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IX.47 Energy networks, natural monopolies and tariff regulation

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Abstract

Energy networks, such as the networks for the transportation of electricity and gas, are natural monopolies, which implies that competition among these networks is not possible. In order to protect network users against monopoly prices and to give the network operators the incentive to operate efficiently, many countries have implemented tariff regulation. After discussing the economic consequences of natural monopolies and the need for regulation, this chapter briefly compares the various types of tariff regulation, discussing the incentive power, the ability to make a profit, and the reward on the costs of capital. The chapter concludes by discussing how tariff regulation may enable network operators to finance the necessary investments to connect new renewable energy production facilities.

Keywords

Natural monopoly, network regulation, electricity and gas networks, tariffs, yardstick, benchmarking, WACC, investments, energy transition

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IX.47.1 Introduction

Most energy is transported and distributed via networks to end users: cables are required to transport electricity, while pipelines are used to transport gas and heat. These networks generally consist of transportation infrastructure for long-distance transport and the connection of large producers and consumers, and distribution infrastructure for the connection of small-scale producers and consumers. In liberalised markets, these networks are operated by independent operators, which may not be active as producer or supplier. A key economic insight is that these energy networks are *natural monopolies*. In markets where natural monopolies exist, such as the market for energy transportation or distribution networks, costs to society are lower if there is just one market participant, compared to a situation with multiple competing networks. Having just one network results in lower average costs per unit of energy than having more than one network. Although the costs in society of transporting energy are lower with the existence of one network than with the existence of several networks, the tariffs that network users have to pay may still be high, as the network operator may behave as a monopolist. In theory, a monopolist sets the tariffs above the level of what would be socially desirable in order to maximise profits. To prevent this from happening, governments usually implement tariff regulation.¹ The governmental agency responsible for implementing this is called the regulator.

In principle, a regulator can choose from various options to determine the tariffs for a network company, varying from cost-plus to price cap regulation. In setting the tariffs, the regulator has to make sure that network companies are sufficiently compensated for their cost of capital to enable investments, while also ensuring that the return on capital is not too high. This challenge – of setting the network tariffs at the socially efficient level – may increase in the future, in part due to the growing need for investments in the network in order to facilitate investments in renewable energy production, such as wind turbines and green gas facilities.

This chapter is organized as follows. Section IX.47.2 explains why energy networks are regulated; section IX.47.3 outlines how such networks can be regulated; section IX.47.4 discusses how the regulator can provide compensation for the cost of capital in order to give an appropriate return on investments; section IX.47.5 explains how the allowed total revenues of the regulated company can be translated into tariffs; section IX.47.6 discusses the impact of the energy transition on the design of network tariffs; and section IX.47.7 concludes.²

IX.47.2 Why are energy networks regulated?

A basic economic insight is that perfect competition between companies results in the highest possible social welfare. Competition between multiple producers for the provision of one particular good or service may result in lower costs for producers as well as lower prices for consumers. If prices go down, consumers realise an increase in welfare,

¹ Instead of implementing tariff regulation, governments may choose an institutional solution wherein the network operator is operated by a public agency directly, and is subject to political control.

² For a more in-depth discussion of the economics of regulating energy markets and networks, see Mulder (2021).

as there is a larger difference between what they would be prepared to pay for the product (the *willingness-to-pay*) and what they actually have to pay. This difference is termed the *consumer surplus*. Lower prices also imply lower profits for the company, reducing the *producer surplus*. Consumer and producer surpluses together constitute the total welfare of producing and consuming any good. In most countries, competition authorities and regulators are focused on increasing the consumer surplus, at the expense of producer surplus. Nevertheless, as companies also need to be able to realise a certain level of 'normal' profit in order to continue their business and to finance new investments,³ there is essentially a floor for the producer surplus, which regulators have to protect. This floor is referred to as the *financeability constraint* of tariff regulation.

IX.47.2.1 Monopoly pricing and inefficiency

The key difference between competition and monopoly is that a monopolist is able to choose the price of its products, while companies in a competitive market have to accept the prices which result from the interaction of demand and supply. Therefore, companies in a competitive market are *price takers*, whereas a monopolist is a *price maker*. In theory, a monopolist chooses a price which maximises profits. Due to a lack of competition, this monopoly price is higher than what the price would have been in a competitive market. This also means that a monopoly does not result in the highest possible social welfare.

