QUALITY OF POWER SUPPLY IN EUROPEAN VIEW

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Summary This paper deals with comparisons of situation in quality of power supply regulation in some of European countries, which are interested in CEER (Council of European Energy Regulators). Especially we focused our analysis on reliability indices, relationship between supplier and consumer and electric power supply aftereffects. There are discussed differences in each countries and comparison with situation in Czech Republic.

1. INTRODUCTION

Through all European countries liberalization of electric energy market was finished. It brings new Technical, Economical and Legislation problems. One of these problems is relationship between customers and suppliers and standardization of quality of electric power supply. Incentive/penalty regime seems to be one of the possible solutions.

2. RELIABILITY INDICES [3]

Most of European countries use these reliability indices for reliability measurement and analysis:
- „System Average Interruption Duration Index" (SAIDI), in some countries it is used "Customer Minutes Lost per customer per year" (CMLs).
- "System Average Interruption Frequency Index" (SAIFI), it is also used "Customer Interruption per 100 customers per year" (CIs).
- "Momentary Average Interruption Frequency Index" (MAIFI).
- "Energy not supply" (ENS).
- "Average Interruption Time" (AIT).

There five reliability indices are usually reported annually in most European countries. SAIDI, SAIFI and MAIFI are often divided to planned and unplanned. Reliability indices used for **distribution** networks in European countries.

SAIFI, SAIDI and MAIFI per High, Medium and Low voltage level (HL, ML, LL) are monitored in Great Britain, Hungary, Italy and Norway.

SAIDI and SAIFI per HL, ML, LL are monitored in Greece, Portugal, France, Lithuania and Norway.

SAIDI and SAIFI per HL, ML are monitored in Slovenia and Belgium (Walloon).

SAIDI and SAIFI at all voltage level are monitored in Sweden, Estonia and Ireland.

Average duration and frequency per contracted power etc. are monitored in Austria, Spain, Finland, Portugal and Norway.

Here it is big difference between distribution and transmission networks. Reliability indices used for **transmission** networks.

ENS is monitored in Finland, France, Hungary, Ireland, Italy, Lithuania, Poland, Portugal, Spain, Sweden, Great Britain and Norway.

There are used also other indices like AIT, SAIDI, SAIFI and other in different countries.

There are not monitored reliability indices at transmission level in Austria, Estonia, Greece, Latvia and Slovenia.

In Czech Republic are monitored SAIDI and SAIFI at distribution and transmission networks. Total time of interruption is monitored at transmission level too. The problem is, that there is no audit pursued by any authorities e.g. regulator, distribution companies or consultants in Czech Republic to made these data sets more credible and reliable.

3. STANDARDS AND INCENTIVES IN QUALITY REGULATION [3]

This part of article deals with standards and incentive/penalty arrangements regulating quality of electric power supply.

Customer surveys are one of the most important forms of measurement of quality of electric power supply. But it is very important to realize customer survey widely, because only wide customer survey can bring relevant data about customer satisfaction, expectation and Willingness to Pay (WTP) for quality of electric power supply.

There are three common methods for customer surveys:
- Customer satisfaction (Used in Portugal, Hungary, Italy or Great Britain)
- Customer expectations and importance of quality factors (Portugal, Italy, Great Britain)
- Customer willingness to pay (Great Britain, Hungary)

Reasons and methods of customer surveys realized by national energy regulator:

- o Customer surveys on Willingness to pay were realized in Norway, Italy, Great Britain and Sweden.
- o Customer surveys on expectations and importance of quality factors were realized in Hungary and Italy
- o Customer surveys on satisfaction were realized in Hungary, Italy Great Britain and Portugal

In Greece there is customer survey under preparation in will realized in few years.

In other European countries were not yet customer surveys realized, e.g. Austria, Belgium, Czech Republic, Estonia, Finland, France, Ireland, Lithuania, Latvia, Poland and Slovenia.

Only 8 European countries use incentive/penalty method to regulate quality of electric power supply:

- o Italy from 2000
- o Norway and Ireland from 2001
- o Great Britain from 2002
- o Hungary and Portugal from 2003
- o Sweden from 2004
- o Estonia from 2005

Other countries prepare start of incentive/penalty regime from 2008 (Finland, France, Lithuania) in near future Poland, Spain, Slovenia.

4. THEORETICAL MODEL OF INCENTIVE/PENALTY REGIME

There are a lot of theoretical possibilities of using incentive/penalty scheme. We describe only 4 basic models of incentive/penalty schemes.

