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Reactive Power Service to Encourage the Reactive Power Providers in Competitive Markets

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Abstract —*At the present day, competition in the power creation trade has turned out to be a real possibility as a result of the reconstituting of electrical energy industry. To determine the worth of reactive power service from reactive power suppliers is unexpected emergency. Active power delivered by power suppliers has turned out to be a choice. The reactive power is considered like a facility whose objective may be to encourage power system reliability and security. Reactive power is an essential maintain facility considering the present electrical power trend. Power manufacturers or even generators have the ability to deal this facility to generate income. Presented the truth that a power generator requires reactive power to transfers individual active power, but, it will be possible that specific power generators are not able to maintain a system even though they may be producing reactive power. In such a structure we talk about the procurement of reactive power maintain facility. The main objective of this topic is to show the importance of reactive power pricing to encourage the reactive power providers for the system reliability.*

Keywords- Reactive Power, Voltage Control, Ancillary Services, Synchronous generator, Pricing

I. INTRODUCTION

Elements of AC systems consists two kinds of power: active power and reactive power. Reactive power is required for transmission of active power, control of voltage and system and normal operation of power systems. Therefore reactive power service is one of the most important ancillary services in electricity market [1]. Currently electric power systems all over the world are moving from a regulated environment based upon traditional vertically integrated utilities so It is needed to address the issues related to reactive power in electrical services [6].

Reactive power support may be provided by a variety of devices, including generators, synchronous condensers, shunt capacitors and reactors and static VAR compensators (SVCs). In the deregulated power system, these all devices have their own prices and advantages [8]. In the competitive electricity energy markets, the supply of reactive power is important support services. If the supply of reactive power is insufficient, it can be lead to the power system voltage stability problem and system loss. The reactive power support which is necessary to maintain the voltage profile and stability of the system and also affects the active power transmission capability of a network is one of the ancillary services [7]. At present, cost of reactive power support in transmission system is usually recovered from transmission charge. However cost recovery of the reactive compensators should be separated from the transmission charges in order to improve the competence in the future design of reactive market [3].

II. REACTIVE POWER SERVICE

A. Synchronous Generators as Reactive Power Service Providers

Reactive power ancillary services may be provided by generators, transmission/distribution companies, or even large customers, but the importance of synchronous generators in providing the service remains a critical issue. We examine the reactive power generation capability of a synchronous generator. The power output of a synchronous generator is usually limited to a value inside the MVA rating by the capacity of its prime mover. When real power and terminal voltage is fixed, its armature or field winding heating limits determine the reactive power generation from the generator. The armature heating limit is a circle (Figure 1) with radius R1= (VtIa) ½ centered on the origin and the field heating limit is a circle, centered at C2, (0, -Vt2/XS) with radius R2=VtEaf/XS. Vt is the voltage at the generator terminal bus, Ia is the steady-state armature current, Eaf is the excitation voltage and XS is the synchronous reactance. P and Q are real and reactive power generation from the machine, respectively.

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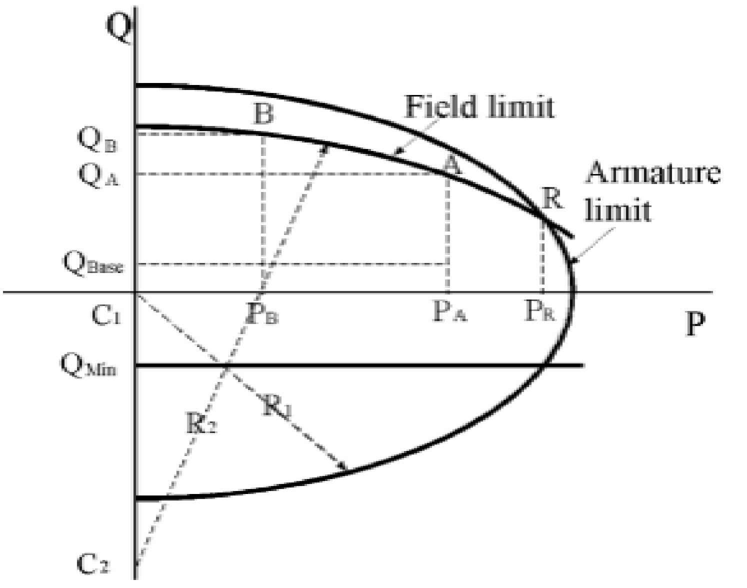

Figure 1. Synchronous generator capability curve

The machine rating is the point of intersection of the two circles ('R' in Figure 1). When $P < P_R$, the limit on Q is enforced by the generator's field heating limit. While, when $P > P_R$ the armature heating limit imposes restrictions on Q. P_R is the real power corresponding to machine rating power.

