COST BASED DISTRIBUTION TARIFFS

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ABSTRACT

COST BASED DISTRIBUTION TARIFFS

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Electrical power systems consist of generation, transmission and distribution systems. These three systems have different economical and financial characteristics such as natural monopolies and competitive markets with divergent cost structures based on diverse investment and operation expenditures.

The aggregation of all these disbursements from generation, transmission and distribution systems forms the overall electricity cost. Revealed cost, which is a result of different market characteristics of different systems, is mainly reflected to customer tariffs, for sustainable and continuous operation.

These costs may vary depending on the demographic, geographical and social characteristics of the regions. The length and characteristics of distribution overhead line, for example, may be a factor that increases investment cost, generally is longer in geographically large areas compared to smaller ones with the same electricity consumption. In this study, the factors that constitute the customer tariffs and the calculation methods of these factors are examined. In addition, the tariff components and values for Turkey are explained since first implementation period, which began in 2006.

Furthermore, operation, investment and power loss including illicit utilization costs of distribution companies are decomposed and analyzed based on electricity distribution regions in Turkey. Regional tariff models are evaluated and compared with the national tariff values. Besides, the factors affecting the change of the operation and investment expenditures of the distribution system are determined by regression analysis.

Keywords: Regional Tariff, Cost Based Tariff, National Tariff, Distribution Electricity Tariff, Loss-Illicit Utilization Cost

ÖZ

MALİYET ESASLI BÖLGESEL ELEKTRİK DAĞITIM TARİFESİ

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Elektrik güç sistemleri elektriğin üretimi, iletimi ve dağıtımı olarak üç ana kısma ayrılmaktadır. Bu sistemler, doğal tekeller ve farklı yatırım ve işletme harcamalarına dayanan değişken maliyet yapıları ile rekabetçi pazarlar gibi farklı ekonomik ve finansal özelliklere sahiptir. Faaliyetlerin sürdürülebilirliği ve operasyonun devamlılığı için son kullanıcı tarifelerinin, elektriğin üretiminden başlayarak son kullanıcıya ulaştırılana kadarki tüm süreçlerde ortaya çıkan maliyetleri yansıtacak şekilde kurgulanması gerekmektedir.

Söz konusu maliyetler, bölgelerin demografik, coğrafi ve sosyal özelliklerine göre değişebilmektedir. Örneğin, coğrafi olarak geniş alanlara konumlanmış, dağınık yerleşimli bölgelerde, aynı elektrik tüketimine sahip dikey yapılaşmış bölgelere kıyasla elektrik dağıtım hat uzunlukları daha uzun olmaktadır. Bu tip durumlar yatırım maliyetlerini artırıcı faktörler olabilmektedir. Bu çalışmada, son kullanıcı tarifelerini oluşturan etkenler ve bu etkenlerin hesaplanma yöntemleri incelenmiştir. Ayrıca tarife bileşenlerinin, 2006 yılında başlayan ilk uygulama döneminden itibaren, Türkiye'deki uygulamaları anlatılmıştır.

Bunlara ek olarak, Türkiye'deki elektrik dağıtım şebekesinin işletme, yatırım ve kayıp kaçak maliyetleri dağıtım bölgeleri bazında ayrıştırılmıştır. Maliyet bazlı bölgesel tarife modelleri analiz edilerek ulusal tarife değerleri ile karşılaştırılmıştır. Ayrıca dağıtım şebekesinin işletme ve yatırım gidelerinin bölgesel bazda değişimini etkileyen faktörler yapılan regresyon analizleri ile belirlenmiştir.

Anahtar Kelimeler: Bölgesel Tarife, Maliyet Bazlı Tarife, Ulusal Tarife, Dağıtım Tarifesi, Kayıp-Kaçak Maliyeti

To My Beloved Family,

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CHAPTER 1

INTRODUCTION

1.1 Motivation

Despite the fact that electricity is characterized in a free market as a product, which is negotiated and traded by participants in a competitive environment, electrical infrastructure can be assumed as public service since it can be defined as an integrated system containing physical components to enable, sustain, or enhance social living conditions [1]. Thus, imposing customers to high prices would cause problems inevitably, however, market structure design must also take into account electricity producers and other participants interests and cover their costs to provide reliable and continuous electricity. Due to all these driving factors, electricity tariffs are used all around the world with different approaches and structures.

The way of reflecting the cost in the customer tariffs is an important issue for structuring electricity tariffs. This fundamental difference constitutes the national tariffs or cost-based regional tariffs. In Turkey, after the transition period, implementation of cost-based tariff design was stipulated, however, in second tariff implementation period, years between 2011 and 2015, transition on the cost-based tariff structure could not been achieved. The tariff model, which was stipulated to be implemented by the end of the year 2015, has again been postponed to end of the year 2020, which is also end of the third tariff implementation period.

Postpone includes both the application price balancing method and the national tariff model and related cross-subsidies. Possibly, imbalance between revenues and foreseen distributed energy volumes in 21 regions will continue to derive the need for the national tariff.

Implementation of the cost based regional tariffs may result in revenue imbalances, since the distribution company revenues will may vary based on different factors such as total rural and electricity consumptions, consumption density etc. The aim of the study is to analyze cost-based regional tariff methodology impacts and to discuss the applicability.

1.2 Scope and Contribution of the Thesis

The focus of this study is to evaluate instruments affecting electricity tariffs, to analyze cost based regional tariff in terms of operational, investment and power loss of designated distribution regions and to compare the national tariff methodology, which is currently applied in Turkey.

Another attention of this study is to determine the factors both technical and non-technical, affecting the investment and operational costs of distribution companies. With respect to the results of analysis, the applicability of the regional tariff is discussed.

1.3 Thesis Outline

The information about the general background of electricity tariff is explained in Chapter 2. Electricity markets overview, instrument affecting electricity tariffs, concept of national and regional tariffs is discussed at the first, second and third parts of this chapter, while the literature review of distribution tariff methodologies is presented in the fourth section of the chapter.

Chapter 3 focuses on the electricity tariff structure in Turkey. Historical background of electricity market and application of the tariff components are explained in terms of transmission, distribution, losses, retail services and tax costs for each implementation periods. The methodology, assumptions, tariff models and presentation of the calculated results are addressed in detail in Chapter 4. Moreover, calculated results of different cost based regional tariff models for each distribution region and national tariff models are given.

Furthermore, factors affecting investment and operational costs of distribution companies are tried to be determined in the sub-scenarios in this chapter.

Chapter 5 concludes the study by evaluating the results from the perspective of distribution companies, customers and relevant stakeholders.

CHAPTER 2

BACKGROUND AND LITERATURE REVIEW

2.1 Electricity Market and Tariffs Overview

Electricity demand has been increasing rapidly worldwide and will continue to increase due to economic and social growth. The increment between years can be evaluated as a consequence of vertical rise by developing life standards and horizontal rise by new habitats. Hence, the importance of providing electricity in a reliable, secure, adequate and continuous way has gained great significance globally.

Electricity liberalization need arose out due to necessity of performing electricity services with the minimum cost and the maximum effectiveness with price transparency to the customers. The transition for the definition of electricity from the concept of the public service to commodity, has led to a situation that, which the product is to be traded in large quantities with low price and profit in a wide competitive environment, that can be interpreted as the one of the main reasons, which has initiated market liberalization.

According to Turkish Constitutional Law,

- Public service is defined as regular and continuous activities performed either by the government authorities or under the control of these authorities in order to meet the general and collective needs of the society within the direction of the public interests and benefits.
- Public services can only be conducted by government institutions, or private entities assigned by government for a certain period of time, such as 20 or 25 years.

Another driving force behind deregulation is the financial difficulties encountered in the operational activities and investments. Requirements for higher performance in the technical and commercial activities of the distribution sector, creates a necessity to manage the system more effectively and more efficiently. Growing need for investment and installation of new technologies require a large amount of financial resource. The global trend of reform in electricity market where electrical commodities are traded by participants in a competitive environment, forces the system to be more transparent in terms of electricity price, losses and taxes.

Electricity market activities are vertically and horizontally unbundled in a fully deregulated market, where generation, transmission, distribution and wholesale-retail trading activities are unbundled from each other, which contrary to the electrical authority structure, where all electrical activities for generation, transmission and distribution are conducted in a single company. The following figures illustrates different structures of the electricity market.

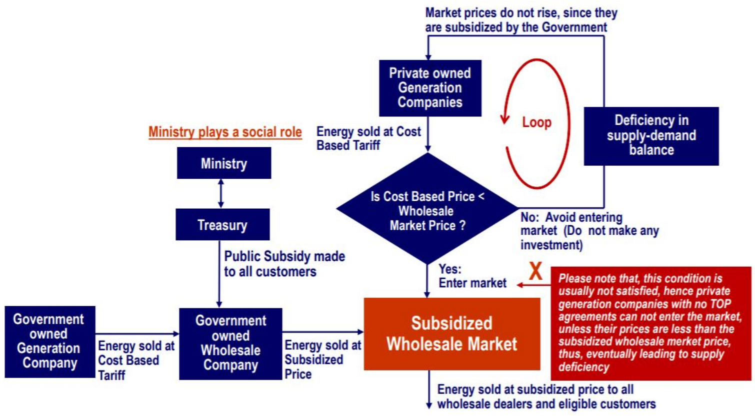

Figure 2.1: Fully - Subsidized Wholesale Electricity Market

In addition, establishing an independent regulatory authority body is essential to bring balance into market not only for customers but also for all participants such as suppliers, retail and wholesale companies in deregulated market. The regulatory authority model, developed by independent regulatory authority, should take into account all dynamics to protect the consumers from the extreme increases in prices, take precautions to prevent participant from exploiting the system and not connive at unfair earnings.

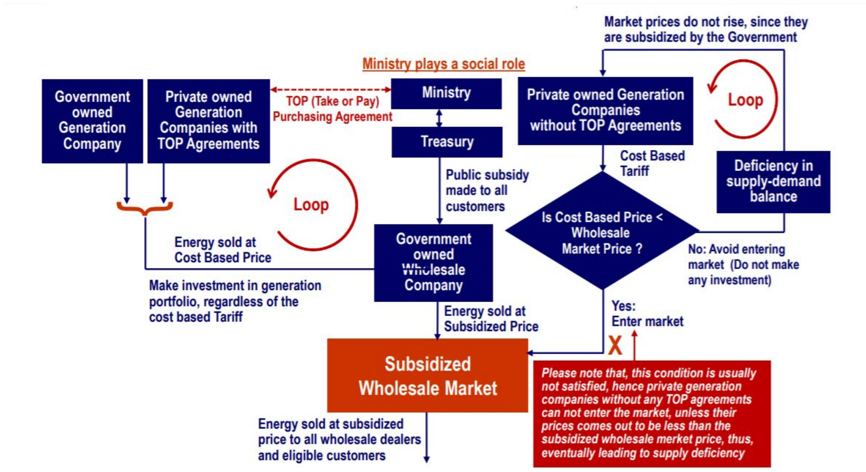

Figure 2.2: Wholesale Electricity Market with TOP (Take or Pay) Agreements

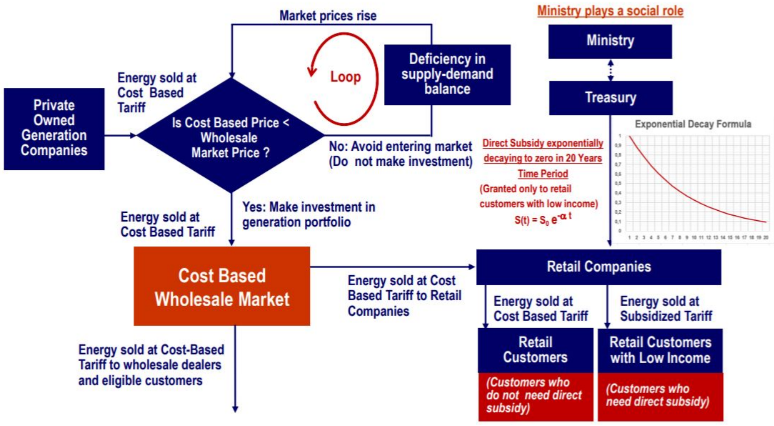

Figure 2.3: Competitive Wholesale Electricity Market

The regulatory authority should be fully independent both from the political influences of the government organizations and the power of private entities. "Tariff" and "Price" are two different terms frequently confused. Tariff is the regulation of price and/or revenue within the direction of protecting of the interests of the customers, employees, sector participants and third parties' rights and benefits. On the other hand, price is the essential term, which has to be paid to use a product or to get service. Also, it can be defined as a value corresponding to a certain amount of a commodity or service. Briefly, price, which is a fundamental term in transactions that can be interpreted as a component of a tariff.

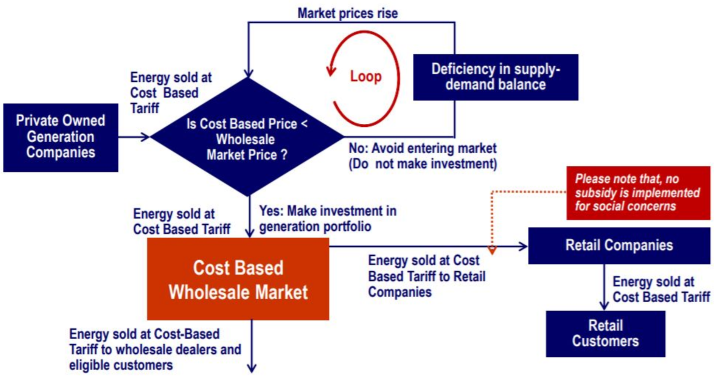

Figure 2.4: Fully Competitive Wholesale Electricity Market

Tariff is a formula for the price in order to satisfy different requirements of shareholders. Since shareholders have conflicting interests and benefits according to their status in the sector, determination of the tariff is a complex procedure. For instance, electricity producers aim to maximize their profits, which are reflected to the electricity price, while the consumers on the other hand, aim to purchase electricity at minimum price. Therefore, one of the most important issues in the tariff design is to balance interest of the counterparts regarding technical, economic, social and environmental aspects, and to resolve these conflicts.

Application of tariff design is of great importance to shareholders in the sector to carry on trading activities from all participants' aspects. In this way, tariffs prevent unfair competition and extreme pricing by making the system well balanced. That is the reason why tariffs are employed in many sectors, especially it is a vital need for deregulated electricity markets. Unbundling of the system, which is the first priority of deregulation, enables the diversification of distribution and transmission tariffs.

