Techno-Economic Analysis of Illegal Electricity Usage in Turkey and Policy Proposals

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Abstract: - Some part of the energy produced in electric power systems does not reach to consumers who make payment because of output loss and administrative applications. The energy loss can be considered in two categories as technical losses and nontechnical losses. Total of these losses is a significant parameter that affects capacity of the system. In this study, the transmission and distribution losses in Turkey power system were researched. The studies carried out for purpose of determining its illegal use and its socio-economical effects were analyzed. It is impossible to prevent the losses completely in the electric energy system. However, in developed countries, it generally remains below 6%. The lost illegal use rate in Turkey was determined as 14.4%. The cost resulting from only illegal use reaches to values that urge the economy of Turkey with a rate that is 1.7 times of the annual transmission and distribution system investment of the country. In terms of energy pricing Turkey is very competitive situation with European Union and OECD countries. However, the losses of Turkey are well above the world and OECD averages. To decrease the technical losses, very serious additional energy investment is needed in the country. Illegal use rate can be decreased to acceptable rates as a result of policy changes and some measures. In the study, some solution suggestions are made to decrease the loss rate that occurs as a result of illegal use. To achieve decrease in illegal use, some measures can be taken such as, speeding up privatization policies, regional price policies, raising of the awareness of the public about economical and social dimensions of the illegal electric use, encouraging of the public to use other energy sources means by being informed and supported economically, awarding of the government officials who determine the illegal use, giving of various incentives to citizens who denounce such use.

Key-Words: - Electricity theft, T&D loses, energy generation, electrical energy demand, cost

1 Introduction

Energy is considered to be a key player in the generation of wealth and also a significant component in economic development. This makes energy resources extremely significant for energy country in the world. In bringing energy needs and energy availability into balance, there are two main elements such as energy demand and energy supply. In this regard, every country should put efforts to attain such a balance and hence conduct research and development studies to develop its own energy conservation programs for the existing and new energy resources [1]. Three key issues will define the shape and future of energy in world:

Sustainability - how much and at what rate is energy consumed, and its effect on long term sustainability; the quality and quantity of available alternative/renewable forms of energy; and the effect of existing energy use on the global environment as a whole.

Efficiency -the technology, planning and management of energy systems that will facilitate efficient use of energy for human activity.

Equity - the appropriate financial mechanism for research, development and use of finite and alternative energy forms, and their equitable distribution for all humankind [2].

Essential question is the influence of deregulation process on quality of electricity

supplied by public electric power system. Sometimes electric power company cutting could result in decreased level of energy quality causing short and long interruptions of the supply voltage, or bad voltage profile. Namely, competitions always cause reduction of employees in ompanies and sometimes it reduces investments in equipment and maintenance. At the same time, customer expectations increase in new business environment. Because of that, it is necessary that regulatory body quantifies acceptable level of supplied electricity, and that includes:

- Long term planning of investments with intention to replace or reconstruct network unsatisfactory parts,
- Reliability calculations for transmission and distribution networks,
- Rates of technical and non-technical transmission and distribution (T&D) losses,
- Detailed study of conditions for connection power plant or bigger consumers on network,
- Network technical data base creation,
- Predetermining parameters important for energy quality (permitted interruptions time, minimal number of consumers needed to reconnect after blackout in specified time, minimal level of voltage decreasing in specified time, period for meter replacement after changing the tariffs, etc.) [3].

1.1 An overview of existing energy potential in Turkey

Turkey's geographical location makes it a natural bridge between the energy-rich Middle East and Central Asian regions. Energy is one of Turkey's most important development priorities. Rapid increase in domestic energy demand has forced Turkey to increase its dependence on foreign energy supplies. Energy is essential to economic and social developmentand an improved quality of life in Turkey as in other countries. Turkey's national energy policies are designed to provide the required energy on a timely, reliable, cost effective, environment- friendly and high-quality basis so as to serve as the driving force of development and social progress. Turkey's existing primary energy resources of oil and natural gas reserves are extremely limited. A large portion of Turkey's 8 billion-tonne coal reserve is low quality brown coal. Turkey's potential indigenous fuel sources for power generation comprise 105*billionkWh* lignite, 16*billionkWh* high-quality coal and 125*billionkWh* hydro [4].