To examine further into the generator’s reactive power supply, let us consider (Figure 2). Q_{base} is the reactive power required by the generator for its auxiliary equipment. If the operating point lies inside the limiting curves, say at (P_A, Q_{base}), then the unit can increase its reactive generation from Q_{base} up to Q_A without requiring readjustment of P_A. This will however, result in increased losses in the windings and hence increase the cost of loss.

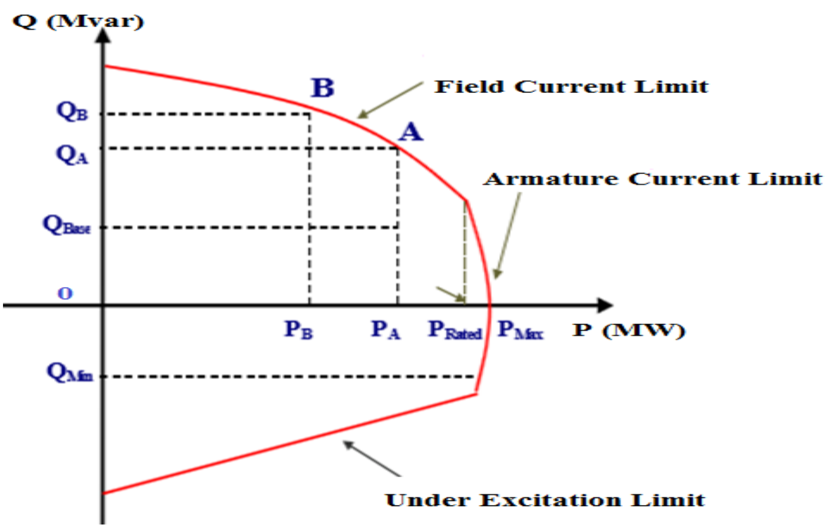

Figure 2. Synchronous generator capability curve

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If the generator is operating on the limiting curve, any increase in Q will require a decrease in P so as to there to the winding heating limit. Consider the operating point 'A' on the curve defined by (P_A, Q_A). If more reactive power is required from the unit, say Q_B, the operating point requires shifting back along the curve to point B (P_B, Q_B), where $P_B < P_A$. Also includes a lower limit on Q, which restricts the unit operation in under-excited mode due to localized heating in the end region of the armature.

B. Reactive Power Pricing

Reactive power pricing and remuneration should be designed to encourage two efficient outcomes. First, it should encourage efficient and reliable investment in the structure needed to sustain the reliability of the transmission system. Second, it should supply incentives for the reliable and efficient generation and consumption of reactive power from the existing structure, taking into consider the opportunity costs [3]. The important of any pricing system allows the system operator real-time control over reactive power resources.

Reactive power pricing in real time shows the important service of supplying information to both the utility and customers about the true burden on the system in terms of the cost and other system parameters viz. voltage drop and increases transmission losses from time to time [4]. Real time pricing of reactive power has been shown to perform better than power factor penalty scheme in terms of providing incentive to all customers to reduce their consumption of reactive power irrespective of their power factor. In other words Reactive Power Pricing is a fair chance of earning normal profits. Reactive power pricing also provide signals that encourage customer to make efficient choice about how they use or consume reactive power [7].

III. OPTIMAL POWER FLOW RESULTS

In the power system production business has become a reality due to the restructuring of electricity industries. Active power provided by power producers has become a commodity. The reactive power is treated as a service whose purpose is to support system security. Transmission system operators procure reactive power support service at a cost. Each generator should provide a certain amount of reactive power to support its own active power selling activity.

