Evaluation of the Reform in Turkish Electricity Sector: A CGE Analysis

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Abstract
Turkey's electricity market has undergone extensive reform since 2001 through market liberalization, unbundling, privatization, and establishment of organized power markets, retail market opening, and the establishment of an independent energy regulatory authority. We employ a static computable general equilibrium (CGE) model to test the impact of power sector reform on the economy. We construct Turkey's social accounting matrix (SAM) for 2010 by using technological coefficients from 2002 input-output tables and the most recent published by Turkey's statistics agency, but opt for actual values for energy accounts in SAM using data published by the International Energy Agency and Turkey's energy regulator. Major findings suggest reform has for a major part been beneficial to the economy. We find out that gross domestic product (GDP) deviates by 0.35% from the baseline when monopolistic rent is reduced in all state-run power companies simultaneously. For the first time, the impact of the establishment of a day-ahead power market (DAM) and privatization of state-run electricity utilities on the economy is tested, with findings suggesting both reform elements affect the economy positively. Larger participation of state-run electricity companies in the DAM generates a positive effect similar to that of privatization, with the GDP turning around 0.2-0.3% above its baseline level after each shock.

1. Introduction

The long quest for optimal allocation of power resources has pushed for fundamental reform in the electricity sector in many countries during past decades. Electricity markets have been subject to significant liberalization starting from the 1980s. However, liberalization in the electricity markets across countries was never an easy process. There still exist challenges to opening up power markets completely due to the sector's complexity and new challenges arising from various generation sources and environmental concerns. Electricity sectors are regulated as to ensure supply and demand are always balanced so that the system does not collapse. The sector has traditionally been recognized as strategic and managed through state-run vertically integrated monopolies with prices set lower than marginal costs. But this has led to high inefficiencies and large burdens on state budgets. Since the 1980s, governments have been trying to open up all or certain segments of the power sector to competition, starting first in Chile, the UK, Argentina, Norway, New Zealand and Australia.

Turkey has also undertaken various reforms to liberalize its electricity market starting from the 1990s.[3] Turkish electricity industry has undergone considerable transformation since a new electricity market law was approved in 2001. The new law introduced large-scale reform in the sector. Key steps in this reform process were (i) unbundling generation, transmission, distribution and trading activities, (ii) establishing an independent regulatory body, (iii) launching wholesale power trading through the day-ahead balancing market, and (iv) finalizing the privatization of distribution companies by 2013. A new electricity market law was enacted in 2013. The new law introduced new changes including, (i) separation of market operator from system operator, (ii) establishment of an energy exchange, (iii) establishment of an intra-day power trading platform, (iv) privatization of generation assets, and (v) the removal of autoproducers' status for private generators. Akkemik (2009) has shown that there has been considerable efficiency improvement during the course of reform in the electricity market.

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[3] See Çetin and Oğuz (2007) for the politics of electricity market reforms in Turkey.

Most studies to date elaborate the general equilibrium structure developed by Scarf (1967, 1973). Theoretical background for more complex models is explained in Willenbockel (1994). We follow the standard model of Scarf but with more complicated features to adapt to features of the Turkish power sector and macro-economic structure. An important characteristic of our model is the introduction of increasing returns to scale and imperfect competition. A pioneering work is Harris (1984), which incorporates internal scale economies for an industry.

Taxation and trade policy were the initial focus of applied CGE modeling, but as the approach became more popular given its advantages to empirical or simpler models of inter-sectoral analysis such as input-output or social accounting matrix models, it started being implemented in function of examining policy impact of a number of other fields, including environment, energy, research and development and the like. In the case of Turkey, Madlener et al. (2004) was the first CGE model with a focus on Turkish electricity sector, and examined how energy conversion technology adoption under uncertainty has performed from an environmental and an investor's point of view. They found that gas-fired power generation technologies while positively contributing to environmental sustainability do not carry clear merits from an investor's perspective.

Electricity market reforms have been subject to academic scrutiny only recently, starting from Chisari et al. (1999). Other studies including Coupal and Holland (2002), Kumbaroglu (2003), Riipinen (2003), Kerkela (2004), Madlener et al. (2004), Hosoe (2006), Küster et al. (2007), Aydin (2010), Lu et al. (2010), Akkemik and Oğuz (2011), PwC (2011), Chen and He (2013), and Lin and Ouyang (2014) examine the electricity markets and reforms in these markets from different perspectives using CGE models. An earlier study examining the impact of reforms in Turkey is Akkemik and Oguz (2011). In this study, a counterfactual analysis of full liberalization of the electricity sector results in a rise in GDP by 0.53% and an improvement in welfare by 1.08% as measured by Hicksian equivalent variations method. The findings in Akkemik and Oguz (2011) suggest important possible outcomes for further reform in the power sector, in which full retail competition is aspired.[4]

The aim of this study is to test the impact of electricity market reform on Turkish economy, employing a static computable general equilibrium (CGE) model. Our findings from policy simulations imply that market liberalization benefits the economy the most if it is undertaken for all state-run power companies simultaneously, and operational inefficiencies of state-run companies are reduced, stronger private-sector participation is realized in the generation segment and establishment of the day-ahead market. Removing the mark-up for state-run power companies, including generation, wholesale trading and distribution segments, leads to a positive change in GDP by 0.35%. A rise in the private sector's share in power generation also boosts GDP significantly, up to 0.18%. More remarkably, the impact of higher participation of state-run companies to the day-ahead market is positive, by 0.25% of GDP.

The rest of the paper is organized as follows. The second section provides an overview of electricity sector in Turkey. The third section briefly discusses the electricity sector reform Section 4 explains the methodology and data. The fifth section reports findings from simulations, and finally the sixth section concludes.

[4] For other studies examining Turkish electricity market see, among others, Akkemik (2009), Bahçe and Taymaz (2008), Karahan and Toptaş (2013), and Zhang (2015).

2. Electricity Sector Outlook in Turkey

Growth in electricity demand is strongly linked to efficiency and innovation in the sector, as well as environmental and supply security concerns. Global shares in generation mix in electricity generation are expected to change, although coal is forecast to maintain its largest share in global power generation at 33% in 2035, from 41% in 2012 (IEA, 2013). The share of renewables will also rise to 31% from 20% and the share of gas will remain at 22%, over the same period. The shift towards lower carbon sources and more efficient power plants will be translated to a 30% fall in CO_2 intensity in the sector. Electricity prices are also expected to rise at the global scale in the coming years (IEA, 2013).

Turkey's average annual per capita GDP growth during the period 2000-2013 was 3%, while electricity demand increased by 5.3% (Figure 1). Gross power demand totaled 257 TWh in 2014, double the demand for electricity in the country in 2000. Annual average per capita power consumption was 3,327 kWh in 2014. And the figure for 2011 was 3,070 kWh or less than half the 6,626 kWh Euro area average. Given that Turkey is an emerging economy, its per capita power consumption is expected to rise as the economy advances. The share of commercial power consumption has changed considerably in the past decade, rising to 18.9% in 2013 from 9.5% in 2000. Household and industrial consumers have given up 1.6% and 2.6% of their shares to total consumption down to 22.7% and 47.1% respectively, for the same period.

Total power generation was 252 TWh in 2014. Of this, natural gas had the lion's share of 47.9%, 30.3% was coal-fired, 16.1% hydro, 3.4% wind and the remaining fuel oil, waste and other renewable generations. Natural gas has the largest stake in generation mix, although it has been falling in recent years. Some 44% of Turkey's total power output was gas-fired in 2013, up by 7 percentage points compared to its shares in 2000. The overall picture has changed substantially from 2000, as shown in Figure 2. Natural gas, geothermal and wind have replaced oil and coal fired generation in the past 14 years. Turkey's increased dependency on gas in this period exposes the country to security of supply risks due to high dependence on foreign resources. It also leads to a heavy burden on the economy's current account balance. Accordingly, one major target for public policy is to encourage diversification of resources and of countries of origin for imported energy commodities.

The Strategy Paper on Energy Market and Security of Supply approved in 2009 has set goals to reach at least a 30% share in renewables, with the target for wind capacity set at 20,000 MW by 2023 (DPT, 2009). Also, Turkey is committed to reach 600 MW geothermal capacity and reduce natural gas share in the generation mix below 30% by the same time. The country is also adding nuclear power to its generation portfolio. The strategy paper aims to ensure at least a 5% in total generation by 2020, and the first 1.2 GW unit of the Akkuyu nuclear plant – Turkey's first – is expected to go online by 2019, with the remaining three units planned to start their commercial activities within the following three years. The shares in the generation mix by 2023 are calculated to be 30-30-24-6% for gas, renewable, coal, and nuclear generation technologies respectively. Given respective shares in 2014 and ongoing power plant projects, although not impossible, meeting this target by 2023 may prove challenging.

Installed capacity rose by 155% from 27.3 GW to 69.5 GW in the 2000-2014 period. Of the total 2014 capacity, hydro held the largest stake at 34%, followed by natural gas with 26.9%, coal with 21.3%, other thermal capacity with 11.9% and wind with 5.2%. With natural gas still baring the largest share in current capacity under construction, lowering gas' share in total generation below 30% by 2023 could prove challenging for Turkey.

