 2008, biofuel/renewable waste and geothermal/solar/wind/wave had almost equal shares, with hydro having a lower percentage in the Middle East. This situation changed in favor of hydro starting from 2010. In the current case, hydro has the highest share followed by biofuel/renewable waste and geothermal/solar/wind/wave, respectively. As for Turkey, in 2008, 2009 and 2010, biofuel/renewable waste had the highest percentage followed by hydro and geothermal/solar/wind/wave, respectively. However, hydro took the lead in 2011 and 2012. Although geothermal/solar/wind/wave energies combined have the smallest percentage throughout the years subject to study, there has been a significant increase from 17.6% in 2008 to 28.9% in 2012.

Arioglu Akan *et al.* [25] have applied a ranking methodology to investigate the renewable energy performance of countries around the world. They have used a total of 17 indicators concerning total renewable energy capacity or generation as of end-2013 and annual investment/net capacity additions/production in 2013. The top 15 countries with respect to this ranking scheme have been listed as China, the United States, Germany, Brazil, Spain, Italy, Denmark, Canada, Japan, Sweden, Turkey, Austria, Cyprus, India and Portugal in decreasing order of renewable energy performance. In the following section of the study, the renewable energy policies of some of these countries are elaborated.

### 3. Renewable Energy Policies: Global Perspectives

As has previously been stated, renewable energy policies integrate environmental, economic and energy policies and, hence, are complex in nature. The most commonly-used policies and their brief explanations have been provided as the following [23]:

Capital subsidy: a subsidy that covers a share of the upfront capital cost of an asset (such as a solar water heater).

Feed-in premium: a type of feed-in policy, where producers of electricity from renewable sources sell electricity at market prices, and a premium is added to the market price to compensate for higher costs and, thus, to mitigate the financial risks of the production from renewables.

Feed-in tariff: the basic form of feed-in policies, where a minimum price (tariff) per unit (normally kWh or MWh) is guaranteed over a stated fixed-term period when electricity can be sold and fed into the electricity network, normally with priority or guaranteed grid access and dispatch.

Fiscal incentive: an economic incentive that provides individuals, households or companies with a reduction in their contribution to the public treasury via income or other taxes, or with direct payments from the public treasury in the form of rebates or grants.

Investment tax credit: a taxation measure that allows investments in renewable energy to be fully or partially deducted from the tax obligations or income of a project developer, industry, building owner, *etc.*

Mandate/obligation: a measure that requires designated parties (consumers, suppliers, generators) to meet a minimum, and often gradually increasing, target for renewable energy, such as a percentage of total supply or a stated amount of capacity.

Net metering: a regulated arrangement in which utility customers who have installed their own generating systems pay only for the net electricity delivered from the utility (total consumption minus on-site self-generation).

Production tax credit: a taxation measure that provides the investor or owner of a qualifying property or facility with an annual tax credit based on the amount of renewable energy (electricity, heat or biofuel) generated by that facility.

Renewable energy certificate (REC): a certificate awarded to certify the generation of one unit of renewable energy (typically 1 MWh of electricity, but also less commonly of heat). Renewable energy target: an official commitment, plan or goal set by a government (at the local, state, national or regional level) to achieve a certain amount of renewable energy by a future date.

Renewable portfolio standard (RPS): an obligation placed by a government on a utility company, group of companies or consumers to provide or use a predetermined minimum renewable share of installed capacity, or of electricity or heat generated or sold;” RPSs often include tradable certificates, and they are referred to as tradable green certificates (TGC systems) in Europe [26].

The above-mentioned renewable energy policies have been used in different combinations throughout the world. Table 2 indicates those adopted by the top 15 countries as identified by Arioglu Akan *et al.* [25] in terms of renewable energy performance.

Arioglu Akan *et al.* [25] have also elaborated on the relationship between the renewable energy performance of the studied countries with the renewable energy policies and investments. They have concluded that the most significant issue that needs to be addressed is that the countries with the highest renewable energy performance have extensively adopted either both (e.g., China, the United States) or one (e.g., Germany) of the two main groups of renewable energy support policies, namely regulatory policies and targets and fiscal incentives and public financing (see Table 2). The most commonly-used policies in the first group are renewable energy targets, biofuels obligation/mandate and feed-in tariff/premium payment and tendering, respectively. As for the fiscal incentives and public financing, the most frequently observed forms are capital subsidy or rebate, public investment, loans or grants and investment or production tax credits, respectively. Among all, renewable energy targets and capital subsidies or rebates are the most broadly-used support policies.

Another finding in Table 2 is the variety of the renewable energy support policies adopted in India. All of the policy types have been utilized in this country, except for reductions, in sales, energy, CO<sub>2</sub> and VAT, and although it is in the 14th place in the country listing, in terms of the adopted policies, it shares second place with Italy after the United States. This is to indicate that the enactment of the respective laws and regulations does not necessarily lead to fast results. Germany is another example to support this fact, because although it is right after the United States in the performance list, the variety of the renewable energy policies are far less than those adopted in the United States. What makes Germany so successful in the renewable energy arena aside from the fact that it is one of the first countries to have realized the necessity of renewable energy is that there is a fact-based monitoring process, namely the Energy of the Future. This system not only makes sure that the energy reforms are being realized, but it promotes public participation and acceptance.

As for Turkey, renewable energy targets, feed-in tariff/premium payment and biofuels obligation /mandate have been used as regulatory policies and targets. Among these, renewable energy targets have been put into effect in all 15 countries. Biofuels obligation/mandate is used in all of the countries, except for Japan. Feed-in tariff/premium payment is in effect in 12 countries. As for fiscal incentives and public financing, capital subsidy or rebate and public investment, loans or grants have been used in Turkey, which are actually, as has previously been stated, the two most common policies in this arena. This is to say that the renewable energy policies in general lack diversity when compared to the rest of the countries. This issue will further be discussed in Section 4.

**Table 2.** Renewable energy support policies for 15 selected countries (adapted from [27]).

Country	Regulatory Policies And Targets							Fiscal Incentives and Public Financing							
	Renewable energy targets	Feed-in tariff/premium payment	Electric utility quota obligation/Renewable	Portfolio Standard (RPS)	Net metering	Tradable Renewable Energy Certificate (REC)	Tendering	Heat obligation/mandate	Biofuels obligation/mandate	Capital subsidy or rebate	Investment or production tax credits	Reductions in sales, energy, CO <sub>2</sub> , value-added	Tax (VAT), or other taxes	Energy production payment	Public investment, loans, or grants
●existing national															
○ existing sub-national															
N new															
R revised															
X removed/expired															
* sub-national															
China	R	R	○				○	○	○	○	○	○		○	○
United States	R*	R*	R*		R*	●	R	●	R	○	X	○	○	○	R
Germany	○	R						○	○	○	○	○			○
Brazil					○		R	●	R		○	R			R
Spain <sup>1</sup>	○				○	○			○	○	○			○	
Italy	○	R	○		○	○	R	○	○	○	○	○			○
Denmark	○	○			○	○	○		○	○	○	○			R
Canada	●	R*	●		●		○		○	○	○	○			○
Japan	○	○	○		○	○	○			○					○
Sweden	○		○			○			○	○	○	○			○
Turkey	○	R							○	○					○
Austria	○	○				○			○	○	○				○
Cyprus	○	○					○		○	R					
India	R	○	○		N*	○	R	●	R	R	○			R	○
Portugal	R	R	○				○	○	○	X	X	○			X

<sup>1</sup> Spain removed feed-in tariff support for new projects in 2012. Incentives for projects that had previously qualified for FIT support continue to be revised.