Since it is conflicting issue among the interests of the market participants, regulatory authority is authorized to design the electricity tariffs. In Turkey, EMRA is the only authorized entity to design the tariffs in electricity, natural gas, petroleum and liquefied petroleum gas (LPG) markets.

Different methods may be used in regulations electricity prices. In general, for distribution companies these methods include;

- Rate of return
- Cost of service
- Price cap
- Revenue cap
- Sliding scale
- Partial overall cost adjustment
- Yard stick competition approach

These methods are explained in the following sections in detail.

2.2 Instruments Affecting Electricity Tariff

Customer electricity tariff consists of four fundamental components;

- Energy price
- Transmission service charge
- Distribution service charge
- Retail service charge

2.2.1 Energy Price

Energy price obviously depends on generation cost, which depends on the market structure and price mechanism of the fuel used to generate energy. In general, capital cost for power plants, fuel costs, operational and maintenance activities costs are directly included to generation cost. In other words, generation cost covers the total cost to infrastructure, finance, maintenance, and operation costs for power plants.

Generation cost can be divided into three groups; Fixed Cost, Variable Cost and Quasi Fixed cost, which goes into building tariff as paid by customers [2]. In energy production, some factors are fixed.

The cost related to these factors doesn't change with amount of produced energy, therefore the cost associated with regular payments for the plant, regardless of the amount of generation, is defined as fixed cost. For instance, if a company has purchased a land to build a power plant, the amount of produced energy by the plant does not have an effect on the costs of the land and the plant.

On the other hand, the cost associated with the quantity of energy generated are expressed as variable cost. Fuel cost is an example of variable cost. It is obvious that, the more plant generates electricity, the more fuel consumed [2].

The last class of costs is called as quasi fixed cost. These costs occur when the plant starts generating electricity. One of the best concepts explaining quasi cost is the example of startup fuel. It is necessary to consume some fuel to start up the plant. The required fuel cost is fixed, which does not change with the amount of energy to be generated. For a plant standing as idle, the startup cost is zero [2].

In general, all these different kinds of generation cost are reflected both national and regional based tariffs. Therefore, the aim with protecting customers from extreme rises in prices, the relatively cheaper plants are first committed with their maximum capacity to the network, the system operator dispatches the more expensive plants for the rest of the energy to reduce generation cost [3].

2.2.2 Transmission Cost

The systems, which transmits electrical power from the generating point to the substations by overhead lines is called transmission system. Since technical losses are inversely proportional to the square of voltage, high voltages are preferred in long distances in order to reduce the power losses.

Investments for the installation of high voltage transmission lines and substations to transmit electricity in order to meet the increasing demand, repair and maintenance activities on the existing system are all terms included in the transmission cost. Therefore, transmission cost includes all the charges, associated with all kinds transmission system operational and planning activities to provide reliable and secure electricity to consumers.

In other words, transmission cost comprises the total cost to infrastructure of investments, finance, maintain and operate for transmission systems.

2.2.3 Distribution Cost

The systems, which enables to transfer electrical power from the secondary side transformers at the high voltage substations to the consumers by medium/low voltage overhead lines and underground cables is called distribution system. Medium and low voltage levels are used to distribute electricity to customers.

Although the transmission company is a single authority that forms a monopoly covering the overall country, distribution companies are authorities that forms monopolies in their own regions, each covering a certain region, consisting of few cities. The operation principles of the transmission and distribution companies are somehow alike, the main objective that the electricity is brought from the source to the demand points.

Since each region has different geographical and social characteristics, distribution system costs vary significantly by regions. For instance, a distribution company conducting distribution activities in a rural region, where customers spread over a wide geographical area, distribution cost increases, as more investments needed, due to long distances.

In other words, it would be more efficient and less expensive to distribute electricity in urban areas, since the distances are relatively shorter. Regulatory Authority determines the distribution tariffs for the rural and urban regions by noting these facts. Distribution cost is reflected to tariffs by the Regulatory Authority.

2.2.4 Costs Associate with Power Loss

Costs associate with power loss is examined into two groups; technical and nontechnical losses. Technical loss occurs in the distribution system, due to heating effect, i.e. the loss due to the square of the current (I) multiplied by resistance (R) formula, hence it is unavoidable, unless the nominal voltage is risen to a higher level.

This loss must be supplied by some generation companies in terms of agreements made between the transmission company and those generation companies. In terms of these agreements, a certain payment is made to these companies, by the transmission company. Hence, the tariff structure must be designed to take into account the cost of technical losses, which is eventually paid by the customers through these tariffs.

Technical losses may be divided into two different types; variable losses and fixed losses. These losses are proportional to the resistance (R) and to the square of the current (I) in related branch. The equation also can be written as function of apparent power (S), real power (P) and reactive power (Q).

Variable losses have a quadratic dependence on the power flows, therefore variable losses are more important than fixed losses during periods of peak load. Lost energy in the transmission system is between 1% and 3% of the energy produced and in the distribution system the range becomes between 4% and 9% averaged over a year in western countries [2].

Fixed losses are caused by hysteresis, eddy current losses in the iron core of the transformers and corona effect on transmission lines [2].

Non-technical losses on the other hand, can be evaluated as third kind of losses, which is caused by the illicit action of some customers action of some customers consuming electricity without any charge. Since some groups or people use electricity without following regulation or obligation, the extra cost consisting of non-technical loss shows up, which is also taken into account on the pricing of the loss terms. Reflecting these extra costs to not only related region, but also to whole country is one of the most important determining factors of the national tariff structure.

Non-technical loss in transmission and distribution system is caused by the illicit utilization, by tampering the meters and metering circuits, in order to reduce the measurement. Thus, preventing the meter from measuring the actual value, causing reduction in measurement without paying any charge.

In general, there are three restrictions to be noted on loss pricing;

- Consumers must not be directly charged for losses.

- Loss collections must exactly be equal loss costs, neither more, nor less.
- Loss charges must be calculated in terms of electrical energy, not in currency [4].

2.2.5 Retail Service Cost

In general, retailing electricity is the final step of providing electricity to customers. To retail electricity includes sale activities to purchase electricity produced either in a free market, where electricity is negotiated and traded by participants in a competitive environment, and in a regulated market where electricity can be seen a public service rather than a commodity.

Despite the fact that the border for the responsibility area for retail service is not exactly drawn in many countries, expenditures associated with the retail services, such as billing and metering are included in the retail service cost, which is directly reflected to the electricity tariff as paid by customers.

In Turkey, in compliance with the Electricity Market Law No:6446, all meters in distribution network are under the ownership and control of the distribution companies, thus, all operations related to meters, including the meter reading is not included in retail service cost, but in distribution cost.

2.2.6 Taxes

“A tax is a financial charge or levy imposed upon a customer by a state to fund various public expenditures.” [5].

As can be comprehended from the definition, electricity tax is an instrument that assists to finance different public expenditures, which might or might not be associated with energy. According to Law No. 6446, taxing for financing those expenditures, mostly for social considerations, not directly associated to energy is regarded to be illicit. Electricity taxation method may be driven within directions of electricity road map such as "Global Energy Transformation A Roadmap to 2050" prepared by International Renewable Energy Agency or specifically country targets.

In general, electricity tax can be levied on either the total amount of energy consumed and final price.

There are different approaches to levy taxes from different entities or industries regarding technical, social and environmental aspects. For example, in some countries in order to promote the generation of electricity from renewable sources, the consumption from these kinds of sources is not imposed to the tax, which can be interpreted as feed-in systems and indirect subsidies [6].

Taxes introduces negative effects on the electricity costs, since they raise the prices. There are precautions, supporting some industries with tax incentives or tax concessions, to minimize the risks affecting adversely the entire country economy from high prices electricity. In Germany, for instance, the manufacturing, agriculture and forestry industries are only required to pay 1.54 cents per kilowatt hours, whereas electricity tax is 2.05 cents per kilowatt hours in 2015 [6].

2.2.7 Feed-In Systems

Feed-in systems are global perspectives for providing incentives to the renewable energy policies. These systems finance the investments for renewable energy as a support mechanism. There are many studies, which indicate that these systems have resulted in successful outcomes in supporting renewable electricity generation in many countries.

The number of EU countries using feed in systems as a support by granting investments or tax incentives has increased from 9 in 2000 to 18 in 2005 and 24 in 2012 [7].

Different instruments may be used to support renewable energies, such as feed in tariff, feed in premium, quota obligations and tax exemptions. The feed in tariff regime assures the investor that the energy produced is to be bought at a fixed price per kWh of electricity and this price is usually guaranteed over a certain time period, which means the investor to renewable energy sources (RES) need not to get involved in the prices variations in the spot market, by offering a price and this price is guaranteed over a certain time period.

On the other hand, under a feed-in premium (FIP) scheme, RES producers are paid a best on top of the market price for electricity on the spot market. Moreover, commonly they receive a feed in support payment apart from their gain from spot market [7].

Regulatory authority stipulates the regulated customers, such as distribution companies, to purchase a certain quota of renewable to energy suppliers, under the quota obligation scheme. An extra cost is not directly imposed to customers with quota obligations, since this quota forces generation companies to be more efficient to exposing them to energy prices. Another instrument to support renewable is tax exemptions, which is intensively used in energy sector. In particular, commonly not only electricity consumers but also all taxpayers financed the tax reduction indirectly [8]. The additional cost arises because of these supporting actions to RES, which directly or indirectly goes into building electricity price as paid by customers.

Since there are different technologies for generating renewable energies, generating costs differ from each other. Therefore, different tariffs and models are used for RES plants. FIT rate is determined by authorized and changes depending on renewable technology for solar, wind or geothermal.

Although supporting generating electricity generation from RES is the target behind feed-in systems, it is not reasonable to meet all costs, since these costs will eventually pass to the customers through the tariff. In such case, customers would be imposed extremely high prices, that may create social reactions. Therefore, drawing the boundaries for caps, limiting the number of plant installations in terms of generation capacity are main considerations in many countries to avoid the rises in prices and control support cost [7]. In general, the additional terms included in the tariff for supporting the renewables are reflected to and financed by the consumers.

2.2.8 Subsidies

“A subsidy is a form of financial aid or support to an economic sector (or institution, business, or individual) generally with the aim of promoting an economic and social policy.” [9].

Direct (cash grants, interest-free loans) and indirect economic intervention (tax breaks, insurance, low-interest loans, depreciation write-offs, rent rebates) can be implemented as subsidies. Cross-subsidization is the use of an undertaking's activities in an area to finance its activity in another area. Thus, the enterprise uses its the market power based on some economic and legal advantages to support an activity in another market.

Cross-subsidies may facilitate some cases of abuse, such as a destructive price and a selective price reduction, but are generally not regarded as the sole abuse of dominant position. The cross-subsidy can be prevented by implementing certain measures such as the separation of accounts in specifically regulated sectors, ensuring full transparency in the financial resources of the dominant undertaking.

Subsidies in electricity can be explained as simply keeping prices and/or costs constant at a certain level in terms of market shareholders. In other words, subsidy is simply granting support to consumers by setting tariffs below the market level or to producers above market level.

Electricity has become an essential service, since even simple activities in daily routines are contingency upon electricity consumption in order to advancing technology; as a consequence, the importance of providing electricity in a reliable, secure, adequate and continuous way to all socioeconomic groups has gained great significance globally.

Thereby, the need for subsidies has appeared on the customer side with the aim of assisting low-income groups to access electricity. Low-income groups can be classified as those people who spend relatively high percentage of their income to electricity consumption.

In general, the main purpose of subsidies on customer side is to support costumers lacking sufficient income by supplying vital amount of electricity. Financing of subsidies come in various forms including explicit subsidies, implicit subsidies, and cross-subsidies.

"Explicit subsidies transfer from the government budget to the producer or consumer that is receiving the subsidy and are transparently reflected in the budget." [10].

For example, If the generation company sees consumers' prices not compatible, i.e. not sufficient in order to cover generation costs, in connection with the government's strategy and the government does not agree to reflect the additional cost to tariffs; then, this difference is transferred to the company as a subsidy by the government.

Subsidies are serious fiscal burdens on the government's side. For instance, in Turkey in compliance with the Electricity Market Law No:6446, it is allowed to subsidize a particular group of customers in certain regions of the country, with social objectives without changing the tariffs. In addition to the amount of the subsidy, principles and procedures also is determined by Minister Council decision in response of proposal of the ministry.

Since they are made for social and political concerns, subsidies are paid from the budget of the Ministry. However, these types of subsidies become not generally sustainable when the government cannot afford to transfer subsidy cost indefinitely, resulting in inefficiencies in the overall system.

Implicit subsidies occur, where "no immediate transfer from the government to the company to cover the shortfall in revenue caused by the presence of the subsidy" [10]. Implicit subsidies are consisting of budgetary transfers not on-budget.

Cross-subsidies scheme results in reduction of the costs for customers in certain regions, while increasing costs in the tariffs imposed to the others [10]. Therefore, surplus can be used to subsidize a particular group, in general, who has relatively lower income owing to group of customers paying more.

Subsidies come in various forms, which are adopted in many countries. To determine a convenient tariff structure might be a simple subsidy, which protects low-income customers. In Pakistan, for example, block tariff structure has been designed for determining the prices with respect to the consumption. In this tariff structure, price is increased significantly with respect to the amount of consumption, i.e. those with higher consumption pays more. Table (2.1) illustrates the block tariff structure range and charges of blocks in Pakistan.

Also, generation side of electricity market is commonly subsidized to support not only generating electricity from RES, but also from other sources.

Table 2.1: Increasing Block Tariff Structure in Pakistan, March 2011

kWh/Month	Tariff (RS/kWh)
< 50	1.87
50-100	4.45
101-300	6.73
301-700	10.65
>700	13.29

Some generation companies have been supported by "capacity payments", for example, with the purpose of ensuring to have sufficient operational reserve. These payments directly subsidize the holding of capacity and commonly producers do not have to make a commitment to assure providing certain amount of energy or a certain price [11]. It may be evaluated as a strategy to manage social perception by constricting electricity prices.

