Renewable Energy 35 (2010) 1469–1476

Contents lists available at ScienceDirect

Renewable Energy

journal homepage: www.elsevier.com/locate/renene

Energy production and sustainable energy policies in Turkey

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ARTICLE INFO

Article history:
Received 14 April 2009
Accepted 14 January 2010
Available online 9 February 2010

Keywords:
Energy utilization
Renewable energy
Sustainable development
Turkey

ABSTRACT

Turkey's demand for energy and electricity is increasing rapidly. Turkey is heavily dependent on expensive imported energy resources that place a big burden on the economy and air pollution is becoming a great environmental concern in the country. Turkey's energy production meets nearly 28% of its total primary energy consumption. As would be expected, the rapid expansion of energy production and consumption has brought with it a wide range of environmental issues at the local, regional and global levels. With respect to global environmental issues, Turkey's carbon dioxide (CO_2) emissions have grown along with its energy consumption. States have played a leading role in protecting the environment by reducing emissions of greenhouse gases (GHGs). In this regard, renewable energy resources appear to be the one of the most efficient and effective solutions for clean and sustainable energy development in Turkey. Turkey presently has considerable renewable energy sources. The most important renewable sources are hydropower, biomass, geothermal, solar and wind. Turkey's geographical location has several advantages for extensive use of most of these renewable energy sources. Turkey has a great and ever-intensifying need for power and water supplies and they also have the greatest remaining hydro potential. Hydropower and especially small hydropower are emphasized as Turkey's renewable energy sources. Turkey's hydro electric potential can meet 33–46% of its electric energy demand in 2020 and this potential may easily and economically be developed. This paper presents a review of the potential and utilization of the renewable energy sources in Turkey.

1. Introduction

The energy demand of Turkey will be doubled between the years 2000–2010 and will be fivefold between 2000 and 2025. This rapid increase in demand is due to the high economic development rate of Turkey. The estimated amount of investments for production facilities by the year 2010 is around 45 billion dollars. Transmission and distribution facilities will require an additional 10 billion dollar investment in the same period. The government has undertaken measures to attract local and foreign private sector funds for new investments and, also, to transfer operational rights of existing units to the private sector for their renewal and efficient operation [1].

Sustainable development demands a sustainable supply of energy sources. One of the most important implications of this statement is as follows [2,3]. Sustainable development in a society requires a supply of energy sources that, in a long term, is readily and sustainably available at reasonable cost and can be utilized for all required tasks without causing negative social effects. Supplies of such energy resources as fossil fuels are finite; other energy sources, including hydropower (HP), are generally considered renewable and therefore sustainable over the relatively long term.

This paper investigates the politics of energy procurement and consumption in Turkey within the context of sustainable development. It examines current and projected energy usage patterns against the backdrop of existing energy procurement strategies and their renewable alternatives. A key consideration in this regard is that Turkey is an energy-importing country: roughly three-quarters of its energy needs in 2005 were met through imports. Given its long term plans for continued economic growth, even conservative projections that privilege efficiency gains over production increases create a scenario in which the energy needs of Turkey will far outweigh the existing productive capacity.

Turkey is still undergoing rapid economic restructuring along neo-liberal dictates, resulting in the gradual withdrawal of the state from the economy and the geopolitical shake-up in the region has highlighted the complex interconnections of the lines of energy transportation from the politically unstable Middle East and Central Asia to the affluent West. It is not, surprising, therefore, that the most recent formulation of Turkish energy policies reflect not only the need for integrating market mechanisms with energy production, but also the continued needs of both the European

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doi:10.1016/j.renene.2010.01.013

Union and United States for energy. While this approach does not entirely replace the 'energy independence' approach, it subsumes its internal logic under a new approach that can be called 'energy interdependence', clearly demonstrated in the recently popularized terms of making Turkey an 'energy terminal' or an 'energy corridor' [4,5].

This restructuring process necessitates a two-pronged approach: creating new and secure lines of energy transportation and investing in new domestic energy creation methods. Thus, prominent energy-related stories from Turkey in recent years have been about the Baku-Tblisi-Ceyhan (BTC) oil pipeline, the Ilısu hydroelectric dam, and the Akkuyu nuclear power plant. The involvement of high profile energy and construction firms in these projects underscores the political economic context within which Turkish environmental policies are being shaped. Minister Hilmi Güler forcefully made this point when he declared that 'Turkey is following a restructuring process aimed at instituting competitive markets, primarily as it is per the norms of the European Union (but also) because of the necessities of economic development and integration with the global economy' [6].

2. Energy production and consumption

In 2005, Turkey produced 26.81 Mtoe (million ton oil equivalent) of energy from primary domestic sources. Annual consumption, however, was nearly three times greater, at 92.4 Mtoe (see Table 1 and Figs. 1 and 2). In other words, in year 2005, only 29% of primary energy was provided by domestic production. It is expected that by the year 2020, domestic energy consumption will reach 222 Mtoe, while domestic production will be at 70 Mtoe, or 30% of national demand. The following section provides a breakdown of the relevant dimensions of energy consumption and production [7,8].