Private sector involvement in the electricity sector in Turkey was very limited until the beginning of the 2000s, as Figure 3 indicates. Private generation counted for just 23% of the total generation in 2000 – of which 10% were production companies and 13% were auto-producers which were utilities that were excluded from the obligation of holding a license and generated for their own power needs. The majority of generation, around 74%, was covered by public generator EUAS and its affiliates. This has changed in about one and a half decade, with EUAS and its affiliates generating just 28% of local output, 2% met by TOOR plants and the remaining 70% of power generated by private companies in 2014. However, it is key to note that 22 percentage points in private generation in 2014 was output by plants operated by private companies under Build-Operate (BO) and Build-Operate-Transfer (BOT) contracts, for which the state guarantees sales at a fixed price revised by the energy regulator EPDK. Given the state support, these firms guaranteed returns to investment plus lucrative earnings on top of costs, thus being not fully exposed to commercial risks. For these reasons, we consider them as part of the public stake in the Turkish power market in this paper.

As to prices, a key objective of the 2001 law was to deliver affordable and fair power prices to end-users. Figure 4 shows how retail power prices have evolved since 2006. Clearly, prices have been increasing for both household and industrial users, therefore missing the ultimate target. Power prices in Turkey are more of a political commodity, and the Turkish government has traditionally depressed them through subsidization of the state-run power and companies. As a rule of thumb, prices will go flat in pre-election years and end-user tariffs are increased in the post-election period.

Turkey established a day-ahead pricing mechanism in 2009, which went through a day-ahead planning phase (2009-2011) and a fully functioning day-ahead market was launched in end-2011. Turkey's power market model was designed as a market where bilateral agreements would dominate and the day-ahead market would complement for the remaining electricity needs. However, physical volumes of the day-ahead market have increased significantly since its establishment in the end of 2009 and over-passed bilateral agreements' market share reaching 53% in the end of September 2015.

3. Reforms in the Turkish Electricity Sector

Before the 1980s, the Turkish electricity sector was in monopoly hands of a vertically integrated state-owned incumbent (TEK). The first attempt to open the electricity industry to the private sector was in 1984 through Law No. 3096, which encouraged private participation via Build-Operate-Transfer (BOT) contracts. The private investor would build and operate power plants for a given period of time (around 15 years in practice) and transfer its ownership to the state at no cost after due date. Private participation was also allowed for distribution and transmission sectors, although interest was limited for these (Ozkivrak, 2005). The same law introduced Transfer of Operating Rights (TOOR) contracts for existing generation where a private company would take over the management of a state-owned plant and invest in its rehabilitation, and then hand operating rights back to the state after the termination of the contract.

The concept of power generation for companies' own needs referred to as auto-producers was another novice of the law. These would produce for their needs and could sell power equivalent up to 20% of previous year sales without holding a generation license. These reforming steps were expected to reduce utilities' financial burden on the state and encourage efficiency. But in practice, agreements between private investors and the Turkish state ended being of the "take-or-pay" nature, with the Treasury guaranteeing purchase of power generated in the framework of BOT and TOOR contracts at fixed price formulas. This created an over-burden on state finances, rather than a relief.

In 1993, incumbent Turkish Electricity Administration (TEK) was divided into two sister companies: TEAS, which covered generation and transmission and TETAS, which covered the distribution segment. In 1996, the Build-Operate-Own (BOO) model was introduced, with the Treasury guaranteeing sales of BOO power plants for 15 years and then ownership remaining with the private investor who would compete at market conditions thereafter. But even this model failed to attract much investment in the beginning, generating just 2.4 GW of new capacity (Tiryaki, 2013). Heavy bureaucracy and the lack of strong institutions, particularly a guaranteed independent and well-functioning conflict resolving mechanism and judiciary, inevitably discouraged private investors although the ministry raised the guarantee period to 20 years. Hence another law followed in 1997, offering 15-years sales guarantees, tax exemptions and international arbitration for potential conflicts arising from BOO contracts. Some 6 GW more capacity was added to the BOO portfolio.

The BOT, BOO and TOOR models could not attract the desired investment levels into the country, due to bureaucratic hurdle and the lack of a comprehensive reform framework for the sector. According to TEIAS statistics, by the end of 2015 the capacity of BOT, BOO and TOOR plants totaled 9.4GW counting for 12.8% of Turkey's installed capacity. Also, this model failed to promote competition in the electricity market due to the take-or-pay terms which guaranteed sales of 85% or more of their output hence eliminating their exposure to market risks and any incentive to increase efficiency (Erdogdu, 2007; Baş and Ülgen, 2008; Tiryaki, 2013).

Turkey undertook a comprehensive power sector reform in 2001, aiming at market liberalization, restructuring, (de)regulation, privatization and the establishment an independent regulatory body. Following approval of the Electricity Market Law (EML) no. 4628 in 2001, the publicly owned vertically integrated incumbent TEAS was restructured into three new state-owned enterprises: Turkish Electricity Transmission Corporation (TEIAS), electricity Generation Corporation (EUAS) and Turkish Electricity Trading and Contracting Corporation (TETAS). The Energy Market Regulatory Authority (EPDK) was established, primarily charged with licensing, regulation of contracts concluded before EML, monitoring market performance, drafting, amending enforcing and auditing performance standards, customer service codes, setting out pricing principles and monitoring their implementation.

Following the approval of secondary legislation in 2002, EPDK defined four stages to competitive power markets as follows (Hepbasli, 2005): (i) licensing power and gas firms; (ii) give eligible consumers the right to choose their supplier; (iii) establishment of a Market Financial Reconciliation Center; and (iv) making this center work. In essence, EML aimed a power market model dominated by voluntary bilateral agreements and complemented by a balancing and settlement mechanism. Regulated third party access to the grid under EPDK supervision was also introduced. All market activities became subject to licensing and were opened to the private sector except transmission services. Cross-subsidization among activities or utilities is banned with the law. Further to promoting competition, the EML introduced a 20% market share cap for private generators, but kept state-owned companies exempt from this application, which is a major shortcoming (Oguz, 2010; Tiryaki, 2013). According to TEIAS statistics on Turkey's generation by utilities for 2015, the state-run EUAS holds 21% share while TETAS occupies 23%.

In the framework of the new law consumers were classified as eligible consumers who are able to choose their electricity provider and non-eligible consumers – mostly households – who is supplied electricity only from retail sale companies or from the distribution company holding a retail sale license in its region. The lower limit of consumption for eligible consumers was reduced to 4.5MWh per annum in 2014, compared to 30 MWh in 2011 and 7.8 GWh in 2004. The number of eligible consumers has increased radically, hitting 447,422 in December 2013 compared with just 27,486 in December 2012 and 7,556 in January 2011 (EPDK, 2012; TEIAS 2012). The ultimate goal is 100 percent market opening by 2016 (MENR, 2014). As is the case in other reforming countries, theoretical openness does not necessarily imply openness at the same rates in practice. However, elimination of the eligible consumer limitations helps develop the demand side of the market, hence increasing flexibility and promoting more competition in the market.

Turkey applies a revenue-cap pricing approach for transmission and distribution revenues (USAID, 2006). The allowed revenues for companies include both operational and capital considerations, namely OPEX, which is return to operations, and CAPEX, which is payments for physical capital depreciation and stranded costs. For the regional distribution companies EPDK employs a number of quantitative methods and benchmarking to assess operational expenditures, while the companies submit regular investment proposals for the measurement of depreciation expenditures (see USAID 2006 for details). Both these items are then reflected into distribution fees to be paid by end users. Final user’s power prices are also subject to a cap, which is reviewed by the regulator quarterly.

The privatization process in Turkey has been completed for all 20 regional distribution companies and is still ongoing for generation assets as of early 2015. On the distribution segment, the country went for competition for the market, rather than in the market, given that competition is not feasible in this sector due to its natural monopoly nature. The privatization process for 20 of 21 regional distribution companies was finalized in 2013, almost a decade from the initially aimed schedule. The main drivers for privatization of the distribution segment were efficiency considerations, on grounds of increasing empirical evidence on inefficient management of state-run distribution monopolies, and the need for new investments in the network as the state lacked needed financial instruments to incur such investments particularly following Turkey’s 2001 economic crisis. International lenders also encouraged the country towards privatization to ease public finances from privatization revenues. The privatization of regional distribution companies was finalized through the transfer of operating rights approach. Elements such as technical losses and illegal use (theft) ratios, operating and investment costs are all taken into account by the regulator for determining distribution fees and final prices applied to end-users. This approach is envisaged to encourage private companies increase efficiency by allowing them to keep any profits from over-scoring efficiency improvement rates. On the generation segment, privatization provisions were brought through amendments to EML in 2006. The Privatization Administration finalized the privatization process of 9 power plants of 141 MW total capacity in 2008. Some 50 run-of-river power plants of about the same capacity were privatized between 2010 and 2014.

Price equalization mechanism was brought to national tariff calculation with amendments to EML in 2006, through which differences of loss-theft ratios and operational expenses among regional distribution companies would be netted off through intra-regional cross-subsidization. Another amendment to the law in 2008 ruled unbundling of distribution and retail activities by 1st of January 2013, which was carried by regional distribution companies by the time.

