How Power Investments Contribute to Jobs and Economic Growth in Turkey

Final Report

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steward redqueen

How Power Investments Contibute to Jobs and Economic Growth in Turkey.

Commissioned by IFC to Steward Redqueen and funded by the Let's Work Partnership.

Redacted Version

1. The Executive Summary and report of the Evaluation entitled *'How Power Investments Contibute to Jobs and Economic Growth in Turkey'* has now been redacted for public disclosure in accordance with IFC's 2012 Access to Information Policy, following the Procedure for Development, Management and Disclosure of IFC Evaluations effective on January 20, 2016.

2. The attached redacted version reflects the following adjustments:

- Redaction of sensitive or confidential information related to financial and proprietary information shared by and used with the consent of IFC clients (e.g. revenues and profits, GHG emissions). This information was originally used in the estimations of economic effects of specific investments.

3. The redacted version was reviewed by Steward Redqueen to ensure that their views, estimations, and assessment are adequately reflected as originally intended.

4. The redacted version will be disclosed to the public in March, 2017. The document will be available on www.ifc.org.

5. Questions on this document should be addressed to Evgenia Shumilkina (eshumilkina@ifc.org) and Hayat Abdulahi Abdo (habdo@ifc.org).

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For IFC

Executive Summary

This study sets out the pathways through which improvements in the availability, affordability and reliability of electricity supply impact on businesses and households. Specifically, it evaluates whether IFC investments into power generation and distribution have helped sustain jobs and incomes in Turkey.

IFC is supporting private sector investment in the power sector in Turkey. The organization has exposure both in power generation and distribution. Since 2008, it has provided USD 1,816 million in (A, B and C) loan capital and invested USD 170 million equity capital. A total of USD 1,666 million loan capital went to four generation companies (Enerjisa Enerji, ACWA, Akenerji, and Rotor Elektrik) while the entire equity investment was made into a sixth generation company (Gama Enerji). The distribution company SEDAS received USD 150 million loan capital (and an additional USD 90 million sourced from international banks). IFC has financed plants with a total installed capacity of 6,109 MW of which 3,053 MW are currently operational and the remainder is under construction.

Methodology

The methodology we used in this study to estimate the economic impact of improvements in the electric power sector in Turkey largely follows the one developed during our previous study in the Philippines. In these studies we analyze the current power supply and demand situation in a country and then construct a counterfactual situation of what would have happened had IFC not invested in power capacity. In this way we calculate the changes in electricity price, GDP and employment relative to a hypothetical case in which IFC-invested projects were not realized. Compared to the study in the Philippines, we expand the framework for Turkey to capture the impacts on more economic sectors (besides manufacturing) and to investigate the effects of investments in electricity distribution. The composite methodology developed in this research project consists of:

1. Econometric and statistical analysis of the existing data sources to quantify how power availability (outages) and affordability (price) affect economic output;
2. Construction of an electricity price model based on the observed supply and demand information in Turkey for 2015 and construction of a hypothetical counterfactual in which IFC investments have not taken place;
3. Construction of an economic input-output model with which the effect the electricity price changes on economic output, GDP and employment can be estimated; and
4. Investigation of the specific contribution of one generation company (Enerjisa) and one distribution company (SEDAS) to jobs and incomes, and the contribution of IFC.

The input-output model used to trace the effect of economic output changes associated with changes of power outages and price, relies on a number of well-documented assumptions.

Headline results

The main findings of this research are:

1. IFC has played an important role in Turkey's energy market privatization.
    - IFC has financed plants with a total installed capacity of 6,109 MW of which 3,053 MW are currently operational, representing 4.4% of the country's operational capacity;

- IFC attributable generation capacity in operation, based on the amount invested is 926MW, or 1.3% of total capacity in operation in the country in 2015. This number will increase to about 2.0% once all financed power plants are operational;

2. The average outage time in Turkey is relatively low and there is no strong evidence that outages have reduced further since IFC's involvement in the electricity sector;
3. The addition of IFC's attributable capacity to Turkey's power fleet has led to an estimated 4.79% - 1.73% lower market clearing generation price in 2010 and 2015 respectively, compared to a hypothetical situation in which IFC-financed capacity was not realized. This translates into comparatively lower end-user tariffs of 3.55% in 2010 and 1.28% in 2015. The reason that the impact has decreased over the period 2010-2015 is that power generation capacity has expanded so much that Turkey currently faces a situation of high reserve margins. When considering the impact of all IFC-financed capacity without attribution, the 2015 clearing price decrease is 5.38%, corresponding to a 3.99% drop in end-user tariff. Simulation of the 2010 situation without IFC attribution is not possible because removing all IFC-financed generation capacity would result in observed system loads higher than the cumulative power supply, meaning that without it Turkey would have faced a power generation deficit;
4. Compared to the counterfactual situation, the IFC-attributable lower electricity cost for companies resulted in:

    - An estimated increase of GDP of USD 178 million (2010) and USD 64 million (2015), or between 0.03% and 0.01%;
    - An estimated 14,390 jobs sustained (0.05% of the labor force) in 2010 and 5,195 (0.02%) in 2015 and 14,390 jobs. Of these jobs an estimated 29% were for women and 23% for skilled workers;

    These results are the amalgamate of an increased GDP contribution by electricity consumers which are partially offset by a decrease in GDP in the electricity sector due to the lower prices;
5. When IFC attribution is not taken into account, the estimated GDP increase is USD 200 million (0.03%) and the number of sustained jobs is 16,159 (0.06%) in 2015;
6. When expressed as average multipliers for the period 2010-2015, every 1% increase of generation capacity causes a 2.43% decrease of electricity generation cost, a 0.014% increase in GDP and a 0.025% increase in employment;
7. The corresponding GDP and employment multipliers found in the Philippines study (2015) were higher: 0.091% and 0.085% respectively. The two main reasons for this are the larger electricity factor shares of companies in the Philippines and a higher electricity price elasticity;
8. IFC's investments in Enerjisa had both forward and backward effect on the Turkish economy:

    - The capacity addition of Enerjisa resulted in a 4.03% - 11.59% lower generation cost in Turkey, compared to a situation in which IFC-funded projects were not realized. This is associated with a USD 150 m – 432 m higher GDP (0.02%-0.07%%), 12,100 – 34,800 jobs sustained (0.04%-0.12%);
    - Project development expenditures of Enerjisa made possible due to IFC's investments are estimated to have contributed the economy by USD 105 m and 17,800 man-year (i.e. short-term) jobs on average between 2007 and 2016;
9. Financing by IFC enabled SEDAS to reduce losses and invest in network improvements:

    - Loss and theft (L&T) ratio reduction from 7.0% to 6.7% since 2011 enabled annual increase in electricity distribution of 29.1 GWh;
    - SEDAS actual and planned investments between 2011 and 2020, on average, are estimated to contribute USD 28 m and 1,642 man-year jobs for the period 2011-2020.

IFC portfolio impact	With IFC attribution			Without attribution
	2015	Average	2010	2015
Δ Market clearing generation price	-1.73%	-3.26%	-4.79%	-5.38%
Δ End-user tariffs	-1.28%	-2.42%	-3.55%	-3.99%
Δ Value added				
USD million	64	121	178	200
% GDP	0.01%	0.02%	0.03%	0.03%
Δ Employment				
Number of jobs	5,195	9,791	14,390	16,159
% Labor force	0.02%	0.03%	0.05%	0.06%

Recommendations

Based on the results and the current state of the power sector we make three recommendations:

1. Turkey currently faces a situation of high reserve margins and low power prices associated with them. With a significant number of power plants planned or under construction and demand growth slowing, the situation is likely to persist for some time. This may weaken the attractiveness of investing in the Turkish power sector. But at some point in time additional generation capacity will be required. IFC should therefore monitor supply and demand trends to see whether it can serve as a catalyst in case the market risks to 'undershoot' needed investments;
2. Related to the first recommendation, Turkey is planning to substantially expand its coal generation capacity to be used with local lignite and coal resources in order to reduce its dependence on imported gas. This will drastically increase the country's greenhouse gas emissions. It remains to be seen whether banks will underwrite these projects because of the risk that coal plants become stranded assets. But given its very small installed based, huge potential, decreasing costs, and (currently) attractive feed in tariffs, (small and large scale) solar generation may be a medium-term opportunity for IFC to help green Turkey's power generation while reducing its import dependence;
3. Unlike IFC client SEDAS, a number of distribution companies in other regions in Turkey still face high technical and non-technical losses as well as power outages. Given the negative impact that power outages have on private sector output in general, IFC could potentially increase its development impact by exploring financing opportunities in these distribution companies.

1 INTRODUCTION

The absence of reliable, adequate and affordable power is recognized as one of the main barriers to broad-based economic growth and social development. Poor and/or expensive electricity supply stifles economic activity by reducing productivity and hampering the development of industry and trade which are important drivers of employment and growth.

Since the 1970s, the Turkish energy market has undergone a major transformation. The country unbundled and (mostly) privatized its vertically integrated state-owned energy companies. Contributing to Turkey's transition to a liberalized energy market, IFC has made investments in privately owned power generation and distribution companies in Turkey. Investments include financing of renewable energy and energy efficiency projects. Based on deal value IFC's investments represent 1.3% of capacity in operation.

The objective of this project is to assess the impact of IFC's investments in power generation and distribution on employment and economic growth in Turkey, both at the macro and micro level. By doing so we aim to contribute to the understanding of how improvements in the power availability and affordability affect development across economic sectors and actors. The theory of change and previous research indicate that a stronger physical infrastructure, in particular in the power sector, has an important impact on economic development for shared prosperity and poverty reduction through different channels including improvements in energy efficiency and reliability of power supply, acceleration of structural transformation, improved labor market mobility and flexibility, promotion of female labor participation, and acceleration of productivity growth in both formal and informal enterprises. While the authors acknowledge the role of power in the broader context, this report focuses specifically on the impact of the recent IFC investments on employment and economic growth in Turkey.

1.1 Structure of this Report

This report is structured as follows:

- Section 2 describes some macro-economic characteristics of Turkey and includes an overview of the power sector and details of the energy and electricity intensity of the economy;
- Section 3 discusses IFC investments and the proposed attribution methodology;
- Section 4 contains a high-level overview of academic literature on the relationship between economic growth and the use of electric power. Based on this review a framework is proposed for the analysis of the economic impact of electricity in Turkey;
- Section 5 outlines the analysis steps taken in the study, including the construction of an integrated price model; and an analysis of the response of the economic sectors to changes in effective electricity price;
- Section 6 describes two case studies: Enerjisa (power generation) and SEDAS (distribution);
- Section 7 summarizes the main conclusions and implications.

1.2 Acknowledgements

The report was led by Evgenia Shumilkina (Results Measurement Specialist) and Hayat Abdulahi Abdo (Senior Strategy Officer). The study was supervised by Ana Maria Torres-Soto (Senior Results Measurement Specialist), Camillo Mondragon-Velez (Senior Research Officer) from the Development Impact Unit, and Omar Chaudry, Head Strategy and Finance Unit.

In addition to IFC staff which lead and facilitated this project, we would like to acknowledge some people in particular for their contribution to this report:

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The funding and the guidance for this project was provided by the Let's Work Global Partnership.

2 Economy and electric power profile

2.1 Macro-economic profile

Turkey is the 17th largest economy in the world and is in close proximity to one of the largest consumer markets, the EU. Turkey's demography, economic growth, large domestic market and location, have caused it to be included in the moniker MINT group (together with Mexico, Indonesia and Nigeria) thereby recognizing its potential as one of the next economic powerhouses. Since 2003, Turkey enjoyed strong and non-inflationary growth for a decade at an average rate of 7% (Exhibit 1). In recent years, however, economic growth has slowed significantly, with the global recession revealing structural problems within the Turkish economy, especially an overreliance on foreign investment which renders the country sensitive to external shocks. The country currently faces a high current account deficit, high inflation (which reduces its competitiveness), low export growth and sharply decreased foreign direct investment (FDI). Issues identified as having contributed to the slowed and mercurial economic growth, are Turkey's fiscal policy, labor market, and education sector[1].

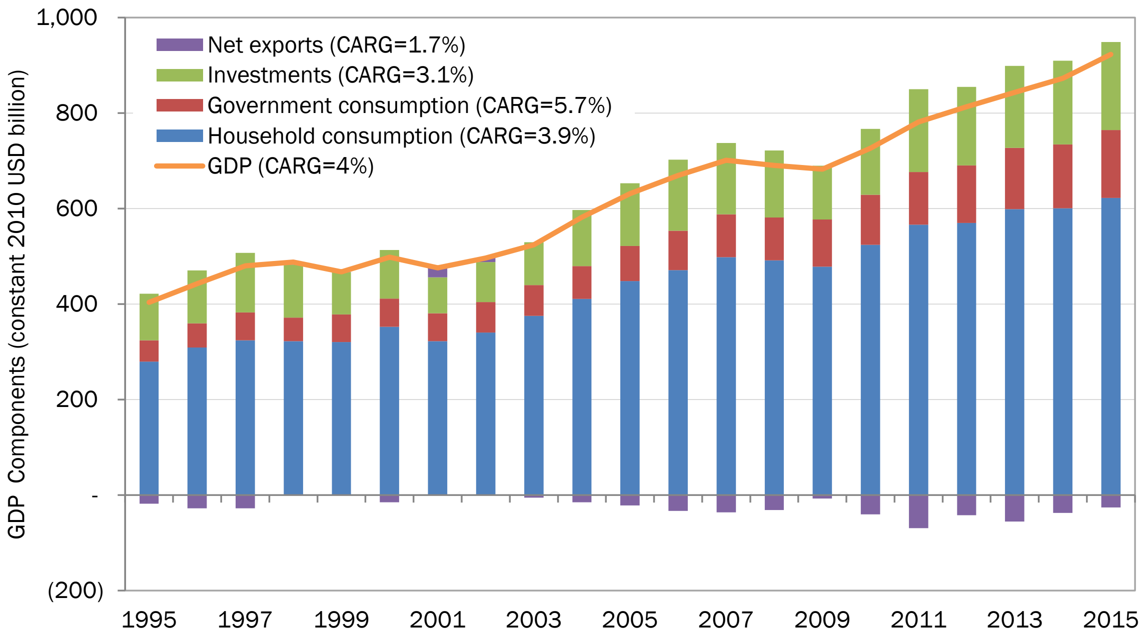

Exhibit 1: GDP breakdown per component
(Source: World Bank Development Indicators)

Yet despite the structural problems, political turbulence and security threats from both within and outside of its own borders, the Turkish economy grew by 4% in 2015. Of the group of the 20 biggest economies, its GDP growth was surpassed only by China, India and Indonesia. Growth in late 2015 was primarily driven by short term changes such as higher private consumption due to real wage growth, low oil prices and depreciation of the lira. Turkey is heavily reliant on foreign fuel and the recent drop in oil prices reduces external imbalances and narrows the negative current account deficit. A depreciating lira, caused by the termination of quantitative easing in the US[2], unpredictable domestic politics, and lackluster economic figures, is reducing imports and improving export growth. However, in the long term, a weakening lira will continue to stoke an already high rate of inflation.

[1] IMF Staff Report (2014) http://www.imf.org/external/pubs/ft/scr/2014/cr14329.pdf

[2] The higher interest rates in the US are diverting funds from emerging markets back to the US.

Over the past 20 years, the country has continued its transition towards an industrialized economy dominated by the manufacturing and services sectors (Exhibit 2). The services sector in particular has experienced a strong growth since 1995, led by an increasingly important financial sector. The construction sector has been integral to Turkey's recent economic development: transforming infrastructure, the urban landscape, and providing approximately 10% of employment. The construction sector's growth, in line with overall GDP growth, has been driven by a large number of government-backed infrastructure developments and increased demand for housing. Turkey is also a leading producer of construction iron and the production of basic metals makes. The steel sector makes up approximately 10% of Turkey's manufacturing sector and has grown steadily in the past years. Other large and growing manufacturing industries are the manufacture of food, production of motors and transport equipment, and manufacture of electrical equipment. In contrast, the relative size of the textiles and apparel industries in terms of manufacturing production value has fallen from more than 20% to approximately 14% of manufacturing GDP, due to lower demand and competition from lower wage countries.

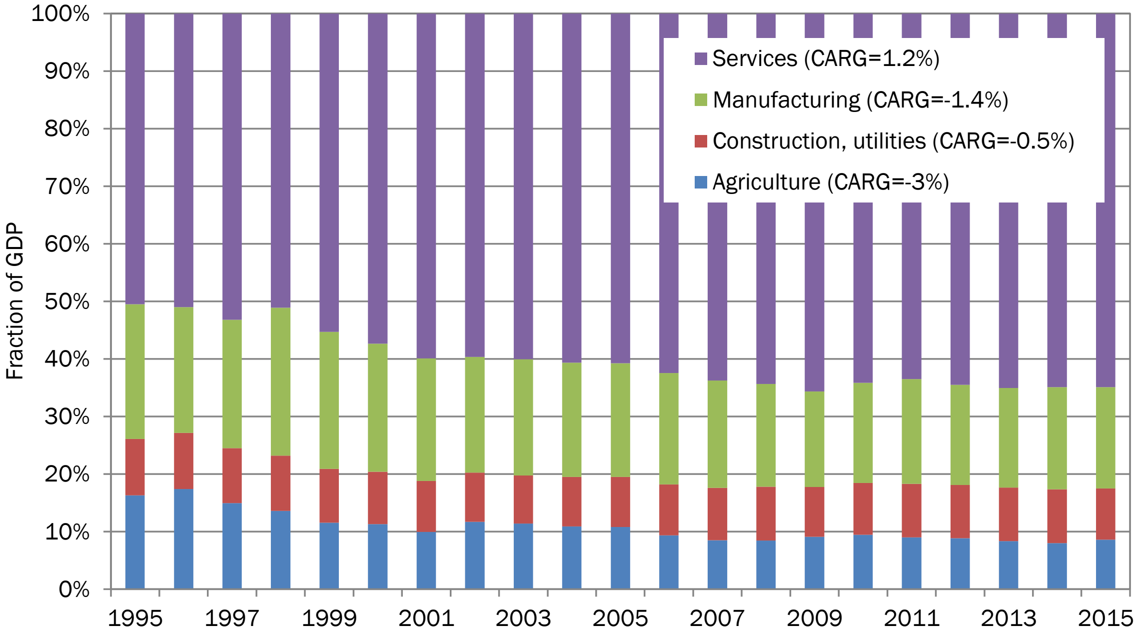

Exhibit 2: GDP breakdown per sector
(Source: World Bank Development Indicators)

Historically, trade has been an important part of the Turkish economy due to its strategic geographical location. Although trade has reduced in recent years, exports still constitute 28% of GDP. The slowing trend in exports over the past few years is linked to the slump in the global business cycle and in particular the sluggish economic environment of the EU, which accounts for 40% of Turkey's trade and approximately three quarters of FDI into the country. The Turkish export basket is largely made up of manufactured goods such as household appliances, textiles, machinery, and iron and steel products. Despite the relative decrease in size of the textile and apparel industry, Turkey is the 8th largest textile and 7th largest clothing exporter in the world.

The loss in momentum of Turkey's economic growth has led to fears that Turkey has fallen into the middle income trap, whereby it is unable to sustain its high growth rate and join the ranks of high income countries. The high growth rate diminishes as the comparative advantage that Turkey has in labor-intensive commodities reduces due to a decline in surplus labor and an increase in real wages. In order to continue to add value, the economy and labor force must be equipped with capabilities to produce knowledge and innovation intensive commodities that can compete with wealthy high-skilled manufacturing countries such as Germany.[3] However, as shown in Exhibit 3, Turkey's high-tech manufactured goods exports are small and do not grow.

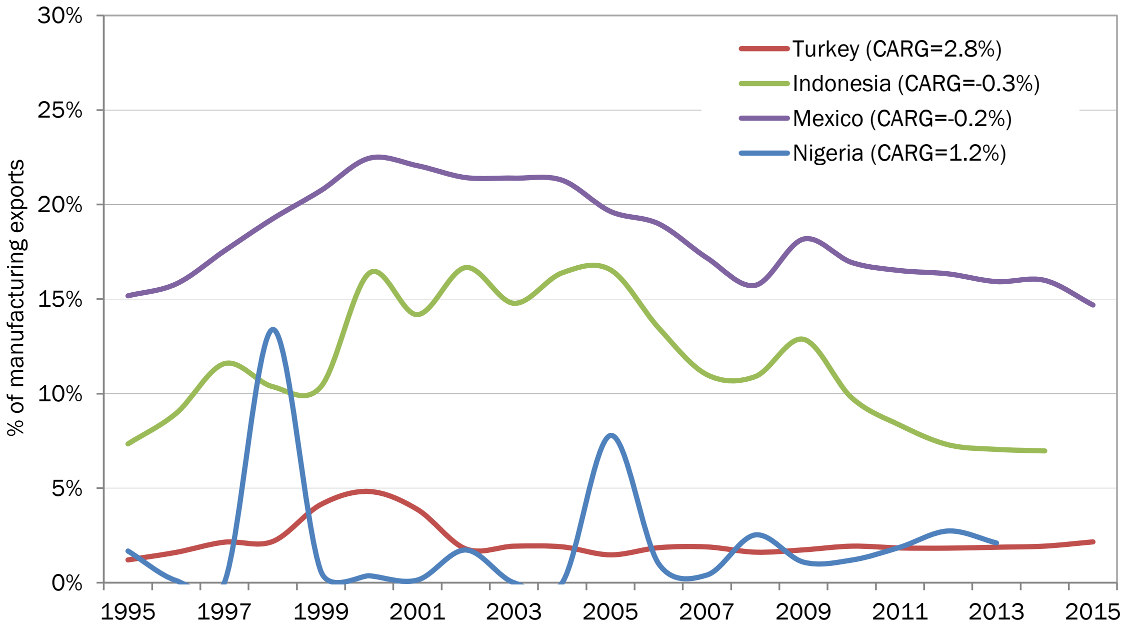

Exhibit 3: Share of high-tech manufacturing exports
(Source: World Bank Development Indicators)

Gross fixed capital formation hovers around 20% of GDP, slightly below peers like Mexico and Indonesia. On average, FDI as a percentage to GDP in emerging market G-20 countries in 2013 was approximately 2.5% compared to 1.6% of GDP in Turkey. However, infrastructure projects and privatizations are acting as catalysts for foreign investors. These developments include renewable energy incentives, and the proposed privatization of portions of the Istanbul stock exchange, the natural gas distribution company, and insurance and pension companies[4].

[3] The Economist, 2016, Erdoganomics. http://www.economist.com/news/special-report/21689874-turkey-performing-well-below-its-potential-erdoganomics

[4] Financial Times, 27 November 2014, Comment: Foreign capital could be the answer to Turkey's debt woes

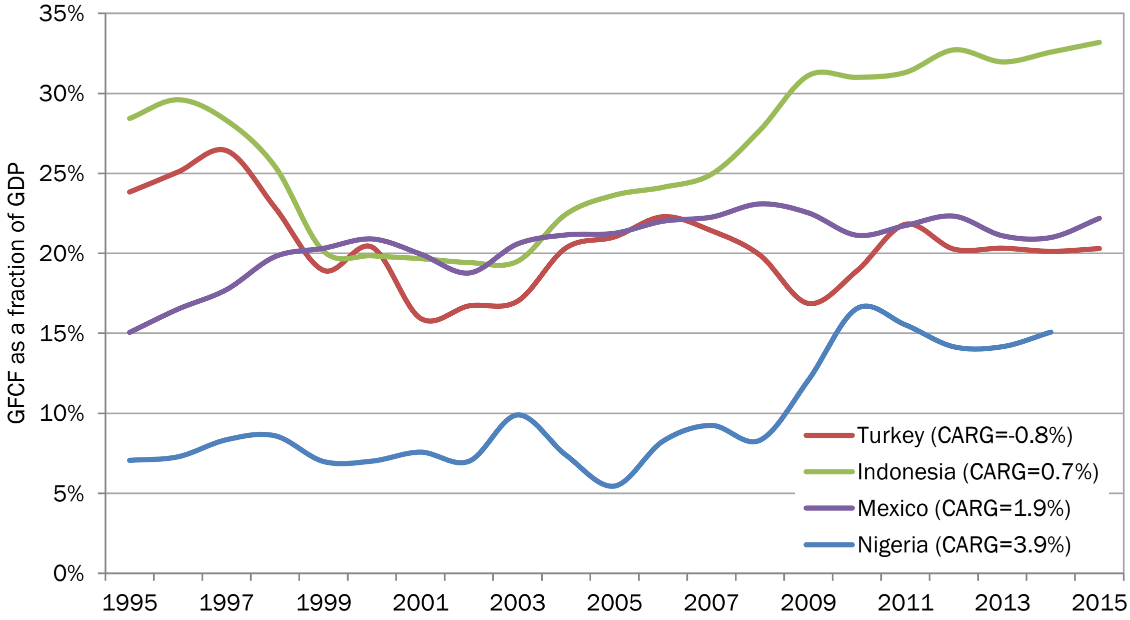

Exhibit 4: Gross Fixed Capital formation (GFCF) as % of GDP
(Source: World Bank Development Indicators)

According to the World Bank Ease of Doing Business ranking, Turkey scores below comparable economies with an overall rank of 55 out of 189. The global financial recession and problematic regional and domestic political issues, including the overspill of insecurity from both Syria and Iraq, and a reignited dispute with Kurdish nationalists, have led to a decrease of investments in the country.

The Turkish labor force is large but low educated. The overall employment rate in 2014 was 50%, well below the OECD average of 65.5%. Whilst the labor force is growing, the level of employment has stagnated (Exhibit 5). The rate at which jobs are created in Turkey is not high enough to absorb the growth of the labor force. In 2015, there was a sharp decline in overall job creation due to large employment reductions in the industry sector, despite growth in both the services and construction sectors. Low employment is particularly an issue amongst women and young adults. In 2015, the overall unemployment rate was 10.1% and among the youth 18.5%, both of which are above OECD average. A challenge for Turkey will be the high demographic pressure on the labor market exerted by a large young population. A major issue remains the level of education in general and especially for women: 78% of the female working-age population has less than a high school diploma.

Turkey has a human development index rank of 72. The economic development that Turkey has enjoyed this past decade has been distributed relatively equally. Between 2002 and 2012 extreme poverty fell from 13% to 4.5% and the consumption rate of the 40% poorest people increased at approximately the same rate as the average consumption rate.