Briefly, subsidies can be viewed as a kind of privilege by treating one particular group of participants or a specified region more favorably than the others. Therefore, the methodology to be followed to subsidize a particular group in an electricity market is a controversial issue. For example, to assist low-income group to use electricity, lower tariffs may be implemented to residential customers, which inevitably cause industrial or commercial customers to be imposed of more expensive tariffs; as a consequence, electricity prices in the whole country might be negatively affected. Besides, subsidies come in various forms, which include leading to waste of resources by inefficient use.

Sometimes there may be cases, where subsidies are designed in line with interests of political goals to manipulate society without consideration of long-term harm. In case of using subsidy as a political instrument, may lead to a situation that not only customers but also whole country might be eventually affected.

In general, politicians always exhibit a tendency for popularity to customers by subsidizing electricity prices for collecting the votes of the customers to win the next election.

However, it should be noted that subsidy made on the electricity prices will ultimately be paid by a large number of customers not benefiting from the subsidy.

In order to minimize the negative effects of subsidies, and to review the effect of the advantages and especially disadvantages of subsidy the resulting cash flow among the segments of the customers must be analyzed. Also, the time period in, which the subsidy is to be implemented is an important parameter to realize the objective expected.

2.3 National and The Cost Based Regional Tariffs

National electricity tariffs are those, which are not bound by states, distribution regions or any other particular considerations. Regional tariffs on the other hand, vary by regions, social considerations, customer types or connection points. In Turkey, a residential customer in Konya and a residential customer in Ordu, for example, are imposed to the same the national tariff, in spite of the fact that there may be different distribution costs because of being in different geographical conditions.

Briefly, in national electricity tariffs model; distribution, transmission and retail service costs are identical everywhere in the country for all customer groups. For example, in Turkey, distribution charge is defined as a payment for each kWh distributed, which is calculated by dividing the total amount of electricity distributed in the country by the total costs associated with distribution activities.

Costs affecting the electricity tariffs are explained in detail in the above sections. Generation cost exclusively depends on fuel and machine type, market structure. If the generation cost is regulated with the revenue or price cap methods in partially deregulated markets for binding customers, who purchase electricity from incumbent supplier, tariffs will be affected directly through these regulated prices. However, the fundamental concept is that generation cost should be charged to all customers without taking into account the distribution regions.

Companies conducting the transmission and distribution activities are inherently monopolies due to their structure, i.e. being single, without any competitive counterpart.

However, distribution systems may be divided into separate regions in, which different companies may have commercial activities. Under the national tariff model, transmission and distribution costs are calculated and implemented across the overall country, even if there are different regions.

Power losses are examined into two groups; technical and nontechnical loss. Specifically, non-technical losses, which is also known as illicit electricity consumption or illicit utilization have great impact on tariffs. Implementation of different tariff models, for reflecting the non-technical losses may lead to great differences in prices.

Distribution companies are assigned by the Concession Agreement, with the responsibility of reducing power losses progressively by taking the necessary precautions within the 25 years duty period, which the companies are obliged to reduce the losses and illicit utilizations with respect to a descending curve put in the Concession Agreement, showing the rate of reductions within the 25 years assignment period, that will assign payment duty to the companies from their own resources otherwise, in case that the responsibilities have not been realized.

In fact, the main source of illicit utilization in a region is the social condition of the people, residing there, and their ability to make payment for electricity. The political authority always tends to exhibit a tolerant behaviour to those people for their illicit action, due to political concerns, i.e. to be able to gain their votes in the next election. This situation leaves almost no freedom to the distribution companies, for applying legal sanctions to those customers, except obeying the tolerant behavior of the government.

In general, it is well known that, the western regions in Turkey exhibit smaller percentage of have a lower share of illicit utilization, while the other parts relatively higher. Under the national tariffs scheme, the payment to be made for the illicit utilization is charged to all regions in the country equally, without any consideration to the situation that these losses differ in regions. For instance, a residential customer in Kahramanmaras and in Diyarbakır are both charged with the same loss ratio, although Dicle distribution company serving to Diyarbakır, has much higher power loss ratio, 72.12%, while Akedas distribution company serving to Kahramanmaras, has the lowest power loss ratio, 4.98% in 2015 [12].

The difference between the loss ratios of these companies is mostly based on the operational performance and effectiveness of the distribution companies in achieving figures as illustrated in the curve drawn for the target loss ratios in the Concession Agreements.

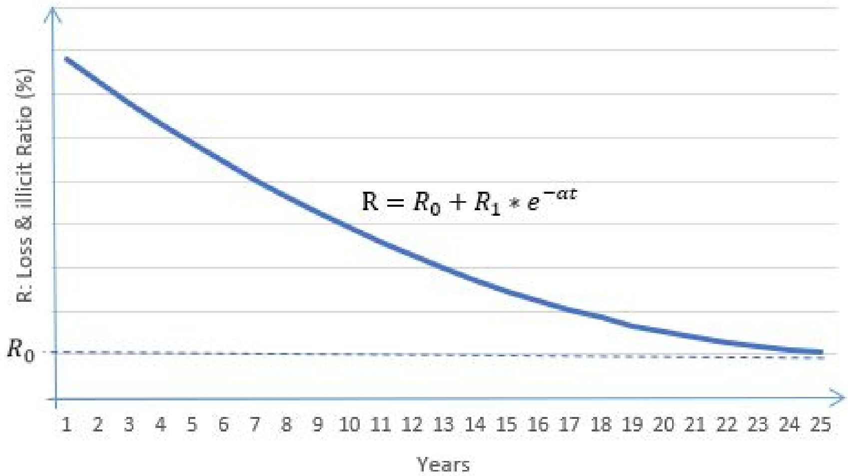

Figure 2.5: Target Loss Ratios in Years

In the national tariff model, retail service costs, such as billing and laboring costs related to the operational performance of the retail company are equally paid by all customers. Tax may be regarded as an instrument for realizing the national strategy, since it helps to finance various public expenditures. It may be designed in a regional manner, where different taxing models are implemented by the government. Taxing models are not dependent on the national tariff model.

A price balancing mechanism may be applied to ensure that the revenues of the regulated companies, such as distribution companies or supplier companies with fixed prices in long term agreements are compensated by subsidies in order not to be affected by the differences in revenues arising from the national tariff model. Implementation of the national tariff model makes it necessary to support those distribution companies affected by the price differences arising from the national tariff. The differences in prices between the national tariff and regional tariff are balanced by subsidy funded by the Treasury of the Government in order those, which companies not to be affected by those differences.

2.4 Electricity Distribution Tariff Models

Regulation of the electricity distribution sector yields the optimum condition for the operational/ investment costs reflected on the tariffs implemented to the distribution system users, versus the service quality [13]. The responsibility for finding this optimum condition between customer tariffs, distribution company revenues and distribution service quality is determined by the Regulatory Authority and issued regularly to the distribution companies. Critical aspects of designing an effective, sufficient and suitable regulation system can be listed as follows;

- Designing a regulatory regime, that can increase efficiency of distribution companies, while also maintaining high service quality, sustainable supply and reasonable customer tariffs.
- Establishment of a model used for determining the revenue for of each distribution company for practical implementation of the designed regulatory regime.
- Realization of the designed regulatory regime and establishment of the designed model on the customers, distribution companies and laws [14].

There are certain procedures and principles especially on the roles and responsibilities of regulatory authorities for designing a suitable regulatory regime in regard of determination of tariffs as defined within the directives of the European Union. Even though there are differences among the methods implemented in member states, the general rules are determined in accord with the Directives numbered 2009/72/EC and 2012/27/EU. The 2009/72/EC Directive, the main regulation for designing of the electricity market structure in Europe, specifies that the national regulatory authorities are obligated to design and approve tariff models in accordance with the recommendations of the distribution companies.

The regulatory authorities must design and reflect the appropriate costs to the distribution companies, without making any discrimination between the parties, by taking into consideration the long-term marginal costs and minimization of system operation costs through distributed generation and demand-side management in Article 37(1)(a).

During the regulation or approval of the tariffs and methodologies, the regulatory authorities should provide the necessary incentives to promote the short and long-term efficiencies of the distribution companies, to improve the market integration, to support the relevant research activities and to ensure the supply security as defined in Article 37(8).

In addition, the Directive also specifies that energy efficiency/demand-side management criteria or distributed generation responsibilities may be taken in consideration during the process of development of distribution system infrastructure. On the other hand, some limitations must be set to prevent cross-subsidy between different fields of the distribution activity as defined in Article 25(7).

The methods implemented for revenue regulation implemented to distribution companies across the world can be gathered under two main headings. While the revenue is calculated within the period of operation by measuring and evaluating the operational expenditure in terms of the improvements in cost and efficiency revenue, investments are calculated, evaluated and feedbacked within longer terms of planning.

The trade-off between the investments and operational costs must be balanced by the regulatory authority in order to ensure the conditions for the quality of service are satisfied, as well as the necessary investments are realized up to a certain level, while not violating the conditions for efficiency. In other words, revenues of the distribution companies must be regulated at a level that, is high enough to meet the initial investments (privatization-transfer) as well as annual investments and operation costs, while keeping service quality and efficiency at a satisfactory level [15].

In calculation of revenue, the additional expenditures and losses, arising from circumstances out of control of the companies and originating from external sources must be compensated, but the expenditures arising from administrative deficiency or operational inefficiency of the company must be clearly distinguished and not paid in this process [16]. The following basic linear equation provides the formula for calculation the revenue of distribution companies.

$$\mathbf{P}(\mathbf{c}) = \mathbf{f} + (1 - \mathbf{b}) * \mathbf{c} \quad (1)$$

Where;
$\mathbf{P}$ is the tariff,
$\mathbf{f}$ and $\mathbf{c}$ are the fixed and variable costs,
b is a coefficient, known as, the incentive factor [17].

The revenue is equal to the total expenditures represents the service cost mechanism, while variable costs are minimized represents the price cap method.

The situations between these two extremes can be regarded as a simplified representation of incentive-based revenue models, which can also be expressed as "revenue sharing contracts” or "performance-based regulation”. Mechanisms, where prices/revenue are partially correlated with variable costs, and again prices/revenue are partially ex-ante will provide the optimum revenue mechanisms [18].

In summary, the service cost and internal profitability rate mechanisms, which involve tariff determination based on costs of distribution companies, are relatively of low profitability, wherein distribution company costs may not be fully controlled and, which can result in high customer tariffs. Incentive based mechanisms like price cap, revenue cap and yardstick method, which aim to improve efficiency and service quality may be considered as optimum tariff methods in regard of public welfare, company revenues and regulatory issues. However, the literature also points out that incentive based regulatory methods are frequently an extension of cost-based mechanisms such as service cost method [19].

2.4.1 Cost Based Tariff Mechanisms

Cost-based tariff mechanisms are based on compensation of some or all costs of the distribution companies while determining the revenues of these companies. Cost-based mechanisms can be grouped as Rate of Return (RoR) Method and Cost of Service Method.

In the purpose of the first of cost-based mechanism revenue (RoR), is to keep the profit to be gained by distribution companies at a certain level, while at the same time, to prevent reaching excessively high price levels and to decrease the costs of distribution service.

However, unlike the price cap method detailed below, this method does not limit the retail price, but the profit margin that will be added on the distribution service costs.

In this method, costs, depreciations, amortizations, taxes, and other expenditures for one-year period, which is referred to as the base year, will be calculated, and a certain profit margin will be added to this figure to find the revenue cap; [20].

$$\mathbf{E}_n = \mathbf{E}_0 + \mathbf{r} * \mathbf{RAB} \tag{2}$$

Where;
$\mathbf{E}_n$ is the revenue cap for the nth year,
$\mathbf{E}_0$ is the base annual expenditures,
r is the rate of return in percentages,
RAB is the Regulatory Authority Base.

As seen in the above equation, the distribution company revenue cap $\mathbf{E}_n$ determined for a certain year n is calculated as the base annual expenditures $\mathbf{E}_0$ plus the rate of return on the physical assets serving as basis of profit, RAB, in percentage $\mathbf{r}\%$.

Advantages of the method are;

- Addition of the rate of return term on the costs provides distribution companies a net profitability rate.
- It is a simple and easily applicable.

On the other hand, disadvantages of the method are;

- In case of an unproductive or abnormal year (high inflation periods, transitional periods, etc.) there is a risk that the calculated revenue does not reflect the actual figures in that year.
- Since rate of return is calculated on basis of the service costs in the base year, the companies may tend to show their costs in the base year higher than the actual figures. This might result in an effect exactly opposite of the main purpose of keeping the service costs lower.

- As a certain return rate is guaranteed for the investments, it can result in over-investment [21].

As the rate of return method is based on addition of a certain profit margin on the service costs for determination of revenue, it may be regarded as a cost plus method.

The second cost-based method is the cost of service contracts. In this system the distribution companies will report their costs to the regulatory authority every year or at the end of tariff period, and the regulatory authority will determine the payments the amounts corresponding to these costs to the companies.

Advantages of this method may be listed;

- Since the calculation is made based on the complete and exact amount of costs, over-profitability is prevented and the consumer is protected.
- Since all costs are exactly met, there is no risk of loss for the distribution companies.
- It is a simple and easy to use method.
- Due to decreased risk for companies, this method helps companies to find financing easier and decrease their financing costs.

On the other hand, disadvantages of this method may be evaluated;

- It can increase the risk of over-investment and cause unnecessary expenditures.
- There is no incentive to decrease service costs for the companies (return on cost decreasing measures in 0 %)
- The high costs caused by high input prices reflect as high prices on the customer tariff.
- Since the regulatory authority may not be able to reach detailed and true information on the activities, the companies may mislead regulatory authority to a condition, against the interests of the consumers.

The main problem cost of service method is the difficulty in calculating a "reasonable revenue rate" for the returns on the investments included in the asset base.

2.4.2 Incentive-based Mechanisms

Preconditions for active and effective use of incentive-based revenue regulation mechanisms can be listed as accounting systems providing an accurate record of operation and investment expenditures, cost reporting protocols, data collection, storage and reporting protocols, which also cover information regarding the performance aspect of distribution activities other than costs [18].

In addition to these, parameters like a Regulatory Asset Base (RAB), a reasonable revenue rate (WACC - Weighted Average Cost of Capital) and depreciation must also be defined and calculated. Effective monitoring of these parameters and cost reporting can eliminate or minimize the asymmetric information disadvantage of the distribution regulation in incentive-based mechanisms, and the additional information advantage created in this process can improve the performance and quality of the service provided.

