Complexity of Electricity Markets and their Regulation: Insights from the Turkish Experience.

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Complexity of Electricity Markets and The Future of Regulation: Insights from the Turkish Experience

Abstract

Electricity pricing models were designed at a time when technology was relatively stable. The natural monopoly model was based on a uni-directional pricing mechanism. Electricity was generated at one end and transferred to the other end. Pollution was not a big issue. There were no solar panels over the houses of consumers. Many contemporary issues of the ecosystem of electricity were not relevant. The tariff model was meant to be a simple one, even though it included many variables. It was not a complex system. This paper argues that a model that was designed within a simple system cannot efficiently adapt to a multidimensional and interdependent system. The use of the old regulatory model within a complex system creates rents and inefficiencies.

This paper evaluates the electricity tariff model in Turkey under the light of recent technological advances and changes in the structure of electricity markets. The changes in the institutional environment of the market bring electricity markets closer to a complex system. We argue that the tariff mechanism should also be revised accordingly. We use the Turkish electricity industry as an example, as it reflects the issues in a developing country.

Keywords: Complexity; electricity distribution; electricity tariffs; regulation; renewables; Turkish electricity industry

1. Introduction

Electricity pricing models were designed at a time when technology was relatively stable. It had the characteristics of the natural monopoly model. The natural monopoly model was based on a uni-directional pricing mechanism. Electricity was generated at one end and transferred to the other end. Pollution was not a big issue. There were no solar panels over the houses of consumers. Many contemporary issues of the ecosystem of electricity were not relevant. The tariff model was meant to be a simple one, even though it included many variables. It was not a complex system.[1] This paper argues that a model that was designed within a simple system cannot efficiently adapt to a multidimensional and interdependent system. Any attempt to use the old tariff model within the new system opens doors to rents and inefficiencies.

This paper looks at the current regulatory model in Turkey from a complexity theory perspective. The regulatory tariff models are based on the assumption of an electricity system with well-designed and stable agents and technologies. Increasing complexity of the electricity system started to change this presumption. More importantly, the changes in the institutional environment of energy markets brings electricity distribution closer to a complex system. However, both the theory and practice of regulation remains stuck in the natural monopoly thinking..We argue that tariff mechanisms should also be revised accordingly. We use the Turkish electricity industry as an example. Turkey is relatively behind in terms of complexity of the electricity systems. Existing problems of implementations and imperfections of the tariff model increases the costs of not adapting to a complex market order. Obviously, the issue is relevant for many countries that use some kind of tariff model.[2]

Electricity tariffs are based on the strict separation of supply and demand. Regulatory policy controls the supply with a given demand structure. It assumes that the boundaries of supply and demand are well defined. When the boundaries become blurry, the regulatory tariff model becomes unsustainable, as the ‘Sun Tax’ experience in Spain shows. When consumers began to be producers and reduced their demand for grid-supplied electricity, the costs for existing customers increased, creating a vicious circle for the grid. The ensuing implementation of grid-tax on solar power made things worse leading to the elimination of the ‘sun tax’. The increasing complexity of the system could not be controlled with a centralized Pigovian tax.

Recent advances in technology are not limited to new methods of generating electricity. Consumers control their consumption with different devices such as storage beyond the meter and intelligent appliances. Devices such as smart thermometers and advanced appliances influence patterns of consumption and weaken the century-old assumptions of the electricity

[1] The distinction between simple and complex systems is based on the complexity literature. See Page (2011) for a general discussion.

[2] Rate of return or price/revenue cap models are widely used in tariff mechanisms around the world (Joskow, 2008; Viscusi et al., 2005).

industry. Electricity infrastructure moves toward being a platform that brings together different parties rather than being a one-way production system from generation to consumption.[3]

Technological advances, even if they are widely observed and studied, have not triggered a need for change in regulatory models around the world. Even in the advanced economies such as the United States and EU countries, the dominant policy is to wait and see how the change in technology will play out in terms of regulatory consequences (Revezs and Unel, 2020).

The large scale utilities will continue to dominate the energy markets for the foreseeable future. However, the fall in costs of individual generation and storage facilities increase decentralization in terms of pricing-decisions. The existence of arbitrage opportunities for consumers make utilities more vulnerable to non-regulated aspects of electricity markets.

