

THESES OF PhD DISSERTATION

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EFFECTS OF INDUSTRIAL CHARACTERISTICS AND REGULATION ON
THE PRICE OF ELECTRIC POWER SYSTEM SERVICES AND CAPITAL
EXPENDITURE DECISIONS

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1. BACKGROUND AND OBJECTIVES OF THE RESEARCH

Energy is one of the most important areas of today's economy, while of all energy types, electric power is certainly one that practically all of us gets into contact with. As power plays such an important role in the economy and according to all indications it will remain so in the future, it is important to understand the fundamental features of this sector. The domestic electricity market represents a special environment for the relatively few enterprises operating here. This means a combination of competitive and monopolistic elements within a strongly regulated environment. Due to the capital intensive nature of the industry, presence of large state-owned holdings and multinational energy companies is typical. In this environment capital expenditure (CAPEX) decisions related to power grids normally need to be made on a very long-term basis.

Even though relationship between energy prices and investments is undoubtedly interesting in general as well, the topic of the current dissertation is constricted to a narrower topic: to the relationship between the price of power and the investments made into the power grids. The choice of this industry has come almost naturally: I obtained the biggest proportion of my work experience and knowledge here. However power-related investments still represent an extremely wide topic. Within this field my thesis focuses only on issues related to power grids. Electricity price components related to grid operations, serving as a source for maintenance and development of the network are strictly supervised by the regulator. As a result, the relevant regulation also has to be in the scope of a research performed in this field. The enterprises being in focus cover those being responsible for the grid in Hungary: until 2007 the vertically integrated energy suppliers, later on the grid companies including the transmission system operator (TSO) and distribution system operator (DSO) companies.

The primary objective of the current doctoral dissertation has been to present the historical trends of power grid investments and their relationship with the regulatory and pricing cycles.

In order to achieve this goal, it was necessary to carry out the following tasks:

- to overview, systematize, and present the relevant literature;
- to overview, analyse and present the key points and attributes of the regulatory environment of the industry, including the regulation of Hungary and the European Union as well, with a special focus on grid service pricing and grid investment relevant topics;
- to identify statistical data sources and perform a comprehensive data exploration in order to prepare a database that is suitable to provide a reliable basis for the analyses;
- to review and analysis of key attributes of the pricing methods applied in the power industry
- to represent the pricing cycles and analyse the historical price data sets;
- to analyse the internal structure of electricity prices, with a special emphasis on the development of the network usage element, and its effect to the final consumer's price;
- to examine and analyse the historical trends of the grid investment cycle;
- to reveal the correlation between the pricing and investment cycles;
- to evaluate the effects of the regulation on the operation of grid enterprises, especially on their financial stability and operational behaviour, including their pricing and investment policies;
- to work up strategies or proposals based on the results.

The starting point of the timeline of the research has been the restructuring of the state owned companies of the Hungarian electricity industry into joint-stock companies at the beginning of the 90s. On the other end of the timeline my data

collection extended until 2013, but calculations and detailed examinations have been done only until 2012. Main reasons for this have been: (1) the lack of complete data sets for the two recent years and (2) a substantial change of regulatory approach regarding energy policy and pricing methods. Although I have certain presumptions on the effects of these recent changes, properly reveal, quantify and evaluate these would be problematic yet.

Based upon the review of the relevant literature and my experience obtained from working in the electricity sector the hypotheses set for the research have been:

1. The price of the system services, the network tariff has developed according to a steady and calculable trend. Fluctuation or volatility of the final electricity prices has not been caused by network element.
2. Versus the generally accepted point of view of energy companies realising an unduly high rate of return, this is not true for grid companies. On the contrary, these entities are characterized by an insufficient rate of return and lack of sufficient funding for necessary capital expenditures.
3. Strong, provable relationship exists between the pricing and investment cycles both in the transmission and the distribution segments. Thus policy makers' approach of the grid including definition of applicable pricing methods essentially influence investment decisions into this key infrastructure and as a result on a long-term its quality as well.
4. Regulation applied on the analysed timeframe did not ensure proper incentive for the network companies to reach a sufficient level of grid investments.
5. Key term unbundling of European Union's energy regulation is still rather a formal than an effective measure on the domestic electricity market. As a result significant cross-subsidies still exist or may exist between competitive and monopolistic activities.

2. MATERIAL AND METHOD

During the preparation of my dissertation I was following the requirements of the Ph.D Doctoral Regulations (Kaposvár University, 2013). In order to obtain a detailed understanding of the research topic, I have carried out a comprehensive data collection. In the course of processing and analysing data, I aimed to be able to make statements characteristic of the whole domestic power grid segment.

