THE INFLUENCE OF REGULATORY CHANGES IN REACTIVE ENERGY ON ENERGY EFFICIENCY IN ELECTRICAL DISTRIBUTION NETWORKS AND QUALITY OF THE SERVICE

NICUȘOR I.A., GROSU F.
Low Danube Galati University, Romania
Iulian.Arama@ugal.ro

Abstract: Discharging reactive power distribution networks contributes to reducing active energy losses and increasing electricity transit capacity. Inappropriate management of reactive power sources in distribution networks, including those from network users, leads to uncontrolled reactive power circulation with effects on voltage levels and losses. Considering that to date the charging of the electricity distribution service is made through simple (monome) rates expressed in RON / Mwh, without considering billing power absorbed and maximum consumption time, the only element by which the user is warned over network behavior is the reactive energy billing mode. Regulatory changes to reactive energy can also lead to changes in addressing technical aspects of installations at the managed delimitation point. Both the change of retailer's revenue from reactive energy and the penalty mode impacts has an impact on the quality of the distribution service. Switching from full billing to capacitive reactive energy (energy sent to the grid) upon admission of an unanswered reactive injection equivalent to 48.44% of active energy is a technical and financial relaxation for users with consequences for distributors. The lack of analyzes or studies related to regulatory changes allow us to present some considerations regarding reactive energy in distribution networks..

Key words*:* reactive, power factor, revenue, CPT (energy losses).

1. INTRODUCTION

The power distribution service consists in ensuring the transit of active electrical energy, including reactive energy, in electrical networks with a voltage until 110 kV. Until 2017, the neutral power factor was the limit to which inductive reactive energy transit is considered to not significantly affect the losses and reactive power regulation in the grid.
For economic system considerations, the value of the neutral power factor was set at 0.92 for many years.
Reactive electricity prices and payment methodologies have evolved, depending on the technical opportunities of the measured quantities and the active energy / energy reactive power ratio.

These tariffs envisaged increased energy losses in public networks as a result of the reactive energy transit over the accepted limits.

Over-compensation of reactive energy has been sanctioned to limit additional reactive transit.

Both increased reactive consumption and overcompensation were penalized when the power factor was below 0.65.Invoicing reactive energy is intended to sanction the disruptive regime of users on the network.

Starting with 2017, the concept of neutral power factor has been replaced by a power factor limit, and the value has been set at 0.9 for both inductive and capacitive regimes, with economic and technical effects on distribution network operators. Some of these are presented in this paper and leaving for further analysis.

2. CONSUMPTION AND SALE OF REACTIVE ENERGY

Although reactive power (energy) is sometimes presented as an abstract matter reserved to specialists and without a real stake, in the following we present some economic aspects related to the reactive energy value.

When all economic agents were captive, reactive energy charges, at voltage levels, accounted for 10% of the single energy monom tariff (D). In fact, in a first phase of the reactive capacitive electric energy billing, the transit of the reactant was quantified with 10% of the active energy tariff at the price corresponding to the active energy. Currently, the reactive energy tariff is 30% of the average electricity purchase price to cover energy losses at the level of each distribution operator. Reactive power consumption for reactive consumption was the amount that exceeded 42.6% of the active energy.

Revenue from reactive energy has remained for a good period of time at the supply and distribution companies.

In the baseline notes on costs and average activity prices and final consumers of electricity, the revenues from reactive electricity did not enter into the respective economic balance sheet.

At present, the revenues from the invoiced reactive energy are transferred to the distribution operators only that they are taken into the value balance of the revenues required to be covered by the active energy distribution tariffs in the sense that the revenues necessary to cover the accepted costs are diminished with those obtained from the energy reactive.

In order to highlight the penetrating effects of transit of the reagent over the acceptable limits, we present the situation of active and reactive power consumption and sale in 2004 and 2014 in Table 1.