Reform in the electricity market has been expanded through a new electricity market law (new EML) enacted in March 2013. It brought complementary provisions to the unbundling of retail and distribution activities, including clauses that prevent direct partnership of a distribution company into a retail firm and vice versa, and also explicitly stating, “distribution companies cannot engage in any activity other than distribution" (Article 9). However, Tiryaki (2013) argues that attaching activities considered as competitive segments of the power sector, such as counter reading and billing and maintenance services to distribution services with the new EML marked "one of the most prominent losses of liberalization movement" in the country. An essential change introduced by the new law was the separation of market operator from system operator activities – which were both held by grid operator TEIAS previously. Market operator EPIAS was corporatized in March 2015 and started operating as of the beginning of September in the same year. The new EML also envisioned the creation of an energy stock exchange which was launched in October 2015 through the existing Borsa Istanbul's Futures and Options Market.

Another newly introduced license type was the supply license, which takes previous wholesale and retail licenses under one single shelter. The doubling of threshold for unlicensed generation to 1 GW has been considered a positive aspect of the new law. The Council of Ministers has authority to increase this limit up to 5 GW, which is also set as a target in the recent national action plan for renewables (ETKB, 2014).

The new EML excluded all provisions on auto-producers, generators that used most of their output for their own consumption needs, however, it envisaged that any participant holding a generation license that transferred a part of its output for use by its own facilities, parent, or mother company without using transmission and distribution grids, will be kept exempt of taxes and other market limitations (Tiryaki, 2013). There existed a need to address auto-producer issues, as these were thought to affect day-ahead prices in accordance with their own needs by purchasing power from own plants during peak hours and buying from the market in off-peak hours, which increased electricity costs for end-users (Oguz, 2010; Tiryaki, 2013). But above-mentioned clauses preserved the notion of auto-producers with the only difference that from this time on, any company with a generating license that did not use the national and regional grids was eligible for 'auto-producer benefits'.

4. Method of Analysis

We construct a static general equilibrium (CGE) model for the Turkish economy to examine the impact of power sector reform. CGE modeling allows for the analysis of economy-wide effects following a policy shock. We also construct a social accounting matrix (SAM) for this purpose. Turkey's most recent input-output table was published in 2002 by the official statistical agency (Turkstat). Based on previous estimates by Erten (2009) and Telli (2006), we also construct Turkey's SAM for 2010. 2010 was chosen as the benchmark year in our modeling exercise due to availability of data at a sectoral level for energy sectors and it is a good starting point to examine and predict how power market reform will affect the economy as the reform process has been carried for about a decade.

4.1. Social Accounting Matrix

Data are extracted from a number of sources, including the statistics agency (Turkstat), the treasury, the central bank, Ministry of Energy and Natural Resources (MENR), Ministry for Economy, grid operator TEIAS, state-run companies EUAS, TETAS and TEDAS and the International Energy Agency (IEA).

Power generation account is disaggregated into public sector and private sector power generation. While the first represents power generated by EUAS, EUAS affiliates, BOO, BOT and TOOR plants, the latter counts for power generated by independent private generators and auto-producers. Ownership disaggregation helps measure policy impact on public and private sectors for generation, to test for privatization of state-run generation assets, a key objective of reform. A key distinction between state-run and private utilities' behavior is their pricing policies. Private-sector power plants price their products under competitive-market pressure, sales of their output are not guaranteed so they have to operate in the most efficient way possible to be able to profitably sell electricity through bilateral agreements or in organized power markets. State-run utilities, on the other hand, guarantee sales for most of their generation in the form of bilateral agreements with TETAS and distribution companies with a universal service obligation.

Further on the electricity industry, four new satellite accounts are created in order to measure the impact the reform has had on power trading – by public and private sector companies, organized power markets (PMUM), and electricity distribution segments. It is important to mention here that although PMUM is a market place, rather than a producer of a good or service, here it is treated as a separate account in SAM. This is due to the nature of this marketplace which resembles a pool where buying and selling counterparts make anonymous power trading transactions. Hence, the PMUM account represents activities by participants rather than the marketplace itself.

Table 1 presents the macro-SAM with 2010 as the base year. While aggregate figures on gross output are updated in line with statistical data published by TUIK for 2010, the input-output coefficients are produced from Turkey's 2002 input-output tables due to lack more recent data. There are three factors of production, namely, labor, private-owned capital and state-owned capital (public capital). Institutions include households, enterprises, government, private sector and state savings as well as the rest of the world.

Input-output data for the Turkish economy in 2010 are derived using 1998 and 2002 tables. Turkey's 1998 IO table is prepared using United Nation's ISIC Rev.1 while the 2002 IO table uses European Union's NACE Rev.1 classification. Hence, we first reorganized sectors in each classification under the more aggregated 16 sectors and five electricity sectors (public-sector power generation, private-sector power generation, electricity retail, electricity wholesale). These sectors are presented in Table 2.

IO tables published by Turkstat are expressed in basic prices, that is, values of goods and services show the amount receivable by the producer, minus any tax payable plus any subsidy receivable and net of all trade and transport margins. In the SAM, the elements in the final-use block are expressed in producers' prices to ensure balance between columns and rows, given that columns for each sector include taxes on production, namely sales taxes, customs duties and export levies, but rows do not. For this purpose, we used tax matrices for 1998 and 2002 published by Turkstat. The amount of tax corresponding to final use blocks in the net tax matrices are added to the final demand accounts in the IO table. To compute labor compensation by each sector we also use statistics made available by Social Security Institution (SGK). We made an adjustment to labor compensation to count for compensation of workers in the informal economy. We added to each figure for private sectors the same proportions as in Erten (2009).

For the purpose of this paper we disaggregate the electricity sectors into subsectors. We separate generation into private and public sector and introduce four new satellite accounts to the SAM. A breakdown of the Turkish electricity market in 2010 is shown in Figure 5. A simplified version is presented in Figure 6. We assume that there are only two categories of generators: state and independent private generators. The former consists of state-owned utility EUAS and BO, BOT and TOOR plants, and the latter consists of all auto-producers and independent private producers (IPP). On the wholesale segment, we introduce three new accounts, namely, state-owned wholesale company TETAS, organized power markets PMUM, and independent private wholesale power trading firms (Wholesale). Finally, 21 regional distribution companies (EDAS) constitute the last account. The distribution and retail activities were not unbundled until the new electricity market law in 2013; therefore, they are considered in a single account in the SAM. We calculated the market volumes in monetary volumes for the SAM using average prices at which power is purchased and sold in various segments by market participants, which were obtained from the relevant institutions. To calculate the unregulated power prices, we assumed that (i) the price at which IPPs and auto-producers sell to eligible consumers is 2.5% lower from the regulated price distribution companies sell to this group, (ii) the price at which wholesale companies sell to eligible consumers is the same as the price these companies sold to PMUM, (iii) prices at which IPPs and private wholesale companies sell power to distribution companies (EDAS) are the same with respective average prices the former two groups sold to PMUM, (iv) the price at which auto-producers bought power from IPPs and TETAS is the same with the price at which they bought from PMUM, (v) the price at which IPPs bought electricity from IPPs is also assumed to be the same as the price this group bought power from PMUM, (vi) wholesale companies sold to IPPs at the same price as they sold to PMUM, (vii) the price at which private wholesale companies sold to other wholesale companies is the same as prices at which these firms sold to PMUM, and (viii) the price at which private wholesale companies bought power from IPPs and auto-producers is the weighted average price at which these firms, IPPs and auto-producers bought power from PMUM.

4.2. The Structure of the CGE Model

The most important novelty of the CGE model in this paper is that we disaggregate the electricity sector into state-run and private sector generation and supply segments, to test how larger participation of the private sector in the electricity market affected the economy. Our model is based on the standard CGE model approaches developed in Scarf (1967, 1973) and IFPRI model in Lofgren et al. (2002) and the economic framework set in Turkey's SAM for 2010. Table 3 exhibits a summary of previous CGE studies with a focus on energy market policy and reform.

In a simple economic setting, typical households use their income on consumption of goods and services, make savings, provide with factors of production, pay taxes to the government and receive transfers from government or firms. Firms utilize factors of production and intermediate inputs to come up with final output, invest, pay taxes to government and get involved in international trade (in the case of an open economy) through importing and exporting activities. And the typical government collects taxes, spends on goods and services, saves and invests. The standard features of the model (Armington assumption of imperfect substitutability between domestic goods and imports, CET aggregation between exports and domestic goods) can be followed from the list of equations in the Appendix.

The closure rules of the model are such that (i) government savings are flexible and all tax rates are fixed, (ii) government consumption is fixed as a share of GDP, (iii) the current account clears with floating foreign exchange rate while foreign savings are fixed, (iv) saving-investment balance is ensured by savings-driven closure, i.e., total investment equals total savings.