Basis for the analyses made have been the relevant Hungarian and international economics literature, furthermore the papers and studies prepared or ordered by the local and EU regulators. Besides reviewing theoretical studies I have also searched for the available research publications, with a focus on domestic results. The most important literatures have been listed in the Bibliography. Furthermore useful information have been acquired from the relevant international organizations, especially the studies, publications and data tables of ENTSO-E, ACER, CEER and EuroStat.

Key source for the Hungarian electricity market relevant decrees, decisions, information reports and statistical data has been the local regulator MEKH (Hungarian Energy and Public Utility Regulatory Authority). Furthermore valuable information has been and is continuously publicised by the transmission system operator MAVIR as well on the Hungarian electric system's energy flows. As a result of the data collection a comprehensive database was compiled that contains the most fundamental data on Hungarian electricity market for the longest possible period. This database contains:

- Statistical datasets of the Hungarian Power System.
- Grid-relevant datasets including track length per voltage level and quality indicators measured by the Authority.
- Data series of electricity price and price components (product price, network-relevant tariffs, other elements and taxes), broken down to

consumer segments where available. The network usage tariff data includes available information on both officially announced prices that represent the highest allowed price (price cap) and those effectively applied by the grid service providers.

- Quantity and price data series of the few years old organized electricity market (power exchange) HUPX.
- Available, published information regarding the methodology of the regular cost and price monitoring performed by the Authority, including data on cost, investment and rate of return acknowledged during the fee calculation.
- Available statistical grid investment figures.
- Balance sheet, income statement and cash-flow figures of the grid companies and their parent companies.

Even though my thesis has focused only on the grid segment of the electricity market, in many cases the research had to cover the whole market. In order to be able to analyse the internal structure of electricity prices and compare the behaviour of the network component to that of the whole price, I had to search for data on all price components. However I came up against significant difficulties at this field. Exact value of price elements regarding a certain consumer characterised by its precise consumption and grid connection attributes can easily be retrieved for any selected moment. On the other hand, examination of prices in general is more complicated: all price components are set as different values per customer groups at any time. However criteria for customer segmentation are different for product price, network-relevant tariffs, taxes and other elements as well – none of these categories do overlap. Thus internal structure of the price may be calculated as an average and thus projected for the total consumption: in this case the resulting structure is relevant for a fictive average consumer only, but not factual for any of the real customers. Still, average network tariff per a consumed kWh adequately represents

the cost relevant for consumers in general, and also the source realised by the grid service providers via the network tariffs. Another possible calculation method would be to set up a complex matrix structure by using the different segmentation criteria of each price component, then identify and analyse the internal structure of the price per each subset. However this (1) would require a statistical-analytical method that exceeds the frameworks of the current dissertation, while (2) subsets of price component data series are not available in this depth in many cases, and finally (3) dilemma regarding final calculation of average (kWh specific) price would still emerge at the final step. Therefore I decided to apply the first method. This choice is in line with the dissertation's goal to reveal the overall relationship of prices and investments (capital expenditure), and thus considered to be adequate.

Based upon review of the relevant literature and from my work experience, I worked out the hypotheses for the research. In order to confirm or reject these I made several calculations and analyses based on the comprehensive database resulting from the secondary data exploration. I applied both theoretical information gained during the first research phase and my experience originating from working in the energy sector to interpret the results. This interpretation was aggravated at some points by the changing structure and contents of the available datasets: information published for the different regulatory cycles and market models have continuously changed. As a result I had to perform some corrective calculations as well to obtain comparable data series for the whole timeline.

Relevance of the research result is limited somewhat by the low cardinality of available datasets. The timeline of the final calculation had to be narrowed at some points to the period starting from 2003 due to lack of information. On the other hand even this narrowed timeline covers a complete decade and several regulatory cycles, thus enables to generate scientific value.

Finally, based on the analyses performed and on my theoretical and critical reflections I phrased my proposals.

3. RESULTS

As the final goal of my research has been to reveal the relationship between electricity prices and grid investment, in the first step I explored electricity prices: historical information on price levels and the internal structure of the end-user price with a special emphasis on the network component. The second part was to analyse grid investment levels, funds for the CAPEX, then the correlation between data series of prices and investments, and finally the factors that may serve as an indicator for the adequacy of the investment level. Where the data sets allowed I performed the calculations separately for transmission and distribution.

Most analyses covered a timeframe ending with 2012, as most data series have been available until this year. Such limitation of the scope has been adequate in respect of the regulatory regime as well – policy making and regulatory approach took such a significant turn in the last few years that analysis of the period starting from 2013 in itself could serve as the topic of a complete dissertation.