To ensure supply reliability in the long-term, it is very important to reply how the forecast electric energy demand can be met. In both scenarios mentioned in the energy production planning report between 2005-2020 years made by using the MAED (Model for Assessment of Energy Demand) by Turkish Electricity Transmission Company (TEIAS) in Turkey, the changing estimation for energy demand is given in Fig. 1 [5].

In forecasts made as end of 2008 year, the demand meeting period of the established power in construction and production having a license was calculated as 2011 in the first scenario and as 2014 in the second scenario. The existing established power will only reach to critical point in meeting the demand at the end of 2009 according to the first scenario and 2010 according to the second scenario [5]. These figures indicate how important the energy investments in Turkey and productive use of the existing energy. In this study, the output losses that occur in the electric network of Turkey and economical value of such losses are emphasized and energy parameters of Turkey are compared.

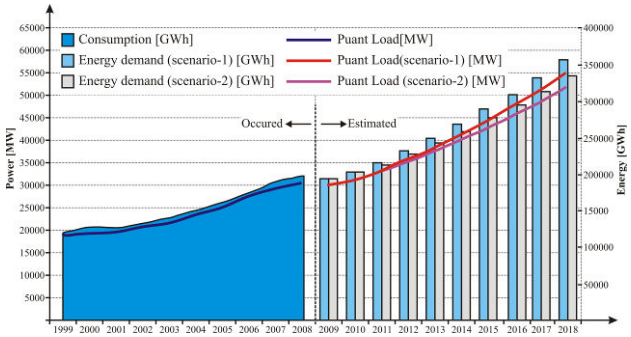

Fig. 1 Puant load and energy demand of Turkey between 1999 – 2018 years.

2 Output Losses in Power Systems

Some part of the energy produced in electric power systems does not reach to consumers who make payment because of output loss and administrative applications. The energy loss can be considered in two categories as technical losses and nontechnical losses. Total of these losses is a significant parameter that affects capacity of the system. According to the result of an investigation made for 102 countries in 2000, the share of these losses in total production change 4-10% in 34 countries, 11-15% in 25 countries, 16-20% in 15 countries, 21-53% in 28 countries [6]. Often, to pinpoint of these losses is not possible. However, using the new techniques in power system analysis,

calculated rates are increased continuously [7]. These losses above 16% indicate that there exists a comprehensive electric theft in the country. The rate above 40% is a very significant economical and social problem resource for the countries [6]. Technical losses in power systems generally result from the reasons given below.

2.1 Intra-System Use

The electric power systems consume some electric energy to produce and distribute electricity. The power consumed for needs of the production and distribution centers such as illumination, maintenance etc is called as intra-need power and it is not a power measured or sold in economical respect. For this reason, mostly it is not included in the above stated rates. The intra-need power varies between 2% and 6% of the produced energy.

2.2 Technical Transmission and Distribution Losses

The electric energy incurs losses while passing from the transmission lines and transformers during transmission and distribution. The systems having long transmission lines incur more transmission and distribution losses than the systems with short line. Besides, the quality of lines and transformers may affect the output of transmission and distribution. The technical T&D losses may be decreased by baking important investments on maintenance in power systems and by using high technology materials in distribution systems. This value is measured and generally, its economical dimension can be calculated.

2.3 Energy Distributed Free of Charge

It is the electric energy used for distribution free of charge. Though it varies between the countries, the power systems supply energy free of charge to private persons and establishments. For instance, electric energy used in places such as prime ministry and presidency residences, parliamentary lodging buildings, royal palaces, parliament buildings may be supplied free of charge. For this reason, as the occurring energy losses are legal, they are included in the technical losses [6].

