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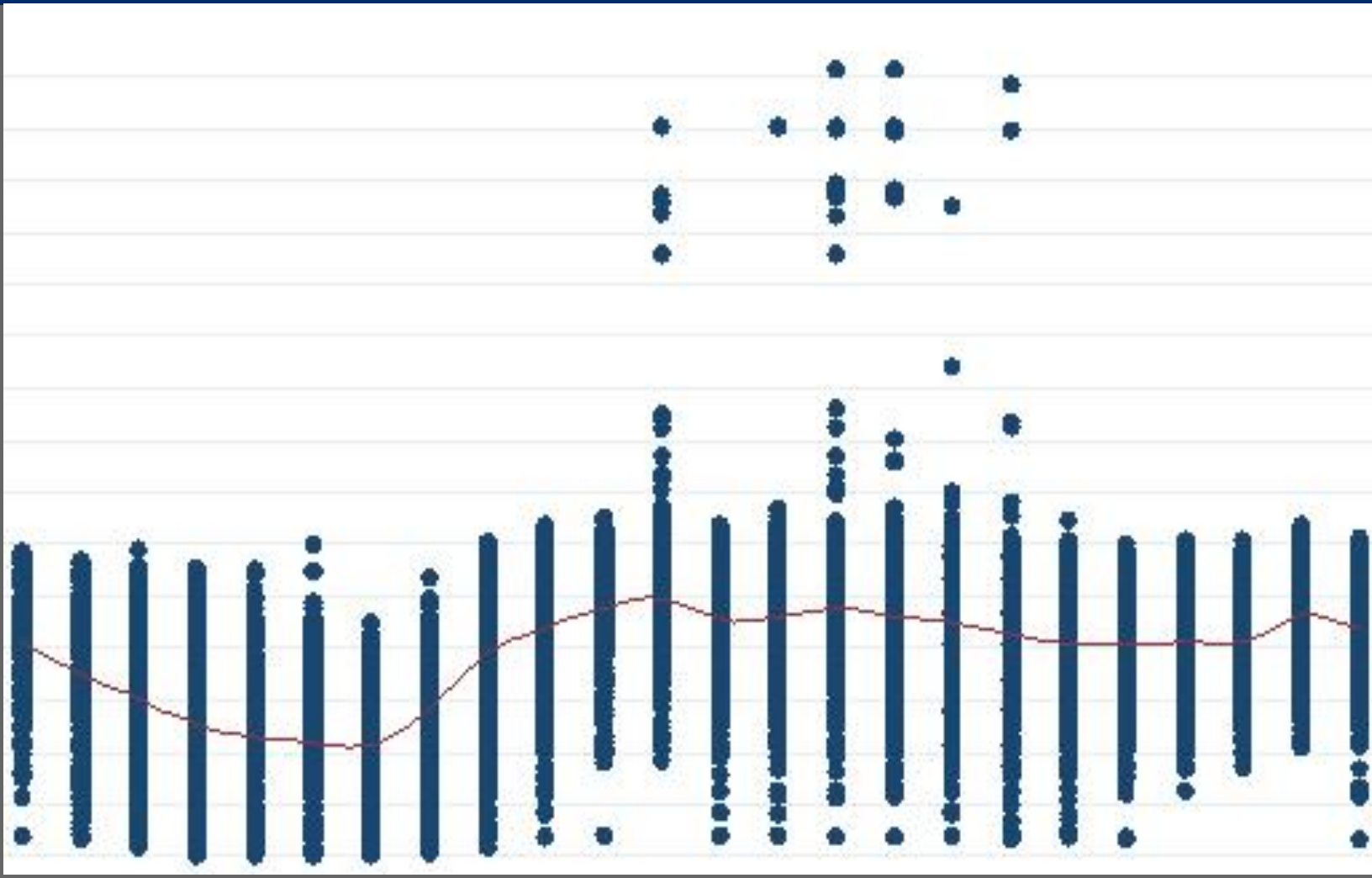
Hydropower Investment Promotion Project (HIPP)

Turkish Electricity Price Curve Analysis (2010-2011)



March 9, 2012

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USAID HYDROPOWER INVESTMENT PROMOTION PROJECT (HIPP)

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DELOITTE CONSULTING LLP

IN COLLABORATION WITH BLACK & VEATCH AND PIERCE ATWOOD LLP

USAID/CAUCASUS OFFICE OF ENERGY AND ENVIRONMENT

MARCH 9, 2012

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Acronyms Used in this Report

BM	Balancing Market
DAM	Day-Ahead Market
DAP	Day-Ahead Price
DAPM	Day-Ahead Planning Market
EMRA	Electricity Market Regulatory Authority of Turkey
ENTSO-E	European Network for Transmission System Operators for Electricity
EUAS	Electricity Generation Incorporated Company
GDP	Gross Domestic Product
GWh	Gigawatt Hours
HIPP	Hydropower Investment Promotion Project
HPP	Hydro Power Plant
IFI	International Financial Institutions
KGÜP	Final Day Ahead Production / Consumption Program (Kesinleşmiş Gün Öncesi Üretim/Tüketim Programı)
kWh	Kilowatt Hours
MO	Market Operator
MW	Megawatt
MWh	Megawatt Hours
PMUM	Market Financial Reconciliation Center (Piyasa Mali Uzlastirma Merkezi)
SO	System Operator
TEIAS	Turkish Electricity Transmission Corporation
TETAS	Turkish Electricity Trading and Contracting Company
TPP	Thermal Power Plant
USc	US Dollar Cents

EXECUTIVE SUMMARY

- USAID's Hydropower Investment Promotion Project (HIPP) intends to help facilitate private sector development of at least 400 MW of new, climate friendly hydropower in Georgia. This report has been published in support of this goal.
- Turkey has been identified as a potential export market for Georgian electricity. This study provides an analysis of power market prices in Turkey, thereby enabling potential private sector developers, governments, IFIs, and other stakeholders to better understand the economics of investment into the Georgian hydropower market.
- In 2010, the Turkish economy recovered after contracting in 2009. GDP grew by 9% year-on-year, compared to an 8% increase in demand for electricity.
- In 2011, GDP grew by 6.6% while demand for electricity increased by 8.5% over the same period.
- In the DAPM, the average price was 8.10 US c/kWh in 2010 while it was 7.39 US c/kWh in 2011.The reduction was mainly due to increased electricity output and participation on the exchange from lower cost hydro sources.
- In 2010, peak, off-peak, and shoulder-peak prices were 9.49, 5.07 and 8.80 US c/kWh, respectively, while they were 8.63, 4.77 and 7.98c/kWh in 2011, also respectively.
- In 2011, the highest price on the PX was 30.26 US c/kWh and the lowest price was 0.00 US c/kWh.
- During January, 2010 - April, 2011, almost 30% of available energy in the market was traded in the DAPM and BM. Of this, up to 80% was generated by gas fired plants.
- On September 18, 2010, the Turkish electricity system entered into a 1-year Trial Synchronous Parallel Operation with the ENTSO-E system. Turkey is expected to become a full member of ENTSO-E in 2012. This has important implications for the export of Georgian hydropower.
- Import and export electricity figures for the year 2010 were realized at 1,143GWh and 1,917GWh, respectively, equal to less than 2% of total national electricity production.
- Market prices were at their highest during the summer period, and decreased during neutral and winter periods.
- A total of 119 generation licenses were granted in Turkey in 2010, allowing for a total increase of 2,769 MW in installed capacity.
- Georgia is the second largest exporter of electricity to Turkey.
- December 2011 experienced the first full month of activity on the newly created DAM.

1. Introduction

USAID's HIPP intends to help facilitate private sector development of at least 400 MW of new, climate friendly hydropower in Georgia. This report has been published in support of this goal.

Turkey has been identified as a potential export market for new Georgian electricity. By examining the hourly prices of the Turkish DAPM, this *Turkish Electricity Price Curve Analysis* intends to help potential private sector developers, governments, IFIs and other stakeholders to better understand the economics of investment into the Georgian hydropower market.

The report examines the hourly prices of the Turkish DAPM for a two year period between its opening in December 2009 and its termination –when it was replaced by the DAM -in November 2011. A particular focus is placed on the identification and evaluation of electricity price clusters in order to categorize peak, off-peak, and shoulder-peak prices, and to separate time periods analyzed within days, weeks, seasons, and years.

2. Turkish Electricity Market Structure

In 2010, HIPP published a report titled *Turkish Electricity Market Overview,* which provides detailed background information on the evolution and mechanics of the Turkish power market. Rather than repeat this here, below we present solelya summary description of recent developments.

