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A new energy paradigm for Turkey: A political risk-inclusive cost analysis for sustainable energy

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ABSTRACT

Implementing sustainable development policies in order to achieve economic and social development while maintaining adequate environmental protection to minimize the damage inflicted by the constantly increasing world population must be a major priority in the 21st century. While the emerging global debate on potential cost-effective responses has produced potential solutions such as cap and trade systems and/or carbon taxes as part of evolving sustainable energy/environmental policies, this kind of intellectual inquiry does not seem to be an issue among Turkish policy-making elites. This is mainly due to their miscalculation that pursuing sustainable energy policies is much more expensive in comparison to the utilization of fossil fuels such as natural gas. Nevertheless, the pegged prices of an energy sector dominated by natural gas are illusive, as both the political risks and environmental damage have not been incorporated into the current cost calculations. This paper evaluates energy policies through a lens of risk management and takes an alternative approach to calculating energy costs by factoring in political risks. This formulation reveals that the cost of traditional fossil-based energy is in fact more expensive than renewable energy. In addition to being environmentally friendly, the paradigm shift towards renewable energy policies would provide Turkey with a significant opportunity to stimulate its economy by being one of the first countries to develop green technologies and as a result this burgeoning sector would prompt job creation as well; mainly due to the externalities.

The country which succeeds at grading the prices of renewable energy with that of fossil based resources and harnesses the power of clean, renewable energy will be the super power of the future. Barack Obama, February 2009

1. Introduction

The European Union (EU) – to which Turkey has pledged to become a member – aims to increase renewable energy consumption to 20% in 2020. For geographical reasons, even though Germany is far less able to harness solar energy than Turkey, the former has been taking significant steps to develop its solar energy capabilities. Generation of electricity from non-traditional renewable sources such as solar and wind is not financially competitive with traditional means in the current prevailing market conditions without subsidies. Hence, governments have resorted to supporting enterprises for renewable energy development. For instance, Greece has been granting subsidies from 26 to 50 Euro cents/kW h for renewable energy development with guarantees of purchase, Bulgaria from 38 to 39 Euro cents/kW h, and Italy from 36 to 49 Euro cents/kW h (DEK-TMK). In comparison to these subsidies, the renewable energy bill proposed to the Turkish Parliament in November of 2010 is far too modest, from 5.5 to 10 Euro cents/kW h (Dunya Bulteni). In contrast to this meager subsidy, Turkey should set objectives that would ultimately lead to the capability for independent energy production, promote the development of local energy sources, and save 50 billion dollars spent on imported energy. However, Turkish policy-makers' conservative approach to energy has not allowed for such a shift in energy policies.

According to Thomas Kuhn's well-known conceptualization, a paradigm is a coherent pattern of research designed around commonly held theoretical propositions and models, and a paradigm shift is the emergence of an alternative framework of common and shared analysis. As a philosopher of science, Kuhn (1962, p. 10) stressed the development of science and intellectual ideas; nevertheless, a paradigm is a sufficiently open-ended concept "to leave all sorts of problems for the redefined group of practitioners to resolve". Thus, paradigm shifts can occur in policy as well. Several significant events such as environmental degradation due to climate change can lead to

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changes in the existing mind-set of policy-makers and eventually pave the way for new policy objectives and means. In order for the materialization of this paradigm shift in policy to occur, a change of ideas is essential.

This paper's main objective is to contribute to a growing body of academic literature concerning shifts in prevalent ideas on energy and environmental policies (Eriş, 2002; Helm, 2007) to achieve sustainable energy/development (Tester et al., 2005; Podobnik, 2006; Elliott, 2007), thereby, fostering a paradigm shift towards sustainable policies with a special reference to Turkey's hydro-carbon based energy infrastructure. Utilizing risk-management as a means to take into account political risks, this paper ultimately aims to propose a formula that will reveal that the cost of the traditional fossil energy is indeed higher than the costs associated with renewable energy.

The first part of the paper will make a conceptual analysis of energy sustainability by applying Richard Duncan's 'Olduvai Theory'. Against this theoretical backdrop, the paper will go on to argue that since traditional energy policies prioritizing fossil fuels are not sustainable, policies should be adopted that emphasize renewable energy resources to make this transition. This will be elaborated upon with figures and data on energy projections. The second section will examine the state of renewable energy in Turkey and provide detailed information on the local potential for renewable energy sources. The third section will propose a political risk-inclusive approach for the adoption of sustainable energy policies in Turkey. Adding up political risks to the classic cost equation, we have tried to corrupt the orthodox cheap/un-risky fossil energy understanding. According to our proposition, sustainable energy policies would not only produce environmentally friendly and politically risk-free outcomes, but also stimulate the Turkish economy. Ultimately, renewable energy and related technologies will shape the future of the world and Turkey should shift its energy paradigm to secure its place among the first green economies.

2. Sustainability in energy and the effect of renewable energy on sustainability

Undoubtedly, developing and implementing sustainable energy policies are among the major problems facing humanity in the 21st century. The use of sustainable energy not only entails providing sufficient energy for present and future energy needs, but also protecting the environment and the integrity of ecosystems. In addition, it provides measures to avoid security threats and potential geopolitical conflicts that might occur from increasing competition for the improperly scheduled distribution of energy resources (IAC, 2008).

Many developed and developing countries in the world are energy importers and these countries are searching for new ways to develop and implement new sustainable energy policies and strategies. Four main issues should be considered in detail in order to create sustainability in energy production and consumption:

i. Making new investments in order to respond to increasing demand and enhancing the infrastructure.
ii. Rehabilitating current resources, and efficient usage of such resources.
iii. Developing new/alternative energy technologies at competitive prices.
iv. In terms of energy supply, not being dependent on a single source, region, or country.

If these four points are taken as one integrated issue, the necessity of renewable energy becomes apparent. Renewable energy resources, such as those obtained from sunlight, wind, water (hydropower), biologic processes and geothermal resources are most commonly defined as sources which are able to replenish themselves at the same rate or more quickly than the energy they consume. For example, a car utilizing solar energy consumes this energy but the energy that it consumes is trivial in comparison to the amount of solar power available. In this way, renewable energy cannot be depleted. In contrast, fossil-based resources are theoretically renewable in the long term but are prone to depletion in the short and medium terms. On average, dependence on fossil resources is around 85% and nuclear-based energy is 6%. Renewable resources comprise a mere 8% of total energy consumption. Fig. 1 demonstrates the average proportions of energy resources today (while these proportions fluctuate from year to year, they hover around an average). It is estimated that 50% of fossil energy resources are used in electricity production.