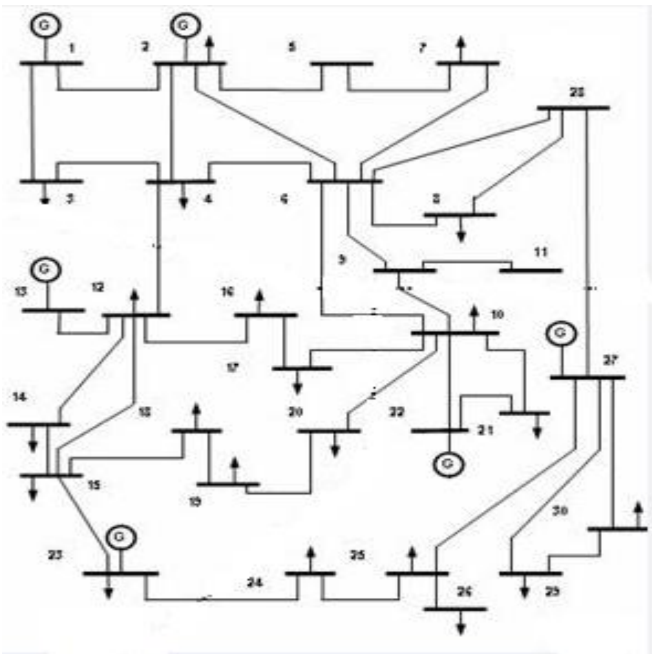

Figure 3. Single line diagram for IEEE 30 bus

Consider Figure 3 representing a standard IEEE 30 Bus single line diagram. For a given system load, total system generation cost should be minimum.

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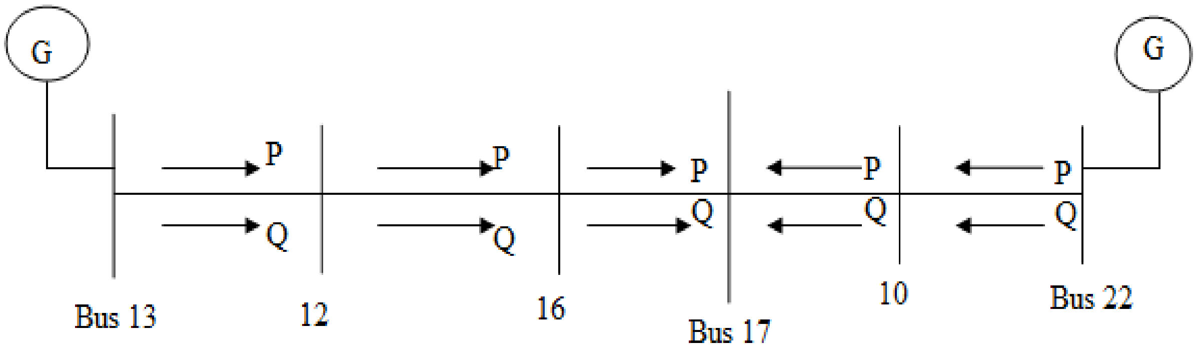