In incentive-based mechanisms there are some risks arising from the uncertainty of the service costs of the companies, while in cost-based mechanisms all of the service costs of the companies are approved by the regulatory authority and therefore the risk rests on the public.

Due to this characteristic, the tariffs created by cost-based mechanisms are frequently audited and updated by regulatory authorities, while incentive-based mechanisms are not updated (excluding external factors like inflation) until the end of implementation period, which generally ranges between 3 and 7 years. On the other hand, cost-based mechanisms focus on the cost, the incentive-based mechanisms on the other hand, focus on the performance of the companies and provide the companies with the opportunity to generate revenue not only with their investment, but also from the improvements in their service quality and operating costs.

The first incentive-based method is the price cap method, which was first developed by Littlechild [22].

In this revenue model, the topmost price (price cap) that can be billed to the customers by the distribution companies will be determined ex-ante at the beginning of the implementation period. The companies may determine their own prices provided that they remain under this price cap. The price cap may be fixed on the long term, or can be "dynamically" updated at the beginning of each implementation period.

During the implementation period (IP), the price cap can only be adjusted with respect to external factors outside the control of the company. Therefore, the distribution companies may use this method to make cost improvements, thus, gaining the amount between the price cap and their costs as profit, which incentives the company managements towards to take efficiency increasing measures.

The following equation shows the general formula for calculation of regulatory price cap within the implementation period;

$$\mathbf{P}_{t+1} = \mathbf{P}_t * (\mathbf{EPE} - \mathbf{X}) \tag{3}$$

Where;
$\mathbf{P}_{t+1}$ are updates on the on price cap, calculated by three/six months,
$\mathbf{P}_t$ is the base price cap,
EPE is expected inflation rate,
X is efficiency factor.

Here, the updates applicable on price cap $\mathbf{P}_{t+1}$ are calculated by three/six month or annual periods, typically shown as the base price cap $\mathbf{P}_t$ adjusted by the expected inflation rate $\mathbf{EPE}$ minus the efficiency constant (X-factor). In addition to X-factor, in some cases some adjustments based on quality indicators, which are referred to as the Q-factor, may also be implemented [17].

In the price cap method, the regulatory authority does not know the real costs of the distribution company due to the reserve selection effect of asymmetric information, which can lead to higher price cap points [23], [24].

Advantages of the method may be listed as follows;

- Since there is no direct relation established between company costs and allowed prices, this method provides some of the best incentives for cost reduction for the companies.

- At the end of each implementation period (IP) the price cap can be decreased on basis of ex-post cost observations, providing continuous incentive for efficiency.

- The regulatory authority has relatively lower need for intervention in market operations and access to company information. This decreases administrative costs.

Disadvantages of the method on the other hand, may be outlined as follows;

- In case the costs cannot be decreased/minimized sufficiently, or the price cap is determined too low there is high risk of loss for distribution companies.

- Distribution companies who expect the price cap to be lowered in the following implementation period (IP), may show their costs higher than the actual in order to affect the decision of the Regulatory Authority.

- The efforts to decrease the costs might result in decrease in service quality.

One of the most critical points in price cap method is determination of the factors affecting the price cap and efficiency at the beginning of the initial implementation period. Higher price cap and/or low efficiency factor might result in extreme profit margin and ineffective incentives for cost reduction. While the regulatory authority is responsible for achieving the delicate balance needed at this juncture, taking necessary measures to reduce the information asymmetry may be an important factor for increasing effectiveness of the method.

In addition, presence of standards and incentives aimed at maintaining and increasing quality of service will also minimize an important disadvantage of price cap model. Annual review and update of price cap according to costs of companies will cause this method to converge towards RoR method, thus, transferring the disadvantages of the RoR method to the price cap method.

Another incentive-based model like price cap method is the revenue cap method, a variation of which is implemented in Turkey. In this model the distribution companies are subject to a fixed revenue cap within an implementation period in order to incentive them to decrease the costs and improve the efficiency in their operations. A simple representation of base year revenue cap calculation is shown below [16].

$$\mathbf{R}_t = \mathbf{a} * (1 - \mathbf{C}_{t*}) + (1 - \alpha) * \mathbf{C}_t \tag{4}$$

Where;
$\mathbf{R}_t$ is the base year revenue cap,
$\mathbf{C}_t$ is realized costs,
$\mathbf{C}_{t*}$ is active costs,
α is weighting costs.

The base year revenue cap $\mathbf{R}_t$ is calculated based on realized costs $\mathbf{C}_t$ and active (effective) costs $\mathbf{C}_{t*}$ of the relevant company and with weighting factor α. The equation below represents the most general definition of revenue cap adjustment in an implementation period [13].

$$\mathbf{R}_{t+1} = \mathbf{R}_t * (1 + \mathbf{EPE} - \mathbf{X}) + \mathbf{Y}_t + \mathbf{L}_t + \mathbf{Q}_t \tag{5}$$

Where;
$\mathbf{R}_{t+1}$ is the revenue cap,
$\mathbf{R}_t$ ia previous year realizations,
X is the efficiency factor,
$\mathbf{Y}_t$ is costs originating from increase in load or demand,
$\mathbf{L}_t$ is loss/illicit utilization,
$\mathbf{Q}_t$ is the service quality.

Calculation of the revenue cap $\mathbf{R}_{t+1}$ for the year $\mathbf{t+1}$ takes the realizations of previous year $\mathbf{R}_t$ into account. Also referred to as the efficiency factor, the X-factor can be determined as a combination of previous performance and assumptions on expected future developments.

In addition to efficiency factor, items like costs originating from increase in load or demand $\mathbf{Y}_t$, incentives aimed to decrease loss/illicit utilization $\mathbf{L}_t$ and incentives aimed to increase service quality $\mathbf{Q}_t$ can also be taken into account in revenue cap calculation in some cases [25], [26] This kind of adjustment can be determined as an absolute figure, or can be calculated on basis of changes in revenue cap calculation items.

The fundamental difference between this method and the previous price cap method is the fact that the rate of demand increase is also included in revenue cap calculation. This way, the excessive profit or loss effect originating from the deviations in demand estimates of companies with high fixed costs is reduced.

Another important difference between this method and the previous price cap method is that, the energy price is included as a term in the price cap method, with the price cap is applied on it. This price, however, is a term determined by the companies who supply fuel for the generation companies, with the prices determined by worldwide, not countrywide. Thus, an attempt to put a price cap on fuel prices may lead to bankruptcy of the distribution companies, as the difference between their payments and revenues become negative.

In general revenue cap methodologies determine the targets for each tariff period in advance (ex-ante) and the revenue cap targets will be reviewed according to realizations and new developments in the sector for the next implementation period. Advantages of the method may be listed;

- Presence of a fixed revenue cap incentives distribution companies to decrease their costs and to improve their efficiency.
- Since X-factor is determined at the beginning of the implementation period, improvements made beyond this factor will provide a direct effect to increase the profitability of the distribution company.
- In addition to efficiency increase, the X-factor allows sharing of the returns from this increase between companies and users of the distribution system.
- In comparison to price cap method, this method provides more managerial freedom to distribution companies.

- Based on the level of inclusion of investment costs in the revenue cap, this method promotes the optimum trade-off between Operational Expenses (OPEX) and Capital Expenditure (CAPEX).
- In addition to determining and limiting the total revenue, the Revenue Cap method can also be used with different variations like determination of revenue per customer (TL/customer) or revenue per unit of distributed power (TL/MWh) [23]

On the other hand, disadvantages of the method may are;

- A too low revenue cap may cause companies to withdraw from market or go bankrupt, while a too high revenue cap may cause companies to attempt to gain profits by showing their costs high based on their asymmetric information advantage.
- Update of revenue cap after efficiency and determination of X-factor based on previous realizations may cause distribution companies to view increase in efficiency as a penalty and drive them to keep their costs high as a strategic move (ratchet effect) [27]
- As this method does not take the changes in the structure of system outputs, it is seen as a model that does not incentive the quality of improvements.

Methods incentivizing cost improvement by determination of the prices the distribution companies may bill to the customer partially proportionate to the changes in costs are generally referred to as the partial overall cost adjustment method.

The adjustment made on the internal profitability rate – in comparison to reference value – in the sliding scale method is made on the overall costs of the company in this method.

The costs taken as basis of price adjustment and the real and comparative costs comprise the total unit cost of the distribution company, and they are calculated on basis of a group of inputs and outputs determined by the Regulatory Authority, prices of inputs and time, and are weighted.

The weights given to the input prices should reflect the effect of these prices on the total cost, while the weight given to the outputs should reflect scale and scope economy, and the weight given to time component should reflect the effect of accounting adjustments, such as depreciation. Partial overall cost adjustment method has similar advantages and disadvantages to the sliding scale method

The last of and one of the most important incentive-based revenue determination mechanisms may be the methodology referred to as yardstick regulation. In the literature this method was first defined as Yardstick Competition in 1985 by Andrei Shleifer. Yardstick competition can be implemented as a direct revenue methodology or as a supportive mechanism for other method currently in use.

This method is designed based on comparing the companies subject to revenue regulation not against their own previous or current performances, but against other similar/comparable companies, and separation of company revenue and tariff from the previous cost realizations of the company. This methodology does not limit the rate of return the distribution companies can obtain and guarantees a minimum rate of return to the companies.

Yardstick competition model arose from the need to eliminate negative effects of cost-based revenue methods and price cap methodology like "reserve selection" and "moral risk", and especially the "ratchet effect." Even though the theory behind yardstick competition is established on comparison of costs of identical companies operating in different regions and/or markets for comparative performance assessment, i.e. competition between identical companies operating in different markets, it is also implemented in regard of competition between companies possessing different characteristics.

Accordingly, this method rewards the company who improves their costs while penalizing the company who continues its operation with the same or higher costs.

CHAPTER 3

ELECTRICITY TARIFF IN TURKEY

3.1 Electricity Market Overview in Turkey

First market restructuring step in Turkey, is realized by dividing the Turkish Electricity Authority (TEK) into two entities; Turkish Electricity Generation and Transmission Company (TEAS) and Turkish Distribution Company (TEDAS) in 1994. TEAS was in charge of generation, transmission and wholesale electricity, while TEDAS carried out distribution activities and retail sale.

Further, upon the enactment of the Electricity Market Law in the year of 2001, TEAS was decomposed into Electricity Generation Company (EUAS), Turkish Electricity Trading and Contracting Company (TETAS) and Turkish Electricity Transmission Company (TEIAS), which have been charged by the functions of generation, wholesale and transmission, respectively [28].

Republic of Turkey Prime Ministry Privatization Administration (PA) has decided to privatization of TEDAS in 2004 on the basis of TOR (Transfer of Operation Right). The following figure shows 21 regions in the Turkish distribution electricity system based on geographical priority. 20 of these regions have been included in the privatization program. Thus, distribution companies have been charged distribution and retail sale of electricity and provision of retail services to customers.

Turkish Constitutional Law, Article 168, Exploration and Operation of Natural Resources includes items below;

- Natural wealth and resources are always under the control the government.

- Exploration and operation right of natural wealth and resources always belong to the Government.
- The Government may delegate such rights, to real or legal entities for a specified period of time.
- Explicit permission of the law adjudicates, which natural asset and resource ventures are to be carried out directly by real or legal persons.

Figure 3.1: Distribution Regions in Turkey

According to Turkish Constitutional Law, transfer of ownership of the property for exploration and/or operation of the public natural wealth and resources is legally prohibited. Because of that restriction the privatization of distribution companies is realized by implementing the Transfer of Operating Rights ("TOR") method. KCETAS was the first distribution region, whose TOR was given in 1990, a partially private company.

According to the model, the investor is the sole owner of the shares of the distribution company, which is the unique licensee for the distribution of electricity in the designated region, but which doesn't have the ownership of distribution system assets and other items that are essential for the operation of distribution assets [29].

TEDAS has ownership of all distribution assets, however, Transfer of Operating Rights Agreement ("TOR Agreement") gives and guarantees the right of operation of the distribution assets to the investor.

Distribution companies are responsible for reading meters, providing maintenance and operation services in specified areas, where they act as regional monopolies with distribution licenses granted by Energy Markets Regulatory Authority ("EMRA") for a maximum 49-year period. Besides, only distribution companies are allowed to sell electricity to non-eligible customers within the region of operation at a specified rate defined in retail electricity tariffs approved by EMRA.

In compliance with the Electricity Market Law No:6446, supplier company is defined as the legal entity responsible for retail and/or wholesale, import, export and commercial activities (transactions) of electrical power and/or capacity. Supplier company may carry out wholesale and retail sales activities to eligible customer without any limitation of the area.

Turkey has realized a significant progress to establish a competitive market structure with the directions envisaged in the Electricity Market Law No:4628 came into force in 2001. In addition to Electricity Market Law No, one of the most important steps was taken by the privatization of TEDAS in 2004.

Consequently, the need of methodology to be followed arose to manage the process of change. Therefore, tariff implementation periods and implementations to be followed in the periods were expressed by Regulatory Authority.

In other words, transition period requires for such a product, which is inherently not storable but a fundamental necessity for the society to be traded on the competitive market environment. That is the reason why first tariff implementation period which is also called the transition period within the years 2006-2010 which includes the implementations to protect the investors from losses that may arise during the transition period.

After 2010, cost-based tariff is planned to be implemented, however, in second tariff implementation period, within the years 2011 and 2015, transition to the cost-based tariff structure could not been achieved, due to social and political influences.

Afterwards, the national tariff is decided to be kept in effect in second implementation period in first provisional article in 6th Chapter of Electricity Market Law No:6446.

According to provisional article; The price balancing mechanism, which was formulated by the Regulatory Authority, shall be kept in effect by the end of 2015, with the purpose of protecting the consumers who purchase electricity through the regulated tariffs in a way to protect them partially or completely from the existing price differences due to cost differences between the distribution regions.

Supply companies involved in all public and private distribution companies are included in the price balancing mechanism. In compliance with the 4th paragraph of the article, decision no: 2015/8317 came into effect on December,2015. In line with this decision, the tariff model, which was stipulated to be implemented by the end of the year 2015, has again been postponed to the end of 2020, which is also end of the third tariff implementation period. Postponement includes the application both the price balancing and the national tariff models and related the cross-subsidies. Obviously, the imbalance between revenues and the price to be paid for the energy to be bought in 21 regions will continue to derive the need for “The National Tariff”.