For theoretical model we use Portugal incentive/penalty scheme with parameters from 2005. Portugal is the most comparable country to Czech Republic in EU. It is modification of Fig. 1d.
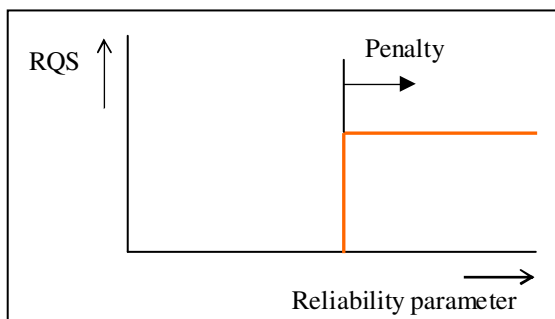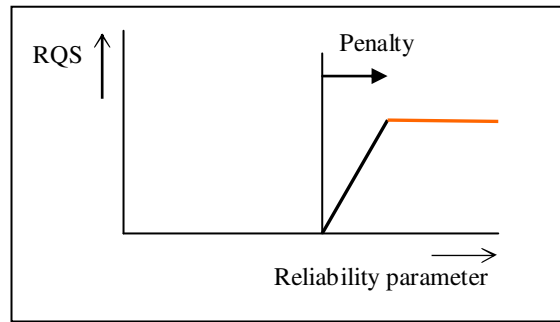
Fig. 1a. Incentive/penalty scheme
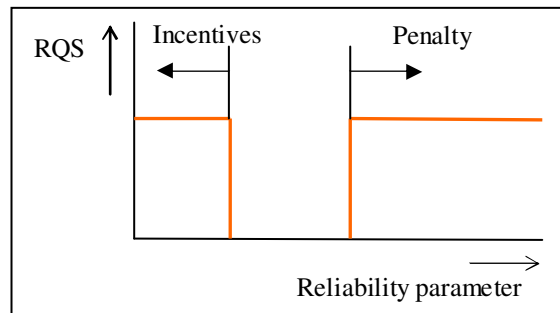
Fig. 1b. Incentive/penalty scheme
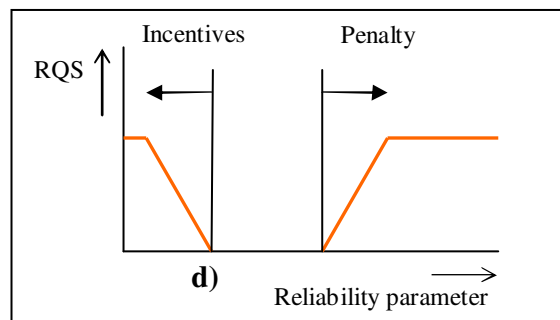
Fig. 1c. Incentive/penalty scheme

Fig. 1d. Incentive/penalty scheme

There is energy not supply (ENS) used as a reliability parameter in this model. In some countries is only one parameter used in incentives/penalty scheme (only SAIDI) in some countries are used SAIDI and SAIFI together (two incentives/penalty systems).
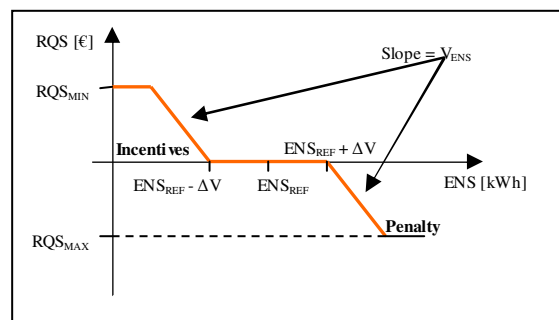
Fig. 2. Incentive/penalty scheme – Portugal model[3]

Values used in this theoretical model [3]:

- o The incentive is symmetric (not necessary) and related to a reference value (target) of the Energy Not Supply (ENS_{REF}).
- o Dead bands are used (not necessary).
- o If the value of ENS in a given year is less than $ENS_{REF} - \Delta V$, which means that the network had a good performance, the distributors' revenues are increased by an amount RQS (revenues for quality of supply). RQS is computed using a per-unit-value of the ENS, V_{ENS} and is proportional to the difference between the actual ENS in the year and the target $ENS_{REF}-\Delta V$:

$$RQS = V_{ENS} \cdot \left[\left(ENS_{REF} - \Delta V \right) - ENS \right], \qquad (1)$$

- o If the value of ENS in a given year is greater than $ENS_{REF} + \Delta V$, which means that the network had a bad performance, the distributors' revenues are decreased by an amount RQS. RQS is computed using a per-unit-value of the ENS, V_{ENS}, and is proportional to the difference between the actual ENS in the year and the target $ENS_{REF}-\Delta V$:

$$RQS = V_{ENS} \cdot \left[ENS - \left(ENS_{REF} + \Delta V \right) \right], \qquad (2)$$

- o If the value of ENS in a given year is near ENS_{REF} value, the distributors' revenues are not affected. (RQS=0)

$$ENS_{REF} - \Delta V \le ENS \le ENS_{REF} + \Delta V , \qquad (3)$$

Portugal model with parameters from 2005:

- o The reward and the penalty have the same maximum value

$$\left| RQS_{MIN} \right| = \left| RQS_{MAX} \right| = 5\ 000\ 000\,€ , \qquad (4)$$

- o Target ENS_{REF}=0,0004 x ES (ES – energy supplied in the year)
- o Dead band: ± ΔV=0,12 x ENS_{REF}
- o Value of ENS: V_{ENS} =1,5 €/kWh

On the basis of these theoretical bases we tried to apply Portugal incentives/penalty model to Czech power energy environment.

