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Recognizing and Charging Generators for Their Contribution to Network Voltage Support in a Market Environment

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Abstract— **the paper discusses the so-called voltage service, an essential auxiliary service needed for the transmission network voltage support provided by generators. The dispatchers must manage the voltage service in order to guarantee adequate covering of the system demand even under disturbed or congested operating conditions in order to provide customers with increased quality, security, and affordability of the electrical energy supply.**

Keywords— Energy market, secondary voltage regulation, indication, and price are ancillary services and voltage services.

I. INTRODUCTION

Newly defined power plant services, such as those for network voltage and frequency support, have emerged as a result of the restructuring of the electric utility industry and the growing competition in the electricity market that has resulted. These services are closely related to the performances of the corresponding control systems. In order to address the rising requirement for the accurate and unquestionable economic recognition of their contribution, it appears that the proper measurement of the field performances of power plant automatic regulators as well as of their effective support to the network operation must be solved. This new issue related to the ancillary services industry provides a strong impetus for in-depth research as well as the development and specification of workable solutions.

It has to be compliant with both legal requirements and official Energy Authorities guidance. The network's Independent/Transmission System Operator (ISO/TSO) is in charge of managing these new services to ensure both a safe and dependable network operation and the proper financial recognition of the various contributions to the services. The main goal of network voltage regulation, one of the ancillary services for the power system, is to maintain the network voltages as close to the optimized values as possible in the face of ongoing load changes and network perturbations, thereby achieving high levels of quality, security, and efficiency in power system operation. The local reserves, including unit capabilities, synchronous compensators, shunt capacitors and reactors, static var compensators (SVCs), as well as the local on load tap changers, are the focus of the required automatic coordination of reactive power resources because the voltage problem is a prevalent local issue.

Therefore, a decentralized voltage control system operating a local coordination in each area or region where the overall transmission system can be divided can be used to pursue the goals of the voltage control service. Nevertheless, in each region, the considered coordination requires exchanges of data and control signals between the local dispatcher and the local power plants/ substations. The more the data are exchanged in real-time according to the power system dynamics, the best the voltage control system can increase its performances and effectiveness. To further reduce losses, it is crucial to coordinate the mutual control actions and exchange measurements of the edge-busses voltages and tie-line reactive power flows with the nearby utilities. The increasing rivalry in the power market has made it difficult to improve the automation of transmission voltage regulation. A complex task to organize, the accurate measurement and computing of the power plant control systems performances for the recognition of their network support and related economy requires a thorough understanding of the various control systems' philosophies, functionality, and limits. Additionally, the potential practical solutions vary depending on the state of the art. Therefore, new and specialized monitoring systems are needed, of the operating control systems not only at power plant level but also at Regional and Central Dispatchers' levels, which coordinate the power plant's control efforts in accordance with the centralized global system view and control strategy. If the investigated generators operate under SVR, it will be demonstrated that the indicators of their contribution to network voltage support are straightforward and accurate as well as that there are discrepancies in their performances compared to the contractually specified control availability.

In this situation, a new power plant voltage-reactive power regulator—referred to as a "high side voltage control regulator" [1–2]—is typically necessary and is the key to understanding the practical viability of the paper concept. Additionally, from this perspective, SVR provides not only an efficient method for maintaining network voltage, but also a significant simplification and clarity on the issue of the financial support provided by generators for maintaining network voltages [3–8].

II. VOLTAGE SERVICE

The true contribution of each generator to network voltage support is difficult to quantify and identify, and when it comes to economic considerations, it generally becomes a contentious issue. However, the topic under discussion is a well-known, complicated issue for a variety of reasons:

The generator contribution is, in theory, related to the remote control (on-line/off-line, manual/automatic, etc.) operated by the network dispatcher. The accuracy of the power plant operator maneuvers, in accordance with the requests of the dispatcher, cannot always be monitored and demonstrated. The real-time measurement of the coordination of the generator reactive power delivery/absorption with respect to the other generators in the power plant; is a burdensome lack of information. The plant cannot fully guarantee the effectively available nominal capability in over- and under-excitation without limitations imposed by stability issues, protection intervention, plant operator unjustified caution, and incorrect changes in the control parameter setting.

Furthermore, the AVR stability within a defined operation field as well as the AVR correct dynamics even when operating the over- or under-excitation generator limits, as well as the proper coordination between the generator protections settings and its available continuous- time operation field, are all strongly related to the effectiveness of the generator voltage support.

