CLEAN AND RENEWABLE ENERGY SITUATION AND FUTURE SUGGESTIONS IN TURKEY

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ABSTRACT

In the world, energy is an essential factor to achieve sustainable development. So, countries striving to this end are seeking to reassess their energy systems with a view toward planning energy programs and strategies in line with sustainable development goals and objectives. The main aim of the energy policies is to meet the energy needs of increasing population and growing economy in a continuous, qualified and secure manner through primarily private sector investments in a competitive and transparent free market environment. In this context, it is the main target to supply the required energy timely, uninterrupted and at minimum costs while making energy supply planning. Energy access for all will require making available basic and affordable energy services using a range of energy resources and innovative conversion technologies while minimizing greenhouse gasses (GHG) emissions, adverse effects on human health, and other local and regional environmental impacts in the country. To accomplish this would require governments, the global energy industry and society as a whole to collaborate on an unprecedented scale. Much of the world's energy, however, is currently produced and consumed in ways that could not be sustained if technology were to remain constant and if overall quantities were to increase substantially. The need to control atmospheric emissions of greenhouse and other gases and substances will increasingly need to be based on efficiency in energy production, transmission, distribution and consumption in the country. On the other hand, electricity supply infrastructures in many developing countries are being rapidly expanded as policymakers and investors around the world increasingly recognize electricity's pivotal role in improving living standards and sustaining economic growth. It is presented and discussed clean and sustainable energy policy in Turkey.

Keywords: Renewable energy, energy demand, energy supply, hydropower, Turkey.

1. Introduction

Global energy consumption in the last half century has rapidly increased and is expected to continue to grow over the future. The past increase was stimulated by relatively "cheap" fossil fuels and increased rates of industrialization in North America, Europe and Japan; yet while energy consumption in these countries continues to increase, additional factors make the picture for the next five decades years more complex. These additional complicating factors include China and India's rapid increase in energy use as they represent about a third of the world's population; the expected depletion of oil resources in the near future; and, the effect of human activities on global climate change. On the positive side, the renewable energy technologies of wind, biofuels, solar thermal and photovoltaics are finally showing maturity and the ultimate promise of cost competitiveness (Yuksel and Kaygusuz, 2011; IEA, 2006; IEA, 2007; IEA, 2008; Goswami, 2007).

The total primary energy demand in the world increased from 7 223 Million tons of oil equivalent (Mtoe) in 1980 to 11 730 Mtoe in 2006 (Table 1), representing an average annual increase of 2%. However, it is important to note that the average worldwide growth from 2001 to 2006 was

4.1% with the increase from 2004 to 2008 being 4.3%. The rate of growth is rising mainly due to the very rapid growth in Pacific Asia, which recorded an average increase from 2001 to 2006 of 8.6% (IEA, 2008).

Table 1: World primary energy demand by fuel in the Reference Scenario (Mtoe).

	1980	2000	2006	2015	2030
Coal	1 788	2 295	3 053	4 023	4 908
Oil	3 107	3 649	4 029	4 525	5 109
Gas	1 235	2 088	2 407	2 903	3 670
Nuclear	186	675	728	817	901
Hydropower	148	225	261	321	414
Biomass and waste	748	1 045	1 186	1 375	1 662
Other renewables	12	55	66	158	350
Total	7 223	10 034	11 730	14 121	17 014

More specifically, China increased its primary energy consumption by 35% from 2000 to 2006 (IEA, 2008). Unconfirmed data show similar increases continuing in China, followed by increases in India. Fuelled by high increases in China and India, worldwide energy consumption may continue to increase at rates between 3-5% for at least a few more years. However, such high rates of increase cannot continue for too long. Even at a 2% increase per year, the primary energy demand of 11 730 Mtoe in 2006 would double by 2050 and triple by 2070. With such high energy demand expected 50 years from now, it is important to look at all of the available strategies to fulfil the future demand, especially for electricity and transportation (Yuksel and Kaygusuz, 2001; IEA, 2008; Goswami, 2007; IEA, 2008).

