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South-eastern Anatolia Project (GAP) factor and energy management in Turkey

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ABSTRACT

Turkey has an adequate amount of water in general, but it is not always in the right place at the right time to meet present and anticipated needs. Turkey has 665.000 ha of inland waters, excluding rivers and small streams. There are 200 natural lakes, with a total area of 500.000 ha, and 775 dam lakes and ponds with a total surface area of 165.000 ha [2,20]. On the other hand, Turkey has made a positive step towards implementing future energy efficiency policies by drafting the Energy Efficiency Strategy Paper, which includes indicative sectoral targets. It was recently conveyed to the prime minister's office via the Ministry of Energy and Natural Resources (MENR), for formal approval by the High Planning Council (YPK). This paper deals with energy management and Southeastern Anatolia Project (GAP) in Turkey.

1. Introduction

At the time of the 2009 Evaluation, several International Energy Agency (IEA) member countries including Finland, Ireland, Japan, Korea, Turkey and the United States, were planning or had implemented policies to promote energy efficiency in small and medium-sized enterprises (SMEs). For the 2011 Evaluation, a handful of additional countries reported energy efficiency policy developments for SMEs. Italy's National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), for example, is planning activity in this area. Portugal's Cabinet Resolution no. 2/2011, passed in January 2011, created the legal framework for energy service companies (ESCOs) and procurement management of energy services for SMEs (IEA, 2012).

In the Energy Efficiency 2011 Evaluation, governments reported on efforts to ensure that voluntary and mandatory energy efficiency policies are adequately monitored, enforced and evaluated. For example, Australia's Energy Efficiency Opportunities Act (EEO Act) established measures for compliance and verification. Consultation with large energy-using companies in the EEO program is underway to establish better monitoring and evaluation procedures for the EEO program's second cycle, which runs from July 2011 to June 2016.

In Turkey, a new Division of Monitoring and Evaluation was established in the General Directorate of Electrical Power Resources Survey Administration (EIE) at the end of 2010. A new project will start in 2011 to establish a comprehensive monitoring and evaluation system and infrastructure.

On the other hand; Southern Anatolia Project (GAP) originally planned by the State Hydraulic Works (DSI) is a combination of 12 major projects primarily for irrigation and hydroelectric generation in Turkey. 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 ha of land will be irrigated and 27 billion kWh hydroelectric energy will be generated annually (Yuksel, 2012; DSI, 2010).

Turkey's energy demand is met through thermal power plant consuming coal, gas, fuel oil and geothermal energy, wind energy and hydropower. Because Turkey does not own any nuclear power plant yet, the installation of first nuclear power plant with a capacity of 1000 MW is on the schedule as a plan of the near future. In 2008, the energy consumption of Turkey is about 106.525 kilo tons of oil equivalent (ktoe) as shown in Table 1. Turkey's installed generation capacity is also 41.818 GW and electricity generation is 198.418 GWh in 2008 (Yuksel, 2012; DPT, 2010).

According to Turkey's Ninth Development Plant, 66% of Turkey's generated electricity is supplied from thermal power plants. Contribution of wind and hydro power plants are 0.2% and 32.20%, respectively. 49.00% of Turkey's electricity is generated by Electricity Generation Incorporation (EUAS), 39.70% is generated by auto-producers, and 9.5% is generated by affiliated partnerships of EUAS and 1.8% by distribution of electricity generation by primary resources by 2007 is given in Fig. 1 (Yuksel, 2012; MENR, 2008; TEIAS, 2008; WECTNC, 2008; EIE, 2010).

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Table 1
Primary energy consumption (ktoe) (DPT, 2010).

Energy sources	2008	2009	2010
Hard coal	16,427	16,165	16,861
Lignite	15,217	15,031	15,891
Petroleum products	31,784	27,652	29,312
Natural gas	33,807	30,764	33,603
Hydroelectricity	2,861	3,121	3,354
Renewable energy	1,645	1,910	2,102
Wood	3,679	3,610	3,591
Animal waste and plant residue	1,134	1,150	1,120
Total primary energy consumption	106,525	99,360	105,791
Per capita consumption (kgoe)	1,423	1,312	1,381

ktoe: kilo tons of oil equivalent; kgoe: kilo gram of oil equivalent.