The final issue that needs to be pointed out is the necessity of the respective investments. Environmental investments have always been subject to skepticism because their returns cannot be observed in the short run. However, it can be stated that the top performing countries are past this issue because global investment in renewable power and fuels (excluding large hydro-electric projects) was \$270.2 billion in 2014, nearly 17% higher than the previous year [1]. The biggest renewable energy investments in 2014 were realized in major economies, with China far out in front at \$83.3 billion, the United States in second place with \$38.3 billion and Japan in third place with \$35.7 billion. India was up 14% compared to 2013 at \$7.4 billion and Brazil 93% higher, at \$7.6 billion [1]. The other significant fact is that substantial renewable energy investments have been made in developing countries in 2014, wherein a total of \$131.3 billion has been invested, 36% higher than the 2013 figures. On the other hand, the corresponding number is \$138.9 billion for developing countries, which is only 3% higher than the previous year. Indonesia, Chile, Mexico, Kenya, South Africa and Turkey were the countries that made significantly high investments [1]. Turkey invested \$1.8 billion in renewable energy in 2014 [1]. Hence, it can clearly be stated that there is a strong relationship between renewable energy investments and how well countries perform in this arena and that developing countries are eager to catch the top performers in a short amount of time [25].

This section also includes a more detailed perspective on the renewable energy policies of certain selected countries in three groups, namely OECD countries, non-OECD countries and EU members.

### 3.1. Renewable Energy Policies of Selected OECD Countries

The OECD was established in 1961 with the aim of “promoting policies that will improve the economic and social well-being of people around the world” [28]. Currently, there are 34 member countries spanning the globe, from North and South America to Europe and the Asia-Pacific region [28]. Turkey is one of the founding members.

In 2010, 18% of the world population lived in the OECD countries with 74% of the world gross domestic product (GDP) being created in its 34 member countries. The TPES of the OECD in 2010 represented about 44% of global energy supply, while the total energy production constituted 30% of the global energy production [29]. Bigerna *et al.* [17] address three main pillars of energy and environmental policy for sustainability as investments in RES, increases in energy efficiency and promotion of energy savings behaviors. The OECD countries have adopted certain energy efficiency policies, such that each government made its own decision regarding the measures to be taken and their implementation [30]. These measures fall under the following basic categories [30]: (i) restrictive regulations; (ii) information to the public; (iii) creation of market asymmetries; (iv) funding/loan programs; and (v) state capital/private capital partnerships.

Two OECD countries, namely the United States and Germany, have been listed as second and third, respectively, in terms of renewable energy performance (see Table 2). Germany is also an EU member country, so its renewable energy policies are outlined in Section 3.3. This section briefly provides an overview of the United States. The United States, which accommodates 4.5% of the world population and consumes 19.2% of the world’s energy (second largest after China), is one of the richest countries in terms of renewable energy portfolio [31]. Being criticized for the significant variation in renewable energy policy designs among states, the United States underwent major developments in the energy policy arena over the course of the last few years, diverging from fossil fuels towards a sustainable and coherent energy system with greater energy independence [32,33]. Some of these renewable energy policies include, but are not limited to: subsidies for wind, solar and geothermal producers; biomass grants; increasing the amount of biofuel that must be mixed with gasoline; making geothermal energy more competitive with fossil fuels in generating electricity; tax reductions; loan guarantees and RPS in most states [31]. The most significant developments in the policy arena are [32] the enactment of the American Recovery and Reinvestment Act (ARRA) (2009), through which the Department of Energy (DOE) invested more than USD 31 billion in energy infrastructure, clean energy projects and energy efficiency, the President’s Blueprint for a Secure

Energy Future (2011), which set forth a clear agenda for the medium-term direction of federal energy policy based on doubling of electricity generation from wind, solar and geothermal sources by 2020, halving net oil imports by the end of the decade, doubling energy productivity by 2030 and providing international leadership in clean energy, and the “All-of-the-above” strategy (2012), which aimed at support for economic growth and job creation, enhanced energy security and deployment of low-carbon energy technologies, through a series of defined policy actions.

Despite the above-mentioned developments and the RPS adopted by many states, there are still certain unsolved issues on the national level regarding how the goal of doubling renewable energy production from wind, geothermal and solar sources by 2020 compared to 2012 will be reached [32]. Certain remarks and suggestions concerning the renewable energy policies of the United States have been made, some of which are the need for effective, coordinated and diversified national policies to maintain investor confidence in secure electricity infrastructure, inclusion of the end-use sectors of transport, industry and buildings in policy making, a consistent, predictable and long-term policy support to create market certainty, especially to attract investments in grid transmission and biomass logistics, the reflection of the external costs of using fossil fuels on the United States macro economy, keeping the investments in fossil fuel or nuclear-based electricity at a level that will not undermine the immediate effects of renewable energy policies, reducing the fluctuations and uncertainties in tax incentives, equitable distribution of the subsidies for electricity generation and implementation of a national feed-in tariff and RPS [32–35].

### *3.2. Renewable Energy Policies of Some Non-OECD Countries*

In 2007, the OECD decided to invite some countries, like Chile, Israel and Russia, to open discussions for the membership of the organization and offered an “enhanced engagement” program to Brazil, China, India, Indonesia and South Africa [28]. This section provides a brief outline of the renewable energy policies of China and India. These countries have been selected because, as has previously been stated, China has the highest renewable energy performance and India has the world’s fifth-largest electricity generation capacity [36] with a wide array of renewable energy policies (see Table 2).

China is the world’s largest energy user, accounting for one fifth of all global energy consumption with an expected increase by 60% by 2030 [37]. Energy conservation, efficiency in energy utilization and emission reduction have become the main foci in China’s energy policy. As a result, it has become a global leader in renewable energy, installing more new renewable energy capacity than all of Europe and the rest of the Asia Pacific region in 2013 alone [37]. Some of the steps taken to achieve these policies are [38]:

- Various energy-saving renovations are implemented.
- Efforts have been made to support new and renewable energy developments.
- Improvements have been made in civil energy use conditions (energy service level, access to natural gas and electricity, combined heat and power projects, *etc.*).
- Environmental protection has been increased.

The country’s energy consumption per-capita is low and decreasing every year. The energy consumption for every 10,000 yuan of GDP decreased by 20.7% from 2006–2011 [38]. China aims to increase the use of non-fossil fuels by developing new and RES by the end of the 12th Five-Year Plan. It is the leading renewable energy producer in the world with the world’s richest hydropower resources, and currently, less than 30% of its resources have been utilized [38,39]. These resources can help China to achieve the goal of increasing the non-fossil energy consumption share to 15% by 2020. The Chinese government wants to provide hydropower development by using local resources and local employment. This country is also the fastest growing wind power market in the world [40]. Thus, the goal is to encourage research and development (R&D) studies in wind-power equipment production, to improve the standards and control in the sector, to optimize the wind

power production and develop offshore wind farms. Other significant aspects of China's renewable energy policies involve the following [38,41]:

- Promote and encourage the development and utilization of its rich solar energy resources with the construction of power stations, solar power generation projects, efforts to generalize solar heating, cooling, water heaters and industrial applications of solar energy.
- Make nuclear power plants safer and more efficient, especially after the Fukushima Daiichi nuclear disaster in 2011.
- Benefit from the biomass potential in rural areas.

