APPENDIX III – Description of Monte Carlo Methodology to Model Random Forced Outages

FSSTF

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Monte Carlo for Random Forced Outages

- For each thermal unit (and hydro units), it is assumed that there are two states:
  - On (unit is online producing its maximum output)
  - Off (unit is offline, on a forced outage, producing zero output)
- The time a unit spends in either of the above two states is assumed to be a random variable with an exponential distribution (this is a standard reliability assumption). The cumulative density function (CDF) of the exponential distribution is

$$F(x) = 1 - e^{\frac{-x}{\alpha}}$$

where α is the mean of the distribution (i.e., the mean time a unit is online or the mean time a unit is offline)

Monte Carlo for Random Forced Outages

- The mean time a unit is online (or mean time to failure) and the mean time a unit is offline (or mean time to repair) can be estimated from the GADS data.
- If a random number R is drawn, then the time-in-state, T, can be computed using the CDF of the exponential distribution

$$T = -\ln(R) * \alpha$$

- For instance, for a given unit the mean time to failure is 1,111 hours while the mean time to repair is 84 hours
- Let's assume that in the first replication of the Monte Carlo, the unit starts online

Monte Carlo for Random Forced Outages

- To determine for how long the unit is online, we draw a random number R. Let's assume the first random number is 0.59. Therefore,

$$T_1 = -\ln(0.59) * 1{,}111 = 586.2\ hrs$$

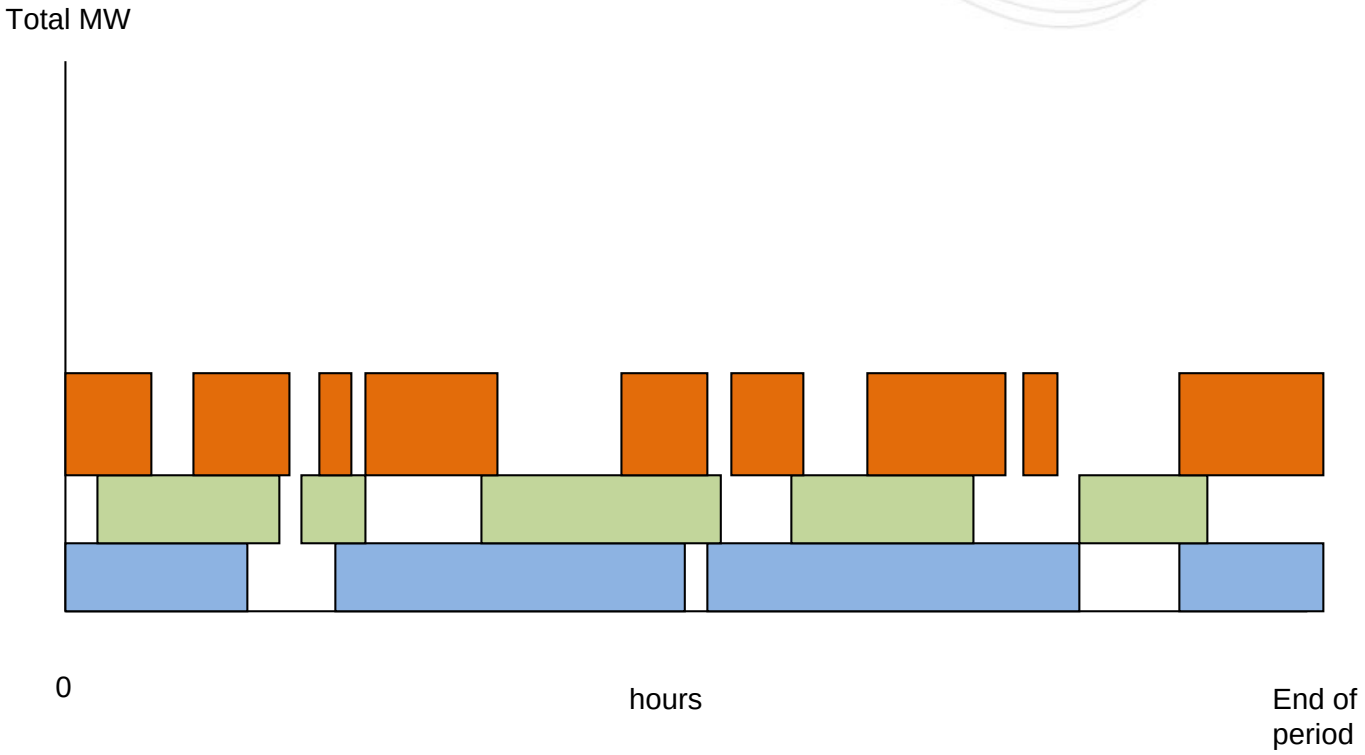
- When the simulation clock hits 586.2 hrs, the unit transitions to the offline state. To determine for how long the unit is offline, we use a second random number, say 0.43. Therefore,

$$T_2 = -\ln(0.43) * 84 = 70.9\ hrs$$

- After the forced outage, the simulation clock hits 586.2 + 70.9 = 657.1 hrs. At this time, the unit transitions to the online state and a new random number is generated. This sequence is repeated until reaching the end of the simulation period.

Monte Carlo for Random Forced Outages

- Graphically



In this graph, only 3 units are considered (each one represented by a different color)
Each colored block represents the time a unit is online whereas the white spaces in between represent the time a unit is offline (on a forced outage).
More units can be stacked up in the plot.
A plot such as this one is useful to determine the total amount of capacity available at each hour of the period studied.

This plot represents 1 simulation run.
In the analysis, a total of 1,000 simulations are run.
The random numbers generated by the program change between runs.
Thus, each simulation is likely to result in a different graph.