As Table 1 shows, coal and lignite make up almost half of the entire national production and, with added imports, nearly a third of national consumption. However, Turkish coal and lignite are largely inappropriate for the purposes of sustainable development as their usage is cost-ineffective and responsible for air pollution in urban centers, as was the case in Ankara during the 1970s and 1980s [7]. This is because Turkish lignite has low calorific value and high sulfur, dust and ash content whereas Turkish hard coal is low-grade [8].

While Turkey has a functional oil exploration and production program under the Turkish Petroleum Corporation, annual crude oil production meets only 10% of the national demand for oil and the remainder is imported from elsewhere in the region. At 42%, oil consumption is the single most important component of Turkish energy consumption and accounts for over 61% of energy imports [8].

Natural gas, which was introduced in the 1980s as a cleaner alternative to coal and lignite, is rapidly becoming an important

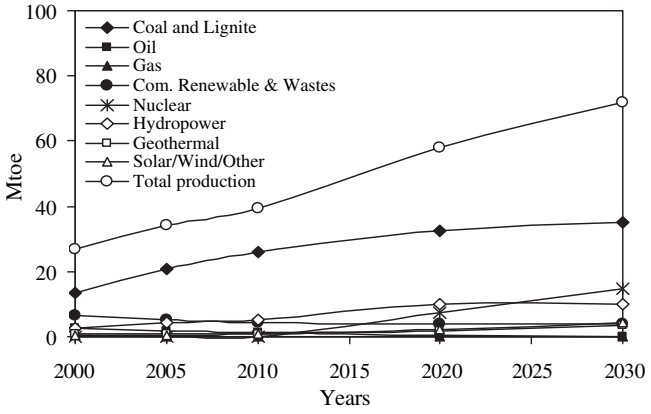

Fig. 1. Turkey's primary energy production during 2000–2030 (Source: Ref. [8,10]).

dimension of energy consumption, even though its domestic production is and will remain very limited. In fact, natural gas is the fastest growing primary energy source in the country. It currently makes up 15.1% of national primary energy consumption and nearly a quarter of all energy imports [7]. On the other hand, at 25.3% of national production and 9.7% of national consumption, biomass and other renewable energy resources remains an important dimension of energy policies in Turkey. However, the contribution of the biomass resources in the total energy consumption dropped from 20% in 1980–9.7% in 2005 [8]. Both fuel wood and animal wastes play important roles in heating and cooking, especially in low-income urban-peripheral and rural settlements. Table 2 provides a further breakdown of non-hydro renewable energy sources in 2005. It is crucial to note that the types of non-hydro renewable energy sources that could hold the key to sustainable development comprise only a quarter of total production in this category [8].

Two further analytical breakdowns are necessary to complete the current energy production and consumption picture of Turkey. The first set of figures, presented in Table 3, depicts the final consumption figures for Turkey in 1990, 2000 and 2005. This is an important category to consider as it gives an indication about the transformation of primary energy sources into secondary energy types.

The implications of Table 3 are extremely important, if not immediately obvious. First, as far as increases in productive capacity go, the limited availability of oil, gas, and sufficiently high quality coals and lignite, leaves electricity as a growth area in Turkish energy production. Therefore, already making up 13.4% of overall consumption and growing at an annual 8.5%, electricity is arguably the single most important and contentious aspect of Turkish energy. Putting the issue of energy conservation and efficiency gains aside momentarily, it is important to understand the

Table 1
Turkey's Primary energy production and supply in 2005 (Mtoe).

Energy sources	Production	% of total	Supply	% of total	Imports	% Total
Coal and lignite	13.29	49.4	23.81	26.2	10.52	11.5
Oil	2.9	10.8	29.22	32.1	26.32	28.8
Gas	0.6	2.2	26.44	28.9	25.84	28.2
Comm. renewables and wastes[a]	6.81	25.3	5.4	6.1	–	
Nuclear	–	–	–	–	–	
Hydro-power	2.98	11.1	4.24	4.6	–	
Geothermal	0.2	0.7	1.90	2.1	–	
Solar/wind/etc. renewables	0.11	0.4	0.41	–	–	
Total (Mtoe)	26.89	100	91.42	100	62.68	

[a] Comprises solid biomass, biogas, industrial waste and municipal waste. Source: Ref. [8].

