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Implementation of Performance Based Regulation in Distribution of Electricity in Croatia

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Abstract: - Directive 2003/54/EC emphasized the importance of introduction of regulated third party access as a prerequisite for introducing fully functioning electricity market. This provision relates both to transmission and distribution of electricity. In addition it gives regulatory authorities powers to set or at least approve terms for networks' access, including a methodology for setting transmission and distribution tariffs. Croatia as a candidate country for the EU membership has to adopt respective EU directives' provisions through its national legislation. This article gives the state of the art of distribution activity in Croatia in respect to the energy market reform. In addition it deals with different methods of economic regulation, emphasizing the possibility of applying Performance Based Regulation in distribution of electricity in Croatia with the reference to the quality of supply mechanism.

Key-Words: - Regulated Third Party Access, Distribution of Electricity, Economic Regulation, Performance Based Regulation - PBR

1 Introduction

Reform of electricity market requires enforcement of many processes which should be carried out harmoniously. Its success, therefore, depends on many factors: governments, energy undertakings, regulatory authorities, financial institutions, consumers etc. Regulatory authorities as a new factor in a scene, not having previous 'code of conduct', should be even more careful in imposing their regulatory policies. To varying degrees, regulatory authorities are responsible for monitoring electricity markets, setting and monitoring different rules and prices and generally to act as a watchdog against anti-competitive behavior.

Their task is even more complicated in economies in transition, which do not have market oriented past. Therefore, implementation of a successful regulatory policy, especially in the field of economic regulation, often could be a serious problem to national energy regulatory authorities. Directive 2003/54/EC [1] emphasized a role of regulatory authorities in respect to price setting mechanisms for network activities. However, this role should be accompanied with other measures of regulatory control, such as control of quality of supply, thus not creating negative effects of the electricity market reform.

2 Methods of economic regulation

Development of regulatory regimes in the electricity sector implicitly includes development of different methods of economic regulation. Regulatory authorities introduce more and more complex methods, thus, trying to achieve ultimate goals of economic regulation: efficiency and productivity improvement, not undermining the quality of supply. Once widely used methods, described as a Rate-of-return (or cost plus) methods (RoR) are replaced with alternative approaches such as:

- Price caps,
- Revenue caps and,
- Hybrid forms (combined price-revenue caps or earning sharing).

These alternative approaches are very often accompanied with the measurement of performance parameters such as costs of different inputs and quality of supply parameters. When using these performance targets in a regulatory regime, than, so called Performance Based Regulation (PBR)[1], is applied.

When designing or evaluating effects of different PBR models, it is possible to define two phases [2]:

1. Phase – Setting of goals to be achieved with implementation of PBR

[1] PBR was introduced as an alternative to cost-of-service regulation in the United States' electricity sector in the late 1980s and early 1990s [3].

2. Phase – Designing of PBR model which follows the set goals.

The rational for abandoning classical RoR lies in the fact that several fundamental problems should be overcome:

- information asymmetry between regulated undertakings and regulatory authority, including only limited information about the efficiency efforts of undertakings,
- although customers benefit from any cost savings, there is no efficiency incentive for the undertakings to lower the costs,
- although under a fixed price regulatory regime the efficiency incentive for the undertakings are high, customers do not benefit from any cost savings.

The balance between two last mentioned problems should be found. Possible solution lies in the alternative methods of regulation and thus avoiding the critiques which relates to RoR. Properly designed alternative methods can improve undertakings' efficiency and productivity, providing more flexibility to the undertakings, while protecting customers from the potential market power abuse. In order to achieve such goals several measures should be taken:

1. Introduction of external adjustment factors outside of undertaking's management control (e.g. K – factors),
2. Definition of performance targets through the benchmark with external data to the regulated undertaking,
3. Introduction of reward-penalty mechanism in order to meet desired performance targets,
4. Establishment of quality of supply measurements (to minimize undesired effects),
5. Introduction of efficiency gains shearing mechanism.

The order of introducing above mentioned measures in a respective regulatory regime should not be necessarily in the given order. However, alternative methods have their negative sides as well. One of the most emphasized is that a well-design PBR system tends to be quite complex and as such its overall efficiency impacts can be poorly understood.

