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Research on the Automatic Generation Control (AGC) coordinated control modes between provincial dispatching and regional dispatching in Yunnan Power Grid

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Abstract

With the constant expansion of Yunnan power grid, in current dispatching Automatic generation Control (AGC) mode, the use effect of small and medium-sized hydropower resources in the unified dispatching was not ideal. By building zoning control model artificially, the control targets and their coordinated relationship between main area and sub-areas are explicitly pointed out. The zoning and layered control mode of AGC between provincial dispatching and regional dispatching is put forward. Analysis and comparison are also made of the “independent zoning and layered control mode” and “coordinated zoning and layered control mode”, and then their existing problems are pointed out. The research can provide the foundation of further study on AGC coordinated control strategies between provincial dispatching and regional dispatching, which can realize single goal and multi-objects of AGC coordinated control in the power grid.

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1. Preface

Yunnan power grid develops rapidly. Until early 2011, the installed capacity of Yunnan Power Grid scheduling ups to more than 28015.7 MW, including hydropower 17520.2 MW, accounting for 62.5% of the total. The current AGC scheduling mode has been difficult to adapt to Yunnan power grid development condition and operation conditions. Provincial scheduling plans to adjust current scheduling

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mode, a part of unified dispatching 110 kV equipments’ operational authority and some small and medium-sized hydropower generating equipments’ real-time scheduling right will be move to regional scheduling, then provincial scheduling is responsible for the balance of the entire network of power consumption. According to national regulation, the units whose installed capacity reached more than 40MW need to undertake AGC control. Scheduling relationship should adapt to development of the scheduled power grid to adjust the scheduling relationship among various grids is the inevitable trend [1-3]. Because of the different control goals between provincial scheduling and regional scheduling, further more, both of them are closely linked on the problems of power send and system security and stability, so to unified research the coordinated two-level scheduling AGC control mode is particularly important.

This research can better understand the control ability of regional scheduling AGC, which facilitate coordination and cooperation of AGC strategy between provincial dispatching and regional dispatching, and the medium and small hydropower resources will be used rationally [4-6]. In addition, the new mode will reduce scheduling complexity and ensure dispatching reliability to adapt to the development of Yunnan Power Grid and to maximize the advantage of AGC coordinated control between provincial dispatching and regional dispatching.

2. AGC Centralized control mode

For centralized AGC system , the Energy Management System (EMS) in control centers calculate generating power of each controlled power unit, and through the workstations of network communication and Remote Terminal Unit (RTU) that installed in power plants, then AGC commands directly are sent to power plant controller and unit controller, AGC instructions include the object choice and generating power setting[7-8].At the same time, the information about power plants and generator is sent to provincial scheduling control system through network communication control system. All the information of each AGC generator should be uploaded to the control center, which will create the conditions for calculation of each unit’s power output. Additionally, other tie-line power information that has a relationship with active power distribution also should be sent to provincial dispatching control system. The control mode is shown in Figure 1.

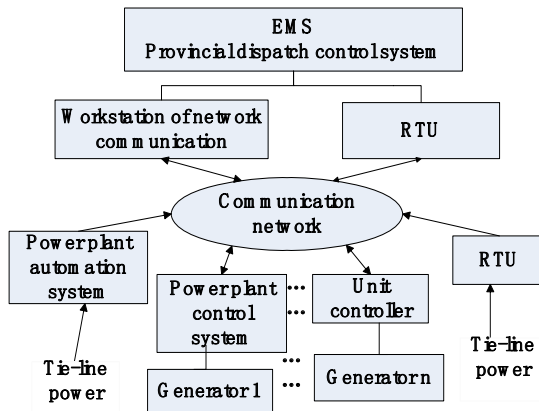


Fig. 1 Schematic diagram of AGC Centralized control mode

In this mode, the AGC power plants only can be dispatched by the provincial dispatching. Because of the limits of power grid structure, power plant capacity and the different regulate speed of units, various types power plants have huge difference on use effect and dispatched number. The number of dispatched

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large-capacity power plants (greater than 500MW) up to 30000/ year, while some small-capacity power plants had no specific regulation goals. The small-capacity hydroelectric power plants of united dispatching was difficult to rationally use the regulation effect was also poor. However, the installed capacity of the hydropower by co-operation dispatching reached 3160.7MW, accounting for 18% of the total installed capacity of hydropower. This mode is obviously not the economic and scientific, which has been difficult to adapt to the current development and operating conditions of Yunnan Power Grid.