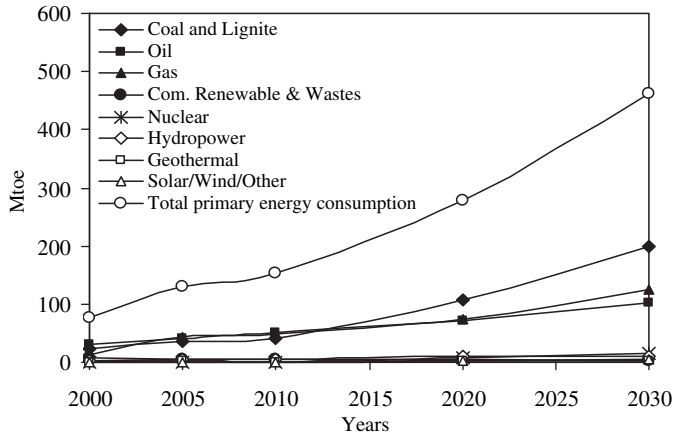

Fig. 2. Turkey's primary energy consumption forecast 2000–2030 (Source: Ref. [8,10]).

nature of electricity production and consumption in Turkey, presented in Table 4.

It is clear from Table 4 that thermal electricity generation, given its heavy dependence on lignite and natural gas, makes for an unacceptably high percentage of overall production. This is not only because of the potential problem of air pollution from lignite-burning thermal power plants and continued energy dependency on imported natural gas, but also due to their contribution to Turkey's carbon dioxide emissions, which contribute to global warming. This conclusion is particularly stark given the relatively small share of hydro and almost non-existing role of wind and other renewable (sun, wave, etc.) sources in electricity generation.

The final consideration of this section is the breakdown of energy consumption into its constituent user subgroups, presented in Table 5. These percentages are relatively stable across time, although, as would be predicted, increased economic activity has steadily but consistently raised the share of industrial energy consumption, mainly at the expense of consumption by households. As for electricity consumption, industrial and other commercial interests consume nearly 60% of national electricity, with housing taking approximately 25%, and the remainder going to governmental offices, street lighting, agriculture and other miscellaneous uses [7,8].

In 2005, primary energy production and consumption has reached 28 and 94.3 million tons of oil equivalents (Mtoe) respectively (Tables 6 and 7). The most significant developments in production are observed in coal production, hydropower, geothermal, and solar energy. Turkey's use of hydropower, geothermal and solar thermal energy has increased since 1990. However, the total share of renewable energy sources in total primary energy supply (TPES) has declined, owing to the declining use of non-commercial biomass and the growing role of natural gas in the system. Turkey has recently announced that it will reopen its nuclear programme in order to respond to the growing electricity demand while avoiding increasing dependence on energy imports [7–9].

Table 2
Renewables in 2005, in Turkey (ktoe).

	Production	(%)
Hydropower	4112	36.6
Fuel wood	4081	36.3
Animal and plant waste	1376	12.3
Geothermal	1412	12.5
Solar	262	2.3
Wind	3	0.0
Total	11,246	100

Source: Ref. [8].

Table 3
Final energy consumption in Turkey (ktoe).

	1990	(%)	2000	(%)	2005	(%)
Oil	19,931	47.1	26,536	43.1	29,254	31.8
Natural gas	784	1.9	5088	8.3	14,146	15.5
Electricity	3928	9.3	8268	13.4	15,164	16.5
Coals and lignite	9226	21.8	13,187	21.4	19,786	21.5
Non-commercial	7208	17.0	6457	10.5	9212	10.0
Other	1263	3.0	1997	3.2	4344	4.7
Total	42,340	100	61,533	100	91,906	100

Ktoe: kilo tons of oil equivalent. Source: Ref. [8].

3. Projected demand and supply of energy in Turkey

For any analysis of the future demand for energy in Turkey to be accurate, it has to be grounded in the understanding that rapid and continued economic growth are and will remain the single most important national aspirations. According to 2005 figures, Turkey has a population of 72.6 million. This translates to a per capita GNP of $4900 and per capita energy consumption of 1.2 Mtoe, placing Turkey last in both categories among OECD countries [10].

Another revealing expression of the difference between Turkey and developed industrial nations is the ratio of energy consumption and GNP. The ratio for Turkey is 0.37, whereas the OECD average is 0.66 and the EU average 0.57 (Calculated by using per capita Mtoe energy consumption and per capita income in 1000s). The difference between the OECD and the EU can largely be accounted for by the energy-intensive nature of the US economy, which suggests that the correlation between development and energy consumption need not be straightforward or unidirectional. Nevertheless, the large gaps between energy consumption and income in Turkey and the EU suggest that any future scenario has to acknowledge the high probability that energy consumption in Turkey will rise significantly if the national aspiration of 'catching up' is to materialize [5,10,11].

Table 8 depicts the historical and projected relationship between population, economic output, and energy demand. Several relationships are worth highlighting. First, the population projections signal the slowing down of population growth. At the same time the GNP is expected to nearly double every ten years. A similar relationship between population, per capita energy demand and total energy demand is projected. The implication of these figures is that the energy intensity of the Turkish economy will substantially improve over time, going from 81 Mtoe/GNP/capita in 1973–40 Mtoe/GNP/capita in 2000–33 Mtoe/GNP/capita in 2020 [12].