Electricity tariffs will be low in the western part of Turkey than those in the Eastern, which is highly undesirable as the Eastern part of Turkey needs cheaper energy to overcome the poverty and to boost the economic development. “Implementation of national tariffs, however, will result in imbalances in the revenues since the revenues of the distribution companies will differ from each other due to the differences in the revenue caps. In order to eliminate such imbalances, EMRA will continue to implement the tariff balancing scheme to transfer the revenues across the regions. [30]

EMRA is regularly reviewing and publishing customer tariffs each quarter of year for customer groups purchasing electricity from the official supplier company, with the tariffs revised three times in one year. The figure given below illustrates the growth of the active-single rate low voltage consumers’ and transmission consumers’ customer tariffs within years 2007-2016.

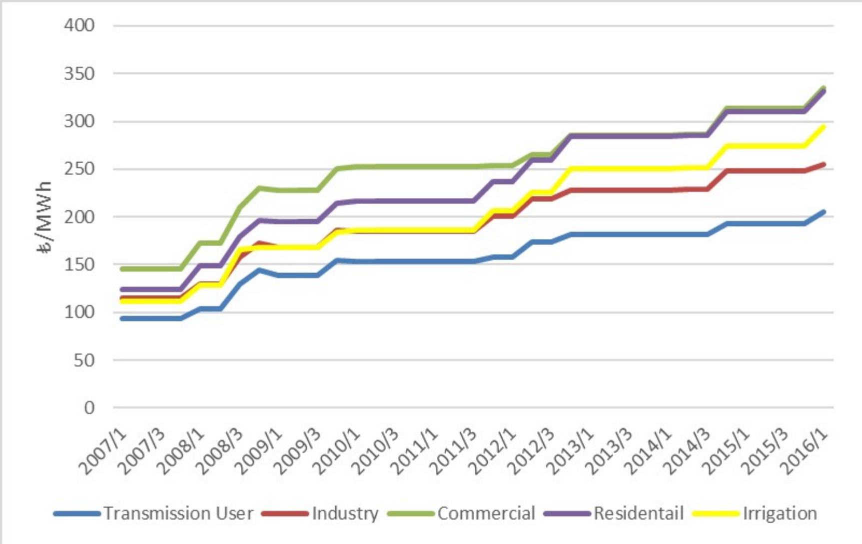

Figure 3.2: Customer Tariff Growth

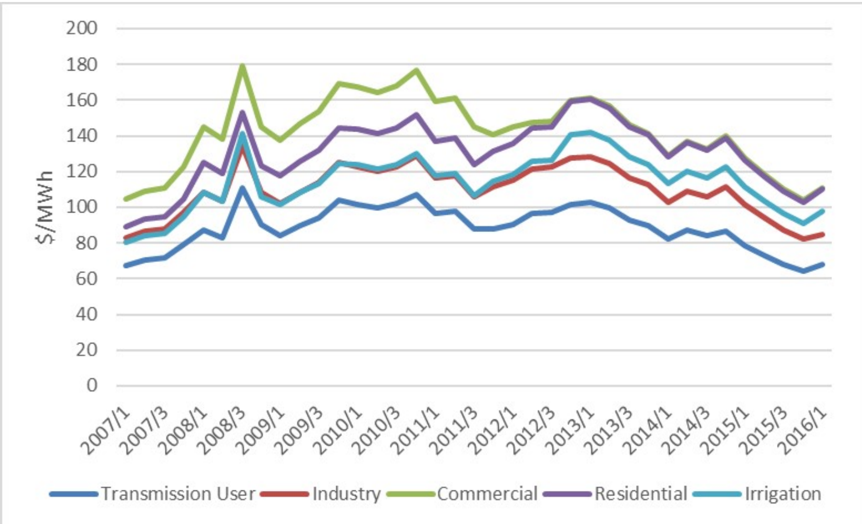

Figure 3.3: Customer Tariff Growth, USD/MWh

3.2 Transmission Cost

Transmission cost is defined as the payment made by the distribution system users for the transmission tariff charged by TEIAS to the distribution companies. Distribution companies are charged by TEİAS for the transmission capacity allocated in terms of MW/Year. This charge is then reflected by the distribution companies to customers under the name of "Transmission System Cost" in terms of TL/kWh, i.e. a payment for each kWh consumed.

TEIAS has a similar revenue cap design as distribution companies with three years' implementation periods. However, in contrast to distribution companies, TEIAS is a state-owned monopoly, which is not planned to be privatized.

TEIAS is not allowed to make electricity trading, but collect the revenue requirement from the charges collected for the transmission services and transmission losses in compliance with the Electricity Market Law No: 6446. Therefore, TEIAS has to charge all system users including the distribution companies to cover its expenditures for the system operation and capital expenditures, Weighted Average Cost of Capital requirements and the transmission system losses. Transmission System Charges have two components; System Usage Charge and System Operation Charge.

System Usage Charge is associated with cost of installing, operating and maintaining transmission system for bulk transfer of energy and system security and quality of supply. On the other hand, System Operation Charges are related to the costs of the real time generation-demand balancing service and ancillary services.

Both System Usage and System Operation Charge are paid by all users of the system including producers and consumers based on installed capacity in MW/year. It is aimed to collect the 50% of each of the revenue requirement, which is consisting of Use of System and System Operation Charges, from generation and 50% from the demand. Price differences in the regions are mainly driven by the supply-demand balance in the region. The transmission tariff is determined by a particular method, called "nodal pricing", which is used to calculate the connection tariffs in 14 regions of the country as shown in the following tables.

Table 3.1: Transmission Tariff for Generation in Turkey

Region	Generation		
	System Usage Fee (TL/MW-year)	System Usage Fee (TL/MWh)	System Operating Fee (TL/MWh)
1	31,888	7.17	1.40
2	34,764	7.17	1.40
3	35,082	7.17	1.40
4	35,536	7.17	1.40
5	37,081	7.17	1.40
6	38,967	7.17	1.40
7	39,190	7.17	1.40
8	43,168	7.17	1.40
9	44,864	7.17	1.40
10	49,817	7.17	1.40
11	52,471	7.17	1.40
12	54,714	7.17	1.40
13	57,059	7.17	1.40
14	61,205	7.17	1.40

Generation system connection tariffs are the lowest in the main consumption belt around Istanbul, whereas the tariff is highest in the generation abundant North-Eastern region in Turkey. The Consumption system use tariffs follow exactly the opposite logic and are highest in the main consumption belt around Istanbul, whereas it is lowest in the generation abundant North-Eastern region in Turkey. Nonetheless, in the retail tariff, transmission charges are pass-through and to be collected by the distribution companies from suppliers and paid to TEIAS.

In the first and second implementation periods, transmission charge is calculated as a price per kWh consumed by the users. However, it is included in the Distribution Cost in 2016, which is the beginning of the third implementation period. The following table shows the transmission costs announced by EMRA for the LV users.

Table 3.2: Transmission Tariff for Consumption in Turkey

Region	Consumption		
	System Usage Fee (TL/MW-year)	System Usage Fee (TL/MWh)	System Operating Fee (TL/MWh)
1	56,389	6.50	1.46
2	54,785	6.50	1.46
3	54,900	6.50	1.46
4	54,327	6.50	1.46
5	53,474	6.50	1.46
6	52,046	6.50	1.46
7	50,780	6.50	1.46
8	49,259	6.50	1.46
9	47,596	6.50	1.46
10	44,343	6.50	1.46
11	43,634	6.50	1.46
12	42,089	6.50	1.46
13	41,010	6.50	1.46
14	37,792	6.50	1.46

Table 3.3: Transmission Cost in Turkey

Date	Industrial	Commercial	Residential	Agricultural	Lightening
10.2008	0.4	0.42	0.42	0.43	0.42
1.2009	0.45	0.46	0.46	0.46	0.46
4.2009	0.45	0.46	0.46	0.46	0.46
10.2009	0.44	0.44	0.44	0.44	0.44
1.2010	0.44	0.44	0.44	0.44	0.44
1.2012	0.84	0.84	0.84	0.84	0.84
4.2012	0.87	0.87	0.87	0.87	0.87
10.2012	0.85	0.85	0.85	0.85	0.85
4.2013	0.67	0.67	0.67	0.67	0.67
7.2013	0.72	0.72	0.72	0.72	0.72
10.2013	0.72	0.72	0.72	0.72	0.72
1.2014	0.87	0.87	0.87	0.87	0.87
7.2014	0.89	0.89	0.89	0.89	0.89
10.2014	0.89	0.89	0.89	0.89	0.89
1.2015	0.87	0.87	0.87	0.87	0.87
4.2015	0.89	0.89	0.89	0.89	0.89
7.2015	0.9	0.9	0.9	0.9	0.9
10.2015	0.95	0.95	0.95	0.95	0.95

3.3 Distribution Cost

The distribution cost reflected to the users is determined by required the revenue cap of distribution companies to sustain their activities. Distribution system cost may vary by 21 distribution regions. However, one of the reflections of the national tariff applications is to calculate the total amount of revenue required for 21 distribution companies after calculating the revenues in each region. The total cost determined for national level is reflected in the same manner. Price balancing mechanism is used to ensure that system customers are partially or fully protected from existing price differences due to cost variances between distribution regions. Table (3.4) shows the distribution costs announced by EMRA for LV customers. Transmission cost included in the Distribution Cost in 2016. That is the main reason for the noticeable increase from 2015 to October 2016.

Table 3.4: Distribution Cost in Turkey

Date	Industrial	Commercial	Residential	Agricultural	Lightening
10.2008	0.8	2.07	2.14	2.18	2.33
1.2009	0.97	2.51	2.59	2.61	2.78
4.2009	0.97	2.51	2.59	2.61	2.78
10.2009	1.19	3.13	3.22	3.21	3.41
1.2010	1.19	3.13	3.22	3.21	3.41
1.2012	1.46	3.85	3.96	3.95	4.19
10.2012	1.38	3.64	3.75	3.74	3.97
4.2013	0.8	2.09	2.15	2.15	2.28
7.2013	0.86	2.26	2.33	2.32	2.46
10.2013	0.83	2.2	2.26	2.25	2.39
1.2014	1.04	2.73	2.81	2.8	2.97
4.2016	4.96	11.51	11.24	9.44	10.79
7.2016	4.96	11.36	11.08	9.31	10.57
7.2017	4.96	12.07	11.78	9.9	11.59
10.2017	4.96	11.86	11.57	9.73	11.39
1.2018	5.71	13.36	13.04	10.96	12.8

The annual revenue that can be gained by distribution companies in an implementation period is regulated by Energy Market Regulatory Authority in line with relevant legislation, separately for the operating costs and investment costs. The revenue cap system in force incentives the distribution companies to realize the desired performance level with a lower budget. In other words, the aim is to have the regulated companies meet their revenues and reach their efficiency and quality goals with lower costs to gain profits.

Data envelopment analysis (DEA) is used as a comparison method for efficiency in Turkey. X-factors above 0% affects the revenue cap in a negative way because of relevant legislation. There have been some differences among implementation periods even though tariff identification method has been the standard. In the next chapters, tariff determination process and the difference between implementation periods are described.

3.3.1 2006 – 2010: First Implementation Period

20 Distribution Companies' Instruction About Revenue Regulation for the first implementation period that contains procedures and principles about the adjustment of distribution system revenues was published as updated in the Official Gazette dated 21 December 2006 and numbered 26383 in order to be implemented in the transition period.

The realization expenditures of AYEDAS Company before 2006 was evaluated as a benchmark by TEDAS. A calculation method has been used considering only distribution system reference revenue, the rate of electricity market index and the efficiency for 2006, which was the first year of implementation period.

X-factor for the first implementation period is determined by TEDAS, which is presented in Table (3.5). There has been made some comparisons with similar countries' operation expenses in terms of system development, operation, maintenance, general management, line length and transformer number.

Cost reduction potential of each distribution region was determined for individual item.

Table 3.5: X-Factors, 2006-2010

Distribution Region	2006	2007	2008	2009	2010
ADM	0%	0%	0%	0%	0%
Başkent	0.7%	1.4%	3.9%	3.8%	3.8%
Sedaş	0.8%	1.7%	4.3%	4.2%	0%
Kayseri ve C.	-	-	-	-	-
Meram	0.5%	0.9%	2.5%	2.5%	2.4%
Osmangazi	0.3%	0.7%	1.8%	1.8%	0.9%
Çamlıbel	1.1%	2.2%	6.2%	6.2%	6.1%
Uludağ	0.5%	1%	2.8%	2.6%	2.4%
Çoruh	2%	4%	11.2%	11.1%	11.1%
Yeşilırmak	0.9%	1.7%	4.8%	4.7%	4.6%
Akedaş	0.9%	1.7%	4.8%	4.8%	4.8%
Fırat	1.2%	2.5%	6.7%	6.3%	6%
Trakya	0.5%	1%	2.7%	2.7%	0%
Akdeniz	0.6%	1.1%	3.1%	2.9%	2.7%
Boğaziçi	0%	0%	0%	0%	0%
GDZ	0%	0%	0%	0%	0%
Dicle	0.9%	1.8%	5.1%	4.9%	4.8%
Aras	0.9%	1.7%	4.6%	4.3%	4.1%
Vangölü	1.9%	3.8%	10.6%	10.5%	10.5%
Ayedaş	0.1%	0.2%	0.6%	0.6%	0.6%
Toroslar	1.1%	2.1%	5.9%	5.7%	5.4%

Afterwards productivity increase requirements were estimated for each company by using the regional data. Period of redemption for the first Implementation Period was 5 years. Average alternative cost ratio has been calculated as 9.35% for the first implementation period. Even though 50/50 structure is aimed for debt/equity ratio for the first implementation period, it was stipulated that 25.87/100 would be appropriate to be used.

3.3.2 2011 – 2015: Second Implementation Period

Turkey has implemented revenue cap methods for the distribution and price cap for retail sale services in second implementation period covering the years 2011-2015. Distribution cost that distribution companies can invoice to customers per unit energy has been limited with update on dates having different periods, such as October 2011, January 2012, July 2012 within the framework of demands of distribution companies and relevant legislation after approval of tables related to second Implementation period.

Efficiency parameters included in operating expense activities, determined for years covering 2011-2015 Implementation Period, have been reflected to the revenue cap, determined for distribution companies. Since efficiency percentage of some distribution companies are 0%, this situation has had no effect on revenue cap within this context, however for some distribution companies, this situation caused revenue caps to fall. The purpose of this application was to encourage cost reduction of distribution companies and minimize the effect of operational expenditures on tariff.