It is also stated in the REmap 2030 analysis of China [37] that significant potential exists for renewable energy in end-use sectors. Industry can achieve a 10% renewable energy share, and the building sector can transform its fuel mix to two-thirds renewables. Solar thermal heat and electrification pose a significant potential, as does modern biomass for process heating and space/water heating.

As has previously been mentioned, India has the world's fifth-largest electricity generation capacity, which currently stands at 243 GW with a highly diverse power sector, varying from commercial sources, like coal, natural gas, hydro, oil and nuclear, as well as unconventional sources of energy, like solar, wind, bio-gas and agriculture [36]. Nonetheless, the country is facing an emerging supply-demand imbalance situation with the increases in total electricity demand, resulting from industrialization, urbanization, population growth and economic growth [36,42]. To be able to provide adequate electricity to its population, India needs to more than double its current installed capacity to over 300 GW by 2017, and the demand for oil in 2015 is expected to be 41% higher than in 2007 and almost 150% higher in 2030 [43]. There is also a rising concern over climate change [36]. The country currently emits approximately 4% of global greenhouse gas emissions, while its per capita emissions are only one-quarter of the global average and less than one-tenth of those of most developed nations [43]. The government has committed to reducing the emissions intensity of its economy to 20%–25% below 2005 levels by 2020 and not exceeding the per capita greenhouse gas emissions of industrialized nations [43]. These have made the use of renewable energy inevitable in India, and establishing a sustainable energy base has gained significance since the early 1970s [42].

India has substantial RES, including a large land mass that receives among the highest solar irradiation in the world, a long coastline and high wind velocities that provide many opportunities for both land-based and offshore wind farms, significant annual production of biomass and numerous rivers and waterways that have potential for hydropower [43]. Although the total renewable energy potential from various sources in India is 249,188 MW, renewable energy, including large hydro, constitutes only 28.8% of overall installed capacity, and the country has been able to achieve only 12.95% of its renewable energy potential as of 31 March 2014 [36]. The government has set ambitious targets for renewable energy: a doubling of existing renewable energy capacity to 55,000 MW by 2017 [44]. In 1992, the Government of India established the Ministry of New and Renewable Energy (MNRE), the world's first ministry committed to renewable energy, with the aim of expanding contributions of renewable energy in all of India's end-use sectors and undertaking the respective policy and planning activities [43]. Moreover, in order to expand the use of renewable energy, certain policies and instruments have been introduced, some of which can be listed as the following [43]:

- Electricity Act 2003, which mandates that each State Electricity Regulatory Commission (SERC) establish minimum renewable power purchases; allows for the Central Electricity Regulatory Commission (CERC) to set a preferential tariff for electricity generated from renewable energy technologies; provides open access of the transmission and distribution system to licensed renewable power generators.
- National Electricity Policy 2005, which allows SERCs to establish preferential tariffs for electricity generated from renewable sources.

- National Tariff Policy 2006, which mandates that each SERC specify a renewable purchase obligation (RPO) with distribution companies in a time-bound manner with purchases to be made through a competitive bidding process.
- Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) 2005, which supports extension of electricity to all rural and below poverty line households through a 90% subsidy of capital equipment costs for renewable and non-renewable energy systems.
- Eleventh Plan 2007–2012, which establishes a target that 10% of power-generating capacity shall be from renewable sources by 2012 (a goal that has already been reached) and supports phasing out of investment-related subsidies in favor of performance-measured incentives.
- National Action Plan on Climate Change (NAPCC) 2008, which aims to promote development goals while addressing greenhouse gases mitigation and climate change adaptation through eight specific missions (including solar energy, energy efficiency, water, sustainable habitat and related topics).
- The Clean Development Mechanism (CDM) of the Kyoto Protocol, which supports the development of renewable energy projects.

Certain recommendations have been made for policy makers concerning more effective utilization and expansion of renewable energy. These include, but are not limited to: improving short-term wind forecasting and adequate grid connectivity for wind; implementation of domestic content regulation (DCR) and imposition of anti-dumping duties to shield local industry from inexpensive import from China, *etc.*, for solar panels; speedy implementation of policies by states and R&D activity to provide accurate hydrological and site data for small hydropower; creation of biomass/bagasse cogeneration-related policies by all states and setting up fuel depots for biomass/bagasse; creation of waste to energy-related policies by all states and setting up of a fuel supply chain for waste [36].

### *3.3. Renewable Energy Policies of the EU*

The EU has particularly been included in the analysis, because Turkey is in the accession process to the EU. The country has also signed the European Energy Charter Treaty in 1991, which sets forth a legal framework for international energy cooperation [45] with equal rules for trade, investment and production in the energy sector [46]. Thus, the energy policies adopted in Turkey should be compatible with those of the EU member countries. This section briefly summarizes the renewable energy policies of the EU and points out Turkey's position in terms of renewable energy use with respect to the EU.

Environmental concerns, supply security and competitiveness considerably affected the EU policies, especially those related to the renewable energy sector, resulting in an effective renewable energy policy since 1997 [47]. The Renewable Energy Directive 2009/28/EC (RES Directive) sets forth a European framework for the promotion of renewable energy by 2020 through mandatory national renewable energy targets [48]. Thus, the current policy of the EU for 2020 aims at 20% substitution of fossil fuels by renewable energy resources that include biomass and waste, hydro, geothermal, solar and wind power [49]. The other targets for 2020 are greenhouse gas emission reductions of 20% relative to emissions in 1990 and 20% savings in energy consumption compared to projections [50]. These objectives are commonly referred to as the "EU 20-20-20" program, and the EU employs the Emissions Trading System (ETS) for cost-effectively limiting greenhouse gas emissions, making the overall EU system the most comprehensive among its counterparts in the world [51]. Consequently, 19.9% of the absolute European energy generation in the EU27 in 2009 was produced by renewables, with hydro-power taking the lead (11.6%), followed by wind (4.2%) [52].

Each member of the EU has decided on its own strategies to meet the above-stated energy targets and published these in Renewable Energy Action Plans (NREAP) between July 2010 and January 2011 as required by the EU (Directive 2009/28/EC) [53]. The most common RES support strategies implemented in the EU can be listed as the following [53]: (i) feed-in tariffs; guaranteed

prices; (ii) feed-in premiums; production premiums; (iii) tender schemes; (iv) quota obligations with TGCs; (v) investment grants; (vi) fiscal measures (tax incentives, *etc.*); and (vii) financing support (loans, *etc.*). Table 3 depicts the renewable energy policies on the country level for the EU members that have been listed under the top 15 renewable energy performing countries (see Table 2). The renewable energy policies have been provided under three main categories, namely electricity from renewables (RES-E), heating and cooling using RES (RES-H & C) and RES used in transport (RES-T).