2.4 Non-Technical Losses

An electric power system can never be 100% confident against to theft. The theft rate in developed countries is in low rate (1-2%) in proportion to produced total electric energy. However, the financial loss reaches to very high values as the distributed energy amount is much. In literature, various examinations are carried out especially on countries that have high loss rates and suggestions are made. For instance, in India, the cost of lost energy reached to a very serious figure $(4.5 billion\$)$ according to the data in 2004. This value equals to 1.5% of the gross national product (GNP) value [8]. It was determined with a study made in 2009 that Jamaica had the similar features. In this study, it is introduced that the electricity theft cost that was equal to 0.4% of GNP in 1996 increased to 1.4% at the end of 2008 [9]. In the study made for the South Africa, the nontechnical energy loss for 2007 year was calculated as $6100 GWh$. This value increases the energy demand in rate of $3600 MW/year$ and this value equals to production of a power station with about 6 units. 27% of total energy production is not billed [10].

In 2006, a very detailed study was realized for Texas State of USA and it was calculated that the electricity theft cost for houses in the state was about $10.6 million\$/year$ and about $186 million\$/year$ for the whole country [11]. Financial losses reached to critical points for electric distributions companies in some countries. This may result with income losses and decrease in profit rate, necessity of increase in capacity of power system and in production capacity to handle the power losses and restriction in necessary investments to be made for improving of infrastructures. One of the largest pitfalls for any distribution network is the level of energy losses suffered by the system. Distribution losses depend largely on the physical properties of the network, such as conductivity and resistance of the cables, the number of voltage transformations made and the size of the network. The second, and sometimes more significant, form of losses comes under the heading of non-technical losses (i.e. theft and fraud). There are four theft events commonly seen in power systems. Extension of theft depends on many factors from cultural factors to management of the power distribution system [12].

2.4.1 Fraudulence (Forgery)

Electric utilities lose large amounts of money each year due to fraud by electricity consumers. Electricity fraud can be defined as a dishonest or illegal use of electricity equipment or service with

the intention to avoid billing charge. It is difficult to distinguish between honest and fraudulent customers. Realistically, electric utilities will never be able to eliminate fraud. It is possible, however, to take measures to detect, prevent and reduce fraud [13]

With fraudulence event, the consumer tries to cheat intentionally the institution or organization that supplies electricity. The general application is to adjust the electric meter in a manner enabling it to indicate the energy lesser than the used amount. This may be a risky method for an amateur. Many death cases have been reported because of electric shock during this operation. However, in some cases, professional electricians make this operation against a fee. This has been mostly applied by individual consumers. However, very big industrial establishments make fraudulence attempts though it is rarely [6].

2.4.2 Illegal Electricity Use (Electricity Theft)

Electric theft is made by installing a line from the power source to necessary point for purpose of by-passing the electric meter. Determination of illegal lines is easy as they are installed above the ground and highly visible. However, the personnel who discover and report it may have anxiety to be attacked. Besides, the personnel in electricity institutions may be given a bribe for continuance of the application. In a wider scale, companies may give a bribe to the power administration personnel to install a direct line to their own buildings or offices and in order the consumed energy not to pass their electric meter. The bribe amount may be lesser than the power cost. Besides, money can be given to auditors in order not to write a theft report or ignore it.

2.4.3 Billing irregularities

Invoicing irregularities may result from various sources. Some power system establishments may not be effective in measuring of the used electric energy amount and determine lower or higher usage fee unintentionally. These unintentional irregularities may always occur. However, in some systems, it may be very easy to arrange bills with lesser values than their real values. Employees may be given a bribe to record the value lower than the value indicated by the electric meter. The consumer pays lesser fee and the official who reads the electric meter takes an unofficial fee. The other kind of invoicing irregularities is that official rolls the point in fee to the left. For instance, a bill in amount of $372.60\$$ is paid as $37.26\$$. The consumer who makes the payment may not know it. Officials can easily earn money by means of such application and it is not easy to determine it. In some places, such applications may be institutionalized and officials may consider the illegal payments as part of their job [6].

2.4.4 Unpaid bills

Some persons or organizations do not pay their electricity debts. The individual or commercial customers may move from the city or an entrepreneur may bankrupt. Some systems have permanent nonpaying customers. Such persons who are politically very powerful and rich know that their electricity will never cut regardless of they pay or not. Some persons consider that electric energy is a service that must be supplied by governments free of charge. Politic governments may try to get vote by not cracking down on that situation. Not to pay bills is not defined as a theft by some persons. However, when persons or institutions think that they will be rid of bills by not making any payment, unpaid bills must be classified as a theft.

