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Impact of Dynamic Response of Different Generation Technologies on Frequency Control Ancillary Services (FCAS) Market

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Introduction: Electricity markets were introduced in late 90's with the aim to reduce the cost of electricity and defer investment, while maintaining a safe and reliable system. Ancillary services markets were then introduced (e.g. in Australia, frequency control ancillary services (FCAS)) to ensure system stability and reliability. In particular, the FCAS is responsible for regulating the system frequency during normal operation and contingency scenarios [1]. This paper focuses on a major issue that currently affects the Australian FCAS market, i.e., the market requires generators to behave in the same linear manner irrespective of the generation technology [2]. This is impractical for a non-linear system having different generation technologies with different dynamic characteristics [3]. Therefore, this paper investigates the dynamic behaviour of the different technologies under different frequency excursions to determine the acceptable response times for each generator technology.

Research Design: In order to characterise the dynamic response of different generator technologies, such as hydro turbines, steam turbines and gas turbines, a single-machine single-load test system was formulated in DIgSILENT Power Factory. Then, different load disturbances were created in the system to study the primary frequency response of the individual turbine-governor system. Once the frequency response of each generator technology was characterised, then power system frequency response with different generation technology mixes was analysed using the New England-39 bus system.

Results and Discussion: Simulation results for a 5% load change are shown in Figure 1.

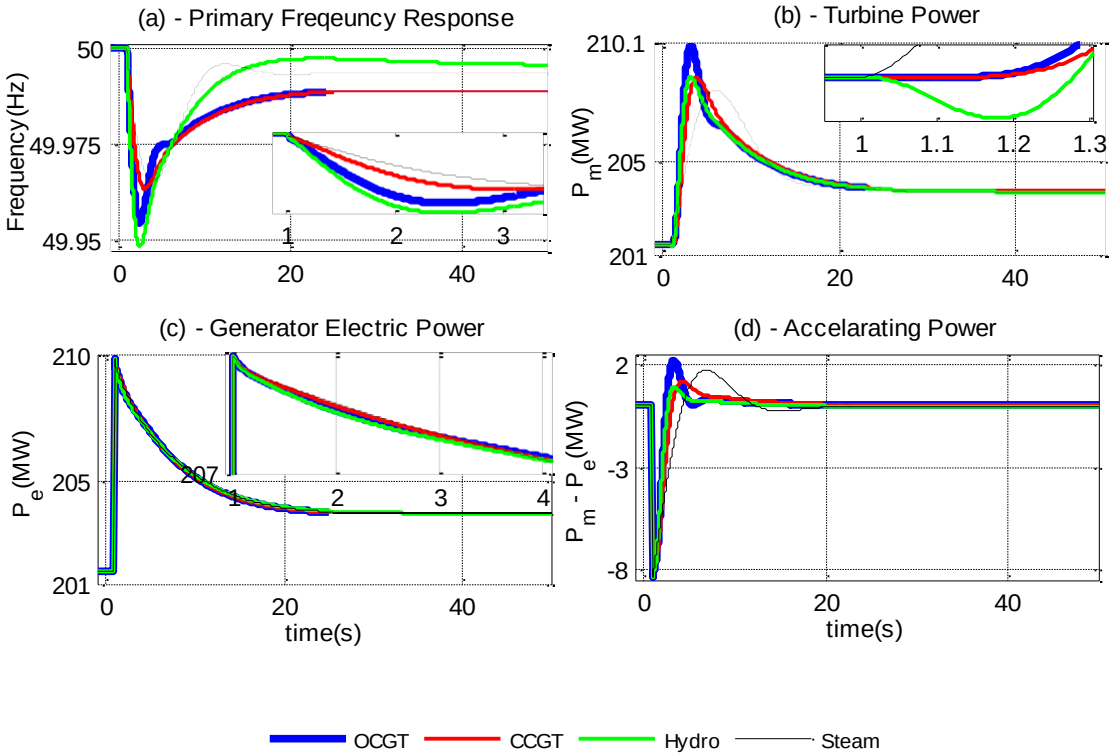

Figure 1. *The primary frequency response of different generator technologies.*

Fig. 1-(a) shows with high inertia, the initial rate-of-change-of-frequency is much smaller for steam and combined-cycle gas turbine (CCGT) generators compared to Hydro and open-cycle gas turbine (OCGT) generators with lower inertia. Although Fig. 1-(c) shows the inertial response is technology neutral, Fig. 1-(b) shows the primary frequency response is very much technology dependent. Furthermore, the OCGT and CCGT are highly nonlinear systems owing to their temperature control loop, hence at different operating points, they have different dynamic responses [4]. Also, for all generators, if their governor deadbands are enabled, then their responses will be different from what was shown in Fig. 1.

Conclusions: The dynamic response for different generation technologies are investigated in this study with realistic governor-turbine models using DIgSILENT Power Factory software tool. The study findings suggest the penalising and rewarding strategies for FCAS generators should be augmented to consider their frequency response characteristics.

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