Figure 4.. Single line diagram for Bus17

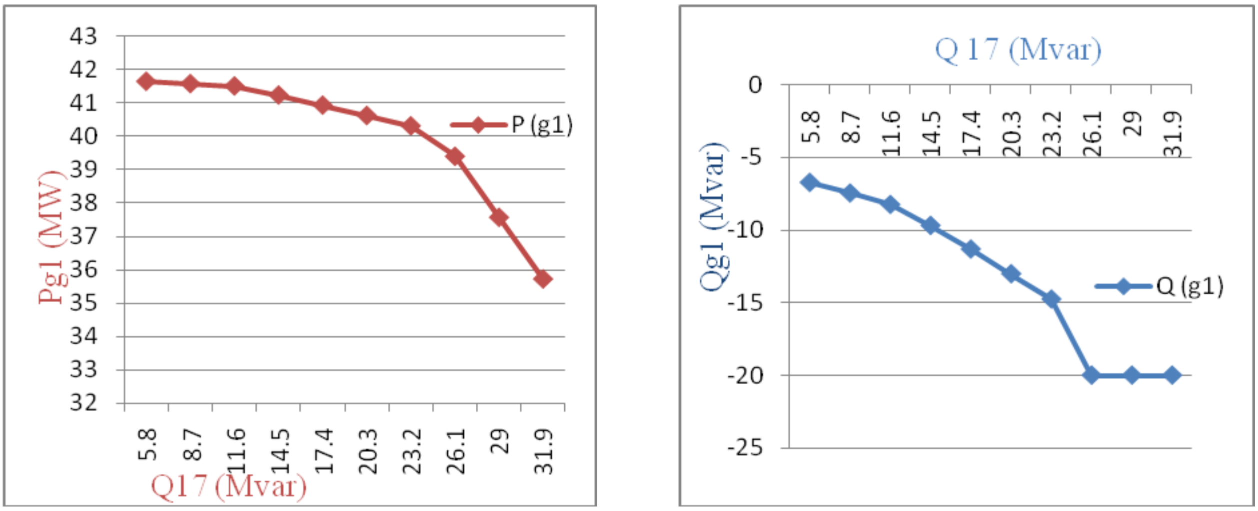

Figure 5. P-Q Generation on G1

With injecting Q at specific bus 17, for Generator 2, Q generation increases and P generation decreases.

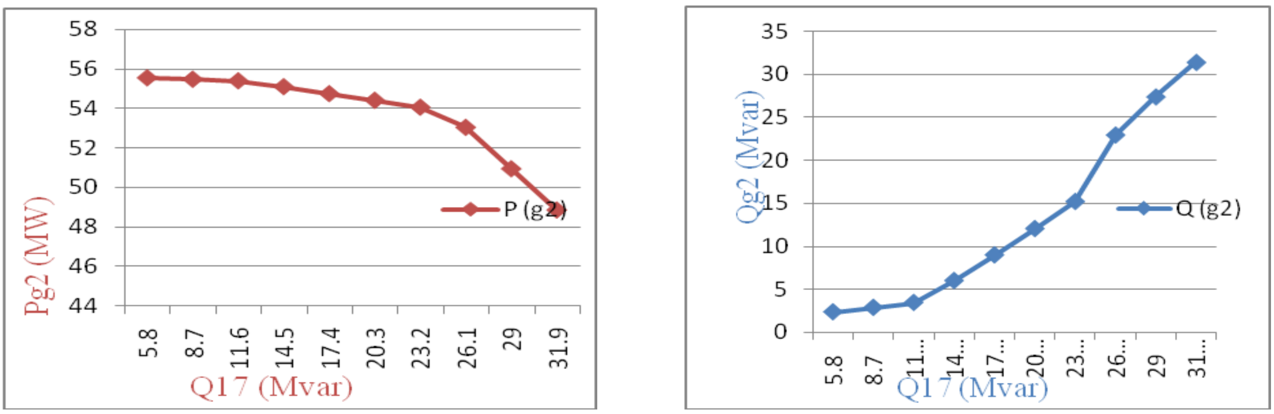

Figure 6 P-Q Generations on G2

With injecting Q at specific bus the Q generation increases while P generation decreases for Generator 2.

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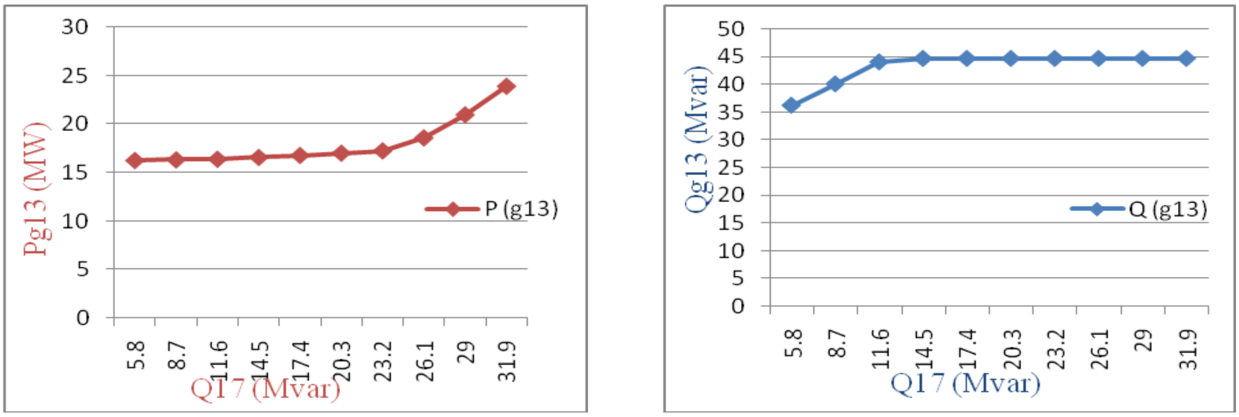

Figure 7. P-Q Generation on G13

With injecting Q at specific bus the Q generation increases and then became constant while P generation increases for Generator 13.