According to the 'Olduvai Theory' coined by Richard Duncan, the current dependence on fossil resources is not sustainable. After 1930, which is considered as the beginning of the oil based industrialization, energy consumption per capita ($\hat{e}$) reached its peak in 1979 and started to decrease as of this date. If this process continues in this manner, the world will experience black outs as of 2012 and in 2030 the amount of energy consumed per capita will decrease to the same levels as it was in the 1930s (Duncan, 2001). The Olduvai Theory makes this prediction in Fig. 2.

Although the Olduvai theory has been seen as being excessively utopian, nonetheless it reminds us that the current traditional energy policies are not sustainable and that renewable energy resources should play a key role in the process of transitioning to a sustainable system for energy production and consumption. Indeed developing renewable energy technologies might well result in significant benefits due to the worldwide availability of these resources (Fig. 2).

Developing renewable energy resources is desirable for the following reasons:

i. They have numerous benefits for the environment and public health (most have nearly zero carbon emissions and produce minimal waste).
ii. They contribute to the supply and security of energy (i.e., decreasing fluctuation in prices and less dependency on imported resources, as well as the availability of a diversity of resources).

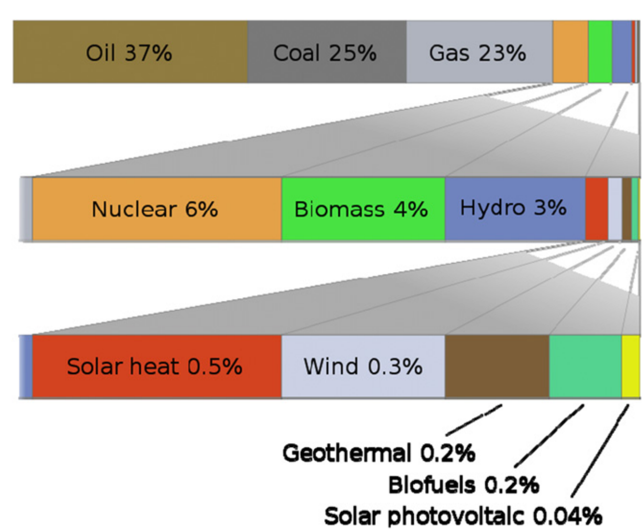

Fig. 1. Energy usage per resources.
Source: (Wikipedia).

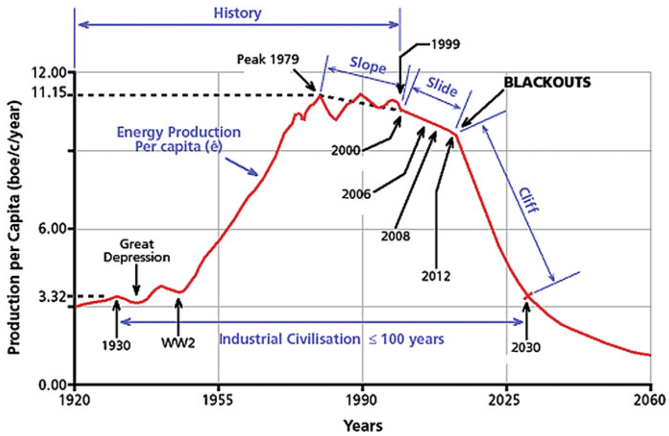

Fig. 2. 1930–2030 projection of Olduvai Theory.
Source: (Duncan, 2001, p. 18).

Table 1
Global increase scenario in renewable energy (2004–2030).
Source: IEA (2007, p. 1).

	2004	2030	Approximate increase (times)
Electricity generation (TW h)	3179	7775	> 2
Hydropower	2810	4903	< 2
Biomas	227	983	> 4
Wind	82	1440	18
Solar	4	238	60
Geothermal	56	185	> 3
Tide and wave	< 1	25	46
Biofuels (Mtoe)	15	147	10
Industry and Buildings (Mtoe)[a]	272	539	2
Commercial biomass	261	450	< 2
Solar heat	6.6	64	10
Geothermal heat	4.4	25	6

[a]Excluding traditional biomass.

iii. They contribute to economic and social development (access to service in rural areas, and an increase in employment opportunities due to new technologies).

While dependence and investments on fossil energy does continue, in some areas of the world plans are being made for the implementation of green technologies and renewable energy. According to optimist scenarios regarding renewable energy resources put forward by the International Energy Agency (IEA), it is estimated that dependence on these resources will increase by 75%. To which fields should one primarily invest in regarding renewable energy resources? Which renewable energy resources are going to make more progress? Table 1 demonstrates the projections of IEA concerning these questions. According to this projection, the share of solar, wave, tidal stream and wind energy will increase in the given order.

Besides its positive aspects, renewable energy resources might also have some disadvantages, similar to other energy resources. Most of these weaknesses stem from the following facts: the resource for the energy is scattered in different regions, the intensity of the power is low and interruption is likely. Some renewable energy investments – such as hydropower plants (HPP) – require a large water basin, which may have negative effects, such as altering the climate and endangering endemic species. This situation brings along the concern that some renewable energy investments might have negative effects on the ecosystem. However, most of the time, the negative aspects associated with renewable energy can be eliminated via precautions such as proper implementation, technologic modifications, and local adaptation (for example, many small-scale HPPs could be constructed instead of one large HPP) (IAC, 2008, p. 91).

Despite the drawbacks, the development of renewable energy resources plays a very important role in the foundation of a sustainable energy strategy. Renewable energy resources are the ultimate remedy to polluting and non-renewable fossil fuels, dependence on imported energy resources, increasing import costs and climate change. Once the technical and economic problems are solved, renewable energy resources will become among the top primary energy sources and a crucial step will be taken in the transition to a sustainable system of energy.

