Introduction to Real Time Pricing of Electricity

The Australian electricity industry has recently become deregulated, giving rise to the National Electricity Market. Economic competition is achieved through spot pricing of electricity which determines, every half-hour a new price for electricity in a given region of the network. The spot market essentially schedules the cheapest generators that are able to supply the load.

The concept of a real time price arises when one considers increasing the frequency at which the price is calculated. The spot market makes assumptions about the physical nature of the electricity system that are valid on a time-scale of 30 minutes. However, in reducing the interval to be of the order of seconds, requires information about power system dynamics.

The thesis addresses how to design an optimisation that incorporates a model of the electricity system with the economic model for spot pricing. The motivation behind such an optimisation is to maximise the value of trade while simultaneously managing the quality of supply issue of maintaining the frequency at 50Hz. This may allow additional services in a power system to compete in the spot market.

1. Combined Optimisations

The aim of a combined optimisation problem is to consider a single optimisation that incorporates information about generators, the price of electricity and some simple generator models.

Calculation of open-loop optimal controls reveals that the real time price for electricity, for a simplified power system is an expression for the frequency error. A closed-loop system can be determined using some insight from open-loop controls yielding a feedback law that calculates the real time price and that can be used for generator scheduling.

However, for a complicated power system, there is no clear way for deriving a similar feedback law. This gives rise to consideration of the dynamics involved in the problem as well as consideration to the time-scales upon which the dynamics act.

2. Intermediate Level

The spot market model calculates setpoints for generators using a static model of system behaviour. Such behaviour ignores the effects of generator ramping and frequency effects. By considering the spot market and power system as two separate entities as shown in the following diagram, it becomes apparent that an intermediate level between them could assist in managing their differences.

3. Load Frequency Control Intermediate Level

This intermediate level takes setpoints from the spot market. A contingency recovery block solves the spot market every five minutes, in order to account for generator fallout. A ramping cost optimisation then uses model predictive control in order to calculate the best ramping strategies for generators such that they maintain both their spot market setpoints and supply the total amount of load. The output of this block reflects the power requirement from each generator. The frequency cost optimisation accounts for the overall effect of local generator controls, using the power setpoints as a guide. The generator references are chosen to minimise the frequency errors in the power system, thus maintaining it at a nominal value of 50Hz.

The time scales on which each optimisation act grow progressively shorter, moving from the commercial model to the physical model. This is in order to account for the fact that the dynamics of frequency in a power system act on much faster time scales to those of the spot market.

4. Conclusions

The technique of separating the concerns of a spot market and those of the physical system show that an intermediate level is able to move the power system from one spot market "solution" to another. While a price for electricity does not arise from the intermediate level as for a combined optimisation, it provides a basis for accounting for higher amounts of complexity. This comes from having sub-optimisations that deal with subsets of the overall problem.