3. AGC zoning control in Yunnan Power Grid

3.1. Zoning model and zoning control

According to the characteristics of the control area structure, and considering the stable section which should be monitored actually, the whole of Yunnan current zoning-based automatic generation control will be divided into main area and sub-area, of which the main area boundaries is Yunnan's foreign tie-line, that is, The stability of the corresponding section, sub-regional boundaries is the sub-region's external tie lines. In the normal control, the main regional and sub regional through 220kV main transformer as the main regional and sub regional control the interface. Power plants and the corresponding AGC units, according to their respective location, are attributed to the main regional and sub regional, shown in Figure 2.

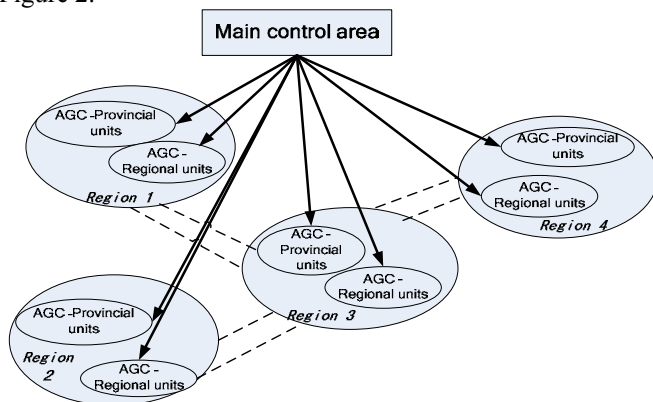


Fig. 2 schematic diagram of AGC zoning model in Yunnan power grid

3.2. Control goal of main area

According to principles of unified scheduling and hierarchical management, provincial scheduling is responsible for the safe operation of provincial grid, besides, power generation in accordance with the plan of power generation and control principles to improve the power quality and operational level. Provincial scheduling belongs to main control area, the AGC control objectives are for the power grid frequency and / or the whole region of net exchange of external tie-line power. It is responsible for controlling the whole power grid of Area Control Error (ACE). In the Tie-line Bias Frequency control (TBC) mode, ACE can be described by the following formula:

$$ACE_{main} = 10B(f - f_0) + I - I_o \tag{1}$$

ACE_{main} is ACE of main control area; B is frequency deviation coefficient of the whole area, take positive; f is the frequency of the actual measured; f_0 is rated frequency; I is actual exchange power of entire regions; I_0 is plan net exchange power of entire regions.

3.3. Control goal of sub-area

According to need to select a different sub-regional AGC control objectives, the common control objectives are as follows:

- 1) Sub-region through directly controlling the transmission power of a stable cross-section which is constituted by its external tie lines, thus power flow constraints of stable cross-section are converted to sub-regional control objectives, that means the transmission power of stable cross-section will be limited to limits or a given value, which is the most common control objectives. Each sub-area respectively is used to control the transmission power of corresponding control section. The units that participate in the area control should bear the incremental output, as shown in the following equation:

$$ACE_{\text{sub}} = \Delta P = P_{T0} - P_0 \quad (2)$$

ACE_{sub} is ACE of sub-area; P_{T0} is control target of transmission power of stable cross section (limits or a given value); P_0 is actual transmission power of stable cross section.

- 2) According to the incremental load from short-term load forecasting or super short-term load forecasting to achieve advanced control of partition AGC units.
- 3) Virtual section control of power plant, that is: based on the recent or temporary adjust generating plan to control power plant cross-section.

3.4. The targets coordination of partition layered AGC

Under normal circumstances, the AGC function of main area can meet TBC control requirements, each sub-area controls this area's objectives to meet the power generation and load balancing within the district. The main regional AGC objectives and the sub regional AGC objectives are relatively independent. The main control region and sub-areas constitute coordinated control system of different levels and different emphasis, namely to meet the control objectives of whole grid and the coordinate sub-area objectives, namely to meet the control objectives which will satisfy the local optimum, reach to the global optimum.