Last but not least, the country's rules/regulations on the generator contribution to network voltage and reactive power control frequently require the generators to adhere to what appear to be simple, not-detailed service criteria. In practice, are frequently difficult to conform with and permit (that is the worst) the generator operation against the real network needs: excess of over or under excitation with respect to necessary. It is clear that the amount of reactive energy does not accurately reflect the real generator contribution to the voltage service, which is instead significantly influenced by the generator's available reactive power near its normal operating point, and by the continuous control of that generator that is coordinated with the controls of the other generators in the same plant as well as the controls of the generators in nearby plants. The "primary voltage regulation," which uses the AVR to keep the generator terminal voltage at the set-point value, is insufficient for a satisfactory voltage service because the power plant operators manually control the Airs' set point, resulting in subpar timing and coordination of control actions. The objective to automatically control in real-time and in coordination the generator's effectively available reactive power resources, can be achieved. The generator available capability can be continuously monitored and therefore constrained. The perspective of a new power plant "high voltage side regulator" (REPORT) also required by the SVR is the true, concrete possibility to achieve the objective of an effective voltage service.

Through REPORT facilities, a straightforward but accurate and unquestionable monitoring system of each generator's actual contribution to grid voltage support can be accomplished for possible comparison with the contractually anticipated performance and the accurate computation of the generator economic recognition.

III. VOLTAGE SERVICE IF A COORDINATED VOLTAGE CONTROL SYSTEM IS AVAILABLE

A hierarchical control structure is typically the foundation for the coordinated voltage regulation in a transmission network (see Appendix, Fig. 1 for an example of an Italian hierarchical control scheme). This allows for the network to be divided into electric zones around the so-called pilot nodes, which are grid buses chosen among the strongest ones based on the computation of sensitivity matrices and short-circuit powers. The Regional Voltage Regulator (RVR) devices, which keep the pilot nodes voltages at the correct values by controlling the reactive powers of those generators which most impact those buses, give these regions with suitable signals of "reactive power level," one for each area.

The power plant voltage and reactive power regulator (REPORT), which directly affects the set points of the Automatic Voltage Regulators (Airs) of the generating units in the plant, is used to locally manage the generators at the power plants (See Appendix for more details). According to the actual network state and the long- or short-term forecasting of the optimal pilot nodes voltages and area reactive power levels, the central NVR in the Tertiary Voltage Regulation (TVR) framework controls the RVRs in closed-loop at the utility level for a secure and efficient operation (See Appendix).

The VS under SVR: Metering Simplification and the Role Played by the Power Plant Regulator (REPORT). The general goal of the REPORT is the power plant units' automatic, coordinated, and in-the-moment support of the transmission network voltage. According to the actual over- and under-excitation limitations of each generator, REPORT continuously regulates the reactive powers of the power plant generators at the same percentage value. These dynamic limits, which were also calculated by REPORT in accordance with the thermal prescriptions of the generator manufacturer and continuously compared with those operating inside the AVR, represent the generator's maximum available capability field. According to the terms of the contract between the power plant and ISO, REPORT may assign the generator's maximum available capability field entirely or in part to the voltage service.

IV. -INDEX OF GENERATOR CAPABILITY THAT IS AVAILABLE

REPORT computes the corresponding reactive power limit values in over and under excitation to be imposed on the generator and verifies their consistency with those operating on the AVR for each generator under its control, taking into account the voltage and active power measurements at the stator terminal edges. It goes without saying that the power plant operator can choose or modify the generator limitations in REPORT in accordance with the needs of the generators' functioning and security. The new "voltage service meter" receives the measure of the generator's dynamic reactive power field through a REPORT for a real-time comparison with the relevant limit values continually computed by the meter on the basis of the contractually agreed upon capacity curve parameters.

The generator's available capacity is 100% as long as the reactive power limit Slim of the generator matches the contractual Slim contra values in both over and under excitation. When the generator is not under the control of the REPORT, the availability value is regarded as zero. In light of what was stated above, the following represents an important indicator of the generator's contribution to the voltage service in terms of available reactive power capability.

V. GENERATOR AVAILABLE VOLTAGE INDEX FIELD

For each generator under its management, REPORT enables the fixation of the stator voltage field permitted around the nominal value, the verification of its compatibility with the generator protections, and the signaling of the forced operation at a voltage limit. Naturally, the power plant operator may vary the generator voltage restrictions in REPORT in accordance with operational requirements and machinery security considerations, which may result in more stringent limits than those specified by the alternator manufacturer. It is necessary to measure this potential generator voltage field reduction since it may make it more difficult to use the permitted generator capabilities.