Technological advances move very quickly to developing countries. For example, Turkey's renewable market has grown substantially over the last decade. The regulatory model in Turkey has its own imperfections. The inefficiencies of the system is widely discussed in the literature (Cetin and Oğuz, 2007). In general, design problems, the openness to political interference and institutional shortcomings can be traced back to deficiencies in pricing mechanisms. The privatization model in Turkey was intended to bring more competition to the industry. Yet, the policy-makers could not pursue competition-based policies forcefully (Ulusoy and Oğuz, 2007). Legal setbacks and economic constraints limited the process. The model assumed a smooth process of transition based on the theoretical model of privatization process (e.g., Megginson and Netter, 2001). However, strong interdependencies among stakeholders made the outcome uncertain and indeterminate.

While there is a growing literature on different aspects of the Turkish electricity markets, the challenges for the regulatory model that originate from increasing complexity of the electricity system has not taken much attention. The dearth of studies that focus on the economic consequences of the tariff model provided the motivation for this paper. We aim to contribute to the literature by discussing the potential and actual problems with the existing model and address policy issues surrounding it.

The paper starts with a discussion of basic characteristics of complexity and its implications for energy markets. In the second section, we outline major changes in energy markets that contribute to the complexity of interactions among market participants and regulators. The third section focuses on the regulatory model in the Turkish electricity markets. Our emphasis is on the structure of the tariff mechanism. The fourth section focuses on problems in the current model that originate from regulating a complex market with a model that cannot account for complexity. We also discuss the consequences of inability to implement the current model. We conclude with recommendations about the future of the tariff model in Turkey.

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[3] Some recent work argues for a Uber of Airbnb type of role for electricity distribution (eg., Kiesling et al. 2019). Even though electricity markets are still far from this point, technological advances make it more plausible as time passes.

2. On the Complexity of Modern Electricity Markets

Let us start with the distinction between a simple and complex system (Mitchell, 2009; Page, 2010).[4] Melaine Mitchell (2009: 13) defines a complex system as 'a system in which large networks of components with no central control and simple rules of operation give rise to complex collective behavior, sophisticated information processing, and adaptation via learning or evolution.' What separates a complex system from a simple one is the role of adaptability and interdependency.[5] In complex systems, agents can change their behavioral patterns and adapt to new situations. The second characteristic of a complex system is about existing interdependencies between agents. Being part of a network becomes a bigger factor than individual traits of agents. These characteristics are essential parts of current electricity markets at different levels.

The modern electricity systems evolve toward complex adaptive systems. They have become adaptive and interrelated in many respects from generation to retail markets. Central command over the system becomes increasingly absent. Understanding each sub-sector or agent does not tell much about the whole system (Bale et al., 2015).

Until recent times, electricity markets did not involve much complexity. However, economic and technological advances made them complex systems. In a modern energy system, there are many agents such as households, suppliers, regulators, governments and so on. They continuously adapt themselves to a changing environment. Having only limited knowledge and ability to interpret the environment, they cannot act as perfectly rational. Bounded rationality of actors in the electricity system along with interdependency and adaptive behavior turns electricity into a social evolutionary system, which goes beyond the engineering model underlying the supply of electricity.

Social networks of agents are central decision-making processes along with physical characteristics of the energy system. Institutions start to play a major role in decisions by households' electricity consumption and government policies toward the suppliers. A spontaneous order evolves out of these interactions. Disequilibrium dominates outcomes and norms and institutions evolve to reduce frictions in the system. Path dependency and adaptive behavior dominates the system. In the end, electricity is generated and consumed, yet the process and outcome take a shape different from any well-designed equilibrium model anticipates. It no longer fits the simple model of neoclassical economic optimization.

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[4] The complexity theory, or complex adaptive systems, has advanced substantially for the last three decades, particularly after the founding of the Santa Fe Institute. Since our intention is not to delve into this literature, we provide a very simple description.

[5] There has been some recent work that apply complex adaptive systems to electricity markets (e.g., Bale et al. 2015, Lukszo, 2018). The simulations developed in the literature usually assume a decentralized, multi-agent, multi-equilibrium processes. There are also recent concepts such as Transactive Energy that would potentially bring more decentralization to electricity markets. See Yin et al. (2019) for a discussion.

In complex electricity systems, individual participants control almost nothing, but affect everything.

Electricity has long been described as a natural monopoly (Cornell and Kihm, 2015). Provision of electricity through a monopoly franchise was meant to be a practical solution rather than a theoretical advance. Yet, it has become the standard model of regulation in electricity markets, particularly in distribution. The natural monopoly model assumed that there was a one-way relationship between generation and retail. It required regulation by the government via price and quantity controls. The tariff model did not have any mechanisms for interdependencies within the system. For example, consumers were not allowed in the model to be producers at the same time and they did not change their position depending on market signals. Each segment of the market was modeled separately. For example, the function and cost structure of a distribution company was shaped by this one-directional relation from transmission to wholesale market.