3.1 ELECTRICITY PRICES AND THEIR INTERNAL STRUCTURE

3.1.1 Pricing cycles

The time period analysed in the dissertation may be decomposed via two key aspects of pricing cycles. First aspect is represented by the main milestones of the market liberalisation process: within this we may mention public utility, dual market and liberalized competitive market models. In parallel to these since the privatisation performed in the mid-90s, four-year long price regulatory cycles have been applied originally for the whole electricity price, later – with the progress of liberalisation – for the network tariffs and universal service prices only (MEH, 2012).

Market models related to the phases of the liberalisation have defined the overall frameworks within which the power industry operated, while the four-year long cycles represent the factual and detailed regulation of prices. At the first year of each

cycle prices are set as a result of a comprehensive cost-review performed by the regulator, while prices for the next three years are calculated by a pre-defined price formula. The methodology has continuously been justified, with an increasing emphasis on quality aspects built directly into the price calculation method.

3.1.2 Components of the price

Key components of electricity price are the *product price* (i.e. the price of the energy supplied itself), the *network usage tariff* elements related to the system services, *other (so called “financial” or “tax like”) items*, and finally *taxes*. Before executing the unbundling of competitive and monopolistic activities, required by the European Union, there was no need for the separation of most of these components. However since the initial step of unbundling performed in 2003, each price element is calculated and invoiced to the customers one by one. Network tariffs incorporate several further tariff groups: (1) transmission system dispatching, operation and development, and (2) distribution system operation. As the network-relevant activities are still considered to be a natural monopoly (Kiss, 2009), these fees are set by the Authority.

3.1.3 The rate of return of grid activities

Network usage tariff calculations are based on the cost acknowledged by the regulator. This cost includes acknowledged rate of return as well, that represents the cost of capital investment into the grid. This solution is in line with the international practice as well (ETSO, 2008). As in market environment no investor will be willing to provide funds for an activity that does not yield at least the similar investments' rate of return, therefore regulators normally strive for preventing realization of excess profit, but in the same time aim to ensure a “fair” rate of return for the regulated companies that is in line with the market capitalization rate.

According to the analysis of corporate financial statements, the overall rate of return realized by the *distribution* segment has typically remained below the values

acknowledged as fair by the Authority. The justified level of return has been defined between 7,8% and 9,3% during the time period of the research. Even though individual corporate return rates showed a significant variance, there was no DSO that would permanently surpass the threshold. On the other hand each company's return rate remained close to the acknowledged rate, this the segment in fact realized an adequate profit.

On the contrary while the same acknowledged return rate has been applied for the *transmission* activity, its factual rate of return remained between 2% and 4%. As by its nature distribution and transmission are similar and the cost-based regulatory expectations were also similarly defined for each, it is likely that the difference is caused by other organizational and operative features. Such features may be the different operation of a state-owned, non-competitive company, and/or the TSO being an integrated part of the vertically integrated MVM Group, and thus not acting purely as a grid company, but as a member of a vertically integrated group.

3.1.4 Calculation of the yearly average network tariffs

Detailed price component-level data regarding network usage is available since 2003, therefore my analyses in this topic also started from this year. I examined the network usage fees separated into two major segments: (1) those relating to the distribution network and (2) those related to the transmission system, including the overall system services and dispatching. This segmentation has been reasoned by the internal structure of the grid segment. As I my initial data collection did not result in finding official or previously calculated and published data series regarding the average network tariffs, I made own calculations to obtain the data required by the research. This resulted in the average network tariff per one kWh for each year, that represents well the cost relevant for the average customer, and also the source realised by the grid service providers via the network tariff. Basis for the calculations have been the official tables published by the regulator MEKH. As instead of referring to a time period (e.g. a year) these came into effect by exact calendar dates,

I had to calculate the average tariff as well to obtain the yearly average figures. The averages have been calculated with using the figures of monthly electricity consumption statistics as weights.

Per unit network usage tariff has developed according to a steady, calculable trend of a 0.32 HUF yearly average increase per kilowatt-hour in the relevant timeframe. Strong indication of changes occurring in the segment exists as this has drastically changed in 2013, which may serve as an interesting topic for a future step of the research. The key element of this trend has been the increase of distribution prices that represent the higher proportion of the whole network usage tariff. On the other hand, within the whole fee tariffs related to the transmission, dispatching and system-level services were characterized by a higher volatility than those related to distribution. Most important reason behind this has been the relatively frequent change of the tasks assigned to the TSO that has been followed by the change of price elements allocated to fund its operations as well.