In 2001, the introduction of the Turkish Electricity Market Law[1]helped liberalize the power sector in Turkey. Since then, generation has become competitive, while transmission and distribution activities continue to beregulated by EMRA. Current legislation ensures that the market operates under free market principles, where all participants are treated equally.

Today, market participants are classified as eligible consumers, non-eligible consumers, generation, distribution, wholesale and retail sale companies, auto producers, auto producer groups, and the transmission company. Table 1 below defines all electricity market participants covered by the Turkish Electricity Market Law. All market activities are conducted under licenses issued by EMRA.

- Generation companies are either state owned by EUAS or privately owned.
- Auto producers and auto producers groups are generating electricity for their own needs and operate in parallel to the transmission and distribution system. They can sell a maximum of 20% of their annual generation to the market. However, this ratio can be modified by EMRA.
- The transmission company, TEIAS, is obliged to control and operate the power system and to provide and prepare transmissions, connections, system tariffs, and a grid code. At the same time, TEIAS establishes international interconnection activities, forecasts generation capacity, and supervises activities on the recently opened DAM.

[1] Electricity Market Law No. 4628, Energy Market Regulatory Authority (EMRA) of Turkey

- TETAS and private wholesale companies operate in the wholesale market. TETAS executes energy sales and purchase contracts. Primarily, it purchases electricity from EUAS. TETAS can also make new purchase contracts in order to meet its contractual obligations to distribution companies. Wholesale companies, except TETAS which cannot, can sell electricity to eligible consumers. Wholesalers can import and export electricity from any country. According to EMRA, the total market share of any private wholesale company must not exceed 10% of the total electricity consumed during the previous year.
- Distribution companies can only execute generation and retail sales activities under separate legal entities. They are also mandated with preparing regional demand forecasts for the regions in which they distribute electricity.
- Eligible consumers can be directly connected to the transmission grid or consume electricity above the threshold set by EMRA. In 2010, this threshold was 100 MWh per annum compared to 480 MWh per annum the previous year. EMRA has the right to lower or raise the eligibility threshold on an annual basis.

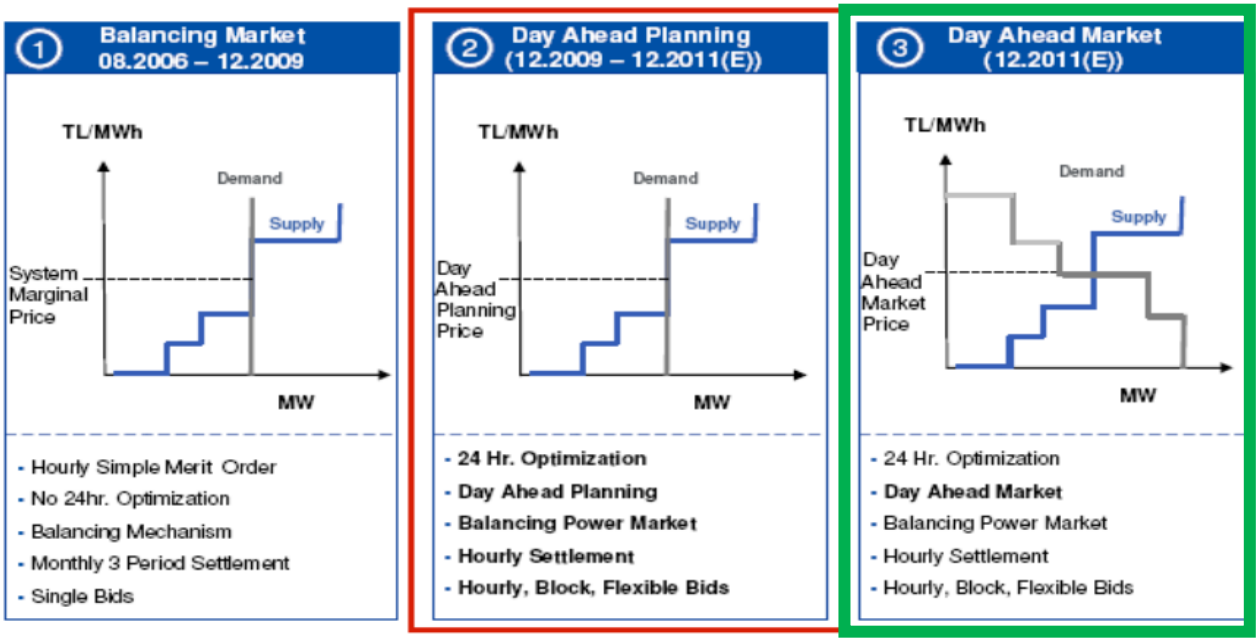
Table 1. Definitions of Turkish Electricity Market Participants

Eligible Consumer	Any real person or legal entity that has the liberty to choose its supplier due to its consumption of more electricity than the amoun set by E M R A and/or its direct connection to the transmission system;
Non-eligible Consumer	Any real person or legal entity that can purchase electric energy and/or capacity only from retail sales companies or from a distribution company holding a retail sales license in its region;
Generation Company	Any legal entity, except for auto producers and auto producer groups, engaged in generation of electricity and the sale of the electricity it has generated;
Distribution Company	Any legal entity engaged in electricity distribution in a certain geographical region;
Wholesale Company	Any legal entity engaged in the wholesale, import, export, trade of electric energy and/or capacity and the sale of the same to Eligible Consumers;
Retail Sale Company	Any legal entity engaged in import of electricity and/or capacity and retail sale to consumers, excluding those directly connected to the transmission system, and in providing retail sale services to consumers;
Auto producer	Any legal entity engaged in electricity generation primarily for its own needs;
Auto producer Group	Any legal entity engaged in electricity generation primarily for the needs of its affiliates;

Reforms in the electricity sector resulted in the development of a transitional, three phase plan for the market, including the formation of a BM, DAPM and DAM, each with hourly settlement. The transitional plan and corresponding dates are shown below[2].

[2] Figure 1 is extracted from Bakatjan Sandalkhan's presentation on the topic "The Evolution of the Wholesale Electricity Market in Turkey."

Figure 1. Turkish Wholesale Electricity Market Evolution



As can be seen in Table 2, the total number of participants in the DAPM increased over the two years of its operation, and most noticeably, the share of private companies. Consequently, the Turkish electricity market appears to have successfully fulfilled a transitional process towards a competitive electricity market.

Table 2. Distribution of DAPM Market Participants

License Type	End of 2010		End November, 2011	
	Public	Private	Public	Private
Production	5	209	6	265
Auto Producers	0	139	1	146
Wholesale	1	78	1	129
Retail	12	7	9	12
Auto Producers Group	0	1	0	2
Distribution in Organized Industrial Zone	0	1	0	0
Total	**18**	**435**	**17**	**554**

Source: TEIAS

2.1DAPM Operations

While almost all the protocol described below has remained in effect during the DAM phase, this report analyzes price curves solely during the day-ahead planning phase, which started in December 2009 and ended in November 2011. During this time, the MO coordinated all actions in order to balance forecasted hourly demand for the day ahead. Each day, before 11:30, the SO forecasted electricity demand and monitored system congestion. At the same time, market participants projected their generation/consumption and sent hourly based offers and bids to the MO. After 11:30, no bids or offers were accepted. Between 11:30 – 12:30, the MO prepared a generation/consumption schedule that balanced the forecast hourly demand and determined DAPs. The MO also formed system sales and purchase instructions for all accepted bids and issued up and down regulation instructions. Between 12:30 – 13:00, market participants checked whether or not the sales and system purchase instructions issued by the MO for day ahead planning were consistent with the related system sales and purchase bids and had an opportunity to object to any inconsistent instructions. Finally, between 13:00-14:00, the MO evaluated objections and re-determined and announced system marginal prices. The system DAP was considered as the reference price for the BM[3].

3. DAPM Electricity Price Curve Analysis

Information on DAPM system production levels and day-ahead hourly prices are based on data available from the TEIAS/PMUM website[4].This report assumes three (winter, neutral and summer) seasons within a year. Based on HIPP's studies, the winter period includes December, January and February, the neutral season includes March, April, May and June, October and November and the summer period includes July, August and September. Table 3below summarizes key DAPM price dynamics in US c/kWh for the two years the DAPM was operational.