**Table 3.** Renewable energy policies of selected EU-28 [54].

Country	Renewable Energy Support Policies
Austria	Electricity: feed-in tariffs, subsidies for PV installations Heating and cooling: incentive scheme on the level of the individual federal states Transport: quota system
Cyprus	Electricity: subsidy combined with a net metering scheme Heating and cooling: currently none Transport: currently none
Denmark	Electricity: premium tariff and net-metering Heating and cooling: exemption from tax obligations and a direct tariff for biogas Transport: quota system, tax incentives for biofuels and a direct premium tariff for selling of biogas
Germany	Electricity: feed-in tariffs and low interest loans for investments in new plants Heating and cooling: Market Incentive Programme (MAP), investment support by the Federal Office for Economic Affairs and Export Control (BAFA) and low interest loans Transport: quota system and fiscal regulation for some types of biofuels
Italy	Electricity: combination of premium tariffs, feed-in tariffs and tender schemes; tax regulation mechanisms for investment in plants Heating and cooling: tax regulation system and a price-based mechanism for installations Transport: quota system for biofuels
Portugal	Electricity: feed-in tariffs for existing installations and specific power granting tenders for new installations Heating and cooling: currently none Transport: biofuel quota system and a tax exemption to small producers
Spain	Electricity: a tax regulation system for related investments Heating and cooling: currently none Transport: quota system for biofuels
Sweden	Electricity: a quota system, tax regulation mechanisms and a subsidy scheme Heating and cooling: tax exemptions Transport: tax exemption for biofuels

Analysis of Table 3 reveals that the most commonly-used policies in the top performing EU member countries for electricity from renewables are feed-in tariffs, premium payments and subsidies. For heating and cooling, tax exemptions are commonly in effect. Cyprus, Portugal and Spain do not currently have any policies in this arena. As for RES-T, all of the top-performing EU countries have adopted quota systems for biofuels, except for Cyprus and Sweden. The former does not have any policies for renewables in transport, and the latter has adopted tax exemptions for biofuels. While each member of the EU has its own strategies and policies, there have been recent efforts regarding an integrated policy framework for the period up to 2030 with the following targets [55]:

- reducing EU domestic greenhouse gas emissions by 40% below the 1990 level and by 2030,
- increasing the share of renewable energy to at least 27% of the EU's energy consumption by 2030, with flexibility for Member States to set national objectives
- establishing a market stability reserve in 2021,
- developing a set of key indicators to assess progress over time and to inform any future policy intervention, and

- establishing a new governance framework based on national plans for competitive, secure and sustainable energy.

The progress of the EU Member States against the targets set forth by the RES Directive are carefully being monitored. The results so far can be summarized as the following [56]:

- Twenty two Member States were on track regarding the RES trajectories defined in the NREAPs, and six underachieved. Only France and The Netherlands did not meet the 2011/2012 milestone with respect to the interim targets defined in the RES Directive.
- In the RES-E sector, 12 Member States (Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, Germany, Italy, Poland, Slovakia, Spain and Sweden) met or overachieved on their 2012 target, with the most significant overachievement in Estonia (95% more RES-E than planned in the NREAP for 2012).
- In the RES-H & C sector, only five Member States (Ireland, Portugal, Latvia, France and The Netherlands) underachieved their 2012 target.
- In the RES-T sector, which has seen less progress than the former two, only eight Member States (Austria, Czech Republic, Italy, Luxembourg, Malta, The Netherlands, Slovakia and Sweden) met or overachieved on their 2012 target.

The remainder of this section highlights the renewable energy policies of Germany. Germany has been selected for further analysis because it has been listed as the third most successful country after China and the United States (see Table 2) and, thus, the top renewable energy performing country in the EU. Germany initiated the development of renewable energy technology for electricity over two decades ago [57]. In 1991, the German government passed the Electricity Feed In Law (Stromeinspeisungsgesetz or StromEinspG), which later evolved into the Renewable Energy Act (Erneuerbare Energien Gesetz) (came into effect in 2000), to promote the feed-in of energy produced by renewable energy technologies into the grid for electricity suppliers [57]. With the Renewable Energy Act, the entire regulatory framework for renewable energy technologies was revised, and differentiated tariffs were adopted for each form of renewable energy [57]. As a result of these efforts of the German government to become one of the most energy efficient and environmentally-sound economies in the world without compromising the country's affordable energy prices and economic growth, renewable energy use underwent dramatic changes [5,58]. The share of renewable energy in final energy consumption in Germany increased from around 4% in 2000 to more than 12%, and its share in gross electricity consumption enhanced from around 6% in 2000 to over 25% by 2013 [59]. In 2000, hydropower constituted the largest part of renewable generation (60%), followed by wind power (26%) and biomass (13%); whereas in 2013, wind power took the lead (35%), followed by biomass (31%), solar PV (20%) and hydropower (14%) [59]. Overall, the share of renewables in the primary energy demand of Germany increased from 1.3% in 1990 to 11.7% in 2013 [60].

The most significant steps that the policy makers have taken are the Energy Concept (Energiewende) (2010) and its energy reforms (2011) [5,58]. The Energy Concept, which was built on the success of previous policies (especially the Integrated Energy and Climate Programme of 2007), set forth the principles of a long-term, integrated energy pathway to take the country to 2050, placing renewable energy at the center of future supply [58]. Germany's energy goals include the reduction in greenhouse gas emissions by 40% by 2020 and by at least 80% by 2050 and a decrease in primary energy consumption by 20% by 2020 and by 50% by 2050 (base year 2008), and the proportion of energy consumption covered by renewables is to rise to 30% by 2030 and to 60% by 2050 [5].

An important issue that has affected Germany's attitude towards renewable energy use is the Fukushima Daiichi nuclear accident in March 2011 [57,58]. A key feature of the Energy Concept was a proposal to extend the operating lifetime of the German nuclear power fleet by an average of 12 years, therefore postponing the nuclear power phase-out agreed by the former government [58]. However, after the Fukushima nuclear disaster, the German Government intensified efforts towards nuclear phase-out by 2022, starting with the immediate closure of the eight oldest plants [57,58]. This decision

resulted in the adoption of a second package of measures, which completed the Energy Concept, to support renewable energy and grid expansion, promote energy efficiency, fund the reforms and reverse the previous decisions to extend the lifetime of the nuclear plants [58].

In order to follow the developments concerning the use of clean energy, Energy of the Future, a long-term and fact-based monitoring process, was designed to inform the public comprehensively about the restructuring of the energy system, to promote public participation and to increase acceptance of the reforms [5]. It included an annual monitoring report (the first being submitted in December 2012) to outline the general facts and status and a more detailed progress report (to be submitted every three years starting from 2014) to evaluate the future challenges and needs [5].