3.1.5 The internal structure of the price of electric power

Proportion of network usage tariffs within the end-user electricity price has changed between 27% and 38%. Even though in general electricity price and network tariffs have developed into a similar direction, significant changes (volatility) in the end-user price were not entailed by price of the network usage. While network-relevant tariffs have increased by a slow and steady trend, other elements of end-user price have been subject to frequent changes due to the overall economic environment, changes in the regulation and the economic crisis. This also results from the network usage pricing methodology (MEH 2008, 2008b) that soothes the effects of yearly fluctuation in network costs and investment levels, and does not allow the immediate and direct transmission of these changes into the tariffs. As a result high value one-time investment effects do not cause a direct tariff increase.

3.2 CAPITAL EXPENDITURES

3.2.1 Trends of grid-relevant capital expenditures

Analysis has been focused on the nominal grid investment (capital expenditure, CAPEX) data, as nominal and real data series showed similar behaviour; while CAPEX per one kWh consumed energy has also shown a development identical to the total (nominal) investment amount in the research period.

Analysis of nominal *distribution grid* investment data revealed a clear connection with regulatory changes. DSOs conducted a continuous, vivid investment activity on the period relevant for the current research. Investment levels have increased significantly after the legal unbundling and market liberalization. Furthermore it is remarkable that in spite of the economic crisis starting from 2008, nominal investment level remained relatively steady for a long period. These investment decisions have certainly been influenced by the direct incentive regulation measures launched in the 2009-2012 regulatory cycle. Significant decrease in both nominal and real figures may be identified in the year of 2012, as a result of the long-lasting crisis and economic policy decisions being disadvantageous for electricity sector, including changes in taxation and pricing methods as well. This implies that application of stricter unbundling rules and measures, integrated with other regulatory tools such as the incentive regulation have enabled to enhance the favourable development of infrastructure investments for the most part of the analysed period. On the other hand the latest, recent changes indicate a reverse direction: the slow and non-significant descent of investments made turned into a significant descent at the very end of the analysed period.

Transmission network capital expenditures showed off a more calculable path: except for a temporary downfall in 2006 – that overlapped in time the asset and activity handover between two legal entities –, investment level remained even in the 2005-2008 cycle, while increased constantly during the next cycle. On the other hand, the same downfall occurred in 2012 as in the case of distribution investments.

3.2.2 The funding of capital expenditures

Official statistics (VEZESTÉK, 2012) divides funds of grid investments to the service provider's funds (including own sources as well as loans) and other funds including one-time connection fees paid directly by the customers and free asset transfers.

Majority of *distribution network* developments have been financed from the service provider's funds on the examined time period, while the proportion of other funds have decreased from an initial 20% in the 90s to the current 8%. Funds of the service providers have been dominated by the resources generated by the operative activities, while external loans typically represented 5 to 10% of the investments, except for 2003-2004 when a temporary increase took place. As in these two years the DSOs were in a relatively good funding position, this effect has possibly been caused by the operative and organisational effects of the initial phase of unbundling, but may be linked to the temporary increase of investments as well.

Analysis of the financial statements revealed that the DSOs did not have significant long-term loans between 2000 and 2012. Further, overdrafts and short term loans also did not fund directly the grid activity. On the other hand liabilities towards associated companies and the cash-pool systems launched from the mid 2000s played a significant role in the operations. The DSOs showed a constant positive cash-pool position, while the total cash-flow remained near to zero after the unbundling. This is considered to be direct evidence of the DSOs receiving funding from the vertically integrated energy group they belong to, even after performing first the accounting and then the legal unbundling.

Funding ensured for capital expenditures via the tariff system is represented by the sum of cash-flow from operations and the directly paid connection fees. In the examined time frame, only three years occurred when the DSOs did not spend at least the amount of the operative cash-flow to CAPEX, each year preceding the launch of the incentive regulation. On the contrary there were six years when

CAPEX significantly exceeded the amount of the funds arising via the tariff system and external loans as well. In these years the funds for capital expenditures were definitely complemented via intragroup funding. This is clearly confirmed by the cash-pool positions on the period after 2007. It is likely that the same applies for the preceding period as well, however due to the lack of respective data there is no direct evidence to support this.

The same analysis has turned out to be more problematic in the case of *transmission grid*. No information has not been available for analysis regarding loans related directly to the network activities. Furthermore interpretation of cash-flow data is also more complex: the total cash-flow of the TSO is influenced by several other activities than the transmission grid's as well, while cash-flow generated solely by the transmission activity is not calculated and included into the financial statements. Still, the available information clearly reveals that the steady development of the transmission-relevant capital investments took place against a strongly volatile funding position of the TSO. The volatility has apparently been caused by reasons being independent from the transmission activity. The TSO's position has also significantly been influenced by the intra-group transactions. Unlike the distribution segment's constant positive net intra-group cash-pool position, the TSO's net position changed regularly: in several years the group provided funds for MAVIR, while in other years it has been in a negative position, thus funds have been drawn by the group.