2.1 Price Cap Regulation

Price Cap Regulation sets the upper limit for the individual prices or the average prices of a basket of prices allowing flexibility below this upper limit. In case of cap on a basket of prices actual price index should be calculated:

$$API_t = \Sigma w^i_{t-1} * p^i_t \quad (1)$$

Where are:

API_t – actual price index in period t,
w^i_{t-1} – weight of price i in period t-1,
p^i_t – price i in period t.

Price cap mechanism allows adjustment of the caps due to the:

- Inflation (I), which increases unit costs and thus should result in an upward adjustment of the cap,
- Productivity factor (X), which reduces unit costs and thus should result in a downward adjustment of the cap,
- Factors external to the regulated undertaking (so called Q – factors), which can result in both, an upward and a downward, adjustment of the cap.

A following formula represents a dynamic adjustment of the price cap throughout a regulatory period:

$$PC_{t+1} = PC_t * (1+I-X) \pm Y \quad (2)$$

Where are:

PC_{t+1} – price cap in period t+1,
PC_t – price cap in period t,
I – inflation index,
X – productivity gains' factor,
Y – external factors.

So called Y–factor can represent different external influences:

$$Y = K \pm Q \pm S \quad (3)$$

Where are:

K – adjustment for factors outside of management control (e.g. tax, accounting, regulatory or legislative changes not reflected in inflation measure),
Q – quality of supply adjustment factor,
S – infrastructure investment's factor (in cases of lump sum investments).

Inflation index (I) can be represented by different indexes. All this indexes are independent of regulatory authority influence and should be publicly available. These indexes could be:

- Consumer Price Index (*CPI*)
- Gross Domestic Product Price Index (*GDPPI*)
- Producer Price Index (*PPI*)

On the other hand X–factor which represents the productivity gains could be defined using different benchmarking methods [4] as shown in Fig. 1. A wide range of methods, that differs in the mathematical techniques and consequently in data requirements, could be used. The common feature of these methods is that they all involve setting targets for cost reduction that are independent of the actual cost reduction achieved by the undertaking during the regulatory period.

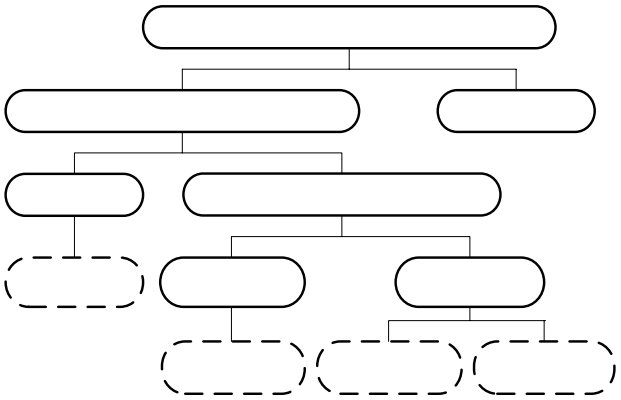

Fig.1 Benchmarking methods for calculating *X*–factor

The impact of the *I*–factor, which is always grater than 0, and *X*–factor on a price cap in the regulatory formula, is shown in Table 1.

Table 1 Influence of *X* – factor on the price cap

X factor (*I*>0)	*X*<0	*X*=0	0<*X*<1	*X*=1	*X*>1
Nominal price	↑ faster than *I*	↑ at *I*	↑ slower than *I*	Const.	↓
Real price	↑	Const.	↓ at *X*	↓ at *X*=1	↓ at *X*

A crucial step in a Price Cap Regulation is a design of an initial price level. Ideally it should be based on a detailed review of costs. However, very often existing prices (rates) are used as a starting point. The third option for the initial price level setting is a benchmark with a best practice undertaking. In this case a thorough insight in operation of benchmarked undertakings is needed.

2.2. Revenue Cap Regulation

In Revenue Cap Regulation the upper limit is set on revenues and only indirectly constrains prices. Like in Price Cap Regulation this method does not constrain profitability directly. The cap in this case can be set on:

- Total revenue,
- Per customer revenue,
- Average revenue (revenue per unit of output).

In case of cap on total revenue, the cap should be adjusted for growth in number of customers and other factors influencing the revenues of regulated undertakings (e.g. higher or lower usage of electricity per customer). The formula for dynamic adjustment of revenue cap is as follows:

$$R_{t+1} = (R_t + CGAF_t * \Delta NoC) * (1 + I - X) \pm CF \quad (4)$$

Where are:

R_{t+1} – revenue in period t+1,
R_t – revenue in period t,
$CGAF_t$ – customer growth adjustment factor in period t,
ΔNoC – change in number of customers,
CF – capital additions' adjustment factor.