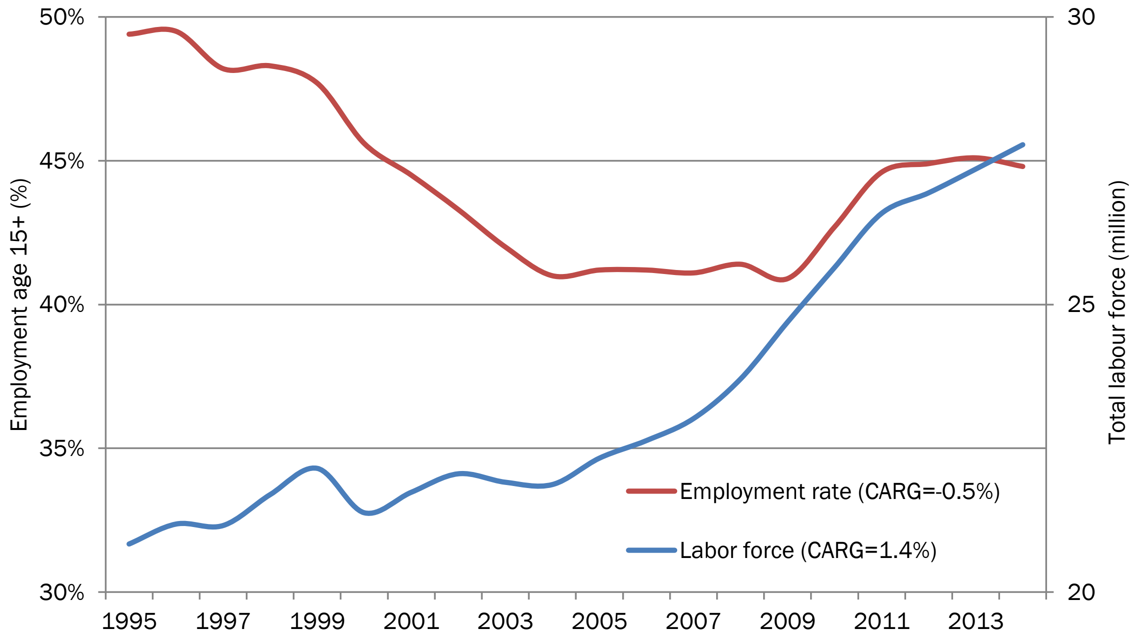

Exhibit 5: Employment and labor force growth
(Source: World Bank Development Indicators)

2.2 Macro-economic energy and electricity intensity

Turkey's total energy consumption in 2014 was 85,915,800 tons of oil equivalent (t.o.e.). The per capita energy use was 1,546 kg oil equivalent (kg.o.e) in 2013. As shown in Exhibit 6, most energy is consumed by the industrial sector. Energy consumption in the agricultural sector and by households has decreased, whilst the services sector has shown a strong increase in relative energy consumption.

Much of Turkey's electricity supply comes from fossil fuel-fired power plants. But the government has been pursuing policies to develop the renewable energy market and reduce the dependence on imported gas. In order to transition effectively to renewable energy, investments are needed to make the power grid more flexible. The growth of the Turkish economy has been accompanied by growth in electricity consumption (Exhibit 7).

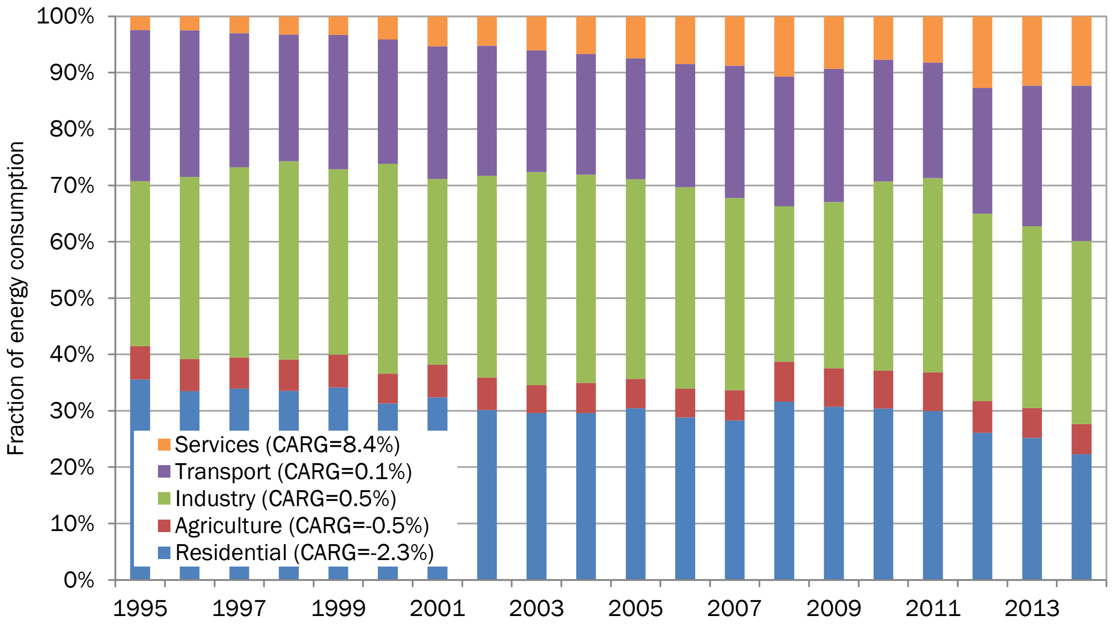

Exhibit 6: Breakdown of energy use in Turkey by end user
(Source: Eurostat)

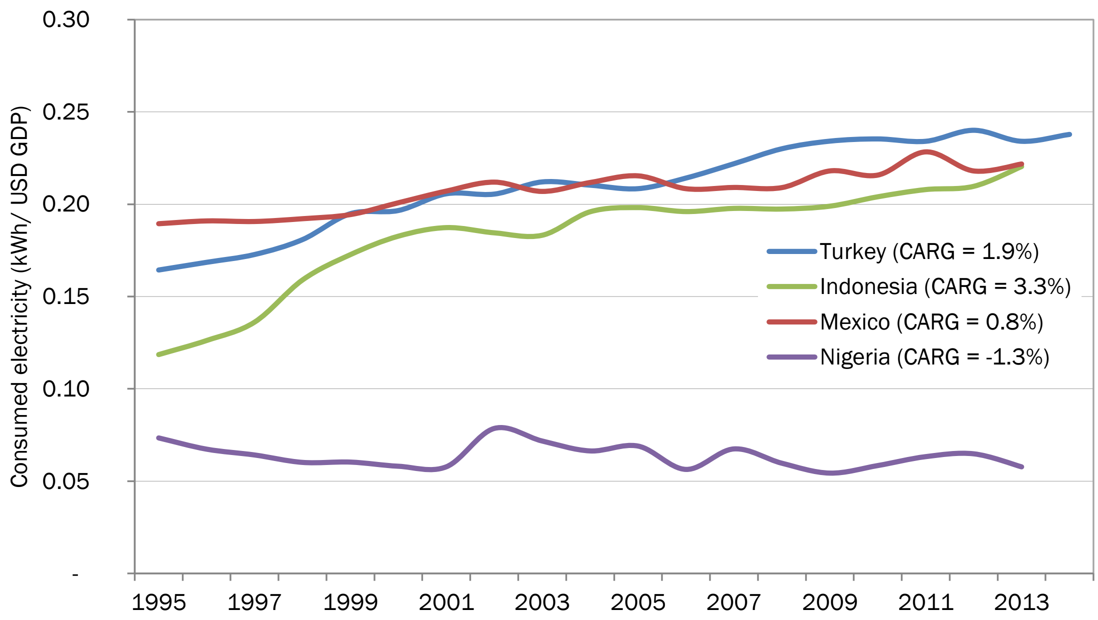

Exhibit 7: Electricity intensity of the economy (kWh/GDP in constant 2010 USD)
(Source: World Bank, TEIAS)

While the GDP per capita exhibited average annual growth of 2.5% in the last 20 years, per capita electricity use has been increasing at an average annual rate of 4.5%. The electricity intensity of the country has increased form 0.16 kWh per (2010) dollar of GDP in 1995 to 0.24 in 2014, somewhat above Mexico and Indonesia.

2.3 Power sector overview

Until the 1980s, the Turkish electricity sector was concentrated in the Turkish Electricity Authority (TEK) – the integrated monopoly for generation, transmission and distribution. Since then, the government has unbundled and partially privatized the industry.

In 1984, the state allowed private sector participation in generation by introducing different investment models: build-operate-transfer (BOT), build-operate-own (BOO), transfer of operating rights (TOOR), independent power production (IPP) and auto-production. Under a BOT concession, a private company could build and operate a plant for an agreed period and then transfer it to the state at no cost. A BOO concession is similar to BOT but allows investors to retain ownership of the assets at the end of the contract. Under a TOOR model, an existing state facility would be operated by a private entity under a lease agreement. The BOT, BOO, and TOOR contract were signed between the private investors and the state-owned generation and transmission company and included a “take-or-pay” clause, under which the government would purchase the output at fixed prices.

In 1997, with the technical and financial support of the World Bank, Turkey’s Ministry of Energy and Natural Resources (MENR) began preparing the legal framework for a competitive electricity market. Following the enactment of the 2001 Electricity Market Law, Turkey unbundled the sector into different business activities as is shown in Exhibit 8.

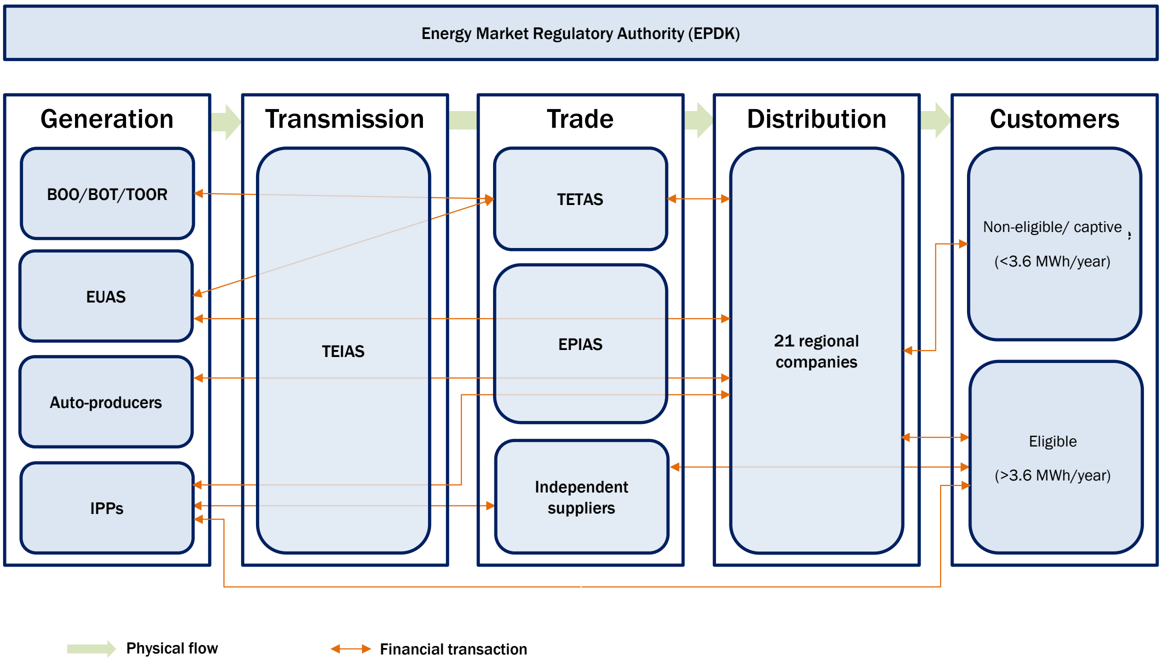

Exhibit 8: Overview of the electric power sector in Turkey after privatization

The state-owned generation and transmission company (former TEAS) was split into three new entities responsible for generation (EUAS), transmission (TEIAS), and wholesale (TETAS). At the beginning of the liberalization process, TETAS acted as a single buyer for private generation and then was transformed into a market participant exposed to competition. It is the only remaining state-owned supply undertaking after privatization. The number of wholesale licenses has been increasing rapidly since 2003. Currently, there are around 156 private companies holding wholesale licenses. TETAS took over the BOT, BOO, and TOOR contracts and it is also responsible for electricity import and export. TEDAS, the state-run distribution and retail entity, was restructured into 21 regional distribution companies, all of which are privately owned. Distribution and retail activities were unbundled following the electricity Market Law of 2013. Since January 2013, distribution companies are allowed to carry out generation and wholesale activities but only under separate legal accounts.

The electricity law of 2011 also mandated an independent regulatory authority – the Energy Market Regulatory Authority (EMRA), to issue licenses; determine and approve tariffs; set the eligibility limits for market opening; draft secondary legislation; and solve disputes and apply penalties in electricity, natural-gas, petroleum and LPG markets.

In 2015, EMRA announced the establishment Turkish Energy Stock Market (EPIAS). It was established as a private company (with 40% of its shares held by private companies, the rest held equally by TEIAS and the Istanbul Stock Exchange) and authorized to manage and control electricity merchandise throughout the country. EPIAS operates electricity transactions both in day-ahead market and intra-day. In 2015, about 30% of the total electricity was sold on the market, while some 70% of wholesale traded capacity is done through bilateral negotiated contracts.

On the demand side, eligible consumers (purchasing more than 3.6 MWh per year) are free to procure electricity from a supplier of their choice. Non-eligible consumers can purchase electricity only from retail companies holding retail license in their region.

2.4 Power generation, transmission and distribution

2.4.1 Electricity generation

As of the beginning of 2015, the total generation capacity in Turkey as was 69,121 MW and by the end of the year it stood at some 73,000 MW. Of this 20,323 MW (28%) was owned by EUAS (see Exhibit 9). The majority of the generation capacity (59%) is owned by Independent Private Producers (IPPs), which were absent before 2004 and now constitute the bulk of the market. Private-sector investment in generation capacity has increased significantly over the past 10 years and the government has progressed on the privatization of its state-owned generation and distribution assets. As BOO, BOT and TOOR contracts are ending, their relative share has decreased to 13% at end 2015. Another 5,000 MW of gas-fired plants built under the BOO/BOT schemes are expected to be phased out in 2018/2019.

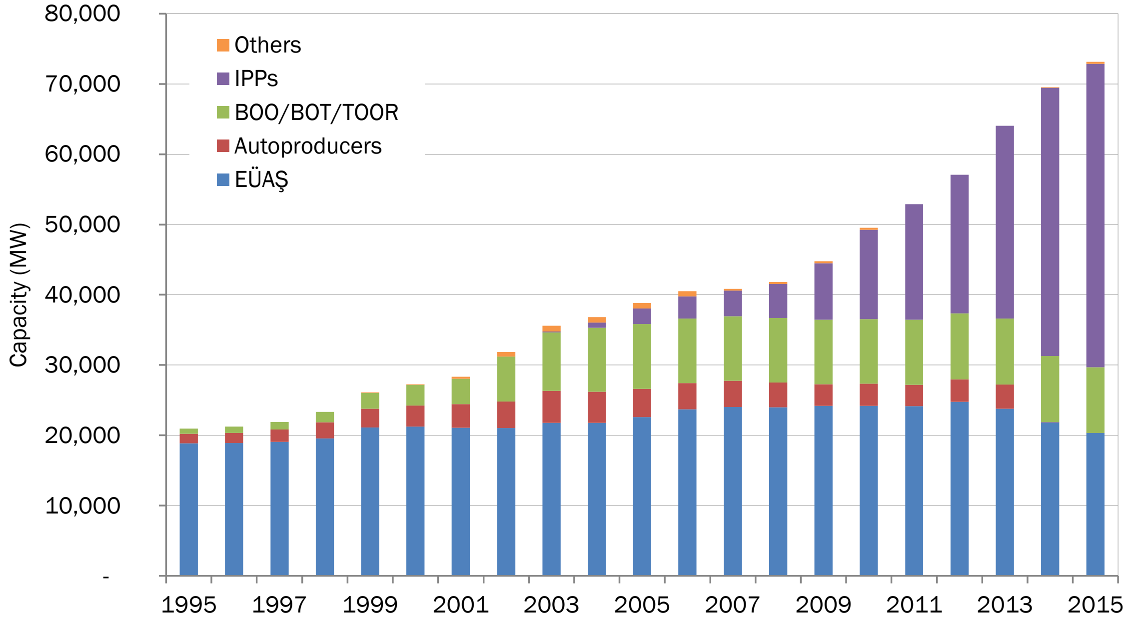

Exhibit 9: Development of generation profile by ownership
(Source: TEIAS)

Hydro-power is an important source of electricity, with 35% of total generation in 2015 (Exhibit 10). But conventional thermal fuels continue to dominate the Turkish generation infrastructure: Natural gas, mainly imported from Russia and Iran accounts for 28%; lignite and domestic coal comprise 13% while imported coal represented 8%. In order to reduce import dependency and improve energy security, the country is planning to double its coal power production by 2020 by installing more than 80 plants.[5] However, while the country has substantial reserves of lignite (15.8 billion tons[6]), hard coal is scarce (1.6 billion tons[7]). The country plans to build 80 new coal power plants in the coming years, which come on top of the 25 existing. By 2019 the government is aiming to increase the electricity generated by coal to 60 million MWh, from the current 36 million MWh.[8] Estimates of the additional new coal capacity

[5] Power Engineering International (2015). *Turkey plans doubling of coal-fired power capacity by 2020.* http://www.powerengineeringint.com/articles/2015/05/turkey-plans-doubling-of-coal-fired-power-capacity-by-2020.html

[6] Ministry of Energy and Natural Resources of Turkey Info Bank http://www.enerji.gov.tr/en-US/Pages/Coal

[7] Turkish weekly (2015). *Turkey's 2015 national coal policy.* http://www.turkishweekly.net/2015/03/31/comment/turkey-s-2015-national-coal-policy/

[8] Republic of Turkey Ministry of Energy and Natural Resources. *2015-2019 Strategic Plan*. 2015 http://www.enerji.gov.tr/en-US/Strategic-Plan

under construction vary between 37 GW and 65 GW.[9] This of course would greatly increase Turkey's carbon emissions.

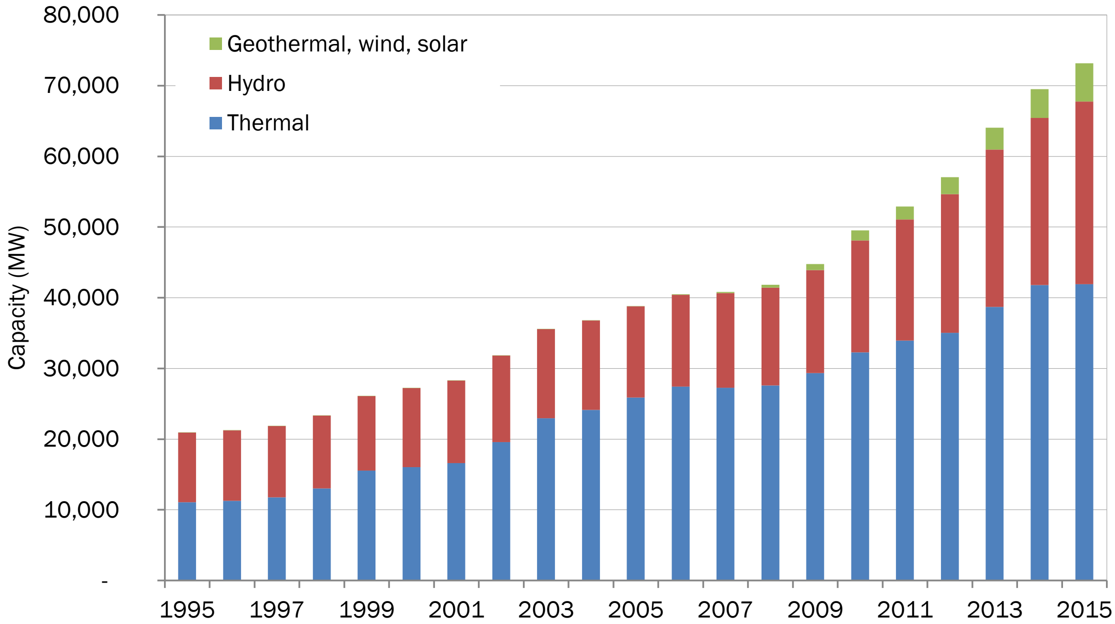

Exhibit 10: Development of generation profile by fuel type
(Source: TEIAS)

The large share of thermal in the energy mix of the country contributes to Turkey's GHG emissions. In 2014, total emissions were 467.6 million tonnes (Mt) CO_2-equivalent. Compared to the European average, emissions per capita in Turkey were lower (6.08 versus 8.31 tonnes) while emissions per unit of GDP were higher (0.34 versus 0.25).[10] The share of emissions from the electricity sector in Turkey amounted to 132Mt, or 28% of the total, similar to the share in Europe (31%). Although Turkey is not among the top polluters in Europe, its emissions have more than doubled since 2000.[11] Over the same period, emissions from electricity also nearly doubled, in contrast to Europe where both the overall and the electricity emissions decreased on average.

Before the Paris Climate Change Conference in December 2015, Turkey pledged a 21% emission reduction (compared to a business-as-usual scenario) by 2030.[12] The government has listed a series of plans and policies to achieve its commitment, among which are: tapping the country's full hydroelectric potential; reducing electricity transmission and distribution losses; and increasing the renewable generation capacity (10 GWh solar and 16 GWh wind by 2030).[13] To encourage investments in renewable generation, the government has introduced a number of policies. One of these is the Feed in Tariff (FIT) mechanism, which offers USD 0.073 per kWh for run-of-river hydroelectric and wind power

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[9] World Resource Institute. *Global Coal Risk Assessment*. http://www.wri.org/publication/global-coal-risk-assessment).

Euractive. *Turkey to double coal capacity in four years*. http://www.euractiv.com/section/health-consumers/news/turkey-to-double-coal-capacity-in-four-years/

[10] All GHG data from OECD. The European average is based on OECD-Europe countries.

[11] Increase of 58%, highest amongst OECD countries.

[12] The pledge is controversial as experts have questioned the realism of the business-as-usual scenario, which foresees an unusually high growth of GHG emissions (e.g. BBC Turkey, 30 November 2015).

[13] UNFCCC. *Republic of Turkey Intended Nationally Determined Contributions.* http://www4.unfccc.int/submissions/INDC/Published%20Documents/Turkey/1/The_INDC_of_TURKEY_v.15.19.30.pdf

plants, USD 0.105 per kWh for geothermal power plants and USD 0.133 per kWh for solar power plants. Further price incentives are offered for power plants using local components. License hurdles and cost were lowered as well: only renewable generation plants above 1 MW need to be licensed, for fees which are 10% of the ordinary pre-license and license fees. As can be seen in Exhibit 10, the geothermal, wind, and solar capacity has grown substantially over the last year as a result of these incentives. Nevertheless, electricity from these sources constituted only 7% of the total generation in 2015 and much investmants are needed to reach the 2030 goals. The solar segment in particular seems to provide future growth opportunities. In 2015, its capacity in the country was less than 250 MW and was made up entirelly of small unlicensed installations. The combination of small installed base, high solar energy potential of Turkey (due to its geographical location), favorable tariffs, and declining technology costs, makes solar an attractive opportunity to green Turkey's power generation while reducing its import dependence.

It is worth mentioning that the renewable and coal capacity expansions are planned at a time of slowing demand growth (see Section 2.5.1) and high reserve margins in the generation market. This may exacerbate the decrease of utilization rates of existing power plants which already has driven producer prices down (especially in the spot market). Pressure is felt particularly by less efficient natural gas plants which have high operating costs and hence are becoming uncompetitive at the current market.

2.4.2 Electricity transmission

The government-owned Turkish Electricity Transmission Company (TEIAS) operates the country's entire transmission network which encompasses 53,725 km of powerlines above 66 kV (17,747 km of 400kV; 85km of 220 kV; 35,384 km of 154 kV and 509 km of 66 kV). Transmission losses in the network were 2.0% in 2015, compared to 2.8% in 2001. TEIAS announced in 2016 that it plans to invest $3.5 billion in power transmission lines from 2016 to 2019.

2.4.3 Electricity distribution and retail

In 2005, the government-owned distribution company was broken up into multiple regional monopoly companies which since 2015 are all privately owned. Privatization of distribution companies was executed using a Transfer of Operating Rights backed Share Sale model (TSS model). Under the model, investors purchased the shares of distribution companies and were granted operating rights of all assets for 30 years. TEDAS retains ownership of any existing (and future) assets. Investors have the obligation to carry out any necessary investments in the distribution network. EMRA sets revenue caps which cover operating expenses and investment requirements. Distribution rates are determined in line with tariffs prepared by distribution companies and submitted to the Energy Market Regulatory Authority (EMRA) for approval. A distribution company thus makes a pre-defined return on its investments and retains savings from efficiency improvements by outperforming its loss/theft target. The average loss and theft ratio in the country decreased from 21% to 15% between 2000 and 2006 and has been relatively stable since then. There are, however, large regional differences ranging from 6-7% in the best three performing regions (Trakya, Sakarya, Akedas) to 28%, 66% and 75% in the worst three (Aras, Vangolu, Dicle). There are 21 retailers (assigned regional suppliers), which are required to provide electricity to non-eligible customers in their region. They are also allowed to supply eligible consumers countrywide and serve as suppliers of last resort.

2.5 Electricity consumption

2.5.1 Consumption per user group

In 2015, the total electricity consumption in Turkey stood at 264,139 MWh. Of this, 7,411 MWh (2.8%) was imported electricity. Electricity consumption in Turkey has been growing at about 5.5% per annum between 2000 and 2015 and the government expects that growth will continue at this rate until 2030, although these estimates are likely too optimistic given the lower expected economic growth and the reduced electricity consumption elasticity to GDP.[14,15] Turkey is following a similar trend to Poland, Portugal and Spain in: as the country becomes richer, energy and electricity demand flattens.

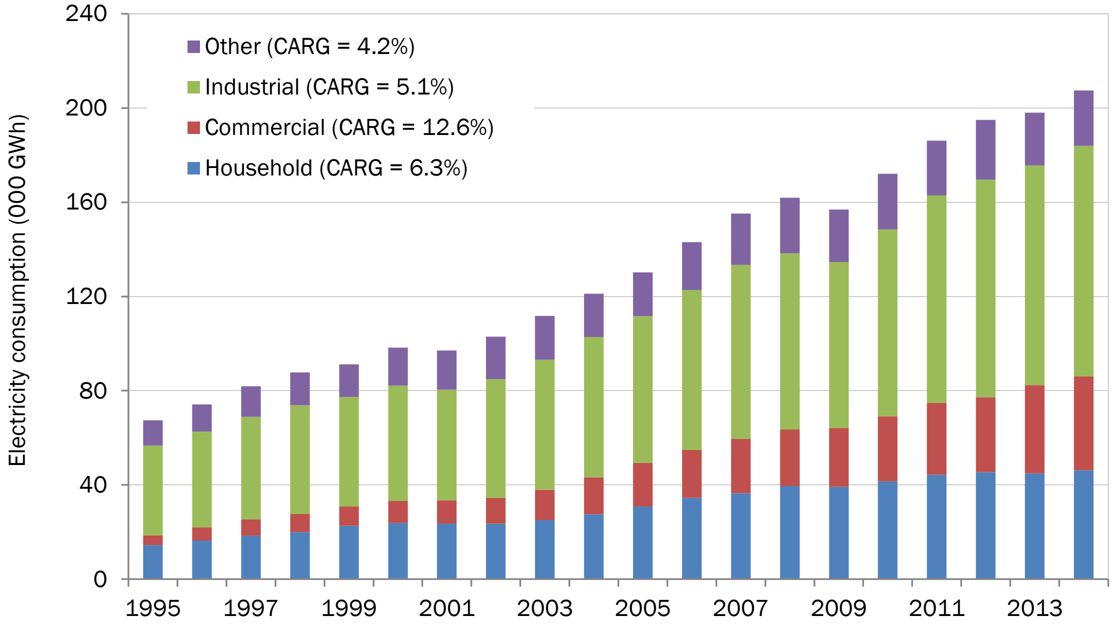


Exhibit 11: Electricity consumption per user group[16]
(Source: TEIAS)

Some 47% of all electricity is consumed by industry, 19% by the commercial sector and 22% by households (Exhibit 11). Among these three categories, growth of electricity use has been fastest in the commercial sector and slowest in the industrial sector.