3.2.3 Correlation of between pricing and investment cycles

3.2.3.1 Distribution grid

The analysis revealed a clearly observable positive correlation of the distribution segment CAPEX with the per unit distribution network usage tariff and the end-user electricity prices. The relationship has been stronger in case of the launched (being in progress) investment data series than in case of the capitalized (put into operation)

ones. This indicates the price level's direct and material effect to the current year's capital expenditures, but also the existence of an effect on the next period(s) behaviour. On the other hand none of the results showed a really strong, deterministic relationship.

According to the analysis results, price of the network usage is an important factor of grid-relevant capital expenditure,s but not the only one – other factors such as the regulatory environment and the overall economic circumstances also influence them. Relationship of CAPEX has been stronger with the end-user prices than with the network usage tariffs, providing further evidence of the still existing cross-subsidies within the large, vertically integrated holdings. Thus decision on investment into the grid still depends on the overall profitability of the group as well, not only on the network segment's results.

3.2.3.2 Transmission grid

Analysis of the *transmission grid* figures again turned out to be more problematic, while the results are more ambiguous. The range of TSO's activities is complex in relation with network-relevant tasks (including transmission grid operations, dispatching and providing system-level services) as well, further several other tasks have been allocated to this entity as well. The range of the latter tasks has changed several times in the research period, inducing changes in the tariffs and incomes too. In consequence while transmission-relevant CAPEX increased on a steady, well-balanced course, the entity's fluctuating income financed a changing range of activities including operations and development of the transmission network.

Proceeding from the wider tariff groups to those belonging directly to the transmission activity, weak positive relationship of transmission CAPEX has been found with the total end-user prices and the total per unit network usage tariff. On the contrary weak negative relationship was detected with the total network usage tariffs owing to the TSO, while no relationship showed off at all with the same data isolated from other (tax-like or financial) items. Taking one more step towards the

“pure” tariff belonging to transmission, the tariff element called transmission fee served directly for funding the transmission activity on a partial period. This data set has been available until 2007 only as later on the fee has been merged with another tariff element, but it showed a significant positive relationship with CAPEX on this short period.

The remaining relations indicated either no or sometimes negative correlation. Considering this and the weak positive correlation with the total network usage tariff and the end-user prices, the results indicate a weaker relationship of capital expenditures and funds ensured via the regulated prices than in the case of distribution. Still, relationship with the narrowly defined transmission fee is likely. Further, the results clearly evidenced the prolonged existence of cross-subsidies within MVM group where the TSO MAVIR belongs to, and similar cross-funding may exist among the several activities of the TSO as well. This is implied also by the fact that the material decrease of funding provided for MAVIR in the regulatory cycle starting from 2009 did not entail a similar change in the CAPEX, while the downfall of grid-relevant expenditures in 2012 occurred with a parallel increase in network-relevant tariffs and resources.

3.2.4 Adequacy of investment levels

Even though increase in the capital expenditures is a positive sign, to evaluate the adequacy and efficiency of investments made it is not an adequate indicator in itself. To answer the last question of the dissertation, several other factors needed to be explored and evaluated.

Analysis of *distribution*-relevant indicators resulted as below:

- Several quality indicators are continuously measured by the Authority. In the incentive regulation regime some of these have a direct effect on the network usage tariffs via penalty (fee-reduction) applied in case of non-compliance of the pre-defined quality improvement goals. Results of these indicators evidenced a steady improvement on the timeline of the research,

and an active monitoring by the Authority that resulted in penalties applied in some cases as the quality improvement did not always reach the goal.

- Value and proportion of network losses have significantly decreased, indicating a quality improvement.
- Quantifiable expansion of the network has been evaluated via growth of the total network length and via the lengths of network put into operation. A certain fluctuation of the the total length has been revealed, including decrease of the length occurring in some years due to large reconstructions and possible data publication errors. On the other hand length of network parts put into operation showed a continuous, but not even development activity. No connection was verified between capital expenditures and network length, thus this aspect is considered to be inefficient for evaluating adequacy of network capital expenditures.

Altogether, efforts made by DSOs to reach the continuously raising quality requirements have turned out to be sufficient. This also indicates the applied regulation's success.

