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Renewable and sustainable energy policies in Turkey

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Abstract
Due to the current development in the renewable energy sector and the investor-friendly possibilities such as the feed-in tariffs in the different sub-sectors of the renewable energy, might be interesting for the Dutch companies, industries and other interested that deal with renewable energy. As the 17th largest economy in the world and 6th largest in Europe, Turkey is experiencing an increase in its energy demand. Turkey has become one of the fastest growing energy markets among the OECD countries in the world. Turkey's energy policies and strategies are based on energy supply security, alternative energy resources, diversity of energy resources, utilization of domestic energy resources to create additional value to economy, liberalization of energy markets, and energy efficiency. Due to this perspective, special emphasis has been made to maximum utilization of local and renewable energy resources as highest priority. The rapid pace of urbanization, the positive demographic trends, the economic expansion and rising per capita income are the main drivers of the energy demand. The energy demand is estimated to increase around 2-4% yearly until 2030. The Turkish government has made it a priority to increase the share of renewable sources in the country's total installed power to 30% by 2030.

Keywords: Sustainable energy; renewables; electricity; primary energy; climate change

1. Introduction

Global primary oil demand grew by a little more and to reach 87.4 million barrels per day in 2011 [1]. The trajectory that oil use over the coming decades differs considerably, reflecting the different assumptions about government policies to curb rising demand and emissions. According to the Scenarios, oil use increases in absolute terms to 2040, driven mainly by population and economic growth in the emerging economies, in response to strong policy action to curb fossil-energy use [2]. The share of oil in total world energy demand falls and it reaches 27% in 2040 while 32% in 2011 [1, 2]. On the other hand, global energy-related CO2 emissions stayed flat in 2014 despite an increase about 3% in the global economy [1]. This is the first time in at least 40 years a reduction in emissions has not been tied to an economic crisis. Across the OECD, emissions continued to decouple from economic growth in 2014. China's emissions figures give early signs of a weakening in the link between economic and emissions growth, albeit not yet a detachment [1-8].
Turkey uses the energy sources inefficiently and consumes more energy to produce a product. Coal is the most reliable domestic energy source in Turkey should be consumed more in the industry and electricity production in order to reduce the energy production costs of Turkey and the dependency on other countries. Oil and natural gas are an expensive energy sources and the consumption of these sources are high in Turkey. Also, energy production from renewables should be improved to reduce the dependency and environmental pollution. The authors believes that Turkey does not use its renewable energy sources efficiently and should promote new technologies and use all its renewable energy potential. The present study gives oil spill from accident aftermath around the planned oil rigs at the Black Sea for energy production and consumption.

2. Energy and climate change

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2.1. Global energy trends by scenario

Short-term changes in energy demand and the composition of the fuel mix are largely a function of economic conditions, energy prices and the weather [6]. But longer-term trends can be significantly changed by the manner in which governments intervene in markets to tackle energy-related challenges [7]. Nonetheless, across the scenarios several fundamental energy trends persist: rising incomes and population push energy needs higher; energy-market dynamics are increasingly determined by the emerging economies; fossil fuels meet most of the world's energy needs, from an ample resource base; and providing universal energy access to the world's poor remains an elusive goal [6-8].

The first of these fundamental trends is that the world's energy needs are set to rise. With the assumed expansion of the global economy of almost 140% and an increase of 1.7 billion in the world's population, more energy will be needed to satisfy growing demand for energy services, even though new policies and programs are put in place to encourage energy savings [1]. World primary energy demand increases by 35% between 2012 and 2040 in the New Policies Scenario as shown in Table 1 [1]. This represents a sharp slowdown in the energy demand growth experienced over the past two decades, testament to the anticipated effect that already implemented and planned policies would have on energy markets [1-5].