2.5.2 Electricity tariffs

Eligible customers, accounting for 37% of electricity consumption in the country, are supplied through bilateral agreements with suppliers at unregulated prices. The national electricity tariff applicable to non-eligible consumers is regulated by EMRA. A price equalization mechanism is applied over the national tariff to protect consumers from price variations resulting from difference between distribution companies. Variances of loss-theft and cost ratios between regional distributors are evened out through intra-regional cross-subsidization.

On average, non-eligible industrial users paid between TL 0.21 and TL 0.31 (USD 0.07 – 0.10) per kWh in 2015, while the average price for domestic users was TL 0.39 (USD 0.13) per kWh. The evolution of the national tariff since 2007 is shown in Exhibit 12. In 2008, the government increased nominal residential and industrial tariffs by 49% and 41% respectively (in real terms the increase was 33% and 26%). After a period of slow growth in the subsequent two years (average 6% for industrial and 3% for residential), both prices for businesses and households went up by around 20% in 2011. It is important to note that even though since 2012 the tariffs have been going up by an average of 4% annually, in real terms electricity prices have come down by some 3% annually. The regulated end-user prices are currently not cost-reflective, but a transition to cost-reflectivity is ongoing.[17]

[14] Bloomberg New Energy Finance. *Turkey's Changing Power Market* – Whitepaper (November, 2014).

[15] Experts estimate demand growth of 3.3% in 2016 and 4.7% in 2017. http://www.icis.com/resources/news/2016/03/15/9979104/turkish-power-market-braced-for-two-year-capacity-surge/

[16] Others refer to government, illumination and agriculture.

[17] Energy Community Secretariat. *Energy Governance in Turkey.* 2015

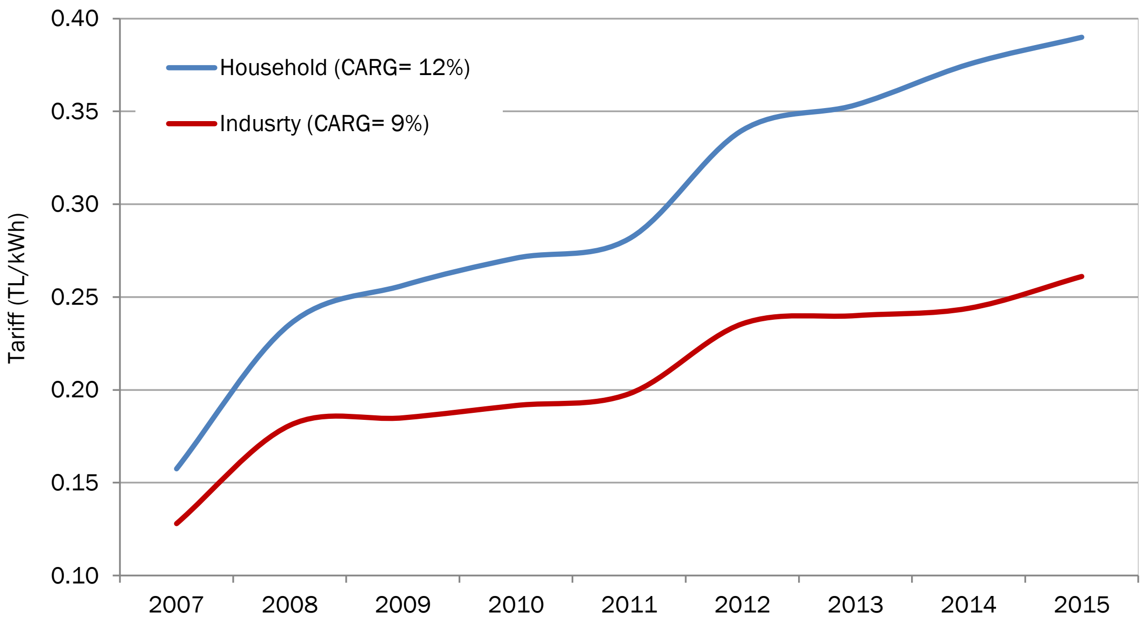


Exhibit 12: Nominal electricity tariffs for industrial and domestic customers
(Source: EMRA)[18]

The electricity tariff consists of the generation cost, transmission and distribution fees, as well as cost for losses and services (such as metering). As shown in Exhibit 13, the generation component is the largest part, representing 74% of the total end-user price. The transmission tariff is proposed by TEIAS and approved by EMRA while the distribution tariff is set by EMRA based on data of the distribution companies. The retail cost has a cap of 3.49% above the price at which retail companies buy electricity.[19]

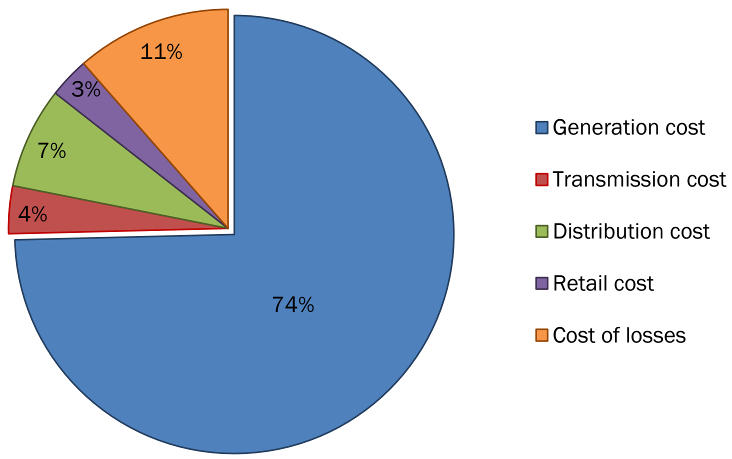


Exhibit 13: Breakdown of industry tariff by components
(Source: EMRA)[20]

[18] Based on industrial clients with consumption between 2,000 and 20,000 kWh.

[19] The cap was reduced to 2.38% in 2016

[20] Based on industrial tariff for medium voltage customers in 2015. No substantial variation among industrial customers and years.

2.5.3 Incidence of power outages

In March 2015, Turkey suffered a massive nation-wide power cut, which left the country without power for more than 10 hours. The outage was caused by a failure in transmission lines. Despite this large-scale blackout, outages do not severely affect companies in the country. Table 1 shows the total number of monthly outages; their duration; and the total outage time as reported in the World Bank Enterprise Survey from 2012. In total, companies experience between 3 and 13 hours of power outage time per month. Using an estimate of 250 working hours per month, that means that on average power outages affect companies 1% – 5% of operating time[21] although a the 1% - 2% range of the median value. Outages are most common in the South-East, due to transmission line problems.

Approximately 41% of all companies own or share a generator. Even though medium and large companies experience similar outage time per month, the latter are more likely to own a generator: Reflecting the substantial scale advantages in power generation, the propensity of companies to own a generator depends largely on their size and not on the total outage duration.

Table 1: Power outages and self-generation per company size and sector
(Source: WBES 2012)

	Number of outages (per month)		Duration of outage (hours)		Total outage time (hours)		% firms with generator
	Average	Median	Average	Median	Average	Median	
Total	4.9	3.0	2.3	1.0	9.0	3.0	41%
Micro <5	3.9	3.5	1.8	1.5	6.9	6.0	32%
Small >=5 and <=19	4.7	2.0	1.8	1.0	8.8	3.0	27%
Medium >=20 and <=99	4.4	3.0	2.7	1.0	9.0	4.0	45%
Large >=100	5.9	3.0	2.3	1.0	9.5	4.0	61%
Food	5.6	3.0	3.4	6.5	12.9	4.0	54%
Textiles, garments	3.8	2.0	2.1	2.0	8.6	4.0	38%
Furniture, wood, paper	3.8	3.0	1.3	3.1	3.3	3.0	37%
Chem, plastics, rubber	4.6	3.0	1.8	1.5	6.9	4.0	56%
Non-metallic minerals	3.7	2.5	1.8	1.8	6.1	4.0	45%
Metals, machinery	6.6	2.0	2.4	2.4	9.8	3.0	33%
Publishing, printing	2.0	2.5	1.0	1.0	2.3	2.5	40%
Construction, transport	8.6	3.0	1.8	4.1	5.6	5.0	35%

[21] The margin of error of this data in the World Bank Enterprise Survey is 1.3% for manufacturing firms and 3.7% for services and retail firms. The data exhibits a substantial right skew. The median value is therefore a better single number description than the average. The median is also more robust to the presence of unrealistic and/or "protest" responses. The median value can, however, be overly conservative because it is not affected by very large values even when they are real. These large values are better represented in the average value of the sample. In this report we therefore pragmatically define the median and average as realistic minimum and maximum values. It is worthwhile to note that the difference between average and median is equal to the product of non-parametric skew and standard deviation of the underlying probability distribution; the larger the skew and/or variance of values are, the wider the range of realistic values.

Retail, wholesale	4.1	2.0	2.2	1.6	6.3	3.0	32%
Hotels, restaurants	5.0	4.0	1.6	1.0	6.0	4.0	33%

3 IFC INVESTMENTS IN THE POWER SECTOR

IFC has considerable exposure to the power sector in Turkey, both in power distribution and, especially, in generation. Since 2008, it has provided USD 1,816 million in (A, B and C) loan capital and invested USD 170 million equity capital. A total of USD 1,666 million loan capital went to four generation companies (Enerjisa Enerji, ACWA, Akenerji, and Rotor Elektrik) while the entire equity investment was made into a sixth generation company (Gama Enerji). The distribution company SEDAS received USD 150 million loan capital (and an additional USD 90 million sourced from international banks). IFC has financed plants with a total installed capacity of 6,109 MW of which 3,053 MW are currently operational and the remainder is under construction. Table 2 provides a detailed overview of all investments the generation sector.

In Section 5 we will investigate the economic and employment impact of IFC-financed capacity, with and without attribution. As per early 2015, **the total IFC-financed operational capacity of 3,053 MW represented 4.4% of the country's 69,121 MW installed operational capacity.** In order to attribute an amount of power generation capacity to IFC we have used the following two rules:

1. For equity financing the power generation capacity is multiplied by the percentage ownership equity ownership;
2. For debt financing, the capacity addition is multiplied by the IFC debt financing as a percentage of the total deal value. Because all the loans were provided for greenfield projects the capacity addition is equal to the plant capacity.

The result of the applying the two attribution results is shown in Table 2: A total of 1,870 MW installed and 926 MW operational capacity are attributed to IFC. **The IFC-attributable operational capacity represents 1.3% of total operational capacity and is projected to go up to about 2%** when projects under construction will commence operations.[22] When broken down by generation technology, large hydro accounts for 42% of the attributable capacity in operation, gas combined cycle for 41%, small hydro 11% and wind 6%. Upon completion of all the projects, these exposures are 19%, 68%, 10% and 3% respectively. It is important to note that, although straightforward, these attribution rules are somewhat arbitrary.[23] Although different attribution rules of course affect IFC's overall impact, they would not affect the methodology used in this report.

In addition to the financial contribution, IFC's involvement had other benefits. During interviews with representatives of Enerjisa and SEDAS, both parties acknowledge the catalytic effect of IFC's financing. IFC invested in Turky's electricity sector while it was still in transition, generation costs were high, and while there was a deficit of generation capacity. Back then private sector investments were needed but merchant power had a high perceived risk. The success of these first IFC deals accelerated the privatization process, which was off to a slow start. By paving the way for others to invest in merchant power, IFC played an important role in the development of a competitive electricity market in the country. This helped to attract further investments and enhanced the availability and reliability of supply. The increasing power generation capacity also contributed to declining generation costs.

IFC also provided support in setting up formal environmental, health and safety (EHS) management systems which did not exist prior to privatization. The fact that the companies were now meeting the high IFC quality standards in these areas was a credible signal to other investors. IFC also offered advice on business strategy, human resources, technical aspects (such as on the distribution system reliability indices for SEDAS).

Besides the catalytic effect for the projects it financed, IFC triggered mobilization of capital to the entire sector. The Turkish power sector had large financing needs, but regulatory uncertainty and country risk

[22] The increase from 926 MW to 1,870 MW installed capacity would bring the 1.3% share to 2.7%, but the total installed capacity is projected to grow as well, hence the estimation of about 2%.

[23] We used the same attribution rules for Turkey as done in the study in the Philippines. The Philippines study, including the attribution methodology, was discussed with IFC – World Bank Sector experts and IFC Chief Economist office.

hampered the investment climate.[24] Especially new investment in generation required high risk premiums, which pushed up energy costs. IFC was the first institution to finance merchant plants, something that others shied away from. The success of these deals demonstrated the viability of a liberalized power sector to other private investors. Futhermore, investments in hydro and natural gas contributed to reducing Turkey's reliance on coal, thereby reducing carbon intensity and improving security of supply.

[24] World Bank Group. *Turkey's Energy Transition; Milestones and Challenges*, 2015 (Section 3.2.1.3)

Table 2: Overview of IFC investments in power generation disbursed before end-2015

Company	Power plant	Year	Company stake	LCOE category	Installed capacity (MWe)	Capacity in operation (MWe)	Total project size (USD m)	IFC loan (USD m)	IFC equity stake	IFC attribution	attributable capacity (MWe)	capacity in operation (MWe)
Gama Enerji	Birecik	2014	20.00%	Hydro Large	672.00	672.00	pre-existing		27.0%	5.4%	36.29	36.29
Gama Enerji	Lamas III-IV HES	2014	99.95%	Hydro small	35.26	35.26	31.50		27.0%	27.0%	9.51	9.51
Gama Enerji	Çakırlar HES	2014	100.00%	Hydro small	16.21	16.21	15.80		27.0%	27.0%	4.38	4.38
Gama Enerji	Sares RES	2014	96.00%	Wind onshore	27.50	24.75	31.85		27.0%	25.9%	7.13	6.42
Gama Enerji	Karadağ RES	2014	96.00%	Wind onshore	10.00	9.60	12.35		27.0%	25.9%	2.59	2.49
Gama Enerji	Gökres 2	2014	96.00%	Wind onshore	35.00	35.00	45.00		27.0%	25.9%	9.07	9.07
Gama Enerji	İç Anadolu Natural gas Kombine	2014	96.00%	Gas CC	840.00	-	862.00		27.0%	25.9%	217.73	-
Gama Enerji	Marmara	2014	96.00%	Wind onshore	10.00	-			27.0%	25.9%	2.59	-
Gama Enerji	Kırkağaç RES	2014	96.00%	Wind onshore	45.00	-			27.0%	25.9%	11.66	-
Rotor Elektrik	Gökçedağ RES	2009	100%	Wind onshore	135.00	135.00	288.86	71.50		24.8%	33.42	33.42
Akenerji	Feke II HES	2010	99%	Hydro small	69.34	69.34	81.74	15.78		19.1%	13.26	13.26
Akenerji	Feke I HES	2010	99%	Hydro small	29.40	29.40	31.49	6.08		19.1%	5.62	5.62
Akenerji	Burç Bendi ve HES	2010	99%	Hydro small	27.33	27.33	29.27	5.65		19.1%	5.22	5.22
Akenerji	Gökkaya Barajı ve HES	2010	99%	Hydro small	28.54	28.54	81.12	15.66		19.1%	5.46	5.46
Akenerji	Himmetli Reg ve HES	2010	99%	Hydro small	26.98	26.98	84.71	16.36		19.1%	5.16	5.16
Akenerji	Bulam HES	2010	99%	Hydro small	7.10	7.03	80.08	15.46		19.12%	1.36	1.34
ACWA	Acwa Power Kırıkkale Doğalgaz	2014	100%	Gas CC	927.40	-	1,000.00	45.00		4.5%	41.73	-
Enerjisa Enerji	Bandırma Doğalgaz Kombine Çev	2008	100%	Gas CC	936.18	936.18	625.30	252.12		40.3%	377.47	377.47
Enerjisa Enerji	Kandil Enerji Projesi HES	2008	100%	Hydro Large	207.92	207.92	280.80	113.22		40.3%	83.83	83.83
Enerjisa Enerji	Hacınınoğlu HES	2008	100%	Hydro Large	142.28	142.28	165.10	66.57		40.3%	57.37	57.37
Enerjisa Enerji	Sarıgüzel HES	2008	100%	Hydro Large	102.54	102.54	122.20	49.27		40.3%	41.34	41.34
Enerjisa Enerji	Dağdelen HES	2008	100%	Hydro small	8.00	8.00	18.20	7.34		40.3%	3.23	3.23
Enerjisa Enerji	Kavşak Bendi ve HES	2008	100%	Hydro Large	191.28	185.85	210.60	84.91		40.3%	77.12	74.94
Enerjisa Enerji	Yamanlı II HES	2008	100%	Hydro small	81.85	-	135.20	54.51		40.3%	33.00	-
Enerjisa Enerji	Kuşaklı HES	2008	100%	Hydro small	20.00	20.00	54.60	22.01		40.3%	8.06	8.06
Enerjisa Enerji	Köprü HES	2008	100%	Hydro Large	155.85	155.85	146.90	59.23		40.3%	62.84	62.84
Enerjisa Enerji	Menge Barajı ve HES	2008	100%	Hydro Large	85.00	85.00	50.70	20.44		40.3%	34.27	34.27
Enerjisa Enerji	Çambaşı Reg. ve HES	2008	100%	Hydro small	44.10	44.10	57.20	23.06		40.3%	17.78	17.78
Enerjisa Enerji	Bandırma II Doğalgaz Kombine Ç	2010	100%	Gas CC	1,000.00	-	902.20	500.22		55.4%	554.45	-
Enerjisa Enerji	Yamanlı II HES	2010	100%	Hydro small	81.85	-	224.90	124.69		55.4%	45.38	-
Enerjisa Enerji	Doğançay HES	2010	100%	Hydro small	61.95	-	93.60	51.90		55.4%	34.35	-
Enerjisa Enerji	Dağpazarı Regülatörleri ve Birka	2010	100%	Hydro small	48.50	48.50	80.60	44.69		55.4%	26.89	26.89
Subtotal				Hydro large	1,556.87	1,551.44	976.30	393.65			-	-
Subtotal				Hydro small	586.41	360.68	1,100.01	403.21			-	-
Subtotal				Wind onshore	262.50	204.35	378.06	71.50			-	-
Subtotal				Gas CC	3,703.58	936.18	3,389.50	797.34			-	-
Total					**6,109.36**	**3,052.65**	**5,843.87**	**1,665.70**			**1,869.57**	**925.65**
			A	B	C	D	E	F	G	H	I	J

Sources: IFC documentation; Enerji Atlasi; Company information; Steward Redqueen analysis. Only investments made and disbursed before end-2015 are included. IFC investments until 2016 are shown in Annex 3.
Calculations: H = (G x A) + (F / E); I = H x C; J = H x D.

4 ECONOMIC IMPACT ANALYSIS FRAMEWORK

In this section the analysis framework will be introduced. First a literature overview is given in Section 4.1 on the causal relationship between electricity consumption and economic growth. Based on that and the characteristics of the Turkish power sector the framework is presented in Section 4.3.

4.1 Relationship between electricity consumption and economic growth

A large body of academic literature exists on the relationship between energy or electricity consumption and economic growth and which one causes the other. Typically the findings depend on country, analysis methodology,[25] selected variables and the period under consideration. Unsurprisingly, no consensus has been reached; all four possible relationships between electricity consumption (EC) and GDP have been found:

- Growth hypothesis: electricity consumption causes GDP growth (EC $\Longrightarrow$ GDP);
- Conservation hypothesis: GDP growth causes electricity consumption (GDP $\Longrightarrow$ EC);
- Feedback hypothesis: electricity consumption and GDP growth cause each other (EC $\Longleftrightarrow$ GDP);
- Neutrality hypothesis: electricity consumption and GDP growth are uncorrelated (EC $\not\Leftrightarrow$ GDP).

Academic literature on the nexus between electricity consumption and GDP growth in Turkey mostly points to the growth or feedback hypothesis. Acaravci et al (2015)[26] found a unidirectional short-run and long-run causality running from per capita electricity consumption to per capita GDP growth for the period 1974-2013. Using Granger causality, cointegration and vector error correction analysis, Soytas and Sari (2007)[27] find that from 1968-2002 industry electricity consumption unidirectionally causes industry value added. Kargi (2014)[28] also finds that from 1970-2010 growth industrial electricity consumption and GDP growth mutually cause each other. He also finds that residential electricity consumption (Granger) and GDP growth mutually cause each other. Aslan (2014)[29] confirms the bidirectional relationship between electricity consumption and GDP growth, Finally, Dogan (2015)[30] finds support that in the long run renewable electricity consumption (Granger) causes economic growth in the long run and a bi-directional causation between non-renewable energy consumption and economic growth[31].

Analyzing data from a large number of countries, Adhikari and Chen (2012)[32] found a strong relation running from energy consumption to economic growth for upper middle income countries and lower middle income countries and a strong relation which runs from economic growth to energy consumption for low income countries. However, in a recent meta-analysis of 133 studies, World Bank economists,

[25] Notably Granger causality and co-integration analysis, applied in bivariate or multivariate ways.

[26] Acaravci, A., Erdogan,S. and Akalin, G., *The Electricity Consumption, Real Income, Trade Openness and Foreign Direct Investment: The Empirical Evidence from Turkey*, Intl. J. Energy Econ. And Policy, 5(4), 2015.

[27] Soytas, U. and Sari, R., *The relationship between energy and production: Evidence from Turkish manufacturing industry,* Energy Economics 29(6), 2007.

[28] Kargi, B., *Electricity Consumption and Economic Growth: A Long-Term Co-integrated Analysis for Turkey*, Intl. J. Econ. And Fin. 6(4), 2014.

[29] Aslan, A. *Electricity Consumption, Labor Force and GDP in Turkey: Evidence From multivariate Granger Causality*, Energy Sources, B Economics, planning and policy, 9(2), 2014.

[30] Dogan, E., *The relationship between economic growth and electricity consumption from renewable and non-renewable sources: A study of Turkey*, Renewable and Sustainable Energy Rev. 52, 2015

[31] Based on these findings the author somewhat puzzlingly recommends to reduce the share of electricity from renewable resources and to increase the usage from non-renewable resources for sustained growth rates.

[32] Adhikari, D. and Chen, Y., *Energy Consumption and Economic Growth: A Panel Cointegration Analysis for Developing Countries*, Review of Economics & Finance, 2012.

using very strict criteria, concluded that there exists no reliable statistical evidence that an increase in energy consumption contributes to economic growth[33].

Nevertheless, the importance of energy for economic production is undisputed; in its essence production is the transformation of material inputs into outputs through the addition of energy and knowledge and organization (i.e. labor and capital). In this thermodynamics-based view of the production process, energy and materials are the primary factors of production in contrast to mainstream economics which considers capital, labor and land as the primary factors. And because electricity has become the dominant carrier of energy[34], one might extend this statement and define electricity as a primary factor. It is clear that electricity cannot be substituted (entirely or considerably) by capital or labor. In fact, the industrial revolution was made possible by extracting thermodynamic work from energy sources other than humans.

Viewed in this way, **energy and thus electricity play an especially important role in industry**, as was found in the previously mentioned studies of Soytas and Sari[27] and Kargi[28]. A number of studies in other countries have confirmed this. Inglesi-Lotz and Blignaut (2011)[35] concluded that in South Africa only industrial output exhibits statistically significant price elasticity. They also find that manufacturing output responds positively to positive shocks in electricity consumption. For manufacturing in Malaysia, Bekhet and Harun (2012)[36] observe long-run (but not short-run) uni-directional causality from energy consumption to production for the period 1978-2009. Harun and Ishak (2014)[37] also find that compared to capital and labor, energy is a more important factor for the manufacturing sector in Malaysia. Qazi et al. (2012)[38] draw the same conclusion for electricity consumption and industrial output in Pakistan from 1972-2010 and even conclude that "energy shortage is one of the main reasons of the downturn of the industrial sector, particularly in large-scale manufacturing. As a result, plenty of small-scale industries are shut down and many of large-scale industries are moving out of Pakistan." Kwakwa (2012)[39] found that although in Ghana economic growth (uni-directionally) Granger causes energy consumption, electricity consumption and manufacturing Granger cause each other. In Kenya, Nelson et al. (2013)[40] found short and long-run bidirectional causality between electricity consumption and manufacturing output. Electricity consumption was found by Abid and Mraihi (2014)[41] to Granger cause industry GDP in the long run in Tunisia. Most recently, in a working paper of the IMF, Alvarez and Valencia (2015)[42] conclude that a 1% decrease of electricity price would increase of manufacturing value added in Mexico by 0.28%.

The reason that the output response to cheaper electricity is found to be stronger in manufacturing than in commercial sectors is because electricity is largely a variable cost for manufacturing and largely a fixed one in most other sectors. (Put very simply, an office needs to be lit or cooled independent of the

[33] Only three of the 133 studies did not suffer from econometric estimation problems and two of those have potential data measurement issues.

[34] Electricity is the highest grade (lowest entropy) form of energy which can be converted into other forms (heat, motion etc.) at great efficiency and is easily transported over distances.

[35] Inglesi-Lotz, R and Blignaut, J.N., *Estimating the price elasticity of demand for electricity by sector in South Africa*, South African journal of economic and management sciences, 14(4), 2011.

[36] Bekhet, H.A. and Harun, N.H.B., *Energy essential in industrial manufacturing in Malaysia,* International Journal of Economic and Finance, 4(1), 2012.

[37] Harun, N.H. and Ishak, M.S., *Analysis of the production theory for manufacturing industry and construction industry in Malaysia*, Proceeding of the Global Summit on Education GSE 2014.

[38] Qazi, A.Q., Ahmed, K. and Mudassar, M., *Disaggregate Energy Consumption and Industrial Output in Pakistan: An Empirical Analysis*, Economics E-Journal, 2012.

[39] Kwakwa, P.A., *Disaggregated energy consumption and economic growth in Ghana*, International Journal of Energy Economics and Policy, 2(1), 2012.

[40] Nelson, O., Mukras, M.S. and Siringi, E.M., *Causality between disaggregated Energy Consumption and manufacturing growth in Kenya: an Empirical Approach*, J. Econ. and Sust. Development 4(16), 2013.

[41] Abid, M. and Mraihi, R., Energy consumption and industrial production: Evidence from Tunisia at both aggregated and disaggregated levels, J. Knol. Econ, 2014.

[42] Alvarez, J. and Valencia, F., *Made in Mexico: Energy Reform and Manufacturing Growth*, IMF WP/15/45, 2015.

number of employees present whereas increasing manufacturing output requires more electricity, although many sectors fall somewhere between these two extremes.) This is probably the main reason why the World Bank Enterprise Surveys only ask information on electricity use from companies in the industrial sector.