Not to pay bills is a problem not punished with imprisonment especially in poor countries. In all countries, some persons may experience problems in paying their bills regularly because of increases in electric prices. This situation may direct people towards adjusting their electric meters to decrease their bill amounts. In more traditional definition of the electric theft, it may not include unpaid bills. However, this is an extension of the problem for some countries and its effects create very serious problems. The unpaid bill data cannot be obtained easily [6].

3 General Structure of Turkey Electric T&D System

Turkey is a country with population of $71.5 million$ and 100% electrification as year of 2008 and it is a developed country with this regard. Though increase in population slows down in recent years, it still continues. There exist facilities that have $41.81 GW$ electric production capacity. Annual energy demand is about $198 TWh$. Though the sections that produce the electric most are the west and North West regions, facilities with significant production capacity locate in the East and South East regions. This means using of very long energy transmission lines. The total length of energy

transmission lines is $46283km$; $14338km$ is in voltage of $380kV$, $84.6km$ in voltage of $220kV$, $31383km$ in voltage of $154kV$ and $477km$ in voltage of $66kV$. The installed transformer powers in these voltages are $66.35GW$. The length of medium voltage $(33kV)$ and low voltage $(0.4kV)$ lines is $81500km$. The transformer power in these voltages is given as $81GW$ [14]. In Fig. 2, population increases of the country and consumed and supplied energy amounts are given graphically. The difference between the supplied energy and net consumption includes T&D losses [15].

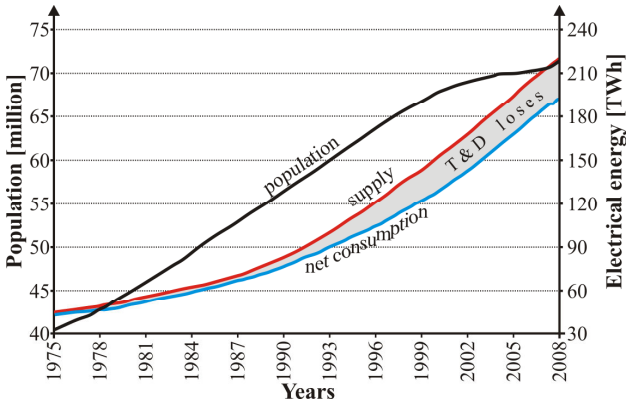

Fig. 2 Changing of population and supply and net consumption of electrical energy by years.

Turkey has five important primary energy sources such as petrol, natural gas, coal, hydroelectric and renewable energy sources. There are several other primary energy sources such as fossil roots reserves (pit coal, lignite bitumen, crude oil, natural gas, uranium and thorium) and endless sources potential (hydraulic energy, geothermal energy and solar power). However, coal, geothermal and hydraulic energy reserve and potential is only 1% of the world sources [16].

The analysis of the last 15 years period indicates that the increases and the decreases in the annual electrical consumption and gross national product (GNP) are in parallel and there exits a close relation between economic growth and electrical energy consumption.

As the country is foreign-dependent in great extent in terms of natural gas and petroleum, the share of domestic resources in total electric production was %40 for 2008 year. As a result of the wrong energy policies, Turkey became a country that imported electric energy indirectly. Because of the unstable economical structure of the country and the production policy depended on fossil fuels of which prices continuously change according to the market conditions, continuous fluctuations occur in the electric energy prices. Nevertheless, electricity prices in Turkey in recent years have reached a level close to the OECD average. In 2008, the average electricity sales price for residental and industrial usage has been as $0.165\$/kWh$ and $0.139\$/kWh$ respectively [15]. In Fig. 3 the retail prices of electricity of some OECD countries, are seen by the year of 2008. As shown in this graphics, Turkey can not compete with many European countries on this issue.