[3]FatihKolmek's presentation on the topic "Turkish Electricity Market", 2010

[4]Market Financial Reconciliation Center, http://dgpys.teias.gov.tr/dgpys/

Table 3. Summary of DAPM Prices (US Cents/kWh)				
Description	**2010**	**2011***	**Change**	
Base Average Price	8.10	7.39	-0.71	-8.77%
Peak Average Price	9.49	8.63	-0.86	-9.06%
Off-Peak Average Price	5.07	4.77	-0.3	-5.92%
Shoulder-Peak Average Price	8.80	7.98	-0.82	-9.32%
Highest Traded Price	28.06	30.26	2.2	7.84%
Lowest Traded Price	0	0	0	0%
Summer Average Price	10.08	8.68	-1.4	-13.89%
Summer Peak Average Price	11.52	9.95	-1.57	-13.63%
Summer Off-Peak Average Price	7.57	6.35	-1.22	-16.12%
Summer Shoulder Peak Average Price	10.43	9.08	-1.35	-12.94%
Neutral Average Price	7.27	6.63	-0.64	-8.80%
Neutral Peak Average Price	8.56	7.71	-0.85	-9.93%
Neutral Off-Peak Average Price	4.04	4.03	-0.01	-0.25%
Neutral Shoulder Peak Average Price	8.18	7.34	-0.84	-10.27%
Winter Average Price	7.84	7.73	-0.11	-1.40%
Winter Peak Average Price	9.35	9.45	0.1	1.07%
Winter Off-Peak Average Price	4.72	4.61	-0.11	-2.33%
Winter Shoulder Peak Average Price	8.51	8.24	-0.27	-3.17%

* First 11 months only

Base average price contains an average of all the hourly prices in the examined periods. Peak, off-peak, and shoulder-peak average prices and the highest and lowest traded price contain prices for already determined peak, off-peak and shoulder-peak hours and maximum and minimum prices during the two years. Seasonal peak, off-peak, and shoulder-peak average prices are determined for selected winter, summer and neutral seasons.

3.1 Price Dynamics in 2010 and 2011

PMUM's web site provides day-ahead demand and production forecasts. Data is also provided on KGUP that is the final schedule of the next day's production after day-ahead bidding[5]. HIPP uses KGUP as a proxy for demand on the Turkish power market.

Electricity production in Turkey varies hourly, weekly and seasonally, while the general yearly trend is upward sloping. In order to analyze price clusters for the two years, HIPP used the computer software STATA. According to PMUM data, three price clusters were identified. Peak hours were categorized during 11:00-19:00, whereas off-peak hours were between 02:00-08:00 and shoulder peak hours were 08:00-11:00 and 19:00-02:00.

Fig 2. Distribution of Electricity Prices, Turkish DAPM, 2010-2011

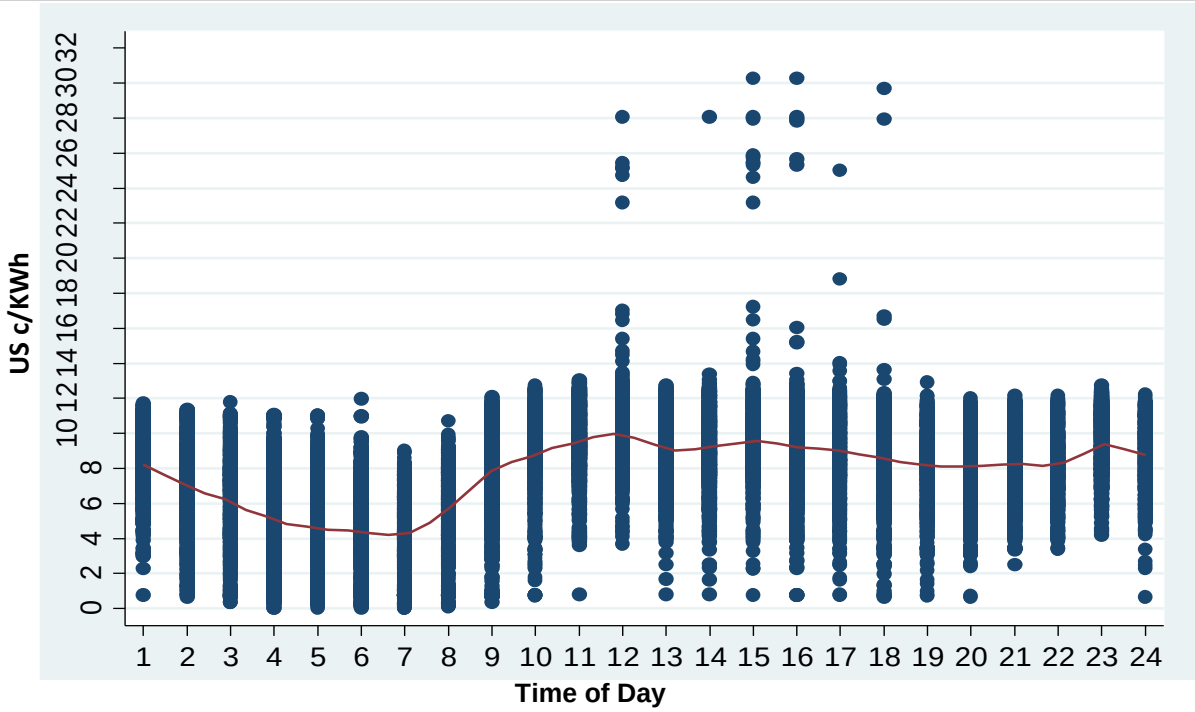


Figure 2 provides hourly electricity prices for every day of the two years the DAPM was operational. The maximum price, 30.26 US c/kWh, was recorded during peak hours 14:00-15:00 and 15:00:16:00 of September 7. As for off-peak hours, the minimum price was0 US c/kWh during 03:00-04:00 in both 2010 and 2011.This may be due to summer time practice. Every year, on March 28th, Turkish clocks are set forward by one hour at 3 AM. As a result, daylight is increased and electricity consumption is decreased. According to Turkey's electricity corporation, Turkey saves 600-700 million kWh of electricity annually through summer time practice. The red line on the graph describes the general trend of DAM prices. As expected,

[5] We estimated the difference between actual monthly production and KGUP monthly production at 1.3% in 2011. (Total sum of KGUP production for the year of 2011 was 208 946 GWh, while for the same time period actual production was 206 260 GWh).

DAM prices during off-peak hours were low due to low demand for electricity and non-electricity intensive activities. However, prices tend to increase during shoulder peak and peak hours respectively during working hours when electricity intensive services and activities are most intense.

Figure 3. Average System Load and Prices by Hours, DAPM, 2010-2011

Figure 3 describes the dynamics of system loads and prices. On average, prices for 2010 were relatively higher than in 2011. The reduction in electricity prices was mainly due to increased electricity output and participation on the exchange from lower cost hydro sources. We think the fact that 2010 was a transitional year after the DAPM was established also had an impact.