Because electricity is so crucially important, many companies that can afford investments in back-up generation capacity have done so. Companies that turn to self-generation to substitute for grid electricity typically incur a cost increase because of the scale advantages present in electricity generation and because typically expensive fuel must be transported to the site. Power outages for these firms means higher costs which render them less competitive and lowers the output level at which they maximize profits. Power outages effectively are a time-varying tax on electricity. This tax is lower for larger companies due to scale advantages in power generation. The effect of outages on companies that do not have access to back-up generation capacity is discussed in Section 4.2.

Based on the literature overview presented above we conclude the following:

- The balance of evidence from Turkey and countries in a similar development stage points to a bidirectional relationship between energy and electricity use on the one hand and economic growth on the other;
- This causal relationship runs substantially, but not exclusively, through electricity intensive sectors, prime among which is industry.

4.2 Impact of power outages on economic output

The overview in the previous section demonstrated the role of electricity consumption as a facilitator or enabler of economic growth. One can thus safely assume that power outages negatively affect economic output.

Power outages can affect economic output through (i) loss or production; (ii) restart costs (iii) equipment damage; and (iv) spoilage of raw or finished materials. There are a number of factors that can completely or partly mitigate these negative impacts. In addition to self-generation, which was discussed in the previous section, firms can (i) continue operations without electricity or reschedule production; (ii) adopt technologies that allow faster production during hours when power is available; or (iii) procure energy intensive semi-finished goods and thereby eliminate power-intensive production steps. **The diverse impacts and mitigation measures make it plausible that the ensuing effect of power outages varies substantially per economics sectors.**

An often used indicator to monetize the impact of outages is the so-called “Value of Lost Load” (VoLL). The VoLL expresses the value per kW power load, although it is more commonly expressed as the value lost per kWh foregone electricity consumption (Value of Lost Consumption, VOLC). It can be expressed for an individual firm, for an economic sector or for an entire economy. When expressed as loss of value added per kWh it essentially is the inverse of the electricity intensity. Using Exhibit 7, this means that the VoLC for Turkey is USD 5.80 per kWh.[43] VoLC values are nearly always an order of magnitude higher than the all-inclusive cost of power, an argument that is often used that investments in power yield great economic returns. But because the VoLC does not reflect self-generation or any of the other mentioned mitigation measures it is obvious that it is a drastic overestimation. Moreover, when the VoLC would be determined for individual sectors it would yield the logical but counterintuitive result that it is highest for the least electricity intensive sectors. For example, construction is not very electricity intensive and thus has a very large VoLC but it is obvious that the bulk of construction activities can continue when there is no power.

[43] The electricity intensity is 0.24 kWh / 2010 USD GDP. Taking the inverse and multiplying it by the 2014/2005 GDP inflator of 1.39 yields USD 5.8 per kWh.

The heterogeneity of how power outages affect firm output is illustrated by Alam (2013)[44] who studied brick kilns, rice mills and steel mills in India. The majority of brick kilns do not use any electricity at all and their output is thus not seriously affected by outages. Rice mills are electricity intensive but can change their production such that a 10% increase of outages affects their output by only 0.1% (although profitability is affected more because material use goes up by 7%). An identical increase of outages in steel mills in contrast leads to 11% loss of output (and 2% lower use of materials). Alcott (2014)[45] also found that electricity shortages have very different effects for self-generators and grid dependents in India, but notes that power shortages affect profitability much less than revenues due to avoidable cost. Abotsi (2016)[46] found that power outages impact negatively on firm production efficiency using World Bank data of 2,755 firms in 10 African countries. In Senegal, Cissokho (2013)[47] showed that in response to more frequent power outages the ownership of generators increased by 47% in between 2006 and 2011. The same study shows that although SMEs tend to become better in dealing with outages (higher technical efficiency), outages do hinder their growth (scale efficiency).

4.3 Analysis framework

Based on the overview presented in Section 4.1, the analysis framework for the economic impact of increase power supply and distribution is presented in Exhibit 14. Going from left to right, **an increase in power generation and/or distribution capacity leads to a lower price of power[48] and/or reduces the number of outages.** Each of these two outcomes increases the production level at which companies maximize their profits and they will increase their electricity use to produce more output.[49] This in return increases their intermediate demand from other Turkish firms (both users and non-users, e.g. agriculture) and value added[50]. The resulting increase of value added increases GDP and employment. Finally the higher GDP increases the demand for electricity, which increases the electricity price and thus offsets some of the before-mentioned effects. Since this is a counterfactual study, results should be interpreted relative to a situation in which IFC had not invested in power projects in Turkey. We do not refer to the estimated effects as created, as we measure all impacts against a counterfactual which has not occured.

The impacts of improved grid supply (second order growth effects), as well as of operations, are sustained impacts to the extent that the operation is recurring each year, though yet possibly subject to a dynamic development.[51]

The framework does not include the effect of lower electricity price on investment (either directly or indirectly), a feedback that may be relevant in the longer run.

In the following sections the steps of the analysis framework presented in Exhibit 14 will be elaborated upon. The framework is valid to determine the impact of both power generation and distribution, but the way through which these two activities affect power price and outages are obviously different.

[44] Alam, M.M, *Coping with Blackouts: Power Outages and Firm Choices*, Working Paper, Dept. Economics, Yale University, 2013.

[45] Alcott, H., Collard-Wexler, A. and O'Çonnell, S.D., *How Do Electricity Shortages Affect Productivity? Evidence from India,* American Economic Review, 2015.

[46] Abotsi, A.K., *Power Outages and Production Efficiency of Firms in Africa*, Int. J. Energy Econ. and Policy, 6(1), 2016.

[47] Cissokho, L. and Seck, A., *Electric Power Outages and the Productivity of Small and Medium Enterprises in Senegal*, ICBE-RF Research report No. 77/13, 2013.

[48] Compared to the counterfactual situation in which power generation capacity was not increased.

[49] The exhibit depicts relationships between two variables. The negative relationship between e.g. electricity price and consumption means that a lower price is associated with more consumption (and vice versa).

[50] Value added for a sector is defined as the contribution of this sector to overall GDP. The components of value added consist of compensation of employees (salaries), taxes, and gross operating surplus (profits).

[51] Unlike the second order effects, impacts of the construction phase (backward effects) are a one-off effect due to the non-recurring character of the construction investment. In Sections 6 and 7 we refer to the jobs sustained during construction as man-year jobs.

This study largely follows the methodology we developed for the 2015 study *"Economic impact of IFI investments in power generation in the Philippines."* The reason for this is that the electricity sector and market in Turkey are similar to the ones in the Philippines in terms of structure and operation. The crucial similarity with the Philippines is that the power generation cost price is market based. An important difference between is the shape of the supply curve, which in the Philippines is significantly steeper[52], which causes market clearing generation prices to vary more. Another important difference is that in Turkey about 30% of all power is traded on spot markets compared to less than 10% in the Philippines. The two countries are compared in more detail in Annex 1. We expand the analysis framework for Turkey by including the effects of investments in electricity distribution and by capturing impacts on all economic sectors, as opposed to only manufacturing in the Philippines.

In the Section 5 the impact of IFC's investments in the power sector are described along the lines of Exhibit 14. Section 5.1 deals with the power outage data and in Sections 5.2- 5.4 we describe the supply and demand based model with which we quantify IFC's impact on power generation cost.

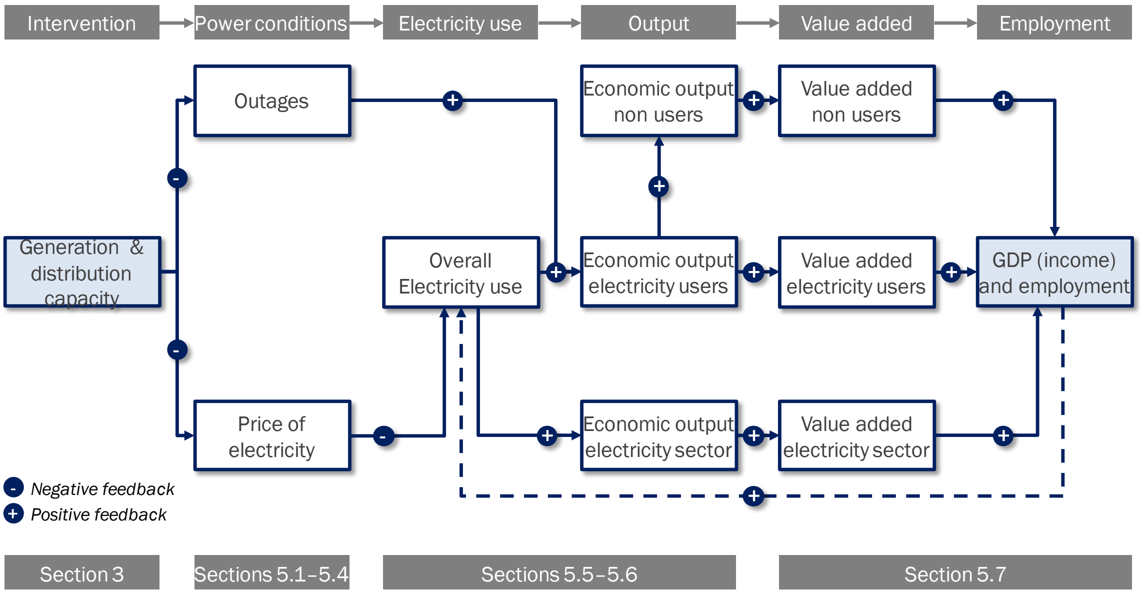


Exhibit 14: Impact analysis framework

52 In the Philippines, gas plants are being run as base load (they are typically mid-merit elsewhere) together with,coal and geothermal plants. The cost increases sharply beyond the base load. Hydro plants are being run as mid-merit and peaking plants due to the opportunity cost of losing hydro pressure (head) at times when prices are low. Expensive thermal peaking plants are often used as well.

5 ECONOMIC IMPACT OF IMPROVED GRID POWER SUPPLY

5.1 Power outages

A reduction of power outage time decreases the output losses incurred by companies as was discussed in Section 4.2. No exhaustive dataset exists from which the trends in outages can be inferred. By triangulating qualitative and quantitative information we conclude the following:

1. **Power outages in Turkey are relatively scarce.** Data from the 2014 World Bank Enterprise Survey puts the median outage time for companies at 3.0 hours per month, which is about 1% of operational time;
2. **Most power outages occur due to faults in the transmission and distribution networks**;
3. **The frequency and duration of power outages have not decreased substantially**, if at all, over the last eight years. For a panel of 138 firms in the World Bank Enterprise Surveys in 2009 and 2014, the median outage time is unchanged, although the average outage time (which includes outliers and unrealistic “protest” answers) has decreased slightly.

Confirming the third point, data from investee company SEDAS do not show a downward trend since the time it was privatized in 2010, largely because outages have been low historically (see **Error! Reference ource not found.** in Section 6.2). Of course it is possible or even likely that in lieu of IFC’s debt capital power outages would have increased because the electricity demand growth necessitated substantial investments in the network. However, unlike the situation in power generation, where a counterfactual can be constructed by leaving out one or more of a large number of individual power plants, in distribution electricity is delivered using a single network. This makes it pretty much impossible to construct a counterfactual of what would have happened without the network investments or if IFC had not provided capital. For that reason we are unable to quantify the employment effect through this pathway. The methodology and some analysis results can be found in Annex 2.

5.2 Derivation of the power generation supply curve

5.2.1 Long and short-run marginal cost for different power generation technologies

Different power technologies incur distinct costs. Broadly speaking one can differentiate five different cost components: Investment cost, fixed operating cost, variable operating cost, fuel cost and environmental cost. In order to construct a comparable cost picture for different generation technologies, the capital and fixed cost, which are driven by installed power capacity (MW), must be spread out over the life-time power production in order to arrive at a cost per unit of work (kWh). The so-called Levelized Cost of Electricity (LCOE) achieves that by dividing the sum of all costs over the lifetime of a power plant by the sum of all electricity produced over that lifetime. Rather than projecting all cost items for each year, one can use average annual values for the variable (i.e. per kWh) cost and level the investment and fixed operating cost using assumptions on lifespan, discount rate and capacity utilization, as shown in the equation[53] below.

$$LCOE = \frac{\sum_{t=1}^{N} C_t^{TOTAL}}{\sum_{t=1}^{N} E_t} = LC_I + LC_{FOM} + C_{VOM} + C_{FUEL} + C_{ENV} = LC_I + LC_{FOM} + SRMC$$

With:

$$LC_I = \frac{C_I \cdot CRF}{8{,}760 \cdot c_f} \cdot \frac{(1 - T \cdot D_{PV})}{(1 - T)}$$

[53] We here follow *The Manual for the economic evaluation for energy efficiency and renewable energy technologies* by Short. W, Packey, D and Holt, T., DOE-NREL, 1995.

$$LC_{FOM} = \frac{C_{FOM}}{8{,}760 \cdot c_f}$$

$$C_{FUEL} = P_F \cdot H$$

$$CRF = \frac{(d + d')(1 + d + d')^N}{(1 + d + d')^N - 1}$$

Where:

C_t^{TOTAL}	Total annual cost in year t	USD
LC_I	Levelized investment cost	USD / kWh
LC_{FOM}	Levelized fixed operating & maintenance cost	USD / kWh
C_{VOM}	Variable operating & maintenance cost	USD / kWh
C_{FUEL}	Fuel cost	USD / kWh
C_{ENV}	Environmental cost	USD / kWh
$SRMC$	Short Run Marginal Cost ($C_{VOM} + C_{FUEL} + C_{ENV}$)	USD / kWh
C_I	Investment cost	USD / kW
C_{FOM}	Fixed operating & maintenance cost	USD / kW / y
CRF	Capital recovery factor	%
D_{PV}	Present value of depreciation	%
T	Corporate tax rate (20% in Turkey)	%
c_f	Capacity utilization factor	%
d	Minimum discount rate in power sector in Turkey	%
d'	Technology-specific discount premium	%
N	Lifespan	Years
P_F	Price of fuel	USD / BTU
H	Heat rate	BTU / kWh

Ideally the LCOE would be known for all plants in Turkey. For most plants such information is not available because they are owned by private operators. However, because the technology used is known for all plants one can use international data sources to construct a reasonable picture of their LCOE. We have combined information from the OpenEI Transparent Cost Database, the US Energy Information Agency (EIA) and the World Energy Council to get minimum, median, average and maximum values on several parameters in the LCOE equation. Fuel price ranges are based on observed prices in Turkey for imported natural gas, coal, fuel oil and diesel as well as for domestic lignite. This allows a Monte Carlo simulation to establish a reasonable range of LCOE values per technology.[54] Specifically we assume six independent stochastic variables (underscored):

$$LCOE = f\left(\underline{C_I}, \underline{C_{FOM}}, \underline{C_{VOM}}, \underline{P_f}, \underline{c_f}, \underline{H}; d, D_{PV}, N\right)$$

By assuming probability density functions (pdf) for each of the stochastic variables,[55] a large number[56] of possible combinations have been generated, each of them with a corresponding LCOE value. Using the parameter values given in Table 13 (Annex 2), the resulting LCOE probability distributions for the technologies present in the Turkish electricity grid are shown in Exhibit 15.

[54] We have not considered the environmental cost (e.g. carbon taxes) which would increase the fossil-fuel based technologies. Their inclusion would be very straightforward however as a cost incurred per kWh (and would be included in the SRMC).

[55] We have assumed the distribution of each variable to consist of two parts: half of the probability mass is uniformly distributed between the minimum and median and the other half is uniformly distributed between the median and the maximum value. In case the median value is exactly in between the minimum and maximum values this is a uniform pdf. In case it is not, the skewness of the distribution is preserved. This would not be the case if the "lack of knowledge" triangular distribution was used.

[56] The accuracy of the Monte Carlo method is inversely proportional to the square root of the number of realizations. The 20,000 realizations used here are sufficiently large for accurate results. A doubling to 40,000 realizations would only improve the estimations of the mean values from $0.007\sigma_{LCOE}$ to $0.005\sigma_{LCOE}$, which is insignificant given the inaccuracy of the specified minimum, median and maximum values.

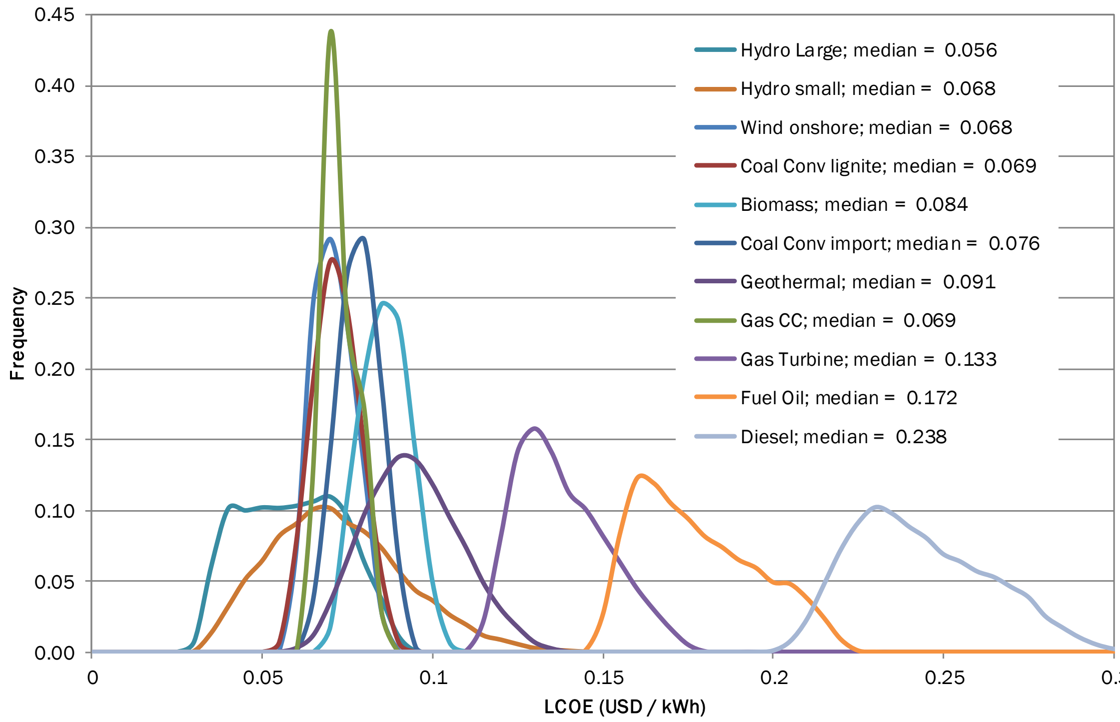


Exhibit 15: LCOE distributions resulting from Monte Carlo analysis

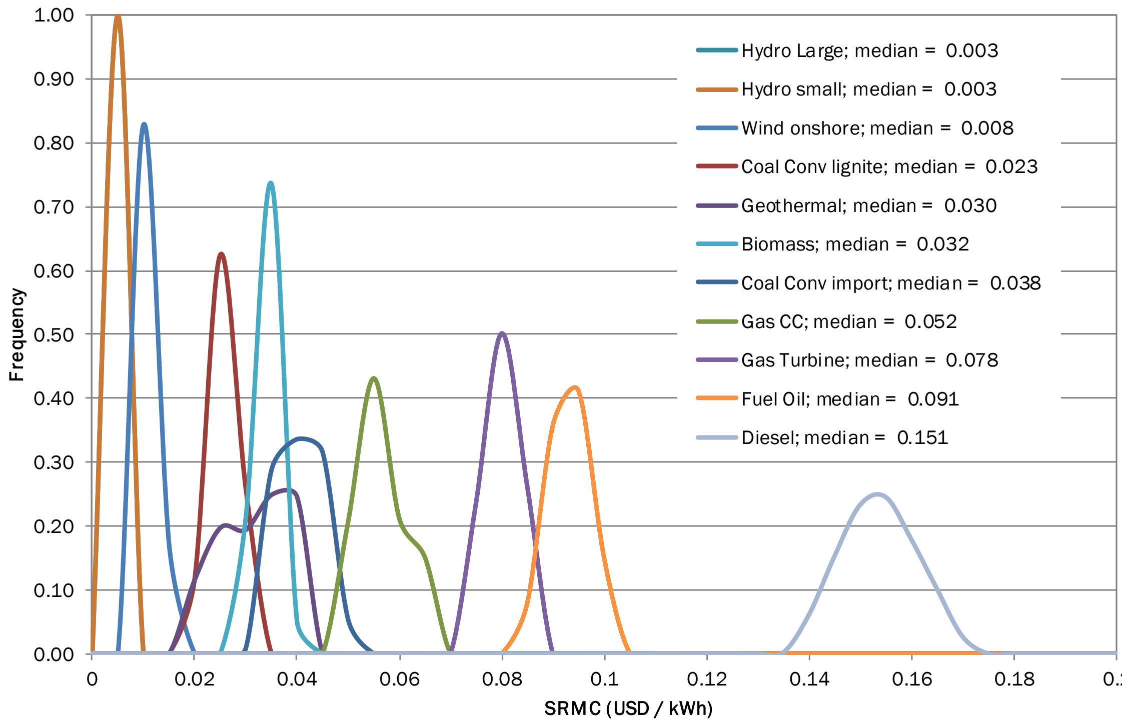


Exhibit 16: SRMC distributions resulting from Monte Carlo analysis

Over their entire life cycle, power plants must achieve a price equal to their LCOE in order to break even. In the short run, however, plants will deploy excess capacity when they can realize a price above their short-run marginal costs (SRMC). Exhibit 16 shows the SRMC distributions. Reading the different technologies from left to right in the exhibit resembles the so-called merit order. By and large, plants will run (i.e. dispatch power) according to their position in the merit order, although there are some exceptions. Small (run-of-river) hydro plants which cannot store large amounts of water, wind and solar plants are 'non-dispatchable' technologies, which cannot be turned on at will. These plants, which have near zero SRMC and therefore dispatch electricity whenever they can, typically receive a pre-determined feed-in-tariff (FiT) and are not included in the merit order.[57] Large hydro plants with reservoirs are dispatchable (i.e. can be turned on at will) and come first in the merit order but in order to preserve hydraulic head they sometimes run only when electricity market prices are high (i.e. at peak times). Of the non-renewable technologies lignite plants tend to be cheapest in Turkey, although their availability tends to be rather low (i.e. a low capacity factor). Geothermal, biomass and especially the imported coal plants provide the base load and tend to dispatch whenever available (i.e. their capacity utilization equals their availability). Combined cycle natural gas (gas CC) plants supply base load, but depending on their efficiency will not all be in merit during non-peak hours (i.e. capacity utilization is lower than their availability). When demand is very high, gas turbine, fuel oil and diesel generators, which have low capital cost but a high SRMC, can be used to satisfy demand.

5.2.2 Power supply curve

Table 3 provides an overview of the Turkish power fleet as per early 2015. Using the average availability per technology[58], the installed capacity of 69,121 MW translates into an average available capacity of 41,341 MW. Natural gas combined cycle plants represent the lion's share of available capacity, followed by large hydro and the two coal technologies. The non-dispatchable small hydro and wind technologies represent 8% of the available and 15% of available capacity.

Table 3: Installed and available capacity of power plants per technology
(Source: Plant license information from EMRA[59])

Technology	Operational plants	Installed capacity (MW)	Availability	Available capacity (MW)
Coal Conv import	8	6,076	0.75	4,549
Coal Conv Lignite	31	9,188	0.44	4,022
Gas CC	68	21,277	0.90	19,150
Geothermal	21	635	0.55	351
Hydro large	73	17,890	0.35	6,213
Hydro small	393	5,749	0.35	1,997
Wind onshore	109	4,319	0.31	1,359
Gas Turbine	194	1,296	1.00	1,296
Biomass	82	452	0.37	165
Fuel Oil	30	2,227	1.00	2,227
Diesel	1	12	1.00	12
Total	**1010**	**69,121**		**41,341**

It is important to note that the annual average is often not representative; hydro power plants exhibit a considerable seasonal variation and wind power has a seasonal as well as diurnal pattern.[60] In April, when hydro power is abundant, capacity utilization of the coal plants reduces sharply. For each of the 1,010 available power plants in Turkey, LCOE and SRMC values have been generated by systematically

[57] Because these non-dispatchable plants decrease the time that other plants can run, they effectively increase the LCOE of plants in the merit order (a lower c_f in the LCOE equation causes the LCOE to go up).

[58] For the non-dispatchable and base load technologies (i.e. small hydro, wind and large hydro, coal, biomass and geothermal) the availability is equal to the observed capacity factors in 2015.

[59] http://lisans.epdk.org.tr/epvys-web/faces/pages/lisans/elektrikUretim/elektrikUretimOzetSorgula.xhtml

[60] The availability data for small hydro plants show that on average they have the ability to store a limited amount of water to be released when demand (and prices) are high (when demand is lowest, small hydros produce at about 95% of the daily average utilization which enables them to run at about 105% of the daily average around 12:00.

sampling[61] the LCOE and SRMC distributions for the different generation technologies shown in Exhibit 15. Subsequently the non-dispatchable plants (i.e. small hydro, wind and solar), which must dispatch when available, have been placed at the left of the supply curve, followed by the BOT/BOO/TOOR plants for which take-or-pay guarantees are in effect. When taking into account the availability (see Table 3) the resulting power supply (or dispatch) curves are shown in Exhibit 17.