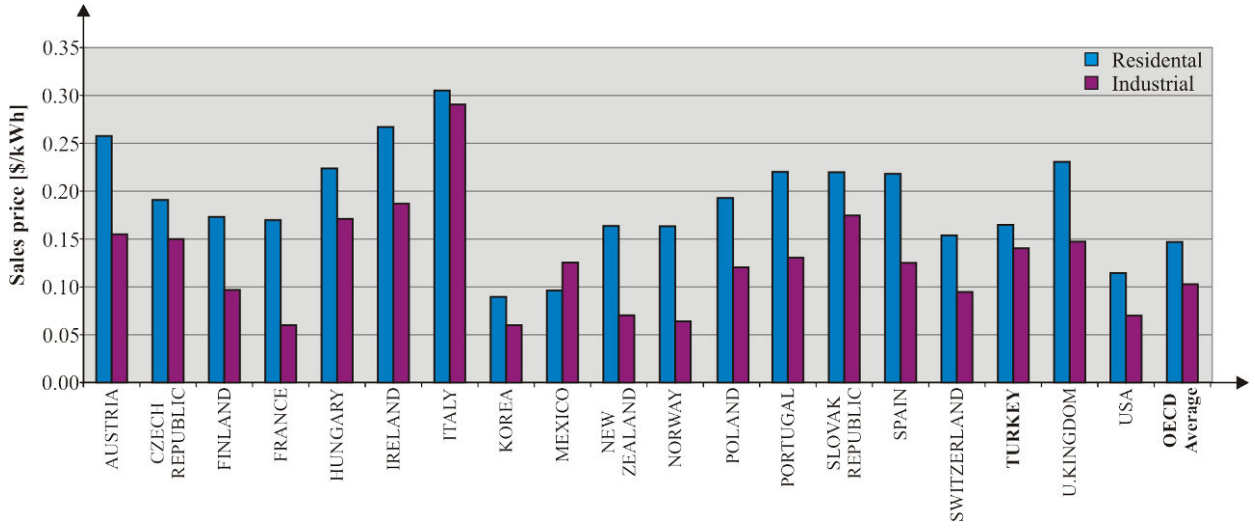

Fig. 3 Unit electrical energy prices of some countries [15].

The global financial crisis started to show its effects in the middle of 2007 and into 2008. Around the world stock markets started to fall. Large financial institutions collapsed or were bought out. Therefore, the governments even of the wealthiest nations had to come up with rescue packages to bail

out their financial systems. In Europe, a number of major financial institutions failed or needed rescuing. Most economic regions have been facing recession since then. This includes the US, the Eurozone, and many others [17]. In 2009, the data are not published yet therefore, They were not taken into account in this study. Because of impact of global economic crisis, especially with some increases has been in energy prices in this year.

4 Illegal Electricity Use in Turkey

According to the definition made by Turkish Electricity Distribution Corporation (TEDAS);

- To make changes and adjustments on the measurement system, electric meter, relay, measurement circuits, voltage and current transformers, cables, circuit breaker and square conduit box that are placed on electric network and subscriber lines, their extensions, main column and these lines without information and consent of the organization or company to enable them to give lesser consumption values and to change their places,
- To make or have others to make connections to these facilities and to make or have others to make connections without waiting the connection process that must be carried out by the organization or company after the contract is signed,
- To change the setting of measurement system by interfering the sealed electric meter circuit after being subscriber, to remove bridging (dropping the hook), prevent rotation of the disc, connect the electric meter in reverse position and delete the index, detach seals on the electric meter cover and seals of sections that belong to measurement circuits are considered as illegal electric use [14].

The transmission and distribution losses of Turkey according to the data published by TEIAS [15] are given in Fig. 4. The loss rate that increased to value of 19.1% between years of 1998-2000 realized as 14.4% at the end of 2008. This rate is well above the world average that was 8.9%. As seen in Fig. 4, transmission losses generally move horizontally. As the distribution losses cover the electricity theft, they have a more variable appearance. In Fig. 5, a comparative chart of T&D loses rates of Turkey, OECD countries and average values is shown.