Analysis of *transmission*-relevant indicators resulted as below:

- The minimal quality indicators defined by the Authority revealed a positive tendency. Even though no indicators with a direct network usage tariff effect have been set up for the TSO, a yearly quality assessment by the Authority took place for this segment as well, with no quality issues identified.
- Due to technical reasons, network loss of the transmission grid is significantly lower than that of the distribution. Value and proportion of this loss stayed on a constant level, while no requirement for decrease has been defined by the Authority. The fact that the loss did not increase indicates an adequate level of measures taken by the TSO in this aspect.

- Total length of the transmission grid increased at a slow, steady pace in the research timeline. On the other hand no proper indicators have been identified regarding the adequacy of this increase.

Altogether indicators of the transmission grid either grew better or at least did not deteriorate, indicating the adequate level of grid investment activity.

In order to evaluate the *optimality* of efforts made in order to develop the grid, besides adequacy – defined as the investments being appropriate enough to sustain or even increase quality –, the non-excessive nature of the factual CAPEX level should also be examined. However analysis of this aspect would require (1) a research involving completely new factors such as in-depth analysis of key society needs, furthermore (2) significantly extending the applied methodology, and finally (3) a resulting thesis of materially longer wordage. Therefore excessive or non-excessive level of capital expenditures has not been analysed in the current dissertation: this topic represents one of the possible directions to extend the research in the future.

4. CONCLUSIONS

Electricity service plays an important role in the economy. Within this industry, grid or network segment is a smaller part that ensures transporting the energy from the generation to the customers. Most important parties of the network segment are the state-owned and private service providers, the electricity consumers, the representatives of the government and the regulator. All of these parties have different motivations and interests.

- **Consumers'** main interest is to receive a good quality service on a favourable price. In practice there is certain level of trade-off between the two: high-quality service makes a certain level of cost and expenditure necessary, thus the price – in this called network-relevant tariffs – may not be lowered at will. On the contrary high price neither guarantees the high quality, thus regulation and monitoring of the services are necessary.
- From a theoretical aspect the **government's** most important task is to ensure that the service that is considered to be a public interest is provided in an adequate quality, on affordable price and minimal cost, in other words to ensure the fulfilment of the above described interest of customers. However in reality the government is not independent and unbiased at all: for example it is directly involved in the results of the domestic electricity market's dominant energy holding MVM. Therefore regulatory and pricing decisions affect the decision maker in direct and indirect ways. This is the main reason why economic practice lead to set up independent regulators, like the Hungarian Energy and Public Utility Regulatory Authority (MEKH) in Hungary.
- **Service providers** form the third important party of the network segment. Among these entities my research concerned only to the network operators who maintain and develop the power grid. As all enterprises in a market environment, these companies also aim to generate an acceptable and

predictable profit. The expected or guaranteed profit's role is important due to the capital intensive nature of the industry and the time horizon of the investment decisions that are usually needed to be done for decades and then lead to high fixed costs. Thus industrial characteristics make predictability a necessity for proper operations.

Based upon the industry's characteristics there is no doubt that electricity market, and within it the network segment needs to be regulated. However regulation, its approach and the methodologies applied by regulation may vary to a great extent. Final success of regulation in ensuring an adequate environment for network maintenance, operation and development certainly affects the whole economy.

The summarised research results in respect of the initial hypothesis are as follows:

The *first hypothesis on the steady and calculable trend of network tariffs has been confirmed.* From a theoretical aspect the pricing (tariff calculation) methodology enhances the balanced development of funding possibly realised via the tariff system, and thus the availability of amounts necessary for justified costs and capital expenditures. The total per unit network usage tariff has increased in a steady and calculable manner until 2011. The key element of this trend has been the increase of distribution prices that represent the major proportion of the whole network usage tariff, while tariffs related to the transmission, dispatching and system services were characterized by a higher volatility. Most important reason behind this has been the relatively frequent change in the scope of tasks assigned to the TSO. Proportion of network tariffs within the end-user electricity price has changed between 27% and 38%. Even though in general end-user prices and network tariffs have changed into a similar direction, significant changes (volatility) in the end-user price were not entailed by price of the network usage. While network-relevant tariffs have increased by a slow and steady trend, other elements of end-user price have been subject to frequent changes due to the overall economic environment, changes in the regulation and the economic crisis.

The first part of the *second* hypothesis has been confirmed: the network segment did not realize an unduly high profit. While the second part on insufficient rate of returns had to be clearly rejected for the distribution segment, the numerically low results of the transmission activity urges further studies in the future. Profit rates normally did not exceed the acknowledged level defined by the regulator, thus unjustified profit has not been realized. While the distribution's profit has certainly not been insufficient, temporary lack of resources for capital expenditure has occurred in some cases. Sufficiency of transmission's profit may not be proved unequivocally based on the results, even though the constant increase in capital expenditures until 2011 implies an adequacy.

