

# Bilateral Market for Load Following Ancillary Services

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**Abstract:** Ancillary Services are those services performed by generators, transmission and control equipment, which are necessary to support basic services and to maintain reliable operations and system security. In this paper, we focus our attention on one of these services, load following, and propose a competitive way to provide this service through bilateral contracts between supplier and customer.

## 1. INTRODUCTION

In the deregulated scenario, one of the issues related to the Ancillary Services (AS) is the possibility to provide them competitively. Regulation and load following are services classically provided by, and under the jurisdiction of, a control area to balance the measured mismatch between generation and load. Deviations in load from the scheduled value are normally supplied by some generating units under AGC or participating in manual frequency control. They are substantially the same service except for the time frame. While regulation should follow minute to minute load variations, load following addresses variations that occur over a longer time horizon [1]. In some cases there is no real possibility of distinguishing between the two services. For this reason, we will refer sometimes to both with just the term load following.

In the last few years, there have been several proposals for creating competitive markets for AS [2-4]. The main idea is to let a certain number of generators bid in the market, while the system operator buys an amount of each AS on behalf of the customers. Providing them competitively is becoming a reality. Still many issues related to AS, and in particular to the provision of load following, remain unresolved.

A major problem is the proper role of the Independent System Operator (ISO), or an equivalent authority, in the competitive market. In some cases, the ISO is the institution ultimately responsible for the procurements of AS. If each competitive market for ancillary services is treated individually and sequentially [2], the ISO has the additional task of redispatching generating units once a market is closed. In other cases, the role is primarily a supervisory one because the competitive market can be decentralized [3].

Other examples of unsolved issues linked to the competitive provision of load following are: who will have the ultimate responsibility for performance, how to increase the number of suppliers involved, and how to allocate payments specifically to customers. The last item, in particular, has become an extremely important issue: we, together with many researchers, believe that the FERC pro forma tariffs should be changed to reflect the impact of each user on the AS market.

In this paper, we propose a model which addresses some of these problems. The main difference with others work on the

subject is in our attempt to decentralize the market for load following. In accordance to NERC's definition of Self-Provision [1], we allow the procurement of load following through bilateral contracts between generating units and customers. In addition, there may also be either a competitive market or an authority responsible for the remaining power balance not met by bilateral contracts. The implementation of such a bilateral market is neither trivial nor costless; nevertheless, once some conditions are guaranteed, this could be a way to overcome many of the problems related to the load following provision.

## 2. THE BILATERAL MARKET

### 2.1 Model for a generator with a load following bilateral contract.

The aim of this section is to describe the proposed model structure and the conditions under which it works. The main point is one of considering a type of "local supplementary control" on each generator involved in the bilateral market.

Consider a generator in a control area with a bilateral contract. As shown in Fig.1, a demand signal  $\Delta P_{gl}$ , that arrives directly from the load, is compared to the power output of the generator  $\Delta P_G$  to yield a mismatch that we call Generator Control Error (GCE). One can consider GCE as a type of local ACE. GCE is given as an input to a reset controller that will force the mismatch to zero so that the generator follows the load.

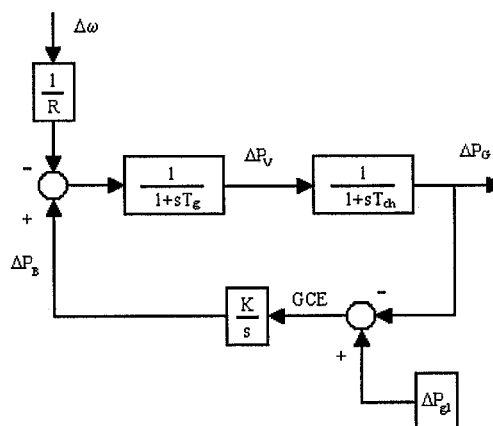


Fig.1 local supplementary control

It is necessary to emphasize that such variation in the classic AGC model [8] does not compromise the frequency control. Such a generator contributes, because of its speed

droop feedback loop, to the primary frequency regulation. It also can be under AGC and join the classic supplementary control while satisfying the bilateral contract; in this case, the governor will receive another power demand signal from the AGC. One problem that can arise in such a situation is the interference between the two inputs. In general, a generator, which is supplying bilateral load following, is expected to have less power to offer to the supplementary control. Sometime the generator may be receiving an input to increase the power output from the load and, at the same time, an input to decrease the power output from the AGC. This kind of conflict can be easily overcome by fine tuning, among generators, the distribution factors of the AGC demand signal. It is expected that generators with bilateral contracts have to respond to a smaller sharing factor.

As shown in Fig.1, the generator control error is defined as:

$$GCE = \Delta P_{gl} - \Delta P_G \quad (1)$$

If another speed droop feedback loop provides input into the local control on the generator, one can define GCE similarly to the definition of ACE as:

$$GCE = -\beta \Delta \omega + \Delta P_{gl} - \Delta P_G \quad (2)$$

with  $\beta$  as the local bias.  $\beta$  can be set simply as  $\frac{1}{R}$ , where  $R$  is the slope of the speed-droop characteristic of the generator under analysis, or it can be set differentially to improve system performance. In fact, non-zero  $\beta$  changes only the speed, not the overall quality of performance, since if  $\beta \neq 0$  the local controller is sensitive to both the frequency and the load variations.