Lastly, but still importantly, is the effect of renewable energy on the real sector, i.e., the economic potential that it may create. Investment in renewable energy will require new areas of business to flourish in many sectors. Fig. 3 demonstrates which businesses may benefit from investments in renewable energy including hydrogen, wind, solar, geothermal, biomass, and biofuel (Fig. 4).

Currently, it is estimated that 2.3 million people worldwide work either directly in renewables or indirectly in supplier industries. Given the incomplete data, this is in all likelihood a conservative figure. The wind power industry employs some 300,000 people, the solar photovoltaic (PV) sector accounts for an estimated 170,000 jobs and the solar thermal industry at least 624,000. More than 1 million people are likely employed in the biomass and biofuel sector. Small-scale hydropower and geothermal energy are much smaller employers. A study commissioned by the German government found that in 2006 the country had some 259,000 direct and indirect jobs in the renewables sector. It is expected that the number will reach 500,000 by 2020 and then 710,000 by 2030 (Worldwatch). This corresponds to an increase of 48% from 2006 to 2020 and 30% to 2030. These figures clearly demonstrate that a shift from a fossil-based economy to a

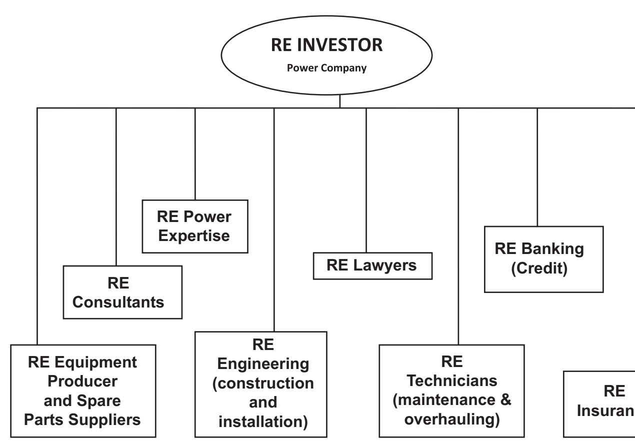

Fig. 3. Expanding sectors and jobs in renewable energy (prepared by authors).

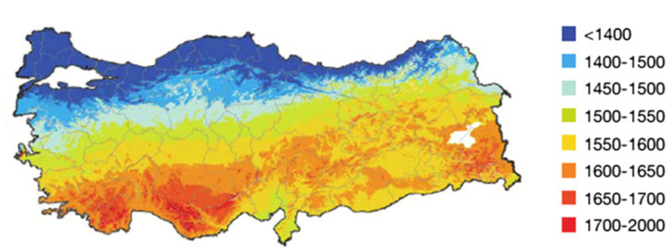

Fig. 4. Annual solar radiation in Turkey (kW h/m^2 per year).
Source: (PWC, 2009, p. 17).

renewable one will not only stimulate the economy, but also create employment. In this context, in the case of a paradigm shift towards sustainable energy policies, the Turkish economy would likely flourish with the abundant renewable energy resources available.

3. The state of renewable energy in Turkey

According to estimations provided by the Ministry of Energy and Natural Resources, it is highly likely that an energy crisis will occur in the future, in parallel with the demands of an increasing population, urbanization, and industrialization. If the necessary investments in local and renewable energy resources are not made, the supply-demand trajectory of energy will track a negative path and Turkey will have to import 80% of its energy (Enerjide Dış Bağımlılık 2020'de yüzde 80 olacak, 2005). For these reasons, the development of every kind of local energy resource – especially green resources such as solar, wind, geothermal, biomass, and hydraulic – is very important.

3.1. Solar and photovoltaic energy

In theory, the solar energy produced in the world in one year is equal to 15–20 times the equivalent of non-renewable fossil resources (Gürsoy, 2004, p. 22). Solar energy is not among the main energy resources of the world today, but it will definitely be the most common energy source of the future. Apart from the negative effects on the environment, which might occur during the production of equipment used in operational technology, solar energy has no negative effects on the environment. It is possible to use solar energy in heating, and it is also possible to obtain solar electricity indirectly and photovoltaic electricity directly from solar heat. There are three main modes of solar energy use:

- As thermal energy or heat collected passively or actively for space conditioning in buildings.
- As thermal energy that is collected and converted to electricity in solar concentrators.
- By the direct conversion of solar energy to electricity using photovoltaic devices (quoted from Tester et al., 2005, p. 544).

Although Turkey is geographically well positioned on the rich Mediterranean Sun Belt, which has an abundance of sunlight, it is not effectively using this valuable resource. There is a huge potential for solar power to be developed in Turkey. Turkey is among the world's pioneering solar energy users with 7.5 million square meters of solar collectors which are primarily used for household hot water. In addition to these, the usage of photovoltaic (PV) batteries is increasing with the implementation of volume heating, also known as solar architecture (Eriş, 2002, p. 162).

According to the data obtained from the General Directorate of Electrical Power Resources Survey and Development Administration (EIEI), Turkey, whose solar energy potential is quite high because of its geographical position, has an average annual sunshine duration of 2640 h (7.2 h per diem) and an average radiance of 1.311 kW h/m^2 per year (3.6 kW h/m^2 per diem). Turkey's annual solar energy potential is around 380 billion kW h (EİE). The monthly average solar potential and sunshine duration values in Turkey are indicated in Table 2. As stated in the table, solar energy potentials and durations vary periodically and the months from May to August are higher than the other months. Among all these given regions, the south-eastern Anatolian region has the highest amount of solar energy, followed by the Mediterranean Region (EİE).

Table 2
Monthly average solar potential of Turkey.
Source: EİE.

Months	Monthly total solar energy (kcal/cm^2 month)	(kW h/m^2 month)	Sunshine duration (h /month)
January	4.45	51.75	103.0
February	5.44	63.27	115.0
March	8.31	96.65	165.0
April	10.51	122.23	197.0
May	13.23	153.86	273.0
June	14.51	168.75	325.0
July	15.08	175.38	365.0
August	13.62	158.40	343.0
September	10.60	123.28	280.0
October	7.73	89.90	214.0
November	5.23	60.82	157.0
December	4.03	46.87	103.0
Total	112.74	1311	2640
Average	308.0 cal/cm^2 day	3.6 kW h/m^2 day	7.2 h/day

The electricity produced from solar energy is still less than 1% of national energy production in Turkey. According to the calculations of the Ministry of Energy and Natural Resources and EIE, solar energy is not used for the production of electricity but in 2010, 602 ktoe[1] and in 2020 1119 ktoe energy will be produced (TOBB).