The core part of the model is the modeling of the electricity market. We make an assumption for power generation, distribution and state-run wholesale segments in the electricity industry, which are far from being competitive markets, but rather exhibit monopolistic market features in Turkey in the selected base year. As their costs do not necessarily reflect optimal allocation of resources, we multiply the share of value added to gross output for these sectors by

(1-χ), where χ indicates the *X-inefficiency* level for each sector and the gross output equation for these sectors (i.e. only for *j*= GENPU, TETAS, EDAS) becomes as follows:

$$Q_j = min\left[\frac{VA_j}{(1-\chi)\alpha VA_j}, \frac{V_1}{a_{1j}}, \frac{V_2}{a_{2j}}, \ldots, \frac{V_i}{a_{ij}}\right] \quad (1)$$

χ is assumed at 0.16 following Bagdadioglu et al. (2007).

$$VA_i = \gamma VA_i \prod_f F_{fi}^{\alpha_{fi}} \quad (2)$$

Increasing returns to scale are assumed for power generation and distribution segments in the power industry which exhibit natural monopoly features.

$$PF_{co}F_{co} = (1+\mu)\overline{\overline{PF_{co}F_{co}}} \quad (3)$$

where the index *c* refers to capital endowment – for both privately and publicly owned capital – and index *o* (for $o\epsilon i$ and *o* = GENPU, TETAS, EDAS) refers to electricity sectors. The left-hand side represents monopoly rent and capital endowment while the terms noted with bar on the right-hand side of the equation are perfect-competition rents and capital endowment levels. This condition is introduced to capture higher monopolistic markups for electricity sectors. Increasing returns to scale benefit producers with prices higher compared to competitive levels. Companies earn a mark-up over marginal costs (non-zero economic profit), expressed as *mu* in this equation. Following Akkemik and Oğuz (2011) we assume that the mark-up is10 percent.

Finally, given the considerable increase in trade volumes since liberalization policies were in place in Turkey in 1990s, elasticity of transformation between domestic sales and exports as well as elasticity of substitution between domestic sales and imports are both assumed to be high. Our selection of coefficient of elasticities for CET and Armington functions is made based on choices presented in Erten (2009). We assume that the elasticity parameter for CET function is 1.25 (which means elasticity is equal to -4) and that the Armington CES elasticity parameter is -0.67 (which means elasticity is equal to 3).[5]

5. Simulations

To analyze the impact of the electricity market reforms we run some simulations. In this section, we briefly describe the set of simulation exercises. A list of simulations is presented in Table 4.

5.1. Simulation Setup

The first set of simulations examines the impact of market liberalization, which is a major objective in Turkey's 2001 energy market law. On theoretical grounds, liberalization shall lead to less monopoly power to incumbent companies in the electricity market, which in turn results in higher efficiency gains. The policy shock to mimic liberalization is given through a reduction in monopolistic rent of capital owned by state-run power companies – namely, EUAS, TETAS and EDAS – by eliminating the monopoly mark-up (μ) which is set at 10%.

In the second set of simulations, we examine technical losses and inefficiencies. The ultimate objective of restructuring and privatization is to promote competition which in turn will drive firms to become more efficient. A key expectation from privatization of distribution companies is reduction in technical and theft losses. Private sector companies have inherited serious levels of theft losses in the electricity distribution segment (see Table 5) and will have to increase their operational and investment performance to lower these losses. The government has set targets for

[5] Sensitivity analysis was run on elasticity parameters, changing the CET and CES to -2 and 2 respectively from their values. No significant differences were displayed in simulation results when elasticities were changed, therefore, the model passing sensitivity tests.

the reduction of distribution losses for each 5-year period in concessionary contracts signed with private firms and the latter group will be able to keep any profits if improvements exceed these required minimum improvements, but will be kept accountable for losses if minimum requirements on the reduction of losses are not met. Technical and theft losses in the distribution segment are expressed in the form of state subsidies to distribution companies. In simulation 2.1, we inject a shock to mimic a 33% fall in distribution sector losses accompanied by a 5% rise in both public-sector and private-sector investment in the segment. Another aspect of reform is the increase in operational efficiency of state-run power companies, tested for all companies simultaneously (simulation 2.2) and only for EDAS (simulation 2.3). Given natural monopoly features for state-run distribution and transmission, their costs do not necessarily reflect optimal allocation of resources. Therefore, an X-inefficiency rate (χ) is attached to the value-added share of state-run power sectors in gross output as expressed in equation 5.8 in the previous chapter. χ is initially assumed at 16% following findings in Bagdadioglu et al. (2007).

The third set of simulations is about the establishment of organized power markets which would generate the right signals for the sectors and investors. This has been a key reform pillar since the new electricity market law in 2001 but the day-ahead market began full-scale operations in 2011. In 2010, the day-ahead market was in the planning phase with participants bidding. In the period 2010-2012, all participants except TETAS increased their sales volumes to the day-ahead market (PMUM). Independent private generators (IPPs) sales to PMUM rose by 46% to 36,807 GWh in 2012, which counts for 15% of Turkey's total power consumption in 2012. And private wholesale power trading companies' sales to the day-ahead market rose by 281% to 5,091GWh for the same period. EUAS and EDAS sales to PMUM also rose by 8% and 1% respectively. In the first scenario (3.1), we increase GENG and WHOLE sales to PMUM by fourfold, and in scenario 3.2 we increase GENG and TETAS sales to PMUM by fourfold. In scenario 3.3, we increase sales to PMUM of all GENG, TETAS, and WHOLE by fourfold.

Finally, in the fourth set of simulations, we examine how power market is affected by macroeconomic policy shocks. World oil prices have experienced a significant fall in the past couple of years, also weighing on natural gas prices whose levels are in general kept indexed to oil prices in long-term supply contracts (usually between states). In simulations 4.1, 4.2, 4.3, and 4.4, we reduce the domestic price of oil and gas by 20%, world price of oil and gas by 25%, domestic coal price by 20%, and world coal price by 25%, respectively.[6]

5.2. Simulation Results

All simulation results are presented in Table 6. In what follows, we discuss each of them in turn. We focus our attention on the macroeconomic results, specifically on GDP and Hicksian equivalent variation (EV) as the preferred measure of welfare, and where necessary we discuss the sectoral results as well.

Market liberalization

The results of the simulations about market liberalization (1.1, 1.2, and 1.3) suggest that simultaneous removal of monopolistic rent from the state-run electricity companies has a positive impact on the economy. GDP performs 0.35% higher when the markup (μ) is removed for all state-run power companies, compared to its baseline. GDP is reduced when μ is removed for only one or two state-run power companies at a time by 0.38% or 0.16%. The deviation of

[6] This simulation is inspired by shocks given in the PwC study on Turkish energy market reforms which suggests gas prices are likely to fall by 20% after the gas market is liberalized.

EV from the baseline is positive for all scenarios (1.1-1.3) which suggest households will benefit from a reduction in the monopolistic mark-up of power utilities. This result is straightforward, as the reduction in the mark-up has a direct impact on prices, enabling consumers to purchase the same service at a lower price.

Losses and X-inefficiency

In simulation 2.1 we find that the impact of reducing technical losses by 33% on GDP is positive, although marginal in magnitude, by 0.01% above its baseline. Almost all macro-variables are positively affected by the shock. Notably, government savings increase by 9.74% owing to the cut to subsidies provided to the distribution segment. Electricity is a political commodity as much as an economic one in Turkey (Oğuz et al., 2014), and the government has financed its losses in the power sector through cross-subsidization of costs, as regulated power prices for the final consumer are unique (Turkey has a single national tariff for power) regardless of the level of theft loss rates in various regions.

The impact of reducing X-inefficiency on GDP is positive, as expected in both scenarios (2.2 and 2.3) although very small in magnitude (0.004% and 0.006%, respectively). The deviation of GDP from the baseline is higher when X-inefficiencies are reduced only for distribution, rather than for all state-run segments simultaneously. The larger impact on GDP in scenario 2.3 suggests that addressing inefficiency issues in the distribution sector should be of uttermost importance for the economy, given power distribution's strong backward and forward linkages with other sectors. Households are the largest beneficiaries from improved operational efficiency for state-run electricity utilities, as private consumption is 0.41% above the baseline in both scenarios. However, the direction of policy impact in each scenario differs for private savings, which is below the baseline when X-inefficiency is removed for all state companies but it is positive when inefficiency is removed only for EDAS.

Establishment of Day-Ahead Market

In simulations 3.1 to 3.3 we examine the impact of quadrupling the sales of various segments of electricity supply to the day-ahead market (PMUM). When sales of state-run generation and wholesale trading segments (GENG and TETAS) to PMUM rise by fourfold, GDP turns 0.25% higher compared to the baseline. Interestingly, the impact on GDP is lower when sales of all four segments representing generation and wholesale trading quadruple their sales to the day-ahead market.

Another interesting outcome is the considerable impact of the expansion of the day-ahead market on private investment which is 20% higher when participation of private sector segments rises. Higher participation by state-run generation and wholesale to the market also affect private investments positively. Higher participation to the day-ahead market increases benefits to the economy. Expansion and deepening of organized markets will likely boost savings and investment both for private and public sectors. Higher participation of state-run segments to organized markets generates larger benefits for GDP compared to privatization (compare simulations 3.2 and 2.1).