Although Germany is one of the leading countries in terms of renewable energy policies, there are still issues that need to be addressed. These can be listed as the following [5,58,61]:

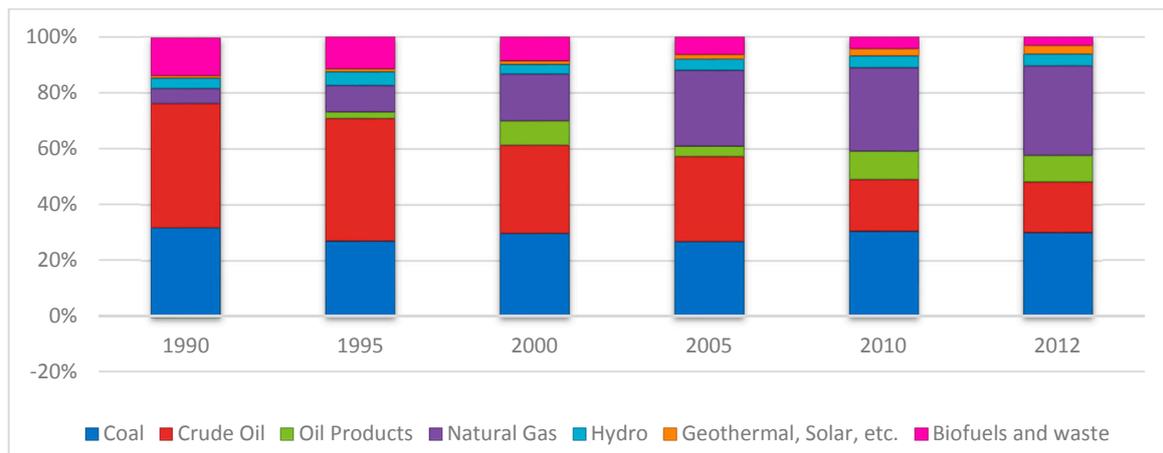
- Continue to increase funding for research, development and deployment (RD&D) to meet the goals stated in the Energy Concept.
- Involve all stakeholders through a stronger co-ordination platform.
- Continue to assess its RD&D challenges and to adjust its RD&D portfolio as national energy policy priorities change.
- Continue efforts in energy education and training to meet future demands for researchers and engineers.
- Improve energy statistics to provide a solid perspective, especially those related to international energy prices and energy consumption in the household, transport, and trade sectors.
- The German Renewable Energy Sources Act (EEG) must be preserved in principle for the transformation of the electricity supply. Feed-in tariffs should be kept up-to-date to support technological innovations that reduce costs.
- Introduce non-budgetary subsidy instruments for the expansion of renewables in the heat sector to especially include the existing stock of older buildings.
- Set incentives and specifications in the transportation sector to further reduce the amount of fuel consumptions of motor cars and utility vehicles

#### **4. Renewable Energy Status and Policies of Turkey**

The renewable energy situation in Turkey is elaborated in this section under four headings, namely the current renewable energy status, respective legislation, international commitments and evaluation of the renewable energy policies and strategies.

##### *4.1. Current Energy and Renewable Energy Status in Turkey*

The energy consumption in Turkey is constantly increasing (see Figure 1) due to the economic developments, population growth, increasing urbanization and industrialization [10,62], and thus, it is in a position to import over 70% of its primary energy supply in the form of fossil fuels, namely coal, oil and natural gas [45,63]. The total net import values were 19.1 Mtoe, 12.2 Mtoe, 37.3 Mtoe and 18.7 Mtoe in 2012 for crude oil, oil products, natural gas and coal, respectively [45]. Coal, specifically lignite, is the most abundant hydrocarbon energy source in Turkey, and it is the second primary energy source following gas [45]. In terms of production, it is by far (more than half of the total) the largest source of energy, providing 15.5% (35.8 Mtoe) of Turkey's TPES in 2011 [45]. Figure 10 presents the share of the individual energy sources in TPES for 1995–2012 in five-year periods. It can be seen in Figure 10 that natural gas has the greatest share (30%) in 2012. There has been a significant decrease in crude oil percentage, while the share of oil products has increased in the TPES.



**Figure 10.** Share of individual energy sources in TPES for 1995–2012 (data source: [23]).

In terms of RES, there has been significant developments in hydropower, geothermal and solar energy production [64]. This situation has clearly been depicted in Table 4, which outlines the renewable energy supply in Turkey for the years 2008–2012. Despite these developments, the share of renewable energy in electricity generation was only 17.4% by the end of 2008 [65], and the share of renewable electricity generation in final electricity consumption was 21.6% for the same year (see Table 4). Moreover, the share of RES is estimated to be only 9% of TPES in 2020 as opposed to the actual value of 12% in 2000 [66]. On the other hand, the assessment of RES potential in Turkey showed that there was already 25,857 MW of RES installed capacity (including hydro resources) as of January 2014 [45], which is sufficient to meet the accelerated demand [62]. There is considerable potential for RES in Turkey, estimated at 720 TWh/year, three times the gross demand of 242 TWh in 2012 [45]. Turkey has vast and diverse RES, which can be summarized as the following [45]:

- Hydro, which is the main and most developed RES in Turkey, with water resources being located in all seven geographical regions. Hydro accounted for 24% of electricity generation in 2012. There was an installed hydropower capacity of 6256 MW from rivers and 16,237 MW from reservoirs as of the end of January 2014. Overall, Turkey has 16% of Europe’s economic hydro potential.
- There is significant potential for wind power development in Turkey [62], with high average annual wind velocities creating the potential for its efficient utilization in the Mediterranean shores, Aegean Sea coast areas and the northern and western parts of the Marmara Sea coast. However, wind energy has had little, but increasing implementation in Turkey so far, with an installed capacity of 2815 MW as of the end of January 2014.
- Biomass has been a major source of renewable energy, but air pollution concerns and deforestation have resulted in a decrease in biomass use, changing the composition of the renewable energy supply in favor of wind energy [62,66]. The significant agricultural activities in large areas of the country provide residues for biomass combustion or gasification. The country also has combustible industrial waste, forestry and waste from wood processing, domestic and municipal waste and waste from areas polluted by oil and petroleum products, with a total potential of 8.6 billion toe. However, the installed capacity was only 239.6 MW, and the current energy use of biomass is 6 Mtoe, mainly for heating purposes.
- Turkey is rich in thermal waters. The geothermal potential for heating purposes is estimated to be 31,500 MW, of which 4809 MW has been made available as of the end of 2012. The installed capacity of geothermal energy was 310.8 MW as of the end of January 2014. Currently, geothermal energy is directly used for central heating systems, greenhouse heating and thermal tourism purposes.

- The climatic conditions and geographical location of Turkey especially in the southern half provide substantial potential for the production of electricity and heat using solar energy. Although the solar energy potential using concentrated solar power (CSP) technologies across the entire country is very high (380 TWh), there are no large-scale solar power installations. Currently, solar energy is widely used for water heating, greenhouse heating and for drying agricultural products. Solar collectors are available in 3–3.5 million residences, mostly in the Mediterranean, Aegean and Southeast Anatolian regions.

**Table 4.** Renewable energy supply in Turkey [19–23].

Renewable Energy Sources	2008	2009	2010	2011	2012
<b>Primary energy supply</b>					
Hydro (ktoe)	2861	3092	4454	4501	4976
Geothermal, solar, etc. (ktoe)	1643	2181	2648	3095	3508
Biofuels and waste (ktoe)	4829	4667	4559	3662	3653
Energy production from renewables (ktoe)	9333	9940	11,661	11,258	12,137
<b>Share of Renewables in TPES (%)</b>	<b>9.5</b>	<b>10.2</b>	<b>11.1</b>	<b>10.0</b>	<b>10.4</b>
<b>Electricity Generation</b>					
Hydro (GWh)	33,270	35,958	51,796	52,338	57,865
Geothermal, solar, etc. (GWh)	1009	1931	3584	5417	6759
Biofuels and waste (GWh)	219	340	457	469	721
Electricity generation from renewables (GWh)	34,498	38,229	55,837	58,224	65,345
<b>Share of renewable electricity generation in final electricity consumption * (%)</b>	<b>21.6</b>	<b>24.7</b>	<b>32.8</b>	<b>31.6</b>	<b>33.9</b>
<b>Total final consumption **</b>					
Geothermal, solar, etc. (ktoe)	1431	1678	1823	2093	2231
Biofuels and waste (ktoe)	4771	4583	4441	3547	3529
Total consumption from renewables (ktoe)	6202	6261	6264	5640	5760
<b>Share of renewables in total final consumption (%)</b>	<b>8.3</b>	<b>8.5</b>	<b>8.1</b>	<b>6.9</b>	<b>6.6</b>

\* Final electricity consumption does not include losses and energy industry own use. \*\* Total final consumption does not include energy used for electricity generation, therefore the hydro energy is totally excluded in this section.

