Scheduled maintenance

In a nutshell, maintenance scheduling has to decide which parts of the generating units or the transmission infrastructure to shut down during time windows with reduced energy demand at an acceptable failure risk so that profit losses/costs are minimal. In principle this requires to combine integer maintenance decisions with complex physical models on technical restrictions (ramping, power flow, etc.) as well as with stochastic models for the development of supply (e.g. due to wind and solar energy), demand and prices. Further restrictions include the necessary equipment and personnel. Because each single component is mathematically already a challenge, the main body of literature can be found in engineering journals while so far there is very limited coverage by mathematical journals.

In the past, solution techniques only considered a coarse discretization of the time horizon (weekly time steps) and the problem was decomposed into single production units (fossil fuel power plants, hydro-electric units,...). Stochastic aspects were considered at the unit level with scenario modeling for hydro inputs and marginal costs. For the optimization over a single unit Dynamic Programming is a simple and efficient approach.

Nowadays, models are using a finer discretization (daily time steps). Technical coupling constraints between the different production units are incorporated (for eg. limited ressources to perform certain operations). The main solution methods are local search heuristics, decomposition approaches (Bender's, Dantzig Wolfe and Lagrangean Relaxation) and occasional Mixed Integer Programming (MIP) or Model Predictive Control (MPC) models.

In practice MIP approaches require small time windows for the schedule of maintenance. Local search approaches are less restrictive but don't provide proofs of optimality. A flurry of approaches for this problem have been developed in the 2010 ROADEF Challenge. There is much room for future work in mathematical methodology. Stochastic models should cover aspects like demands, renewable productions, delays in maintenance operations and availability of power plants (failures, efficiency,...). A highly desirable aim is to achieve stability of the computed schedule with respect to small modifications in the input. In deregulated markets game theoretic aspects enter because an independent system operator must approve time windows in view of the proposals of several competitors.

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