The existence of state-run electricity companies may last for many years to come due to security of supply issues or the long-term nature of BO, BOT and TOOR contracts, including those signed for nuclear power supplies and for other political considerations. But this does not necessarily imply they will not improve efficiency by participating more in organized markets. On the other hand, increasing the market focus on shorter-term may not necessarily be good for the sector. Participants tend to avoid long-term commitments due to uncertainties still prevailing in the market. State-run companies have not made their pricing and/or production policies public yet, and regulated domestic power prices continue to be reviewed quarterly while natural gas prices monthly which makes longer term forecasts for companies and investors more difficult. Adding to these, it is still not clear how will the BOT and TOOR plants be managed once their concessionary contracts with the state expires.

Energy Price Shocks

When natural gas and oil is compared to coal, a cut in prices for the first two has a greater impact on the economy. Simulation results reveal that a 20% fall in domestic natural gas and oil prices leads to a rise in GDP 0.1% above its base level. While a fall in world gasoil prices by 25% has a negative impact on GDP, it encourages private consumption which is 1% higher than the baseline. For coal, any reduction in the price of this commodity has a positive impact on the economy but smaller in magnitude compared to the change in oil and gas prices. The results suggest that natural gas, oil and coal are vital commodities for households, businesses and the government, and they are well connected not only to electricity but also to other key sectors in Turkish economy such as the transportation services sector. Therefore, a decline in their prices leads to higher demand.

Due to regulated gas prices, a fall in world gas prices is not necessarily reflected on domestic gas prices in Turkey's energy market. Therefore, the outcome of simulation 4.1 suggests reform in the gas market aimed at increasing competition in organized markets that generate clear and transparent price signals. Where marginal cost pricing is in place, they will be beneficiary for Turkey.

6. Conclusion

This paper focused on the impact of power sector reform on the Turkish economy by using a CGE model with 2010 as the base year. The objectives of the electricity market reform in the first article of the electricity market reform is stated as the development of a "*financially sound and transparent electricity market operating in a competitive environment under provisions of civil law and the delivery of sufficient, good quality, low cost and environment-friendly electricity to consumers ...*".

Our major findings suggest that, electricity market reform had a positive impact on the Turkish economy. Market liberalization, introduction and expansion of the day-ahead market, demand management and higher share of the private sector in power generation are the reform elements that have the largest impact on the GDP. Full liberalization as operationalized by removing the mark-up for state-run utilities leads to a rise in GDP by 0.35% above the baseline. We also show that market liberalization is effective when applied for all state-run monopolies at a time. The finding is particularly important for the Turkish power market given that GENP, TETAS and EDAS are three well-connected structures and liberalizing just one of them shall not necessarily lead to competitive pressure for the other companies, therefore optimal results may not be achieved. Our findings also suggest that a larger participation in the day-ahead electricity market has a positive impact on the economy.

One policy implication of the findings is that the presence of state-run companies is not necessarily bad for the sector, and that when exposed to competitive market pressure, these companies are also forced to increase efficiency and offer a better performance. One real example of this is the case of UK's state-run nuclear utilities which failed to be privatized in

1989 when the country first launched its power market reform due to lack of interest. Remaining in public-sector hands did not stop these utilities to increase efficiency in the years following the reform.

The benefits of privatization and/or larger private-sector participation in network industries have been proven through decades since the liberalization wave started in the 1980s. Another important point from this simulation is to realize that the impact of a rise in private-sector generation in the generation mix on GDP could be equivalent to the impact of stronger participation by generation and trading companies in the day-ahead and potentially, other organized markets.

Another important finding is the positive impact that stronger demand-side participation has on the power sector and overall on the economy. The number of eligible consumers in Turkey has increased considerably in recent years as competition among providers pushes wholesale power prices on the downside. Moreover, the country mulls to fully eliminate the lower consumption limit for eligible consumers in coming years in a bid to reach 100% retail market openness. However, as experience in other countries shows, not all eligible consumers choose to switch providers. Therefore, policy makers should develop tools to promote a more active demand-side participation. Awareness campaigns and the launch of an online portal where verified tariffs offered by different suppliers can be compared are some examples.

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Appendix: Model Equations and Glossary

PRICES

Consumer prices	$(1 - salestax_i)PC_i \cdot CC_i = PD_i \cdot DC_i + PM_i \cdot M_i$
Import prices	$PM_i = \varepsilon \cdot PWM_i$
Gross output prices	$PQ_i \cdot Q_i = PD_i \cdot D_i + PE_i \cdot E_i$
Export price	$PE_i = \varepsilon \cdot PWE_i$
Value added price	$PVA_j = \left(1 - prodtax_j\right)PQ_j - \sum_i a_{ij}PC_i$
Consumer price index	$CPI = \sum_i cdshare_i \cdot PC_i$

PRODUCTION AND TRADE

Gross output	$Q_j = min\left[\frac{VA_j}{\alpha VA_j}, \frac{V_1}{a_{1j}}, \frac{V_2}{a_{2j}}, \dots, \frac{V_i}{a_{ij}}\right]$
Gross output (elec.)	$Q_j = min\left[\frac{VA_j}{(1-\chi)\alpha VA_j}, \frac{V_1}{a_{1j}}, \frac{V_2}{a_{2j}}, \dots, \frac{V_i}{a_{ij}}\right]$
Value added	$VA_i = \gamma VA_i \prod_f F_{fi}^{\alpha_{fi}}$
Intermediate demand	$V_j = \sum_i a_{ij}Q_j$
Factor demands	$PFD_{fi} \cdot \overline{PF}_f F_{fi} = \alpha_{fi} \cdot PVA_i \cdot VA_i$
Return to capital (elec.)	$PF_{co} \cdot F_{co} = (1 + \mu)\overline{\overline{PF_{co}F_{co}}}$
Output (CET) transformation	$Q_i = \gamma_i^Q \left[\beta_i^E E_i^{\rho_i^Q} + (1 - \beta_i^E)DC_i^{\rho_i^Q}\right]^{\frac{1}{\rho_i^Q}}$
CET funtion F.O.C.	$\frac{E_i}{DC_i} = \left(\frac{PE_i}{PD_i} \cdot \frac{1-\beta_i^E}{\beta_i^E}\right)^{\frac{1}{\rho_i^Q - 1}}$
Armington function	$CC_i = \gamma_i^{CC}\left[\beta_i^M M_i^{-\rho_i^{CC}} + (1 - \beta_i^M)DC_i^{-\rho CC_i}\right]^{-\frac{1}{\rho CC_i}}$
Armington F.O.C.	$\frac{M_i}{DC_i} = \left(\frac{PD_i}{PM_i} \cdot \frac{\beta_i^M}{1-\beta_i^M}\right)^{\frac{1}{1+\rho_i^{CC}}}$

INSTITUTIONS

Factor income	$YF_f = \sum_i PFD_{fi} \cdot \overline{PF_f} \cdot F_{fi}$
Total private income	$YH = YF_L - UNEMPAY + ETRH + GTRH + \varepsilon \cdot ROWTRH$
Unemp. benefit payments	$UNEMPAY = \overline{PF_L} \cdot UNEMP$
Household expenditures	$EH = CP + TRH$
Total private consumption	$CP = (1 - mps)(1 - incometax)YH$
Private consumption	$PC_i \cdot CP_i = cdshare_i \cdot CP$
Private savings	$SP + PSIG = mps(1 - inctax)YH$
Corporate income	$YE = (1 - corptax)\sum_c YF_c + GTRE + DDGPAY + \varepsilon \cdot ROWTRE$
Firms' transfers to households	$ETRH = YE - FDPPAY - ETRROW$
Firms' transfers to rest of the world	$ETRROW = etrrowshare \cdot YE$
Gov. income	$YG = \sum_i(prodtax_i \cdot PQ_i \cdot Q_i) + \sum_i(salestax_i \cdot PC_i \cdot CC_i) + UNEMPPAY + TRE + TRH + \varepsilon \cdot NOT$
Corporate tax revenues	$TRE = corptax \sum_c YF_c$
Income tax revenues	$TRH = incometax \cdot YH$
Gov. transfers to firms	$GTRE = gtreshare \cdot YG$
Gov. transfers to households	$GTRH = gtrhshare \cdot YG$
Aggregate gov. cons.	$CG = congshare \cdot GDP$
Gov. consumption	$PC_i \cdot CG_i = cgshare_i \cdot CG$
Private investment	$ID_i = idshare_i(IP/PC_i)$
Gov. investment	$IG = igshareGDP$
Public investment	$GID_i = gidshare_i(IG/PC_i)$

SYSTEM CONSTRAINTS

Labor endowment	$FS_L = \sum_i F_{Li} + UNEMP$
Capital market	$FS_c = \sum_i F_{ci}$
Composite goods	$CC_i = V_i + CD_i + CG_i + ID_i + GID_i$
Gov. balance	$SG = YG - CG - GTRE - GTRH - DDGPAY - FDGPAY$
Household balance	$YH = EH + SP + PSIG$
Gross domestic product	$GDP = \sum_i PC_i(CP_i + CG_i + ID_i + GID_i) + \sum_i(PE_i \cdot E_i) - \sum_i(PM_i \cdot M_i)$
Balance of payments	$(FDPAY + PDGPAY)/\varepsilon + \sum_i(PWM_i \cdot M_i) = ROWTRE + ROWTRH + NOT + SF\sum_i(PWE_i \cdot E_i)$
Saving - inv. balance	$PSIG = IG - SG - \varepsilon \cdot SF$