2. Renewable energy sources and future aspect in Turkey

Renewable energy supply in Turkey is dominated by hydropower and biomass, but environmental and scarcity-of-supply concerns have led to a decline in biomass use, mainly for residential heating. Total renewable energy supply declined from 1990 to 2004, due to a decrease in biomass supply. As a result, the composition of renewable energy supply has changed and wind power is beginning to claim market share. As a contributor of air pollution and deforestation, the share of biomass in the renewable energy share is expected to decrease with the expansion of other renewable energy sources. Table 2 shows renewable energy production in Turkey (MEF, 2007; IEA, 2005; MENR, 2009).

Total gross hydropower potential and total energy production capacity of Turkey are nearly 50 GW and 112 TWh/yr, respectively and about 30 % of the total gross potential may be economically exploitable. At present, only about 35 % of the total hydroelectric power potential is in operation (DSI, 2008). The national development plan aims to harvest all of the hydroelectric potential by 2010. The contribution of small hydroelectric plants to total electricity generation is estimated to be 5-10 % Yuksel and Kaygusuz, 2011; Yuksek *et al*., 2006; Kaygusuz and Kaygusuz, 2002).

Among the renewable energy sources, biomass is important because its share of total energy consumption is still high in Turkey. Since 1980, the contribution of the biomass resources in the total energy consumption dropped from 20 to 8 % in 2005 (DPT, 2001). Biomass in the forms of fuel wood and animal wastes is the main fuel for heating and cooking in many urban and rural areas. The total recoverable bioenergy potential is estimated to be about 35.4 mtoe in 2003 (Balat, 2005; Kaygusuz and Turker, 2002).

Biogas systems are considered to be strong alternatives to the traditional space heating systems (stoves) in rural Turkey (MEF, 2007). The economics of biogas systems are compared with traditional heating systems fuelled by wood, coal and wood mixture, and dried animal waste in three different climatic regions in the country. The technical data used in the analysis are based on the experimental results. Seven different comparisons are made between the biogas and traditional systems. The payback periods, cumulated life-cycle savings and the cost

of biogas are calculated for a wide range using two unstable economic parameters, discount and inflation rates. The quality of the model and the assumptions are discussed. The results provide evidence of the economic viability of biogas systems over the traditional space heating systems of rural Turkey in many instances (IEA, 2005-2009; MENR, 2009).

Table 2: Renewable energy supply in Turkey.

Renewable energy sources	1990	1995	2000	2002	2007
Primary energy supply					
Hydropower (ktoe)	1 991	3 057	2 656	2 897	3 442
Geothermal, solar and wind (ktoe)	461	654	978	1 142	1 374
Biomass and waste (ktoe)	7 208	7 068	6 457	5 974	5 456
Renewable energy production (ktoe)	9 660	10 779	10 091	10 013	10 272
Share of total domestic production (%)	38	40	38	40	41
Share of TPES (%)	18	17	12	13	14
Generation					
Hydropower (GWh)	23 148	35 541	30 879	33 684	35 624
Geothermal, solar and wind (GWh)	80	86	109	153	155
Renewable energy generation (GWh)	23 228	35 627	30 988	33 837	47 639
Share of total generation (%)	40	41	25	26	26
Total final consumption					
Geothermal, solar and wind (ktoe)	392	580	910	1 048	1 148
Biomass and waste (ktoe)	7 208	7 068	6 457	5 974	5 865
Renewable total consumption (ktoe)	7 600	7 648	7 367	7 022	7 134
Share of total final consumption (%)	18	15	12	12	12

Turkey is one of the countries with significant potential in geothermal energy (at present seventh in the world) and there may exist about 2000 MWe of geothermal energy usable for electrical power generation in high enthalpy zones. Turkey's total geothermal heating capacity is about 31 500 MWth. At present, heating capacity in the country runs at 1 220 MWth equivalent to 147 000 households. These numbers can be heightened some seven-fold to 6 880 MWth equal to 585 000 households through a proven and exhaustible potential in 2010. Turkey must target 1.2 million households equivalent 7 700 MWth in 2020 (Yuksel and Kaygusuz, 2011; Geothermal Energy in Turkey, 2008; Kaygusuz and Kaygusuz, 2004).