Fossil fuels account for 59% of the overall increase in demand, remaining the principal sources of energy worldwide. Global oil demand will reaches 94.2 million barrels per day in 2020 [1]. Demand growth is slowed by planned policies, including efficiency measures, and by higher prices. Oil remains the most important fuel in the primary energy mix, but its share drops to 24% in 2040 [1, 2]. Coal met 54% of the rise in global energy demand between 1990 and 2012, growing faster even than total renewables. It is projected that coal demand to continue to rise in the medium term, with growth slowing from around 2020 [1]. Natural gas demand bounced back by a remarkable 8% in 2012, after declining sharply in 2009, as a result of the global recession. It projected that demand to rise from 3.5 trillion m3 in 2012 to 6.0 trillion m3 in 2040, an increase of 50%. Its share of the global energy mix rises from 22% in 2012 to 24% in 2040, all but catching up with coal [1, 2, 4].

Table 1.World primary energy demand by fuel (Mtoe)

	2012	**2020**	**2030**
Coal	3 879	4 211	**4 342**
Oil	4 194	4 487	**4 689**
Gas	2 844	3 182	**3 797**
Nuclear	642	845	**1 047**
Hydropower	316	392	**469**
Bioenergy	1 344	1 554	**1 796**
Other renewables	142	308	**581**
Total	13 361	14 978	**16 720**

Table 2 shows the global renewable energy capacities in 2013 [5]. As shown in Table 1 and 2, the share of renewables in world primary energy demand reaches 18% in 2040, from 13% in 2012. This rapid increase is underpinned by incentives to overcome market barriers, falling technology costs, rising fossil fuel prices and in some cases carbon pricing. Most of the growth occurs in the power sector (1580 GW), where their share in total generation grows from 20% to 31%, a near tripling in actual generation. Hydro accounts 1018 GW capacity for power generation and its share is 64%. The second contribution is given by wind energy (319 GW). The amount of transport fuels is around 114 billion liters per year in 2013 [3, 5].

2.2. Energy sector and CO2 emissions

Greenhouse gas emissions (GHGs) from the energy sector represent roughly two-thirds of all the GHGs and CO2 emissions from the sector have risen over the past century to ever higher levels [6]. Effective action in the energy sector is, consequentially, essential to tackling the climate change problem. In recently, an important change in the energy sector has been the rapid drop in world oil prices and, to a lesser extent, natural gas and coal prices [7]. At the global level, lower fossil-fuel prices are likely to act as a form of economic stimulus. Yet, so far regional impacts have varied hugely between net importers and exporters, large and small consumers and countries with fossil-fuel subsidy schemes and those without. Oil and gas exporters have seen their expectations of economic growth trimmed and many have revised government budgets as a result [6, 7].

Table 2. Global renewable energy capacities in 2013

Renewable energy	Capacity
Power generation (GW)	
Wind power	319
Biomass power	88
Solar PV	138
Geothermal power	12
Concentrating solar power (CSP)	3.4
Hydropower	1 018
Ocean power	0.5
Hot water/heating (GW_{th})	
Modern biomass heating	320
Solar colectors for hot water/space heating	373
Geothermal heating	66
Transport fuels (billion liters/year)	
Ethanol production	87.8
Biodiesel production	26.3

Lower natural gas prices have improved the competitive position of gas in some markets, although coal still has a cost advantage over gas [1, 2]. Despite lower fossil-fuel prices, there were no signs of weakening appetite for renewables in 2012: global investment in renewable-based power generation was $270 billion and positive policy moves have continued in many countries. India has declared an aim to have an installed non-hydro renewable energy capacity of 182 GW by 2030 [1, 3, 5].

Table 3.Turkey's energy production and consumption in 2014 (Mtoe)

Energy source	Production	Consumption
Hard coal	990	17 692
Lignite	13 973	13 182
Asphaltite	488	416
Oil	2 485	33 896
Natural gas	443	37 628
Hydropower	5 110	5 110
Geothermal (electric)	1 173	1 173
Geothermal (heat)	1 463	1 463
Animal & plant wastes	1 666	1 666
Wood	2 707	2 707
Wind	650	650
Solar	795	795
Total	31 944	120 290

Renewable technologies are becoming increasingly cost competitive in a number of countries and circumstances, but public support schemes are still required to support deployment in many others. Renewables-based power generation capacity is estimated to have increased by 128 GW in 2012, of which 37% is wind power, almost one-third solar power and more than a quarter from hydropower [3]. This amounted to more than 45% of world power generation capacity additions in 2012, consistent with the general upward trend in recent years. The growth in wind capacity continued to be led by onshore installations. China remains the largest wind power market, with 20 GW of new capacity. Germany installed more than 5 GW of wind capacity, while US capacity additions bounced back from the very low levels of 2013 to almost 5 GW in 2014 [1, 3, 4, 5].