It is worth emphasizing that, even if both population and economic output were to grow more slowly than projected, it is almost certain that energy demand will increase. Two factors critical to sustainable energy development in Turkey, however, are harder to predict. The first is the energy intensity of the economy. While the reported and predicted decreases seem impressive, it is by no means clear from this table whether this is the best that can

Table 4
Breakdown of domestic electricity production in 2005, in Turkey (GWh).

	Production	(%)
Thermal	122,174	75.42
Hydropower	39,658	24.48
Wind and geothermal	153	0.1
Total	161,985	100

Source: Ref. [8].

Table 5
Categorization of energy consumers, 2005 (Mtoe), in Turkey.

Type	Consumption	(%)
Industry	33.66	36.5
Residential	26.84	29.3
Transport	18.91	20.5
Agriculture	4.46	4.8
Non-energy	3.65	3.9
Own-use	4.63	5.0
Total	92.15	100

Source: Ref. [8].

be achieved in Turkey. If even sharper reductions are possible, increased economic growth could be delinked from energy consumption. The second is the type of primary and secondary energy sources that are required to fulfill future energy needs. In other words, the decision on the mix of energy production technologies and primary sources needs to be considered carefully, as certain combinations of technologies and primary sources are likely to result in more sustainable outcomes. It is important, therefore, to understand the determinants of energy intensity and energy supply [5].

At the national level, it is possible to state energy intensity as a function of the structure of the economy and energy efficiency. The former refers to the sectoral composition of an economy. An economy characterized by industrial production is likely to be more intensive than one specialized in services. Similar breakdowns are also possible within each sector. Energy efficiency in this context includes energy production, energy transmission and energy use. Both economic structure and energy efficiency are open to a significant extent to governmental maneuvering through a variety of policy mechanisms. Better outcomes would require different types of regulatory forces that privilege environmental sustainability as a policy outcome in Turkey [10,11].

The nature of the energy supply is dependent on two main factors: resource availability and price. Resource availability refers to the geological, geographic and climatic conditions that shape available energy production. While certain policy tools can help discover energy sources or make their processing more efficient, resource availability is largely an exogenous variable that cannot be easily changed. Certain policy interventions, however, could have a dramatic impact on shaping the relationship between geological, geographic and climatic conditions and energy production. For example, in a country endowed with rich wind resources, policies supporting wind energy technologies can hold great potential.

The price factor denotes both the relative and absolute cost of energy imports or production and is also largely independent of policy interventions. For example, international markets determine the price of oil and, with the possible exception of the US, countries cannot devise policies to influence it. The cost of converting primary sources to energy supply, however, could be influenced by technology policies that can either make energy production more effective or eliminate the need for importing advanced technologies, such as nuclear power reactors. Similarly, the state in Turkey is in a position to decide between competing technological solutions, such as hydro, wind, and nuclear energy.

The findings of the MENR suggest that the primary energy demand will be equivalent to 91,030 kilo tons of oil equivalent (ktoe) in the year 2002, and 314,353 ktoe in 2020 in Turkey. In line with this trend, in 2025 marking the centennial of the country, the primary energy consumption will reach 367,780 and 407,106 ktoe, 2 years later in 2025. According to the Ministry's production forecasts, domestic production of primary energy will level 31,091 ktoe in 2000 and 79,399 ktoe by 2020. The projections foresee domestic generation to top 95,946 ktoe in 2025 and 106,507 ktoe in 2030 [13]. Table 9 shows renewable energy supply and projections for future in Turkey, respectively [8,10,14].

Table 6
Selected indicators of primary energy consumption and resources (Thousands TOE) in Turkey.

	2005 Realization		2006 Estimate		2007 Estimate	
	Amount	(%)	Amount	(%)	Amount	(%)
Commercial Energy	89,050	94.4	93,680	94.7	96,680	94.5
Hard coal	14,805	15.7	15,052	15.2	16,052	15.2
Lignite	10,760	11.4	11,005	11.1	12,005	11.1
Petroleum products	32,855	34.8	35,160	35.6	37,160	35.6
Natural gas	25,665	27.2	27,356	27.7	29,356	27.7
Hydraulic energy	3744	4.0	3801	3.8	3981	3.8
Renewable energy	1350	1.4	1427	1.4	1627	1.4
Non-commercial Energy	5250	5.6	5200	5.3	5,6080	5.5
Wood	4100	4.4	4100	4.1	4100	4.1
Biomass	1150	1.2	1100	1.1	1100	1.4
Total	94,300	100	98,880	100	102,288	100

TOE: Tons of Oil Equivalent; KEP: kilogram of oil equivalent. Source: Ref. [9].

4. Energy policies in Turkey

The preceding discussion already has laid the foundations for an analytical framework necessary to understand the structural dynamics and political forces at work. The discussion of the determinants of energy intensity and energy sources makes it clear that specific policy outcomes can be understood as a function of two conceptual categories concerning policy-making: regulation and technology. While these two conceptual categories account for most aspects of environmental and energy policy outcomes, a third indicator, political outlook, is required to fully capture the domestic and geopolitical forces at work in Turkey.