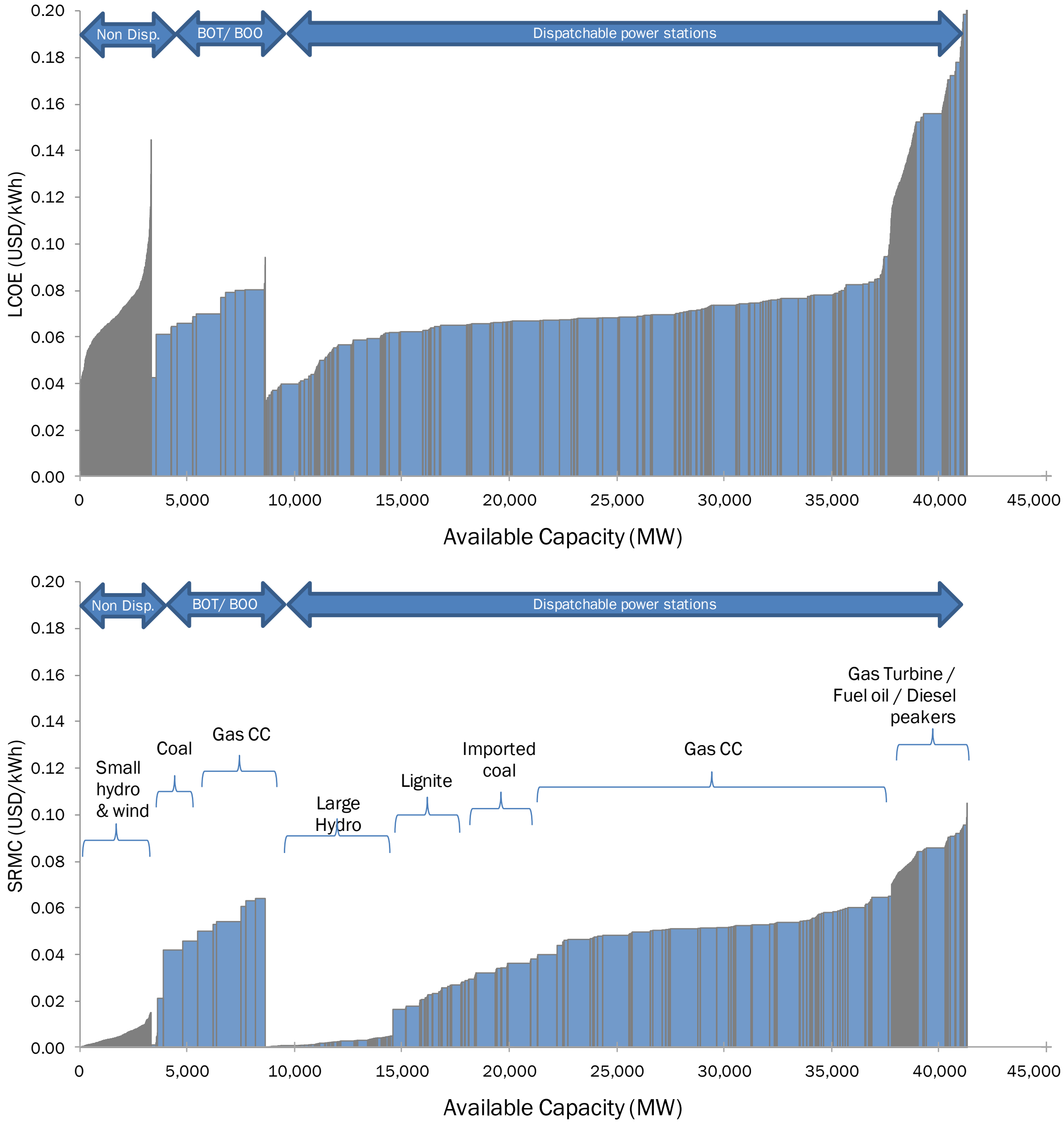


Exhibit 17: LCOE and SRMC power supply curves based on average available capacity

As will be shown later, **using the SRMC-based supply curve we are able to reproduce the observed price behavior of the Turkish day-ahead power market.** The supply curves shown in Exhibit 17 are yearly average. Because of the seasonal and diurnal patterns of renewable power, the exact supply curve in

[61] Sampling is done by converting the probability densities shown in Exhibit 15 and Exhibit 16 into a cumulative distribution (cdf) which ranges from 0 to 1. This cdf is sampled using *n* equidistant steps, where *n* is the number of power plants of the respective technology which have an operational capacity larger than 0.

the model depends on the month and the time of day. Supply varies by some 2,500 MW between the months and the diurnal variation reaches 1,000 MW in April.

5.2.3 Interconnection with other countries

Turkey's electricity grid is connected to the grids of its neighbors which allows for import and export of electricity (see Table 4). Although in theory this means that the power supply curve needs to be modified to reflect this, this would be nontrivial in practice due to the time dependence and contractual obligations that govern the direction and magnitude of the flows. As per November 2015 the interconnection with Greece and Bulgaria enabled Turkey to import 650 MW and export 500 MW of power, although typical import capacity is 350 MW, which is a rather small amount in the entire supply curve. In 2015, power premiums in Turkey over its neighbors have come down sharply which reduced cross border flows. For these reasons we have not modified the supply curve.

Table 4: Transmission interconnections of Turkey with its neighbors

Country	Import MW	Max typical import MW
Georgia 1	150	
Georgia II	700	
Aremenia	0	
Azerbajan	50	
Iran 1	50	
Iran 2	250	
Iraq	0	
Syria	0	
Bulgaria 1		52
Bulgaria 2	650	
Greece		350

5.2.4 Effect of IFC attributable power on power supply curve

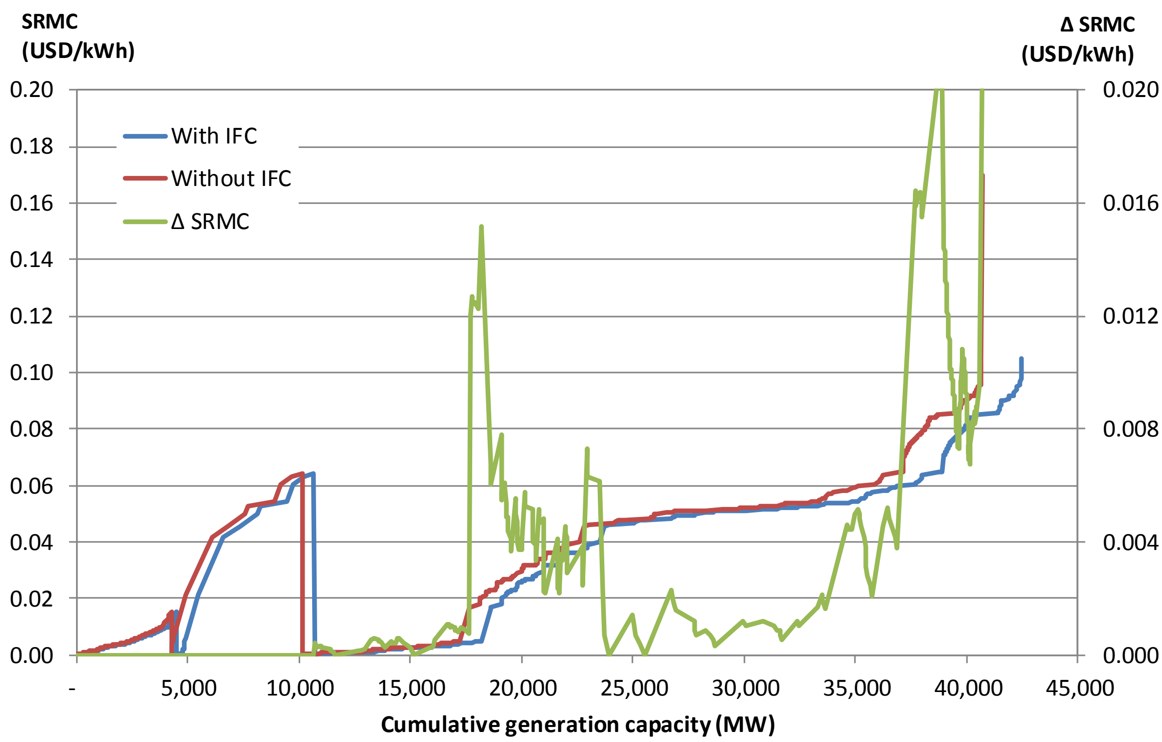
In order to examine the influence of the IFC-financed power projects (Table 2), the power supply curve depicted in Exhibit 17 can be modified by taking out that capacity. The result is shown in Exhibit 18, which shows the supply curves for the month of April (high hydro availability) with and without the IFC-financed capacity (both with and without attribution), as well as the difference in SRMC for any level of demand (i.e. the vertical distance between the two curves). The SRMC difference of course is lower when the financed capacity is attributed to IFC as explained in Section 3.[62]

Looking at the part of the supply curve to the right of the BOT plants, the vertical difference between the two curves (Δ SRMC) is relatively large between 18,000 and 25,000 MW. This region comprises the lignite and imported coal plants, which vary considerably in terms of their SRMC and result in a steep section. The IFC-financed 2,116 MW (548 MW with attribution) hydro and wind capacity to the left in the supply curve (with an average capacity factor of 44%) has a considerable effect. **The market, however, normally clears in the region from 30,000-40,000 MW where the supply curve is quite flat and SRMC differences are smaller.** This flat supply curve comprises the non-BOT/BOO combined cycle gas plants which have SRMC values in between USD 0.050 – 0.060 per kWh.[63] At times of very high demand the

[62] The attribution for most plants is 20%-40% of their installed capacity, although the (pre-existing) 672 MW Birecik hydro plant (BOT) is attributable for only 5% to IFC. This explains why the large shift between the supply curves without IFC attribution around 4,900 MW in Exhibit 18 is not observed in the graph with IFC attribution.

[63] A 60% efficient gas plant (i.e. a heat rate of 5,690 BTU / kWh) has an SRMC of about USD 0.05/kWh whereas a 50% efficient plant (which would find itself out of merit most of the time) has an SRMC of about USD 0.06/kWh. These values are based on a natural gas price ranging from USD 8.10 – 8.30 per mmBTU, the average for 2015 (which is approximately USD 0.30 per cubic meter).

IFC-financed capacity more often prevents the necessity of expensive peak capacity and therefore has a much larger price effect.



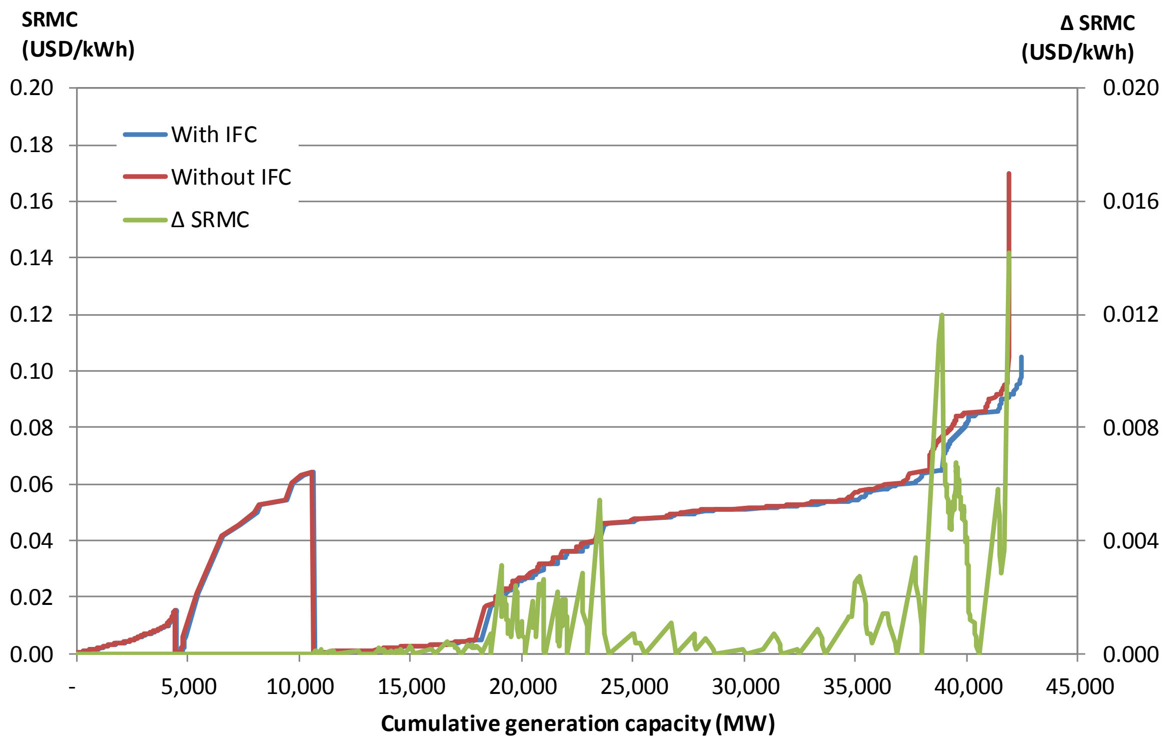


Exhibit 18: Power supply curve with and without IFC-financed capacity. Top graph without attribution and bottom graph with IFC attribution

5.3 Power load curve

Electricity consumption was discussed in Section 2.5. In order to determine electricity prices one needs to know the system power load in terms of MW rather than consumption in MWh. This power load, when inserted on the horizontal axis of the power supply curve, yields the 'market clearing' generation charge. For each month we have selected for the second Wednesday as being representative. The advantage of using individual days is that it allows for a comparison of the model with the observed prices from the EPIAS day-ahead market.

Electricity demand fluctuates, both over the course of the day as well as per month as shown in Exhibit 19. Power demand during daytime is about 10,000 MW higher than during the night, but fairly stable without very pronounced peaks. There is a clear seasonality with demand in the warm and busy tourist month August about 10,000 MW higher than during the low season in October.

Analysis of the GDP and electricity consumption growth rates in Turkey reveals a ratio of 1 : 1.05[64] that is statistically highly significant. The relationship is much lower than the historic 1 : 2 ratio which was used for demand forecasts. This, together with the **slowing GDP growth caused demand forecasts to be overly optimistic, which in return is likely to have contributed to the current high reserve margins.**

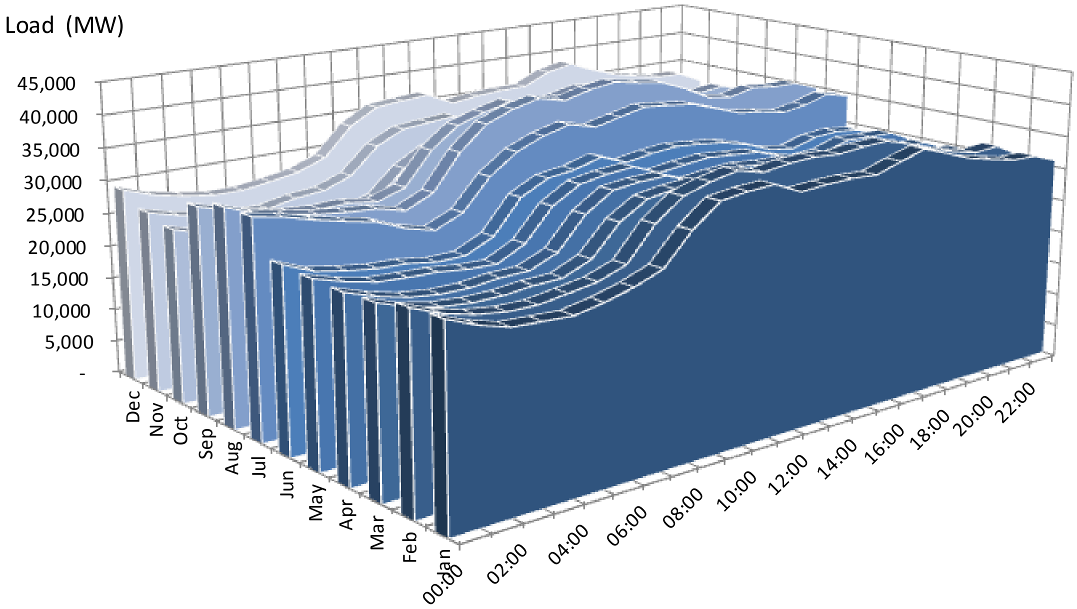


Exhibit 19: Daily power load curves for the second Wednesday of each month
(Source: TEIAS)

5.4 Power supply and demand based price model

With the power supply and load curves defined as described in the sections above, a model has been constructed that combines them. For each hourly load value the model determines the market clearing plant, whose SRMC is assumed to be the market clearing generation price. By using the feed in tariffs for renewable capacity and the market clearing price for the remaining capacity one can determine the weighted average generation costs. Because it applies to some 90% of the generated power, a lower market clearing price typically means lower average generation costs.[65,66]

By running the model using the supply curve with and without the IFC-attributable power (Exhibit 18) the IFC-attributable price difference can be determined. The results are shown in Exhibit 20, which depicts

[64] This is very similar to the 1 : 1.11 in the World Bank report *Turkey's Energy Transition; Milestones and Challenges*, 2015 which did not include the year 2015.

[65] We assume the market clearing price to be also valid for the bilateral contracts. In the absence of information on bilateral contracts, this is not an unreasonable assumption to make according to EPIAS and EMRA staff.

[66] Because renewable technologies have feed in tariffs which normally are above the market clearing prices it is possible that the average generation costs increases. In the model however this occurs infrequently.

the modelled hourly market clearing prices as well as the observed prices of the EPIAS day-ahead market for the corresponding days.

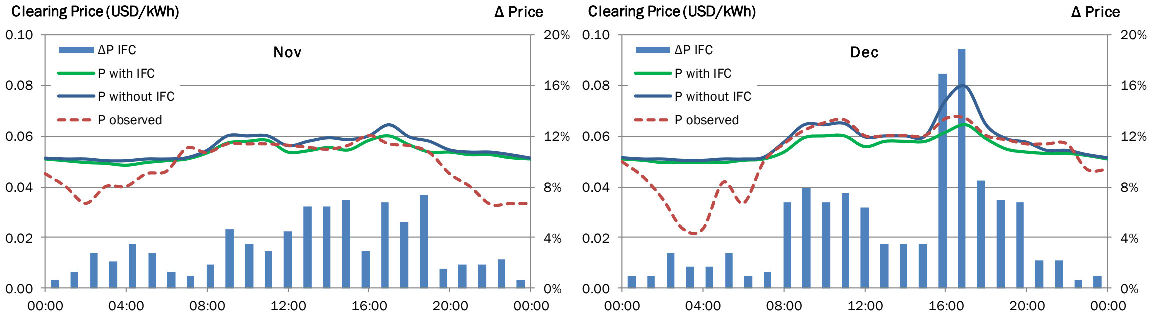


Exhibit 20: Market clearing generation price with and without IFC-financed capacity (no attribution) for load curves in Exhibit 19 and observed prices

It must be noted that about 30% of all electricity is traded through the day-ahead market with the remaining 70% under bilateral agreements. This together with the fact that availability of plants is incorporated as the statistical average of the generation technologies means that no perfect match between model and observations can be expected. That said, **the model tracks observed clearing price behavior fairly well**, the two main exceptions being:

1. The month of January where market clearing prices are anomalously high despite low demand. In fact, prices in the first half of the January (including this second Wednesday) were 80% above 2016 prices and 20% above 2014 prices and also markedly above price levels in subsequent months which had substantially higher demand;
2. The model overestimates clearing prices during night time, most likely because plants bid low prices in order to prevent the need to shut down (which is costly due to start-up cost) as well as bilateral obligations that require them to run partially, causing some excess which is offered at low prices at the day-ahead market.

The difference between the market clearing prices derived using the supply curves with and without IFC-financed capacity is less than 3% most of the time, in line with the remarks accompanying Exhibit 18. Unsurprisingly, clearing price differences are largest (about 20%) when demand is high in the months of August on September. In these months, modelled reserve margins dip below 4% at peak times and without IFC-financed capacity demand would have exceeded supply.[67]

Exhibit 21 shows the load weighted daily average modelled and observed clearing prices of Exhibit 20. In addition to the daily averages, the average results for the periods of low demand (0-7h), medium demand (18-23h) and peak demand (8-18h). The pattern of model overestimation during hour of low demand and the close correspondence of the model with observations during peak hours can be seen.

[67] According to a study by Deloitte Turkey (2016), in September 2015 the real reserve margin (i.e. 1 – Daily Peak Demand / Available Installed Capacity) was about 2% which is sufficiently close to the modelled value considering that the model works with average monthly availability factors for wind and run of river hydro whereas they can show substantial diurnal variation.

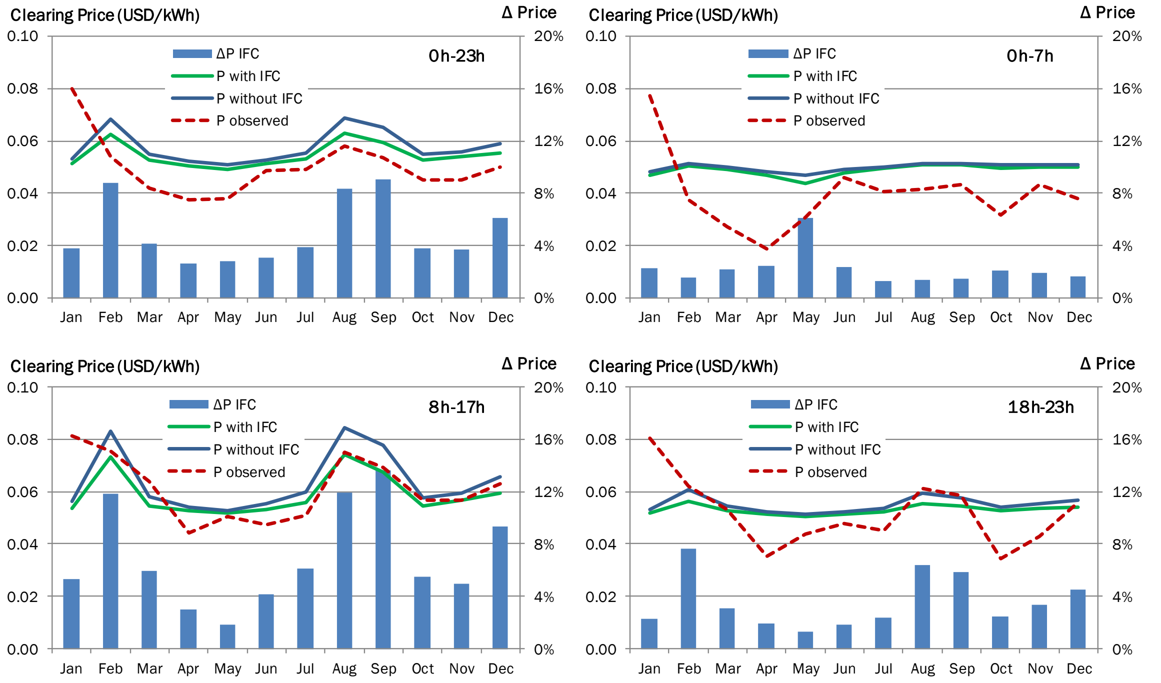


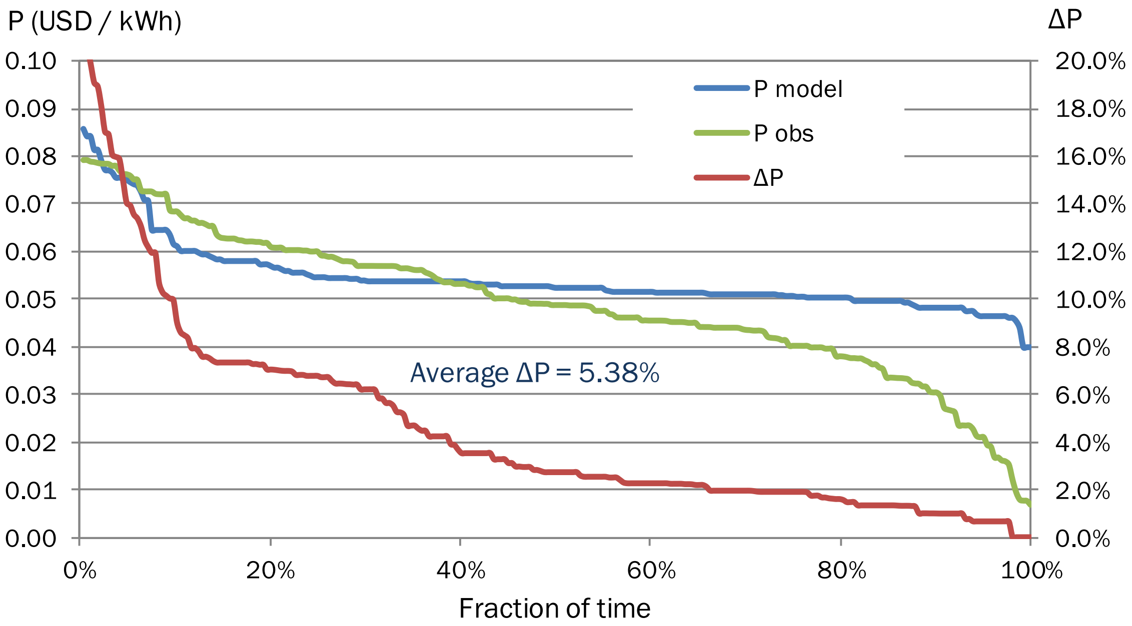
Exhibit 21: Load-weighted daily average prices and price difference corresponding to Exhibit 20 (no attribution)

By sorting the counterfactual modelled and observed clearing prices and the IFC-attributable price difference, the price duration and price difference duration curves can be derived. These curves, shown in Exhibit 22, indicate the fraction of time that the clearing price (difference) is above a certain value. The inability of the model to reproduce the market clearing price during hours of low demand can be observed. The price difference between the with and without IFC-financed capacity (without attribution) is less than 3% for about half of the time and larger than 7% for less than 20% of the time. **Across the year, the difference of the load weighted average market clearing price between the situations with and without IFC-financed capacity is 5.38%. When taking into account attribution, the price difference is 1.73%.** Alternatively stated, the IFC-attributable market clearing price difference is 32% of the difference when considering the full capacity of the financed plants. This is very close to the average attribution factor of 30%.[68] As previously mentioned, this price decrease should be interpreted as relative to the hypothetical situation in which IFC had not invested in power capacity projects in Turkey, i.e. the 2015 market clearing price would have been higher had IFC-financed power projects not been realized.

Electricity prices have been falling since 2014 and the attributable price difference of 1.73% is therefore too low to be representative for the years that IFC has been invested in the Turkish power sector. The lower electricity prices reflect the fact that power supply has expanded faster than demand and that as a result reserve margins have gone up and prices have come down. Reserve margins are quite volatile and reflect actual power supply (which depends on the availability of thermal plants, water reservoirs levels and wind speeds) and demand data. Because we do not have information on available actual capacity, we use installed capacity in the calculation of theoretical reserve margins below. The reserve margins obtained in this way are obviously substantially higher than (and thus should not be compared with) real reserve margins (based on actual available capacity) which in the model can be as low as 4% in 2015.[69]

[68] I.e. 925.65 MW / 3052.66 MW in Table 2

[69] The actual reserve margins of 4% corresponds pretty well with the the smallest actual reserve margin of 2% found by Deloitte Turkey in a recent study



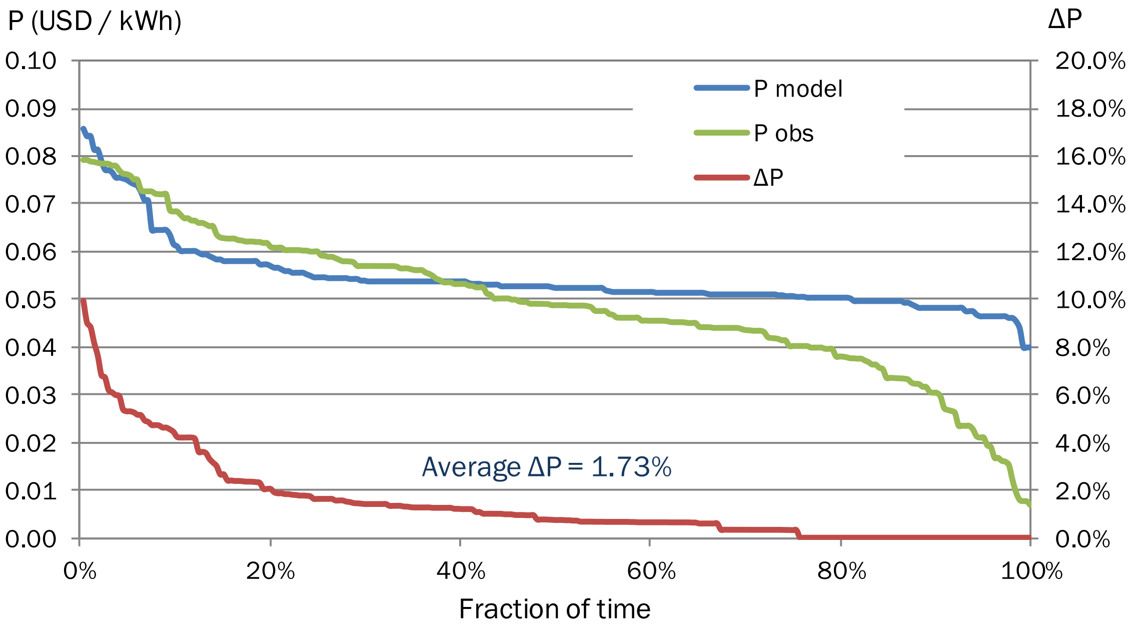


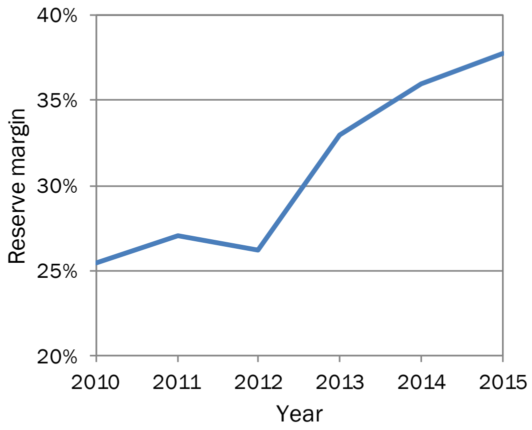
Exhibit 22: Duration curves of modelled and observed price difference due to IFC-financed capacity, without attribution (top) and with attribution (bottom)

Analysis of historic data shows that the system peak load in a year is 35% - 40% higher than the average load. Based on that and the average load for the past five years, the left panel of Exhibit 23 shows that theoretical reserve margins have gone up from about 25% until 2012 to 38% in 2015[70]. It is somewhat impractical to reconstruct supply curves in the years prior to 2015 because it would involve backtracking which of the 1,010 generating units were added over that time.[71] But by increasing demand in the model

[70] According to a Deloitte Turkey study mentions an increase of theoretical reserve margins (i.e. 1 – Peak Demand of the Year / Installed Capacity) from 32% to 41%. The difference is most likely due to the fact that in the Deloitte study installed capacity has been counted that never was available throughout the year. This study and the Deloitte study agree however on the substantial increase that happened in 2013.

