

# Strategic 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 long term perspective coincides with a year frequency, and with this horizon in mind the *maintenance* refers to *sheduled maintenance*. In details the main goal of the maintenance processes in electrical systems are:

- Power plants long 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 long 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.

## General purpose solvers

### References:

1. F. Brandt, "Solving a Large-Scale Energy Management Problem with Varied Constraints", Diploma Thesis At the Department of Informatics Institute of Theoretical Informatics.
2. Adam Wojciechowski, "On the optimization of opportunistic maintenance activities", Department of Mathematical Sciences, Chalmers University of Technology Department of Mathematical Sciences, University of Gothenburg SE-412 96 Göteborg, Sweden 2010.
3. Salvador Perez Canto, "Using 0/1 mixed integer linear programming to solve a reliability-centered problem of power plant preventive maintenance scheduling", Optimization and Engineering September 2011, Volume 12, Issue 3, pp 333-347
4. Lobato, E. Sanchez-Martin, P. Saiz-Marin, E., "Long Term Maintenance Optimization of CCGT Plants", Power and Energy Engineering Conference (APPEEC), 2012 Asia-Pacific, 27-29 March 2012, pp 1-4.
5. Aurélien Froger, Michel Gendreau, Jorge E. Mendoza, Eric Pinson, Louis Martin Rousseau, "Maintenance Scheduling in the Electricity Industry: A Literature Review", CIRRELT 2014 n. 53, October 2014.
6. K. Dahal, K. Al-Arfa j, and K. Paudyal. Modelling generator maintenance scheduling costs in deregulated power markets. European Journal of Operational Research, 240(2):551561, 2015.
7. X. Xu and M. Kezunovic. Mobile agent software applied in maintenance scheduling. In Proc. 2001 North American Power Symposium, 2001

### Contributor:

Dr Fabrizio Lacalandra, QuanTek