Analysis of Non-Physical Dispatch in the Gas and Electricity Pricing Models

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Abstract

Over the past decade, the New Zealand and the Australian electricity industries have undertaken a process of reform and deregulation with the aim of establishing a fully competitive wholesale electricity market structure. Currently the Victorian gas market is undergoing a similar process.

One important aspect of such markets is the short–term dispatch of supply and demand connected to the transmission network, and the consequent calculation of prices for electricity or gas at all points (called *nodes* or *buses*) in the network[1]. In both the New Zealand and the Australian electricity markets, such a dispatch is determined in the following general manner: "Blocks" or "amounts" of generation, load, and reserve, each with an associated bid price, are offered into the market by producers and consumers connected to the transmission grid. The market is then "cleared" by solving an optimisation model of the dispatch process, and the corresponding nodal prices are determined. Based on the result of the optimisation, the market players may revise their offers, and the process is repeated. A similar process occurs in the Victorian natural gas market.

The optimisation model used to determine the dispatch is a linear program that maximises the net benefit of generation or production subject to the system constraints. In the electricity dispatch model, net benefit is defined as the revenue obtained from supplying electricity less the cost of supply. The cost of supply consists of the cost of generation, plus the cost of providing reserve. The constraints include standard DC power flow equations, and constraints governing reserve, system risk, and system security[2]. Transmission losses are modelled via a set of constraints that determine the transmission loss as a piecewise linear function

[1]The price at a node is a quantity that reflects the marginal cost of supplying electricity (or gas) to that node. As such, it implicitly incorporates the cost of generation (production), the cost of any transmission losses and all constraints associated with generation and transmission. For a complete exposition of nodal pricing of electricity, see [1].

[2]The Grid Operator may impose generation (production) and/or flow limits on transmission equipment for security reasons.

of power flow. Nodal prices are given by the value of the dual variables corresponding to the nodal power flow balance constraints governing the power flow into and out of the network nodes.

The gas dispatch LP is similar in construction to the electricity dispatch model. Net benefit is defined as the value of demand and end-of-day linepack[3] less the cost of supply. The constraints include equations governing system operation (such as ramping constraints) and equations modelling gas flow in the pipeline system. The (steady state) flow of gas in a pipeline is a nonlinear function of the gas pressures at each end of the pipe; in the LP pipeline flow is modelled as a piecewise linear function of this pressure differential. Again, nodal prices are given by the value of the dual variables corresponding to the nodal flow balance constraints governing the flow of gas into and out of the network nodes.

Normally, the LP model correctly provides a dispatch that is both optimal to the LP and physically implementable. However, both dispatch formulations attempt to model nonconvex physical phenomena via the use of a convex piecewise linearisation. Therefore, under certain conditions, the "optimal solution" given by the LP may not correspond to an implementable, or physical, dispatch. In this presentation we first provide a description of the non-physical dispatch problem as it applies to the gas and electricity industries. We then outline some techniques and procedures that have been considered to overcome this problem.

References

[1] E. G. Read and B. Ring. *Dispatch Based Pricing.* Trans Power New Zealand, Wellington, 1995.

[3] Linepack refers to the volume of gas "stored" in the transmission pipelines.