Table 1. Active and reactive power consumption and sale in 2004 and 2014

	2004	2014
Active energy consumption by economic agents (GWh)	25296	29449
Invoiced inductive consumption (Gvarh)	2797	2043

If we take into account the capacitive reactive energy quantity invoiced in 2014 by 750 GVarh, we find that the invoiced reagent is similar, lowering only the inductive reagent. Valorically, the amounts of reactive energy invoiced were important weightings in covering costs or supporting some network work. From various distribution system reports, we determined the share of reactive energy of the costs of covering network energy losses in Table 2:

Table 2. Share of reactive energy of the costs of covering network energy losses

Year	Distribution Operator	CPT Cost (Thousand RON)	Reactive Income (Thousand RON)	CPT reactive weight (%)
2008	Muntenia Nord	173401	34440	19,86%
2009	Muntenia Nord	178034	32134	18,05%
2011	Muntenia Nord	197069	30097	15,27%
2009	Enel Banat	131517	28150	21,4%
2011	Transilvania Sud	139753	23152	16,56%
2012	Transilvania Sud	137023	25756	18,78%
2013	Transilvania Nord	132386	24181	18,26%

Although reactive energy revenues were fully transferred to distribution operators by 2013, the controversy surrounding this issue led to new approaches, correcting possible errors or giving other interpretations of methodological texts.

The specific distribution tariffs were calculated according to a type method, ceiling basket. The annual level of initial target revenues was established taking into account controllable maintenance costs, uncontrollable operating costs, purchase costs of electricity for approved CPT coverage, working capital requirements, increased efficiency set by the competent authority, harmonization of the regulated base of assets (BAR). In the revenue computation formula, the revenue from reactive energy for the distribution network (O 39/2007) also did not intervene.

As the methodology for setting tariffs for the transport network included reactive energy revenue, there was criticism that there was no similar procedure. Orders for approving the methodologies for the two sectors, transport and distribution were issued at a distance of approximately three months, the first one being for distribution. Thus, it was appreciated that if during 2010-2013 the profit of reactive energy (with an intuitive definition) was taken into account when determining the tariff for the distribution service, the tariff level should have been reduced annually. The situation can be presented in Table 3:

Table 3. The profit of reactive energy (2010-2013)

Balance sheet item	2010	2011	2012	2013
Return reactive energy consumption (RON)	147887276	145739061	148308623	126103670
Distributed energy (MWh)	40851493	42305112	42503843	41004020
Influence of reactive energy consumption (RON/MWh)	3,62	3,44	3,48	3,07

By taking into account the said income (profit) from the reactiv, the distribution tariffs would have been reduced by 1.5-2%. All justified costs related to the energy distribution service are included in the tariffs for active electricity.

Starting with the third regulatory period, first-year tariffs for the 2014 period were determined by making corrections for the closure of the second regulatory period 2008-2012, including 2013 as the transition year.

Corrections included the redistribution to service customers of 50% of profits from reactive energy and other activities using the regulated asset base paid through active energy distribution tariffs, defined as a profit-sharing mechanism.

In the Income Revenue Formula to set distribution tariffs for 2014-2018, Revenue Billing Income is down, which was not reflected in the formula of the previous regulatory methodology.

Income from reactive energy remains with the distributor, but taking into account leads to lower energy tariffs. It is considered that only the income gap should be covered by the tariff. In order to have a comparison term for the amount of revenues no longer benefited by operators, we present in Table 4 the situation for the years 2014 and 2015:

Table 4. Between 2014 and 2015

	2014	2015
Total investments recognized in the connection tariff (million RON)	869,3	1028,3
Invoiced reactive energy consumption value (million RON)	244,11	284,02
Reactive Value / Investment Cost Report (%)	28,08%	27,62%

By modifying the regulatory rules, part of the revenues are returned to network users by lowering distribution tariffs, thereby increasing the pressure on distribution operators to reduce operational costs.