The first category, regulation, concerns both the means of devising regulatory frameworks on energy and the overarching goal of such policies. The second category also comprises two variables: the relationship between technology and risk and the nature of technology implementation. Finally, the category of political outlook comprises a discursive alignment and outlook on the nature of international relations [7,8,10].

Using these three categories, it is possible to construct a matrix of the competing energy and environment discourses in Turkey. For the sake of simplicity, this chapter uses only two major orientations, though a variety of combinations are possible. These do not necessarily correspond with real world actors as the matrix is merely intended as a heuristic device to chart the profile of the ongoing policy debates in Turkey. Naturally, the real world of energy politics has various shades of gray, and it is not uncommon for actors to borrow from each camp over time. Nevertheless, these two positions, Greens and Developmentalists, capture the tenor of the ongoing debate in Turkey [5].

Greens believe in extensive environmental regulation. In line with their European and North American counterparts, Greens in Turkey articulate their positions with an implicit critique of markets that question both their desirability as social institutions and effectiveness as regulatory tools. Thus, this position is characterized by calls for the direct involvement of the state in protecting the environment through command-and-control mechanisms. Moreover, Greens privilege ecological protection over continued economic growth. This is not to suggest that this position rejects economic growth entirely, since such deep ecology-inspired movements in Turkey remain relatively rare. The practical upshot of this for their energy policy is built around small-scale and alternative technologies, such as wind farms and solar panels. Finally, in their political outlook, the Greens in Turkey parallel the 'liberal' school of international relations, constructing their discourse

Table 7
Developments in production and consumption of energy between 2000–2005 in Turkey.

	2000	2001	2002	2003	2004	2005
Primary energy production (TTOE)	27,621	26,159	24,884	23,779	24,170	28,020
Primary energy consumption (TTOE)	81,193	75,883	78,322	83,936	87,778	94,300
Consumption per capita (KOE)	1204	1111	1131	1196	1234	1249
Electricity installed capacity (MW)	27,264	28,332	31,846	35,587	36,824	39,596
Thermal (MW)	16,070	16,640	19,586	22,990	24,160	26,481
Hydraulic (MW)	11,194	11,692	12,260	12,597	12,664	13,115
Electricity production (GWh)	124,922	122,725	129,400	140,580	150,698	165,346
Thermal (GWh)	94,011	98,653	95,668	105,190	104,556	124,321
Hydraulic (GWh)	30,912	24,072	33,732	35,390	46,142	41,025
Electricity import (GWh)	3786	4579	3588	1158	464	636
Electricity export (GWh)	413	433	435	587	1144	1812
Total Consumption (GWh)	128,295	126,872	132,553	141,151	150,018	
Consumption per capita (kWh)	1903	1857	1914	2011	2109	2240

Source: Ref. [8,9].

around concepts such as multiculturalism and universal human rights, believing on the one hand that non-state actors are increasingly important in energy politics and on the other interpreting the interstate system as one characterized by win–win cooperation [5].

Developmentalists believe in minimum state involvement in the economy, including the environmental regulation of energy procurement and consumption. When regulation is necessary, the preferred method is through market-based mechanisms and to secure unbridled economic growth. They are characterized by their belief in the Promethean promise of risk-prone technologies, such as nuclear power. Where new technologies are not adequate or appropriate, conventional mega projects that are emblematic of both state power and its developmental goals are favored. Finally, when energy policy decisions intersect with issues of ethnic, cultural, or gender rights, Developmentalists follow a nationalist approach closely matched by the realist school of international approach, prioritizing state sovereignty and national strategic goals over the rights of subnational groups or the rights of peoples in other nation-states. As a corollary, the Developmentalist position takes a dim view of international cooperation, believing zero-sum outcomes to be the norm [5].

The differences between these two positions can be demonstrated clearly by evaluating the ongoing debates on electricity procurement and consumption. By focusing on this emblematic issue, the section demonstrates how the tension between the Greens and the Developmentalists resonates through the entire spectrum of Turkish energy politics and policy. Growing at nearly 10% per annum, electricity procurement emerges as the single biggest challenge to energy politics and policies in Turkey [12]. Persistent and unpredictable power cuts are reminders of the nation's growing electricity shortage. Therefore, nearly 82% (US$ 56 billion) of Turkish energy-related expenditure until 2010 will be allocated to electricity [15]. This translates into an annual investment of US$ 4–5 billion, expected to continue well into the 2020s. As argued in the previous section, however, it is important to resist the identification of this 'fact' of electricity shortage with any specific policy proposal before a thorough national debate is conducted.

Hydropower, already making up about 40% of the country' electricity production and slated to rise exponentially over the years. Since the inception of an ambitious and continued dam construction program in the 1930s, Turkey has constructed 202 large and 317 small dams; 114 of these dams also operate as hydroelectric power plants (HEPP) and over 200 new HEPPs of varying sizes are either in construction phase or are being planned. Until the mid-1980s, plans for dam construction remained largely outside the political sphere and were treated mainly as technical decisions. However, the progressive development of democratic politics in southeastern Turkey, where the majority of these dams are being constructed, have finally politicized the link between the growing need for electricity and the necessity of dam construction [9,16,17].