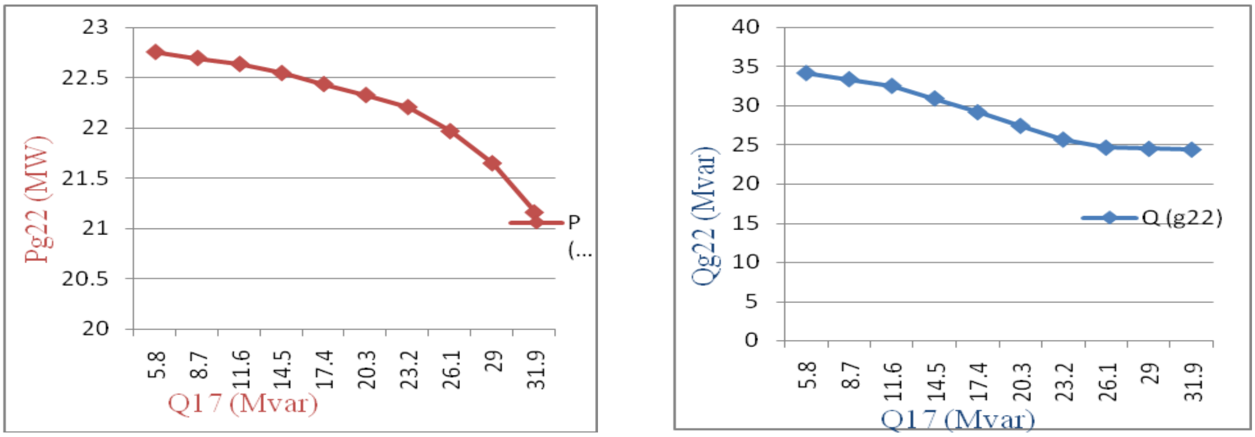

Figure 8. P-Q Generation on G17

With injecting Q at specific bus the Q generation decreases while P generation decreases for Generator 22.

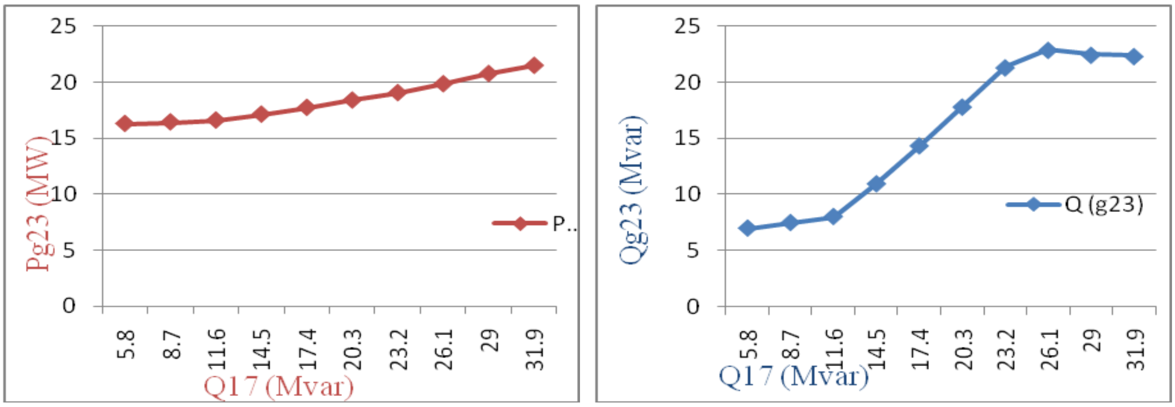

Figure 9. P-Q Generation on G23

With injecting Q at specific bus the Q generation increases while P generation increases for Generator 23.