In order to encourage efficiency in operational expenditures of the legal entities with distribution license; efficiency parameters were defined by comparing the performances of similar applications both in the country and abroad. These parameters are determined and reflected to revenue cap of the distribution companies. During this procedure data of 2007, 2008 and 2009 have been taken into consideration and models have been established by carrying out the overall efficiency analysis, data envelopment analysis and partial efficiency analysis, while establishing these models, efficiency of the distribution sector for the years 2007-2009 have also been taken into consideration.

Efficiency parameters determined for the second implementation period are presented in Table (3.6). Efficiency percentages were implemented by reducing for years 2011 and 2012.

Table 3.6: X-Factors, 2011-2015

Distribution Region	2011	2012	2013	2014	2015
ADM	0%	0%	0%	0%	0%
Başkent	0.58%	1.44%	3.35%	3.35%	3.35%
Sedaş	0.45%	1.14%	2.64%	2.64%	2.64%
Kayseri ve C.	0.78%	1.95%	4.53%	4.53%	4.53%
Meram	0.99%	2.46%	5.71%	5.71%	5.71%
Osmangazi	0.14%	0.36%	0.83%	0.83%	0.83%
Çamlıbel	0.31%	0.77%	1.78%	1.78%	1.78%
Uludağ	0.07%	0.17%	0.39%	0.39%	0.39%
Çoruh	0.43%	1.09%	2.52%	2.52%	2.52%
Yeşilırmak	0%	0.01%	0.01%	0.01%	0.01%
Akedaş	0.73%	1.83%	4.25%	4.25%	4.25%
Fırat	0.53%	1.33%	3.08%	3.08%	3.08%
Trakya	0%	0%	0%	0%	0%
Akdeniz	0%	0%	0%	0%	0%
Boğaziçi	0%	0%	0%	0%	0%
GDZ	0%	0%	0%	0%	0%
Dicle	0.33%	0.83%	1.93%	1.93%	1.93%
Aras	0.67%	1.68%	3.91%	3.91%	3.91%
Vangölü	0.9%	2.25%	5.21%	5.21%	5.21%
Ayedaş	0%	0%	0%	0%	0%
Toroslar	0.1%	0.25%	0.58%	0.58%	0.58%

In second implementation period, distribution companies submitted the reports concerning their net operational expenditures for the distribution and retail service activities to the regulatory authority, within the years 2007- 2009 in order to be able to foresee these expenditures for the following years within the implementation period.

Distribution operational expenditures (OPEX) have been calculated by using the composite index formula for the year 2011, which was the first year of the second implementation period, by taking 80% of annual line increase, 10% of increase in number of customers, 10% of growth in the distributed energy in terms of the figures observed within the years 2007-2009 declared by distribution companies.

Annual investment needs for the regions have been analyzed by the distribution companies for each tariff year in the second Implementation Period, like in the first Implementation Period. Unredeemed capital expenditures have been calculated through a reasonable rate of return for cost, left out amount, redeemed for each tariff year and then approved by EMRA, thus, financial sustainability of the distribution companies has been ensured.

Reasonable rate of return has been determined as 10.49% (WACC) for the average alternative cost and as 9.97% for the corrected rate of return. Period of redemption, which was determined as 5 years for the first implementation period, has now been changed to 10 years. Amounts regarding the differences between the foreseen and the realized redemptions in investment expenditure calculations, have been corrected in second implementation period within the years 2006-2010.

"Procedures and Principles regarding the Legal Unbundling of the Distribution and Retail Sales Activities" for the distribution and retail sales activities under separate legal entities, have been approved and published in this period.

Additionally, according to Regulation published in Official Gazette in 2010, issue no. 27802, It has been announced that following items shall not be implemented until 2013;

- No cost term, which is not directly related to market activities, shall be put in the price structure of the tariff.
- When subvention is needed for supporting the consumers in certain regions, who suffers from poverty and/or for certain purposes, shall be subsidized in a way called "Direct Subsidy", that the amount, principles and procedures shall be determined by the Ministry of Energy and Natural Resources and Council of Minister's Decree without intervening in the prices and tariff structure.

3.3.3 2016 – 2020: Third Implementation Period

It is decided by the Regulatory Authority with the that Board Decision No 5885-1 that Data Enveloping Analysis (DEA) shall be used as a comparison method. In general, following components are included in the efficiency models and uncontrolled costs are not included in the model;

- Components of the operational cost,
- Line length,
- Number of Transformer,
- Installed capacity of transformers,
- Geographical area,
- Number of customers.

Furthermore, other components, such as the ratio of household consumption, ration of economical development and ratio of realized loss under the title of environmental factors can also be included in the model. Efficiency parameters, which is presented in Table (3.7) for distribution companies for the period within the years 2016-2020 are determined and announced in January 2016.

According to the regulation, which aims to decrease the illicit utilization in distribution systems, which is published under scope of Temporary Article No 18 of the relevant Law in 2015 December, it has been decided that efficiency parameter shall not be included to controllable operational expenditures for Vangolu, Dicle and Aras regions until 2020, which is the last year of the implementation period.

Distribution companies have presented their net operational expenditures realized in years 2013 and 2014 for revenue requirement calculations. Distribution operating expenditures (OPEX) have been increased by predicating on distribution assets, customer number growth, distributed energy growth by calculating through values realized in years 2013 and 2014 declared by distribution companies.

Table 3.7: X-Factors, 2016-2020

Distribution Region	2016	2017	2018	2019	2020
ADM	0%	0%	0%	0%	0%
Başkent	1.28%	1.28%	1.28%	1.28%	1.28%
Sedaş	0.54%	0.54%	0.54%	0.54%	0.54%
Kayseri ve C.	2.34%	2.34%	2.34%	2.34%	2.34%
Meram	0.79%	0.79%	0.79%	0.79%	0.79%
Osmangazi	0%	0%	0%	0%	0%
Çamlıbel	0%	0%	0%	0%	0%
Uludağ	0.43%	0.43%	0.43%	0.43%	0.43%
Çoruh	0%	0%	0%	0%	0%
Yeşilırmak	0.53%	0.53%	0.53%	0.53%	0.53%
Akedaş	0.02%	0.02%	0.02%	0.02%	0.02%
Fırat	0%	0%	0%	0%	0%
Trakya	0%	0%	0%	0%	0%
Akdeniz	1.61%	1.61%	1.61%	1.61%	1.61%
Boğaziçi	0%	0%	0%	0%	0%
GDZ	0%	0%	0%	0%	0%
Dicle	-%	-%	-%	-%	-%
Aras	-%	-%	-%	-%	-%
Vangölü	-%	-%	-%	-%	-%
Ayedaş	0%	0%	0%	0%	0%
Toroslar	0.61%	0.61%	0.61%	0.61%	0.61%

Furthermore, there are other items that are considered to be in the category of regulation based operational expenditures. These items are included in revenues in the way of increasing general calculated fixed and variable revenues in a certain amount. The first of these covers expenditures that are spent in the areas of judicial trials, execution activities, courts, social responsibilities, consultancy activities, administration and support services, representation and hosting and advertisements, which are included in the calculations resulting in an increase in the fixed and variable expenditures by 7%. R&D expenditures have been calculated to result in an increase by 1% in the operating expenditures.

While making calculations on tariff, upper bounds for investments determined by the Regulatory Authority are always taken into consideration. It was decided that average alternative cost shall be 12.66% whilst, the corrected rate of return before taxation shall be 11.91% during the implementation period, which shall start by 2016. Besides, it was announced that the amortization period for the investment costs, which was determined to be 10 years for the third implementation period.

3.4 Cost of Power Losses

3.4.1 2006 – 2010: First Implementation Period

In Turkey, cost of power losses was generally accepted as a component in the average retail energy price upper bound, that shall be determined with respect to the regulations and was calculated according to the existing average energy price of TEDAS, independent from the single and multi-time frame tariffs in the first period. This price could then be recalculated with respect to the changes in the energy prices of the distribution companies. These changes were reflected to consumers except the transmission system users.

In year 2007, a significant improvement was aimed in reducing the illicit utilization in all districts excluding Çoruh and Uludag regions. 11% improvement was anticipated in reducing the illicit utilization losses in Dicle, Vangolu and Aras regions for the following years.

Table 3.8: Power Loss Targets, 2006-2010

Distribution Region	2006	2007	2008	2009	2010
Akdeniz	10.78%	8.16%	8.05%	7.95%	7.84%
Aras	26.86%	25.8%	22.85%	20.25%	17.95%
ADM	12.24%	8.29%	8%	7.74%	7.49%
AYEDAŞ	10.28%	8.44%	7.76%	7.14%	6.57%
Başkent	11.66%	10.24%	9.51%	8.84%	8.23%
Boğaziçi	15.84%	13.09%	12.03%	11.05%	10.15%
Çamlıbel	10.67%	10.34%	9.77%	9.24%	8.74%
Çoruh	12.91%	13.58%	12.91%	12.28%	11.7%
Dicle	54.77%	53.01%	46.95%	41.58%	36.83%
Fırat	17.43%	14.56%	13.23%	12.02%	10.95%
Gediz	10.81%	8.27%	8.1%	7.93%	7.8%
Akedaş	13.49%	12.53%	12.25%	11.99%	11.76%
KCETAS	-%	-%	-%	-%	-%
Meram	9.23%	8.86%	8.71%	8.57%	8.43%
Osmangazi	6.84%	6.76%	6.67%	6.57%	6.48%
SEDAŞ	9.6%	8.38%	7.71%	7.09%	6.54%
Toroslar	17.09%	11.83%	10.82%	9.89%	9.06%
Trakya	8.74%	7.21%	6.88%	6.55%	6.24%
Uludağ	7.67%	7.87%	7.23%	6.64%	6.1%
Vangölü	55.11%	51.04%	45.2%	40.03%	35.45%
Yeşilırmak	19.92%	12.5%	11.81%	11.17%	10.59%

3.4.2 2011 – 2015: Second Implementation Period

While the targets for reducing the illicit utilization determined in the first Implementation Period, the calculation method for the illicit utilization ratio and energy loss compensation method has been changed in the Second Implementation Period.

Table 3.9: Power Loss Targets, 2011-2015

Distribution Region	2011	2012	2013	2014	2015
Akdeniz	8.86%	8.45%	8.05%	8.02%	8.02%
Aras	22.92%	19.04%	25.7%	21.35%	17.73%
ADM	9.8%	9.34%	8.9%	8.49%	8.09%
Ayedaş	7.12%	6.79%	6.61%	6.61%	6.61%
Başkent	8.46%	8.07%	7.88%	7.88%	7.88%
Boğaziçi	9.12%	8.69%	10.76%	10.26%	9.78%
Çamlıbel	7.72%	7.36%	7.02%	6.92%	6.92%
Çoruh	10.9%	10.39%	10.15%	10.15%	10.15%
Dicle	60.96%	50.63%	71.07%	59.03%	49.03%
Fırat	12.59%	11.65%	11.11%	10.59%	10.09%
GDZ	8.48%	8.08%	7.7%	7.34%	7%
Akedaş	10.03%	10.03%	10.03%	10.03%	10.03%
Kayseri ve C.	10.01%	10.01%	10.01%	10.01%	10.01%
Meram	8.59%	8.28%	8.28%	8.28%	8.28%
Osmangazi	7.21%	7.21%	7.21%	7.21%	7.21%
SEDAŞ	7.66%	7.31%	6.96%	6.64%	6.33%
Toroslar	9.38%	8.94%	11.8%	11.25%	10.72%
Trakya	7.7%	7.7%	7.7%	7.7%	7.7%
Uludağ	6.69%	6.9%	6.9%	6.9%	6.9%
Vangölü	46.45%	38.33%	52.1%	43.27%	35.94%
Yeşilırmak	10.35%	9.87%	9.41%	8.97%	8.78%

A new methodology based on calculating the amount of energy distributed was used during the Second Implementation Period.

Targets for reducing the illicit utilization in Dicle, Vangölü, Aras, Toroslar and Bogaziçi were revised in 2012, by regarding that the records in the regions were not reliable, since some of the distribution companies have not yet been privatized.

3.4.3 2016 – 2020: Third Implementation Period

Rules and Procedures Concerning the third implementation period for the Distribution Companies has been published and put in action in 2015. Targets for reducing the illicit utilization and technical losses within the third implementation period, is determined each year annually.

3.5 Cost of Retail Services

Energy supply cost consist of other expenditures, such as energy cost, gross profit margin and retail sales revenue cap. Upper bound for gross profit margin that has been determined as 2.33% by foreseeing the balancing market cost and by referring the retail costs of AYEDAS in the first implementation period, has been kept valid for years 2011-2012, which was the first two years of the second implementation period for the Distribution Companies. Upper bound for gross profit margin for 2013-2015 has been approved as 3.49%. Upper bound for gross profit margin that will be valid for 2016-2020 has been decided to be 2.38% in the Energy Market Regulatory Board meeting in 2015 for third period.

3.6 Taxes

Taxes and other deductions is an additional component comprised of value added tax, which is 18%, municipality tax; 1% for commercial customer group, 1% for others, energy contribution tax 1%, Turkish Radio and Television (TRT) tax 2% added onto the tariffs.

CHAPTER 4

TARIFF MODELS IN TURKEY

4.1 Methodology and Data Set

In this chapter, data set, assumptions and various tariff models for the regulated residential customers are examined. The applied methodology and assumptions used, while in the tariff models, are explained in detail.

Three main cases are studied with respect to different regional cost-based tariff structure for 21 distribution companies in Turkey. In these studies, different scenarios are considered by unbundling the tariff components.

Retail price is calculated as the ratio of the energy supply cost to the energy distributed by the distribution company. In this cost, TETAS tariff price, market swap price and any other incentives costs, such as renewable energy sources are all included. TETAS tariff price published in TETAS 2017 sector report as 16.25 kr/kWh. For simplicity, all the energy distributed is assumed to be taken from TETAS. To find the energy price, including the generation cost the following formula is used;

$$\mathbf{E}_f = (\mathbf{E}_s * \mathbf{TETAS}_p) * (1 + \mathbf{GPM})/\mathbf{E}_s \tag{6}$$

where;
$\mathbf{E}_f$ is energy fee (kr/kWh),
$\mathbf{E}_s$ is the amount of energy given to the system,
$\mathbf{TETAS}_p$ is TETAS tariff price (kr/kWh),
$\mathbf{GPM}$ is gross profit margin (%).