In a typical electricity tariff model, there are many variables and the model gets very complicated in many instances. At this point a distinction should be made between complex and being ^complicated', following Page's description (Page, 2011). A complicated system can involve many variables and huge amounts of data. As long as it does not involve adaptability of agents and interdependencies between them, it is not called a complex system. For example, chess is a very complicated game, but it is not a complex one, as pieces in the game do not change the way they act during the game and actions of pieces are independent.

Models developed within the complexity science provide tools to investigate the interactions between elements of a system.[6] The emergent behavior of the system and the way it responds to its environment can be studied in an evolutionary way. The concept of complexity is used in electricity literature to refer to engineering and economic optimization problems that have to be solved (Crampton, 2017: 591). In the terminology of complexity theory, unless endogenous adaptation and interdependency play a dominant role in decision-making process, it remains as a complicated model, not a compex one.

A complex system can be modeled based on a number of characteristics (Bale et.al., 2015):

- Agents
- Networks
- Dynamics
- Self-organization
- Path-dependency

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[6] Complexity theory started mostly with the work by the Santa Fe Institute in the United States. The pioneering work by Brian Arthur and others made it possible to analyze economic activity as a complex adaptive system (Arthur, 1999). Friedrich Hayek was also instrumental in providing the outline of complex systems (Fiori, 2009).

- Emergence
- Coevolution
- Learning and adaptation

Agents, for example, refer to individuals or groups within the system. Complexity models are able to account for the learning and adaptation by agents with the help of advanced computing technologies. They respond to changing conditions and evolve in terms of their behavioral patterns. In an energy market, households are typical examples of agents. They can constantly change their electricity consumption, become producers and affected by the legislation or infrastructure.

Agents and other components of energy systems are usually studied by equation based models in a partial equilibrium or general equilibrium context. More sophisticated models such as Computable General Equilibrium (CGE) can include many variables. Yet they remain in the area of simple models as they cannot account for adaptation and interdependence in an evolutionary environment. Tariff models used for regulating electricity markets are very complicated models. However, they are in the spirit of natural monopoly pricing. Even though their system is very complicated, a natural monopoly model of electricity distribution does not have the characteristics of a complex system. The regulation of a complex system with a simple tariff model opens doors to inefficiencies in many instances.

Recent developments such as agent-based models were developed to address issues with static modeling. Yet, their complicated structure did not find many advocates among practitioners. Complex adaptive systems have begun to be used to provide tools to deal with increasing dynamic structure and complexity of the system.[7]

The evolution of the electricity grid from a complexity perspective can be described in the following way (Lave, 2016):[8]

1. Traditional Modeling: Based on well-established physics and mathematics. Electricity is thought to be an engineering subject. Right mathematical construction is sufficient to solve any grid problems. Calculating power flow with known loads and generation can be given as an example. Decisions about the necessary line rating, current amount etc. can be done easily within this modeling.
2. Non-traditional Modeling: Uncertainty can be introduced into the model, as more data becomes available. Complicated models such as stochastic optimization models

[7] For example, Argonne National Laboratory is in the process of developing the Electricity Market Complex Adaptive System Model. See https://ceeesa.es.anl.gov/projects/emcas.html. Its models are designed for regulatory authorities interested in market structure and its effect on consumers, transmission and market operators. The model provides guidance to understand the electricity system, market performance and strategies by distribution companies. See also Sanstad (2015) and Tesfatsion (2018).

[8] Lave (2016) provides a detailed analysis of implementation of complexity to energy markets.

become possible to use. Questions such as how to account for intermittent solar power for supply security can be dealt with in this perspective.

3. Complex modeling: Complex systems involve human action in a learning and evolving environment. Determining the probability and effects of events that happen seldomly. Simulations about weather changes, cascading failures, agent-based models can be given as examples to used models. Decisions about designing best electricity grid structure to optimize resilience can be made by using these models.

There has been some recent work on implementing complexity theory in electricity systems such as smart grids (Pagani and Aiello, 2011), the behavior of agents such as prosumers' activities and dynamic behavior of the grid and studying cascading failures in interdependent networks. Recent applications of complexity theory in electricity markets reflect the increasing decentralization of the electricity system. An electricity system starts to look like a self-organizing process, rather than a static engineering model.