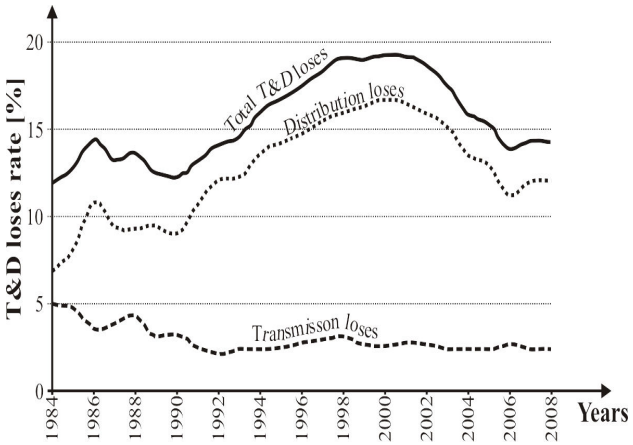

Fig. 4 Changing of T&D loses of Turkey by years

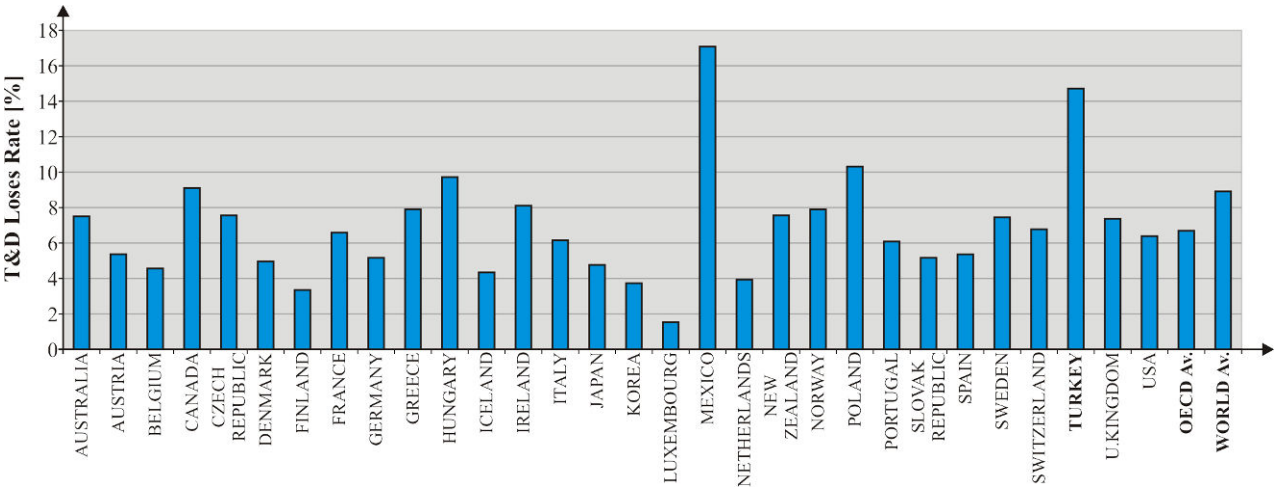

Fig. 5 Transmission and distribution lose rates of some countries in 2008.

In Fig. 6-a, the dispersion graphics in cities of Turkey in terms of lost illegal use rates and energy amounts are given. When the lost illegal use rates are considered, the alignment is rather variable (Fig. 6-b).