The relationship among the targets as shown in Figure 3:

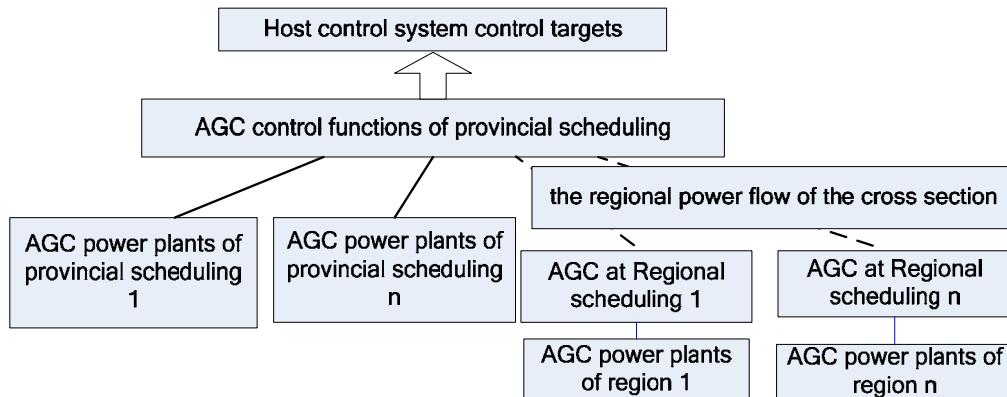


Fig. 3 relationship of partition layered control targets

By the above figure we can see that, from the view of main area control objectives, the directly dispatching AGC units or power plants at provincial scheduling and AGC control function of regional scheduling have the same status, but we can see that, relative to directly provincial scheduling AGC power plants which undertake frequency and tie line fluctuations control, the regional dispatching control is not directly controlled by the provincial dispatching AGC, such as: compensation issued to regional scheduling, corresponding adjustment of the ACE issued to regional scheduling. According to the corresponding regional sections, regional scheduling regulates the section power flow by itself and control fluctuations in load area.

4. Independent AGC zoning and layered control mode

In this control mode, provincial dispatching will play a leading role only when provincial dispatching assigns AGC tasks to regional dispatching one-time, and evaluates the AGC task completion situation of regional dispatching. Besides, directly provincial scheduling AGC power plants and its straight for load areas will constitute an independent control area, which is responsible for the tie-line power and frequency control to complete their AGC task. While regional scheduling and its directly dispatching power plants also will constitute independent control areas, then according to its own control goals to develop appropriate power plan curve. If provincial dispatching approval the power plan curve, then regional scheduling can undertake AGC operation to finish its AGC tasks. In this control mode, the AGC control between provincial dispatching and regional dispatching are relatively independent. It must be clear delineation of control areas, which do not stay blind angle and each control areas need to complete their tasks well in order to better complete the whole grid AGC control objectives.

Compared to the AGC centralized control mode, provincial dispatch center do not have to collect all the information of stand-alone AGC units. But simply to provide the overall information of equivalent

machines within its jurisdiction, such as the total active power, control system state, etc. Not every generation power should be calculated by EMS of provincial dispatching, and just need to assign AGC tasks to regional dispatching one-time, but regional dispatch centre must have AGC control function, so as to allocate the AGC instructions.

5. Independent AGC zoning and layered control mode

In this mode, provincial scheduling centre will put cluster electricity generator units as an equivalent unit treat. Provincial dispatching will assigns AGC tasks to regional dispatching one-time, and evaluates the AGC task completion situation of regional dispatching. In additional, To control its straight dispatch power plants to responsible for finishing the AGC tasks of main area and the AGC work of regional dispatching didn't be finished obviously provincial scheduling tells AGC tasks of multi-jurisdictional region take overall charge. As shown in Figure 4.