Figure 4. Price Range, DAPM, 2010 and 2011

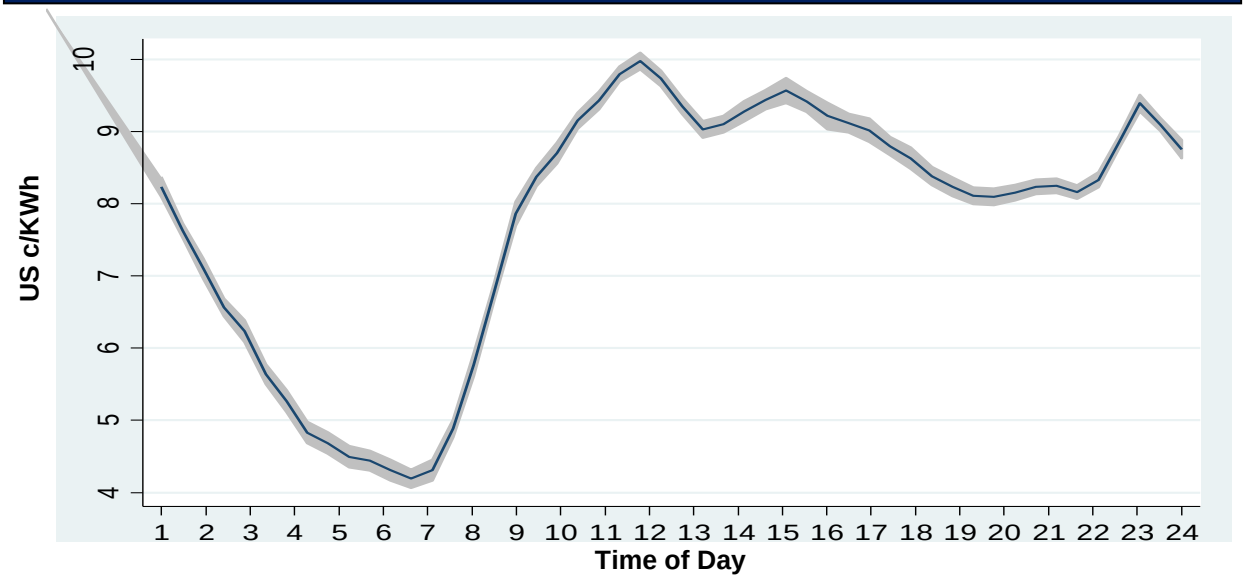
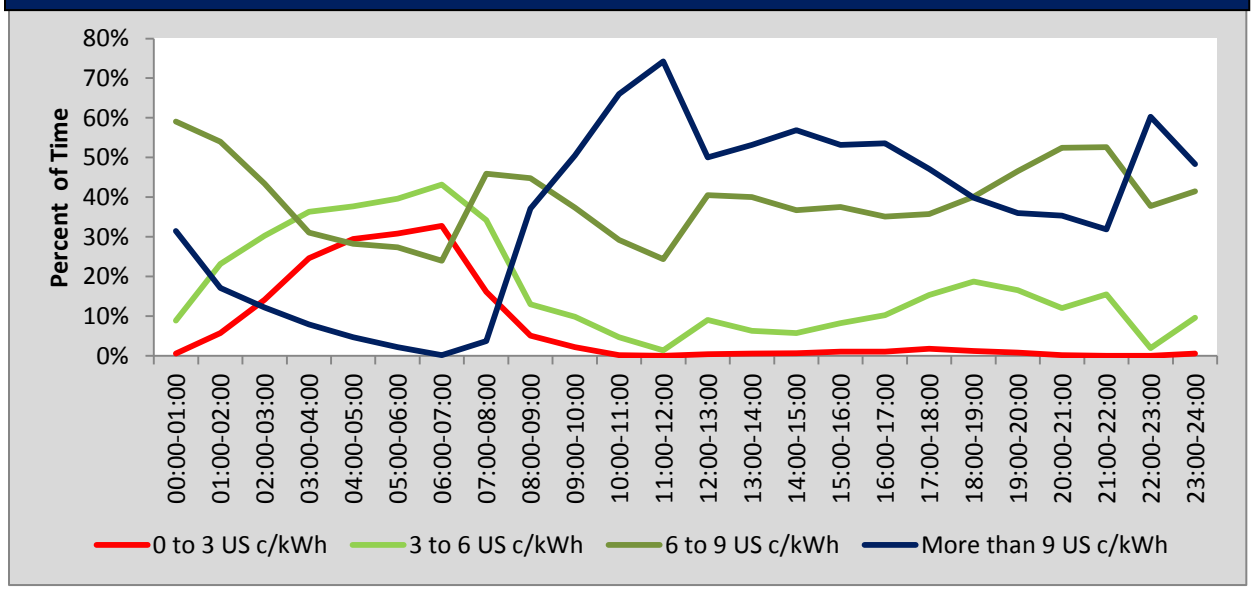


Figure 4 provides price fluctuations by hours based on statistical analysis. Applying polynomial regression, we observe DAM price ranges between 4 US c/kWh and 10 US c/kWh with a 95% confidence interval within the dashed areas.

3.1.1 Price Sub Groups on Turkish DAPM

In Figure 5, we use PMUM data to group hourly kWh prices in four price bands. We categorize results according to prices in each hour.

Figure 5. Distribution of Price Ranges, 2010-2011



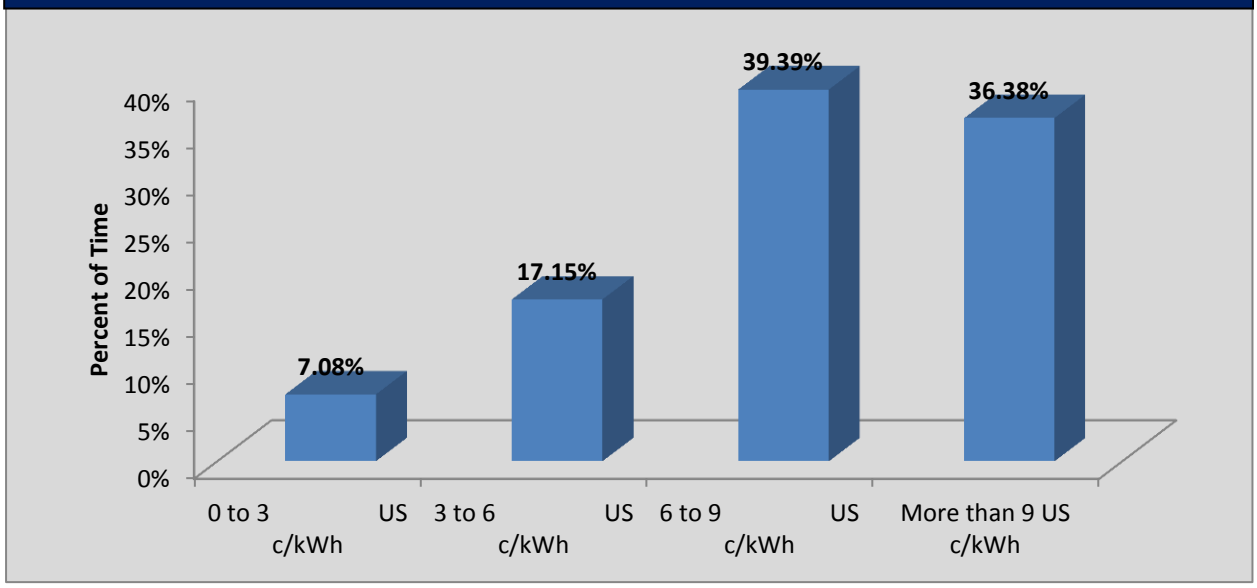
Below 3 US c/kWh. The total number of hours when prices were below 3 US c/kWh was 1,241 out of a total 16,790 hours under study. Off-peak hours dominate this figure, contributing up to 1,080 of those hours. During peak and shoulder peak hours, prices below 3 US c/kWh are insignificant.

***3 to 6 US c/kWh*.** This price range follows a similar trend. The total number of hours for this rangewas3,004, mostly recorded off-peak. For the shoulder-peak and peak periods, hours when prices were noted between 3-6 US c/KWh are 548 and 841, respectively, out of 16,790 hours under study.

***6 to 9 US c/kWh*.** There were 6,902 hours in this price band during 2010 and 2011, 2,118of which occurred during shoulder-peak and 3,324of which occurred during peak hours.

***Over 9 US c/kWh*.** Prices in this band accounted for 6,148 hours of the total 16,790 hours under study, and demonstrated similar characteristics to 6 to 9 US c/kWh prices. Over the 23 months studied, the total number of off-peak hours in this price band was 225, while on peak and shoulder-peak hours within this category totaled 3,124 hours and 3,024 hours, respectively. Figure 6 provides distribution by price band for the period under study.

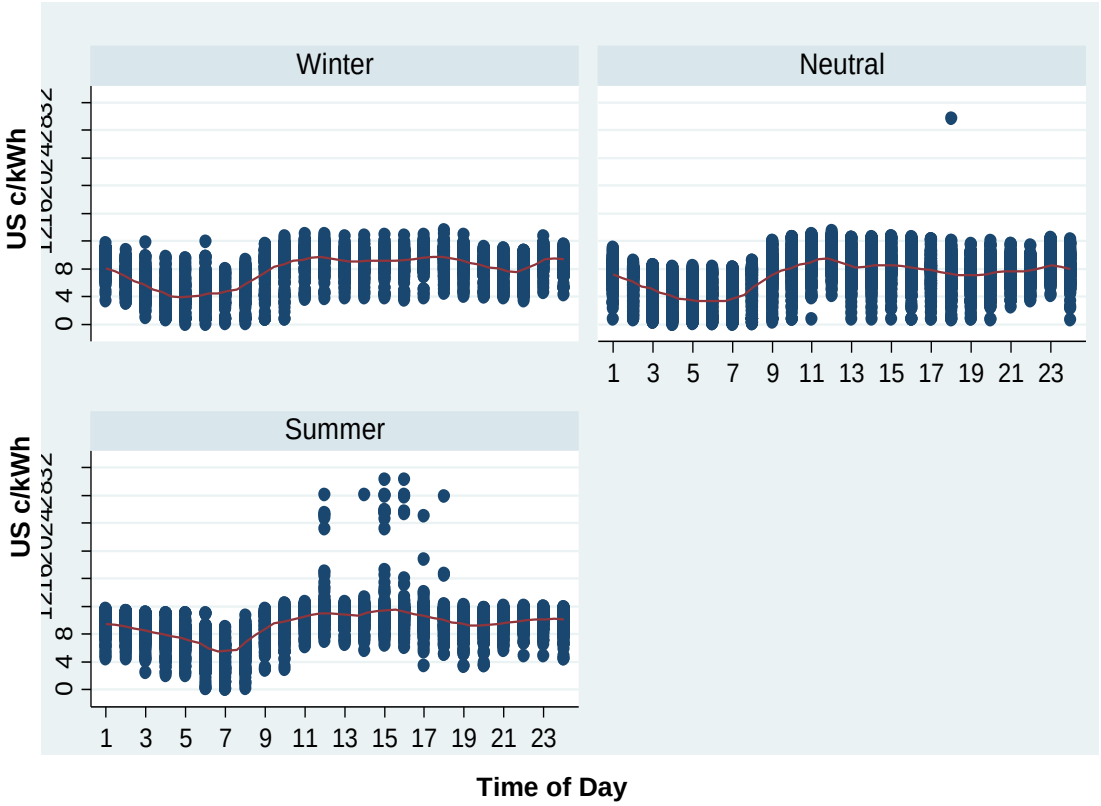
Figure 6. Distribution by Price Band, 2010-2011