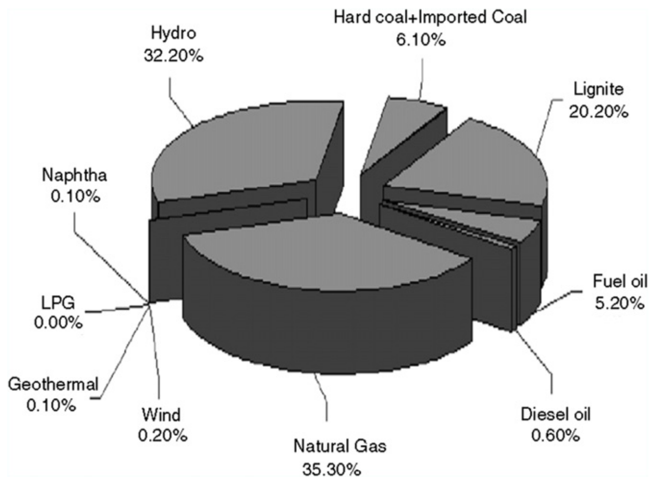

Fig. 1. Percentages of electricity generation by primary energy resources by 2007 (MENR, 2008; TEIAS, 2008; WECTNC, 2008; EIE, 2010).

2. Sustainability development, energy and GAP

Sustainability is a rather new concept in international development literature. Here, each country is expected to determine its sustainable development criteria by paying due consideration to its specific circumstances. To conduct relevant assessments in this field, the GAP Administration held a seminar in March 1995 in co-operation with the United Nations Development Program (UNDP). This seminar was attended by all sectors related to the process of development in the GAP region and set the following targets in the context of sustainability based upon the objectives and projections of the Master Plan (Southeastern Anatolia Project, 2004; Yuksel, 2006):

- Enhancing investments so as to ensure the maximum possible improvement of economic conditions in the region.
- Bringing education and health services up to national standards.
- Creation of new fields and opportunities for employment.
- Improving the quality of urban life and upgrading urban infrastructure so as to bring about healthier urban environments.
- Completing rural infrastructure so as to allow for optimal development of irrigation services.
- Improving intra and interregional accessibility.
- Responding to infrastructure needs of existing and future industries.
- Giving priority to maintaining the quality of water, land and air and protecting eco-systems linked to these resources.
- Promoting people's participation in decision-making and project implementation.

The basic components of sustainable development in the GAP region were identified as social sustainability, agricultural sustainability, economic viability, physical and spatial sustainability and environmental sustainability. Environmental and cultural sustainability depend upon the sustainability of natural resources and the conservation of environmental and cultural heritage. Economic viability is closely associated with the implementation of efficient and effective projects, employment opportunities, economic development and involvement of the private sector. Finally, social sustainability rests on the adoption of the principles of participation, equality, fairness and development of human resources (Yuksel, 2006; Bagis, 1997; Yildirim and Cakmak, 2004).

3. Energy management in Turkey

Turkey should continue to take advantage of proved practices in other countries to improve energy efficiency. The transport sector is an area where urgent attention is needed. Turkey should set ambitious fuel-economy standards for vehicles and regulate non-motor components that affect vehicle energy efficiency (e.g. tire rolling resistance and tire pressure). Taxation should be used to favor the purchase of more efficient vehicles (IEA, 2012).

Energy saving potential still untapped in the buildings sector is a matter for Turkish policy makers to look at in the long term. Energy labeling of buildings is a recent positive development, but more policy developments are needed to implement energy performance requirements in building codes in new buildings; there is also a need for systematic and rigorous collection of energy efficiency information on existing buildings and on barriers to energy efficiency (IEA, 2012).

The role of energy utilities to deliver energy savings should not be underestimated in Turkey-planned measures to allow energy efficiency measures to be bid into energy pools on an equal basis to energy supply options should be implemented, or other relevant policy measures should be considered.