In addition, a monopolist has less incentive to improve its efficiency or to raise the quality of its goods. A monopolist will reduce costs if it results in a higher profit, but cost reductions are not required for a monopolist to maintain or raise its market share. In a competitive market, however, increasing efficiency is necessary for a company to gain sufficient profits or even to survive. In a similar fashion, a monopolist does not have any reason to invest in quality improvements, as clients cannot switch to another supplier. A company in a competitive market, however, has to improve quality to keep its customers satisfied and prevent them from switching to a competitor. Because of these drawbacks of monopolies, most societies have implemented competition policy to prevent the creation of monopolies (for instance via merger control), or implemented controls to prevent existing monopolies from abusing their market power.⁴

IX.47.2.2 Natural monopoly

In some circumstances, however, it is good for society to have only one company supplying a product, thus creating a natural monopoly. A market supports a natural monopoly if the production of a good or service by a *single* firm minimises long-run average cost.⁵ An example of a natural monopoly is the infrastructure for transporting and distributing electricity, gas and heat. This is because it is cheaper for society to transport energy

³ This level of profit, which is needed to give the investors (shareholders and lenders of debt) a market-based return on their investment, is called *normal profit*. The profit that exceeds this normal profit level is called *supra normal* or *economic profit*.

⁴ Market power can be defined as the ability of a market participant (or group of participants) to influence the outcome of market transactions, in particular the price of the products. In principle, it is not forbidden to have a monopoly, but any abuse of market power resulting from the monopoly is generally not permitted.

⁵ Viscusi, Harrington and Vernon (2005) 524.

through one network instead of two or more networks. As energy networks are natural monopolies, many countries have implemented sector-specific regulation. The objective of this regulation is (a) to prevent monopoly pricing, (b) to foster efficient behaviour, and (c) to guarantee a minimum level of service quality. The first two objectives are pursued through tariff regulation, which is the topic of the remainder of this chapter.

IX.47.3 Types of tariff regulation and incentive power

The aim of network tariff regulation is not only to prevent monopoly pricing, but also to encourage regulated companies to become more efficient. The tariffs should not be too high for consumers, while they should also incentivise the network company to operate the network efficiently. Neither should the regulated tariff be set too low to protect the financeability of the company. A starting point for tariff regulation can be established by finding the level at which an efficiently operating network company would be able to generate a normal profit.

In order to realise the aforementioned objectives by setting the tariffs, the regulator faces two types of information-asymmetry problems: *hidden information* and *moral hazard*. Hidden information refers to a lack of information on the precise characteristics of the regulated company. Moral hazard refers to the behavioural risks that arise from a lack of information on the actual behaviour of this company. The background of these two informational problems is that it is impossible or highly expensive for a regulator to acquire the same level of information and knowledge as regulated companies about their characteristics and actual activities. As a consequence, the regulator should not precisely prescribe how the company should be managed, because this entails an enhanced risk of implementing inefficient measures. The regulator should also not abstain from intervention, as a hands-off approach may easily result in monopoly profits. Intermediate forms of regulation are thus the most appropriate by setting constraints on performance and profits, providing incentives for improving efficiency, and then giving the company freedom in management decisions.⁶

IX.47.3.1 Cost-plus regulation

The problem of hidden information is that the regulator has less information than the regulated company to determine the appropriate tariff level that ensures a normal profit. This problem can be solved by using all the available information from the company, then setting the allowed tariffs equal to the actual costs of the company.⁷ This type of tariff regulation is called cost-plus regulation. Cost-plus regulation is a low-powered form of tariff regulation. All actual costs of the regulated company are reimbursed through the network tariffs, no matter what the level of these costs are. The 'plus' refers to the compensation for the costs of capital, implying that cost-plus regulation grants compensation for the company. Therefore, if a company raises its costs, it will also be allowed to raise its tariffs. In such circumstances the regulated company does not have

⁶ Vogelsang (2010).

⁷ Because of the information asymmetry between regulator and regulated company, regulators usually require cost reports from independent accountants, which reduces the risk that a regulated company will try to misinform the regulator by overestimating its actual costs.

any incentive to improve its efficiency. Although the regulated company may say to the regulator that it will do its best to improve efficiency, the regulator cannot precisely observe to what extent the regulated company is trying to achieve this. Cost-plus regulation may solve the problem of hidden information, but it creates the problem of moral hazard.