The Developmentalist position on this issue is characterized by the stance it takes on the Southeastern Anatolia Project (GAP in its Turkish acronym), a complex network of dams and irrigation channels. Although current justifications for this mammoth project mention irrigation and regional development as key objectives, the earlier plans were articulated squarely in terms of providing a secure electricity supply. Techno-scientific optimism, belief in mega projects, and willingness to put economic development over other policy objectives characterize the Developmentalist view on GAP.

The Southeastern Anatolia Project (GAP) project originally planned by the State Hydraulic Works is a combination of 12 major projects primarily for irrigation and hydroelectric generation. The project includes the construction of 22 dams and 19 hydroelectric power plants on the Euphrates and the Tigris rivers and their tributaries. It is planned that upon completion, over 1.8 million hectare of land will be irrigated and 27 billion kWh hydroelectric energy will be generated annually.

The GAP area is rich in water resources. The Euphrates and Tigris rivers represent over 28% of the country's water supply by rivers, and the economically irrigable areas in the region make up 20% of

Table 8
Turkey's Population, economy, and energy.

	Population (000s)	GNP/capita	Total GNP	Total Energy demand (Mtoe)	Energy/capita (Kep)	Energy intensity
1973	38,072	1994	75,915,568	24.6	646	81
1990	56,098	2674	150,006,052	53.7	957	50
1995	62,171	2861	177,871,231	64.6	1039	44
2000	67,618	3303	223,342,254	82.6	1218	40
2010	78,459	5366	421,010,994	153.9	1962	35
2020	87,759	9261	812,736,099	282.2	3216	33

Source: Ref. [12].

Table 9
Renewable energy supply in Turkey.

Renewable energy sources	2000	2005	2010	2015	2020
Primary energy supply					
Hydropower (ktoe)	2656	4067	4903	7060	9419
Geothermal, solar and wind (ktoe)	978	1683	2896	4242	6397
Biomass and waste (ktoe)	6457	5325	4416	4001	3925
Renewable energy production (ktoe)	10,091	11,074	12,215	15,303	19,741
Share of total domestic production (%)	38	48	33	29	30
Share of TPES (%)	12	12	10	9	9
Generation					
Hydropower (GWh)	30,879	47,287	57,009	82,095	109,524
Geothermal, solar and wind (GWh)	109	490	5274	7020	8766
Renewable energy generation (GWh)	30,988	47,777	62,283	89,115	118,290
Share of total generation (%)	25	29	26	25	25
Total final consumption					
Geothermal, solar and wind (ktoe)	910	1385	2145	3341	5346
Biomass and waste (ktoe)	6457	5325	4416	4001	3925
Renewable total consumption (ktoe)	7367	6710	6561	7342	9271
Share of total final consumption (%)	12	10	7	6	6

Source: Ref. [8,10].

those for the whole Turkey. The development of the region was originally planned as relating to its water resources, which were later combined in a comprehensive water and land resources development package. For this purpose, total 12 groups of projects were planned on the Euphrates and Tigris rivers and their branches by the General Directorate of State Hydraulic Works [18,19].

The package included the construction of 22 dams, 19 hydroelectric power plants and the irrigation facilities to serve 1.7 million hectare of land. The total installed capacity of the power plants is 7500 MW with an annual production of over 27 billion kWh. There are two main basin projects: the Euphrates and the Tigris basin projects. The Euphrates basin projects has 5304 MW installed capacity, will generate 20 billion kWh of energy and will irrigate 1 million hectare of land. Fourteen dams and 11 hydroelectric power plants are planned for this basin. The Tigris basin projects have 2172 MW installed capacity, will generate 7 billion kWh of electric energy and will irrigate 700,000 ha of land area. Eight dams and eight hydroelectric power plants are planned for this basin [20].

The Lower Euphrates Project is one of the GAP schemes on the Euphrates river and consists of Atatürk Dam and Hydroelectric power plant (HEPP), Şanlıurfa tunnels and hydroelectric power plant, Şanlıurfa–Harran irrigation, Mardin–Ceylanpınar irrigation, Siverek–Hilvan pumped irrigation. Main public investments in this project have been completed. Atatürk dam was completed in 1990 which the sixth largest-volume dam (48.7 billion m^3) in the world. Type of dam is rock packed with 169 m high from river bed and 1664 m crest long. Body packed volume of the dam is 84.5 million m^3. Water reaches from the Atatürk dam to Şanlıurfa–Harran plains via the Şanlıurfa tunnels system, which consists of two parallel tunnels each 26.4 km long and 7.62 m in diameter. This irrigation tunnel system is the largest of its kind and it has numerous irrigation networks, canal systems constitute the physical groundwork in water resources. Tunnels were completed in 1997, and irrigation is now practised in a 250,000 ha; (total is 476,000 ha) [18,19].