While electricity systems evolve into complex models, the regulation of these systems still follow the traditional modeling. In the rest of the paper, we look at the regulatory model and emphasize the necessity to create an adaptive tariff model to address the dynamic structure of a complex electricity system.

Technological advances increase interdependency and make the agents more adaptive to changes. In the next section, we touch upon a few major changes in electricity systems, which are extensively dealt with in the relevant literature.[9]

3. Reasons for Reconsidering the Regulation of DSOs

The regulatory model of electricity distribution was designed when the technology was relatively stable. It started with the rate of return regulation and evolved into the incentive regulation models. Many countries around the world implement some kind of incentive regulation model such as price and revenue caps (Joskow, 2008). When Stephen Littlechild and Michael Beesley (1980) first developed incentive regulation, it aimed to eliminate the problems of the rate of return regulation. The goal was to replicate competitive outcomes as closely as possible. Regulation was a transitory stage in the transition to a competitive market.

During the last few decades technology has advanced substantially and the natural monopoly model started to create inefficiencies in the tariff model. One example may give some idea on the speed and size of the change. The share of solar in the new installed capacity is increasing around the world. It was around 50% percent in the U.S. in 2017. The same trend is observed in many developing countries as well. For example, there has been a substantial increase in solar panels beyond meters in Turkey (Bulut and Muratoglu, 2018). The fall of the cost per kw is the major factor in this increase in the share of solar. The cost of residential solar systems has

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[9] There is now an expansive literature both academic and non-academic. See IEA (2016) for a general discussion.

dropped more than 70 percent since 2010 (Fu et al., 2018). Even though the cost of residential solar has not dropped to a level that encourages people in cities to install solar panels en masse, technology is not far from that point.[10]

In the traditional regulatory model, DSOs had the role of being 'transporters' of electricity. Thus, they had to provide some kind of universal access to electricity. They were assumed to provide the service as efficiently as possible and transfer gains of efficiency to consumers.

The role of DSOs changed substantially in the last decade. The following are some of the major changes (Perez-Arriega and Knittel, 2016):

1. One fundamental change came from advances in distributed generation. The advances in wind and solar power and small scale hydro turbines changed the structure of the supply and demand. Advances in small scale generation such as rooftop solar also changed the relationship between the DSO and consumers. As a result, not all electricity goes through the distribution system. Bilateral contracts that bypass the distribution segment and generation by consumers increase the average cost of the grid-based consumption. The reduction in the share of electricity through the distribution system makes the existing tariff model unsustainable in the long-run.
2. Advances in storage technology and electric vehicles create diversification and increase the share of electricity that move beyond the distribution market. The distribution tariffs started at a time when distribution meant using a resource that was not storable, and the use was not a substitute for other energy resources such as oil.
3. Technological advances have the tendency to decrease the DSO revenues (Pérez-Arriaga, 2010). The integration of distributed generation, energy conservation measures and other factors reduce electricity demand during the implementation periods. The increasing flexibility of non-distribution components of electricity markets increases the complexity of the system.
4. The revenue-cap model does not encourage innovation as expected. Empirical studies show that the ratchet effect is more prominent in the industry. The model does not have any variable or component to reduce the ratchet effect. In other words, it encourages x-inefficiency of distribution companies.[11]

In this changing environment, the role of DSOs also evolves. They become more than just a network operator. Advances in financial and technological dimensions require changes in the tariff model as well. These advances in technology create the possibility of transforming electricity distribution into a platform market rather than being an integrated entity (Kiesling et

[10] Falling costs in commercial and utility level solar has been higher than residential solar over the last decade (Fu et al., 2018). The difference between change in utility and residential level solar costs create potential issues on the long-term sustainability of the grid.
[11] Ratchet effect is widely overlooked in regulation of distribution companies. It signals the DSOs that they do not have to improve their efficiency, as there is no clear way of measuring productivity increases apart from comparing DSOs relatively. See Hellwig et al. (2018) for an empirical analysis of the ratchet effect in the German electricity markets.

al., 2019).[12] The change in electricity markets can be seen as similar to developments in other platform markets. The fall in transactions costs makes the integrated entity of a distribution company relatively more inefficient in comparison to other alternatives such as vertical disintegration of the distribution operator. Kiesling et al. (2019) argues that “as peer-to-peer transactions in energy capacity become more feasible, our results suggest that ownership of DER capacity will be driven less by one’s expected intensity of use and more by relative price concerns and subjective preferences for energy self-sufficiency or environmental attributes.”