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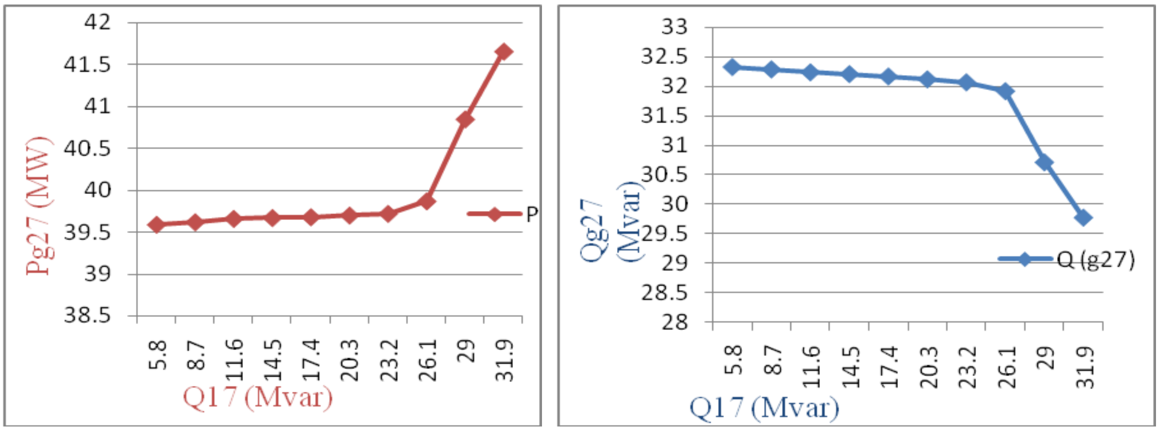

Figure 10. P-Q Generation on G27

With injecting Q at specific bus the Q generation increases while P generation decreases for Generator 27.