Relatively high costs for offshore wind and delays in the build-up of grid connections have resulted in delays to projects in some countries or the cutting of capacity targets, though other countries have responded by boosting their support to the industry. Solar PV expanded strongly in Asia. Lower oil prices proved to be a challenge for other forms of renewables, including biofuels in transport and renewable heat. While biofuels face challenges arising from lower oil prices, some other developments served to improve their outlook: to

counter current bleak prospects for biofuels in Brazil, the government increased the ethanol blending rate from 25% to 27% and that for biodiesel from 5% to 7%, and increased gasoline taxes, while Argentina and Indonesia raised their biofuel mandates [6]. On the other hand, nuclear power is the second-largest source of low-carbon electricity generation worldwide, after hydropower. Nearly all new nuclear construction in recent years has taken place in price-regulated markets or in markets where government-owned entities build, own and operate the plants [1, 3, 5].

3. Energy security in Turkey

3.1. Energy situation in Turkey

As a developing country [9], due to its fast growing economy and population Turkey's energy consumption has increased rapidly as shown in Figure 1. For example, while total primary energy consumption in 1996 was 71 Million tons of oil equivalent (Mtoe) in 2013 it raised 120 Mtoe and total energy production in 1996 was 28 and 32 Mtoe in 2013 [10]. Turkey is an energy importing country and dependent on the imported energy sources as given in Table 3 [11]. Furthermore this trend seems to be continuing in the future. Although it has a wide variety of energy sources, the quality and quantity of most of the sources are not sufficient to produce energy. Some of the energy sources in Turkey are hard coal, lignite, asphalt, oil, natural gas, hydropower, geothermal, wood, animal and plant wastes (biomass), solar and wind energy [12]. The proven reserves of lignite, the most abundant domestic energy source, is 7300 million ton and found in almost all of the country's regions. Lignite has the largest percentage in total energy production with its 43% share. After lignite, wood has the greatest share in total energy production with its 20% and oil accounts for 13%, 12.4% hydro and the final 15% includes animal wastes, solar, hard coal, natural gas, geothermal electricity and geothermal heat [12-14].