The fact that one-time heads of the State Water Works (DSI in Turkish), which was created in 1953 to ensure efficiency in HEPPs' planning and construction, have often gone on to hold influential positions in Turkish politics demonstrates the centrality of dam construction to the Developmentalist position. In fact, regardless of the party political positions of the nation's top officials, support for aggressive HEPP construction remains constant in modern Turkish history. The sources of the HEPPs (rivers) are flowing away. We need to make use of these. If we don't convert this water into energy, we will have to import on expensive energy resources that place a big burden on the economy by the years [16,17].

In fact, the constellation of criticisms against HEPPs that can be collected under the rubric of the Greens is predicated upon a number of clearly articulated, if not always immediately feasible, policy positions. Of the two most important critiques, the first concerns the potential efficiency gains and the other highlights the availability of alternative, Green energy generation schemes. For example, a 1997 report by Greenpeace Mediterranean, entitled 'Turkey at an Energy Crossroads', argued that until 2020 the energy needs could be met mainly through efficiency gains [21]. According to the Greens, such gains represent low-hanging fruits across the entire spectrum of economic activities in Turkey. Given the contentious nature of the issue, accurate assessments of the scope for efficiency gains are difficult to obtain, although the available evidence indicates substantial potential. A study by Ministry of Energy and Natural Resources (MENR), for example, argues that currently 17% of the electricity in the national system is lost during transmission and distribution [7]. Another study, by the Electrical Power Resources Survey and Development Administration (EIE), found that while losses of 3% in transmission are acceptable, Turkey has an exceptionally high rate of 20% loss in distribution [22]. Even more impressive are figures for potential savings in electricity usage, both by industries and households. According to the studies by the EIE, buildings can save up to 50%, industry 25% and transportation 25% from current levels of usage, generating efficiency gains of USD3 billion per year [23].

The second prong of the criticisms launched by the Greens is that Turkey has abundant potential for alternative energy sources. Recently, a spate of studies by Turkish scientists has demonstrated that significant unexplored renewable energy potential exists in wind [24], biomass [1,25], geothermal [26], and solar [27]. These alternative energy sources support the general tendency of the Greens to favor small-scale and alternative technologies. These studies make it clear that, especially when combined with efficiency gains, renewable energy sources stand to meet a significant proportion of the future energy need of Turkey [13,18], [28–31].

Various branches of the Energy Ministry also report similar findings, yet the energy policies set by successive governments have consistently underplayed the importance of renewables and focused, instead, on hydropower and nuclear power.

5. Global climate change and Turkish energy policies

One major disadvantage of the two-actor matrix presented above is that it gives the false impression that Greens and Developmentalists are evenly matched in their struggle to shape energy politics in Turkey. The actual struggle, however, is far from being between two equals. Developmentalist ideology rules supreme in Turkey and energy politics is no exception to this rule. While energy-related environmental activism, as exemplified by the movements against the Gökova thermic power plant, the Akkuyu Nuclear Power Plant, and the Fırtına valley hydropower dam, is at the heart of environmental politics in Turkey, they either achieve short-lived victories (e.g. the reintroduction of the plans of nuclear power plants) or end-of-pipe solutions that do little to change the overall policy structures (e.g. installation of filters at Gökova). Yet, as several other contributors have argued in this collection, the state in Turkey remains highly sensitive to international forces and dynamics and has frequently improved its environmental policies and practices in response to outside pressures. Therefore, this concluding section discusses the potential impact of global warming and the Kyoto Protocol on the future of Turkish energy policies [32–36].

Total CO_2 emission in Turkey in 2005 amounted to 252.2 million tons, of which 47% was from coal, 42% from oil and 11% from gas. Emissions of another important greenhouse gas, methane (CH_4) reached about 1.3 million tons in 2005, a carbon equivalent of 8 million tons. Nitrous oxide emissions in 2005 totaled 17,500 tons, about the equivalent of the heat trapping capacity of 1.5 million tons of CO_2 [11]. As absolute figures, greenhouse gas emissions in Turkey do not seem alarming. However, two factors suggest the potential development of a serious problem. First, energy-related carbon emissions have been growing much faster than the economy at an annual rate of 6 per cent annually since 1990. Second, the carbon intensity of the Turkish economy is higher than that of developed countries. Therefore, the CO_2 emissions of Turkey are fast becoming a foreign policy consideration [7].

When the United Nations Framework Convention on Climate Change (UNFCCC) was adopted in 1992, all OECD members were included in the list of developed countries in Annex II. Turkey asked for an exception on the grounds that its relative underdevelopment from other OECD members justified special treatment. Such an exception was granted at the Seventh Conference of Parties in Marrakech in 2001, where Turkey was removed from the Annex II. Consequently, the parliament is expected to ratify the Convention. This exception is notable because the flexible implementation mechanisms of the Kyoto Protocol (assuming eventual ratification by Turkey) will open up new avenues for foreign investments for energy efficiency and clean technology projects [10].