Since the actual voltage limit values are not known in advance, the new "voltage service meter" recognizes and remembers them when they are reached and indicated by REPORT. In a similar vein, their alterations are updated as noticed. Because they were most recently measured on the ground, the generator operating voltage limitations in REPORT can be compared in real time with the equivalent limit values specified in the generator voltage service contract: The generator available voltage field is 100% as long as the generator voltage field Vn V lim matches the contractual value of Vcontr; otherwise, it decreases.

When the generator is not under the control of the REPORT, the availability value is regarded as zero. The following is a crucial indicator of the generator's contribution to the voltage service in terms of the voltage field that is available:

$$\mathrm{Iq}\ (\mathrm{T}) = 100/\mathrm{T}\int_{0}^{T}(Q\,lim(t)/Q\,\mathrm{lim\_contr(t)dt}$$

indicating the averaged proportion of the correspondence between the actual and contractual generating voltage field over the time interval T. That is, Iv is only 100% when Vlim (t) = Vlim contr for the entire period T that the generator was controlled by REPORT.

The Power Plant's New Voltage Service Meter The on-field generator's actual performance to be used for network voltage service cannot be known beforehand, and what the power plant asserted regarding this issue may change or prove unworkable in the absence of any credible check and warranty. The recently revealed power plant new concept meter, which is entirely dependent on the presence of the new voltage and reactive power regulator (REPORT) in the power plant, will be able to calculate in real-time either the aforementioned Iq and Iv indices or the intervals, inside the period T (T could last one year), during which:

$$\boldsymbol{Iv(T) = 100/T\int_{0}^{T}(Vn - V\,\mathbf{lim}(t)|/\Delta Vcontr)dt}$$

for every one of the two potential REPORT capabilities a) or b) described in clause 3.1. Additionally, the new meter would calculate the amounts of reactive energies in both over excitation and under excitation for each generator in the plant throughout the period T. It must be noted that the power plant operators and SO can always observe (but not change) the progressive values of each generator's performance indicators, computations, and measurements via telecommunications.

Therefore, it is permissible to remotely set the contractual parameters, which serve as performance references for the generator, at the time of contract definition or renewal. It will be possible to compare the generator availability and contribution to voltage support with the components of the voltage service contract in a precise manner on the basis of the values attained over the course of the period T by all the generator performance indicators mentioned, and to assign to each generator a very accurate and unquestionable economic recognition of its network voltage support. The recommended approach is unquestionably accurate, straightforward, and simple:

VI. EXPENSES VS. PROFITS OF THE VOLTAGE CONTROL SERVICE

The power plants, the local, regional, and national dispatchers, as well as the transmission and distribution grids, can all contribute to the capital and operating expenses of the VS. The following points largely concur with the current state of knowledge across the globe. Italian electricity infrastructure is mentioned in the example.

A. Production Fees

The capital costs need to be taken into account because of the following: a Oversizing the generator for producing or absorbing reactive power; b Oversizing the generator transformer in accordance with the generator capability; c) Oversizing the unit exciter; d) Exciter controller, including unit voltage regulator, over and under-excitation limits, compound, PSS, REPORT interface, etc.; and e REPORT apparatus. Regarding point a, the anticipated oversize cost for Eel's thermal generators is equivalent to additional costs ranging from 5.1% to 6.5%, depending on the unit size and cooling. When it comes to hydraulic generators, the size range is fairly wide and the amount of associated oversize varies greatly from one unit to another.

Regarding b, the average transformer oversize is thought to be around 5.4%. When points c) and d) are taken into account, an estimated 65% of the exciter and controls capital expenses linked to voltage and VARs. Moving forward to point e, voltage support must account for 100% of the REPORT equipment capital expenses. For the sake of consistency, the costs of this REPORT and the whole network voltage control system will be combined in the sections that follow. According to the annual production/absorption of reactive power and an evaluation of unitary costs for selected discount rates, the annual rate of the generation capital costs is often estimated.

When taking into account the overall generation capacity of, 31525 MAR, a first attempt at estimating the issue by Eel yields expenses ranging from 2.0 to 3.0 thousands? For each MAR per year. A 370 MVA unit would cost 0.1 to 0.15 million euros per year (ME/year) in operating expenses. The FERC analysis places the investments for voltage control and reactive power supply from generators at 41% of the overall cost of the generator with its transformer, exciter, and controls: 23% for voltage and 18% for VARs. This estimate yields a quantitatively higher outcome. The annual rate for a 370 MVA unit would be 1.0 ME/year based on these figures plus a fixed charge rate multiplier of 0.17.