3.2 Price Curve Dynamics by Season

Turkish electricity prices demonstrate clear seasonality. In general, summer is the peak season, with winter showing the second highest levels of market activity. Autumn and spring can be considered "off peak seasons". As per HIPP's previous studies, this report assumes three seasons in the year - winter, neutral and summer.

Figure 7. Seasonal Trends in DAPM Prices, 2010-2011



As shown in Figure 7, summer is a peak season. The highest prices in the DAPM were recorded within this season. Moreover, the summer period becomes more electricity intensive due to tourism. For the neutral and winter seasons, electricity prices follow a similar general trend.

Figure 8. Seasonal Price Range, 2010-2011

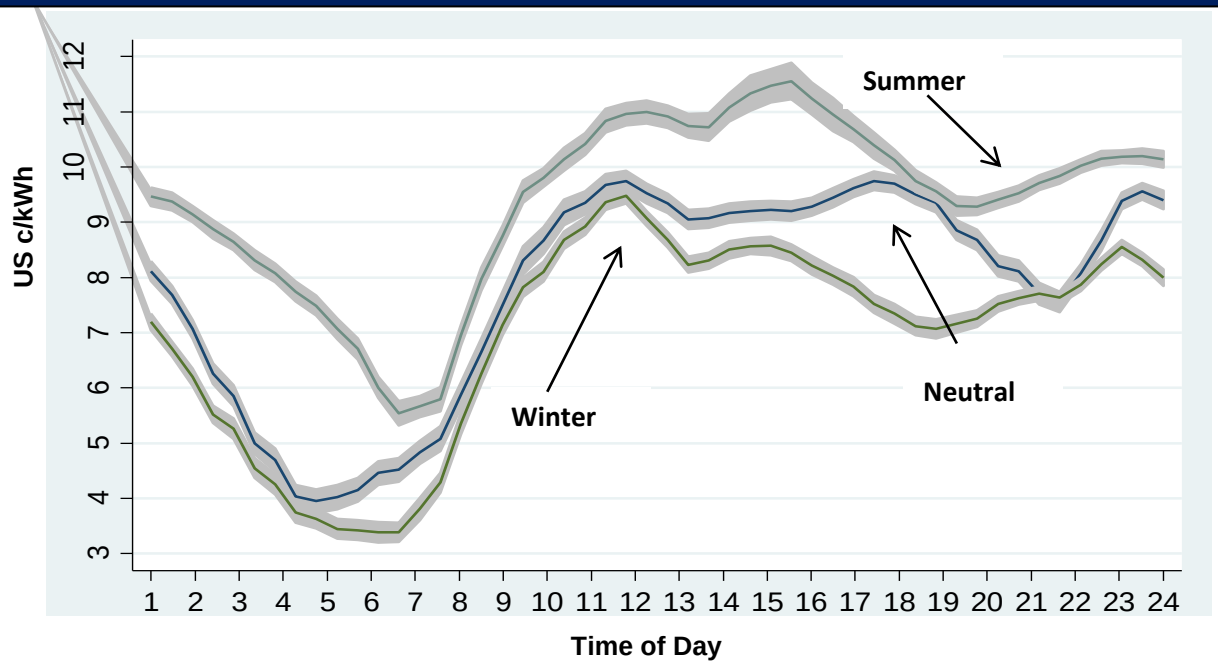
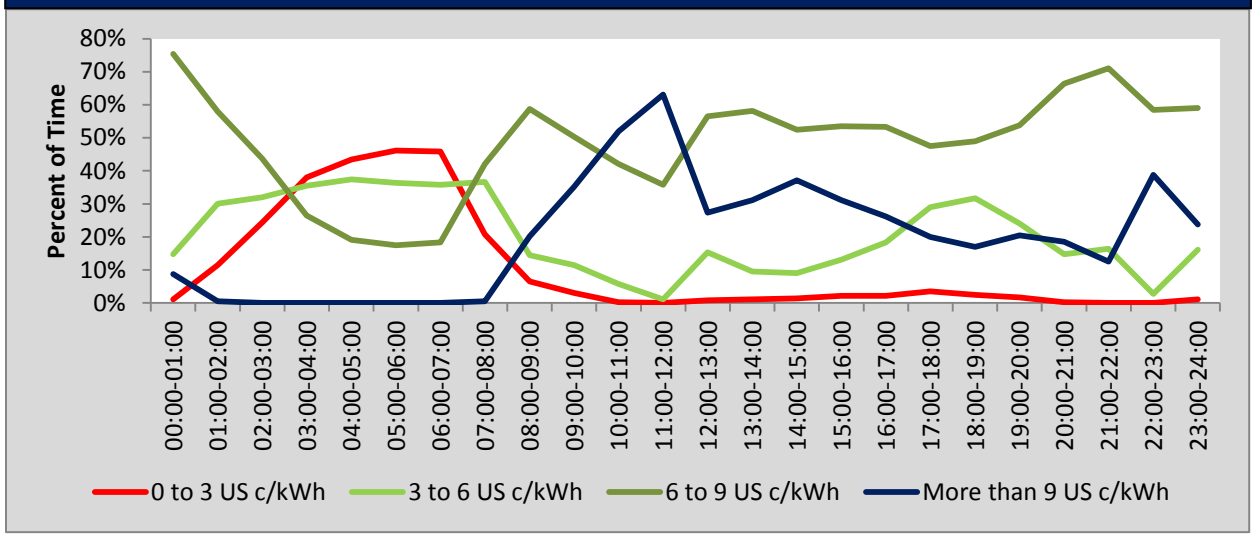


Figure 8above demonstrates price ranges by seasons within a 95% confidence interval level within dashed areas. Applying polynomial regression, it can be seen that in the summer period, off-peak hours are shifted forward by 2 hours. At the same time, peak prices during the summer period tend to increase compared to winter and neutral periods. In the next section, HIPP analyses each season independently.