#### 4.2. Energy Legislation in Turkey

Due to the above-summarized energy status of Turkey, energy efficiency has recently become a significant issue in the government's agenda. Hence, since 2005, the Turkish Government has taken steps to improve the energy efficiency and develop RES, among which are the Law on Utilization of RES for the Purpose of Generating Electrical Energy (2005), the Energy Efficiency Law (2007), accession to the International Renewable Energy Agency (IRENA) in June 2009, the adoption of the Ministry of Energy and Natural Resources (MENR) Strategic Plan (2010–2014) and the Energy Efficiency Strategy Paper published in February 2012 [5,45]. These actions taken to form a legal and institutional framework to support energy efficiency resulted in 40,300 toe total energy savings between the years 2009 and 2013 [5]. In the remainder of this section, the related laws are summarized.

Law No. 4283 (Law on Building and Operating of Electricity Generation Plants by Build-Operate-Transfer Model and Regulation of Energy Marketing) (1997), wherein the participation of the private sector in building and operating energy plants, was accepted [67]. Electricity Market Law No. 4628 and electricity market licensing regulation (2001) (amended by Law No. 5784 in 2008), encouraging electricity generation from RES, put forward two policies: first, paying 1% of the total license fee or the license for construction and being exempted from license fees for the first eight years; second, giving priority status to renewable facilities [46,67].

The Law on Utilization of Renewable Energy Resources for the Purpose of Generating Electrical Energy No. 5346 (2005) (amended by Law Regarding the Amendment in the Law of Utilization of

Renewable Energy Resources for the Purpose of Generating Electricity (Law No. 6094) in December 2010, establishing Turkey's Renewable Energy Support (YEK) Mechanism) aimed at expanding the use of renewable energy used to generate electrical energy [68,69]. The goal was to ensure an increase and diversification in the use of renewable energy without disturbing free market conditions, reducing greenhouse emissions, assessing waste products, protecting the environment and developing the necessary manufacturing sector to realize these objectives [68,69]. In addition, the Turkish market met some incentives, such as licensing, land appropriation and purchase guarantee by a constant feed-in tariff with this law [67,69].

The Law on Geothermal Resources and Natural Mineral Waters-No. 5686 (2007) set forth rules to protect and produce geothermal and natural mineral water resources [67]. Strategy Plan 2010–2014 (2010), covering the period between 2010 and 2014, aims to ensure that the share of renewable resources in electricity generation will be increased by up to at least 30% by 2023 [67]; and the Renewable Energy Law (2011) sets forth new incentives for renewable energy productions [68]. The incentive mechanisms ruled out by the above-mentioned laws can be summarized as the following [68]:

- Exemption of 500 kW of installed capacity from licensing and setting up a company.
- Exemption from annual licensing costs for the first eight years upon license application and an initial fee of only 1% for the license application.
- Priority for system connection.
- Leasing, right of easement or usage permits to properties that are regarded as forest or private property of the Treasury.
- 85% discount in rent, right of easement and usage permits together with forest villagers development revenue and exemption from forestation and erosion control revenues during the first 10 years.
- Feed-in tariffs of 7.3, 7.3, 10.5, 13.3 and 13.3 USD \$ cent/kWh for hydropower, wind energy, geothermal, biomass and solar radiation, respectively.
- Tax exemption for 2% biodiesel blending and premium for oil seeds.

Turkey's energy efficiency is mainly reflected in the Energy Efficiency Law (Law No. 5627, dated April 2007), which aims to increase efficiency in the use of energy resources, to reduce the burden of energy costs on the economy and to protect the environment [45]. This law provides the legal basis and measures to promote and support energy efficiency improvements, such as establishing and operating energy efficiency service markets, including energy service companies (ESCOs), energy auditors and energy efficiency projects, and voluntary agreement schemes to encourage energy-saving investments [45].

A new trend for "co-firing" biomass with fossil fuels (in countries like the U.S., Australia, Japan, the U.K. and Germany) contain conversion of many existing coal and gas-fired power plants [69]. This new trend draws attention to coal power plants in Turkey. The Law on Construction and Operation of Nuclear Power Plants and Energy Sale (2007) introduced regulations regarding the utilization of domestic coal resources for the purpose of generating electrical energy, encouraging the establishment of domestic coal-fired thermal power plants [45]. One of the targets in The Energy Efficiency Improvement Program, within the 10th Development Plan of Turkey, was developing projects to make use of the waste heat of the existing coal-fired thermal power plants in regional heating and agricultural activities [45]. The Energy Efficiency Strategy Paper (2012–2023) issued in the Official Gazette on 25 February 2012 states in this respect that the total average cycle efficiency of the coal-fired thermal power plants, including waste heat recovery, should be increased over 45% by 2023 [45].

The analysis of Table 2 and the above information clearly reveals that Turkey has regulatory policies, such as feed-in tariff and biofuel obligations, as opposed to some other countries (e.g., the United States, China and the EU countries), where support tools, including fiscal incentives (*i.e.*, capital

subsidy, grant or rebate, energy production payment) and public finances (*i.e.*, public investment loans or grants and competitive public bidding), are also widely used to support renewable energy [68,69].

#### 4.3. International Energy Commitments

This section has been compiled using the information provided in the In-Depth Energy Efficiency Policy Review of the Republic of Turkey [45]. Turkey is a member of key organizations, such as the United Nations (UN), the OECD, the North Atlantic Treaty Organization (NATO), the D-8 (Developing Eight), the G-20 (Group of Twenty), the International Monetary Fund (IMF), the IEA, IRENA and the World Bank (WB). As has previously been stated, it is also a candidate country for accession to the EU and signed the Energy Charter Treaty and the Protocol on Energy Efficiency and Related Environmental Aspects (PEEREA) on 5 April 2001, thereby committing itself to formulate and implement policies for improving energy efficiency and reducing the negative environmental impacts of the energy cycle. Hence, Turkish energy legislation should be aligned with the relevant EU energy policy and legislation.

In addition to the above, Turkey's international energy commitments can be grouped under three main categories, namely those undertaken for the import and transport of hydrocarbons, those related to energy efficiency and the ones concerning environmental policies with respect to energy. The remainder of this section briefly summarizes these.

Turkey has been signing international agreements to explore its on- and off-shore hydrocarbon (especially natural gas) potential in the Black Sea, Mediterranean Sea and Aegean Sea since 2004. These include the following:

- The Baku-Tbilisi-Ceyhan (BTC) pipeline (opened in May 2005), which has a maximum capacity of one million barrels per day (or 50 million tonnes per year);
- The Azeri-Chirag-Guneshli (ACG) Project, which was established by the State Oil Company of the Azerbaijan Republic (SOCAR) and currently provides oil to Turkey;
- The South Caucasus Natural Gas Pipeline (SCP) from Shah Deniz Field and the Trans-Anatolian Pipeline (TANAP) projects, which currently provide natural gas to Turkey.