While the physical and regulatory characteristics of the electricity industry do not allow for complete platform markets, falling transactions costs make the distribution companies vulnerable to competitive forces. Advances in technology will give way to more electricity equilibrium beyond the meter.

4. Regulating A Complex System with Price Controls

The reason for economic regulation is to enhance efficiency and fairness in the market simultaneously (Viscusi et al., 2005). The price/revenue cap models used by regulators around the world aim to establish a balance between providing the service with reasonable profit and encouraging the firm to reduce the cost of the service. The firm is guaranteed to retain productivity gains for the regulatory period. The price-cap regulation includes complicated mechanisms to keep different aspects of service under control such as service quality and network security. Successful implementation of the regulation depends on the information flow to the regulator. DSO should be able to provide necessary information to the regulator in a timely manner and reliably.

As the electricity system becomes more complex, the ability of the regulator to govern the industry harder. For example, firms adapt to the regulatory period. Incentives provided by the regulator become less attractive to DSOs toward the end of the implementation period especially for capital expenses (CAPEX), creating issues such as ratchet effect and x-inefficiency.

While there has been major theoretical advances to integrate incentive-based regulatory models with contract theory (Laffont and Tirole. 1993), these works could not penetrate into practice to a great extent. The use of game theory and dynamic/strategic behavior provided tools to reduce principal-agent problems of the industry. These models, even though they are complicated, are not suitable to deal with complexity as they are based on static relationships between independent agents.

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[12] While electricity has had its share of unbundling in recent decades, the separation of distribution monopolies into sub-markets seems to be next, as many services provided by an integrated distribution entity can be obtained from the market. Competition pushes utilities to rely on markets as much as possible to stay profitable..

In a complex market environment, the regulatory authority can only nudge market participants toward efficiency by closing the gap between price and marginal cost. The natural monopoly model starts from the assumption that natural monopoly's cost structure and the available demand is exogenous to the model. Regulatory policy is used to alleviate inefficiencies in the system by designing tariff models, assuming that market participants do not change their behavioral patterns and act according to the model during regulation. These assumptions hold in industries where technology and demand do not change quickly. Electricity was the typical example along with water supply and telecommunications. In recent decades, electricity has started more like telecommunications than water supply in terms of being open to competition.

A major issue with the existing tariff model is its assumption of constant technology. Since the model was designed in a period where the technology of distribution did not change substantially, the evolution of technical and economic aspects of tariffs was not part of the model. Technological advances in electricity markets have increased the complexity of the industry substantially. Generation and wholesale/retail markets have become relatively competitive in recent years. Transmission remains a natural monopoly for the foreseeable future managed by the state enterprises in most cases. Distribution is close to losing its natural monopoly characteristics in the economic sense as a result of recent advances such as distributed energy resources (DER).[13]

Regulatory model was usually thought to be part of a regulatory reform in many countries (Joskow, 2008). Electricity industries around the world evolved toward a more competitive structure, and DSOs began to see that electricity distribution was not a risk-free market. The establishment of the energy exchange and the evolution of complicated market transactions such as bilateral trading contracts created problems for inefficient distribution companies.

In the beginning of regulatory reforms, the infrastructure was not expected to change quickly. The natural monopoly characteristics of the industry were assumed to remain intact for the foreseeable future. Thus, observing inputs and guaranteeing distribution companies some profit margin through regulatory processes were thought to be the right way to go. As a regulatory tool, the revenue-cap model in the distribution sector required the close monitoring of the industry by the national regulatory agency.

5. Dismissing Complexity in the Turkish Electricity Markets.

While the basic regulatory model in many countries are based on the theoretical model of incentive regulation, problems with implementation create major differences. There are many examples of the mismatch between a complex reality and simple regulatory model. Here we will touch upon a few issues to show the problem.

[13] Distribution companies, however, may stay as legal monopolies for non-economic reasons, even though economic reasons for protecting monopoly disappears.

The current regulatory model of electricity distribution was established in 2001 in Turkey. The lack of investments, vast inefficiencies in the industry, and increasing demand contributed to the move toward liberalization (Atiyas et al. 2012; Cetin and Oguz, 2007). However, the model did not have the necessary incentive mechanisms for DSOs to follow the privatizations completely. The absence of well-defined monitoring mechanisms over DSOs was a major impediment on the effectiveness of the regulatory model.