[71] Although in principle this data is public, it is not yet available on the websites of TEIAS and/or regulator.

we can achieve smaller reserve margins as well. As shown in the right panel of Exhibit 23, **the 1.73% price change attributable to IFC increases to 4.79% when reserve margins are at 2010 levels.**[72] We therefore estimate that over the course of its investment activity in Turkey, the IFC- attributable change of market clearing price decreased from more than 4.79% in 2010 to 1.73% in 2015 with an average of 3.26% over the entire period.



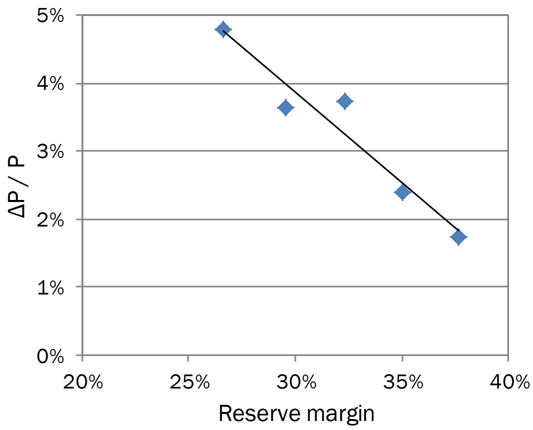


Exhibit 23: Historic reserve margins and IFC-attributable price change as a function of reserve margin

In order to convert a difference in market clearing price (and thus generation costs) to lower electricity tariff one has to incorporate the other tariff elements. As shown in Exhibit 13, generation costs represent 74% of the electricity end-tariff. Therefore, compared to the counterfactual situation in which IFC had not invested in power generation, **end user prices were 3.55% lower in 2010 and 1.28% lower in 2015**. For the analysis on how price affects economic activity, incomes and jobs in Turkey (Sections 5.7.3 – 5.7.5), we will use the average of the two, i.e. 2.42%. In Section 5.7.6 we will present the range of results based on these two limiting values as well as for the no attribution situation where generation cost difference of 5.38% translates into a lower end user price of 3.99%.

5.5 Response of company production to changes in electricity price

To arrive at the elasticity of economic output with respect to electricity price P, one needs to multiply the factor share of electricity consumption, ε, by the price elasticity of electric power consumption, θ:

$$\frac{dY}{dP}\frac{P}{Y} = \frac{dY}{dE}\frac{E}{Y}\cdot\frac{dE}{dP}\frac{P}{E} = \varepsilon\cdot\theta \implies \Delta Y \approx \varepsilon\cdot\theta\cdot\frac{\Delta P}{P}\cdot Y$$

The factor shares are determined from the analysis in Section 5.5.1 (Table 5), while the elasticities are presented in Section 5.5.2.

Using these relationships together with the estimated price change, in Section 5.6 the impact of the grid power increase on output will be determined.

[72] It should be noted that the 2010 situation cannot be simulated when removing all IFC-financed capacity from the model as demand would have been substantially larger than supply. In other words, IFC capacity was essential and without it the observed system loads would not have been possible

5.5.1 Electricity factor share and price elasticity of output

Framework

In order to determine the elasticity of output with respect to electricity cost one can apply the extended Cobb Douglas[73,74] production function:

$$Y = A \cdot L^{\alpha} K^{\beta} M^{\gamma} F^{\delta} E^{\varepsilon}$$

With Y firm sales; L labor (number of employees); K capital (investments), M annual cost of materials (USD), F fuel (cost), and E annual electricity consumption (MWh). A is the so-called total factor productivity (TFP), accounting for changes in productivity unexplained by changes of factor inputs. And α, β, γ, δ, and ε are the factor shares or output elasticities. In case of constant returns to scale, the elasticities sum up to 1. The factor shares can be determined using multiple linear regression analysis on the logarithmic form:

$$\log Y = \log A + \alpha \log L + \beta \log K + \gamma \log M + \delta \log F + \varepsilon \log E$$

The production function is estimated using two separate approaches (i) fixed effects (FE)[75] and (ii) Levinsohn and Petrin[76] (LP). The latter uses an observable firm variable, such as intermediate inputs, as a proxy for the unobserved firm productivity to estimate unbiased production function coefficients, removing the so-called simultaneous equation bias.[77] However, it relies on capital data, which was readily available only for the manufacturing sectors.

Data

In order to determine the relationship between electricity price and sectoral output we have used a longitudinal analysis using panel data of output and cost attributes of individual firms. The data comes from the Turkish Industry and Services Business Inquiry carried out by the TUIK between 2003 and 2013 among business with more than 20 employees. Taking into account data gaps and inconsistencies, the analysis was performed for nearly 484,000 companies: 231,100 in industry (of which 165,800 in manufacturing), 147,500 in trade, 93,800 in services, and 11,400 in agriculture and mining. In the survey, firms reported their revenues, number of employees, as well as spending on input materials, fuel, and electricity. We used data on electricity prices from EMRA to derive the actual electricity usage in kWh. Annual data was also adjusted for inflation.

Results

Table 5 presents the results of the FE and LP regressions. For the manufacturing sub-sectors, the fixed-effects estimates differ somewhat from the LP coefficients, showing different levels of correlation between the inputs and the productivity shocks. In any case, **all factor shares are relatively low, with the majority below 0.1, signifying that 1% decrease in electricity consumption will lead to a 0.1% or smaller increase in output.** Looking at the LP results, all factor shares are significant at the 5% level (with refined petroleum at 10%). The coefficient for chemicals and electronics are insignificant with LP (but significant with FE). The factor shares for the other industry sectors – construction and transport – analyzed only

[73] Charnes, Cooper, W.W., and Schinnart, A.P., *A theorem on homogeneous functions and extended Cobb-Douglas forms*, Proc. Natl. Acad. Sci. USA 73(10), 1976.

[74] Constant Elasticity of Substitution (CES) production functions may be preferable in theory but nesting forms for factors make determination less reproducible. Moreover, given limited importance of capital it would lead to unconventional 'nests'. Transcendental Logarithmic (Translog) production functions (which are generalized Cobb Douglas functions) become too unwieldy in terms of parameters that need to be estimated when more than two variables are considered.

[75] Fixed effects model was chosen instead of the random effects one based on the Hausman test, with significant p-value <0.05.

[76] Levinsohn J. and A. Petrin (2003). "Estimating Production Functions Using Inputs to Control for Unobservables". Review of Economic Studies, 70, 317-341.

[77] Simultaneous equation bias is defined as the correlation between the level of inputs chosen and unobserved productivity shocks, meaning that input quantities will be (partly) determined by the firm taking into account prior information/expectations about its productivity.

with the FE procedure due to lack of readily available capital data, are significant. Trade and services estimates are also significant, though rather low, signifying a smaller response to changes in electricity use than industry. Unsurprisingly, the factor shares for agriculture, forestry and fishing are insignificant.

Table 5: Factor shares for electricity from the LP and FE analysis[78]

	Observations	Levinsohn Petrin (LP) ε	Fixed effects (FE) ε
Agriculture	88		-0.064
Forestry	408		-0.019
Fishing	162		0.190
Mining	10,404		0.092***
Manufacturing	165,831	0.032 ***	0.077***
Food	17,106	0.076 ***	0.045***
Beverages	1,526	0.117 ***	0.117***
Textiles	17,669	0.051 ***	0.065***
Wearing apparel	25,238	0.020 ***	0.093***
Leather	3,757	0.067 ***	0.086***
Wood	2,810	0.065 ***	0.095***
Paper, printing	7,299	0.066 ***	0.073***
Coke, refined petroleum	658	0.045 *	-0.029
Chemicals	16,440	-0.004	0.074***
Non-metallic minerals	13,116	0.048 ***	0.075***
Metals	5,920	0.047 ***	0.061***
Metal products	15,183	0.126 ***	0.058***
Electronics	1,703	0.016	0.069***
Electrical equipment	6,133	-0.038 ***	0.072***
Machinery, equipment	13,051	0.082 ***	0.069***
Motor vehicles	5,761	0.081 ***	0.106***
Transport equipment	1,702	0.075 **	0.163**
Other manufacturing	10,759	0.119 ***	0.065***
Construction	58,498		0.076***
Transport	9,856		0.057***
Trade	147,510		0.036***
Services	75,010		0.049***

Note: * p<0.05; ** p<0.01; *** p<0.001

5.5.2 Electricity price elasticity of output

To derive the price elasticity, we performed regression analysis based on electricity consumption data derived from TUIK Business and Services Inquiry and electricity prices. We assume that

$$EC_{i,t} = B \cdot EC_{i,t-1}^{\varphi} \cdot P_{i,t}^{\theta}$$

[78] The factor shares calculated for Turkey are significantly lower than the ones estimated by Steward Redqueen for other countries, including in the Philippines. To an extent this could be due to the fact that Turkey is a more developed economy as companies focus more on factors such as human capital. A more important reason could be the use of panel data instead of cross-sectional one, such as the World Bank Enterprise Survey (used in the Philippines due to lack of panel data). Estimates from cross sectional studies are usually upward biased as they do not account for persistent differences in efficiency between firms.

where $EC_{i,t-1}$ is electricity consumption of firm i in year t, $EC_{i,t-1}$ in the electricity consumption of firm i in year t-1, and P is the electricity price in year t and B a regression constant. To estimate the relationship, we use Arellano-Bond, a log-linear dynamic panel-data model that includes lags of the dependent variables as covariates and contains unobserved panel-level effects, fixed or random.

The results are presented in Table 6. Overall, the Arellano-Bond (AB) method produces more intuitive results than the fixed effects – for total manufacturing, as well as for most sub-sections the coefficients are negative and significant, meaning that a decrease in electricity price will lead to increase in electricity consumption. **The overall manufacturing elasticity derived with AB of -0.161** is consistent with the -0.168 estimate of Dilaver and Hunt (2010)[79] who analyzed annual industry data over the period 1960 to 2008.

Table 6: Price elasticities of electricity use per economic sector

	Arellano-Bond (AB)	Fixed Effects (FE)
	Θ	Θ
Agriculture	-0.161	-0.032
Forestry	-0.287	-0.007
Fishing	-0.103	-0.054
Mining	-0.209	-0.061*
Manufacturing	-0.168***	0.058***
Food	-0.577***	-0.033*
Beverages	0.054	-0.047
Textiles	0.334***	0.111***
Wearing apparel	0.379***	0.093***
Leather	0.077	0.134***
Wood	-0.133	-0.030
Paper, printing	-0.474***	-0.035
Coke, refined petroleum	-0.357	-0.108
Chemicals	-0.431***	0.049***
Non-metallic minerals	-0.137*	0.044**
Metals	-0.308***	0.056**
Metal products	-0.571***	0.043**
Electronics	0.057	0.047
Electrical equipment	-0.666***	-0.038
Machinery, equipment	-0.387***	0.084***
Motor vehicles	-0.275***	0.046*
Transport equipment	0.009	0.075
Other manufacturing	-0.466***	0.065***
Construction	-0.199*	
Transport	-0.114*	
Trade	-0.243***	-0.001
Services	-0.262***	-0.068***

Note: * p<0.05; ** p<0.01; *** p<0.001; FE regressions were not estimated for the construction and transport sectors

Despite the reliable elasticity of the overall manufacturing sector, some of the sub-sector results are not realistic. The estimated elasticities for beverages, and leather, electronics, transport equipment, are

[79] Dilaver, Z., Hunt, L.C., 2011a. Industrial electricity demand for Turkey: A structural time series analysis. Energy Economics, 33, 426-436.

positive and insignificant. This might be due to the smaller sample available for these sectors. The elasticities calculated for the textiles and wearing apparel sector, for which sample sizes were relatively large, are significant but also positive. Based on the regression analysis we cannot draw conclusions regarding the response of these sectors to reduction in electricity price. The elasticities for the agriculture, forestry and fishing are insignificant, which is likely due to the very small sample sizes. However, the results are not unrealistic, given that typically these sectors are not large electricity consumers. The other analyzed the sectors –construction, transport, trade and services– also exhibit negative response to increases in electricity prices.

5.6 Change of output per sector due to cheaper electricity

Combining the price decrease (Section 5.4), the factor shares (Section 5.5.1) and the price elasticities (Section 5.5.2) yields the increase of output related to cheaper electricity per sector in comparison with the counterfactual situation.

The manufacturing sector, which in 2015 contributed 17.6% of GDP, increased output by 0.05% (USD 339 million). The results for the individual sub-sectors vary from 0.02% in the non-metallic minerals to 0.13% in 'other manufacturing', (which includes diverse activities such as manufacturing of furniture and recycling). Food – the largest manufacturing sub-sector – increased output by 0.11%. The change of output for sectors for which the regression analysis produced an insignificant or unrealistic factor share or elasticity (i.e. negative factor share or positive elasticity) has been set zo zero. For some of these, such as agriculture, the lack of output response to changes in price is intuitive. For others, such as the beverages or textiles, this is probably overly conservative.

Relative to the counterfactual situation, the overall output increase resulting from the cheaper electricity was USD 638 m (or 0.03%).

Table 7: Change of output related to change in electricity price
(Source: Tuik[80])

	ΔY(%)	ΔY(USD m)	Sector share of GDP
Agriculture, forestry, fishing	-	-	8.6%
Mining	-	-	1.4%
Manufacturing	0.05%	339	17.6%
Food	0.11%	131	2.8%
Beverages	-	-	1.0%
Textiles	-	-	1.7%
Wearing apparel	-	-	1.1%
Leather	-	-	0.2%
Wood	-	-	0.2%
Paper, printing	0.08%	17	0.8%
Coke, refined petroleum	-	-	1.7%
Chemicals	0.08%	49	1.8%
Non-metallic minerals	0.02%	4	0.9%
Metals	0.07%	34	1.0%
Metal products	-	-	0.6%
Electronics	0.12%	31	0.8%
Machinery, equipment	0.08%	32	1.5%

[80] GDP breakdown is from TUIK database, except for the manufacturing sub-sectors, which was derived based on GTAP data due to unavailability from TUIK.

Motor vehicles	0.05%	19	0.9%
Transport equipment	-	-	0.2%
Other manufacturing	0.13%	21	0.4%
Construction	0.04%	43	5.8%
Electricity	-	-	2.5%
Transport	0.02%	38	13.2%
Trade	0.02%	54	16.2%
Services	0.03%	163	35.6%
Total economy	**0.03%**	**638**	**100%**

5.7 Total economic output, GDP and employment impact

Having determined the IFC-attributable change of economic output, the final step in Exhibit 14 comprises the determination of the associated value added and employment. The Turkish input-output table is well suited for this since it allows one to trace the knock-on effects of changes in one sector on other sectors. One of the main criticisms of input-output modelling is its inability to consider demand induced price changes. Although electricity price is determined using a detailed supply and demand model (Section 5.4), all other prices are indeed considered constant[81] and the results here may be somewhat overestimated. However, input output modelling is used here solely to trace the impact of the output increase specified in Table 7 on unaffected sectors (e.g. agricultures, textiles etc.) which comprises just under 6% of the total output increase (as will be shown in Section 5.7.3). So any overestimation will not greatly affect the overall results.

5.7.1 Turkish input-output table

In order to determine how a change of economic output translates into changes of GDP and employment we use the Input-Output methodology. The core ingredient of this methodology is the input-output table (IOT). The most recent IOT for Turkey comes from the Global Trade Analysis Program (GTAP), which contains information for 57 economic sectors and is based on 2011 data.[82] The IOT has been updated to 2015 using the often-used RAS method (see section 5.3.1) using the most recent data from TUIK on GDP contribution for 19 sectors (NACE 2 classification). Since the TUIK data did not contain a split of manufacturing into sub-sectors, we used the GTAP manufacturing sub-sector breakdown to split the total manufacturing GDP data from TUIK into 24 sub-sectors. The final table contains coefficients for 37 (sub-)sectors, as well as for household salaries, firms' profits, taxes and imports.

The economic input-output model applied in the report makes a number of assumptions. The most important ones are:

- Fixed production coefficients, meaning that technological changes induced by cheaper/better available power are not included. These changes typically occur over a longer time scales and do not substantially affect the results presented here in the short to medium term;
- Linear relations between economic inputs and outputs. In this report we have applied a non-linear analysis of the output response to changes in the effective power price. This means that the assumption of linearity applies to the second order effects of how the output response in Table 7 affects the sectors.

[81] CGE modelling is theoretically preferable over input output modelling because it allows for volume and price effects whereas IO models only account for volume effects. However, CGE models require a lot more data to specify all parameters which are often not available for developing countries. A full CGE model would also make interpretation of the results harder because of the many "moving parts".

[82] Alternative sources for IOT for Turkey are WIOD and OECD databases, which contain tables for the same year. All tables are based on the latest table published by the Turkstat in 2008 which has a base year 2002. Regardless, the GTAP was deemed a better source for the table as it contains data on direct taxes. It was also used for similar studies carried by Steward Redqueen in other countries, including the Philippines, providing for consistency amongst the assessments.

5.7.2 Treatment of output changes in the Turkish input-output table

The RAS procedure is also used to analyze the spillover effects of increased sector output in the economy, including non-user sectors. Exhibit 24 shows how a new table is constructed that reflects changes in output only. Although it is still assumed that sectors maintain their individual production structures, these structures change in one important aspect namely that the electricity costs for all sectors fall (i.e. the values in the utilities row which indicate the spending of individual sector on utilities). If electricity use does not change, these lower electricity costs translate into higher profits and (corporate) taxes for all electricity consuming sectors at the cost of lower profits and taxes in the utilities sector (i.e. economy-wide value added remains practically unchanged). However, output of the sectors increase as is shown in Section 5.6. This leads to the following changes in the original Turkish SAM:

1. Lower electricity spending of all sectors by ΔP;
2. Add change of electricity cost to profits and taxes (respectively 80% and 20%[83] for all sectors and decrease profits and taxes[84] of the electricity sector);
3. Increase all elements in the sector columns by the change of sector output ΔY (input signal);
4. Increase all elements in the rows by ΔY and lower the imports row by the same amount, reflecting that the increased output substitutes for imports.[85]

Driven by these changes the RAS procedure will, after a number of iterations, yield a balanced SAM[86] in which all sectors produce the necessary additional intermediary output specified in Table 7. The economy wide increase of output and value added corresponding with the lower electricity-price induced increase of output is thus quantified. The feedback loop indicated in Exhibit 14 has not been included in the results because its magnitude is very small. The reason for this is the low electricity price elasticity which causes electricity consumption to not increase very much.

It is important to note that the typical application of input-output modelling, and indeed the original formulation by Leontief, is demand driven: Changes in final demand cause changes in supply and through that changes in value added. The chain of events here is different: an electricity-price induced change in output of users causes changes in changes in demand of the non-user sectors which drive changes in value added. This formulation is more akin to the so-called Ghosh input-output model except that in that model the event chain starts with a change in value added that drives a change in output which then forces a change of demand. The Leontief and Ghosh formulations are two sides of the same coin, each suffering from their own limitations.[87] Given the small output changes imposed, the here used formulation (in between Leontief and Ghosh) in combination with the third rule above, which essentially prescribes the unchanged production structure (and thus value added) for the sectors, is adequate.

[83] The corporate tax rate in the Turkey is 20%.

[84] Since the same physical amount of electricity is produced the cost structure of the electricity sector does not change and lower revenues come at the cost of profits and corporate taxes.

[85] The reduction of imports serves to minimize differences between row and column total which would force the RAS method to make unrealistic numerical changes. Economically it can reasonably be expected that lower electricity costs render local firms more competitive vis-a-vis imports.

[86] Although economic interpretations of the RAS methodology have been given (the alternating rounds of adjustments essentially being changes of intra-sector production efficiency and inter-sector substitution), the method is a mathematical procedure to solve a system of more variables than equations. In practice this means that many solutions are possible. By starting the iterations one time with the new row totals and one time with the new column totals, two different solutions are arrived upon. Because of the linear nature of the procedure, the average of these two solutions is a solution as well. This average solution can be shown to be a better prediction of how cheaper electricity and higher output drives changes elsewhere in the economy. The reason for this is that the sum of squared differences of the diagonal terms between the original and the updated average table is smaller than for two alternatives. The diagonal terms represent the auto consumption of sectors and can (heuristically) be expected to change least in the non-manufacturing and non-electricity sectors (e.g. one would expect the change of demand for agricultural products within the agricultural sector to change relatively little).

[87] For a more in depth discussion: Manresa, A. and Sancho, F., *Leontief versus Ghosh: two faces of the same coin*, REAP2012-18, Xarxa de Referencia en economia Aplicada, 2012.

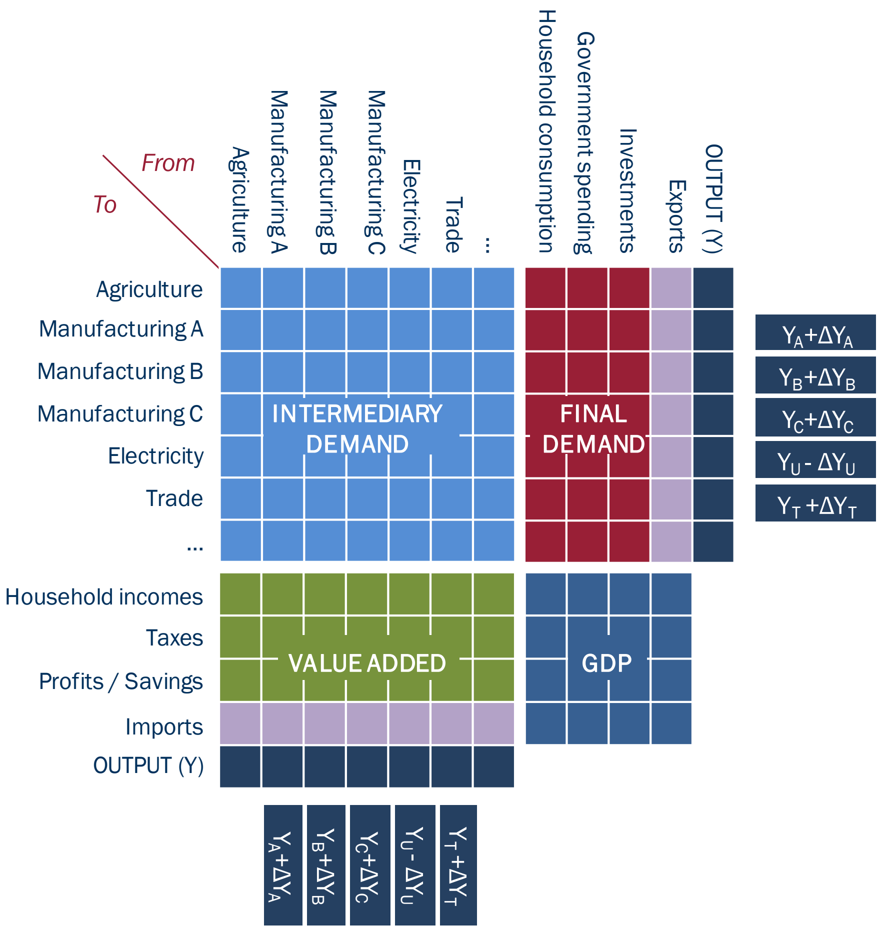


Exhibit 24: RAS methodology to rebalance the Input Output table for changes in sector and utilities output

5.7.3 Output

Exhibit 25 presents the growth in economic output resulting from the changes in the input-output table described in the previous section. The results are based on the average electricity tariff which was 2.41% lower with IFC investments, compared to without IFC investments, as described at the end of Section 5.4. Just as the analysis on price changes, the results presented in this section should be interpreted relative to a counterfactual situation in which IFC-finance power projects were not realized (i.e. even though electricity prices did not decrease, they would have been higher had IFC not invested in additional power supply). In this sense, IFC financing led to lower electricity prices, enabling local businesses to expand production. We estimate that the production output related to these lower prices is USD 638 m (as presented in Table 7 in section 5.6). Due to the local procurement of these firms, companies in 'non-affected' sectors also benefited – mainly agriculture, but also manufacturing sub-sectors such as beverages, textiles, metal products, etc., also expanded their production in order to meet the growing demand for their products. This procurement effect increase total economic output value by USD 39 m (i.e. 5.7%). As electricity prices were lower, the electricity sector lost USD 519 m of the value of its output (mostly as a result of loss of profit, as we'll see in the following section).[88] The net effect equaled USD 158 m, or a 0.01% increase in the Turkish output. In the following section we describe how these changes in output affected the value added in the economy.

[88] It is important to notice that by output we mean the financial value of production and not the volume of production – the electricity sector slightly increased production but revenues decreased due to lower prices.