IX.47.3.2 Price-cap regulation

The problem of moral hazard can be solved by giving the company an incentive to realise a higher level of efficiency. With cost-plus regulation, the company does not see any benefit if it increases its efficiency. However, the regulated company does realise such benefits if the tariffs are based on price-cap regulation. In this type of regulation, the tariffs are not at all related to the actual costs of the regulated firm, but based on other types of information. The tariffs are fully exogenous to the company, just as they are for companies in competitive markets, who have to take the market prices as given. With price-cap regulation, the regulated company is a price taker, while with cost-plus regulation the regulated company is a price maker. Hence, with price-cap regulation, the regulated company has a strong incentive to improve its efficiency. This form of regulation therefore solves the problem of moral hazard, as the regulated company has to deal with all cost changes. It is a high-powered form of tariff regulation.

IX.47.3.3 Rate-of-return regulation

An intermediate form of tariff regulation, falling between cost-plus and price-cap regulation, is rate-of-return regulation. It allows a network company to cover its own costs, with compensation for the costs of capital based on a fixed return on capital. The latter is called the rate of return.

The main advantage of rate-of-return regulation is that a network company has a guarantee that it will always make a minimum rate of return. One disadvantage, however, is that rate-of-return regulation may give the network company an incentive to overinvest – the *Averch-Johnson effect*.⁸ Such overinvestments will occur when the allowed rate of return exceeds the actual costs of capital on the capital market. Empirical evidence has confirmed that, while tariffs subject to rate of return regulation are below the level of unregulated monopolies, they are still indeed higher than is socially desirable.⁹

IX.47.3.4 Yardstick regulation

The crux of the problem in price regulation is that it is extremely difficult to calculate the appropriate price level. If the price is set too high, the firm will make above-normal profits, while if the price is too low, the firm will make a loss, which may harm the continuation of the network operator. The problem of finding the appropriate price level can be solved through benchmarking: using information from other companies which are active in the same business and operate in a similar regulatory environment. A number of methods for benchmarking exist, such as econometric analysis of productivity

⁸ Averch and Johnson (1962).

⁹ Viscusi, Harrington and Vernon (2005); Weyman-Jones (2009).

data of a large group of firms, and so-called greenfield models which simulate an efficient network.

One specific form of using benchmark information in tariff regulation is yardstick regulation.¹⁰ In this type of regulation, the regulated tariff of an individual network company is based on the costs of a group of comparable network companies. Three types of yardstick regulation exist – a uniform, a discriminatory and a best-practice yardstick. In a uniform yardstick scheme, the tariffs of each regulated company are based on the average costs of all companies in the group. In a discriminatory yardstick scheme, however, the tariffs of each regulated company are based on the average costs of all *other* companies in the group. In the latter scheme, the regulated company's own costs are thus not used in the benchmark, while in the former scheme, these costs are also used to determine the average costs. In a best-practice yardstick scheme, the tariffs for all regulated firms in the group are based on the costs of the most efficient company in that group.

These three types of yardstick regulation differ in the strength of the incentives for cost reductions. With a discriminatory yardstick, the tariffs are fully based on the costs of the other firms, which implies that each regulated company is a price taker. In that sense, this scheme is similar to price-cap regulation. With a uniform yardstick, the incentive power (*i.e.* the strength of the incentive to improve efficiency) depends on the market share of each firm. The higher the market share of a regulated company in the group, the lower the incentive power is. In the extreme case, where one company has a market share of almost 100 per cent, this type of yardstick regulation comes very close to cost-plus regulation. For all other firms, whose combined market share is close to zero, the yardstick regulation is close to price-cap regulation.

A challenge for applying yardstick competition is that there may be a problem in finding comparable network companies.¹¹ The regulator will look for companies that are sufficiently comparable in terms of type of activities, type of clients, size and natural circumstances (e.g. mountainous area, presence of water). Network companies, however, have an incentive to emphasise their differences – either before the regulator or in court – and to lobby to be compared to companies with higher costs. If these firms are successful, the average cost figure will rise, leading to higher allowed tariffs.

If the number of comparable firms is too low, the yardstick regulation is likely to be ineffective. One specific risk of having few firms in the benchmark is that these firms may try to collude against the regulator by deciding together that no one will make efforts to improve efficiency. If that occurs, the average costs are not reduced and the tariffs remain the same.¹²

IX.47.3.5 Pros and cons of tariff regulation variants

Each type of tariff regulation has its own pros and cons. One key disadvantage of price-cap regulation is the risk of the regulator setting the cap too high or too low, which

¹⁰ Shleifer (1985).

¹¹ Because of the need to have a sufficient number of comparable companies, yardstick regulation is more feasible for distribution networks, as in most countries there exists a number of distribution-network operators operating under similar circumstances.