Third hypothesis on the strong and provable relationship between pricing and investment cycles has been confirmed for distribution, but in case of transmission the relationship with the narrowly defined transmission fee is likely, but not directly evincible. According to the analysis of resources behind capital expenses, income realized via the tariff system is likely to have a causal relationship with the *distribution grid* investments. Price of the network services is an important factor of grid-relevant capital expenditure,s but not the only one – other factors such as the regulatory environment and the overall economic circumstances also influence them. The analysis revealed a clearly observable, but not deterministic positive correlation of the distribution segment CAPEX with the per unit distribution network usage tariff and the end-user electricity prices. In case of the *transmission* the research revealed weak positive relationship of CAPEX has been found with the total end-user prices and the total per unit network usage tariff, but an unexpected negative relationship was detected with the total network usage tariffs owing to the TSO. Still, relationship with the narrowly defined transmission fee is likely, but the results are weakened by the low cardinality of available data.

Based upon the analysis results, the *fourth* hypothesis on improper incentive ensured by the regulation regarding grid investments had to be rejected for both distribution and transmission. DSOs conducted a constantly active grid investment activity on the research period. Nominal level of capital expenditures remained relatively steady for a long period in spite of the economic crisis starting from 2008. This has certainly been enhanced by the incentive regulation launched in 2009. Significant downfall of such expenditures occurred only in 2012 as a result of the long-lasting crisis and economic policy decisions being disadvantageous for electricity sector, including changes in taxation and pricing methods. The analysis of sources behind capital expenditures implied the regulation's success, as it was able to enhance the sufficient level of expenditures even in those years when the resources ensured for grid operators via the tariff system were relatively low. All examined quality factors showed sufficient efforts in the *transmission* segment, providing indirect evidence for capital expenditure adequacy. Further analysis of investment level optimality beyond sufficiency – including analysis of society-confirmed need for investments – represents a future possibility of extending the research.

The last, *fifth* hypothesis regarding the existence of cross-subsidies between competitive and monopolistic activities in spite of unbundling steps done is considered to be confirmed. Relationship of *distribution's* capital expenditure has been stronger with the end-user prices than with the network usage tariffs, implying that in spite of legal unbundling, cross-subsidies still exist within the large, vertically integrated holdings. Existence of liabilities towards associated companies and an increase of cash-pool financing's importance from the mid 2000s was typical in the segment. Based upon the analysis of cash-flows, it became clear that parent companies of the DSOs drained away resources, then allocated back the amounts necessary for complying with the regulatory expectations. Existence of this intra-group financing has been confirmed via examination of cash-pool positions on the

period starting from 2007. Thus final decision on grid-relevant capital expenditures still depend from the whole group's result as well as from the network operator's own performance.

At *transmission*, integrated intra-group operation is indicated by the fact that the steady development of the transmission-relevant capital investments took place notwithstanding the strongly volatile funding position of the TSO. The material decrease of funding provided for MAVIR in the regulatory cycle starting from 2009 did not entail a similar change in the CAPEX, while the downfall of grid-relevant expenditures in 2012 occurred with a parallel increase in network-relevant tariffs and resources. Further, MVM group also applies a cash-pool system that significantly modified the TSOs position.

Altogether in my opinion regulation and the tariff system has been able to ensure a sufficient level of grid investments until 2011. On the other hand, in 2012 level of capital expenditures suffered a significant downfall at transmission, while a provable fallback occurred in distribution as well. As a result of the continuously disadvantageous regulatory decisions of pricing and taxation in respect of the service providers, increase of investments is not likely in the close future. Sooner or later this will have an effect on network service quality as well. Further, it is also questionable to what extent will the vertically integrated groups be willing to provide additional funds for the network segment within this environment. In consideration of the fact that the distribution segment typically needed this additional funding in the last regulatory cycle, this might represent a critical factor in the close future. These results might serve as a warning for decision makers considering electricity-related measures in general: further deterioration of the industry's profits may have an adverse effect on grid investments both directly via the decline of funds ensured via network tariffs, and indirectly by cutting the resources of intra-group funding as well.

5. NEW SCIENTIFIC RESULTS

Based on the elaboration of the empirical research carried out, the relevant legislation, and the domestic and international literature, the following new and novel scientific results can be formulated:

1. **Calculation of the average per unit network usage fees and revelation of the tendencies of network tariffs within the end-user electricity prices.**

In order to reach this result I examined the internal structure of the electricity prices and within it the structure of network components. Furthermore I have calculated the yearly average per unit network fees for distribution, transmission and other system-relevant activities.

