Medium Term Maintenance

Mathematical models

Like any device or system, all electricity devices requires periodical maintenance. Maintenance in electricity systems is a source of large costs; in the EU the maintenance costs amount to between 4% and 8% of the total sales turnover. In vertically integrated systems the strategic maintenance of power plants' and network's components is performed in an integrated fashion by the monopolist, whereas in those market based, these problems are responsibility of the GenCos and of the Transmission System Operator (TSO) respectively.

The maintenance activities are indeed complex even to classify. For instance if we define ***Preventive Maintenance*** in an abstract way as a general process carried out at predetermined intervals or according to prescribed criteria and intended to reduce the probability of failure or the degradation of the functioning of an item, we can distinguish:

1. ***Scheduled maintenance***: Preventive maintenance carried out in accordance with an established time schedule or established number of units of use. The maintenance is planned in advance.
2. ***Condition based maintenance***: Preventive maintenance based on performance and/or parameter monitoring and the subsequent actions. An example of condition based maintenance is when condition monitoring systems (CMS) are used to control the condition of the component or system, and thereby preventive maintenance is possible to perform.
3. ***Opportunistic maintenance***: Opportunistic maintenance refers to the situation in which preventive maintenance is carried out at opportunities. A typical example is when one component is out for maintenance and it is decided to take out another component for maintenance before failure. Such a decision would be based on a rational decision, e.g. by saving cost by performing several maintenance activities at the same time.

Basically the medium term perspective coincides with one to three months ahead, and with this horizon in mind the *maintenance* refers to ***Conditi on based maintenance*** and most importantly to ***Opportunistic maintenance***. In details the main goal of the maintenance processes in electrical systems are identical to the long term but things are somehow easier to approach:

- Power plants medium term maintenance, e.g. determining a schedule of plant outages aiming at minimizing various costs. The outage schedule must satisfy several constraints in order to comply with limitations on resources which are necessary to perform refueling and maintenance operations. When speaking about power plants we - of course - refer to any kind of power plant including wind, solar and hydro units
- Transmission and Distribution network medium term maintenance, e.g. determining a schedule of branches, transformers and other devices outages. Also in this case these outages must satisfy several security constraints and opportunity costs.

The maintenance process here is simpler because we do respect the long term scheduled issues and we just adjust mainly for opportunistic mainentances, these are usually based on statistic evidence. Some more optimization oriented approach has been proposed also for the short term in coordination with the long term, see e.g. [1].

Related to Prognisis/Condition Assessment is the optimizatin problem of finding the best replace/repair/maintain decisions for each individual pieces of equipment. This can be embedded in a wide planning context: possible change in demand/generation patterns affects decisions on whether to replace/upgrage equipment or maintain the existing equipement. There may be a lot of uncertainly about the state of old equipment (e. g it may not be known how often a transformer has been overloaded) so the problem is stochastic. If this is to be decomposed into decisions about individual bits of equipment then what is needed is an estimate of the cost to the whole electricity system of removing the equipment for maintenance or replacement and the cost of unexpected breakdown. In a decentralied system these cost for planned and unplanned unavailabily need to be built in to contracts.

References:

[1] M.K.C. Marwali and S.M. Shahidehpour. Coordination between long-term and short-term generation scheduling with network constraints. IEEE Transactions on Power Systems, 15(3):11611167, 2000.

Contributors:

Dr David Flynn, Heriot-Watt

Prof. Ken McKinnon, University of Edinburgh