In case of cap on per-customer revenue, in principle, $CGAF_t$ is not needed, although it may be necessary to adjust it for a general load growth. The initial revenue, *I*–factor and *X*–factor are determined analogously as they were explained when discussing Price Cap Regulation. The pros and cons of introducing revenue caps are given in Table 2.

Table 3 Pros and cons for introducing revenue caps

PROS	CONS
De-couple revenues and profits. Often easier to determine and monitor than price caps. Compatible with the existing practice and billing requirements of regulatory authorities.	May lead to significantly distorted prices. Less relevant if undertakings cannot influence its demand.

2.3 Hybrid forms

Broadly said there are two hybrid methods: combined price-revenue caps and earning sharing. An overview of combined price-revenue caps is given in Table 3.

Table 3 Combined price–revenue caps

Category	Combined price–revenue caps
Price – P	$P = (1 - w) f(P_{t-1}) + (w) R/S$
Revenue – R	$R = (1 - w) P \cdot S + (w) f(R_{t-1})$

Where are:

P_{t-1} – price in period t-1,
R_{t-1} – revenue in period t-1,
S – sale in period t.

A coefficient w is defined by regulatory authorities (it should be: $0 \leq w \leq 1$).

An earning sharing principle is used when defining how efficiency gains are split between different stakeholders. It usually includes a targeted return for return on equity, a 'safe' band where there is no sharing and one or several sharing bands beyond a 'safe' band in which sharing principle could have a progressive or degressive approach.

Benchmark met
Total methods
Index methods
Frontier metho
Total Factor Productivity (TFP)
Non-parametric
Data Envelopment Analysis (DEA)
Corrected Least S (CO

3 Quality of supply as an integral element of PBR

Alternative approaches of price regulation provide strong incentives for efficiency improvement but also for quality degradation. Therefore, some kind of quality control mechanism is needed in addition to the price control mechanism, defining thus performance indicators in the PBR. Actual experience with quality regulation in liberalized electricity markets is still limited, especially having in mind that limited information about relations between costs and quality and about customers' preferences reduces the effectiveness of the state of the art mechanisms.

The responsibility for quality of supply has been redistributed among different players due to the process of liberalization, deregulation and unbundling of incumbent utilities. In addition to the companies, regulatory authorities due to the reforms play an important role. Quality of supply is basically determined by two elements:

1. Quality of transmission and distribution networks
2. The volume of installed and available generating capacity.

Since this article deals with a distribution of electricity, emphasized is given to the quality of networks in which three segments could be recognized:

- Power quality
- Continuity of supply
- Commercial quality.

Power quality covers aspects such as voltage and frequency stability, voltage dips, over voltages or harmonic distortions. The other two segments are more related to the quality of supply mechanisms defined and monitored by regulatory authorities. Continuity of supply is characterized by the number and duration of interruptions, which may be planned or unplanned, or by the length of each disturbance. Among a wide range of continuity of supply indicators, which are related to the frequency and duration of outages, the main difference is in weighting factor being used (e.g. customers, load, and energy). The most commonly used indicators to determine continuity of supply are:

- Customer Average Interruption Frequency Index (CAIFI)
- Customer Average Interruption Duration Index (CAIDI)
- Customer Minutes Lost (CML)
- Non-delivered Energy (NDE).

All of above mentioned indexes are related to the individual customers. Indicators related to the system (but could also be related to the certain components) and aggregate information for all consumers are:

- System Average Interruption Frequency Index (SAIFI)
- System Average Interruption Duration Index (SAIDI).

Different countries use different indicators and have different approaches. Such differences complicate a comparison of statistics among them. An example for the EU countries could be seen in CEER report [5].

A term commercial quality represents a set of quality relations between a supplier and a customer. This set could be divided in overall standards that relate to the overall provision of services (e.g. a minimum performance level) and guaranteed standards (e.g. penalty payments in case of non-compliance).

Designing a mechanism to properly compare companies and translate this into an integral price and quality regulation system is challenge that still lies ahead [6].