$\Delta P_{gl}$  indicates the general demand signal. Note  $\Delta P_{gl}$  is not necessarily one load following contract that a generator has with a particular customer. The generating unit can also have, concurrently, several bilateral contracts. In this case, the demand signal from each customer is added to give the total demand signal,  $\Delta P_{gl}$ , for the specific generator and:

$$\Delta P_{gl} = \sum_i \Delta P_{li} \quad (3)$$

It is also possible, with this structure, to provide load following with bilateral contracts across control areas.

The dynamic model for system of Fig.1 is given by:

$$\begin{aligned} T_{ch} \Delta \dot{P}_G &= -\Delta P_G + \Delta P_V \\ T_g \Delta \dot{P}_V &= -\frac{\Delta \omega}{R} - \Delta P_V + \Delta P_B + x \\ \Delta \dot{P}_B &= K \cdot GCE \end{aligned} \quad (4)$$

where  $x$  is the input that the generator may receive from the AGC,  $T_g$  is the time constant of the governor and  $T_{ch}$  is the time constant of the prime-mover.

## 2.2 Performance considerations

The structure we propose here is in line with the new NERC requirements. In the latest version of NERC's Policy 10 [1], a new definition of Self-Provision is introduced. Self-Provision allows a customer to purchase an Interconnected Operation Service (IOS)<sup>1</sup> directly from a third party IOS supplier. It also attempts to split the responsibility of the provision of IOSs between the operating authority and the IOS suppliers. To this purpose, Policy 10 is introducing new performance criteria, besides the traditional measures applied to ACE, that the supplier is required to comply. The new performance criteria are expected to include those applied to a Supplier Control Error (SCE) defined as [1]:

$$SCE = P_a - P_s \quad (5)$$

where  $P_a$  is the supplier actual metered power while  $P_s$  is the sum of all schedules at each sampling period for this supplier. Our GCE in equation (1) can be seen as the SCE in [1] and it is easy to apply new performance criteria, regarding load following and frequency control, to each generator with bilateral contracts.

The advantages of such a bilateral market are many. The possibility of setting the price in the contract directly between customer and supplier solves the problem of the allocation of payment specifically to each customer in an equitable way. Moreover, it allows increasing competition in the ancillary services market and, as a consequence, avoids the problem of shortfalls in supply of load following. The generator with a bilateral contract is compensated in a fair way for the service that it is offering and this could be good reason for generators to join the load following market. An increase in competition also arises because of the possibility that generators may be able to enter into bilateral contracts outside their CA. The other important point is that it discharges the ISO, or an equivalent authority, from the burden of responsibility. With this structure, it is easier to impart liability directly to the supplier, for deviations from the scheduled amount of load following.

## 3. ECONOMIC CONSIDERATIONS

The implementation of the bilateral market for load following, from a technical point of view, is rather straightforward. For such a market to be economically feasible, more considerations are necessary. To begin the demand signal  $\Delta P_{gl}$  must arrive directly from the load. This means that, to create a bilateral market, a necessary condition is that of having a very well developed communication system with the possibility of monitoring customers.

In NERC's Policy 10, among the general requirements for the provision of IOS, the supplier is asked to provide and maintain real-time voice and data communications with the operating authority [1]. The reason is two-fold: one, so the supplier is able to respond to the authority's instructions or

<sup>1</sup> In NERC's definition Ancillary Service is referred to as an IOS

controls and two, so the authority can monitor the performance. In the case of self-provision, the authority should be able to ensure, on and off line, that the self-procurement of ancillary services satisfies all the requirements. For this reason, a customer wishing to self-provide ancillary services should have a real-time communication connection with the center.

For our model, each customer with a bilateral contract shall have a communication channel with the provider. The provider must be connected to the center so that the authority can check and monitor the self-provision of load following. Clearly, this communication requirement means further cost for the customer.

It is important, at this point, to consider some economic issues related to the customer's point of view in such a bilateral market. Besides the previously underlined advantages of our model, choosing to purchase load following through bilateral contracts guarantee the great advantage of having the generation strictly match all the load variations. This is an important point especially for those loads, which create large or fast real time power imbalance. At the present, on the contrary, there is good reason for the customer not to be interested in such a market. The charges applied for services such as load following are still flat and there is no real differentiation between users. Prices for load following are incorporated into tariffs which do not take into account the different burden imposed by each user on the system and do not compensate adequately the generation provider. As long as a new pricing scheme for AS is not developed, it is difficult for any kind of competitive market to be feasible.

#### 4. CONCLUSIONS

In this paper we propose a structure for a competitive provision of load following. Compared to other recent works on the subject, we attempt to decentralize the market for this AS, suggesting the procurement of load following through bilateral contracts. In our opinion, with a bilateral market for load following, it is possible to solve some of the urgent problems related to the provision of this service and, at the same time, it is possible to release the ISO or an equivalent authority from this burden, moving the ultimate responsibility to the supplier. We believe this is critical and needs an urgent review of the pricing methodology for this service. FERC pro forma tariffs do not appropriately identify the impact of each user on the market and make difficult a fair development of any kind of competitive market for AS.

#### 5. ACKNOWLEDGEMENTS

The authors wish to thank Politecnico di Bari and the European Community for providing Ms Nobile with a scholarship to support this work.

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#### 7. BIOGRAPHIES

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