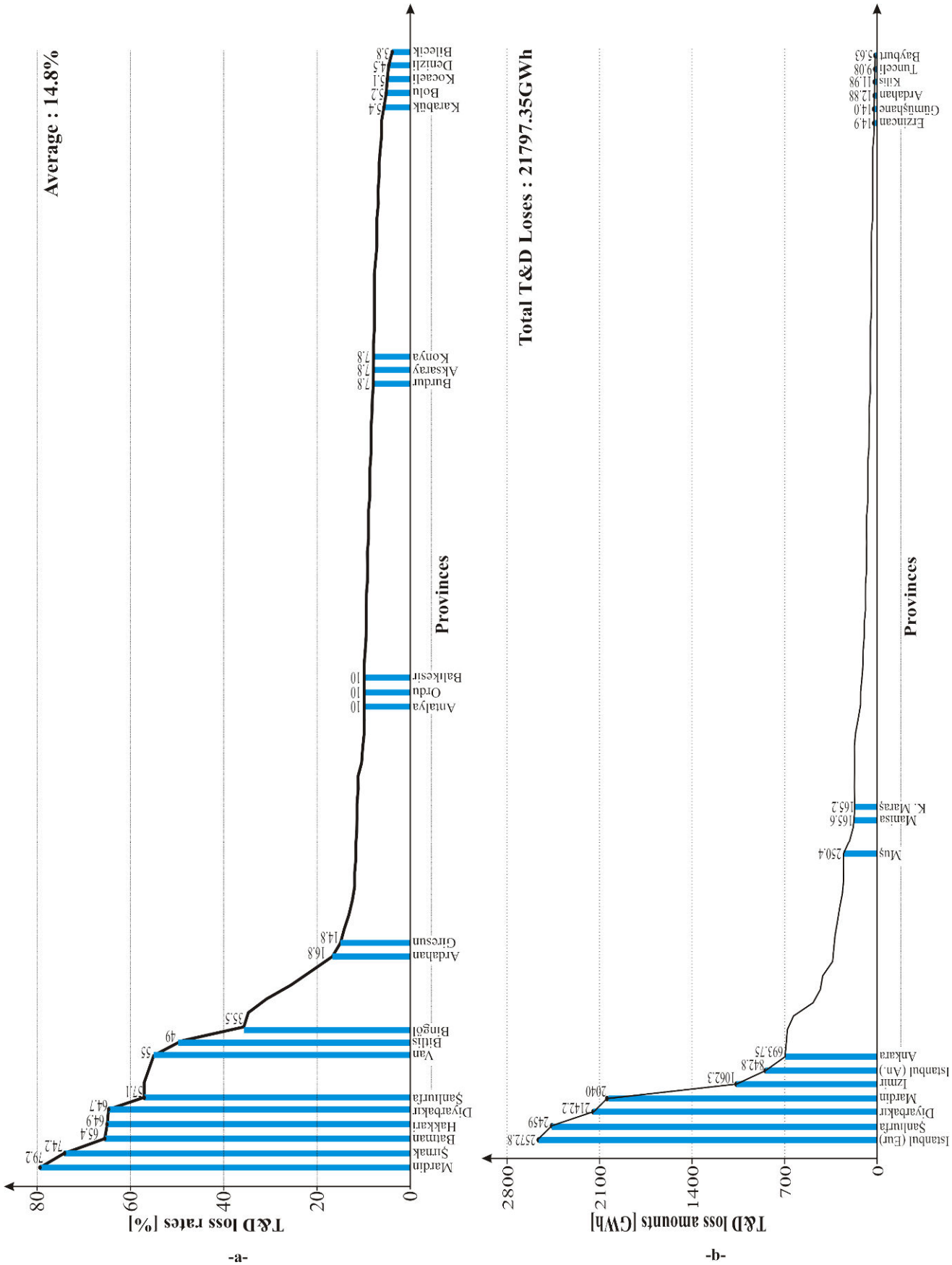

Fig. 6 a-) Loss and illegal consumption rates [%], b-) Loss and illegal consumption amounts [GWh] of Turkey by provinces [14].

The most important reason of it is the population and development differences between the regions. For instance, Istanbul European Side that is in the 20th row in terms of lost rate (12.5%) is in the 1st row in terms of amount. Similar variations are also valid for regions that have the least lost rate. For this reason, lost illegal use rates are not a correct data source for electricity theft.

About 5.4 million subscribers were controlled in 2007 by authorized teams to determine the illegal consumption. It was determined that 189367 subscribers made electricity theft and $217.5 million TL$ $(186.7 million\$)$ fine was imposed. Within that year, $58.5 million TL$ $(50.1 million\$)$ of that fine was collected. In Fig. 7 arranged and collected bills are given. (As end of 2007 year, $1\$ = 1.1666 TL$) [14].