On a horizontal level, Turkey should scale up energy efficiency financing mechanisms and invest in technical capacity building. For example, Turkey should consider encouraging financial institutions to train their staff and develop evaluation criteria and financial tools for energy efficiency projects. It should review current subsidies and fiscal incentive programs to encourage private energy efficiency investments and collaborate with the private financial sector to establish public–private tools to facilitate energy efficiency financing. It should also examine possibilities to promote risk mitigation instruments, such as securitization or public–private partnerships and implement institutional frameworks to ensure regular co-operation and exchanges on energy efficiency issues between the public sector and financial institutions (IEA, 2012).

The Ministry of Energy and Natural Resources (MENR) carries out the general energy planning studies, using the model for analysis of energy demand (MAED) demand model, and Turkish Electricity Transmission Company (TEIAS) carries out energy generation expansion planning studies, using the DECADES model. The MAED model (Yuksel, 2012; MENR, 2005), which was developed by the International Atomic Energy Agency (IAEA), makes projections of the medium and long-term general electricity demand. It takes into consideration a detailed analysis of social, economic and technical systems. The model is based on low, medium and high case scenarios. It is very important to project the energy demand accurately, because decisions involving huge investments of capital are based on these forecasts.

The TEIAS, has prepared the long-term energy generation plan, taking into consideration the MAED model demand outcome. According to the plan, the installed capacity will increase to 57,551 MW in 2010 and to 117,240 MW in 2020. The installed hydropower capacity is anticipated to increase to 18,943 MW in 2010 and to 34,092 MW in 2020. Thus, an additional 1000 MW of hydro capacity should be added to the system annually

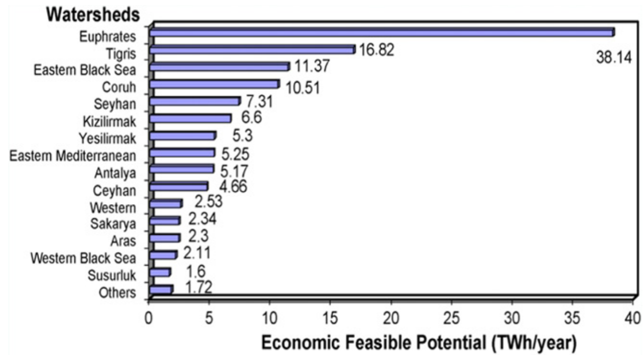

Fig. 2. Distribution of Turkey's hydropower potential on basin level (Ozturk et al., 2009).

over the next 20 years. Turkey is thus seeking support for the development of all its economic potential by 2023, which is the 100th anniversary of the foundation of the Turkish Republic (IHA, 2006; TEIAS, 2005; Yuksel, 2009).

Although Turkey has an adequate amount of water in general, it is not always in the right place at the right time to meet present and anticipated needs. As regards hydrology, Turkey is divided into 26 drainage basins. The rivers in general have irregular regimes, and natural flows cannot be taken directly as usable resources. The average annual precipitation, evaporation and surface runoff geographically vary greatly (Yuksel, 2012; Kaygusuz, 2009; DIE, 2004; DSI, 2004; Yuksel, 2008).

According to Chambers of Turkish Electrical Engineers, Turkey has 259 billion kWh energy potential, but only 35% of this potential can be used. Nowadays, Turkey's electricity generation is approximately 176 billion kWh per year and will be 400–500 billion kWh per year by year 2020. Turkey does not have enough primary energy sources, but has a tremendous hydropower potential (Yuksel, 2012; Ozturk et al., 2009). Nowadays, hydropower is recognized as the most important kind of renewable and sustainable energy sources. The position of hydro power plants (HPP) becomes more and more important in today's global renewable technologies. The small-scale renewable and distributed generation may be the most cost-effective way to bring electricity to remote villages that are not near transmission lines (Yuksel, 2012; Alboyaci and Dursun, 2008).