¹² Dijkstra, Haan and Mulder (2017).

harms consumers or shareholders respectively. In addition, price-cap regulation imposes more risk on those companies: profits will go down when costs go up, as the tariff cannot be changed – at least not until the next price review. Under rate-of-return regulation, consumers bear some of that risk, because companies are able to increase the tariffs to protect their profits. Shareholders thus face more risk in the case of price-cap regulation, which could make them less inclined to invest in the network.¹³

In practice, the difference between price-cap regulation and cost-plus regulation may be smaller than economic theory suggests.¹⁴ When determining the price cap for the first time, for instance, the regulator is likely to set it in such a way that the company earns a reasonable rate of return. In addition, the tariffs themselves are regularly reviewed under both forms of regulation, as the regulator recognises that it cannot perfectly foresee future changes in productivity. In spite of these similarities, most economists agree that price-cap regulation gives network companies stronger incentives to be efficient than cost-plus regulation, for the reasons mentioned above.¹⁵

IX.47.4 Investments and costs of capital

A key component of tariff regulation is the reimbursement of the cost of capital, referred to as the Weighted Average Cost of Capital (WACC).¹⁶ This is the rate that the investors require in return for their investment. It is important to realise that the return rate required by the investors is determined by the market and not by the company's management or by the regulator. The WACC represents the minimum return that a company must earn on its existing asset base to satisfy its equity providers as well as the providers of debt capital. The key distinction between equity and debt is that equity capital faces a risk in the profitability of the firm, while debt capital is protected from that risk.¹⁷ The WACC is calculated by taking into account the relative weights of each source of finance.¹⁸

Regulators may decide to choose different WACC levels for different types of network operator, depending on the type of risks they are facing. For instance, transmission networks bring electricity from power plants to substations and to large electricity (typically industrial) users, while distribution networks carry the electricity from substations to consumers. As these activities face different types of risk, the regulator may apply different WACCs. In each case, the challenge for the regulators is to make an appropriate estimate of the real costs of capital for the regulated company. If the WACC in the tariff formula is too low, the company may not be able to finance new investments – but if the WACC is too high, the company may overinvest, forcing consumers to overpay.

¹³ Cambini and Rondi (2010).

¹⁴ Proost and Pepermans (2016).

¹⁵ Viscusi, Harrington and Vernon (2005).

¹⁶ The WACC is the estimated cost of capital. The regulator uses this to determine the allowed rate of return on capital. In principle, this allowed rate of return should be equal to the actual cost of capital, *i.e.* the return on capital required by investors in the capital markets and banks.

¹⁷ Equity capital is capital to finance a project or firm that receives the remaining profit after all costs have been paid as reward. This profit can also be negative, meaning the equity providers make a loss. Debt capital (*e.g.* loans from a bank) does not face this risk.

¹⁸ The share of debt in total capital is referred to as the *gearing*. The basic formula for the WACC is therefore: cost of debt $\times$ gearing + costs of equity $\times$ (1 – gearing).

IX.47.5 Allowed revenues and tariffs per product

Many countries use price-cap regulation in setting energy network tariffs. Under this type of tariff regulation, the determination of allowed revenues is more complex than under cost-plus or rate-of-return regulation, where the revenues are directly related to the actual costs of the company. With any kind of price-cap regulation, the level of revenues afforded to a company is more or less based on the costs of a group of benchmark firms. The relationship between revenues and costs is expressed in the CPI-X formula (detailed in the following paragraph). The regulator first determines the level of the desired benchmark costs at the end of the new regulatory period. These costs generally refer to total costs of the network company – comprising the total operational costs (OPEX) plus capital costs (CAPEX). This form of regulation has been dubbed TOTEX regulation.¹⁹

Two parameters are used to relate the allowed level of revenues to the benchmark costs: Consumer Price Index (CPI) and the efficiency factor (the X-factor). The first parameter, CPI, is the compensation for the (expected) level of inflation: the increase in the general price level of goods and services in the country. Revenues can then increase with the inflation rate. The second parameter, the X-factor, is the annual percentage change which is needed to take the current revenue level to the level of the benchmark costs by the end of the new regulatory period. While the X-factor is often referred to as the efficiency factor, it is important to realise that the level of this factor only indicates to what extent the current level of revenues must change year-on-year. The incentive power to improve efficiency is not determined by the X-factor, but by the degree that the regulated company's own costs affect the costs of the benchmark, as explained previously.