- o The reward and the penalty have the same maximum value. We set maximum penalty/incentives value as a 1% of annul profit of ČEZ Group (2005) it is 223 000 000 CZK (about 7 500 000 €, 1€ ~ 29,784 CZK in average from 2005).

$$\left| RQS_{MIN} \right| = \left| RQS_{MAX} \right| = 7\ 500\ 000\,€ , \qquad (5)$$

- o Target ENS_{REF}=0,0004 x ES (ES – energy supplied in the year, it is 52 397 GWh in 2004 in Czech Republic – newest data, data from 2005 are not still available)
- o Dead band: ± ΔV=0,12 x ENS_{REF}
- o Value of ENS: Setting of value of ENS is very difficult and it was not make a large customer survey to set value of ENS for various types of customer e.g. large industrial, small consumers, small industrial (business) customer. We made a detail analysis of outage costs in one large industrial enterprise and found out that value of ENS for this case is around 5€/kWh. But it depends on many variables and it can not represent all Czech industrial consumers. V_{ENS}=5 €/kWh, but only in this specific case.
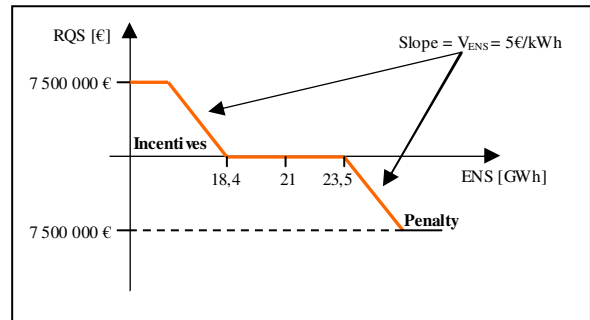

Fig. 3. Application of Incentive/penalty scheme of Portugal model to the Czech conditions and values. (Only example for this specific situation and conditions)

Values of ENS in other European countries [3]:

- o Great Britain – Average value of ENS is 4,18 €/kWh.
- o Ireland – Average value of ENS is 7,20 €/kWh.
- o Italy – Differentiated according to type of consumers (domestic and business) is 10,80 and 21,60 €/kWh.
- o Norway – Differentiated according to type of consumers and to type of outage (unplanned and planned). Industrial 7,90 – 5,51, Trade/Service 11,86 – 8,14, Agricultural 1,80 – 1,20, Residential 0,96 – 0,84, Public service 1,56 – 1,20, Wood processing/energy intensive industry 1,56 – 1,62 €/kWh.
- o Portugal – Average value of ENS is 1,50 €/kWh.
- o Sweden – Value of ENS is differentiated according to density of line and type of outage (planned and unplanned), Urban 12 – 8,6; Suburban 8,8 – 6,3; Rural 7,4 – 5,5

€/kWh Urban 2,5 – 0,4; Suburban 1,9 – 0,3; Rural 1,9 – 0,2 €/kW (Value of lost load).

Reliability indicators used in incentives/penalty schemes in various European countries [3]:
- o CML, CI in Great Britain
- o Outage rate, Number of MV faults per grid length, Average repair time of MV network, Average number of LV grouped faults, SAIDI, SAIFI, Percentage of interruptions restored within 3 and within 24 hours in Hungary
- o SAIDI and Losses in Ireland
- o SAIDI in Italy
- o ENS in Norway, Portugal
- o SAIDI, SAIFI in Sweden

5. CONCLUSION AND RECCOMENDATION

System of incentives/penalty scheme seems to be the most comfortable utility to regulate quality of electric power supply. Experience with this scheme shows that system of incentives and penalty had a direct impact on quality of electric power supply in European countries e.g. Great Britain, Italy, Ireland, Hungary and Norway.

There is a big problem in reliability data collection in Czech Republic, because only global reliability parameters are watched. It is not possible to set reliability parameters of each overhead power lines and cable lines in Czech Republic.

If we can start with incentives/penalty arrangement in Czech Republic first of all we must change reliability data collection system. After that we must set quality of electric power supply standards as for example limits of SAIDI and SAIFI. At the end we must set limits for RQS, we must make decision about using dead band and symmetry of incentives. Type of incentives and penalty must be set too, we can choose from automatic or on request scheme.

Probably the biggest and the most difficult problem will be setting of value of energy not supplied (V_{ENS}).

Our ENS value survey shows a lot of problems with calculation of ENS value for example:
- o Type of customer
  - o Industrial (large, small)
  - o Commercial (large, small)
  - o Domestic
  - o Public service
  - o Other…

- o Type of outage (EN 50160)
  - o Transient
  - o Short interruption
  - o Long interruption
- o Type of outage (planned, unplanned)

Finally national regulatory authorities must set all of these standards and make final decision about acceptation of incentives/penalty scheme in Czech Republic.

We will still continue with analyzing of electric power supply quality standards in European countries at Department of electric power engineering VŠB-TU Ostrava.

Most of the information about quality of electric power supply is two year old so it is possible that evaluation of quality of electric power supply standardization may be changed in details in some European countries, but it has no influence on methodology of electric power supply quality regulation.

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