Gross profit margin represents the retail service charge, which is described in detail in Chapter 3 as Cost of Retail Services. Thereby, the same price for energy is calculated as 16.64 kr/kWh with 2.38% gross profit margin for all distribution companies. Gross profit margin is a uniform profile, as specified by regulator for all incumbent supply companies.

Transmission charge is included in the Distribution Cost in 2016, which is the beginning of the third implementation period. That is the reason why, announced last transmission charge for the regulated residential customers will be used for each distribution region. In the cases, transmission charge is 0.95 kr/kWh, which also covers the technical losses in the transmission system, will be implemented uniformly for residential customers all over the country, which is the currently applied methodology.

Distribution charge has two main terms; OPEX and CAPEX. In the studied cases, OPEX and CAPEX terms in the distribution cost will be calculated separately for each distribution region for Scenario 1 and Scenario 2.

Besides, after determining OPEX and CAPEX regionally and calculating their contributions in the tariff, social characteristics affecting the budgets of the distribution companies will be analyzed.

Redemption time will be defined as one year and the average of the investment costs for distribution companies of within five years period, between 2013-2017 will be used as investment cost.

Since similar procedures are followed in every year and OPEX expenditures do not vary as much as CAPEX, operating expenditures in 2017 will be used for the OPEX term in the tariff. Table (4.1) shows the revenue requirement of the distribution companies published by EMRA.

Cost of distribution system losses will be calculated for each distribution region according to the rates of realized losses in that specified area in Scenario 3, since there will be a certain technical loss for each region, but no illicit utilization will be assumed in Scenario 1 and Scenario 2.

Table 4.1: Operational and Investment Budgets of Distribution Companies

Distribution Region	Operating Expenditures (MTL)	Investment Expenditures (MTL)
ADM	79	150
AKDENİZ	189	133
AKEDAS	82	60
ARAS	166	114
AYEDAS	165	121
BAŞKENT	395	332
BOĞAZİÇİ	331	208
ÇAMLIBEL	117	74
ÇORUH	146	89
DİCLE	299	154
FIRAT	117	78
GDZ	244	153
KCETAŞ	80	61
MERAM	233	170
OSMANGAZİ	137	120
SAKARYA	144	81
TOROSLAR	313	189
TRAKYA	83	68
ULUDAĞ	235	161
VANGÖLÜ	122	50
YEŞİLIRMAK	220	142

Table 4.2: Realized Loss Rate of Distribution Companies

Distribution Region	Realized Loss Rates 2017 (%)
ADM	6.00
AKDENİZ	6.67
AKEDAS	5.48
ARAS	24.55
AYEDAS	6.10
BAŞKENT	6.05
BOĞAZİÇİ	6.74
ÇAMLIBEL	6.59
ÇORUH	8.11
DİCLE	64.82
FIRAT	10.95
GDZ	7.25
KCETAŞ	6.03
MERAM	5.77
OSMANGAZİ	6.97
SAKARYA	6.41
TOROSLAR	11.36
TRAKYA	5.09
ULUDAĞ	4.14
VANGÖLÜ	53.3
YEŞİLIRMAK	7.43

4.2 Methodology and Data Set

The three scenarios examined are explained in the following parts;

4.2.1 Scenario 1

In the first scenario, the regional differences among the distribution charges have been examined. In this examination, distribution system losses were not taken into account in the first step, to understand their influence on the distribution system cost, which may vary among the 21 regions.

In this scenario, the tariff components consist of; operating costs of the distribution companies, transmission cost and the energy cost. Investment costs of the distribution companies and losses arising from illicit utilization were not considered. The overview of regulated residential tariff results for each region is presented in Table (4.3).

The total amount of operational budget required for 21 distribution companies is determined after calculating the revenue amounts for each region in the national tariff application. In the case of the national tariff model, the resulting cost would be 19.92 kr/kWh. As seen in the results, 11 distribution companies from 21 distribution companies pay more than their obligations in the national tariff application in this scenario.

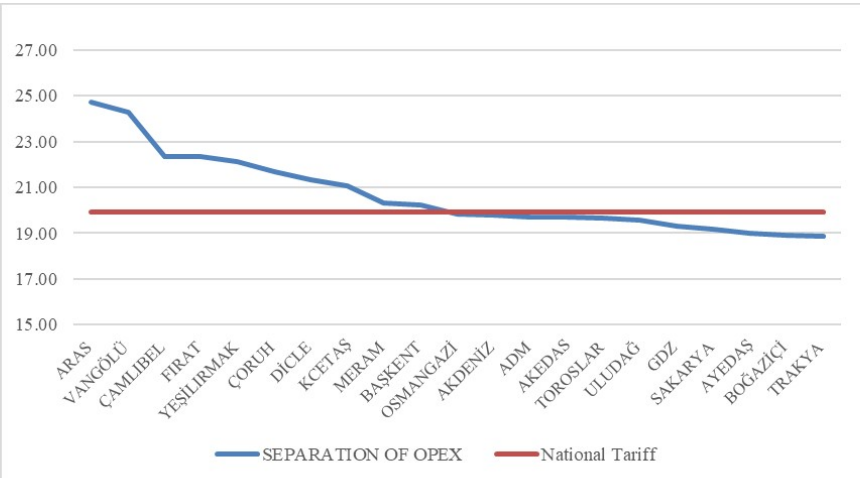

Figure 4.1: Comparison of National and OPEX Based Regional Tariff

Table 4.3: OPEX Based Regional Tariff

Distribution Region	Tariff kr/kWh
ARAS	24.72
VANGÖLÜ	24.29
ÇAMLIBEL	22.34
FIRAT	22.34
YEŞİLIRMAK	22.11
ÇORUH	21.69
DİCLE	21.35
KCETAŞ	21.05
MERAM	20.33
BAŞKENT	20.22
OSMANGAZİ	19.82
AKDENİZ	19.81
ADM	19.71
AKEDAS	19.69
TOROSLAR	19.64
ULUDAĞ	19.57
GDZ	19.29
SAKARYA	19.18
AYEDAŞ	19.02
BOĞAZİÇİ	18.92
TRAKYA	18.87

Since the network features and geographical conditions are different in each region, system operating costs may also vary. For example, in a region, where population and consumption density are higher, the operating cost for meter reading activities and system maintenance activities may be lower. In the scenario, factors affecting the operation budgets of distribution companies are analyzed from this point of view.

In order to examine the effect of the factors on the operation budgets of the distribution companies, several independent variables are identified. Then, these variables have been regressed in different models and their effects on the operation budgets are examined. The purpose of the regression analysis is to determine the statistically significant variables in the models.

Variables in the regression analysis are given in Table (4.4). When the variables have been analyzed statistically in various models, $\mathbf{N}_c$, $\mathbf{d}_c$, $\mathbf{N}_{dtr}$, $\mathbf{L}_{ol}$, $\mathbf{L}_c$, $\mathbf{LT}$ correspond the operation budgets of distribution companies.

The results suggest that each parameter except from consumption density are positively associated with the output. One of the most important points is the correlation between the loss-illicit utilization ratio and OPEX. This correlation shows the fact that the illicit electricity utilization in the regions also affects the OPEX expenditures of the distribution companies, which constitute one of the most important components of the national tariff.

This relationship may be regarded as reasonable when procedures for the OPEX budget are considered. For example, cost of meter reading services may vary depending on the region, since company staff operating on the field may encounter resistances in areas, where a high level of illicit utilization is committed. Another example may be the difference in the number of company staff employed for detecting the illicit utilization. These kinds of activities are more expensive in the regions, where percentage of the illicit utilization is higher than the others.

In this scenario, a sub-scenario has been studied in order to remove the effect of the loss-illicit utilization ratio on the operational budget. The ratio of the distribution regions with high loss ratios were subtracted from the dataset and the average of the others were reflected to all distribution companies.

Table 4.4: Defined Variables of Operational Budget

Variable	Explanation
$\mathbf{N}_{dtr}$	Number of Distribution Transformer
$\mathbf{L}_{MVol}$	MV Overhead Line Lenght
$\mathbf{L}_{LVol}$	LV Overhead Line Lenght
$\mathbf{L}_{ol}$	Total Overhead Line Lenght
$\mathbf{L}_{MVc}$	MV Underground Cable Lenght
$\mathbf{L}_{LVc}$	LV Underground Cable Lenght
$\mathbf{L}_{c}$	Total Underground Cable Lenght
$\mathbf{N}_{c}$	Number of Customer
$\mathbf{G}_{cn}$	Customer Growth Rate, Number
$\mathbf{G}_{cc}$	Customer Growth Rate, Consumption
$\mathbf{S}_{R}$	Rural Total Field
$\mathbf{S}_{U}$	Urban Total Field
$\mathbf{C}_{T}$	Region Total Consumption
$\mathbf{C}_{I}$	Industrial Consumption Rate
$\mathbf{d}_{c}$	Consumption Density
$\mathbf{LT}$	Loss-Illicit utilization Ratio
$\mathbf{C}_{c}$	Consumption per Customer
$\mathbf{\Delta}_{CAIDI}$	CAIDI Change
$\mathbf{E}_{r}$	Elevation of Regions

Table 4.5: Estimates of OPEX Components, Best Solution

Variable	Coeffient
$\mathbf{N}_{dtr}$	0.00095271
$\mathbf{L}_{ol}$	0.001150249
$\mathbf{L}_{c}$	0.004300418
$\mathbf{N}_{c}$	0.0000417
$\mathbf{d}_{c}$	-0.0283145
$\mathbf{LT}$	1.165787813
Constant	-7.364390711
$\mathbf{R}^2$	0.97626
Dependent Variable:	OPEX

The overview of recalculated operating cost and regulated residential tariff results for each region presented in Table (4.6). In the case of the national tariff method, the result would be 19.83 kr/kwh for whole the country.

As seen in the results, 8 distribution companies from 21 distribution companies pay more than their obligations in the national tariff application.

When the loss factor is eliminated, it seems that similar companies remain above the national tariff. This situation explains that the operational budgets of the distribution companies differ with the system size and consumption densities.

Besides, when operational budget based regional tariffs are applied, regions remain above the national tariff are located on the east of Turkey, another point to emphasize is that the income levels of these regions are relatively low. When the regions' gross national product values per capita are added to the graph, tariff levels of regions with lower income are higher than the national tariff level.

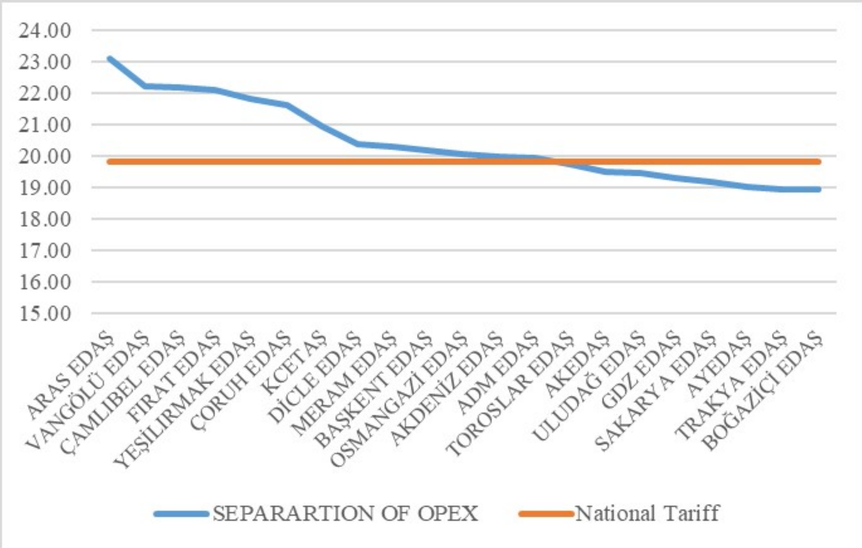

Figure 4.2: Comparison of National and Recalculated OPEX Based Regional Tariff

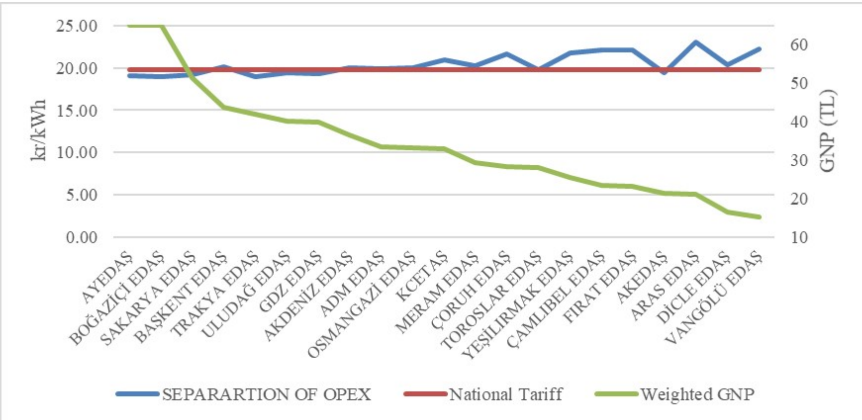

Figure 4.3: Relation Between GNP and Recalculated OPEX Based Regional Tariff

4.2.2 Scenario 2

In this scenario, the tariff components consist of the investment costs of the distribution companies, the transmission cost and the energy cost. Investment costs of distribution companies and the illicit utilization is not considered. The overview of regulated residential tariff results for each region presented in Table (4.7).

The total amount of operational budget required for 21 distribution companies is determined after calculating the revenue amounts for each region in the national tariff application.

In the case of the national tariff method, the result would be 19.29 kr/kwh for whole the country. As may be seen in the results, 9 distribution companies from 21 distribution companies pay more than their obligations in the national tariff application in this scenario.