After the completion of distribution privatizations in 2013, the electricity industry evolved toward a more competitive structure, and companies began to see that electricity generation was not a risk-free market. The establishment of the energy exchange and the evolution of market transactions created problems for inefficient companies and put pressure on the downstream segments of the market.

In the beginning, the infrastructure was not expected to change quickly. The natural monopoly characteristics of the industry were assumed to remain intact for the foreseeable future. Thus, observing inputs and guaranteeing distribution companies some profit margin through regulatory processes were thought to be the right way to go. As a regulatory tool, the revenue-cap model in the distribution sector required the close monitoring of the industry by the national regulatory agency. However, mechanisms that would reduce the transactions costs of monitoring were not in place and the information asymmetry between the regulatory agency and the regulated firms became widespread. Regulatory models encouraged inefficiency in the industry. Asymmetric information problems have given way to stricter regulation of the industry.

Regulatory issues in Turkey are mostly about debts of generation and distribution companies and how to keep consumer tariffs lower (Dilli and Nyman, 2015; Ozbugday et al. 2016). The focus on short-term goals that are closely related to political preferences make it difficult to put long-term issues to the forefront. To give an example, even though the current five-year implementation period ends in 2020, the model for the new period is still uncertain and there is not any discussion about how to account for technological advances within the new model.[14]

While tariff models are complicated and differ in their structure, the widely used approach is to design a key distribution tariff model and relate it to retail tariffs. In Turkey, distribution tariffs create inefficiencies and are not designed to encourage competitive behavior.

5.1. Illegal Use and Productivity Parameter

The regulatory model of revenue cap is based on reducing costs by increasing productivity of firms in the industry. In a successful implementation of the model, efficiency in the industry and

[14] There are a number of EMRA-approved research projects by distribution companies on the tariff structure, renewables and microgrids. However, there is not any indication that these projects will provide input to the rate-making process in the beginning of the new implementation period.

productivity of firms are expected to improve. Empirical evidence shows that distribution companies are reluctant to improve efficiency (Hellwig et al., 2018).

The initially designed model neglected institutional issues of energy markets in Turkey with the expectation that they would be mitigated in the future. Both distribution and retail tariffs include variables that increase the difference between price and marginal cost and distort incentives in the market. Political expediency was one of the reasons behind this approach. The government did not want to create more issues in the industry (Cetin and Oğuz, 2007). It also assumed that competition would take care of some of the issues gradually. This view was based on a static understanding of the concept of competition. The adaptation of market participants, particularly distribution companies, to the new institutional framework made existing issues such as long-term contracts part of the long-term model. To give an example, the cost of electricity theft is included in the national tariff as part of the distribution charge. Since illegal electricity use is around 16%, the addition of illegal use to the national tariff creates a number of inefficiencies as discussed in the literature (Yurtseven, 2015). The model is designed under the assumption that there would not be any leaks in the system such as illegal/unmetered use. Illegal use changes incentives of electricity users. Those who do not pay tend to use electricity excessively. Those who overpay tend to reduce their consumption creating deadweight losses in the market. The distribution company neglects measures to reduce illegal use as long as it gets paid. And, the regulatory authority prefers not to create any political burden for the government. Neglecting the adaptability of behavior and interdependencies between agents in the model creates an environment where the regulation supports inefficiency and rent-seeking instead of reducing them. As a result, illegal electricity use rates remain high (Orucu and Antmann, 2016)

A major regulatory issue in the distribution tariff is the way productivity parameter is calculated. The productivity parameter is key to encouraging firms to eliminate inefficiencies wherever possible so the market moves toward competition. It is intended to incentivize distribution companies to improve productivity. However, the EMRA has chosen to set the x-parameter to some distribution companies until the end of the current implementation period. In this way, productivity parameter loses its close connection with core of the incentive regulation, namely providing incentives to distribution companies (Orucu and Antmann, 2016: 38). This gives the wrong signal to companies about inefficiencies in the industry. Since the distribution model in Turkey is based on the balancing across regions in terms of revenues and expenditures, no distribution company is pushed hard to increase efficiency (Özbuğday et al., 2016)

5.2. Distribution and Prices

Similar problems arise in terms of retail prices as well. The regulatory model kept the price equalization and cross-subsidies across regions intact even though they were assumed to be transitory. The regions with high illegal electricity use are subsidized by regions with surpluses (Atiyas et al., 2012). These tools have become part of the institutional framework.