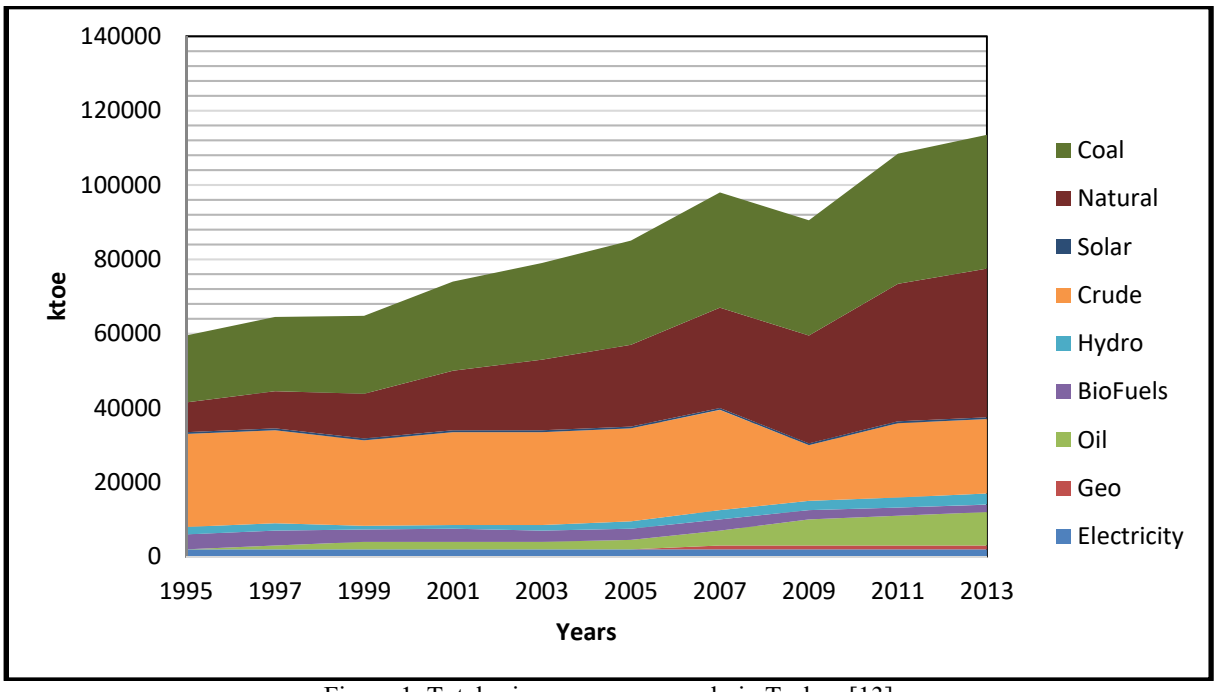

Figure 1. Total primary energy supply in Turkey [13]

Turkey's various renewable energy sources represent its second largest energy source after coal [12]. Wood and animal waste account 32 %, hydropower 37 %, geothermal 19 % and wind and solar account for 10.6 % each of total renewable energy production [13]. Table 4 shows Turkey's total installed power capacity in 2013. In Turkey, 24 % of electricity generation was provided by hydropower in 2013, and will be increased to 36 % in 2020 [14]. The largest hydro power project in Turkey is the Southeastern Anatolia Project (GAP). Upon competition, GAP will have an installed capacity of 7476 MW and 22% of Turkey's total estimated economic potential [12-20].

3.2. The role of renewables for energy security in Turkey

Renewable supply in Turkey is dominated by hydropower and biomass, but environmental and scarcity-of-supply concerns have led to a decline in biomass use, mainly for residential heating [12]. Total renewable energy supply declined from 1990 to 2007, due to a decrease in biomass supply [13].

Table 4. Turkey's total installed power in 2014 (MW)

Energy source	Amount	Percent (%)
Natural gas	20 854	% 31.7
Coal	12 828	% 19.5
Other thermal	5 711	% 9.1
Hydropower	22 898	% 34.8
Wind	2 930	% 4.4
Geothermal	317	% 0.5

As a result, the composition of renewable energy supply has changed and wind power is beginning to claim market share [14]. As a contributor of air pollution and deforestation, the share of biomass in the renewable energy share is expected to decrease with the expansion of other renewable energy sources as shown in Table 5 and 6 [13]. These tables shows that there is an important renewable energy potential in Turkey [12-14].

Table 5. Renewable energy potential in Turkey

Energy source	Potential (MW)	Power plants With licence (MW)
Hydropower	45 000	20 218
Wind	48 000	9 244
Geothermal	600	636
Solar	33	-
Biomass	9.0	54
Biogas	2.0	190

Table 6. Potentials for investment for renewable energies in Turkey

Sectors	Million €	Remarks
Hydroelectric	114	Economical development potential of 28,600 MW, Corresponding 100,000 GWh/a
Wind power	57	Economical development potential of 48,000 MW With wind speed > 7 m/s
Solar thermal	165	Economical development potential of 131,000 GWh/a, Corresponding to approx. 300 million m^2 collector area
Biogas	4	Agricultural residual material and dung, when used for electricity generation, 1,000 MW_e and 7,000 GWh/yr

3.2.1. Hydropower

Hydropower is a renewable form of energy since it uses the power of flowing water, without vested or depleting it in the generation of energy [15, 20]. Because they are clean energy generation plants hydropower can contribute to reducing air pollution and slowing down global warming. Any other air pollutants or toxic wastes are not produced and it promotes energy safety independence and price stability. Hydropower is an electricity sources with long viability and low operation and maintenance cost [13-16].