Provincial dispatching unified the AGC control objectives between provincial scheduling and regional dispatching, the equivalent unit's ACE that EMS calculated is sent to the various sub-control center to adjust for their respective tie-line power control of the various regions .Each regional dispatching regulates its output power in accordance with the received ACE and maintain output power within the region according to plan implementation, and then monitor tie-line power of the adjacent area to meet the provincial directive. AGC units accept the real-time updated AGC signal from regional dispatching to automatically adjust the power output of AGC unit.

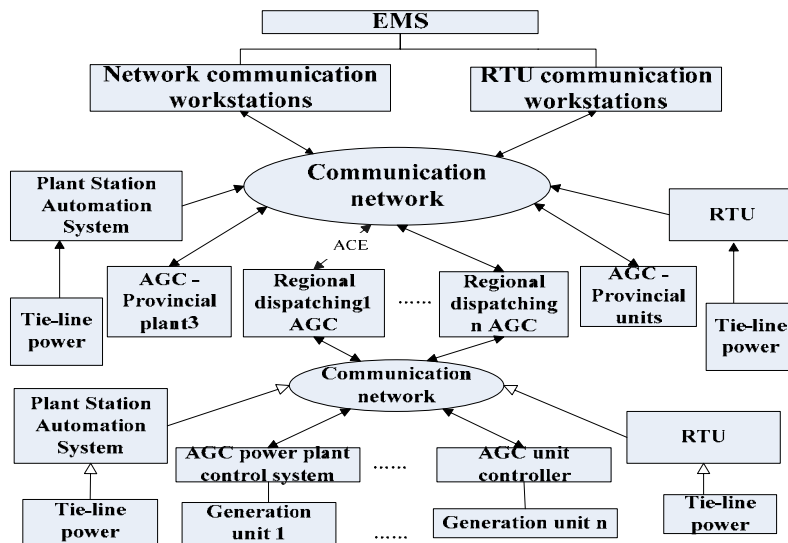


Fig. 4 schematic diagram of coordinated AGC zoning and layered control mode

At the same time, through the network communication system. The jurisdiction of prefecture-level scheduling AGC units' and power plants' information also will be uploaded to the regional dispatching control system to adjust the arrangements for the region to adjust power output. Comparing to the independent AGC control mode, which increases the coordination between the provincial and regional-level dispatching. This will also bring some problems, such as: AGC control behavior between provincial and regional-level dispatching how to influence each other AGC control scheduling behavior between

how the affecting each other, and the issue of control strategy related to security constraints further, the dispatching automation information collection of power plants and the research of AGC coordinated control strategies also should be improved.

6. Epilogue

Adjustment and research on dispatching mode will enhance the operation of the grid operation at all levels management and improve the efficiency of grid operation and utilization of small hydropower. With the AGC operation mode changes, construction and improvement of AGC and other advanced application functions should be carried out actively, to ensure fully mobilize and play a role in ensuring the safe and stable operation of the grid.

Reference

- [1]YI Shi-min,LI Sen,CHEN Hui-kun, LIN Shao-hua.Discussion on change in operating mode of Guangdong Power Grid dispatching.Guangdong Electric Power, 2007, 20(3) :1-5, 11
- [2]CHEN Dong,YI Shi-min.,LIN Shao-hua,WEN Fu-shuan. Design of two kind of dispatching modes for Guangdong Power Grid.Southern Power System Technology,2009,3(3):64-69.
- [3] CHENG Wen-gang.Discussion on dispatching operation mode for 500kV regional control center at Nanning.Guangxi Electric Power,2006,29(2):62-63.
- [4] JIANG Mu,WU Chuan-wen,ZHANG Bo-ming, et,al. Provincial grid layer partition with meritorious real-time scheduling mode and method.Automation of electric power system, 2009, 33(22): 10-13.
- [5]JALEELI N,VAN SLYCK,EWART D N,et,al.Understanding automatic generation control.1992,7(2):1106-1122.
- [6]GREEN R K.Transformed automatic generation control.IEEE Trans on Power System,1996,11(4):1790-1840.
- [7] GAO Xiang, Modern grid frequency control application technology,Beijing, China Electric Power Press,2010
- [8] LIU Wei-lie. Power system frequency and automatic generation control.,Beijing, China Electric Power Press, 2006.