OPTIMISING THE RELATIONSHIP OF ELECTRICITY SPOT PRICE TO REAL-TIME INPUT DATA

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Electrical power is paid for at a marginal price calculated by an optimisation to minimise the total cost of generation based on bids made by the power generation companies and consumer requirements. Generation companies are paid on the marginal rate (the level of the highest bid accepted) determined at their location. Similarly bulk power consumers are charged on the marginal price of supply at their location, which includes costs related to delivery to the user's location.

There are well known laws that determine the amount of power delivered along transmission lines. In the case where power lines form a loop, when a power limit is reached on one of the lines, it is necessary to bring into use more expensive generators to allow an increase in power consumption. This creates a step change in the marginal rates charged to consumers. Further it becomes more difficult to deliver power to one end of the limiting line, which is reflected in increased rates at that end. This sudden change in prices is known as a spring washer, with prices increasing on one side of the limiting line, and decreasing on the other side. This contrasts with the usual conditions where consumer costs are constant (when line costs are negligible). Under some circumstances the change in power costs can become extreme.

Transpower wanted to determine when large spring washers could occur, and also determine when the spring washer is sensitive to the physical parameters of the network.

A simplified version of the network equations were used by the MISG. These were supplied and explained by Transpower and are believed to retain the essential features of the full description.

It was found that when a simple spring washer condition exists, the costs of supply can be plotted as a straight line when the x-axis is the cumulative of the inverse transmission line admittances around the loop. Without a spring washer this line is a constant. This plot allowed an improved understanding of the nature of the spring washer. The position of the line is set, in the simple case, by two power generators. The difference between the marginal power costs at the two generators and the admittance of the line between them, determine the slope of the line, and hence the size of the step change in prices when the spring washer comes into existence. The distance from the generators determines the magnification of the prices, with the effect being similar to a lever.

Where one spring washer is supplying power to a second, an amplification can occur, similar to connected levers, and this is likely to account for the very large power charges seen occasionally.

The switch to operation as a spring washer is a step change, that occurs when a limit to the transmission lines is reached and the use of a more expensive generator becomes necessary. The exact position of this step charge in marginal rates is sensitive to all the parameters in the calculation of dispatch and pricing. The closeness of the current conditions to a large spring washer effect was considered more important than the sensitivity at the switch point.

An investigation of the linear programming equations was carried out to determine if the calculated prices will be sensitive to changes in parameter values. The conditioning number of a matrix depending on the admittance matrix was found indicate the sensitivity near the linear programming solution.

The MISG group proposed two methods to determine the closeness of a possible spring washer. The first is an investigation of near optimal vertices in the linear programming optimisation. The sensitivity figures from the linear programming optimisation can be used as the basis for this calculation. The number of vertices near to the optimum and the proportion of these investigated, will determine the reliability of this method.

The second method is simpler. Perturbations are made to the inputs, such as the demand figures, to the optimisation and the variation in the outputs recorded. The size of the perturbations can be made proportional to the amount of variation seen in the historical values of each variable. To ensure that calculations made are repeatable (necessary for auditing) pseudo random numbers from a generator with known starting conditions could be used, or alternatively quasi random numbers could be used. As part of recording the result of the perturbations, a record of the lines that reach limiting conditions can be kept.

A suggestion yet to be fully evaluated came late in the MISG. It was noted that the severity of the spring washer effect could be reduced by increasing the prices at certain generators. An optimisation that leaves the dispatch of power the same but increases the prices at certain generators to reduce the lever effect of the spring washer was proposed.

The actual power dispatch and pricing is a large and complex calculation, and thus the MISG suggestions need to be tested on small optimisations before being applied to the full dispatch and pricing calculations.