Losses and operation and maintenance expenses are part of the generator operating costs (O&;;M). When reactive power is generated or absorbed, stator copper losses also rise, which is related to the increased losses, which also include fan and core losses. By following the over excitation or under excitation conditions, rotor copper losses and exciter losses can be raised or lowered. More specifically, the additional losses that need to be taken into account are those that are: - in the exciter; - in the exciter's copper; - in the unit alternator and transformer's iron; - mechanical (for the synchronous compensators only);

In the auxiliary services for the cooling of the transformer and alternator; - for the synchronous compensators to start up. Iron and mechanical losses on the thermal units are each calculated at 0.2% of the oversize (6000 MVA). As a result, the entire loss rate is 6.8 ME/year. The aggregate loss rate for the hydraulic units, which have a total oversize of 2000 MVA, is 2.7 ME/year. Between 7.7 and 13.0 ME/year, and 350-400 GWh/year of energy being wasted, is estimated to represent the overall annual losses rate for the Eel units. The upkeep of the hardware and software as well as operator training are also included in the Camp;M fixed and variable costs. They ascribe the generation Camp;M expenses for VARs and voltage to the comparison of the FERC analysis on the matter.

B. *Costs of Transmission*

The installation of reactors, static variable condensers (SVC), and their switching equipment; OLT Cs in transmission and distribution; Sacs; RVRs for secondary voltage regulation; NVR for tertiary voltage regulation; and optimal voltage and reactive power forecasting and dispatching are all related to these capital costs. Points a and b in the Italian power system have capital costs that range from 13.0 to 18.2 ME/year, whereas point c) can be ignored because there are no SVCs present in the Italian power system. With regard to points d) and e, the capital expenses for the practical execution of the SVR and TVR control system comprise installing the REPORT equipment at the primary power plants. The NVR at the national control center, as well as the RVR equipment at each regional dispatcher. The 18.2 ME in costs under consideration are due to:- 5.72 ME for studies, design, and SW development- Manufacturing of control apparatuses: 6.24 M?6.24 ME for installation, AVR interface adjustments, and field-testing. Given that the application will be used for 25 years, the annual cost at an inflation-removed discount rate of 8% is equivalent to: 1.8 ME/year, whereas with an inflation-removed discount rate of 12%, the annual cost increase reaches 2.57 ME/year. Regarding point f, the annual rate is projected to be equal to 0.26 ME/year when taking into account hardware and software tools and their upgrades. The expenses incurred by the transmission include:

Network compensating equipment losses In Italy, these losses total 4840 MWh/year at a cost of around 0.1 ME/year; - Electricity line losses: In the Italian transmission network, these ultimate losses might range from 250 MW to 500 MW, depending on the system operating conditions. These transmission losses cost between 129 and 155 ME per year on average. This cost includes the reactive power flows' component, which is anticipated to be larger than 10%.

The distribution losses can be taken into account similarly.- The price of maintaining and upgrading telecommunication and control equipment used for voltage-var control: Secondary voltage regulation (including Reports and RVRs): 0.3 ME/year; Optimal voltage and reactive power forecasting and dispatching: 0.15 ME/year; Tertiary voltage regulation: 0.15 ME/year; Telecommunication system: (maintenance related)

Costs for voltage/var operation (costs of the operators in the regional and national dispatching centers) for:? Optimal voltage and reactive power forecasting and dispatching: 0.5 ME/year;? SVR and SVR control: 0.5 ME/year. Telecommunication system: (maintenance related to voltage-var control): 0.15 ME/year. The costs associated with "loss of load," or the inability to provide reactive service in the event of an incident that forces customers to disconnect in order to prevent voltage collapse, cannot be disregarded and must be assessed probabilistically by taking into account the so-called Value of Lost Load (POLL). In Italy, the POLL and the risk are both those that are in line with the high levels of reliability provided by the networked European system.

The losses that are caused by network voltage instability and the losses that follow a voltage collapse are further losses that should be taken into account and have value equations that are quite similar to the preceding one. In comparison to the size of the area experiencing the blackout, the likelihood of these incidents is quite low, but the associated expenses are very substantial (tens of billions of liras). Finally, the length of time that the contractual quality of the voltage at the customer's supplying edges is not guaranteed affects the system operator's income loss.