2. **Exploration of the relationship between the network investments and the regulatory and pricing cycles of electricity.**

I have confirmed by analysis of statistical information and financial statements that the tariff system shaped by regulation has a direct, but non deterministic impact on grid investment. To attain this result I examined the development of pricing and investment cycles in the network segment, furthermore the effects of some key changes in regulation, such as the introduction of stricter unbundling requirements and the incentive regulation. During the review of relevant literature I could not find a similar analysis being conducted for electricity network.

3. **Presentation of the trends of network segment's rate of return, revealing that the realised rate of return typically did not exceed the acknowledged level. This implies the success of the monitoring performed by the Authority.**

I have reached this result by review and analysis of the financial statements of the segment's entities, furthermore calculated the rates of returns relevant for

the grid activity. Finally I compared the calculated rates to the acknowledged rates that represent the justified (acceptable) profit of the grid activity. Preceding the date of legal unbundling I applied at each instance the nearest possible results to network operation, for example the activity level financial statements published since the accounting level unbundling of 2003. Rate of return at the distribution has constantly been near to the acknowledged level: thus the operation has been profitable, indicating that the private companies managed grid operation in a way to achieve the highest possible returns. On the other hand, similar indices of the state-owned transmission system operator remained permanently below the acknowledged rate.

4. The regulation – including pricing system and the incentive regulation – has been successful from the aspect of grid investment sufficiency.

The result has been achieved by analysis of the funds ensured by the regulation via the tariff system for the natural monopolistic network services activity. I have compared these resources to the capital expenditures, and successfully revealed the success of the regulation in the distribution segment: it has been able to continuously enforce grid companies to keep up an expected investment and quality level of the services, even in the relatively poorly funded time periods. Even though an analysis of the same depths was not possible at the transmission due to lack of data, the steady increase of transmission-relevant capital expenditures despite the volatile funding of the TSO until 2011 implies the success of the regulation in this segment as well. However it is very important to keep in mind that the current research has covered only the time period ending with 2012. Since then significant changes occurred in the regulation of the domestic electricity market and these changes may have induced a major change of the situation described in this point.

5. **Even though completing the requirements of legal unbundling, network operators still function as members of vertically integrated holdings. This fact has material impact on the grid operations and the funding of capital expenditures.**

I have confirmed via examination of the funding of grid-relevant capital expenditures that distribution network companies have overcome years of a relative lack of funding by drawing intra-group resources. Review of financial statement information revealed that liquidity- and resource management of these companies is completely integrated with their groups: the parent companies regularly withdraw liquid assets and results generated by the grid company, and then reallocate the funds necessary for operations and capital expenditures. Further examination of correlation between investments and prices and network usage fees, the relationship of capital expenditures has been stronger with the end-user prices than with the network tariffs. This implies the existence in intra-group cross-subsidies as well. A similar integrated liquid asset management method is applied by the MVM group incorporating the transmission system operator MAVIR.

6. PROPOSALS (THEORETICAL AND PRACTICAL IMPLEMENTATION)

Based on the analyses and results described above and throughout the dissertation, I make the following proposals:

- Examination of the investment levels has confirmed that introducing a stricter form of unbundling has been followed by an increase of capital expenditures both in the distribution and the transmission segments. The distribution segment has applied the cash-flow realized from grid activity to a sufficient extent for grid investments. On the other hand I did not succeed to reveal a clear connection between funding ensured for transmission by the regulation and the transmission grid relevant capital expenditures. Considering the close relationship of daily politics and MVM group and the still existing intra-group cross-subsidies, is it likely that the decision making of the transmission system operator is not completely independent in spite of the formally accomplished legal unbundling. This aspect aggravated by the fact that the wholesale trader company still dominating the domestic market also belongs to the same group. Therefore **I propose the application of the strictest form of the unbundling for the transmission.** In case of the distribution, level of grid investment showed a stronger relationship with the end-user price than with the network usage fees. This is a strong indication that despite the unbundling, decision on grid-relevant investments still depends rather on the overall results of the vertically integrated group than only on the narrowly defined network activity's returns. Therefore **I suggest a reconsideration of unbundling rules and requirements in the distribution as well.**
- In order to maintain and further ameliorate the service quality and to firm the professional aspects of pricing decisions, **I propose a further strengthening of the link between network tariffs and the valid, factual network service**

costs.

- Even though the Act on Electricity would allow allocating the **revenues resulting from allocation of cross-border capacities** directly to capacity development (and thus grid investment), according to a regulatory decision this amount is now used to decrease the tariff paid by the customers. In my opinion this solution does not support properly the development of the transmission system, therefore **I propose allocating this income at least partially directly to the network developments.**

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