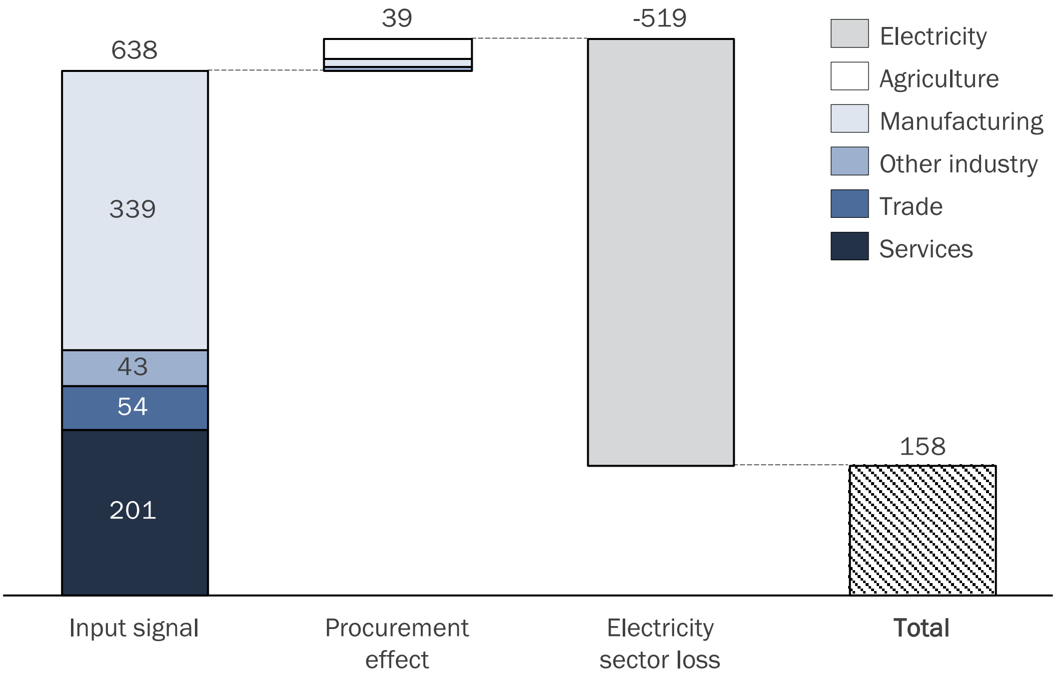


Exhibit 25: Changes in output (USD m) due to 2.42% lower electricity prices (compared to the counterfactual)

5.7.4 Value added

With an estimated higher economic output of USD 158 m, compared to the counterfactual, value added increases by USD 121 m as shown in Exhibit 26. Manufacturing gained the most in terms of value added: USD 257 m, or 0.2% of its GDP contribution. Within the manufacturing sector, the largest increase is in the metals & minerals sector: USD 88 m. The largest manufacturing sub-sector –food and beverages– increased its value added contribution by USD 38 m. Due to increased procurement and lower electricity prices, the value added contribution also grew for sectors which did not respond directly to the lower electricity prices. In the textiles, clothing, and leather sector, for example, value added went up by USD 32 m (0.17%). The agriculture sector also experienced value added growth of 0.07%, as other industries –most notably the food sector-- required more inputs for their rising production. Incomes in the trade and services sectors increased by 0.07% each, which is USD 71 m and USD 214 m respectively.

Only the electricity sector saw its value added contribution decrease, because the lower market prices for generation cause a drop in profits. It is interesting to note in Exhibit 26 that for all other sectors profits grew relatively more than other value added components (household incomes and taxes), reflecting savings from electricity costs. Overall, profits in the economy increased by USD 21 m. Household income went up by 0.03% (USD 71 m). Higher profits and household incomes resulted in higher tax payments – increasing the total tax revenues of the Turkish state by USD 29 m, or 0.02%.[89]

[89] Assuming all related taxes were collected. Based on World Bank data that 20.4% of GDP is tax revenue in Turkey.

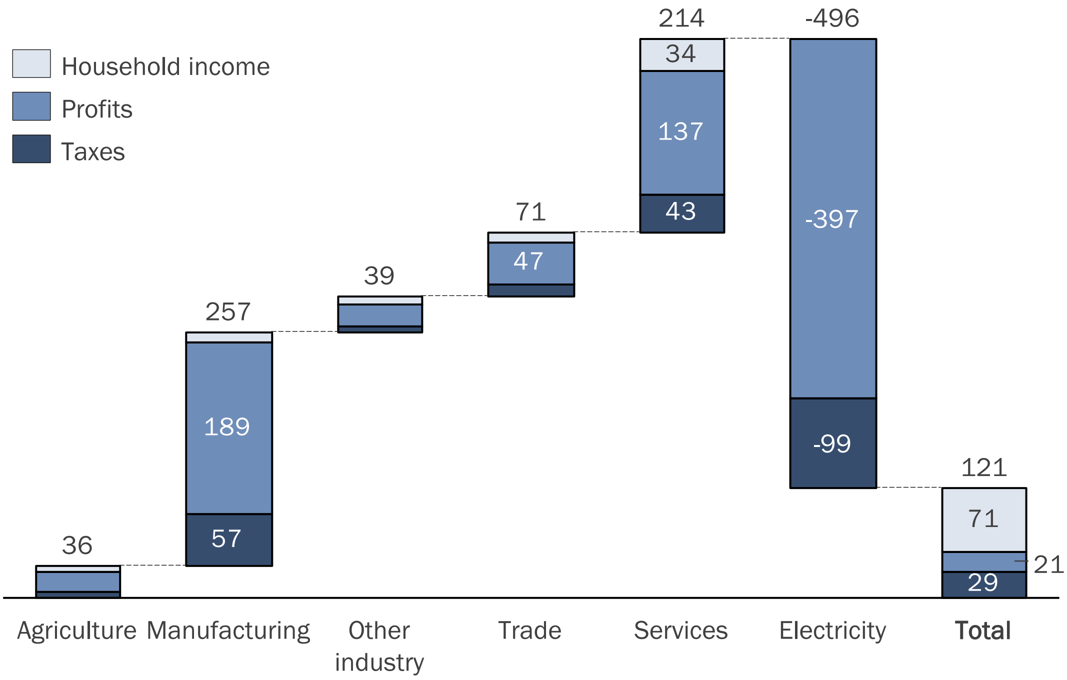


Exhibit 26: Change in value added (USD m) per sector and component due to 2.42% lower electricity prices (compared to the counterfactual)

5.7.5 Employment

In order to translate the sectoral changes in economic output into employment effects we determined the employment intensity of the sectors in the IOT. For this, we use data from the Labor Force Survey carried out in Turkey in 2014 and employment data from the Statistical Abstract 2016 from TUIK. From these sources we established the 2015 employment for 18 economic sectors (NACE 2 classification). Using the output produced in the corresponding year (from the GTAP IOT) we calculate the number of jobs needed in a sector to produce one unit of output (in TL), i.e. the employment intensity of the sector. The TUIK data only contains figures for the overall manufacturing sector. In order to obtain better intensities for the 15 manufacturing sub-sectors included in the IOT, we use data on company employment and turnover from the World Bank Enterprise Survey.[90]

Approximately 9,800 jobs can be attributed to the lower power price (relative to the counterfactual), which is equivalent to 0.03% of the total labor force (Exhibit 27). Most jobs are added in the manufacturing sector which experiences the highest output growth: 4,239 jobs (0.05%). Of these 1,395 were in the food and beverage sector. The trade sector added 1,092 employees, while the services sector experienced an increase of 2,536 jobs. 1,195 jobs were sustained in the agriculture sector (an increase of 0.02%), due mainly to procurement by the food industry from local agriculture and the fact that the sector is relatively labor-intensive. The change in employment in the electricity sector has been set to zero as it is unlikely that in the short term price decreases will lead to a significant change in employment.

[90] The resulting intensities, based on 2012 company data, are then adjusted to 2015 productivity levels using the difference between the overall manufacturing intensity based on the TUIK data (2015) and the overall manufacturing intensity from the WBES data (2012).

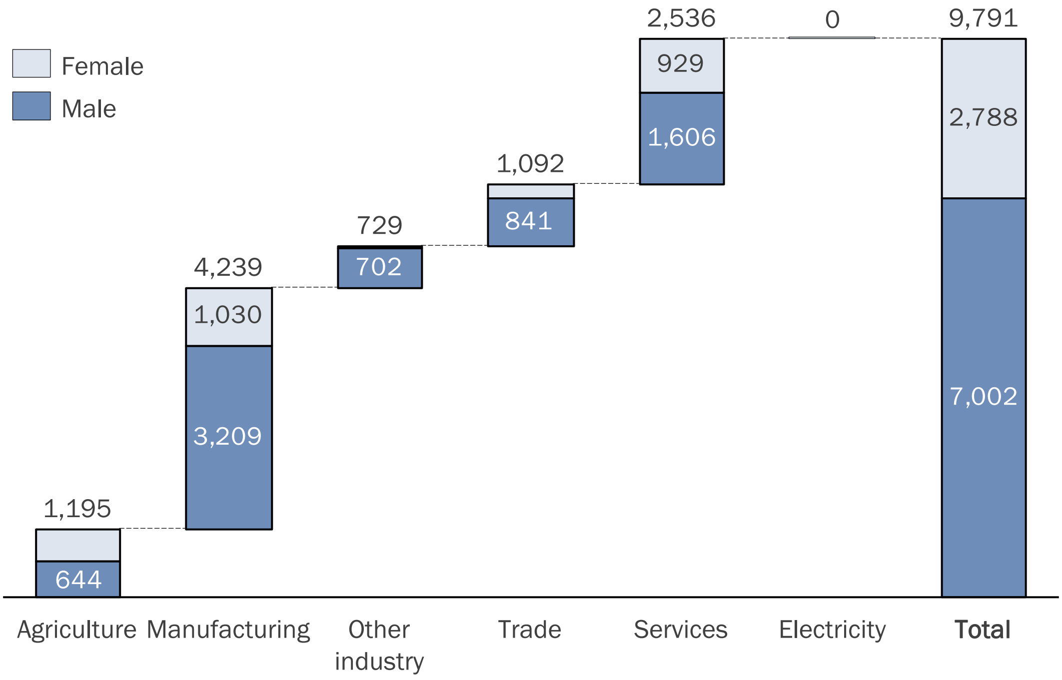


Exhibit 27: Change of jobs per sector and gender due to 2.42% lower electricity price (compared to the counterfactual)

Of the total jobs, approximately 28% are for women.[91] The largest number, 1,030, are in the manufacturing sector. Nevertheless, this only represents less than a quarter of all jobs sustained in the sector (24%). The highest relative increase in female jobs was in agriculture where 46% of the total employment sustained was occupied by women (551 jobs). 251 jobs are also supported for women in the otherwise male-dominated trade sector. The services sector also provides opportunities for female workers, while these are practically missing in sectors such as mining and construction (labelled 'other industry' in Exhibit 27).

The sustained jobs are mostly for unskilled workers (i.e. with no or only primary education) – 7,500, or 77%.[92] This is not surprising given that many of the jobs supported are in the low-skilled manufacturing, agriculture, and trade sectors. Altogether 2,300 jobs are skilled jobs which require secondary education or higher. These are mainly in services sectors, such as telecommunication, financial and business services.

5.7.6 Key results and multipliers

The results presented in sections 5.7.3 – 5.7.5 are calculated using the average end-user tariff which was 2.42% lower compared to the counterfactual situation in which IFC had not invested in power in Turkey. This is the average of the situations with IFC attribution in 2015, when reserve margins were relatively high and 2010, when the reserve margins were much tighter. Table 8 presents the variation in results using the minimum (2015; -1.28%) and maximum tariff changes (2010; -3.55%) estimated using the price model. Looking at the total results, the supported GDP decreased from and estimated USD 178m in 2010 to USD 64m in 2015 for an average of USD 121m. The corresponding figures for employment are 14,387; 5,195; and 9,791 jobs respectively.

[91] The gender split of the workforce per sector is based on the TUIK labor force data.

[92] The input output table provides information on the total amounts paid for skilled and unskilled by sector. Using the TUIK finding that the average salary for skilled workers (who completed secondary and higher education) is 1.4 times higher than for unskilled (i.e. primary and no education) results in the employment breakdown.

The table also contains the 2015 results calculated without taking IFC attribution into account. In that case, market clearing price would have been 5.38% lower relative to the counterfactual, resulting in a 3.99% lower end-tariff. The resulting GDP increase equals USD 200 m and the employment effect is nearly 16,160 jobs. Simulation of the 2010 situation without IFC attribution is not possible because the observed system loads are higher than the cumulative supply without all IFC-financed capacity.[72]

Table 8: Range of impact results for IFC's investments in power

	With IFC attribution						Without attribution	
	GDP (million)			Jobs			GDP (million)	Jobs
	Min (2015)	Average	Max (2010)	Min (2010)	Average	Max (2015)	2015	2015
Agriculture	19 (0.04%)	36 (0.07%)	53 (0.10%)	634 (0.01%)	1,195 (0.02%)	1,756 (0.03%)	60 (0.11%)	1,972 (0.045)
Manufacturing	136 (0.12%)	257 (0.23%)	378 (0.34%)	2,250 (0.03%)	4,239 (0.05%)	6,229 (0.08%)	425 (0.38%)	6,996 (0.09%)
Electricity	-263 (-2.55%)	-496 (-4.87%)	-729 (-7.06%)	0	0	0	-818 (-7.93%)	0
Other industry	21 (0.05%)	39 (0.09%)	57 (0.13%)	387 (0.02%)	729 (0.03%)	1,071 (0.05%)	65 (0.14%)	1,203 (0.06%)
Trade	38 (0.04%)	71 (0.07%)	104 (0.10%)	580 (0.01%)	1,092 (0.02%)	1,605 (0.03%)	117 (0.11%)	1,802 (0.04%)
Services	113 (0.04%)	214 (0.07%)	314 (0.10%)	1,346 (0.02%)	2,536 (0.03)	3,726 (0.04%)	353 (0.11%)	4,185 (0.05%)
Total	**64** **(0.01%)**	**121** **(0.02%)**	**178** **(0.03%)**	**5,195** **(0.02%)**	**9,791** **(0.03%)**	**14,386** **(0.05%)**	**200** **(0.03%)**	**16,159** **(0.06%)**

The results derived in this section are expressed as key ratios in Table 9. The multipliers express the relative change of a variable for a 1% increase of installed capacity.[93] The multipliers need to be interpreted with caution as they represent the impact of different power generation technologies, which are situated in different parts of the supply curve Exhibit 17. The relative GDP increase per 1% installed capacity range from 0.021% in 2010 to 0.008% in 2015. The employment multipliers range from 0.013% in 2015 to 0.037% in 2010. Not taking IFC attribution into account, the effects are 0.024% for GDP and 0.041% for employment.

93 Because the multipliers are based on relative figures they would be more appropriately named elasticities. In order to avoid confusion with the price and income elasticities we chose not to do so.

Table 9: Key metrics of economic impact of power generation

	With IFC attribution			Without attribution
	2015	Average	2010	2015
Price effects				
Δ Market clearing price (%)	-1.73%	-3.26%	-4.79%	-5.38%
Δ End-user tariff (%)	-1.28%	-2.42%	-3.55%	-3.99%
GDP and jobs per 1 MW				
Δ GDP (USD m)	0.07	0.13	0.19	0.07
Δ Employment (# jobs)	5.6	10.6	15.5	5.6
GDP and jobs per 1% capacity increase				
Δ GDP (USD)	48	90	133	48
Δ Employment (# jobs)	3,878	7,308	10,739	3,878
% GDP and jobs per 1% capacity increase				
% Δ GDP (%)	0.008%	0.014%	0.021%	0.008%
% Δ Employment (%)	0.013%	0.025%	0.037%	0.013%
GDP and jobs per USD 1 million financing				
Δ GDP (USD m)	0.04	0.07	0.10	0.04
Δ Employment (# jobs)	3.0	5.7	8.4	3.0

5.7.7 Comparison with the Philippines power sector study

It is instructive to compare the results of this study with the previous study in the Philippines (including attribution). The multipliers for both studies are summarized in Table 10.

Table 10: Comparison of multipliers for Turkey and the Philippines

	Min	Average	Max
% Δ Market clearing price (% / 1% capacity increase)			
Turkey	-1.29%	-2.43%	-3.58%
Philippines	-2.45%	-3.06%	-3.71%
% Δ GDP (% / 1% capacity increase)			
Turkey	0.008%	0.014%	0.021%
Philippines	0.073%	0.091%	-0.111%
% Δ Employment (% / 1% capacity increase)			
Turkey	0.013%	0.025%	0.037%
Philippines	0.068%	0.085%	0.103%

The following observations can be made:

1. The effect of a 1% capacity increase on the market clearing price is lower in Turkey than in the Philippines as the power supply curve in former is flatter than in the later;
2. The effect of a 1% capacity increase on GDP is about 7 times smaller in Turkey than in the Philippines. First, the electricity factor shares of companies in Turkey are much smaller (0.02 - 0.12) than in the Philippines (0.15 - 0.35). Second, the electricity price elasticity of companies in Turkey is much smaller (-0.16) than the assumed value of -0.75 in the Philippines. The net result is a much larger GDP response, despite the fact that in the Philippines only manufacturing companies were considered to respond to cheaper electricity;
3. Because of the much smaller GDP response in Turkey, the employment multipliers are smaller as well, but only by a factor of 4. The reason for this is that in Turkey we considered the direct response of the labor-intensive service sector whereas in the Philippines the impact in the services sector came about only through spill-over effects from manufacturing.

Because the factor shares for the Philippines were determined using a cross-sectional data set, they may have been overestimations, although this cannot be said with any certainty. The lower price elasticity in Turkey relative to the Philippines can be explained by the fact that electricity is the Philippines is considerably more expensive, especially when one takes into account the difference in per capita GDP.

6 IMPACT OF SPECIFIC IFC INVESTMENTS IN THE POWER SECTOR

The results in Section 5 showed the impact of the entire portfolio of IFC investments. In this section, we will investigate the impact of two specific investments in more detail using the framework presented in Section 4.3. Given the size of the commitment and the duration of IFC's involvement we have selected Enerjisa Enerji Üretim A.Ş. (Enerjisa) as the power generation case study. In order to obtain a better insight into the effects of power distribution we also attempted to analyze the investment in SEDAS.

6.1 Investment in generation: Enerjisa

The company portfolio covers almost the entire electricity supply chain in Turkey: electricity generation, trade, sales, distribution, and natural gas operations via enterprises under the umbrella company Enerjisa Enerji A.Ş. The company started as an auto producer of electricity for Sabancı group companies and became an independent power producer in 2005.

In terms of generation, in 2015 Enerjisa had a number of power plants (natural gas, hydro, wind), which equaled nearly 4% of the country's total capacity. Between 2007 and 2015, the installed capacity of Enerjisa increased more than five times. IFC provided investments for the part of the capacity increase.

6.1.1 Forward effects

The impact of Enerjisa's additional capacity on price is determined by using the same approach as discussed in Section 5. The model results show that the investment of IFC in Enerjisa has led to 7.81% lower average generation market clearing price compared to a counterfactual situation in which IFC-financed Enerjisa projects were not realized. This translates into a 5.80% lower end-user tariff, or 2.4 times larger than the price decrease attributed to the total investments of IFC. Therefore, it is not surprising the impact of Enerjisa is more than twice higher than IFC impact described in section 5.7. **Investments in Enerjisa are estimated to have increased GDP by 0.05% and sustained some 23,460 jobs**, as shown in Exhibit 28 and Exhibit 29. Of these, about 70% can be attributed to a lower price of thermal (gas) generation, and 30% to hydro generation.

Similar to the results presented in Section 5.7, the effects for Enerjisa are based on an average price decrease. The estimated value added and employment impact, based on the minimum (2015) and maximum (2010[94]) market clearing price change of -4.03% and -11.59% respectively, range between USD 150 m - USD 432 m and 12,100 – 34,800.

[94] Modeling the 2010 effects for Enerjisa without IFC attribution was still possible since that required removing only a small part of IFC-financed capacity (ie the Enerjisa plants). As explained in footnote 72, deriving 2010 results without IFC attribution for the total IFC investments was impossible since removing all IFC-financed plants would have resulted in demand being substantially higher than supply.

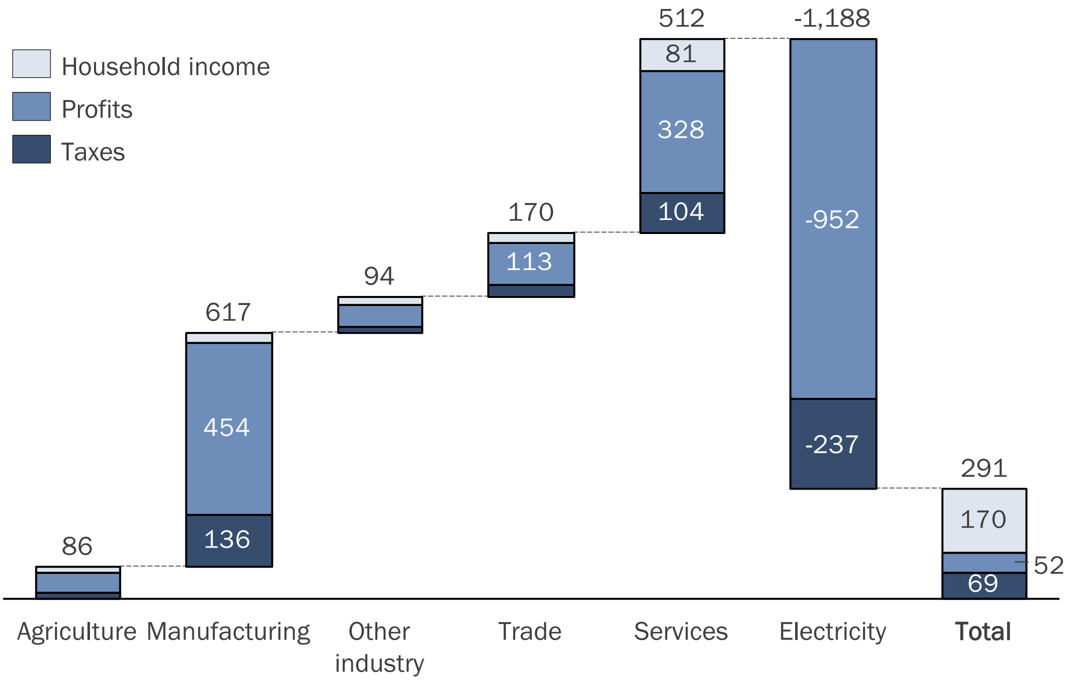


Exhibit 28: Change of value added related to Enerjisa (in USD m)

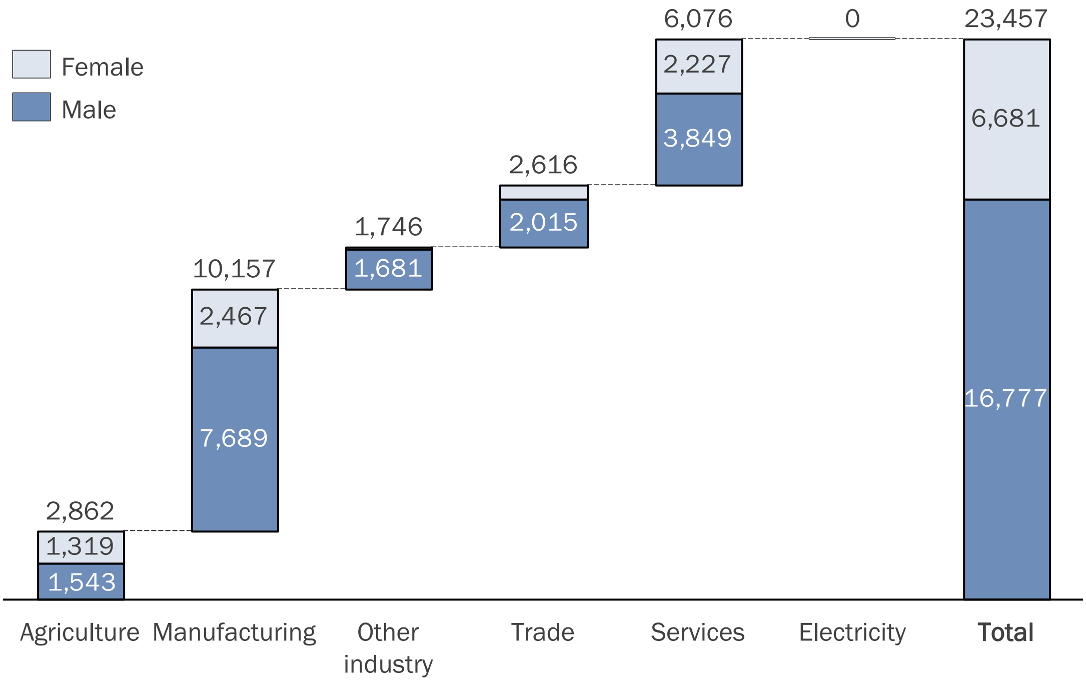


Exhibit 29: Change of jobs related to Enerjisa per sector and gender

The results presented in this section reflect the impact of the total Enerjisa capacity financed by IFC. If we consider only the Enerjisa capacity attributable to IFC, the results would be some 60% lower: generation cost would be between 4.03% and 4.00% lower than if IFC had not invested in Enerjisa, leading to GDP increase of between USD 58 m – 149 m and sustained between 4,700 – 12,000 jobs.

6.1.2 Backward effects

In addition to the Enerjisa's forward economic impact, stemming from the productive use of the electric power it generates, Enerjisa affects the economy through the spending related to construction and operation of power plants and from their backward economic (i.e. supply) linkages. These effects include the direct (related to value added and employment generated at the power plant both for construction and operations), indirect (at the level of the suppliers and the suppliers' suppliers) and induced effects (employment related to re-spending of salaries earned by directly and indirectly related employees).[95]

Sales revenues generated by Enerjisa in 2015 were spent by the company on procurement form local and foreign suppliers and on employee and tax payments. To calculate the related impact, we follow Enerjisa's expenditures through the IOT. The value added and employment results, are presented in Exhibit 30.

Of the estimated total USD 257 m, about USD 66 m is directly generated by Enerjisa, while the remainder is supported at the level of its suppliers and their suppliers. The largest share of the value added are the USD 113m household incomes (salaries paid to employees). The taxes paid to the state are USD 68m, while profits generated across Enerjisa Enerji's value chain are estimated at USD 76m.

In terms of employment, some 6,590 jobs are supported by Enerjisa's operations, both directly and indirectly (Exhibit 31). The power company supports 1,799 jobs in manufacturing through purchases and maintenance of manufactured products such as electronic equipment and other machinery. Procurement from local wholesalers and retailers supported some 1,547 jobs in the trade sector, while local financial, professional and public services procurement was related to 1,100 employees.