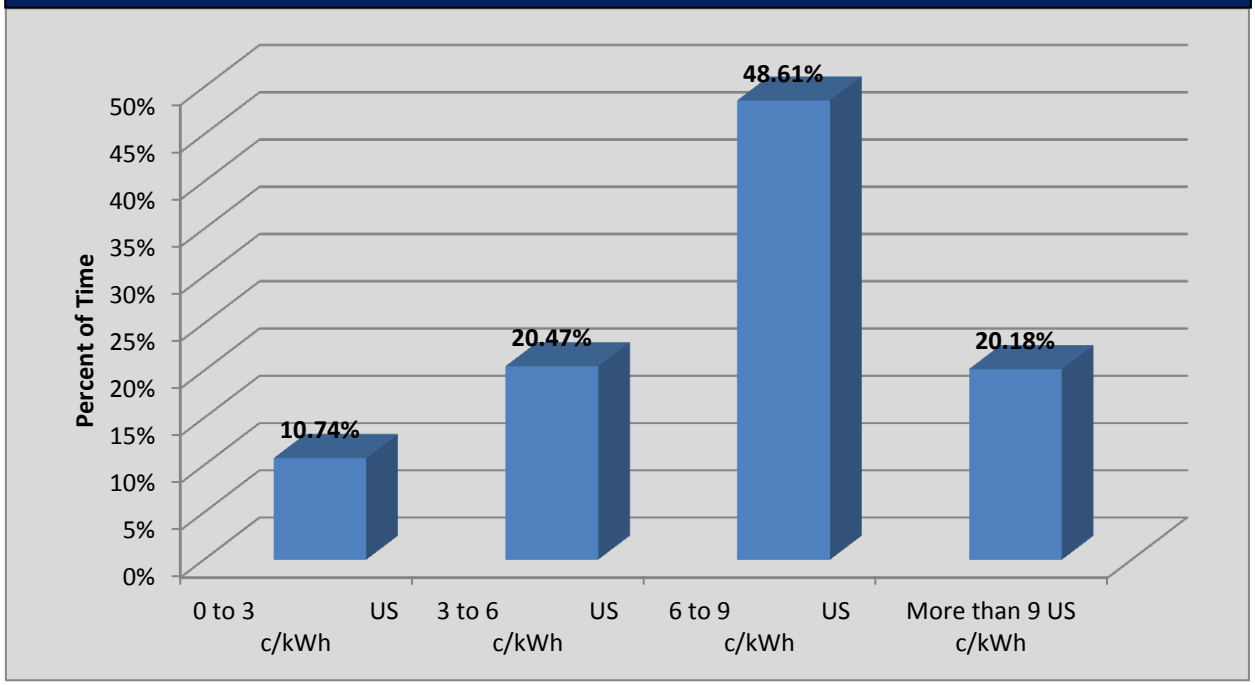
3.2.1 Neutral Season

Figure 9. Distribution of Prices in Neutral Season



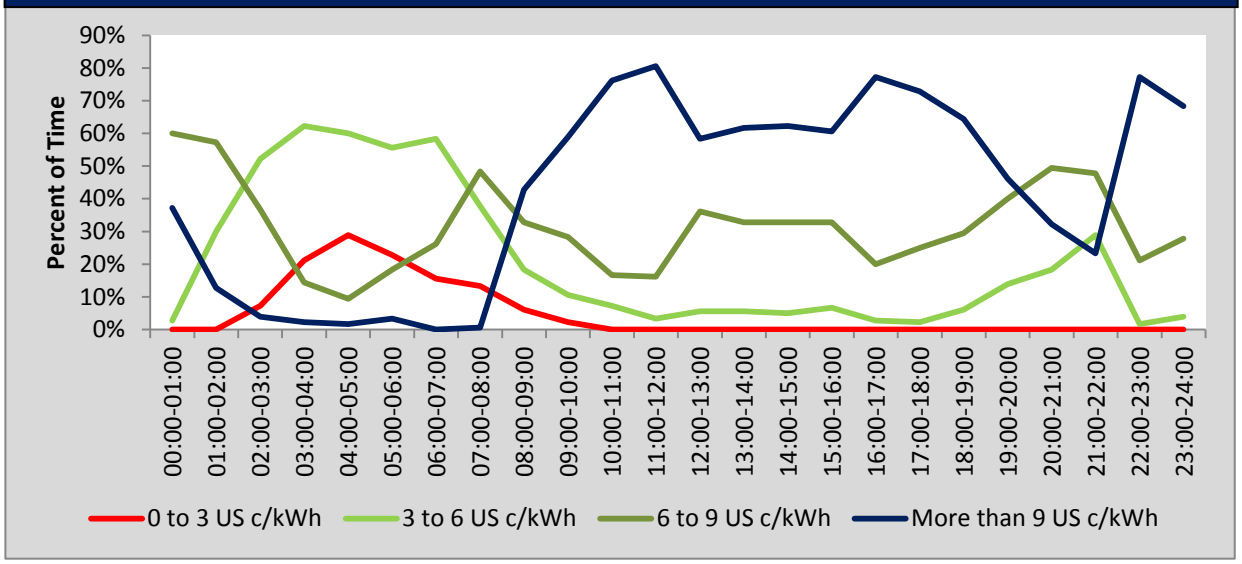
The Neutral seasoncombines data for six months, totaling 8,784 hours over the period under study. Consequently, there is an obvious dominance of this price range in the overall pattern, but not enough to significantly bias results.The total number of hours for the price range below 3 US c/kWh in the neutral season was 943. Prices in the 3-6 US c/kWh range accounted for 1,798 hours, mostly recorded between 01:00 and 08:00. Prices between 6-9 US c/kWh totaled 4,270 hours, and occurred largely between 09:00-24:00. Prices over 9 US c/kWh reached 1,773 hours. Figure 10 provides a distribution by price band for the Neutral season.

Figure 10. Distribution by Price Band, Neutral Season



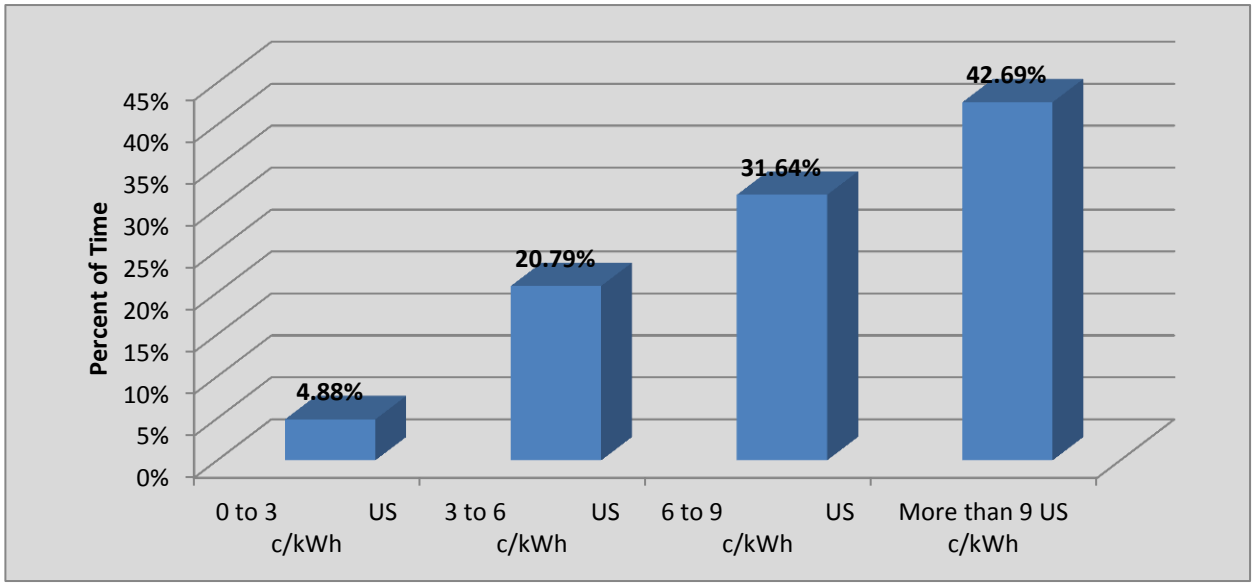
3.2.2 Winter Season

Figure 11. Distribution of Prices in Winter Season



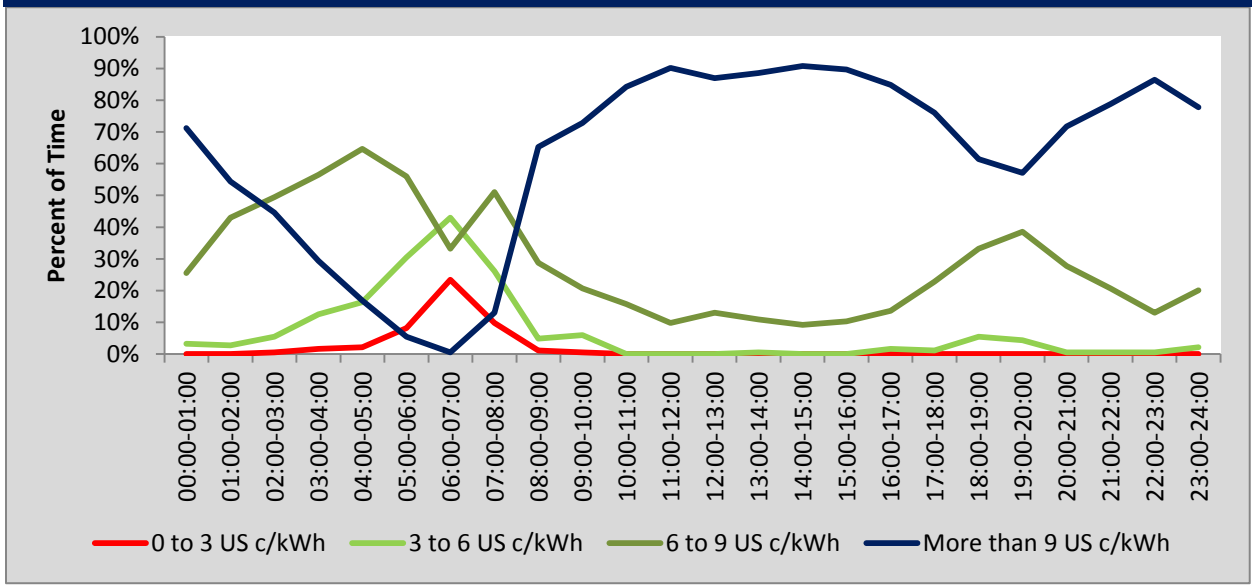
Duringwinter season, the total number of hours for the price range below 3 US c/kWh was 211 out of a total 4,320 hours over the two years. This price range is mostly covered by off-peak hours. Sales in the 3-6 US c/kWh range were mostly recorded during the early morning of the day until noon and after working hours, and totaled 898 hours. Prices above6 US c/kWh mostly occuredbetween 09:00-00:00, and have asignificantly higher shareof total hoursthan under 6 US c/kWh.Figure 12 provides a distribution by price band for the Winter season.