Glossary

Variables	
CC_i	Composite commodity
CG	Total government consumption
CG_i	Government consumption
CP	Total household consumption
CP_i	Private consumption
CPI	Consumer price index
D_i	Domestic sales
$DDGPAY$	Government's domestic debt payments
E_i	Exports
EH	Household expenditures
$ETRH$	Enterprise transfers to household
$ETRH$	Firms' transfers to households.
$ETRROW$	Net profit transfers to the rest of the world
FS_L	Labor supply
FS_c	Capital endowment
F_{ci}	Physical capital
F_{fi}	Factor endowment
$FDGPAY$	Government foreign debt interest payment
$FDPPAY$	Private foreign debt interest payments
GDP	Gross domestic product
GID_i	Public-sector investment
$GTRE$	Government transfers to firms
$GTRH$	Government transfers to households
ID_i	Private investment demand
IG	Aggregate public-sector investment
IP	Aggregate investment by private sector
NOT	Net outright transfers
PC_i	Price of composite commodity produced
PD_i	Price of domestic sales
PE_i	Export price
$\overline{PF_f}$	Economy-wide return to production factor *f*
PM_i	Imported goods price
PQ_i	Gross output price
$PSIG$	Private savings-investment gap
PVA_j	Price of value added
PWE_i	World prices of exported goods
PWM_i	World prices of imported goods
Q_i	Gross output
$ROWTRE$	Transfers from the rest of the world to firms
$ROWTRH$	Workers' remittances
SP	Private savings
TRE	Corporate tax revenues
TRH	Household's total direct tax payments to government
TRH	Income tax revenues (household income)
$UNEMP$	Involuntarily unemployed people in the labor force
$UNEMPAY$	Unemployment benefit payments
V_{ij}	Intermediate demand
V_j	Total intermediate demand
YE	Firms' income
YF_f	Aggregate income of factor *f*
YG	Government income
YH	Household income

Parameters	
α_{fi}	Share of factor *f* endowment in total value added
αVA_j	Share of total value added in gross output
β_i^E	Share of exports in total gross output
β_i^M	Share of imports in total composite commodity
γ_i^{CC}	Shift coefficient of the CES function
γVA_i	Shift parameter in value added function
γ_i^Q	Shift coefficient for the CET function
ε	Nominal exchange rate
ρ_i^{CC}	Elasticity coefficient for the CES function
ρ_i^Q	Elasticity coefficient
a_{ij}	Technology coefficient from input-output tables
$cdshare_i$	Share of sectors in total private-sector consumption
$cgshare_i$	Share of public-sector consumption in gov. consumption
$congshare$	Share of government expenditures GDP
$corptax$	Share of corporate tax payments in total operating surplus
$corptax$	Share of corporate tax payments to total operating surplus
$etrrowshare$	Share of net profit transfers abroad in firms' total income
$gidshare_i$	Shared of dectors in total public investment
$gtrhshare$	Share of state transfers to household in gov. revenues
$gtreshare$	Share of state transfers to firms in government revenues
$idshare_i$	The share of private investment in total priv. investment
$igshare$	Share of total public investment in GDP
$incometax$	Share of income tax revenues to total household income
mps	Marginal propensity to save
$prodtax_j$	Tax rate on production
$salestax_i$	Sales tax rate

Note: The sub-indices are as follows:
f: production factors: *KG*: state-owned physical capital, *KP*: privately-owned physical capital, *L*: labor)
i, *j*: production sectors
c: privately (*KP*) and publicly (*KG*) owned capital.

Figure 1. Growth rates of power demand and per capita real GDP

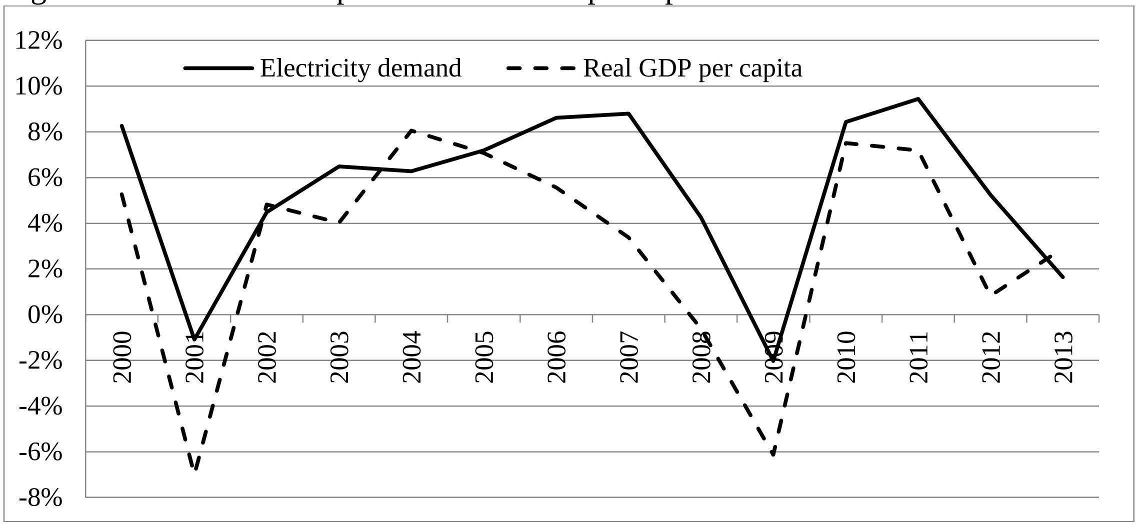


Figure 2. Generation mix: 2000 and 2014

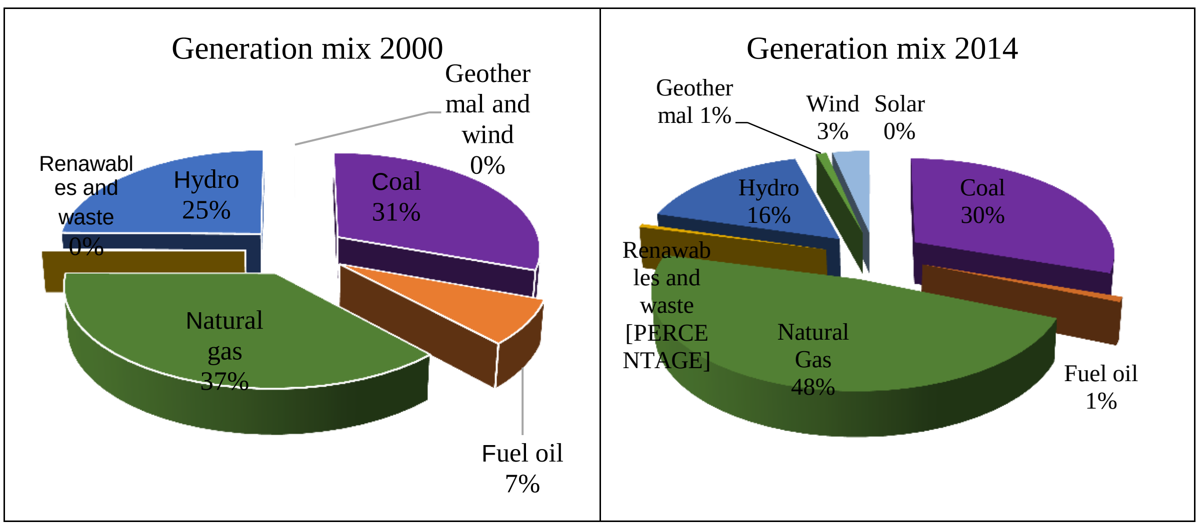
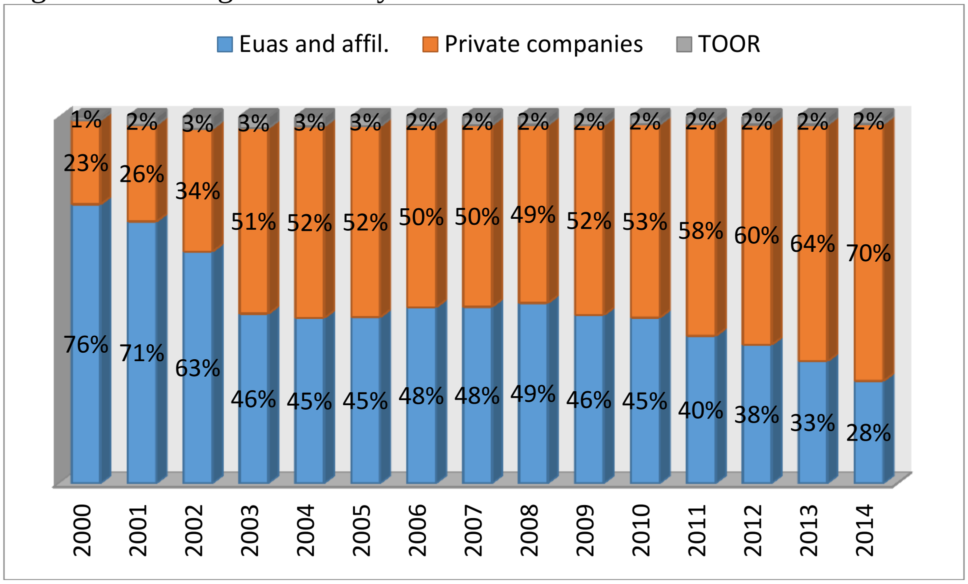
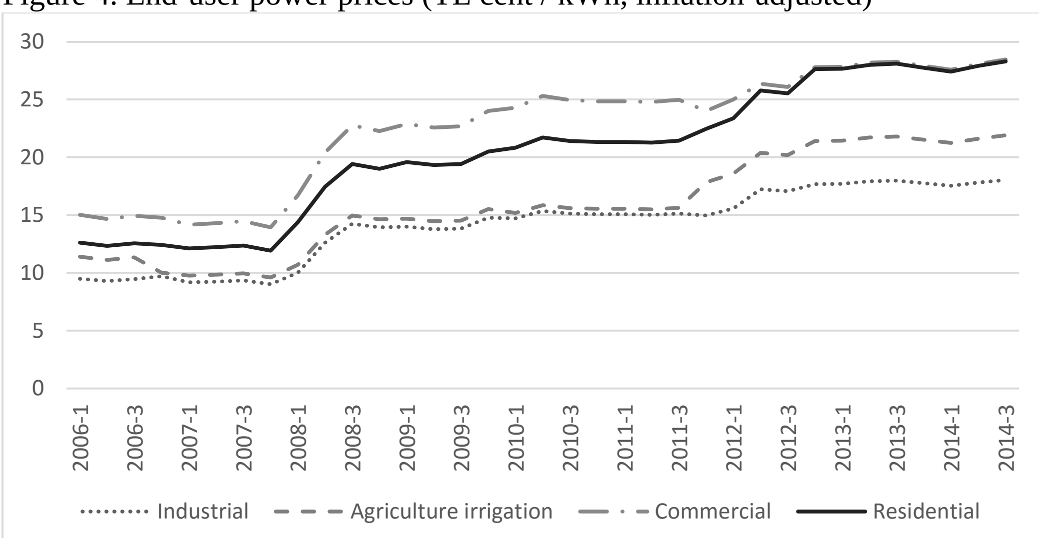


