User Guide

Optimal Power Scheduling in Electricity Generation

(OPSEG)

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1 Background

Consider a number of power stations committed to meeting the demand for electricity for a particular day. Also consider that there are three types of generators across these stations. These generators each have different technical and operating cost characteristics. Timing and level of their use have cost implications for meeting the overall electricity demand for the day. The generator types across the stations can be started or shutdown at any time during the day, and can be operated within their maximum and minimum technical limits. The problem is to centrally optimise the generator types to operate in each period so that the overall electricity demand for the day is met at minimum cost.

2 Model

Let g represent the set of generator types across the power stations and t represent a set of time blocks for electricity demand in a day. Also let $x(g,t)$ represent the optimal capacity output (MW) from generator type g in time block t; $n(g,t)$ represent the number of generator type g operating in time block t and $s(g,t)$ represent the number of generator type g started up in time block t. The overall cost of meeting the demand for electricity in the day is optimised as follows;

$$\underset{totalCost}{minimise}\ totalCost = totalStartUpCosts + totalFixedCosts + totalMarginalCosts \tag{1}$$

such that:

$$totalStartUpCosts = \sum_{g,t}\left(startUpCost(g)\times s(g,t)\right) \tag{2}$$

$$totalFixedCosts = \sum_{g,t}\left(duration(t)\times fixedCost(g)\times n(g,t)\right) \tag{3}$$

$$totalMarginalCosts = \sum_{g,t}\left\{\begin{array}{l} duration(t)\times marginalCost(g) \\ \times\left[x(g,t) - minimumPower(g)\times n(g,t)\right]\end{array}\right\} \tag{4}$$

$$\sum_{g} x(g,t) \geq demand(t) \quad \forall \ t \tag{5}$$

$$\sum_{g}\left(maximumPower(g)\times n(g,t)\right) \geq (1+spinningReserve)\times demand(t) \quad \forall \ t \tag{6}$$

$$s(g,t) \geq n(g,t) - n(g,t-1) \quad \forall \ g,t \tag{7}$$

$$x(g,t) \geq minimumPower(g)\times n(g,t) \quad \forall \ g,t \tag{8}$$

$$x(g,t) \leq maximumPower(g)\times n(g,t) \quad \forall \ g,t \tag{9}$$

where

Variable/parameter	**Description**	**Unit**
$x(g,t)$	Optimal operating capacity of generator type g in time block t	MW
$n(g,t)$	Optimal number of generator type g in operation in time block t	-
$s(g,t)$	Optimal number of generator type g started up in time block t	-
$totalCost$	Total cost of electricity generation to meet overall demand	$
$totalStartUpCosts$	Total starting up costs of started up generators during the day	$
$startUpCost(g)$	Starting up cost of generator type g	$
$totalFixedCosts$	Total fixed costs of operated generators during the day	
$fixedCost(g)$	Fixed cost of generator type g	$
$totalMarginalCosts$	Total marginal costs of operated generators during the day	$
$marginalCost(g)$	Marginal cost of generator type g	$

Variable/parameter	Description	Unit
$minimumPower(g)$	Minimum operating capacity of generator type g	MW
$maximumPower(g)$	Maximum operating capacity of generator type g	MW
$demand(t)$	Demand in time block t	MW
$duration(t)$	Duration of time block t	hours
$spinningReserve$	Spinning reserve requirement	%

Equation (1) states the objective function of the optimisation problem, which is to minimise the sum of start-up costs, fixed costs and marginal costs across all generators and time blocks. Equations (2), (3) and (4) define these costs. Equation (5) is a technical constraint that stipulates that the power generated over all operating generators in each time block satisfies the electricity demand for that block. Equation (6) is also a technical constraint that stipulates that the maximum power available across all operating generators in each time block satisfies the demand for that block as well as the spinning reserve capacity required for system safety. Equation (7) identifies started up generators in each time block whilst equations (8) and (9) constrain each operating generator type in each time block to produce within its technical upper and lower limits.

References

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