Considerable elements of quality regulation are included in conventional regulatory procedures such as incensing, pricing, market and system rules. However, regulatory authorities can take additional measures such as ensuring that defined performance and quality standards are met. When these measures are accompanied with financial incentives, one is talking about PBR.

In the next sections of the paper the possibility and prerequisites for implementation of PBR in distribution of electricity in Croatia will be analyzed.

4 Reform of electricity sector in Croatia

Process of reform of electricity sector in Croatia started in 2001 with adoption of a set of energy laws. The next step due to the harmonization with Directive 2003/54/EC was taken in 2004 [7]. A set of new energy laws brought many changes, especially in structure and organization of electricity market, competences of regulatory authority (Croatian Energy Regulatory Agency) [8] and unbundling of incumbent utility (Hrvatska elektroprivreda - HEP), which supplies all consume in Croatia. A new unbundling approach for HEP's core activities envisages four independent companies with a status of limited liability company within the mother joint stock company HEP:

- HEP Generation
- HEP Transmission system operator
- HEP Distribution system operator

– HEP Supply.

Although the process of restructuring HEP started in 2001, it has been going quite gradually due to the inherited business practice and organization. This fact impedes the implementation of fully-fledged regulatory regime, including a methodology of economic regulation in network activities[2] which should incorporate all previously discussed elements, thus enabling efficiency increase, cost reduction and preventing any further subsidies between market and non-market activities. However, with new energy laws Croatian Energy Regulatory Agency obtain more powers in respect to securing efficient unbundling of accounts/activities and price setting procedure.

4.1 Distribution system operator

Distribution of electricity as an energy activity in Croatia is organized through 21 regional distribution areas, quite different in size, consumption, know-how and age of network. Just for an illustration a population density per km^2 in respective regions varies from 10 (Ličko-senjska county) to 162,4 (Međimurska county) and 1.215,5 (capital city of Zagreb). Furthermore, in order to give an insight into a size of distribution areas, as an illustrative example a comparison of number of metering places or consumption per a distribution area could be given. A number of metering places ranges from 25.950 to 469.576 (in Croatia as whole, there are 2.125.613 metering places), while consumption ranges form 151,8 GWh to 3.183,5 GWh (total consumption is 13.691,5 GWh).

Having in mind previously said, a common approach to regulatory standards setting in relation to financial, technical and quality standards, is quite hard to apply throughout all distribution areas. However, it is important to define a current possibility of implementation of PBR in distribution of electricity in Croatia and prerequisites for it, respectively.

5 Prerequisites for Implementation of PBR in Distribution of Electricity in Croatia

There are many obstacles in implementing of one of the alternative approaches of economic regulation, discussed earlier, in distribution of electricity in Croatia. When analyzing formulas, (2) to (4), which define a dynamic adjustment of prices/revenues in Price/Revenue Cap Regulation several conclusions can be drawn.

Since, HEP is in the begging phase of unbundling and there is no historic data for each energy activity 'perfectly' unbundled from other activities, a thorough regulatory approach should be applied in order to define a starting price or revenue in the price/revenue cap formula. Therefore, many factors should be analyzed through the regulatory overview (e.g. book values, amortization, historic costs, capital employed etc.) prior to implementation of price/revenue cap regulation.

The second observation is in regard to X-factor (efficiency improvement factor). Due to the fact that there is only one distribution company in Croatia, it is impossible to do the benchmark exercise just among Croatian companies. However, it is possible to do it among different distribution areas, or do it with some comparative distribution companies within SEE region, for which thorough insight into non-national distribution companies is needed.

In regard to the external Y-factor, also detailed analysis is needed, especially in respect to Q-factor (quality of supply adjustment factor). Namely, the state of the art of quality supply mechanisms should be explored. HEP-Distribution System Operator has not, so far, introduced a systematic, harmonized mechanism for surveillance of continuity of supply parameters, such as SAIDI/SAIFI, throughout all distribution areas. Actually, operation statuses are registered manually in the operational handbook in each distribution area. Therefore, there is a great possibility that some data is misinterpreted and incorrect in further, summarized data processing and analysis.

As discussed earlier, introduction of the PBR model is a quite complex problem. Therefore, a thorough analysis of the problem is needed which encompass definition of the phases and time framework. Based upon the experience of neighboring regulatory authorities a period of couple of years is needed in order to introduce fully-functioning performance based system which includes cap regulation, quality of supply system and penalty-reward system[3].