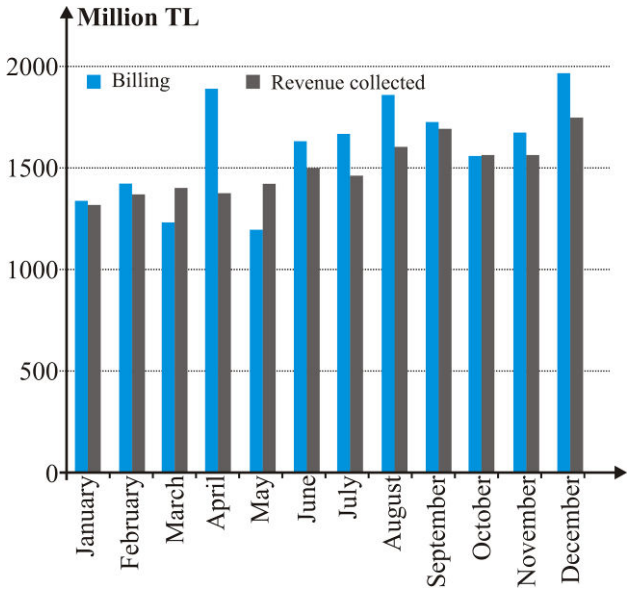

Fig. 7 Arranged and revenue collected bills in 2007.

In 2008, 14.4% of $190.55 TWh$ electric energy given to Turkey interconnected network was used illegally. Total of these losses was determined as $27.48 TWh$. Almost 60% of these losses $(16.64 TWh)$ occurred because of technical reasons and $10.84 TWh$ energy as a result of illegal use. If the energy tariffs [18] applied by EPDK are considered, the amount of total energy used illegally, except value added tax (VAT), is calculated as $3467.97 million TL$ (approximately $2.27 billion\$$!!). The cost that occurs as a result of illegal use is $1368 million TL$ $(895.3 million\$)$ (As end of 2008 year, $1\$ = 1.528 TL$). The total of energy transmission and distribution system investments made in Turkey in 2007 was about $523 million\$$. The cost resulting from illegal use is 1.7 times of that investment.

4.1 Negative Impacts of Illegal Electricity Usage

The electricity theft can be predicted but not be measured definitely. The standard method in measurement of the electricity theft is to make measurement by analyzing the transmission and distribution losses. The method reveals the difference between the produced electric energy (except ones used in the system and distributed free of charge) and the sold energy. If the technical line losses are calculated correctly, it may be set forth that losses except them are the theft amount [6]. In determination of illegal use, in parallel to technical developments, new opportunities such as remote accessed electric meters by means of internet network, digital electric meters and mobile electric meter teams are being used [19]. The economical and social effects of the electricity theft can be summarized as follows;

- The illegal electric use contains practical applications generally result with death danger.
- During illegal electric use, security of life and property is endangered. Besides, risks may occur on the energy system that reaches to consumers who make normal use.
- The illegal electric use increases cost on energy production and causes increase in consumed energy prices. It makes difficult the distribution of high quality, uninterrupted and cheap electricity to subscribers.
- It requires additional repair-maintenance investment [14, 20]

5 Conclusions

The technical and nontechnical losses in the electricity system reach to significant values in social-economical terms. Turkey made great attempts in struggling with illegal use. However, though illegal use decreases proportionally, it continuously increases as an amount and economical value. Decrease in technical losses can be achieved through changing of equipment in the transmission and distribution system or making the maintenance-repair work regularly. Suggestions to achieve decrease in illegal use are made below;

- To speed up privatization policies, ensure necessary information flowing about the benefits of privatization and introducing of them to the public by means of civil society organizations are necessary.
- Regional price policy may be applied. However, this application may bring a short-term solution. The main weight must be given on completion of the privatization process.
- The awareness of the public must be raised about economical dimension of the illegal electric use.
- Social damages of the illegal electric use must be communicated.
- The reality of illegal electric use does not comply with the religious and moral values must be effectively communicated.
- The works that may be carried out without need of electric energy must be determined and the public must be encouraged to use other means by being informed and supported economically. (For instance, use of solar energy in water heating, isolation techniques in heating and use of natural gas and other resources if any)
- The government officials who determine the illegal use may be awarded and various incentives may be given to officials who denounce such use.

Systems that enable remote monitoring of electric meters may be developed on condition that a technical infrastructure will be prepared and legal regulations are made.

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