The R&D studies conducted for the purpose of increasing the usage of solar energy in Turkey focused on photovoltaic batteries. In this context, it is necessary to mention the significant commercial potential of photovoltaic batteries. Several institutions such as EIEI and The Scientific and Technological Research Council of Turkey (TUBITAK) are conducting various studies concentrating on FP batteries and photochemical energy (TOBB).

3.2. Wind

Power systems based on wind, wave, and tidal streams, together with solar energy, are other alternative energy resources which aim to create cleaner energy systems. They have relatively low costs compared to large power plants that require basic electricity infrastructure and transmission-line network investments to transmit power, and in addition their operation time is relatively faster. Furthermore, it is possible to integrate these systems, especially wind energy grids generated by either large wind turbines or wind machines with other energy systems. With the latest technologic developments achieved in the field, it is possible to link wind generators' mechanical energies into the system of hydraulic reserve energy in a single center (Turkrd). Moreover, as with other solar-electric technologies, technological developments in storage such as air energy storage (CAES), superconducting magnets, supercapacitors, advanced batteries, and flywheels will likely to expand the market penetration of wind turbine generators (Tester et al., 2005).

The average annual wind speed on 27% of the world's surface is more than 5.1 m/s. Given that 3–5 m/s wind feasibility is a reasonable level, it might be preferable to use the potential of wind energy in a vast majority of the world. Given that the growth of the wind energy market will bring a drastic decrease in costs, it will also be a reasonable estimation that the consumption of wind energy might increase significantly in the case that the

[1] 1 ktoe = 10000000000 kcal.

necessary arrangements are secured to attract investors in the years to come.

Apart from the required amendments in the energy sector regulations, there are no technical, economic or resource barriers to supply 12% of the world's electricity needs with wind power alone by 2020 (EWEA). According to the scenario foreseen by Wind Force 12, a feasibility report written by Greenpeace (2005) and European Wind Energy Association (EWEA) for a project aimed at having 12% of electricity produced from wind energy, it is possible to:

i. Generate 1200 GW via wind power.
ii. Provide employment opportunities for 2 million people.
iii. Save the world from 10,700,000,000 t of CO_2 emissions.

Within the scope of the Mediterranean Energy Campaign, Greenpeace referred to the wind energy opportunities that Turkey has failed to capitalize on: "Turkey has a very large potential of wind power with its technical potential of 88.000 MW, and this potential wind energy can easily meet the needs of future energy in Turkey. Besides, it promises more employment opportunities than other energy resources" (Greenpeace). Fig. 5 demonstrates the potential for wind power and the wind power plant licenses granted recently.

According to the data obtained from the European Wind Atlas, Turkey is one of the wealthiest countries among 19 European countries in terms of the potential wind resources, available plant locations, and technical capabilities (Uğurlu, 2009, p. 187); Table 3 demonstrates the geographical potential in detail. The Wind Energy Potential Atlas, which was realized for the first time in 2007, points out that there is a wind energy potential of a minimum of 5000 MW in regions where the annual wind speed is 8.5 m/s and 48,000 MW in regions where annual wind speed is 7.0 m/s. As of the beginning of 2008, the established wind power of Turkey was limited to 354.7 MW. Furthermore, in regions such as the Aegean where wind is strong and steady, the production of electricity could be coupled with tidal energy.

One might list the negative effects which might occur due to the technology and designs used in wind-based energy production systems as follows: visual and esthetic pollution; noise pollution; the fact that it causes bird deaths; and, the way it jams the receivers of radio and television. It is possible to reduce these problems to minimum via technological solutions and proper designs (Varınca, 2005).

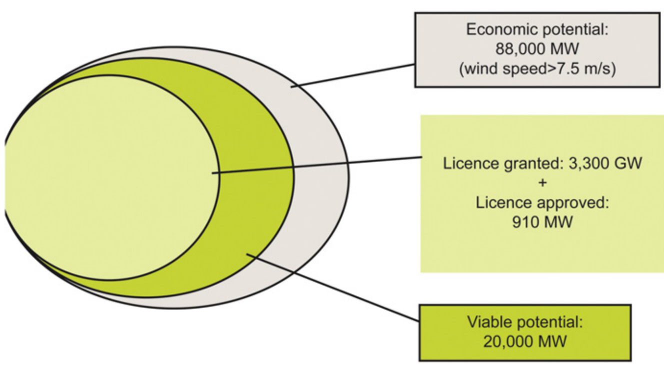

Fig. 5. The potential and utilization of wind power in Turkey.
Source: PWC, 2009, p. 18.

3.3. *Biofuel and biomass energy*

Biofuel is defined as all kinds of fuels at least 80% of whose content (in volume) is obtained from living organisms harvested within the last ten years. It is used in biodiesel, bio-ethanol, biogas, and biomass (Enerji.gov.tr). In 2008, biofuels provided 1.8% of the world's transportation fuel. In 2007, worldwide investments in biofuel production capacities surpassed 4 billion dollars and this number continues to increase daily (UNEP).

The first instances of biomass-biofuel energy were utilized in England in the 19th century when the gas derived from septic tanks was used in lighting streetlights. Turkey started to attach importance to this alternative source of energy in the 1970s with the efforts of the Institution of Soil and Water Research. Later, the

Table 3
Wind characteristics of some selected cities in Turkey.
Source: Kaygusuz and Sarı (2003, p. 474).