The yearly average solar radiation is 3.6 kWh/m^2-day and the total yearly radiation period is approximately 2640 hour, which is sufficient to provide adequate energy for solar thermal applications. In spite of this high potential, solar energy is not now widely used, except for flat-plate solar collectors. They are only used for domestic hot water production, mostly in the sunny coastal regions (Yuksel and Kaygusuz, 2011). In 2006, country has about total 7.0 million m^2 solar collectors and it is predicted that total energy production is about 0.390 Mtoe in 2006. Although solar energy is the most important renewable energy source it has not yet become widely commercial even in nations with high solar potential such as Turkey (Yuksel and Kaygusuz, 2011; DPT, 2001).

3. Conclusions

Energy is essential to economic and social development and improved quality of life in all countries. Much of the world's energy, however, is currently produced and consumed in ways that could not be sustained if technology were to remain constant and if overall quantities were to increase substantially.

The need to control atmospheric emissions of greenhouse and other gases and substances will increasingly need to be based on efficiency in energy production, transmission, distribution and consumption in the country. Electricity supply infrastructures in many developing countries are being rapidly expanded as policymakers and investors around the world increasingly recognize electricity's pivotal role in improving living standards and sustaining economic growth.

Energy access for all will require making available basic and affordable energy services using a range of energy resources and innovative conversion technologies while minimizing GHG emissions, adverse effects on human health, and other local and regional environmental impacts in the country.

To accomplish this would require governments, the global energy industry and society as a whole to collaborate on an unprecedented scale. The method used to achieve optimum integration of energy sustainability with more efficient energy systems should be made. Wide range of energy sources and carriers that provide energy services as a sustainable manner need to offer long-term security of supply, be affordable and have minimal impact on the environment.

REFERENCES

1. Balat M. (2005), Use of Biomass Sources for Energy in Turkey and a View to Biomass Potential, Biomass Bioenerg., 29. 32-41.
2. DPT, State Planning Organization (2001), Eighth Five-Year Development Plan 2001-2005, Ankara, Turkey.
3. DSI, State Water Works (2008), Hydropower Potential in Turkey, Ankara, Turkey.
4. Geothermal Energy in Turkey, www.jeotermaldernegi.org.tr (access date 20 June 2008).
5. Goswami Y.D. (2007) Energy: The Burning Issues, Refocus, 8 (1), 22-25.
6. IEA, International Energy Agency (2005), Energy Policies of IEA Countries: Turkey 2005 Review, OECD/IEA, Paris.
7. IEA, International Energy Agency (2005), CO2 Emissions from Fuel Combustion, 2008 edition, OECD/IEA, Paris.
8. IEA, International Energy Agency (2006), World Energy Outlook 2006, IEA, Paris.
9. IEA, International Energy Agency (2007), World Energy Outlook 2007, IEA, Paris.
10. IEA, International Energy Agency (2007), Renewables for Heating and Cooling: Untapped Potential, OECD/IEA, Paris.
11. IEA, International Energy Agency (2008), World Energy Outlook 2008, IEA, Paris.
12. IEA, International Energy Agency (2008), Deploying Renewables: Principles for Effective Policies, OECD/IEA, Paris.
13. IEA, International Energy Agency (2009), From 1st- to 2nd-Generation Biofuel Technologies: An Overview of Current Industry and RD&D Activities, OECD/IEA, Paris.
14. Kaygusuz K. and Turker M.F. (2002), Biomass Energy Potential in Turkey, Renew. Energ., 26, 661-678.
15. Kaygusuz K. and Kaygusuz A. (2004), Geothermal Energy in Turkey: The Sustainable Future, Renew Sust Energ Rev., 8, 545-563.
16. MEF, Ministry of Environment and Forestry (2007), First National Communication of Turkey on Climate Change (Eds. Apak, G and Ubay, B), Ankara, Turkey, pp. 60-150.
17. MENR, Ministry of Energy and Natural Resources (2009), Energy Statistics in Turkey, available from http://www.enerji.gov.tr (accessed date 06 January 2009).
18. Yuksel I. and Kaygusuz K. (2011), Renewable Energy Sources for Clean and Sustainable Energy Policies in Turkey, J. Renew. Sust. Energ. Rev., 15-8, 4132 – 4144.