Turkey's theoretical hydroelectric potential is 1% of that of the World and 16% of Europe [9]. The gross theoretical viable hydroelectric potential in Turkey is

433 billion kWh and the technically viable potential is 216 billion kWh [12]. The economically viable potential, however, is 140 billion kWh. Annual energy consumption per capita in Turkey has reached 2.900 kWh which is above world average of 2.500 kWh [13]. Currently, Turkey has 178 hydroelectric power plants in operation with total installed capacity of 16 160 MW generating an average of 48.000 GWh/year, which is 35% of the economically viable hydro potential [14]. In 2013, 150 hydroelectric power plants are under construction 8.600 MW of installed capacity to generate average annual 20.000 GWh representing 14% of the economically viable potential. In the future, 1.418 more hydroelectric power plants will be constructed in order to make use of additional 22 700 MW installed capacity. As a result of these works, a total of 1.738 hydroelectric power plants with 45.000 MW will tame rivers to harness the economically viable hydropower of Turkey [12-15].

Approximately 50% of the additional potential of 38 TWh (that is, 19 TWh) could be realized as small hydroelectric plants (SHP), with installed capacities of less than 10 MW [12]. The share of SHP potential in the total, which is 3% at present, would be 14% [13]. On the other hand, in accordance with the results obtained from the pre-evaluation study, about 15% of the increase in 126 TWh/year exploitable energy potential might be achieved by developing additional SHP potential [14]. However, this study gives only rough results about the additional SHP potential of the country and the potential must be evaluated more precisely, with comprehensive master plan studies for each hydrological basin [15-27].

3.2.2. Bioenergy

Half of Turkey´s energy demand is covered by natural gas and oil imports [9]. Turkey´s energy demand is currently covered mainly by fossil fuels, coals, oil and natural gas and less by geothermal and hydro power plants [10]. On the other hand, Turkey has a great potential of biomass and bio-energy production [12]. Biomass energy seems to have a major potential for the usage as a energy source [14]. The total annual recoverable bio-energy potential in Turkey was estimated to be around 30 Mtoe, based on the recoverable energy potential from agricultural residues, livestock farming wastes, forestry and wood processing residues and municipal wastes [10, 11, 12].

The share of renewable energy sources to primary consumption is estimated to be 10 % in 2015 [12]. Additionally, the contribution of energy production share of animal wastes and plant residues to primary energy consumption in Turkey ranged from 6 % in 2000 to 4 % in 2013 as well [20]. It seems that, despite Turkey has a great potential of biomass to produce renewable energy and the law on utilization of renewable energy resources for the purpose of generating electrical energy has been brought into action, but the share of renewable energy in energy production is still low [14]. Biogas production potential in Turkey was estimated to be around 1.5 to 2.0 Mtoe. However, since the share of renewable energy in energy production is so low, the possible contribution of biogas to this share can also be ignored [12-14].

3.2.3. Geothermal energy

Among the renewable energy alternatives, geothermal energy in Turkey has become very attractive [12]. The reason for this interest is features of geothermal energy in direct and indirect use. It is unfortunate that geothermal energy in direct use can only be utilized locally. But, firing fossil fuels at 1500 oC, and using the generated heat at only 50-60 oC is obviously a thermodynamic waste. Although indirect use of geothermal energy with relatively low temperatures seems inefficient with respect to fossil fuel fired energy sources, it has an advantage of base-load power generation with respect to other renewable such as hydropower, biomass, wind and solar energy [13, 14]. Turkey has a significant potential in geothermal energy and there may exist about 2000 MWe for electrical power generation [12]. Turkey's total geothermal heating capacity is about 31,500 MWth. At present, heating capacity in the country runs at 1220 MWth equivalent to 147,000 households. These numbers can be heightened some seven-fold to 7,080 MWth equal to 760 000 households through a proven and exhaustible potential in 2016. Turkey must target 1.2 million house holds equivalent 7,900 MWth in 2020 [12-14].

3.2.4. Solar energy

Turkey is so lucky about solar energy potentials that it has 4.2 hours insulation time avarage per day and 1514 kWh/year.m2 solar radiation level [9]. Only available rooftop area for PV modules is 611 km2 and energy gain from this area will be 90 billion kWh/year. Apart from this area it is determined that the area which has more than 1650 kWh/m2 irradiation level is about 4600 m2 in Turkey. That means this solar energy potential equals to a natural gas plant with a power of 54,300 MW [14-27].