In terms of hydropower potential, with 440 TWh/yr, Turkey is the second richest country after Norway in Europe. This potential can be used technically 215 TWh/yr and economical potential 128 TWh/yr in accordance with the predictions of General Directorate State Hydraulic Works (DSI). Table 2 shows the status of economically feasible hydropower potential in Turkey (Yuksel, 2012; DSI, 2009).

4. Energy and GAP factor in Turkey

Water and hydropower potential in Turkey are distributed into 26 basins and the total flow rate of water sources for energy production is 186 km^3/years. The biggest five basins of Turkey are Euphrates, Tigris, Eastern Black Sea, Coruh and Seyhan as shown in Fig. 2. Euphrates represents over 38% of the national hydropower potential, Tigris represents over 16% of the national potential, Eastern Black Sea represents 11% of the national water supply, Coruh represents 10.5% and Seyhan represents 7.3% of the national water and hydropower potential (Yuksel, 2012; DSI, 2010; Ozturk et al., 2009; Alboyaci and Dursun, 2008; DSI, 2009; Yuksek, 2008; Yuksek et al., 2006).

The construction of more than 329 hydropower plants have been projected to add a total installed capacity of 19 699 MW, thus the total number of hydro plants will have been reached to 483 and the total installed capacity will be increased about 34 592 MW by 2020 (MENR, 2008). This increase includes the south-eastern Anatolia Project (GAP) which covers one-tenth of Turkey's total land area. GAP will have an installed capacity of 7460 MW (TEIAS, 2008; Kaygusuz, 2010; IEA, 2005). Following the succession of this project, 1.7 million ha of land will be irrigated and the ratio of irrigated land to the total GAP area will increase from 2.9% to 22.8% while that for rain-fed agriculture will decrease from 34.3% to 7% (DSI, 2010; Kaygusuz, 2010; GAP, 2007).

Table 3
Energy production in GAP (GAP, 2007).

Name of dam	Yearly energy production (kWh)
Karakaya dam and HPP	106.8 billion
Ataturk dam and HPP	74.5 billion
Kralkızıdam and HPP	0.3 billion
Karkamış dam and HPP	0.6 billion
Dicle dam and HPP	0.1 billion
Birecik dam and HPP	1.6 billion
Total	183.9 billion

On the other hand, 27 billion kWh of electricity will be generated annually over an established capacity of 7460 MW. The area to be irrigated accounts for 19% of all the economically irrigable area in Turkey (8.5 million ha), and the annual electricity generated will account for 22% of the country's economically viable hydroelectric power potential, 118 billion kW. Today the Ataturk and Karakaya dams, the most important investments of the GAP, had generated about 175 billion kWh energy. Table 3 shows the energy production in GAP (GAP, 2007).

Turkey total hydropower capacity is estimated at 440 TWh per year. Some of this potential can be achieved with small hydroelectric plants (SHEPs) having individual capacities of 10 MW or less. It is estimated that, theoretically, Turkey has SHEP resources of 710 GW for project generation and 300 MW for total installed capacity (Alboyaci and Dursun, 2008; Yuksek and Kaygusuz, 2006). SHEP development in Turkey was initiated in 1900. Since then, municipalities in rural areas have installed many decentralized plants by private entrepreneurs, and by some government organizations. It is estimated that, Turkey has SHEP resources of 710 GW for project generation and 300 MW for total installed capacity. Annual increases of SHEP capacity during the past 25 years average 8%–12% (Yuksel, 2012; Yuksek and Kaygusuz, 2006; Yuksel, 2010a,b).

5. Energy policy in Turkey

Turkey's energy intensity, adjusted for purchasing power parity (PPP), comes close to the IEA average. Turkey's energy intensity has remained relatively stable over the past decades. Energy intensity has been reduced by a faster growth in services than in the more energy-intensive industry, but this reduction has been offset by expanding energy use linked to the increasing wealth of the country's young, growing and urbanizing population. This resulted in an average decrease of energy intensity adjusted for PPP of 0.3% per year from 1990 to 2009 (Yuksel, 2010b).