Station	Name latitude N (deg.)	Longitude E (deg.)	Altitude (m) energy density (W/m^2)	Average	Average wind speed (m/s)	
					At 5 m	At 50 m
Akhisar	38.55	27.51	93	44	2.7	4.0
Anamur	36.06	32.50	5	52	3.1	4.3
Antakya	36.12	36.10	100	84	4.0	5.8
Ayvalık	39.19	26.42	4	54	3.1	4.2
Balıkesir	39.38	27.53	147	58	2.8	4.2
Bandırma	40.21	27.58	58	301	5.8	6.9
Bergama	39.01	27.11	45	61	3.5	4.9
Bodrum	37.02	27.26	27	85	3.7	5.1
Bozcaada	39.50	26.04	40	317	6.2	8.4
Çanakkale	40.08	26.24	2	92	3.9	5.4
Çorlu	41.10	27.47	183	103	3.8	5.3
Etimesgut	39.57	32.40	806	49	2.5	3.1
Gökçeada	40.12	25.54	72	70	3.5	5.5
İnebolu	41.59	33.46	64	63	3.7	5.2
Karapınar	37.43	33.33	997	45	2.8	3.9
Malatya	38.21	38.19	898	51	2.7	3.7
Mardin	37.18	40.44	1080	114	4.3	6.0
Samsun	40.21	36.15	44	41	2.7	3.6
Sarıyer	41.10	29.03	56	42	2.9	4.1
Seydişehir	37.25	31.51	1131	45	2.7	3.8
Silifke	36.23	33.56	15	50	2.9	3.9
Sinop	42.02	35.10	32	84	3.6	5.1

General Directorate of Mineral Research and Exploration and several other universities started to conduct research about this subject (Eriş, 2002, p. 165). As concerns about our increasing use of fossil fuels mount, many developed countries are now re-examining the potential for biomass energy to displace some use of fossil fuels. Biomass qualifies as a renewable resource because commercially meaningful quantities are regenerated in time scales that are comparable to or less than typical time scales for human use of the resource (quoted from Tester et al., 2005, p. 420).

As CO_2 and SO_2 emissions are quite low for the production of energy from biomass fuels, they are crucial in the prevention of global warming and acid rain. In addition to biomass's positive contributions to the environment, it is also possible to create self-sufficient energy groups, especially in regions which are distant from other energy sources (Habitatcigenclik). Following the introduction of the technology to produce biomass fuel from herbal, animal, urban, and industrial wastes, biodiesel – an alternative to diesel fuel – has begun to take a leading role among biomass resources. It is also known as biodiesel and/or green diesel. Biomass fuels can also be used by mixing them with fossil fuels in certain proportions (Eriş, 2002, p. 165).

Biodiesel is the most important alternative fuel to diesel, which is used excessively for overland and sea transportation (Karaosmanoğlu, 2008). Adequate and proper infrastructure for biodiesel production is available in Turkey, in particular following the support provided for canola and soybean cultivation. Within the scope of conversation precautions launched in 2006, the south-eastern Anatolian part of Turkey has begun to offer arable lands that are suitable for the cultivation of canola and soybeans. With a rough calculation, one can see that it is possible to produce 1.5 million tons of biodiesel from the above-mentioned crops in the GAP region (Karaosmanoğlu, 2008).

Interest in biodiesel in Turkey has been increasing since 2000 and this fuel has become more and more popular. Within this context, a "Bioenergy Project Group" was established within EİEİ and this special project group drafted scenario alternatives concerning biodiesel production in Turkey in October, 2003, a pilot-level biodiesel production system and a laboratory was established. The Ministry of Energy and Natural Resources and the Ministry of Agriculture and Rural Affairs are also conducting research on this subject. Legal arrangements about biodiesel were made within the scope of the "Fuel Act" dated 2003. In the legal act, it is stated that biodiesel has a privileged tax discount that will be secured for biodiesel fuels. Thereafter, the popularity of vegetable oil and biodiesel energy has begun to increase incrementally in Turkey. Parallel to this growing interest, Turkey has produced approximately 10,000 tones of biodiesel fuel. The Turkish state should encourage investments in this field and biodiesel manufacturers should engage in energy agriculture and/or contractual agriculture by providing the required raw material inputs (Karaosmanoğlu, 2008).

Although biofuels have the potential to be a valuable element of a new energy policy, they also entail risks for biological diversity, environmental security, and food safety unless the required structural amendments for carbon-based energy systems are implemented. Within this context, biofuels might yield positive results in the case that biofuels are used together with other renewable energy resources in a planned and proportioned way (Spangenberg and Settele, 2009).

3.4. Geothermal energy

Geothermal resources are water, vapor, and gases that contain chemicals created by the heat stored in various depths of the earth. Geothermal energy is the energy that we produce directly or indirectly from these resources (jeotermalderneği). Geothermal energy is extracted from the reservoir either by coupled transport processes, such as convective heat transfer in porous and/or fractured regions of rock, and conduction through the rock itself. Following successful implementation of a heat extraction scheme, hot water or steam is normally produced at the surface and converted into a marketable product (e.g. electricity, process heat, or space heat) (Tester et al., 2005, p. 456). The indirect usage of these resources is possible with a system that utilizes water hotter than 150 °C, which is called high-enthalpy, and is used for generating electricity. The most common economically geared use of geothermal energy is direct usage and it is commonly used in greenhouses and heating residences. A loss of efficiency of up to 10–15% is observed in indirect usages (Gürsoy, 2004, p. 133).

Table 4
Present and planned biomass energy production in Turkey (ktoe).
Source: Kaygusuz and Sarı (2003, p. 467).

Years	Classic biomass	Modern biomass	Total
1999	7012	5	7017
2000	6965	17	6982
2005	6494	766	7260
2010	5754	1660	7414
2015	4790	2530	7320
2020	4000	3520	7520
2025	3345	4465	7810
2030	3310	4895	8205
Total	34658	17853	52511

Geothermal energy has many positive aspects: first, it is possible to establish and develop plants as small as 5–10 MW. Second, changes in weather conditions do not affect its production. Third, fluctuations in fossil fuel prices do not affect its production prospects in the long term. Fourth, its carbon emission in closed systems is zero (Eriş, 2002, p. 158). Nevertheless, like all other energy resources, geothermal energy has some negative environmental impacts. The most basic problems are soil pollution, water pollution, and its negative effects on underground resources (Table 4).