3. RULES ON REACTIVE ENERGY CONSUMPTION FROM 2017

At European level, some calculations show that raising the power factor to 0.95, through proper compensation, translates into an estimated economy of

48 TWh. However, a power factor of 0.90 has been set for both inductive and capacitive modes.

To highlight the differences in reactive energies charged in the two (inductive, capacitive) regimes in the period up to 2017 and beyond, Table 5 shows a statement of how to calculate the amount of reactive energy being charged and relaxation:

Table 5.

	Inductiv mode	Capacitive mode
Until 2017	$E_{ifact} = E_{imas} - 0,426\ E_{act}$	$E_{cfact} = E_{cmas}$
After 2017	$E_{ifact} = E_{imas} - 0,4844\ E_{act}$	$E_{cfact} = E_{cmas} - 0,4844\ E_{act}$
Difference	$0,0584\ E_{act}$	$0,4844\ E_{act}$
Relaxation	13,7%	48,44%

Where E_{ifact} represents invoiced inductive energy, E_{imas} measured inductive energy, E_{cfact} invoiced capacitive energy, E_{cmas} measured capacitive energy and E_{act} active energy.

Calculation formulas for inductive energy are as follows:

$$E_{ifact} = E_{imas} - \tan(arccos\ 0,92)\ E_{act} \text{ - until 2017}$$

$$E_{ifact} = E_{imas} - \tan(arccos\ 0,9)\ E_{act} \text{ - after 2017}$$

Calculation formulas for capacitive energy are as follows:

$$E_{cfact} = E_{cmas} \text{ – until 2017}$$

$$E_{cfact} = E_{cmas} - \tan(arccos\ 0,9)\ E_{act} \text{ – after 2017}$$

The difference is the additional amount of reactive energy that can be circulated. There is a relaxation (represented as a percentage in Table 5).

For inductive mode, this change leads to the acceptance of a 13.7% higher non-inventory quantity. If, before 2017, the entire amount of reactive energy sent to the network was invoiced in 2017, a relaxation occurred by accepting the 48.44% of the active energy input into the network without penalty.

This reduces the revenue that is allocated to users, but the operating conditions of the network deteriorate through an insufficiently analyzed capacitive mode.

From postcalculation studies of own technological consumption, it is found that 75% of energy losses in distribution networks are dependent on load. As the losses in the active elements are inversely proportional to the square of the power factor, the shift from 0.92 to 0.9 creates conditions for accepting the increase in losses by 4.5%. The reason for the change was justified by a regulation at European level without an impact study.

Thus, distribution operators, by changing pricing methodologies and reactive energy billing, have to compensate by their own means, revenue cuts, increased losses and worsening quality of service.

4. CONCLUSIONS

Invoicing reactive electrical energy aimed at limiting reagent circulation through networks. The shift from the penetration of reagent consumption to the penetration of network reactive transmission, as the technical means of measurement have allowed the appropriate measurement, has come to the aid of distribution operators by controlling and knowledge of energy flows.

Revenue from reactive electricity remaining at their disposal, without any other economic balancing adjustment, provided support for adjusting other costs until the third regulatory period.

Decrease in Revenue Revenue from revenues from the application of distribution tariffs for active energy was justified by the contribution to lower distribution tariffs, but also reduced part of revenue to support upgrading of distribution networks.

Switching from a power factor of 0.92 (neutral) to a power factor of 0.9 (limit) starting in 2017 for both inductive and capacitive consumption reduces revenue that can then be returned to all users of the distribution network also offer the possibility of increasing the reactive energy quantities that can be transmitted through networks without penalty, with effects on the energy efficiency and quality of the distribution service.

The reconsideration of the neutral power factor based on the current operating conditions of the distribution networks (renewable, reactive injection relaxation) and possibly on the operators seems to be necessary.

The relaxation of the capacitive reagent circulation up to the limit of 48.44% of the active energy can create long-term problems by not controlling the compensation means, but also by sizing the power supply networks.

6. REFERENCES

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