Following the ratification of the Framework Convention and the Kyoto Protocol, Turkey has become eligible for trade in carbon credits under the provisions of the Clean Development Mechanism. While the necessary institutional capacities and information systems remain to be developed, the government declared its willingness to comply with the general provisions of the UNFCCC. Unlike domestic energy procurement strategies, the global warming dimension of energy politics receives scant attention from civil society and environmental NGOs. Nevertheless, international pressure, especially through the European Union, is likely to lead Turkey to take real steps toward helping prevent global warming [11,37].

Toward this end, the preparation of the 8th Five-Year Development Plan included for the first time an Expert Committee on Climate Change. The committee's recommendations lean heavily toward market-based solutions, support the recent trend toward increased natural gas consumption and make a number of commonsensical suggestions [38]. A number of promising steps have been taken toward the implementation of these policies. The Electricity Market Act and the Natural Gas Market Law, both of 2001, increased competition and further private involvement. However, given the projected increase in energy demand and consumption, any meaningful reduction of future greenhouse gases in Turkey will necessitate significant investment in renewable energies beyond the current interest in hydropower.

The most significant sources of renewable energy in Turkey are likely to be wind, solar and geothermal. It is estimated that the usable wind energy potential in Turkey is at around 8000 MW. The western coast and southeastern Anatolia are favorable locations for wind power generation, with annual average wind speeds around 2.5 m/s and annual wind power densities of 2.4 w/m^2. These regions are highly suitable for wind power generation, since wind speeds exceed 3 m/s in most of these areas. While the existing wind power production is not significant with a total installed capacity of 80 MW in 2005, but 72 new projects totaling about 2000 MW are under evaluation by the Ministry of Environment and Natural Resources. Preliminary studies indicate that the country has an average 2640 sunshine hours annually, with an average solar intensity of 3.6 kWh/m^2day. The total solar energy potential of Turkey is calculated as 35 Mtoe per year. In 2001, an estimated 287,000 tons of oil equivalent (toe) of solar heating was produced by both residential and commercial sectors in the southern and western regions [38]. Finally, the overall geothermal energy potential of Turkey is estimated at 35,000 MW. But geothermal energy production for the year 2001 was only 1.760 Mtoe. Its use is expected to increase to 6.3 Mtoe by 2020, especially for direct heating. The proposed Geothermal Law, currently being drafted by the MENR, should provide the necessary regulatory framework for this purpose [28,39,40].

Energy development in Turkey has been dominated by public investment and management. The current government, however, is keen to complete the process of liberalization, restructuring, and privatization in the energy sector. Turkey has made early and extensive use of financing models such as build-own-operate (BOO) and build-own-transfer (BOT). As yet, however, no decisive breakthrough has been achieved. This does not mean a complete withdrawal of the state from energy development. In fact, state involvement in formulating and implementing favorable policies for renewable energy development remains vital. To ensure timely and effective investment in renewable sources, however, the state needs to mobilize the extensive funds available to the private sector. A number of renewable energy projects, such as certain hydropower and solar thermal applications, are already commercially attractive to private interests.

6. Conclusion

The relationship between air pollution and energy consumption is a hot topic that is receiving increased attention by industry, regulatory agencies, as well as the public. Turkey is currently undergoing a profound economic and social transition. Since the late 1990s, Turkey's energy production and consumption have undergone an unexpectedly precipitous up-and-down fluctuation, and the related air pollution has changed dramatically. Meanwhile, Turkey's national economy has kept growing at a fairly high rate. Overall, a combination of slow economic growth, industrial restructuring, broader economic system reforms, and environmental and energy-efficiency policies initially leads to a temporary decline in the growth of energy use, and therefore primary air pollutant emissions. However, with the recent economy recovery and the expansion of some energy-intensive manufacturing sectors, 2003 witnessed a sharp increase in Turkey's energy production and consumption. On the other hand, Turkey has a large potential for renewable energies. Especially hydropower, biomass, geothermal, solar and wind energy are abundant in Turkey. Although the use of renewable energy sources increases steadily, it still remains at low levels.

Renewable energy resources and their utilization in Turkey are intimately related to sustainable development. For the governments or societies to attain sustainable development, much effort should be devoted to utilizing sustainable energy resources in terms of renewables [41].

Turkey's annual electric energy demand in 2010, 2015 and 2020 is predicted that it goes up to 270 TWh, 410 TWh and 571 TWh, respectively. Turkey's hydropower potential can meet 33–46% of its electric energy demand in 2020. By evaluating Hydropower (HP) plants, of which potential can be estimated to be in the order of some tens of TWh/yr, Turkey will provide important part of its electric energy demand from its own HP resources [2].

Acknowledgment

I thanks Professor K. Kaygusuz for him valuable suggestions and assistance in preparing this manuscript.

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