The direct consumption of geothermal energy in Turkey is usually used for central heating. Following the establishment of the first plan in 1987, twelve central heating plants have been established and the capacity of these plants is around 300 MW. They heat 60,000 residences. Their direct generation capacity is approximately 800 MW taking into account their consumption in spring resorts and thermal tourism. The total geothermal energy potential of Turkey was about 2268 MW in 1998, but the share of geothermal energy production, both for electrical and thermal uses, is only 1200 MW. There are 26 geothermal district heating systems existing now in Turkey. The main city geothermal district heating systems are in the cities of Gonen, Simav, and Kırsehir (Kaygusuz and Sarı, 2003). The most rapid development in the usage of geothermal energy has been in greenhouse applications. Turkey's indirect consumption of geothermal resources for electricity production is approximately 17.5 MW, from power plants whose installed capacity is 25.9 MW. After the Germecik and Kızıldere geothermal power plants are completed, the installed capacity in 2010 is expected to exceed 455 MW (see Table 5). According to the estimates of General Directorate of Mineral Research and Exploration, the geothermal energy potential of Turkey is approximately 31,500 MW.

The operation of geothermal fields has been neglected until recently. Today, the R&D studies conducted in the field of geothermal energy clearly suggest positive improvements, but these studies should provide strategy developments suitable for Turkey and implementation of new technologies in fields suitable for electricity production.

Table 5
Projections for geothermal power generation in Turkey zone temperature (°C) 2010 forecast (MW e) 2013 forecast (MW e).
Source: PWC, 2009, p. 18.

Denizli–Kızıldere	200–242	75	80
Aydın–Germencik	200–232	100	130
Manisa–Alaşehir–Kavaklıdere	213	10	15
Manisa–Salihli–Göbekli	182	10	15
Çanakkale–Tuzla	174	75	80
Aydın–Salavatlı	171	60	65
Kütahya–Simav	162	30	35
İzmir–Seferihisar	153	30	35
Manisa–Salihli–Caferbey	150	10	20
Aydın–Sultanhisar	145	10	20
Aydın–Yılmazköy	142	10	20
İzmir–Balçova	136	5	
İzmir–Dikili	130	30	30
	Total	**455**	**550**

3.5. Hydro-energy

In most hydropower plants today, energy is converted into electricity as water flows through tribunes which provide the rotational force for an electricity generator. Technologies for carrying out this conversion are highly developed and efficient, with hydropower installations ranging in scale from a few kW e to over 10,000 mW e (quoted from Tester et al., 2005, p. 520). HPPs, or hydroelectric power plants, are preferable over other energy resources as they use water, as they are environmental friendly (this will be discussed in detail, but it is especially true for small-scale hydroelectric power plants) and they carry little risk. HPPs are adaptable, clean, renewable, highly efficient, long-living, independent local resources, which do not have any fuel expenses. Also, they often serve to bolster energy prices and their costs are relatively low. The technical potential of hydroelectric power in Turkey is 36,000 MW. Currently, 150 operating HPPs have an installed capacity of 13.830 MW, representing only 38% of the total potential. In 2008, hydroelectric power plants provided 17% of Turkey's electricity production. Recent droughts, however, have negatively impacted the expected contribution from hydroelectric power plants (Enerji.gov.tr).

There are serious concerns about the usage of large-scale HPPs not only because of their building process but also because of the negative environmental aspects of their reservoirs. In the case of properly designed projects with environmentally friendly equipment, environmental damage can be minimized (Global Enerji). However, the Turkish government has licensed many large-scale HPP projects in the Eastern Black Sea Region that will likely have detrimental effects on endemic life forms, and for that reason objections have been raised about their construction (Bianet).

In order to avoid these negative aspects of large-scale HPPs, it has been suggested that small-scale HPPs, which have an installed capacity of 1 MW, be constructed. Small-scale HPPs do not require dams that produce electricity with large waterfalls, as they can work as turbines established on small-scale rivers (Gürsoy, 2004). In addition to this, as they do not have large-scale dam reservoirs, small-scale HPPs do not cause climate changes based on evaporation, and cities and agricultural lands are not submerged, eliminating the need for resettlement of local populations (Uğurlu, 2009).

In addition to being environmental friendly, compared to large HPPs small-scale HPPs do not require extensive planning and construction nor do they require large-scale investments. They can thus either be established with smaller amounts of financial sources supplied by the state or by private enterprises. Small-scale HPPs would both contribute to the hydroelectric energy power potential of the country and provide employment opportunities locally (Gürsoy, 2004, p. 135).

Small-scale HPPs comprises only 1% of Turkey's hydraulic energy capacity and many of them have a capacity below 10 MW. As of 2010, the construction of 4 establishments continues and 37 new establishments are being planned. The Turkish Electricity Transmission Company (TEİAŞ) and Public Waterworks Administration (DSİ) foresee that the installed capacity of small-scale HPPs, which was 143 MW in 2000, will reach 418 MW in 2010 and 750 MW in 2020 (Uğurlu, 2009, p. 201–202).

After the foundation of the Energy Market Regulatory Authority as per Law no. 4628, energy production, transmission, and monitoring in Turkey have new regulations. Although new frontiers for private sector were opened in this particular field, the desired progress in implementation has to date failed to materialize. The reason for this is that the policies and strategies peculiar to renewable energy have not been taken seriously.

3.6. Hydrogen energy

Hydrogen energy fuels the heat emitted by Sun and other stars, causing a thermonuclear reaction, which is the main energy source of the universe. Among all fuels known to man, hydrogen has the highest energy content per unit mass (the upper heating value is 140.9 MJ/kg and the lower heating value is 120.7 MJ/kg). 1 kg of hydrogen contains the same amount of energy as 2.1 kg of natural gas or 2.8 kg of petroleum. However, its volume per unit energy is high (Enerji.gov.tr), which increases the costs of storage and transfer.

A transmitter of energy, hydrogen can be produced by breaking down water or organic elements rich in hydrogen. The energy in hydrogen is re-transformed through processes of chemical or electrochemical burning. As the only waste produced in this process is water, it has been recommended as an alternative that, together with other green resources, would help reduce pollution and global warming. There is an increased need for R&D studies to find solutions for technical problems concerning the production, storage and usage of hydrogen (Satman and Arısoy, 2007).