Figure 12. Distribution by Price Band, Winter Season



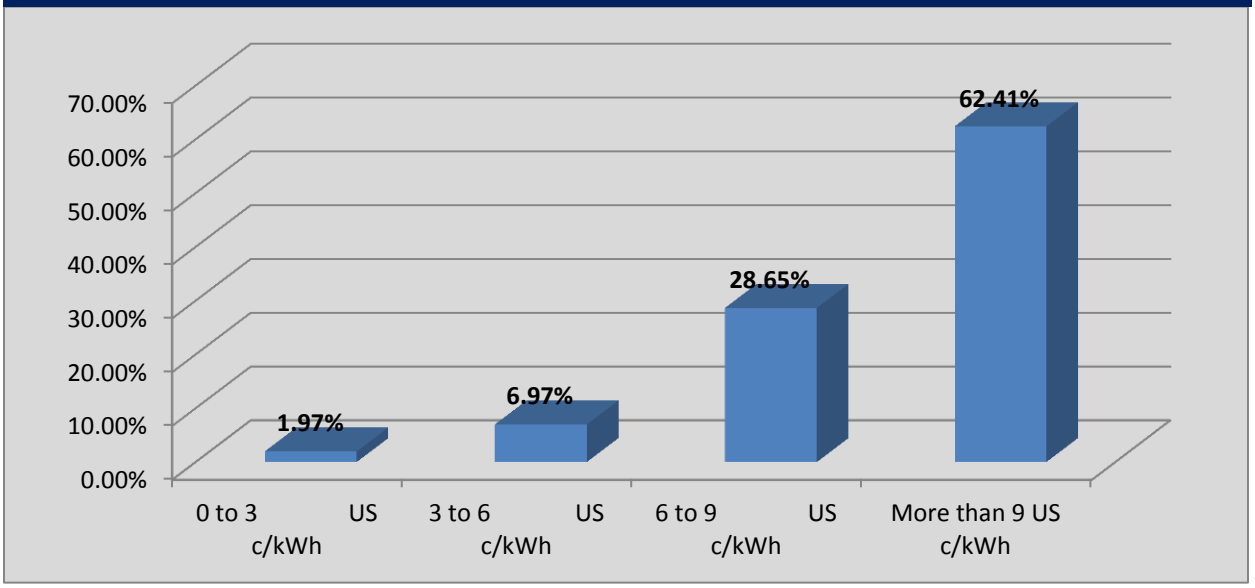
3.2.3 Summer Season

Figure 13. Distribution of Prices in Summer Season



For theSummer season, the total number of hours for the price range below 3 US c/kWh was 87, out of a total 4,416 hours. Lifestyle changes during Summer season, and the impact of tourist activity reduce and shift forward off-peak hours by two hours. Pricesbelow 6 US c/kWh follow a similar pattern, peaking from 02:00 to 06:00, and then flattening off towrads zero for most of the reast of the day. Prices above6 US c/kWh mostly occured during shoulder-peak and peak hours within theSummer season and account for almost 90% of total hourly sales. As shown inFigure 14, which provides a distribution by price band for the Summer season, sales over 9 US c/kWh were very common during this period.

Figure 14. Distribution by Price Band, Summer Season



3.3 Price Curve Dynamics by Month

Turkish DAPM prices demonstrate significant monthly variation, as shown in Figure 15. It seems that there is a monthly pattern in electricity prices. In the summer months prices are high relative to winter and neutral months. Natural gas is the main source of price volatility when it is used for electricity generation and for heating purposes in the winter. In the summer months, electricity prices tend to be the highest due to increased electricity intensive industrial and tourism activity.

Figure 15. Price Dynamics by Months

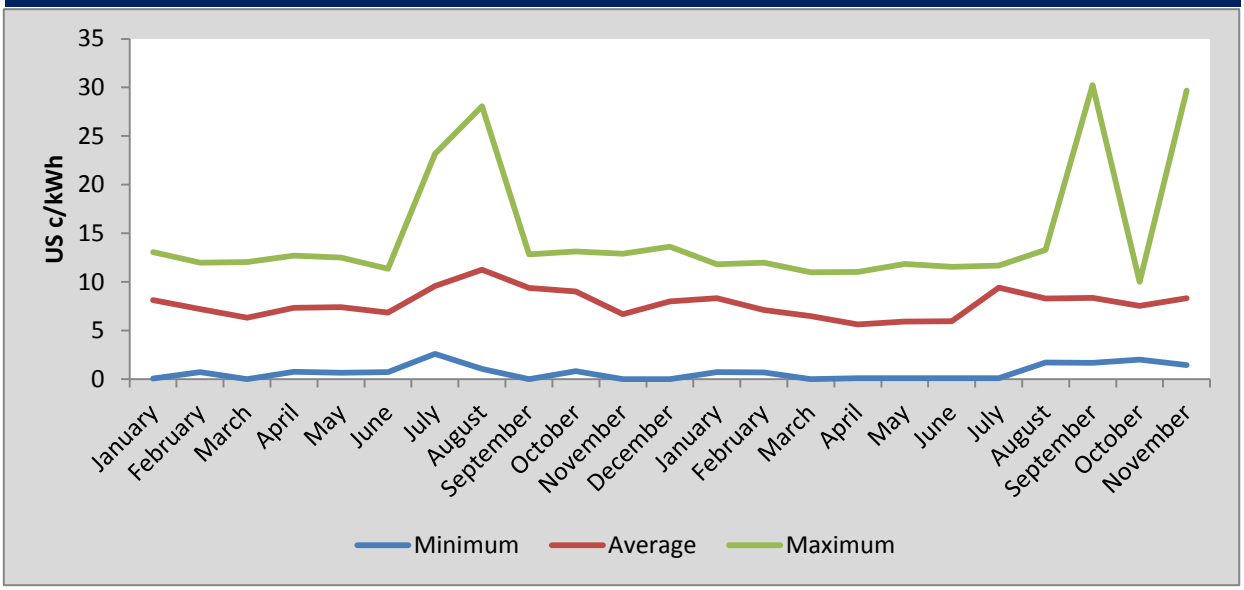
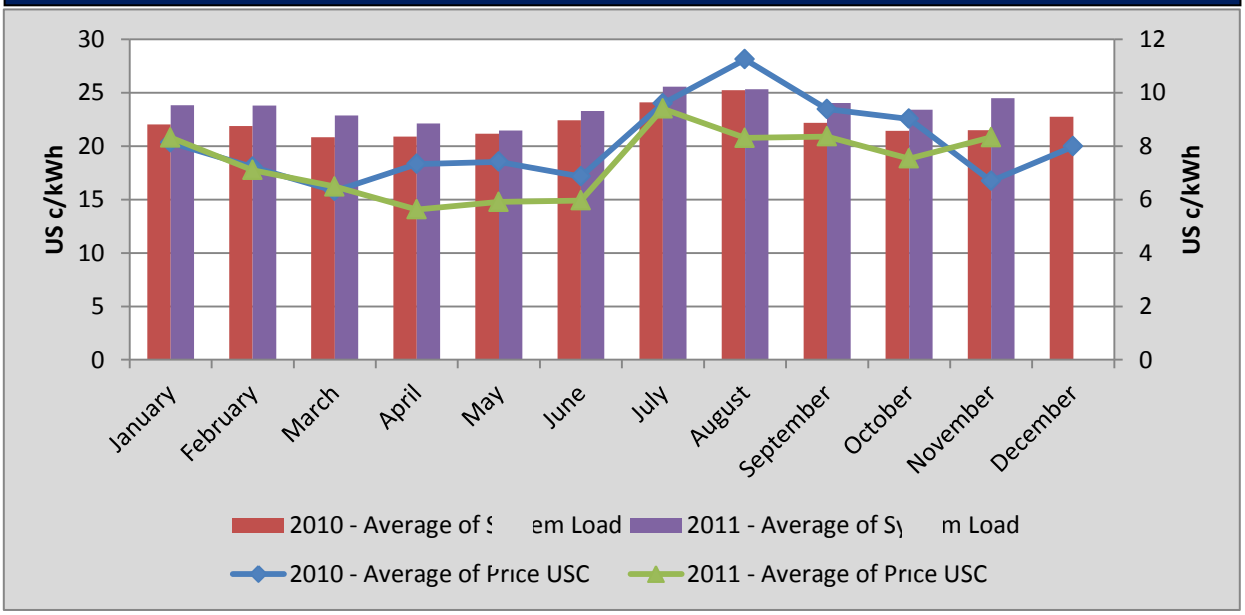


Figure 16 presents the monthly breakdown of system loads and prices. As shown in this figure, the highest prices were recorded for the summer season during both years.