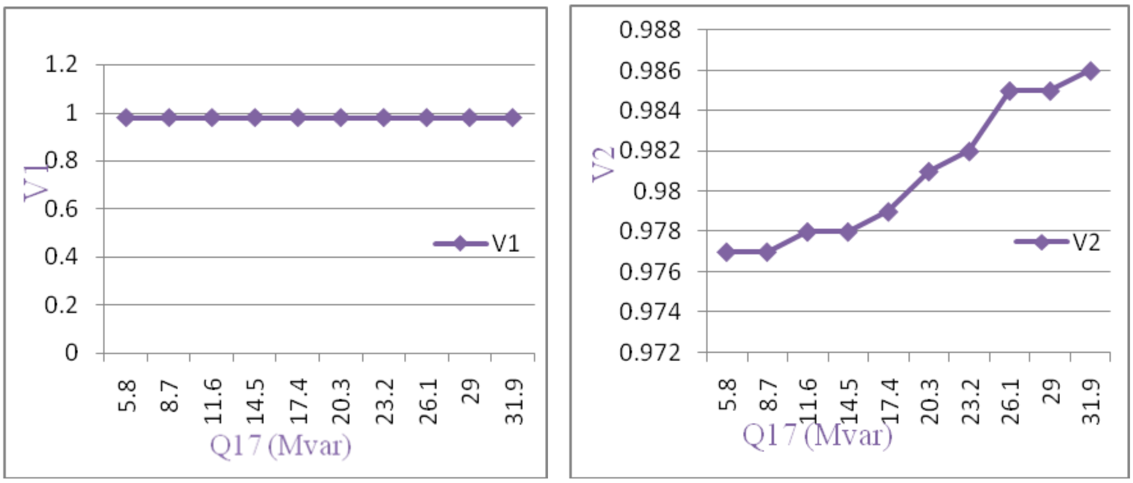

Figure11. Voltage (Mag.) for G1 & G2

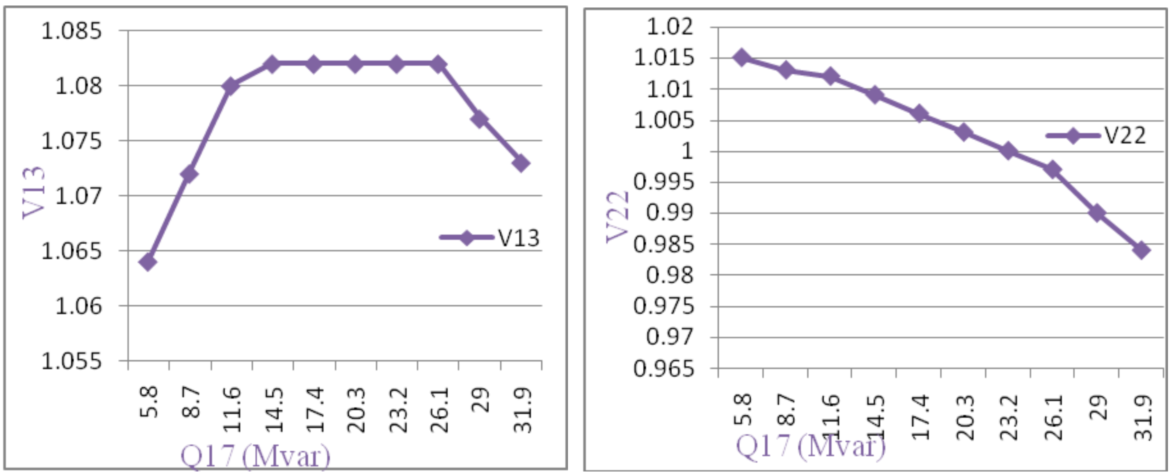

Figure12. Voltage (Mag.) for G13 & G22

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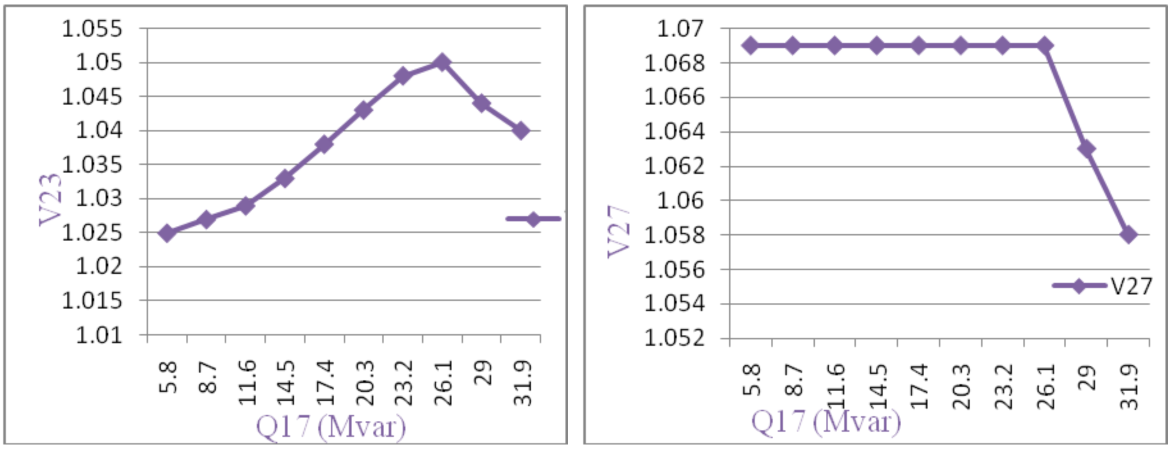

Figure13. Voltage (Mag.) for G23 & G27

With the injecting reactive power at the bus the voltage magnitude of that bus will be increased so that Voltage Profile Improvement is done.

CONCLUSION

Procurement of various ancillary services is a complex task for the Independent Source Operator (ISO) in deregulated electricity markets. Among various factors that need to be considered, are the benefit to the system from a particular service in terms of system security, economics and reliability, and the price of the facility in terms of payments to be made to the service providers. Here provision of reactive power support for improvement of voltage profile is considered which shows the how reactive power flow in loop can affect the voltages of the buses, more the electrical distance for flowing of reactive power more will be the loss occur, and to find the reactive power at shorter distance, its need to offer some remuneration in response of reactive power which being supplied by reducing respective active power generation.. From the optimal power flow of the IEEE 30 bus using MAT power we observe and conclude the different result. Reactive power pricing and support service is necessary and advantageous to the supplier and consumer both. It is one of the ancillary services.

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