Except some special applications PV installation is

almost non existing in Turkey. However, solar energy is widely used for heating water [12]. The hot water heating system installations cover about 10 million m2 surface in 2013. Turkey is the second big country at hot water heating systems all over the world. Apart from this, PV installations are not so much up to now because of the economical issues [10]. While the existing feed in tariff is about 6.5 €cent/kWh, it is foreseen that it will be about 26 €cent/kWh for PV and 22 €cent/kWh for CSP in 2013. Moreover, there will be no licence need for systems up to 500 kW. There are some goals about PV installations in Turkey due to these regulations. It is expected that there will be 3 million installations of private homes which has totally power of 3.000 MW. In addition, the target of installed PV power plant by 2020 is 20.000 MW [12, 14].

The photovoltaic sector in Turkey is still fairly small, providing work for only a small number of employees. The main actors consist of several companies and a number of research institutes [9]. There are approximately 30 companies which are operating in Turkey's PV sector. The main business types are importer, wholesale supplier, system integrator and retail sales. The companies serve in the installation, engineering and project development sectors. PV modules, battery charge controllers and inverters are mainly imported. Batteries, solar lighting systems, etc., may be supplied by the domestic market. Some of the domestic products are exported. There is not any cell production factory in Turkey [12-14].

3.2.5. Wind power

Surrounded by the Black Sea to the north, the Marmara and the Aegean Sea to the west and the Mediterranean Sea to the south, Turkey has huge potential for wind power generation. A study carried out in 2002 concluded that Turkey has a theoretical wind energy potential of nearly 90,000 MW [12]. So far only about 1,000 MW capacity wind farms are in operation in Turkey, generating less than 0.5% of total electricity consumed [12]. There are a number of cities in Turkey with relatively high wind speeds. These have been classified into six wind regions, with a low of about 3.5 m/s and a high of 5 m/s at 10 m altitude, corresponding to a theoretical power production between 1000-3000 kWh/(m2.yr) . The most attractive sites are the Marmara Sea region, Mediterranean Coast, Agean Sea Coast, and the Anatolia inland [14]. Capacity is likely to grow rapidly, as plans have been submitted for just under a further 600 MW of independent facilities. At start 2014, total installed wind energy capacity of Turkey is only 1 900 MW [12-14].

Turkey, in contrast, relies heavily on imported energy. Only around 30% of the total energy demand is met by domestic sources [12]. The Turkish Wind Energy Association has estimated that Turkey could meet 20% of its electricity demand from wind power with a target capacity of 20,000 megawatts, even assuming an average 8% annual growth in power consumption [13]. On the other hand, Turkey has plenty of great natural resources. Geographical location of Turkey is also a great advantage, especially its distance to industry demanding countries, European Union, Arabic states. In addition to that, climate is a varying factor depending on the landscape [14]. Three sides of Turkey is surrounded by Mediterranean, Black and Aegean sea with the warm and nice weather and good amount of stable wind speeds. However, to use all these advantages, Turkey needs energy. Any country that cannot produce its own energy cannot improve and will always be dependent on other countries; will lack freedom [15-27].

It is shown that Turkey has plenty of renewable energy resources which are still not utilized [10, 11]. This paper proves that wind energy is one of those alternative renewable energy resources which help Turkish economy and development in the following years. Since wind energy is not a stable electricity source, it requires other sources of electricity production investments to different energy resources. In addition to that, the demand of Turkish Republic is much more than the amount that can be produced by wind energy [12-14].

4. Conclusion

The usage of renewable energy resources shows a promising prospect in Turkey in the future as an alternative to the conventional energy. In the past decade, wind energy has become a valuable and dependable source of electricity worldwide. There is a promising potential in Turkey for both wind and solar energy. In Turkey, several research institutions have initiated research at various stages on the applications of solar energy. The estimated wind and solar energy potentials: 48,000 MW for wind and 80 Mtoe for solar. Turkey has a considerably high level of renewable energy resources that can be utilized to satisfy a part of the total energy demand in the country. Present applications have shown that

renewable energy sources in Turkey are a promising alternative. In a recent project proposal, short term forecasting of solar power production into the electricity grid system has been submitted to the Turkish Scientific and Technical Research Council of Turkey.

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