Retail price is an average price determined by the EMRA. They are independent of the marginal cost of supplying electricity across regions and across time.[15] Consumers do not pay the actual marginal cost but an average price[16], which distort incentives for efficiency. On a typical summer afternoon, those who consume more electricity tend to pay less than their true marginal cost, as they pay average prices. And the model does not differentiate in terms of willingness to pay. It is used as a cross-subsidy mechanism as in the case of the policy of charging different prices to the industrial customers and household.

An efficiency-enhancing model is expected to adapt to changes in consumer behavior. For example, small scale electricity generation by consumers would change the regulatory model. Increasing share of solar energy such as rooftop solar panels and individual level storage makes demand for distributed electricity more elastic. The result is reduced consumption, increasing grid costs and further reductions in demand. The existing distribution tariffs cannot survive in the long run.[17] In the existing tariff mechanism, retail rate does not reflect enough information signals for consumption and production. Thus, most customers do not change their consumption pattern even when a time-varying pricing mechanism is used. As prices increase in summer afternoons, consumers/producers should have the option to reduce their consumption and not buy/sell the electricity they generated to the system based on price signaling. The implementation of a tariff model that accounts for this complexity would create a major change in terms of distribution costs and sustainability of the grid.

The regulatory model in the Turkish electricity industry is tilted toward the health of the distribution segment. Distribution companies are the center of the system. The government gives special emphasis to making sure that they obtain a reasonable profit. There is also pressure from the consumption side as increasing tariffs comes with political consequences. Thus, the model aims a balance between keeping prices low and profits for distribution companies high at the same time.[18] The tension between these conflicting aims has increased inefficiencies in the market during the last decade. To this end, Köksal and Ardıyok (2018) argue that renewable energy support mechanisms and distortive level of regulated retail tariffs make efficient working of the electricity market difficult. As the feed-in tariff mechanism provided suppliers protection from price volatility, more suppliers joined the system and made the renewable support mechanism unsustainable competitively. As a general rule, when the demand has some responsiveness to prices, political interference in the market would only

[15] As Borenstein and Bushnell (2019) shows, continuously fluctuating demand changes private marginal cost in the same way. However, retail prices do not change in the same way. They are determined by the regulator in long intervals. The difference between demand changes and retail prices create deadweight losses in the market. More importantly, it distorts incentives for consumers. Their consumption increasingly becomes unresponsive to price changes.

[16] The consumer price is not an approximation of the cost of electricity. Instead, the price follows political preferences more closely than it follows the changes in economic costs (Oğuz et al., 2014).

[17] Policies such as Spain's Sun Tax make things worse in terms of efficiency.

[18] This can be seen as an example of the Peltzman model on regulation. In an industry with high levels of debts and widespread inefficiencies, the protection of distribution companies means more deadweight loss and rent-transfer from consumers to distribution companies (Peltzman, 1989).

increase inefficiency and encourage rent-seeking.[19] The electricity market has a complex structure and participants can adapt to changes in the rules very quickly without making a distinction between productive and unproductive entrepreneurial activities. Similarly, interdepencies across players and market segments make political interferences more costly. Including more suppliers to the renewable support mechanisms contributed to the distortion of the wholesale electricity prices, as suppliers are guaranteed to sell all of their capacity.

A major problem in the Turkish model is the absence of capacity pricing, as it is closely related to the complexity of the system. Most of the literature in economics focuses on how to price electricity use. When there is widespread difference between capacity and actual demand, real-time pricing cannot accurately reflect the market demand and supply.[20] Currently, there is a big difference between the capacity and actual use of electricity. At the end of 2017, the installed power capacity was around 85,000 MW.[21] The peak demand, at the same time was around 47,000 MW. The absence of an incentive mechanism to reduce excess capacity invites new investment into the generation market. Correct peak-demand charges that reflect avoidable capacity costs could incentivize consumers move away from electricity use during peak time periods (Revezs and Unel, 2017).The absence of a connection between the capacity and electricity demand in the tariff methodology has encouraged 'too much' investment in the electricity generation. Renewable energy investments remained too high as well. The existing feed-in tariffs in Turkey encourages firms construct wind and solar power plants at a much faster rate than the efficient level since they do not undertake excess capacity costs. These costs are borne by the society because of the way the incentive mechanism is designed.

The above examples show that the existing tariff model is already flawed. They refer to cases where flaws in the model aggravate the costs even without considering increasing complexity in the market. It carries forward the institutional defects and reduces the efficiency of the electricity markets.