Figure 3. Power generation by institution



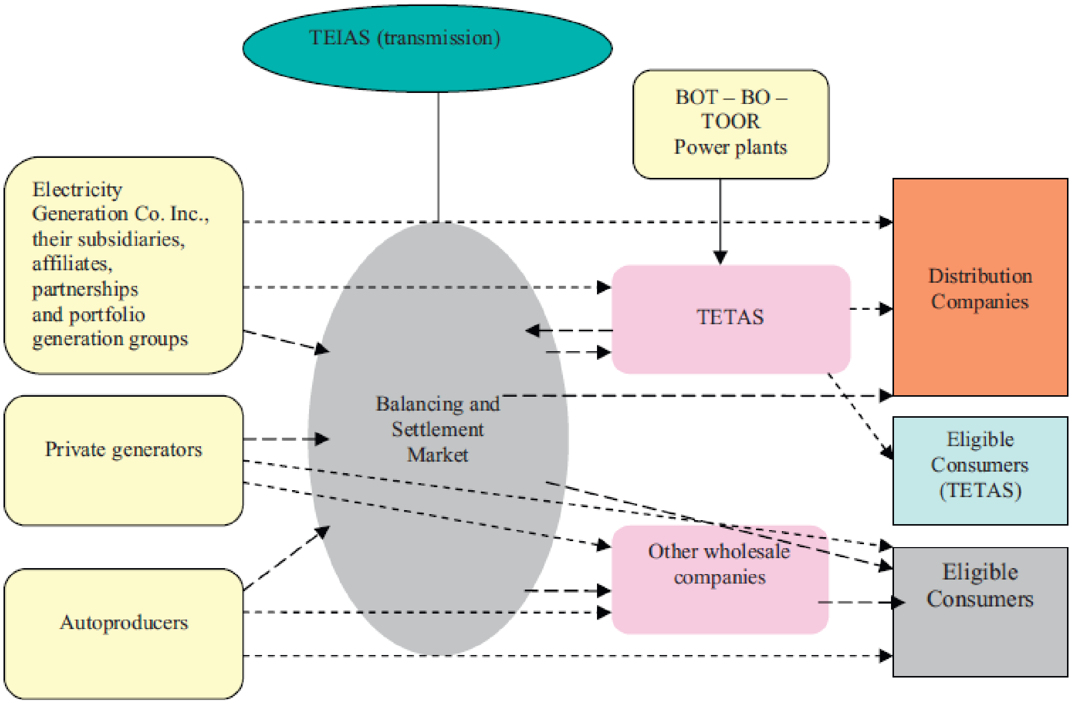
Source: TEIAS.
Note: TOOR refers to state-

Figure 4. End-user power prices (TL cent / kWh, inflation-adjusted)



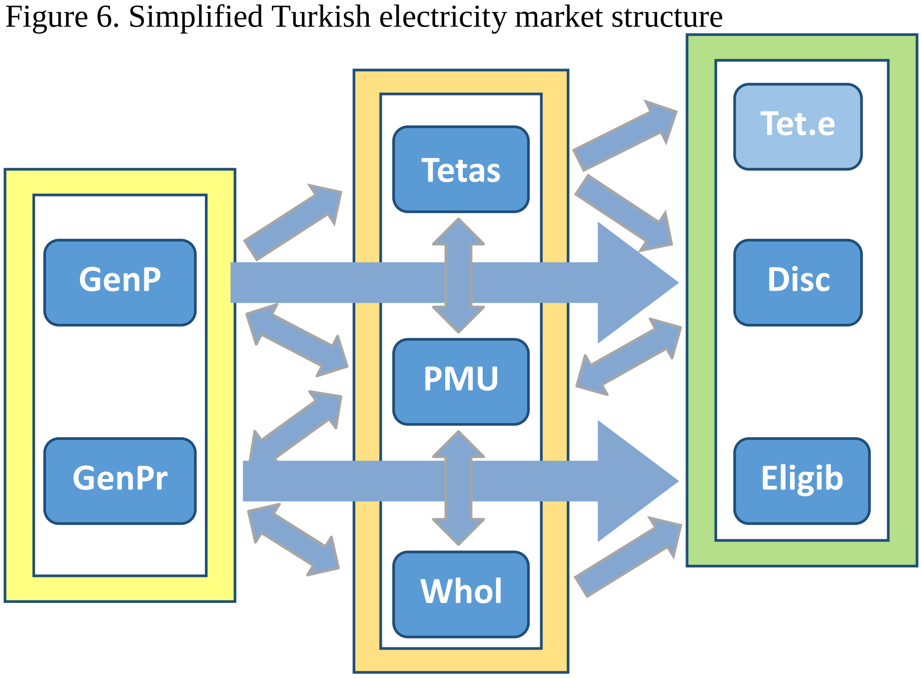
Source: EPDK, own calculations.

Figure 5. Structure of the Turkish electricity market



Source: Camadan and Erten (2011: 1327).

Figure 6. Simplified Turkish electricity market structure



Note: Abbreviations in the figure respond to the following: GenPu – public sector power generation; GenPriv – private sector power generation; TETAS – state-run wholesale company TETAS; PMUM – balancing and settlement market; Wholsl – private sector wholesale trading companies; Disco-s – distribution companies; Tet.elg.cons. – TETAS eligible consumers; Eligible cons. – Eligible consumers. Arrows show flows of transactions.

Figure 7. Production technology

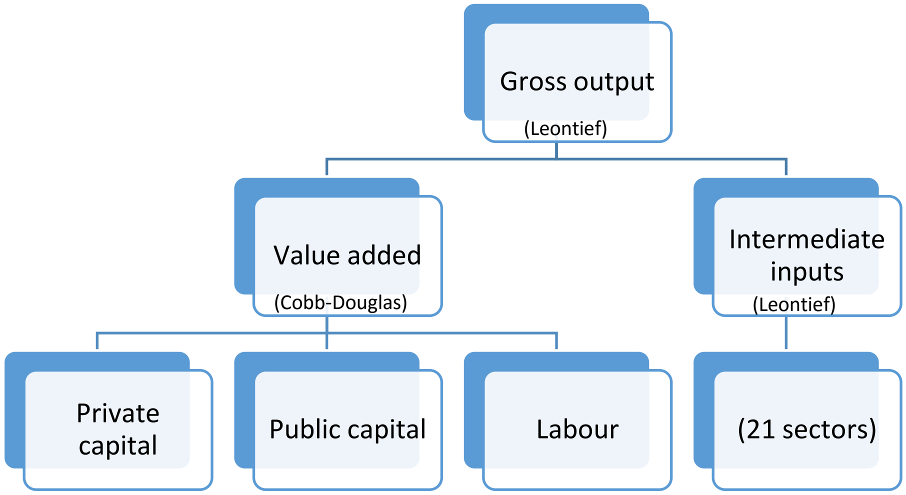


Table 1. Turkey macro-SAM (base year = 2010; million Turkish liras)