Research has demonstrated that hydrogen is presently three times more expensive than other fuels, and that the common use of hydrogen as a source of energy will depend on technological advances that can reduce the cost of hydrogen production. On the other hand, it could still be a viable alternative, under present conditions, to store excess electricity generated over daily or seasonal periods as hydrogen. The use of such stored energy for mass transportation purposes will depend on advances in fuel-cell automobile technologies (enerji.gov.tr).

Presently, an annual amount of 50 million tons of hydrogen is produced, stored, transported and used around the world. The highest number of users is to be found in the chemical industry, particularly in the petrochemical industry. The amount of hydrogen used annually across sectors is illustrated in Table 6.

Table 6
Amounts of hydrogen used annually across sectors around the world.
Source: (Enerji.gov.tr).

Sector	Annual amount used (m^3)
Artificial fertilizer industry	25.000
Vegetable oil (margarine) production	16.000
Refineries	1.200
Petrochemical industry	30.000
Hydrogenated animal fat production	200–300
Gas or liquid hydrogen production	6.000

4. The future of renewable energy in Turkey: a political risk-inclusive cost analysis

The report "The World Energy Outlook" published by the International Energy Agency (IEA) in 2009 stated that administrations in power as of 2010 should fully support the issues regarding renewable energy resources and that by 2030, the share of renewable energy resources used in the total production of energy is expected to be 25% (World Energy Outlook, 2009).

As soon as he took over at the White House, Barack Obama provided a stimulus package of 80 billion dollars for the renewable energy sector and introduced 30% tax discounts, which verifies the IEA's estimations. The US administration sees this stimulation in renewable energy sector not only as a part of their energy strategies but also as an opportunity to overcome the negative effects of the global financial crisis and, more importantly, to revive the nation's economy.

The European Union's (EU) approach to renewable energy shows parallel characteristics. EU member countries see renewable energy investments as an opportunity to reduce their dependence on imported energy and as a source of employment. In the report, The impact of renewable energy policy on economic growth and employment (2009) published by the EU, the 2020 targets were put forward. According to this report, the proportion of renewable energy resources among other energy resources will be 20% in 2020. Therefore, an increase of 0.24% will be marked in the revenue of EU member countries and an additional 410.000 employment opportunities will be created (eu.europa).

Britain's Prime Minister, Gordon Brown, stated that they would prepare green budgets in order to revive the economy, which has been in a recession. The British government, which aims to make Britain a leader in the manufacture and exportation hybrid cars, also hopes to produce 15% of the energy consumed in the country from renewable energy resources. China is also rapidly catching up in the manufacture of solar PVs and wind turbines and is already the dominant force in solar hot water production and small hydropower development.

All of the above-mentioned and other similar developments are indicative of how developed and developing countries have been taking this issue seriously. Turkey, in fact, is not lagging behind in the usage of renewable energy. Fig. 6 shows the position of Turkey as regards the EU and the USA, which are both highly dependent on fossil and nuclear energy. This advantageous position is mostly due to the hydroelectric power plants located in Turkey, which provide a large amount of electricity production.

The Electricity Market Strategy Paper (EMSP) dated 2009 revised the current share of renewables at 20% and aims for that figure to be (including hydro) 30% for total electricity generation by 2023. The plan for wind power is to increase the existing capacity, at 350–450 MW, to approximately 20 GW over the next 13 years, which seems an ambitious figure (enerji.gov.tr). Turkey, which missed the earlier era of industrialization, can compensate for those years by actively pursuing the necessary policies required for this upcoming green industrial revolution.

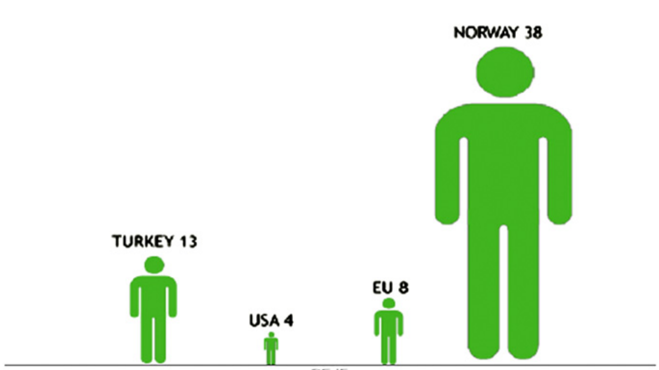

Fig. 6. The proportion of renewable energy in terms of total energy resources (%). *Source*: IEA, 2007. Chart prepared by the authors based on the given statistics.

In order to increase the consumption percentage of renewable energy in Turkey, the following precautions might be effective:

i. Immediate: legal amendments that compensate for pricing distortions and encourage sales and purchase of renewable energy as well as investment in the field.
ii. Mid-term: sectoral institutional re-organization which would enable the implementation of aggressive long-term renewable energy policies.
iii. Long-term: introduction of renewable energy training and capacity building programs in order to create a new energy paradigm.

First of all, a new law on renewables is anticipated, a promotional law that positions renewable energy sector as an important instrument for the overall development policies. Within the scope of such a law, it would be necessary to create budgetary sources for research and development aimed at cost-reducing technologies in the field of renewables. For example, corporations who choose to invest in renewable energy might receive some incentives per kW h according to the type of resource used. Additionally, if they use local technology and equipment, they may receive extra tax benefits, or instead if they prefer to use imported equipment they could enjoy zero tariffs. Parallel to these steps, amendments in the administrative structure of the Ministry of Energy and Natural Resources, EİE, and EPDK in order to facilitate dissemination of renewable energy technologies should be considered. Within this context, the "Balancing and Settlement Regulation" (DUY) needs to be altered so that producers of electricity that use renewable resources should be considered as "concessionaire" and steps should be taken to ensure that they can compete with low-cost natural gas power plants and large-scale HPPs. The renewable energy units formed within the related organizations should closely monitor all concessions and incentives under this scheme. Moreover, the State Planning Organization should re-arrange the five-year development plans attaching more importance to this subject.