C. *Benefits of voltage-var control*

Among the attainable advantages listed below, those predicted to arise from the adoption of the SVR include: - a decrease of up to 5% in power system losses by controlling reactive power flows through improved coordination of reactive power resources. The savings from such a reduction in Italy would be around 1.8 million euros per year; an increase in active power transfer capability under security limitations; and an increase in reactive reserves that can be controlled during transients following significant network disruptions. This increase is accompanied by a reduction in the amount of time, estimated to be between 3 and 5 percent, when loads are partially not fed for safety reasons.

The resultant cost savings would be approximately 0.6 million euros per year; this would result in a 20% reduction in the amount of time when the contractual quality of the voltage at the customer's edges is not guaranteed. The annual economic advantage associated with this reduction is around 0.9 million euros; it also significantly lowers the probability of a power system blackout caused by voltage collapse. This reduction equates to a minimum annual benefit of €9.0 million. This rough estimate of the advantages under consideration needs to be better developed and taken into account in full when calculating the voltage service contributions to the energy tariff.

D. THE VOLTAGE PRICE-DETERMINING CRITERIA

The assumption is that the current pancake tariff will be split into a price for generating, a price for transmission, and a price for distribution, with separate costs for the "system services" (reserve margin, frequency regulation, voltage control). According to the conducted analysis, the voltage control price aims to quantify the improvement in voltage quality, power system security, and operating efficiency to be attributed to the voltage service in the presence of load changes, outages of lines, and generators.

Such tasks are often accomplished by a combination of the following: I Primarily, reactive power is produced or absorbed by generators; ii) Reactive power is produced or absorbed, respectively, by network condensers and reactors; Static var compensators (SVCs) and on load tap changers (OLT Cs), if any, are used to adjust voltage at load buses. The first two points and the pricing criteria based on reactive power energies are closely related. In order for the voltage service to be effective, it is rational to assume that the reactive power resources must be properly coordinated. This coordination must be provided by a cutting-edge, technologically advanced network voltage control system, such as the one previously described, which is capable of automatically and promptly coordinating all the reactive power reserves in a way that minimizes both the control effort and the network losses while consistently maintaining high voltage quality. The Network Voltage Service (Network Voltages Optimization and VS) can only be easily controlled and supervised by the Operating Authority in this way.

The network voltage service cannot be improved from the current dismal performance of the traditional, non-automated reactive power dispatching without an effective automatic voltage control system. In actuality, without automatic coordination, there are frequently several issues with timely and efficient control of unanticipated operating situations, even if the reactive power supplies available were sufficient to meet grid needs. Additionally, despite being consistent, the TSO/ISO effort could frequently produce unsatisfactory outcomes. In light of these factors, the construction and operating expenditures associated with the voltage service that can be justified by the outcomes should be given top priority in the pricing criterion.

E. In terms of, generation

Large units (those over 100 MVA in Italy) should be required to use the Primary Voltage Regulation (PVR) function offered by the AVR. Due to their prompt responses without restriction inside their nominal capabilities (monitored in real-time), in accordance with the actual needs, the generators under SVR contribute to the voltage service in a more recognized and consistent way than the other units under PVR. This calls for the primary factors in the pricing evaluation of the voltage services to be the capital costs (reduced by the depreciation allowance) and operating costs of the units subject to Secondary Voltage Regulation. These units/power plants are candidates for an additional, economic recognition because of their automatic, up to the point, contribution to the network voltage support and the related, calculable benefits for the network customers in terms of voltage quality, system security, and operating economy greater than given standards. This additional, economic recognition will be linked with the measurement of their participation to the SVR. Moving on to the units that solely operate under primary voltage regulation, they a priori do not guarantee comparable and coherent control efforts for voltage support: you can find units of the same power plant counterbalancing their reactive powers negatively or plants partially counterbalancing their reactive powers.

As a result, the calculation of basic reactive power energy does not generally reflect the true contribution to maintaining the voltage service. Additionally, the missed contributions from reactive power counterbalancing typically result in a greater control effort from the other power plants, which has a knock-on effect of costing more money. In some circumstances, not providing assistance could make the power system less reliable and increase the risk of collapse.