The international relations and commitments in the energy efficiency field mainly include those undertaken to monitor and assess energy efficiency, financial support and international collaborations. The project "Development of Monitoring and Evaluation of Energy Efficiency in Turkey" was carried out in 2010–2013 by the General Directorate of Renewable Energy (GDRE) and the NL Agency, with the support of the Government of The Netherlands. The goal was to further develop Turkish expertise in the monitoring and evaluation of existing and new energy efficiency measures and programs. Turkey has also been getting support from international organizations for its RES and energy efficiency projects. These include loans from the World Bank and the International Bank for Reconstruction and Development (IBRD), grants from Global Environment Facility (GEF) and support for private sector investments from the European Investment Bank (EIB). National, international and regional collaborations in the field of energy efficiency are also in effect in cooperation with the UN, World Bank and Japan International Cooperation Agency (JICA).

The third and final international commitments include those concerning environmental policies with respect to energy. Turkey joined the United Nations Framework Convention on Climate Change (UNFCCC) and published the two National Communications 2007 and 2013, respectively. The latter includes the policies and principles of the Turkish government regarding climate change, greenhouse gas emissions and the carbon market. Turkey is also in cooperation with United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), NATO, the Organization for Security and Cooperation in Europe (OSCE), GEF, OECD, EU, the Economic Cooperation Organization (ECO), the World Bank, the Asian Bank and the World Wildlife Foundation (WWF). Moreover, since the Kyoto Protocol took effect in 2009, there has been increased interest

in greenhouse gas emission removal projects in Turkey. However, greenhouse gas emissions have constantly been rising in the country since 1990, due to the growth in industrial activities and consumption.

#### *4.4. Evaluation of Renewable Energy Policies and Strategies in Turkey*

Given Turkey's high energy imports, the main policy goal is securing long-term energy independence by making effective use of the country's domestic energy sources, especially the available RES potential [45]. Along this line, Turkey's general energy policy focuses on issues such as making the most use of indigenous resources together with public, private and foreign capital to meet the long-term demand, diversification of energy supplies, finding new and renewable energy sources, privatization, introducing energy efficiency measures and minimizing losses in energy production, transmission, distribution and consumption [10].

The above-stated principles are also reflected in the Strategy Plan 2010–2014, which sets forth targets for 2023: the 100th anniversary of the Turkish Republic (the Vision 2023 Programme). These targets are making complete use of indigenous coal and hydraulic potential, promoting the use of renewable sources, incorporating nuclear energy into electricity generation by 2020 and securing rapid and continuous improvement in energy efficiency in a way that parallels EU countries [70]. The alignment of the policies with those of the EU is especially significant for Turkey's accession. The "European Union—Turkey Progress Report 2013", which was concluded as part of the EU accession policy, states that Turkey's efforts mainly focus on the security of the internal energy market, renewable energy, energy efficiency and nuclear safety and radiation protection [45]. The following remark has been made in the European Union—Turkey Progress Report 2013 [71]:

"Good progress has been made in the area of energy. Liberalisation of the electricity sector and the level of alignment with the Electricity Directive are advanced. However, a functioning competitive market and progress in legislative alignment in the natural gas sector are still lacking. Progress in the renewable energy sector needs to be speeded up, namely through streamlined administrative procedures. Further efforts are needed in the areas of energy efficiency and nuclear energy, in particular on alignment with relevant EU Directives. Overall, Turkey is at a rather advanced level of alignment in the field of energy."

Although it has been stated that Turkey has made good progress in the energy area, one major issue that needs to be pointed out is the lack of respective regulations designated to each energy source individually. As has previously been stated, Turkey has significant wind energy potential. Policies should especially be developed to effectively utilize this potential in the near future. It has been estimated that between 22.5 TWh and 45.0 TWh of electricity must be generated from RES other than hydropower in the next decade to fill the demand gap [72]. This gap can be diminished by wind and solar energy if the investments are carried out as planned and the goals in the Vision 2023 agenda can be achieved [72]. In its report on Turkish Renewable Energy Policies, IEA [73] has stated that stronger policy support should be considered for the wider use of solar and geothermal heat and biofuels for transport in a sustainable and cost-effective way. In order to ensure this, first the technical issues need to be addressed. Hence, more emphasis should be placed on the integration of new renewable electricity capacity into the grid [73]. Moreover, the generation, transmission and distribution assets in the power sector and gas sectors should be improved to maximize fuel burning efficiency and minimize the technical transmission and distribution losses [45].

There are completed and continuing renewable energy projects in Turkey. However, some of those have not been effective enough. One of the reasons behind this is the fact that premature technologies (which were still under research) were used in many projects, and their design did not allow sufficient, long-term maintenance [74]. This particular area has been mentioned in the "In-Depth Energy Efficiency Policy Review of the Republic of Turkey" [45]. It has been stated

that the government should continue to support R&D activities on renewable energy and energy efficiency technologies. At this point, collaboration with various stakeholders, including the private sector, professional and sector associations, international financial institutions (IFIs), universities, research centers and non-governmental organizations (NGOs) is inevitable in the government's policy formulation and evaluation [45,73].

The financial constraints are another main area that needs to be addressed. Renewable energy technologies are often simply too expensive to be used in Turkey, where financial resources are limited [74]. Hence, the government should continue its efforts on cost-effective pricing with the assistance of the Energy Market Regulatory Authority (EMRA), and future energy policies should be supported by detailed analysis of economic energy efficiency potentials in all sectors of the economy [45]. New and diverse renewable energy support mechanisms should be considered to introduce further flexibility (*i.e.*, premium on wholesale price) [73]. The feed-in tariff system should be extended to cover heat from renewable sources [45]. Foreign investments should be attracted, and in order to achieve this, a predictable and transparent support framework should be developed, while creating technology-specific incentives that will decrease over time [73]. Turkish bureaucracy is an important handicap for foreign investors [66]. In terms of energy pricing in Turkey, although the introduction of the Automatic Pricing Mechanism (APM) in early 2008 has improved the cost reflectiveness of energy prices considerably, the actual import costs are not always directly reflected in consumer prices, as stated by the APM [45].

The renewable energy policies and support mechanisms in Turkey need to address the diverse nature of RES (*i.e.*, the eastern areas being more dependent on fossil fuels) and the socio-economic variability throughout the country. Thus, the government should increase efforts on energy efficiency at regional and local levels, such as regional authorities and municipalities, and more financial resources should be dedicated to decentralized RES generation (through possibly private distribution companies to facilitate connections) [45].

Another significant issue that needs immediate attention is the lack of detailed renewable energy resource assessments and a centrally coordinated project database in Turkey [45,67]. The monitoring of the effectiveness of the chosen policies and measures, both in terms of costs and emissions reductions [75] can only be ensured by means of a comprehensive database, including data from all activities related to energy efficiency in Turkey [45]. Hence, the MENR should strengthen its capacity to analyze and assess energy efficiency and renewable energy to be used for future policy development [45].