Figure 16. Average System Load and Prices by Months



3.4 Price Curve Dynamics by Week-Days

As one would expect, prices on the DAPM tend to be higher during the week, when demand for electricity is stronger. Also worthy of note, prices often peaked around mid-week, when most of the Maximum Daily Consumption events recorded in Table 4 were observed.

Table 4. Maximum and Minimum Daily Consumption

YEARS	*MAX. DAILY CONSUMPTION* (MWh)	*DATE OF MAX. DAILY CONSUMPTION*	*MIN. DAILY CONSUMPTION* (MWh)	*DATE OF MIN. DAILY CONSUMPTION*
2000	400,117.0	12/22/2000	266,905.0	28/12/2000
2001	404,828.0	12/13/2001	238,625.0	3/5/2001
2002	426,245.0	12/26/2002	264,160.0	12/6/2002
2003	435,465.0	12/19/2003	268,151.0	11/26/2003
2004	469,439.0	12/16/2004	260,261.0	11/15/2004
2005	502,306.0	12/23/2005	300,563.0	11/4/2005
2006	548,921.0	12/26/2006	301,498.0	10/24/2006
2007	605,875.0	7/26/2007	323,153.0	10/13/2007
2008	631,179.0	7/23/2008	309,821.0	10/1/2008
2009	609,936.0	8/5/2009	333,798.0	9/20/2010
2010	695,335.0	8/17/2010	379,023.0	11/16/2010

Source: TEIAS

Figure 17 shows that maximum and average electricity prices are high during weekdays, while electricity prices decrease during weekends, as electricity demand softens.

Figure 17. Price Dynamics by Weekdays

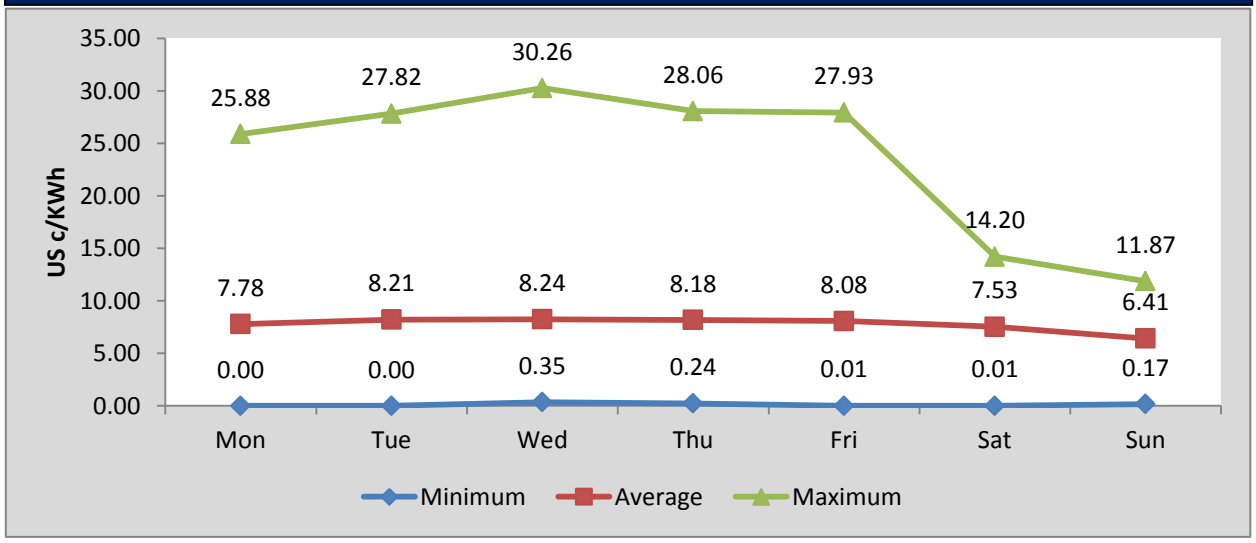
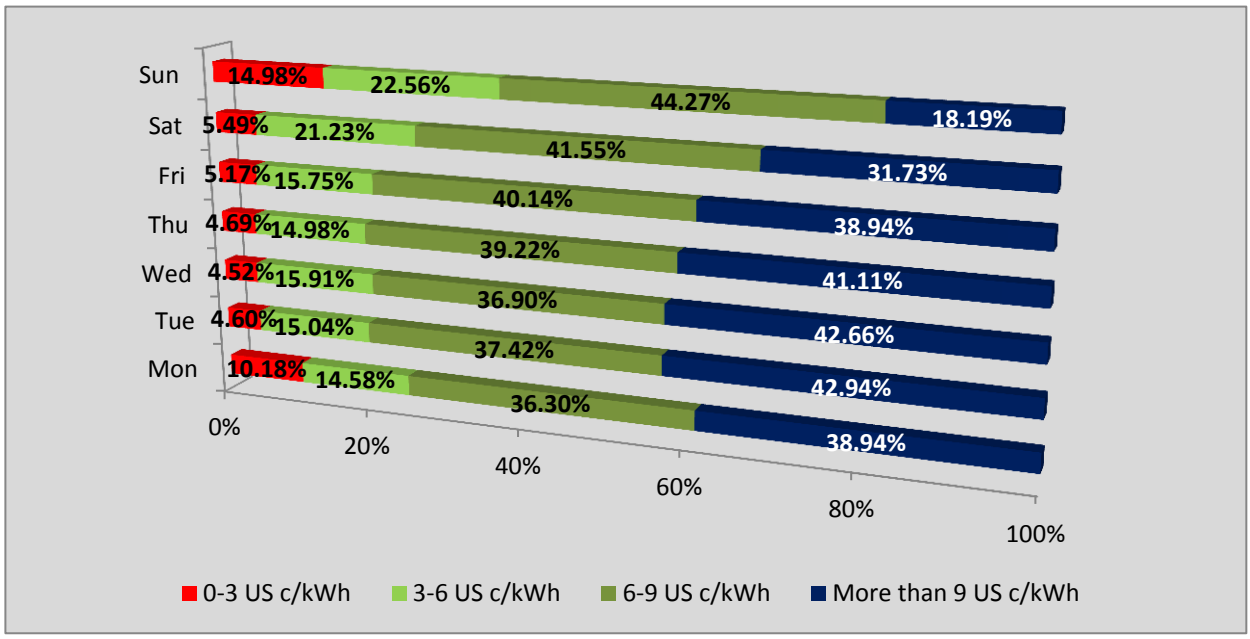


Figure 18 provides a comparision of price bands within weekdays. Prices below 3 USc/kWh were higher during weekends. Prices between 3-6 USc/kWh occurred on all weekdays, but had a far lower share than prices over 6 USc/kWh. During the week, prices were over 9 USc/kWh for around 40% of the time.

Figure 18. Price Range Breakdown by Weekdays



Appendix

Source materials used in this report can be found at the following locations.

1. Electricity Market Regulatory Authority, www. emra.org.tr
2. European Network for Transmission System Operator for Electricity, www.entsoe.eu
3. Hydropower Investment Promotion Project, www.hydropower.ge
4. Market Financial Reconciliation Center (PMUM), dgpys.teias.gov.tr/dgpys/
5. Turkish Electricity Transmission Corporation , www.teias.gov.tr

USAID Hydropower Investment Promotion Project (USAID-HIPP)

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