5.3. Renewable Tariffs and Complexity

Feed-in tariffs for renewable energy sources are determined under the assumption that suppliers will not change their behavioral patterns. However, suppliers as agents adapt to the new tariff mechanisms quickly and create unintended consequences, if treated as static players. The recent experience in the Turkish renewable support system, as discussed below, is a good case in point, even though the examples are abound around the world.

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[19] This point is, even though widely accepted by most economists, usually overlooked in electricity markets.
[20] See Borenstein, S. and S. Holland (2005), On the Efficiency of Competitive Electricity Markets with Time Invariant Retail Prices, Rand Economic Journal, 469.
[21] http://www.mondaq.com/turkey/x/782900/Renewables/Energy+2019

6. Conclusion

Regulation started as an intervention to a one-directional simple model. Now, it has to adapt to the evolving and complex electricity system. Increasing complexity brings more decentralization and regulatory policy needs to have tools to adapt to the new environment. A model that is designed to work in a simple environment cannot deal with an adaptive and interdependent system. As the economic ability of market participants and the legal framework in the market diverge, incentives for rent-seeking and inefficiencies in the industry would increase (Barzel, 1997). Controlling a complex system with simple tools would encourage wealth transfers in the society.

The widespread availability of new technologies such as distributed energy resources, smart meters and smart appliances play a major role in the transformation of traditional uni-directional model of electricity tariffs. The generation beyond the meter and increasing consumer control over the timing of consumption, adaptability of the consumer to the changes in tariffs create more inefficiencies in the system.

The changing ecosystem of electricity increases interdependencies in the system as well. In the old unidirectional model, the dependency of the production system from generation to retail depended only on the demand of the consumer. Now, the consumer has the generation capacity and more power over the timing of consumption. This makes the decision-making in the tariff mechanism multi-faceted.

Recent advances in platform markets will also affect the institutional structure of electricity markets. The distribution companies are the heart of the system in Turkey. Integrated distribution companies have started to become the origins of inefficiencies in the market rather than solutions to existing market failures. Distribution provides services that can be bought in the market to an increasing extent. The reduction in measurement costs creates sub-markets for many services provided by the regional distribution monopolies. They started to outsource many of their services to other firms to keep up with the increasing competition. The system has many characteristics of an evolution toward a platform-based market model.

The concept of opportunity cost requires forward thinking. This also requires making a distinction between 'sunk costs' and 'economic costs'. An efficiency-enhancing tariff model should be designed with a focus on 'economic costs' rather than aiming to recover sunk costs of distribution companies. Normally, marginal costs are expected to be lower than average costs in distribution. However, inefficiencies in the market do not allow evolving complexity to infiltrate the distribution model because of the natural monopoly model. This has been a major issue in the privatization of distribution companies in Turkey (Özbuğday et al. 2016).

The incentive regulation model is used widely around the world. Its problems are also well documented. The problems with the price cap and revenue cap models in the distribution market have led to a move toward more output oriented tariff models. The problems of estimating, benchmarking and even defining CAPEX and OPEX push regulators toward observing output variables so that the need for investigating the expenditures of a distribution company is reduced. As a result, the output based, or result-based, regulatory models have become the subject of research, especially after the implementation of the RIIO model in the United Kingdom.[22] While the UK model is new and its success is not certain, the need to modify the revenue cap model is clear. Turkey needs a model that looks to the future rather than aiming to solve the problems of the past.

Neglecting issues on regulatory dynamics as a result of increasing complexity contributes to the cost of electricity and creates a tension between legal structure and economic behavior. The result is increasing transaction costs and more regulation. Overregulation becomes the norm.

As the new implementation period approaches in Turkey, the existing tariff methodology requires a substantial revision based on the past experience. Technological advances, changes in the demand structure and a more adaptive behavioral patterns by market participants necessitates a new tariff model that can accommodate the evolving complexity of electricity markets. However, the existing debates in media and literature do not provide any signal for a major change. This is unfortunate as the current system encourages inefficiency and punishes productivity gains.

[22] The model is known as 'the RIIO model' (Revenue = Incentives+ Innovation + Output). In this model, the outputs such as consumer satisfaction, reliability and availability, safety, connectivity, environmental impact and social responsibilities are being considered. Each DSO submits an 8-year plan that specifies total expenditures rather than CAPEX and OPEX separately. The aim is to balance conflicting incentives for reducing costs and increasing investments.

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