Another significant issue is public indifference and, in some cases, opposition to RES projects. It has been concluded in various studies that "people with no specific experience with wind energy are more likely to oppose it, overestimate its costs, and underestimate its benefits" [76]. Taking into consideration the fact that wind is one of the most widely-used and accepted forms of renewable energy, the public attitude towards the less common ones may even be more negative. Hence, it is crucial to enlighten the public on environmental problems and the necessity of renewable energy in order to ensure its wide acceptance on an individual level. This and the above-stated recommendations can only be carried out if the newly-established GDRE plays a leading role in developing RES in Turkey, being an effective, appropriately-staffed authority with a clear coordination function [45].

## 5. Conclusions

The increasing scarcity of fossil fuels and rising concerns for sustainability have urged countries to consider renewable energy as an alternative energy source. Consequently, governments and global organizations have adopted respective regulations to ensure the production and use of renewable energy and promote the respective new investments. In light of these developments, this study has been conducted to lay out the current situation of renewable energy use and policies around the world with the ultimate goal of making certain suggestions and pointing out possible solutions in this area.

Turkey is a developing country with sufficient RES to meet most of its energy demand. However, it is still in a position to be an energy importing country, which necessitates the urgent generation and implementation of effective policies in this arena. This will not only be a solution to the country's energy problems, but also provide a solid means for pollution control and, ultimately, sustainable development. Thus, a detailed review and evaluation has been conducted in this study on the renewable energy policies in Turkey and those adopted worldwide with the ultimate goal of making certain suggestions in renewable energy use and respective policies. To this end, first, a comparative statistical analysis has been carried out using the geographical coverage that OECD has provided. Thus, the countries have been studied under nine groups, namely Africa, non-OECD Americas, Asia, China, non-OECD Europe and Eurasia, the Middle East, OECD, world total and Turkey. Descriptive statistics have been provided for this geographical coverage on the share of renewable energy in TPES, individual shares of hydro, geothermal/solar/wind/wave and biofuel/renewable waste and the distribution of the individual shares (expressed as percentages of total renewables) between 2008 and 2012.

Following the statistical analysis on the renewable energy use, the overall renewable energy policies of the EU, OECD and of certain selected non-OECD countries have been investigated. Then, the relationship between renewable energy policies, investments and renewable energy performance has been discussed. The renewable energy situation in Turkey has been provided in a separate section in greater detail. The statistical analysis of renewable energy use revealed that Turkey approaches the world average in renewable energy use and is in a slightly better position than the OECD. As for the individual shares of RES, except for non-OECD Europe and Eurasia and the Middle East, biofuels and renewable wastes constitute the highest percentage of renewables throughout the world. This is especially significant for Africa, Asia and the world total.

In the investigation of the geographical groupings in terms of the distribution of individual renewable sources between 2008 and 2012, a steady behavior was observed, except for the Middle East and Turkey. In Turkey, in 2008, 2009 and 2010, biofuel/renewable waste had the highest percentage followed by hydro and geothermal/solar/wind/wave, respectively. However, hydro took the lead in 2011 and 2012. Although, geothermal/solar/wind/wave energies combined have the smallest percentage throughout the years subject to study in Turkey, there was a significant increase from 17.6% in 2008 to 28.9% in 2012. In fact, Turkey took the lead in 2011 and 2012 in terms of the share of geothermal, solar, wind and wave energies combined in total renewables.

The review on the renewable energy policies showed that the countries with the highest renewable energy performance have extensively adopted regulatory policies and targets and/or fiscal incentives and public financing. Renewable energy targets and capital subsidies or rebates are the most broadly used support policies. It has been observed that the key to renewable energy performance is not only adopting the respective policies, but to monitor their effective use. This promotes public participation and acceptance, as well, which are significant for any sustainability action. Substantial energy investments have been made in 2014 in both developing and developed countries. This is important because it points out the fact that the usual skepticism concerning the necessity of environmental investments has been overcome on a global scale.

The detailed analysis of the current renewable energy status of Turkey, on the other hand, revealed the following results. First, it has been observed that binding legislation should be developed and taken into effect for all sources of renewable energy as opposed to the current situation of the sole coverage of wind and geothermal sources. Following the development of such legislation, equal or even more emphasis should be placed on monitoring and, hence, making sure that all of the involved parties abide by these regulations. In order to ensure this, a solid energy database should be developed.

Currently, Turkey approaches the world average in renewable energy use, most of which is hydro, biofuels and waste. However, the renewable energy use excluding hydro is below the general OECD average. This dominating use of biomass and hydropower is expected to change

in favor of solar and wind energy due to environmental concerns and resource scarcity. Therefore, the simultaneous growth of all RES should be realized. This especially holds for the utilization of geothermal and solar energy potentials. Moreover, the administrative process should be facilitated and technical difficulties should be removed for the efficient grid connection of these sources.

In terms of renewable energy policies, it has been observed that the majority of the policies employed in Turkey are regulatory in nature, including feed-in tariff and biofuel obligations. This forms a limited array when compared to the top renewable energy performing countries, where tools, including fiscal incentives and public finances, are also widely used to support renewable energy. As such, the renewable energy policies should be diversified, and effective economic incentives should be provided to support renewable energy policies. The renewable energy policies and support mechanisms in Turkey need to address the variable distribution of RES (*i.e.*, the eastern areas being more dependent on fossil fuels) and the socio-economic differences throughout the country. The financial competitiveness of RES must also be enhanced, and the licensed investments should be finalized as soon as possible. Another significant issue is the development of regional and global renewable energy-related projects. The bureaucratic difficulties should be addressed to ensure such projects are successful and to increase foreign investments together with international collaborative efforts. R&D and technology investments should also be valued especially for converting energy resources into utilizable energy or into energy. Partnerships with the private sector should be expanded through increased use of public-private partnerships for energy R&D. The public should also be made aware of the increasing scarcity of fossil sources and the necessity of renewable energy to win their collaboration on the individual level. In order to address all of these issues effectively, the role of the GDRE in developing RES should be strengthened.

This study has certain limitations in that a more extensive analysis has to be carried out on the individual renewable energy performance of countries. This poses the most promising area of future research. Data mining techniques can be used to analyze the renewable energy performance based on indicators that include, but are not limited to those used in this study. Moreover, hybrid multi-criteria decision making (MCDM) techniques, such as a fuzzy analytic hierarchy process (AHP), which combine qualitative and quantitative factors, should be used to investigate how renewable energy performance is affected by the respective policies and investments. Renewable energy policy making is a complex issue, not only because of the financial constraints and technical difficulties, but also because it involves environmental, economic and energy issues altogether. As such, it inherits the uncertainties associated with all three policy dimensions. This requires extensive stochastic research on modelling these factors, and thus, the relationship between the energy, economic and environmental perspectives of renewable energy policy making is a promising area for future research, especially in developing countries. Another important area of research is the safety and feasibility of nuclear energy use in Turkey, because so far, it has been a debatable issue. On one side is the questionable need for its utilization and on the other the absence of technical knowledge and experience. Finally, because monitoring the performance of renewable energy use is extremely significant, there is an urgent need for a set of indicators (*i.e.*, including electricity usage from RES) that can be used for this purpose. In conclusion, it can be stated that renewable energy is wide open for future research, not only in terms of technological developments, but also concerning its use and respective policies.

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