[2] Tariffs for use of transmission and distribution networks were defined by Croatian Energy Regulatory Council in 2003 through Regulation on method and criteria for determination of the amount of the fees for use of transmission and distribution network [9] not following fully principles of previously discussed principles of economic regulation.

[3] Hungarian regulatory authority MEH (Magyar Energia Hivatal) was established in 1994. In 1995 already recognized a quality of supply regulation as an integral part of its responsibilities and started introducing measures in regard to quality of supply regulation. Thus, in 2003 Hungarian Energy law recognized through its provisions that MEH was in charge

Therefore, in order to reduce a time frame for preparatory phase of implementation of fully functioning PBR model special efforts are needed from both sides: regulated undertaking and regulatory authority. The first step for the regulated undertaking should be development and implementation of the continuity of supply IT program which is common for all distribution areas. For implementation of such program some preliminary actions should be taken (e.g. introduction of SCADA in all distribution areas, informatization, harmonization of data basis, codes, approaches etc.). All these actions require time, knowledge and financial resources.

Regarding regulatory authority side, quality of supply should be recognized as one of very important pillars of regulation, without which economic regulation can undermine the basic postulates of quality of supply of electricity. However, as mentioned in the Hungarian case, legislator should also recognize the importance of all segments of regulation and powers of regulatory authority, thus giving impetus for development of comprehensive regulatory framework.

6 Conclusion

Croatia is at the starting point of electricity market reform which goes in line with provisions of Directive 2003/54/EC, thus legging behind many other EU countries which fully opened their markets. There are many aspects of a reform (unbundling, liberalization, deregulation development of new institutions etc.) and many phases. In respect to responsibilities of regulatory authorities and development of regulatory models, advanced regulatory authorities so far have developed different methods of economic regulation (RoR, alternative methods) accompanying them with performance parameters' measurement (such as quality of supply parameters), thus introducing PBR. Development of regulatory policies in regard to economic regulation has occurred gradually. However, for the regulatory authorities, such as Croatian Energy Regulatory Agency, which have to speed up development of regulatory policies in order to be in line with market reform milestones, it is very important to implement well prepared and analyzed regulatory measures, not repeating some of the well-known mistakes.

In regard to implementation of PBR in distribution of electricity in Croatia, two-sided (energy undertaking and regulatory authority) and two-track (development of economic regulation and quality of supply surveillance system) measures should be taken. In this way it is possible to speed up actions, which should be taken before implementation of a fully functioning PBR model, and reduce a preparatory period from a 7-8 years period to a 3-4 year period.

References:

[1] Directive 2003/54/EC of the European Parliament and of the Council of 26 June 2003 concerning common rules for the internal market in electricity and repealing Directive 96/92/EC, *Official Journal of the European Union* L176/37, 2003

[2] E. Banovac, *Doctoral thesis: Model of energy activities regulatory system*, Faculty of Electrical Engineering and Computing, University of Zagreb, 2004, pp. 48-50.

[3] National Association of Regulatory Utility Commissioners, *The Regulatory Assistance Project-Performance-based Regulation for distribution Utilities*, Dec 2000, Washington

[4] Coelli, T; Prasada Rao, D.S; Battese, G.E., *An Introduction to Efficiency and Productivity Analysis*, Kluwer Academic Publishers, 1997.

[5] Council of European Energy Regulators, Working Group of Electricity Supply, *Quality of Electricity of Supply: Initial Benchmarking on Actual Levels, Standards and Regulatory Strategies*, April 2001

[6] Adjofhia Virendra, *Integrated Prices and Reliability Regulation: The European experiance*, CEPSI 2002, Fukoka, Japan 2002.

[7] Law on electricity market, Law on regulation of energy activities, Amendments of the Energy law, *Official Gazette of the Republic of Croatia*, No. 177/04

[8] Štritof, I; Grgić Bolješić, K. *Harmonization of Areas and Regulatory Functions of Croatian Energy Regulatory Council with Directive 2003/54/EC*, Energija, 53 (2004). No.6, pp. 505-520.

[9] Regulation on method and criteria for determination of the amount of the fees for use of transmission and distribution network, *Official Gazette of the Republic of Croatia*, No. 109/03

of setting minimum standards of continuity of supply and expected levels of quality of supply. These standards were defined for each distribution company (6) separately in the licensing provisions.