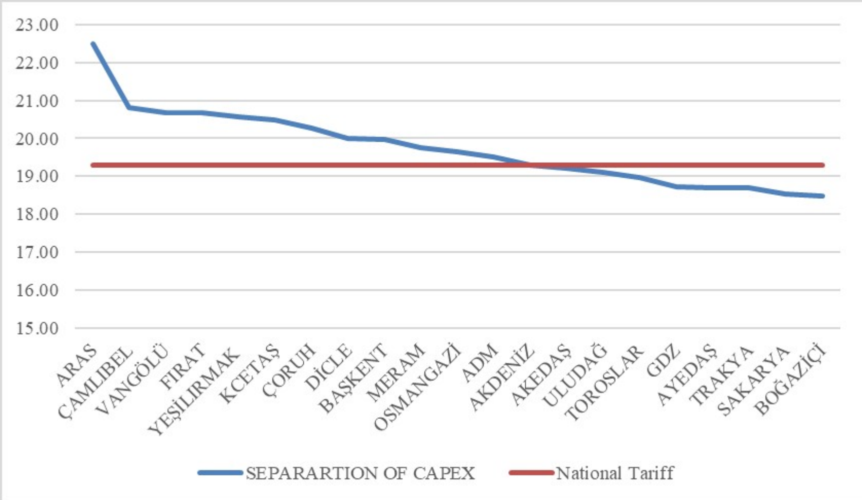

Figure 4.4: Comparison of National and CAPEX Based Regional Tariff

Since the network features and geographical conditions are different in each region, grid investment costs may also vary.

For example, in a region where population and consumption density are higher, the length of line investment per consumer can be lower, but cable with higher unit cost may need to be preferred instead of overhead line. From this point of view, factors affecting the investment budgets of distribution companies were analyzed.

In order to determine the factors influencing the investment budgets of the distribution companies, different independent parameters have been identified. Then, these independent variables were regressed in different models and their effects on the investment budgets, which is defined as the dependent variable were investigated. The purpose of the regression analysis is to determine statistically significant variables in the models. Defined variables are given in the table (4.8)

In the first step, one-year investment data was used. However, results were not statistically significant. In the second step, the 5-year investment data was collected to provide a more detailed examination.

Thus, the effect of financial depth of the company on investment amounts, was tried to be reduced by using long term investment data.

When the variables were analyzed statistically in numerous models, $\mathbf{N}_{dtr}$, $\mathbf{L}_{MVc}$, $\mathbf{L}_{LVc}$, $\mathbf{L}_{ol}$, $\mathbf{d}_c$, $\mathbf{G}_{cn}$, $\mathbf{\Delta}_{CAIDI}$ and $\mathbf{S}_R$ correspond the investment budgets of distribution companies (Table 4.9)

The results show that each parameter except from consumption density, customer growth rate and increment of interruption frequency indices are positively associated with the output. Besides, the regression analysis points out loss-illicit utilization ratio is not correlated to investment budgets. When investment budget based regional tariffs are applied, regions remain above the national tariff are located on the east of Turkey, which is mainly the same result with OPEX based regional tariff, another point to emphasize is that the income levels of these regions are relatively low. When the regions' gross national product values per capita are added to the graph, tariff levels of regions with lower income are higher than the national tariff level.

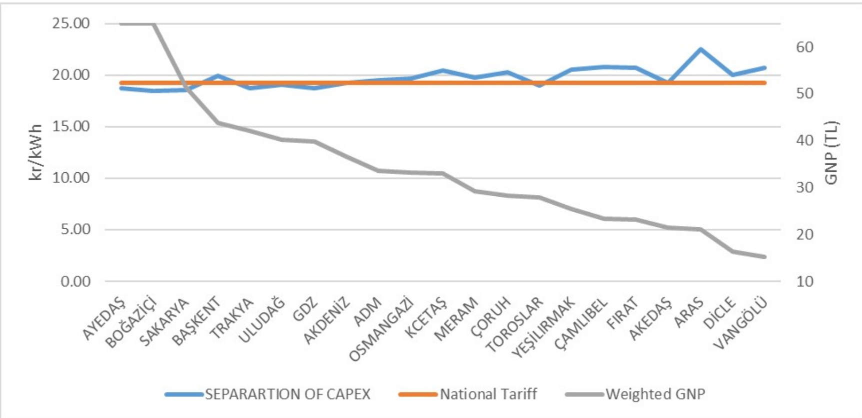

Figure 4.5: Relation Between GNP and CAPEX Based Regional Tariff

4.2.3 Scenario 3

In this scenario, the tariff components consist of the operating and investment costs of the distribution companies, transmission cost, energy cost and cost of distribution loss. The purpose of the third scenario is to examine the regional disaggregation of the distribution loss charge.

It should be noted that distribution charge was reflected at the national level, since to understand the effect of cost of distribution loss, which may vary by 21 designated regions. The overview of regulated residential tariff results for each region presented in Table (4.10).

In the case of the national tariff method, the result would be 24.84 kr/kwh for whole the country. As seen in the results, 18 distribution companies from 21 distribution companies pay more than their obligations in the national tariff application in this scenario.

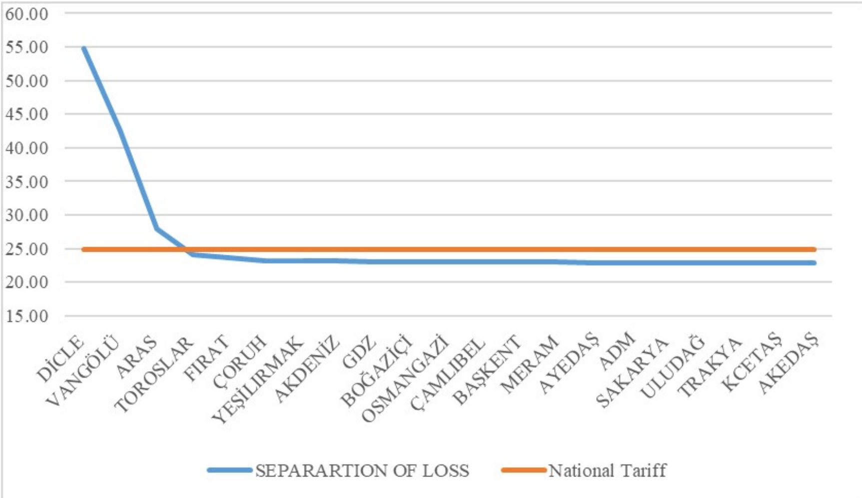

Figure 4.6: Comparison of National and Power Loss Based Regional Tariff

Table 4.6: Recalculated OPEX Based Regional Tariff

Distribution Region	Operational Expenditures 2017 (MTL)	Tariff kr/kWh
ADM	199	19.94
AKDENİZ	204	19.98
AKEDAS	74	19.49
ARAS	128	23.11
AYEDAS	166	19.03
BAŞKENT	387	20.16
BOĞAZİÇİ	329	18.91
ÇAMLIBEL	113	22.18
ÇORUH	143	21.61
DİCLE	220	20.36
FIRAT	111	22.09
GDZ	243	19.28
KCETAŞ	77	20.93
MERAM	231	20.3
OSMANGAZİ	152	20.07
SAKARYA	142	19.15
TOROSLAR	326	19.73
TRAKYA	87	18.94
ULUDAĞ	219	19.43
VANGÖLÜ	84	22.22
YEŞİLIRMAK	206	21.83

Table 4.7: CAPEX Based Regional Tariff

Distribution Region	Tariff kr/kWh
ARAS	22.49
ÇAMLIBEL	20.8
VANGÖLÜ	20.69
FIRAT	20.68
YEŞİLIRMAK	20.58
KCETAŞ	20.48
ÇORUH	20.27
DİCLE	19.99
BAŞKENT	19.96
MERAM	19.75
OSMANGAZİ	19.65
ADM	19.52
AKDENİZ	19.29
AKEDAŞ	19.21
ULUDAĞ	19.09
TOROSLAR	18.96
GDZ	18.72
AYEDAŞ	18.7
TRAKYA	18.69
SAKARYA	18.53
BOĞAZİÇİ	18.48

Table 4.8: Defined Variables of Investment Budget

Variable	Explanation
$\mathbf{N}_{dtr}$	Number of Distribution Transformer
$\mathbf{L}_{MVol}$	MV Overhead Line Lenght
$\mathbf{L}_{LVol}$	LV Overhead Line Lenght
$\mathbf{L}_{ol}$	Total Overhead Line Lenght
$\mathbf{L}_{MVc}$	MV Underground Cable Lenght
$\mathbf{L}_{LVc}$	LV Underground Cable Lenght
$\mathbf{L}_{c}$	Total Underground Cable Lenght
$\mathbf{N}_{c}$	Number of Customer
$\mathbf{G}_{cn}$	Customer Growth Rate, Number
$\mathbf{G}_{cc}$	Customer Growth Rate, Consumption
$\mathbf{S}_{R}$	Rural Total Field
$\mathbf{S}_{U}$	Urban Total Field
$\mathbf{C}_{T}$	Region Total Consumption
$\mathbf{C}_{I}$	Industrial Consumption Rate
$\mathbf{d}_{c}$	Consumption Density
$\mathbf{LT}$	Loss-Illicit utilization Ratio
$\mathbf{C}_{c}$	Consumption per Customer
$\mathbf{\Delta}_{CAIDI}$	CAIDI Change
$\mathbf{E}_{r}$	Elevation of Regions

Table 4.9: Estimates of CAPEX Components, Best Solution

Variable	Coefficient
$\mathbf{N}_{dtr}$	0.001033
$\mathbf{L}_{MVc}$	0.023856
$\mathbf{L}_{LVc}$	0.004276
$\mathbf{L}_{ol}$	0.000251
$\mathbf{d}_{c}$	-0.061543
$\mathbf{G}_{cn}$	-821.535441
$\boldsymbol{\Delta}_{CAIDI}$	-0.273322
$\mathbf{S}_{R}$	0.000476
Constant	35.248816
$\mathbf{R}^2$	0.95703
Dependent Variable:	CAPEX

Table 4.10: Distribution Power Loss Based Regional Tariff

Distribution Region	Tariff kr/kWh
DİCLE	54.78
VANGÖLÜ	42.62
ARAS	27.95
TOROSLAR	24.06
FIRAT	23.63
ÇORUH	23.23
YEŞİLIRMAK	23.19
AKDENİZ	23.14
GDZ	23.08
BOĞAZİÇİ	23.01
OSMANGAZİ	23.01
ÇAMLIBEL	22.98
BAŞKENT	22.96
MERAM	22.95
AYEDAŞ	22.94
ADM	22.9
SAKARYA	22.89
ULUDAĞ	22.89
TRAKYA	22.87
KCETAŞ	22.86
AKEDAŞ	22.84

CHAPTER 5

CONCLUSION AND FUTURE WORK

Different costs arise in the transmission/distribution of electricity to customers. These costs are generally listed as; generation, transmission, loss and illicit utilization, retail service, tax and subsidies; such as renewable incentives costs, which may vary for different regions in terms of topographical, environmental, electricity consumption behaviors and social aspects.

While structuring electricity tariffs, calculation of costs is an important point in the national and cost-based regional tariffs. In other words, various costs arising from distribution designated regions are reflected to whole customers in a country at the same level commensurably, under national electricity tariff scheme.

Electricity system in countries, with electricity liberalization has not yet been implemented, are vertically and horizontally bundled, and hence the national tariff model is used, since it is not reasonable to unbundle the generation, transmission, distribution services, or retail services from each other.

The electric company, in those countries with the electrical services are vertically and horizontally bundled, is called "the Electric Authority", carrying out all electrical activities for generation, transmission and distribution as a single company.

When the electrical services are vertically and horizontally bundled, high costs may come out among the horizontally unbundled distribution regions, leading to high price differences influencing the customers in some of those regions. Thus, the national tariff may be the only applicable tariff model in those countries, unless the vertical and horizontal unbundling have been realized.

For instance, although there are various entities carrying activity in different layers of the electricity, in market and in 21 distribution regions in Turkey, transition from the national tariff to cost based regional tariff could not yet been achieved due to social reactions to be arisen from the price differences among those regions. The national tariff will be kept in action until the end of the year 2020 in compliance with the 4th paragraph of the article decision no: 3015/8317.

In the study, applicability of cost-based tariff in the distribution services is evaluated by modeling three different scenarios, and the results obtained are compared with those in the national tariff model. In the first and second scenarios, operational and investment costs in 21 specified regions were calculated, by ignoring the distribution system losses, in order to be able to evaluate the influence of operational and investment costs of the distribution companies on the tariffs.

Results of these scenarios reveal that the operational cost is affected by the system size, consumption density, number of customers and loss-percentage of the illicit utilization, while investment budget is affected by system size, consumption density, customer growth rate, reliability indices and size of the rural areas. Operational and investment costs distributed in regions tend to increase with the consumption density.

It should be kept in mind that the consumption density and the energy consumptions in these regions are low, where the percentage of illicit utilization is high, since the income in these regions are low. When the gross national product figures per capita are plotted in a graph, tariffs in those regions with lower income come out to be higher. It is also remarkable that the regions under the national tariff are industrial intensive areas, such as Bogazici, Trakya, Ayedas, Sakarya and Gdz. As a conclusion, it is regarded that reflecting the operational and investment costs of the distribution companies at the national level in a national tariff model may be the only applicable solution until the price differences in those regions have been reduced.

In the third scenario, the influence of distribution losses on the tariff is examined. The result shows that customers in 18 of the 21 distribution companies pay more than those in the remaining 3 regions; Aras, Dicle and Vangolu in the national tariff model. Cost-based regional tariff in ARAS, which is one of these companies is just 3.11 kr above the figure calculated in the national tariff.

However, regional tariffs of Dicle and Vangolu distribution companies come out to be much higher because of high illicit utilization. The cost of energy consumed by these illicit utilizations is compensated by about 39 million customers located on the other regions, while the total number of customers is 2.5 million in Dicle and Vangolu.

It may be reasonable to make direct subsidy to the customers in those regions, i.e. in Dicle and Vangolu; by government in order to protect them from the high electricity prices. In other words, treasury of the government may subsidize the customers in those regions in order to reduce the percentage of the illicit utilization profile.

If government provides direct subsidy to those distribution companies, rather than the consumers, distribution companies may be able to provide services at the subsidized prices to the consumers. The target is to encourage and to promote the distribution companies to reduce the power losses in their regions, specifically to reduce the percentage of the illicit utilization. The faster reduction in illicit utilization may lead to faster reduction in the tariff of 39 million users with this method.

The study presented in this thesis seems to have raised new questions. Scenarios include time independent inputs and values. Future work may concern deeper analysis about state estimations of electricity tariff with Kalman filter also known as linear quadratic estimation method. Moreover, multi-objective optimization may be used to study the weight of components consisting of electricity tariff. That is concerned with mathematical optimization problems involving more than one objective function to be optimized simultaneously.

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