According to the estimates of the Ministry of Energy and National Resources, electricity consumption, which is 200 billion kW/h at the moment, will reach 500 billion kW/h by 2023 (enerji.gov.tr). Natural gas has shown the greatest increase among the primary sources of electricity production in Turkey since the 1990s. There are mainly two reasons for this boost: first, it is possible to build and operate gas-transforming power plants in a short period. Second, building and operating natural gas plants are cheaper than the other types of power plants. For example, the time required to construct and operate a large-scale HPP is approximately 5 years, plus the heavy costs of expropriation and re-housing. For this reason, the usage of natural gas has increased rapidly. Moreover, natural gas power plants can immediately respond to urgent needs. According to BOTAŞ's 2008 Natural Gas Report, Turkey uses 50% of imported natural gas to produce electricity. According to the same report, 63% of the natural gas is imported from Russia (Botaş). To understand Turkey's current energy policy, which simply works by responding to the growing need of energy via imported natural gas, one does not have to be an expert to foresee that the use of natural gas in electricity production will increase. The policies that the current Turkish administration, in cooperation

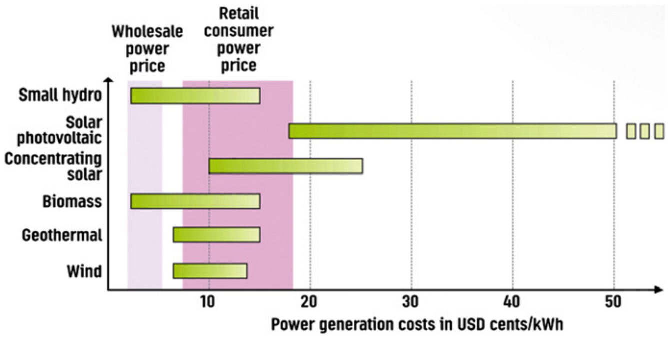

Fig. 7. Cost-competitiveness of selected renewable energy resources (RES). *Source*: International Energy Agency, Renewables in Global Energy Supply, OECD-IEA, January 2007, p. 6.

with the countries of the region, is demonstrate that the plan is to transform the country into an east-west and north-south natural gas/petroleum pipeline transit corridor. This position is expected to create advantages for foreign policy by increasing Europe's and neighboring countries' dependency on Turkey. This approach to foreign/energy policy will definitely make life difficult for renewable technologies. Extra investments for natural gas and nuclear energy and its technologies are a push away from renewable energy technologies. Nevertheless, this is not the only reason why Turkey has been so slow to take action to develop renewable energy resources. On the other hand, in the international arena, the dependence on fossil energy resources continues and Turkey has pursued those policies which best conform to this global trend. Investments in renewable energy technologies are thought to be utopian and a waste of limited sources, for some authorities.

The real question arising at this point is the cost competitiveness of renewable energy compared to fossil energy resources. Fig. 7 shows that due to the high costs of renewables, competing with fossil-based wholesale energy prices is quite difficult. The only close competitors for the time being are HPPs and biomass technologies. It is obvious that the more the cost of renewable resources decrease the more interest it will receive from investors and consumers. Subsidies – either directly through pricing (and relative pricing) or in the form of distorted taxes and fees – affect fuel and technology choices and the quantities of total energy demand (Stephen).

The incentive/subsidy schemes may enable higher and differentiated tariffs for RES certificate holders for the operation of power plants. However, subsidies are not enough to solve the cost-related problems of renewable technologies. Hydroelectric power plants and wind power plants have solved this issue more or less, but to date, solar energy is not competitive price-wise. For example, today for a wind power plant a financial source of 1–1.5 million Euro is sufficient for a 1 MW investment, while a solar power plant of the same capacity requires Euro 6 million.

It is clear that this unfair competition needs to be resolved and the only way of solving the problem is to introduce and adapt a completely different cost paradigm. This new paradigm should consider the risks attached to the current fuel-based costs. In the formulations used here, renewable energy is depicted as (RE); non-renewable energy (NRE); and finally electricity is (*I*).[2] The equation below demonstrates such risk-based approach to calculating the cost of electricity (cI)

$$\mathrm{cI} = \frac{\mathrm{cNRE} + \mathrm{cpI} + \mathrm{ctI} + \mathrm{rsNRE}}{\mathrm{TqI}}$$

In this equation, the real cost of electricity is equal to the cost of fossil-based energy (cRNE) plus the production cost of electricity (cpI) (excluding HPPs) and the cost of transmission (ctI), plus the supply risk of non-renewable energy (rsNRE) divided by the total electricity produced. cNRE, cpI, and ctI can be fixed as a value but rsNRE cannot be (it is difficult to calculate the supply risks for non-renewable energy). As NRE is not produced in Turkey (but rather is imported from neighboring states), Turkey is dependent on foreign sources of supply. The risks attached to the supply of RNE might arise from the producing country as well as the countries that the pipelines pass through before reaching Turkey.

One can also embed into the above equation the exchange rate risks or foreign currency crisis risks that might arise due to inefficient monetary policies. Environmental risk may also be considered as an additional item. When we attempt to convert such risks into real values, the average cost of the electricity that we use may jump to somewhere between 20 and 40 cents/kW h. From a risk management point of view, it is easy to conclude that the cost of electricity we use at the moment is not that cheap and it would not be an exaggeration to say that we mislead ourselves about the current cost of electricity.

5. Conclusion

In Turkey, it is not a common approach to make estimations and offer strategies for a given field or sector for 2030 or even 2050. For this particular reason, highlighting the importance of sustainable energy and renewable energy technologies are deemed utopian and often not taken seriously. But who would have guessed that the Turkish population, which was 13 million in 1927, would reach 72 million in such a short time and that electricity consumption per capita in Turkey would increase 838 times from 1923 to 2008. Many of the problems we face in Turkey today are based on a lack of belief about the impacts of current actions on the future.

Today, even the most basic discussions reveal the vital importance of renewable energy for the future of the world. This paper indicates that renewable energy and technologies will shape the future of the world (both politically and financially). For this reason, Turkey must conduct the necessary research and development studies, implement sectoral and institutional reforms and complete the relevant legal framework before it is too late. The cost of electricity should be re-considered with the aforementioned political and financial risks attached to it. Renewable energy production costs must be pulled down to competitive levels with a series of marketing measures which may include the creation of a green budgetary fund (fed with modest taxes on fossil fuels) commissioned to subsidize renewable energy projects. In addition, green long-term credit schemes specifically aimed at renewable energy industries seems to be a good solution to help this sector flourish.

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