Turkey has made some progress in implementing energy efficiency policies since the 2009 Evaluation. In the industrial sector, for example, between 2009 and 2010, Turkey trained and certified 1525 energy managers. The total number of certified energy managers in Turkey reached more than 4200 in mid-2011. It also hosted the 9th international energy manager course in June 2010. Measures and voluntary agreements, begun in 2009, to encourage energy efficiency in industrial establishments were continuing in 2010 (Yuksel, 2010b).

Table 2
The status of economically feasible hydropower potential in Turkey (DSI, 2009).

Project	Number of project	Total installed capacity (MW)	Annual average energy (TWh/yr)	Ratio (%)
In operation	172	13 700	48	35
Under construction	148	8 600	20	14
In program	1418	22 700	72	51
Total	1738	45 000	140	100

Table 4
Turkey's population, economy, and energy (Yuksel, 2010b; TUBITAK, 2003).

Year	Population (000s)	GNP/capita	Total GNP	Total energy dem and (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

Turkey is attempting to improve methods to ensure both voluntary and mandatory energy efficiency policies are adequately monitored, enforced and evaluated. For example, a new Division of Monitoring and Evaluation was established in the General Directorate of Electrical Power Resources Survey Administration (EİE) at the end of 2010. A new project is planned for 2011 to establish a comprehensive monitoring and evaluation system and infrastructure (Yuksel, 2010b).

Turkey has made a positive step towards implementing future energy efficiency policies by drafting the Energy Efficiency Strategy Paper, which includes indicative sectoral targets. This paper includes some amendments suggested by the Energy Efficiency Coordination Board (EECB), public and private bodies and institutions. It was recently conveyed to the prime minister's office via the Ministry of Energy and Natural Resources (MENR), for formal approval by the High Planning Council (YPK) (IEA, 2012).

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 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 (Yuksel, 2010b; Kaygusuz and Arsel, 2005).

On the other hand, 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 (Kavak-Akpinar and Akpinar, 2004), biomass (Yuksel, 2010b; Kaygusuz and Türker, 2002), geothermal (Kose, 2005), and solar (Ogulata and Oğulata, 2002). 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 (Yuksel, 2006, 2010b; Kaygusuz, 2002; Kaygusuz and Kaygusuz, 2004; Evrendilek and Ertekin, 2003; Balat, 2004; Hepbasli and Ozgener, 2004).

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 hydro-power and nuclear power. View point of population, economy and energy have been presented in Table 4 (Yuksel, 2010b; TUBITAK, 2003).

6. Conclusion

Water is one of the most valuable resources, and a limiting factor for crop production. Agricultural crops are the major consumer of water. Agriculture, with its social and economic aspects, has a dominant role in the nation's life in Turkey. It accounts for about 20% of gross domestic product, 10% of exports and 47% of civilian employment.

On the other hand, waterpower has been utilized since the dawn of history, but only its transformation into electrical energy established the basis for its expansion today to around 35%–40% of the country potential and hydroelectricity will be continue in the future to be one of the most effective options because of the zero emission involved and domestic energy source.

In Turkey, the hydropower industry is closely linked to both water management and renewable energy production and thus has an important role, in cooperation with the international community, and in striving for sustainable development in a world where billions of people still lack access to safe drinking water and adequate energy supplies. Hydropower emits very few greenhouse gases in comparison with other large-scale energy options and thus helps slowing down global warming. In addition, by storing water in rainy seasons and releasing it in dry ones, dams and reservoirs help control water during floods and droughts. These essential functions, protecting human lives and other assets, will be increasingly important in the context of climate change is expected to give rise to even greater variability in the frequency and intensity of rainfall (Yuksel, 2010b).

The GAP project is one of the largest power generating, irrigation, and development projects of its kind in the world, covering 3 million ha of agricultural land. This is over 10% of the cultivable land in Turkey; the land to be irrigated is more than half of the presently irrigated area in Turkey. The GAP project on the Euphrates and Tigris Rivers encompasses 20 dams and 17 hydropower plants. When all projects are completed, 27 billion kWh of electricity will be generated annually, which is 45% of the total economically exploitable hydroelectric potential in Turkey (Yuksel, 2010b).

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