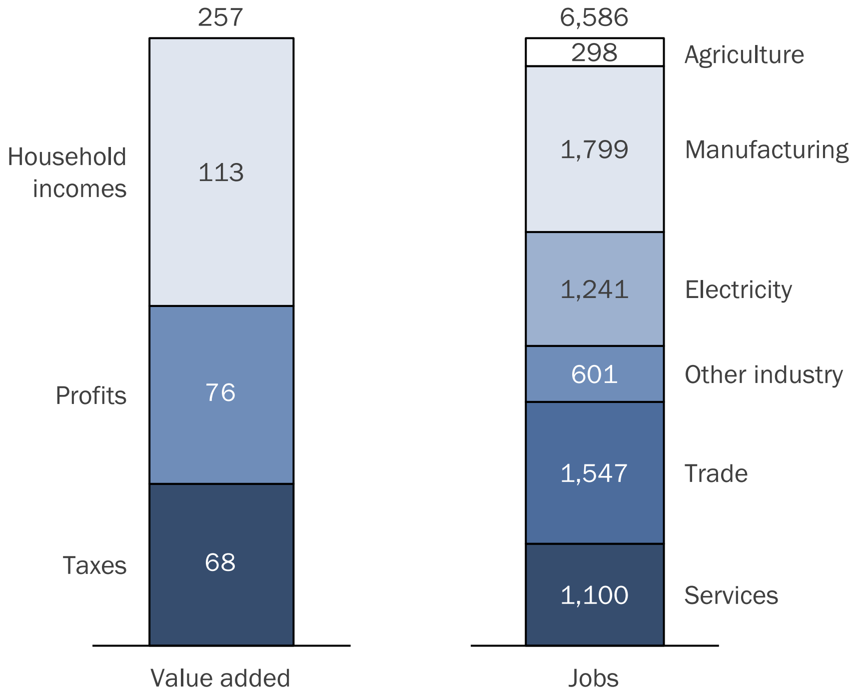


Exhibit 30: Value added (USD m) and employment related to the operations of Enerjisa in 2015

Enerjisa also has an economic impact in the economy through the investment in and construction of new projects. Since 2007 the company invested in the construction of a number of power plants. The annual and average impact of these projects is shown in Exhibit 31. Enerjisa's value chain impact varied

[95] Induced effects are calculated only for the employment results and not for the value added results in order to avoid double-counting of the (effects of) household incomes.

between USD 92 m – USD 779 m in value added and 6,100 – 35, 006 jobs. **On average the company supported USD 408 m in value added and some 17,800 jobs with its investments** for the period.[96] Most of the value added (40%) and jobs (46%) are concentrated in the construction sector. Other industries benefiting substantially are transport, information and communication technologies, and professional and financial services. Most of the jobs – 3,200 – are supported indirectly (at the level of suppliers and their suppliers), while the rest are induced. It is important to notice that these effects are only related to the execution of the project, i.e. construction of the power plants, and do not capture any forward effects of improved power availability (presented for Enerjisa in the previous section). These jobs and incomes would therefore be short-term in nature. For this reason we refer to the supported employment as man-year jobs.

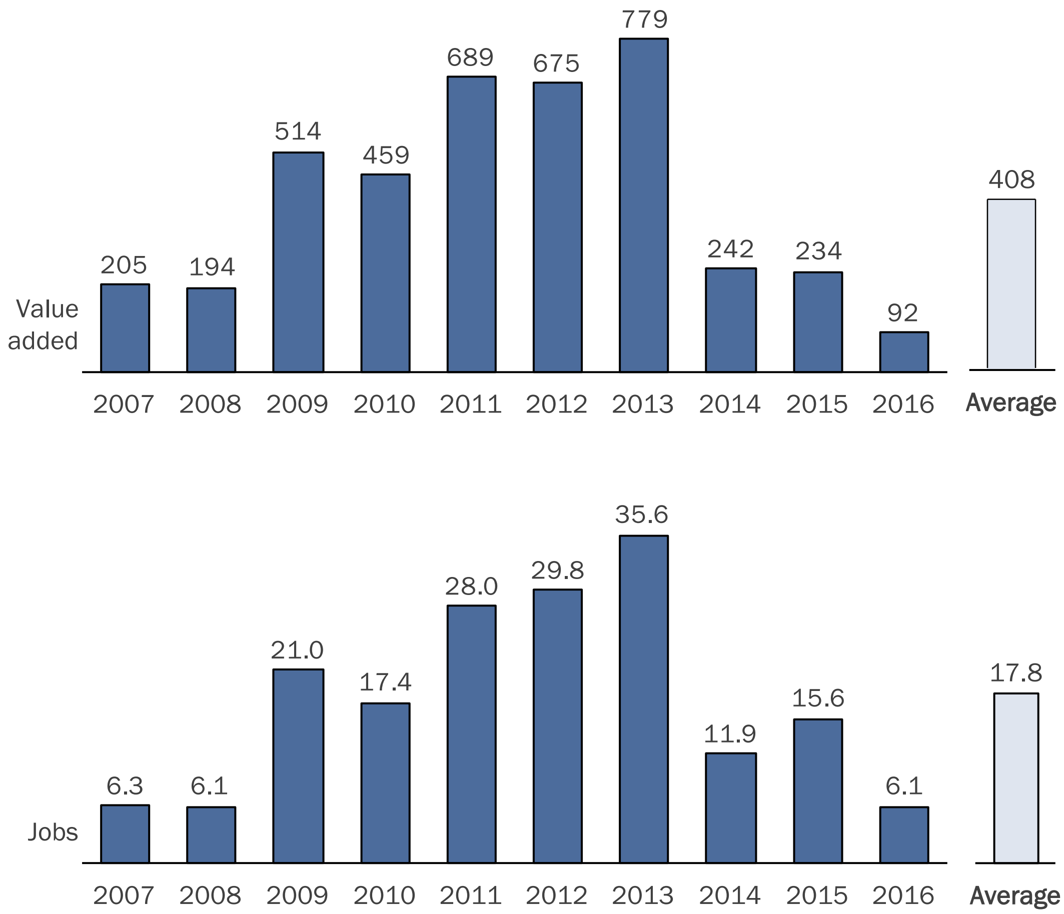


Exhibit 31: Value added (USD m) and jobs ('000 man years) supported by Enerjisa investments

6.2 Investment in distribution: SEDAS

SEDAS serves a distribution region located in North-Western Turkey, in a highly industrialized section of Anatolia extending between Ankara and Istanbul and covering the districts of Sakarya, Kocaeli, Bolu and Düzce. The area its serves has 3.23 million inhabitants. The subscriber base of the company, which was 1.5 m people in 2015, has been growing with 61,000 users per year on average since 2011.

SEDAS is a wholly-owned subsidiary of by Akcez Enerji Yatirimarli, which is owned by the Akkök Holding, a conglomerate consisting of more than 40 trade and industrial companies, and CEZ Group based in the

[96] Employment contribution adjusted for annual labour productivity changes.

Czech Republic. It is one of the 21 distribution companies in Turkey. In 2009, it was among the first distribution companies to be privatized (since 2015 all distribution companies are private). The company holds exclusive rights for electricity distribution in its region until 2036. IFC provided SEDAS a long-term loan of USD 75 million in 2010 which, upon refinancing in 2013 increased to 150 million. IFC's main objective was to demonstrate the ability of distribution companies to obtain long-term project financing, something which no privatized distribution company had been able to accomplish. IFC considered financially creditworthy and operationally sound off-takers of power essential to attract private capital to independent power producers. In addition to this demonstration effect IFC expected to improve SEDAS EHS performance.

6.2.1 Forward effects

The privatization of SEDAS achieved one of the main goals of the process – to spur investments in distribution. However, with the growth of its network, outages have not reduced. Since 2009, total number of consumer outages has increased by 20%. At the same time, its subscriber base grew by some 60,000 users per year, or nearly 24%. Therefore, as indicated in Section 5.1, total outage duration has not substantially, if at all, decreased since privatization. This was confirmed by SEDAS representatives, who indicated that power outages were not a significant problem in the past and have remained constant over the past couple of years. Although it is possible that without IFC financing power outages would have become a bigger bottleneck for companies, it is impossible to construct a counterfactual of what would have happened without the network investments or IFC's capital. For that reason we are unable to quantify the contribution of SEDAS and IFC related to this pathway.

SEDAS has successfully managed to keep losses low. It has one of the lowest loss and theft (L&T) ratios in Turkey, 6.7%,[97] down from 7.0% in 2011. Reduction of the L&T rate for the region did not only improve the revenues of the company, but also allows more electricity to reach consumers. The reduction of losses led to 29.1 GWh increase in electricity distribution. Had the loss rates remained at the 2011 level, achieving this additional distribution would have required extra generation capacity –most likely natural gas-fired, given that gas CC plants supply the base load in the country (see supply curve in Exhibit 17). Therefore, we could say that because of the reduction of the L&T ratio, 3.7 MW[98] of extra gas capacity did not have to be added to the national fleet.

6.2.2 Backward effects

SEDAS has an impact the Turkish economy through its investments.[99] The majority of SEDAS investments are in network infrastructure improvements, while a small portion relates to environment and safety, meters and other projects. The past and future (forecasted) contribution of these investments is shown in Exhibit 32. **The average impact for the period 2011-2020 is estimated at USD 28 m in incomes and 1,642 jobs.** The remarks made regarding Enerjisa's investments impact are also valid here – the value added and jobs results capture only the effects of the execution of these investments and do not reflect improvements in electricity distribution on the subscribers. The jobs and incomes are likely temporary, lasting for the period of the construction work. Because we did not receive the profit & loss statements of SEDAS we could not analyses the direct, indirect and induced economic impact of its going concern operations.

[97] 2015 data from SEDAS.

[98] Based on 0.9 capacity factor.

[99] Similar to Enerjisa, SEDAS also has an impact via its annual operations expenditures. However, this data was not made available for the project.

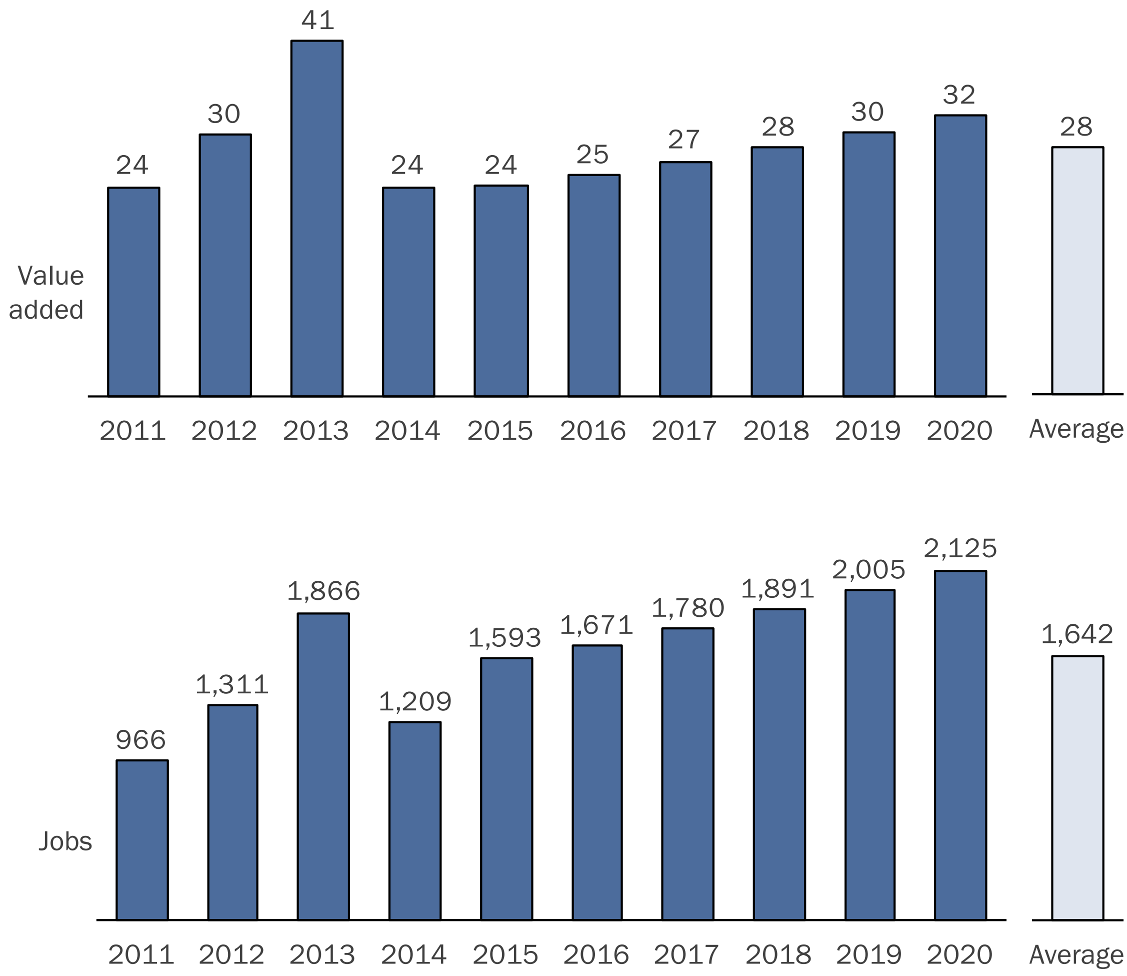


Exhibit 32: Value added (USD) and jobs (man years) supported by SEDAS investments

7 CONCLUSIONS & RECOMMENDATIONS

7.1 Conclusions

Based on the results discussed in this report the following conclusions can be drawn:

1. IFC helped expand several independent power producers and had a pioneering role in one of the first privatizations of the electricity distribution sector:
    a. As per 2015, IFC has invested in 4.4% of the total capacity in operation in Turkey. 1.3% of the operational power capacity can be attributed to IFC. As projects currently under construction will commence operations, this will increase to about 2.0%;
    b. 2.6% of the total distribution capacity in Turkey is attributable to IFC's loan of USD 150 million.
2. Because of lacking evidence that power outages have reduced since IFC's involvement in the electricity sector, we cannot quantify the economic impact associated with a reduction of power outages;
3. Taking attribution into account, IFC's investment in power generation has led to 1.73% - 4.79% lower generation costs compared to a counterfactual situation in which the organization had not invested in power capacity in Turkey. The higher value corresponds to the years 2010-2012 and the lower value to 2015. The lower value of in 2015 is explained by the fact that over the last two years supply increased much faster than demand. When including transmission and distribution costs, end-user tariffs were 1.28% - 3.55% lower compared to the counterfactual;
4. Compared to the counterfactual situation, the lower IFC-attributable electricity cost for companies resulted in:
    a. An increase of GDP between USD 64 million and USD 178 million, or between 0.01% and 0.03%;
    b. An estimated sustained employment between 5,195 and 14,390 jobs (0.02% -- 0.05% of the labor force), of which an estimated 29% were for women and 23% for skilled workers.

    These results are the net effect of a relatively larger increase of GDP contribution by electricity consumers which are offset by a loss of GDP contribution of the electricity sector due to the lower prices;
5. When considering the impact of all IFC-financed capacity without attribution:
    a. Generation costs would have decreased with 5.38% and end-user tariffs by 3.99%;
    b. This would have increased GDP with USD 200 million (0.03%) and sustained 16,159 jobs (0.06% of the labor force);
6. When expressed as multipliers, every 1% increase of generation capacity causes on average a 2.43% decrease of electricity generation cost, a 0.014% increase in GDP and a 0.025% increase in employment;
7. Compared to the results of the Philippines study, the value added and employment multipliers per 1% capacity addition are respectively 7 and 4 time smaller in Turkey than in the Philippines. A first reasons for this are the lower electricity factor shares of companies in Turkey, which means that they increase production less in response to increased electricity consumption. The second reason is that the price elasticity of electricity in Turkey is much smaller than in the Philippines (where electricity is comparatively much more expensive), which means that companies will increase their electricity consumption much less when electricity prices decrease.

8. IFC's investments in Enerjisa had both forward and backward effect on the Turkish economy:
    a. The capacity addition of Enerjisa resulted in a 4.03% - 11.59% lower generation cost in Turkey, compared to a situation in which IFC-funded projects were not realized. This is associated with a USD 150 m – 432 m higher GDP (0.02%-0.07%%), 12,100 – 34,800 jobs sustained (0.04%-0.12%);
    b. Project development expenditures of Enerjisa made possible due to IFC's investments are estimated to have contributed the economy by USD 105 m and 17,800 man-year (i.e. short-term) jobs on average between 2007 and 2016;
9. Financing by IFC enabled SEDAS to reduce losses and invest in network improvements:
    a. Loss and theft (L&T) ratio reduction from 7.0% to 6.7% since 2011 enabled annual increase in electricity distribution of 29.1 GWh;
    b. SEDAS actual and planned investments between 2011 and 2020, on average, are estimated to contribute USD 28 m and 1,642 man-year jobs for the period 2011-2020.

7.2 Recommendations

Considering the results in this report as well as the current and expected state of the power sector we make three recommendations:

1. Turkey currently faces a situation of high reserve margins and low power prices associated with them. With a significant number of power plants planned or under construction and demand growth slowing, the situation is likely to persist for some time. This may weaken the attractiveness of investing in the Turkish power sector. But at some point in time additional generation capacity will be required. IFC should therefore monitor supply and demand trends to see whether it can serve as a catalyst in case the market risks to 'undershoot' needed investments;
2. Related to the first recommendation, Turkey is planning to substantially expand its coal generation capacity to be used with local lignite and coal resources in order to reduce its dependence on imported gas. This will drastically increase the country's greenhouse gas emissions. It remains to be seen whether banks will underwrite these projects because of the risk that coal plants become stranded assets. But given its very small installed based, huge potential, decreasing costs, and (currently) attractive feed in tariffs, (small and large scale) solar generation may be a medium-term opportunity for IFC to help green Turkey's power generation while reducing its import dependence;
3. Unlike IFC client SEDAS, a number of distribution companies in other regions in Turkey still face high technical and non-technical losses as well as power outages. Given the negative impact that power outages have on private sector output in general, IFC could potentially increase its development impact by exploring financing opportunities in these distribution companies.

ANNEX 1: POWER SECTOR IN TURKEY VERSUS PHILIPPINES

	Turkey	Philippines
GDP / capita	US$ 10,515	US$ 2,873
GDP composition Agriculture Manufacturing Other Industry Services	 8% 18% 9% 65%	 11% 21% 11% 57%
Energy use per capita	1,571 kgoe 2,761 kWh	460 kgoe 686 kWh
Energy intensity	83 kgoe/$1,000 GDP 320 kWh/$1,000 GDP	74 kgoe/$1,000 GDP 434 kWh/$1,000 GDP
Liberalization history	Started in 2001 but privatization took off after 2008	Started in 2001 but privatization took off after 2007 when Wholesale Spot Market was established
Structure	Separate companies responsible for energy generation, transmission, distribution, and trading	Separate companies responsible for energy generation, transmission, distribution, and trading
Generation	78% of installed generation capacity is privately owned	77% of installed generation capacity is privately owned
Transmission	Monopoly, managed by the state-owned Turkish Electricity Transmission Company (TEİAŞ)	Monopoly, managed by the state-owned National Grid Corporation of the Philippines (NGCP)
Distribution & Supply	21 private regional companies	140 private regional companies (of which one has 45% market share)
Consumption *Industrial* *Commercial* *Residential* *Other*	 46.6% 27.1% 22.9% 2.9%	 33.6% 29.7% 33.5% 3.2%
Interconnection capacity with other countries	< 3% of installed generation capacity	0% of installed generation capacity
Trading	70% of wholesale traded capacity is done through bilateral negotiated contracts Day-ahead planning and trading since 2009 (PMUM). True spot market under control of EPIAS since 2015	90% of wholesale traded capacity is done through bilateral negotiated contracts Functioning spot market since 2006

ANNEX 2: METHODOLOGY TO DETERMINE IMPACT OF POWER OUTAGES

Based on the statistics on power outages and the associated sales lost the monetary impact can be quantified. However, for all companies combined, the total outage time ranges between 1 - 5% of operational time. The range of output lost due to power outages, however, ranges between 1% and 20% of total output. This implies that for some of the entries in the sample the losses of the power outages are amplified. Food producers without (sufficient) power generation capacity, for example, could suffer more from power outages due to spoilage of raw materials and/or finished goods. Other firms, such as the ones operating in the chemical and non-metallic minerals sectors, are able to partly mitigate the losses caused by blackouts. For each firm we therefore define a loss amplification/mitigation factor ϕ:

$$\phi = \frac{Y^{lost}/Y}{T^{lost}/\,T} \Rightarrow Y_i^{lost} = \phi_i \cdot \frac{Y_i}{T_i} \cdot T_i^{lost}$$

with T^{lost} the operation time lost (number of outages per month multiplied by their average duration), T the operation hours per month)[100]. It thus follows that the lost output for sector i is expressed as:

$$Y_i^{lost} = \phi_i \cdot \frac{Y_i}{T_i} \cdot T_i^{lost}$$

Finally, the output increase of sector i is equal to the reduction of output loss which results from a decreased outage time (be it a lower outage frequency or a reduced average duration) is expressed as:

$$\Delta Y_i = -\Delta Y_i^{lost} = -\phi_i \cdot \frac{\Delta T_i^{lost}}{T_i} \cdot Y_i$$

We intended to establish a relationship between increased power distribution, but power outages in Turkey have not meaningfully declined.

The limiting values of ϕ are determined using the median and average value of the sales lost and outage time values. The results are shown in Table 11.

Table 11: Sales lost, outage time and loss factor for Turkish companies
(Source; World Bank Enterprise Survey)

	% sales lost		% outage time		Loss factors (%sales lost / %outage time)	
	Average	Median	Average	Media	Average	Median
Total	4.0%	1.0%	3.6%	1.2%	1.1	0.8
Small <=19	4.0%	0.0%	3.6%	1.2%	1.1	-
Medium >=20 and	4.8%	0.0%	3.6%	1.6%	1.3	-
Large >=100	1.5%	0.0%	3.8%	1.6%	0.4	-
Food	11.5%	5.0%	5.2%	1.6%	2.2	3.1
Textiles, garments	3.1%	0.0%	3.2%	1.6%	1.0	-
Furniture, wood, paper	6.0%	3.5%	1.2%	1.2%	5.0	2.9
Chemicals, plastics,	0.5%	0.0%	2.6%	1.6%	0.2	-
Non-metallic minerals	1.6%	0.0%	2.5%	1.6%	0.6	-
Metals, machinery	4.8%	2.0%	4.0%	1.2%	1.2	1.7

100 The fraction outage time for a firm is defined as the outage hours per month (outage frequency * average duration) divided by the number of monthly operation hours. When the firm has not reported the number of operation hours the median value of 250 hours has been used.

Publishing, printing	5.0%	5.0%	1.4%	1.0%	3.6	5.0
Construction, transport	9.1%	2.0%	2.1%	2.0%	4.3	1.0
Retail, wholesale	5.3%	2.0%	2.3%	1.2%	2.3	1.7
Hotels, restaurants	20.5%	20.5%	1.5%	1.6%	13.3	12.8

ANNEX 3: IFC PORTFOLIO IN TURKEY'S POWER SECTOR

The analysis in this report is based on disbursed IFC financing (including A, B, and C loands) by the end of 2015. Table 12 shows the IFC loans from 2008 until 2016, including their disbursement status.

Table 12: Overview of recent IFC investments in Turkey

Project name	Industry	Disbursement	Commitment Fiscal Year	IFC loans (USD million)
Enerjisa	**Generation**	**Yes**	**2008**	**804.3**
Rotor Elektrik	**Generation**	**Yes**	**2009**	**71.5**
AkEnerji	**Generation**	**Yes**	**2010**	**75.0**
Enerjisa-II	**Generation**	**Yes**	**2011**	**802.2**
Farcan ACWA	Generation	No	2013	125.0
ACWA Kirikkale	**Generation**	**Yes**	**2015**	**45.0**
Gama Enerji	Generation	Yes	2015	165.0
AkCez II	Generation	Yes	2016	163.1
Akfen Energy	Generation	Yes	2016	100.0
Karaca Hydro	Generation	Yes	2016	44.0
UNIT Equity	Generation	Yes	2016	142.5
SEDAS	Distribution	Yes	2011	150.0
Total				**2,687.6**

The total amount in Table 12 is larger than the amount presented in Table 2 in the report. This is because the later sums up only the disbursed loan capital in power generation made before end-2015 (in scope for this study), i.e. Enerjisa, Enerjisa II, Rotor Elektrik, AkEnerji, ACWA Kirikkale. The sum of these projects in Table 12 is USD 1,798 million[101]. The total loan amount for the same projects in Table 2 is USD 1,666 million. The difference of USD 132 million is due to exchange rate variations.

[101] Enerjisa 804.3 + Rotor Elektrik 71.5 + AkEnerji 75.0 + Enerjisa II 802.2 + ACWA Kirikkale 45 = 1,798. All numbers in USD million.

Annex 4: Power generation technology LCOE parameters

Table 13: LCOE Monte Carlo analysis parameter values per generation technology

Technology	Capital cost (USD / kW)			Fixed OM cost (USD / kW·y)			Variable OM cost (USD / kWh)			Fuel cost (USD / mmBTU)			Heat rate (BTU / kWh)			Capacity factor (-)			Discount rate prem	Deprec. pres val	Lifespan (year)
	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max	Min	Med	Max			
Wind onshore	1,570	1,725	1,880	22.00	23.50	35.75	0.006	0.008	0.011	-	-	-	-	-	-	0.30	0.35	0.40	0%	0.832	20
Solar photo	3,873	4,028	4,183	24.69	26.22	27.75	-	-	-	-	-	-	-	-	-	0.18	0.20	0.25	2%	0.832	25
Solar thermal	4,960	5,067	5,200	60.00	65.00	71.00	0.003	0.003	0.020	-	-	-	-	-	-	0.29	0.39	0.45	2%	0.832	30
Geothermal	2,660	3,920	5,890	68.37	112.16	170.00	0.017	0.030	0.040	-	-	-	-	-	-	0.70	0.80	0.90	1%	0.832	40
Hydro large	1,000	2,040	3,000	13.59	14.85	26.03	0.002	0.003	0.005	-	-	-	-	-	-	0.35	0.40	0.45	1%	0.544	40
Hydro small	1,150	2,250	3,000	11.80	23.20	85.00	0.002	0.003	0.005	-	-	-	-	-	-	0.25	0.35	0.45	0%	0.832	30
Gas CC	960	1,110	1,310	13.17	14.27	15.37	0.002	0.003	0.004	8.10	8.20	8.30	5,593	5,986	7,417	0.65	0.75	0.85	0%	0.544	30
Gas Turbine	676	825	973	7.04	7.19	7.34	0.002	0.003	0.004	8.10	8.20	8.30	8,530	9,099	9,749	0.10	0.15	0.20	0%	0.595	30
Coal conv import	2,300	3,000	3,500	31.18	34.49	37.80	0.004	0.005	0.005	3.20	3.40	3.60	7,700	9,850	12,000	0.80	0.85	0.90	1%	0.544	40
Coal conv Lignite	2,300	3,000	3,500	31.18	34.49	37.80	0.004	0.005	0.005	1.60	1.80	2.00	8,200	10,300	12,600	0.60	0.70	0.80	1%	0.544	40
Diesel	600	700	800	45.00	50.00	55.00	0.000	0.001	0.002	14.00	15.00	16.00	9,500	10,000	10,500	0.10	0.15	0.20	0%	0.832	20
Fuel oil	1,300	1,350	1,400	4.00	5.00	6.00	0.000	0.000	0.001	9.00	9.50	10.00	9,000	9,500	10,000	0.10	0.15	0.20	0%	0.832	30
Biomass	2,400	3,370	4,240	84.00	99.40	158.82	0.004	0.004	0.007	1.80	2.00	2.20	13,000	13,500	14,000	0.75	0.80	0.85	0%	0.832	30