		1	2	3	4	5	6	7	8	9	10	11	*TOTAL*
1	Activities	-	1170958	-	-	-	-	-	-	-	-	231441	1402399
2	Commodities	532516	-	-	-	-	742588	-	75677	163076	48915	-	1562771
3	Labor	355336	-	-	-	-	-	-	-	-	-	-	355336
4	Public capital	434611	-	-	-	-	-	-	-	-	-	-	434611
5	Private capital	39484	-	-	-	-	-	-	-	-	-	-	39484
6	Household	-	-	337448	-	-	-	490704	93464	-	-	1490	923106
7	Enterprise	-	-	0	434611	39484	-	0	47965	-	-	1618	523678
8	Government	40453	90656	17887	-	-	69265	20925	-	-	-	885	240070
9	Public investment	-	-	-	-	-	163076	-	-	-	-	-	163076
10	Private investment	-	-	-	-	-	-51822	-	16982	-	-	83755	48915
11	Rest of world	-	301158	-	-	-	-	12049	5982	-	-	-	319189
	TOTAL	1402399	1562771	355336	434611	39484	923106	523678	240070	163076	48915	319189	0

Table 2. Sectors in Turkey's IO tables

1	AGR	Agriculture
2	TRAN	Transportation
3	ELEC	Electricity
4	COAL	Coal
5	GASOIL	Oil and gas
6	MET	Metals
7	CHEM	Chemicals
8	MINR	Minerals
9	MACH	Machinery
10	MIN	Mining
11	FOOD	Food
12	PAPR	Paper
13	CONST	Construction
14	TEXT	Textile
15	OIND	Other industries
16	SERV	Services

Table 3. Major policy findings from selected energy CGE models

Model	Focus	Model and data	Conclusions
Chisari et al. (1999)	Privatization of utilities in Argentina	Static CGE model	Efficient regulation is key for resource allocation and income distribution and benefits poorer groups more in relative terms compared to inefficient regulation.
Coupal and Holland (2002)	Power deregulation in Washington	Static CGE model	Deregulation reduces state GDP due to higher electricity prices.
Kumbaroglu (2003)	Environmental taxation in Turkey	Static CGE model. Tax revenues are used in public consumption.	Economy benefits apart from emission reduction from environmental taxation if imported fuels are the source of pollution.
Riipinen (2003)	Energy liberalization in the former Soviet Union	Multi-region, multi-country GTAP model	Internal liberalization of energy markets due to worsening terms of trade lead to losses. A rise in export capacity for oil and gas benefits all countries.
Kerkela (2004)	Distortions in Russian energy markets and price liberalization	Multi-region GTAP model	Subsidies in energy commodities cost 6.2% of GDP, more than half of the effect originates from gas. Regulated power and gas tariff hikes have modest, positive effect on GDP.
Madlener et al. (2004)	Energy conversion technology adoption under uncertainty in Turkey	Dynamic technology adoption model, evaluates irreversible investment options in power supply sector.	Gas technologies contribute positively to environmental sustainability but their impact on investment environment is not clear.
Hosoe (2006)	Deregulation in the Japanese power sector	Static CGE model. Electricity sectors are subject to increasing returns.	Removal of rate-of-return regulation leads to improved TFP, stronger power consumption and welfare improvement as high as 0.12% of GDP.
Küster et al. (2007)	Energy policies, labor market imperfections, technology specifications	CGE/MPSGE model	Subsidies for renewable energy lead to unemployment due to inefficiencies in the energy system.
Aydin 2010	Expansion of hydropower share in generation mix in Turkey	Dynamic CGE based on ORANI-INT model. Electricity generation is disaggregated to fossil fuel and hydropower generation.	The growth rates of real GDP, consumption and investment are higher by 0.14%, 0.13% and 0.07%, respectively. Expanding hydro benefits energy-intensive sectors. Carbon emissions fall by 0.012% per annum.
Lu et al. (2010)	Energy investment and emissions in Shaanxi province of China	2-region CGE model	GDP and household income increases by between 0 and 9%.
Akkemik and Oguz (2011)	Rate-of-return regulation in Turkey	Static CGE model. Electricity sector is disaggregated into three sectors and there are increasing returns to scale.	GDP increases by 0.53%, welfare increases by 1.08% of GDP if regulation is removed. Energy prices fall, efficiency gains in generation and distribution rise by 5.4% and 7.2%, inefficiency prevails in transmission.
PwC (2011)	Analysis of changes in Turkish energy sector prices and quantities	Static, multiregional GTAP model	GDP rises by 2.6% from a fall in gas prices due to liberalization. Higher employment, imports, lower exports.
Chen and He (2013)	Deregulation in power generation and retail sectors	Static CGE model. Electricity sector is divided to generation and transmission-distribution sectors.	Deregulation improves efficiency in power generation, increases employment and enhances household welfare.

Table 4. List of simulations

Simulation	Description
1.1	Remove *mu*=10%, for GENG, TETAS, EDAS
1.2	Remove *mu*=10%, for GENG, TETAS
1.3	Remove *mu*=10%, for EDAS
2.1	Technical and theft losses reduced by 33%, EDAS's investment up by 5%
2.2	Eliminate *chi* for GENG, TETAS, EDAS
2.3	Eliminate *chi* for EDAS
3.1	GENP and WHOLE sales to PMUM up by 400%
3.2	GENG and TETAS sales to PMUM up 400%
3.3	GENP, GENG, WHOLE and TETAS sales to PMUM up 400%
4.1	Domestic gasoil price falls by 20%
4.2	World gasoil price falls 25%
4.3	Domestic coal price falls 20%
4.4	World coal prices fall 25%

Table 5. Technical and theft loss ratios for distribution regions (%)

Region	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*
Akdeniz	9.7	9.4	9.3	8.3	8.5	9.8	11.3
Akedas	8.0	7.8	8.4	8.2	8.3	7.2	6.7
Aras	29.3	27.2	27.7	25.5	34.0	33.8	27.6
Aydem	7.4	11.9	10.3	8.7	8.4	8.0	7.6
Ayedas	9.1	8.7	7.5	6.9	6.9	6.9	7.6
Baskent	8.6	8.5	8.9	8.6	9.2	8.7	7.9
Bogazici	12.2	10.8	9.6	9.8	10.8	10.2	9.9
Camlibel	8.8	9.2	8.1	7.3	9.2	8.3	7.6
Coruh	12.0	10.6	11.4	11.6	11.2	10.2	9.4
Dicle	64.8	64.5	73.4	65.5	76.6	71.7	75.0
Firat	11.0	10.4	13.6	12.2	11.1	10.9	9.5
Gediz	10.2	7.5	8.9	8.8	8.8	7.8	9.7
Kayseri	11.1	10.3	10.7	8.7	7.1	6.9	6.9
Meram	8.3	8.8	9.0	9.6	8.9	9.0	7.1
Osmangazi	6.3	5.6	6.8	9.1	7.1	7.2	7.9
Sedas	6.5	7.6	8.0	6.4	7.0	7.1	6.6
Toroslar	10.6	9.9	9.8	8.9	13.8	13.2	15.2
Trakya	7.6	7.2	7.1	6.8	8.3	6.5	6.1
Uludag	8.6	7.5	7.3	7.4	8.9	7.3	7.0
Vangolu	56.2	55.9	55.6	57.2	59.1	59.1	65.8
Yesilirmak	9.1	9.2	10.9	12.9	7.8	7.3	10.5

Source: Ministry of Energy. These were made available on a parliamentary hearing of the ministry of energy. Document available at http://www2.tbmm.gov.tr/d24/7/7-42589c.pdf (accessed in December 2015)

Table 6. Macro-economic impacts of the simulations

	Simulations												
	1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	4.1	4.2	4.3	4.4
GDP	0.35	-0.16	-0.38	0.01	0.00	0.01	0.07	0.25	0.14	0.10	-0.43	0.02	0.02
Equivalent variation (EV)	0.03	0.05	0.10	0.07	0.07	0.07	-0.58	0.03	0.00	0.16	0.13	0.04	0.06
Government consumption	0.35	-0.16	-0.38	0.01	0.00	0.01	0.07	0.25	0.14	0.10	-0.43	0.02	0.02
Private consumption	0.19	0.29	0.64	0.41	0.41	0.41	-3.55	0.21	-0.03	0.97	0.81	0.23	0.40
Government investment	0.35	-0.16	-0.38	0.01	0.00	0.01	0.07	0.25	0.14	0.10	-0.43	0.02	0.02
Private investment	-2.70	1.14	-1.98	0.48	0.49	0.48	21.94	6.18	6.38	3.79	4.51	2.03	0.55
Government savings	1.38	2.20	3.07	9.74	1.64	1.63	8.43	12.00	11.40	1.70	4.38	1.05	1.60
Private savings	4.31	1.19	1.65	-0.86	-0.49	0.31	1.65	1.65	1.65	1.04	1.65	0.96	-0.43
Unemployment	2.01	3.09	3.71	0.73	0.73	0.73	2.11	2.28	4.74	4.52	3.51	2.44	0.80
Exchange rate	-0.01	1.75	1.76	0.00	0.00	0.00	-3.65	-2.74	-2.90	1.20	0.00	0.00	0.00

Note: The figures in the table are percentage changes from the baseline solution. See Table 4 for the descriptions of the simulations.