The final step in tariff regulation is to convert the total level of allowed revenues of the company into maximum tariffs for all products that the regulated company supplies to the market. Energy transportation and distribution networks generally offer many different types of products, often based on capacity requirements and location. Regulated companies may have freedom to choose the specific tariffs per connection, but this is subject to at least one constraint: the expected revenues from all connections should not exceed the cap on total revenues.²⁰ In order to determine the expected revenues, the regulator needs forecasts of the expected utilisation of each product (*i.e.* the intensity of use for each connection point). Based on these forecasts, the regulator can check whether the sum of all expected revenues per connection (calculated by multiplying the tariff and the utilisation per connection) does not exceed the cap on total revenues. Following this,

¹⁹ Although TOTEX means *total expenditures*, this variable refers to *total costs*, as non-expenditure costs (*e.g.* depreciation) are included, while non-cost expenditures (*e.g.* investment expenditures) are not included. Note that costs can be seen as sacrifices made by someone, while expenditures refer to cash transactions (payments). Often both are equal, but not always. An investment, for instance, may result in cash payment, but it is not directly a cost (*i.e.* a sacrifice) as the cash is being replaced by the value of the investment (*e.g.* an asset). An investment only results in costs when it is used. These costs are measured as depreciation.

²⁰ Some regulators also require that each separate tariff is related to the costs of using a specific product. This is, however, a difficult objective to realise, as most costs of network operation are common costs. Common costs are shared by all users and cannot be attributed to specific products. In practice, several rules-of-thumb are used for this kind of cost allocation, such as the Fully Distributed Costs method.

the tariffs of all connections to the grid can be published, ensuring that network users know what to pay when using the network next year.

IX.47.6 Energy transition and tariff regulation

While the energy transition from fossil fuels to renewables makes energy production more sustainable, it also requires network companies to adapt, for instance by increasing the amounts of solar and wind energy that need to be fed into the electricity grid. Offshore wind farms must be connected to the grid, while more and more households and firms put solar panels on their roofs – measures that not only help to reduce greenhouse gases, but also may create bottlenecks, congesting the networks. Likewise, the expansion of power networks, for instance to accommodate the growing use of electric vehicles, also entails extra costs.

In order to facilitate the energy transition, network companies need to be able to finance the required investments to adapt their networks. This means that the regulated revenues must take into consideration the extra costs of investments, with the regulator potentially compensating the network companies that accrue these extra costs. It is important to understand, however, that this increase in revenue is not a means of financing the investments, but a means of compensating network companies for these extra costs.²¹ Generally, one may assume that when a regulated company is certain that it will be reimbursed for any extra costs resulting from a new investment, it will be more able to attract sufficient capital from investors.

There may, however, be a few hurdles. If the network company is uncertain of the extent to which the regulator will view the investment as necessary or efficient, it will also be uncertain of the extent to which its costs will be compensated through regulated tariffs. Due to that regulatory uncertainty, financing the investment may be problematic. For this reason, it is important that the regulator provides clarity in advance about the method that will be used to assess investments in, for instance, extending network capacity to connect new renewable generation. In addition, a company may face financing difficulties related to other constraints imposed by investors, such as the common requirement imposed by lenders of debt capital that the share of equity should have a minimum value. If shareholders are not able to provide additional equity, the investment may not be financeable at all. Such a problem is, however, not related to tariff regulation, but to the functioning of the capital market. In general, tariff regulation schemes are able to adapt the allowed revenues to enable the financing of all necessary and efficient investments in network replacement, extension and adaptation for the sake of energy transition.

IX.47.7 Conclusion

The transportation and distribution of electricity, gas and heat via networks is often considered a natural monopoly. Tariff regulation of such network tariffs is meant to

²¹ Note that investments are not costs, but just expenditures. The costs of an investment consist of depreciation costs and the required compensation by the providers of debt and equity. The tariffs to be paid by network users are only meant to give compensation for the costs of network operators. Tariff regulation affects the expected future revenues from an investment and, hence, the willingness of banks and shareholders to provide capital.

prevent monopoly pricing and to stimulate efficient behaviour of the network operator. In the design of tariff regulation, three basic elements play a crucial role: (a) the incentive power to stimulate companies to become more efficient; (b) the financeability of new investments, which requires that the allowed revenues are sufficient to give investors an appropriate return on investment; and (c) the choice of the allowed revenue level, which should not be so high as to prevent consumers from paying more than is necessary.

It is possible to realise all of these objectives through a system of price-cap regulation if the price cap is based on a group of similar firms, and the allowed return on capital is based on actual costs of capital in capital markets. Although the energy transition may require energy network operators to significantly increase their investments in upgrading and adapting their network, the system of tariff regulation itself does not necessarily require adaptations to facilitate those investments.

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