F. Relating to the transmission

The capital costs of the current automatic voltage control system (such SVR and TVR), as well as the daily forecasts of the ideal voltage plan for the transmission network, should unquestionably be taken into account when determining the pricing for the voltage service. The installation of static condensers, reactors, and their switching equipment, as well as the cost of the OTC placed on transmission and distribution transformers, are additional capital expenses that need to be taken into account. Of course, these capital expenses should be reduced by the equipment amortizing allowances. In the event that a network voltage service exceeds a predetermined threshold, the operational expenses for the network voltage support, which also include additional device losses and maintenance, as well as control equipment maintenance, should be recognized performance threshold. Reactive power resources are typically plentiful at power plants under typical operating conditions with the current power factor adjustment. In the Italian transmission network, the power factor (PF) overage value typically exceeds 0.95, although in the MV and LV network, the PF changed from 0.9 to 0.93 between 1985 and 1994. Under compensated circumstances, the PF fluctuates between 0.96 and 0.98 at its annual peak. The expansion of the 380 kV network and the decrease in energy transits from north to south as a result of the new generating facilities constructed in central and southern Italy. According to the capacity of the power system under consideration, the necessity of potential future PF corrections is gradually losing its previous significance, while the significance of an efficient, coordinated, and automatic control of the available reactive power resources was firmly established. With an operational SVR and TVR, TERNA (the Italian TSO) should be in a prime position to meet the need of the future Italian energy market for an unbundled, efficient, and dependable voltage services.

G. *Pricing effort*

The following pricing approach provides a broad notion to estimate the value of the "voltage duty" delivered by the generation and transmission system in a straightforward but rigorous manner while taking into account for the VS a yearly based contractual market administered by the TSO: All the capital and operating costs required by the VS should be taken into account on the generators' side, as well as all the previously mentioned costs on the transmission side. Iii) At the national/utility level, the previously mentioned advantages of the operational VS should be taken into consideration. Iv) The "Value" to be assigned to the delivered VS is determined by the difference between its entire benefit and total cost;

v) The generation firms and the TSO/ISO must divide the annual expected value of the VS according to nominal percentages that have been established; In front of the generator:

vi) The annual basis depreciation of the capital expenditures, the "nominal" pricing of each generator contribution to VS, and

A percentage of the "Value" attributable to that generator while taking into account the contractual obligations. - The contractually agreed-upon contribution to VS.

vii) The "true" price of each generator's contribution to the virtual system should be dependent on: - The actual contribution made to the virtual system, as confirmed by the suggested real-time metering;

- The fines for breaching the terms of the contract.

On the transmission side: viii)The announced objectives in terms of operation quality, system security, and operation efficiency should be the basis for the "nominal" pecuniary recognition given to the TSO for the VS operation.

- The capital expenses of the transmission system depreciated annually,
- The portion of "Value" that is attributable to TSO.

ix) The continued functioning of SVR TVR as verified by the proposed metering system shall serve as the foundation for the "actual" commercial acknowledgment of the operating VS to the TSO.

- The fines brought on by discrepancies with regard to the stated goals.

VII. CONCLUSIONS

Focus was also placed, on the VS's complexity and the challenge of correctly allocating it within the transmission tariff in relation to the potential provided by the sophisticated automatic voltage control system built on SVR TV. The voltage duty quantitative evolution is a related important issue; two criteria have been examined, and some initial quantitative data have been supplied. The idea is that the VS "Value" needs to be accurately assessed, and the accompanying benefit shared between the providers and clients through an appropriate transmission tariff component. In the newly reorganized energy market, the article provides evidence that the VS's position and relevance will increase. As a result, there will likely be several innovations on the subject that will be significant to global advancements in its quality and accounting performance. Voltage service is in fact related to the quantifiable degree of quality, security, and efficiency of the system operation that can be attributed to VS in the transmission price. In other words, the expenses must be supported by tangible, verifiable benefits. The document provides a detailed explanation of how to monitor each generator's contribution to network voltage service when it is operating under REPORT management. When reactive power may be continually and profitably controlled, the idea is unquestionably founded on the continuous time measurement and monitoring of the real available capability field of each generator.

Contractually fixed within the thermal restrictions imposed by the over and under-excitation AVR limits and consistently triggered by REPORT, the function that determines the feasible reactive power field additionally takes into account its dependency on the unit terminal voltage. The fiscal computation for each generator of the progressive time period during which the available capability field complies with the contractual value and the comparison with the agreed-upon yearly percentage, allows the proposal of an unquestionable performance index of both: - The generator reactive power reserve available in real-time and fully functional for network voltage support.

The harmony of this outcome with the binding contract. The proposed method's clarity, accuracy, and encourage a wide-ranging practical application of the new meter, which is entirely devoted to voltage service monitoring and accounting with the aim of successfully assisting a proper economic recognition of the generator contribution to network voltage regulation. The revenues from the required distribution of the returns from the voltage service will undoubtedly enhance and fuel the competition-based monitoring of the performance of the voltage service.

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