Capacity Planning in Energy Networks by Probabilistic Programming

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Abstract

We consider an energy network consisting of a certain number of nodes and a pre-defined set of transmission lines (arcs) connecting these nodes. The power demand in each node is assumed to be stochastic and following a multivariate normal or truncated normal distribution. We are looking for cost minimal generation and transmission capcities such that the demand in the whole network is satisfied at a given probability level (e.g., $p = 0.99$). This leads to an optimization problem with joint probabilistic constraints of polyhedral type.

Thus the solution of the optimization problem requires the computation of function values and gradients of corresponding probability functions. We will present a new gradient formula which may be viewed as an extension of a well-known result for regular normal distributions. This formula allows to reduce the computation of gradients to the computation of function values again in lower dimensions. Consequently the same methods can be used to compute function values and gradients. In addition the relative error of the computed gradients is the same as the absolute error of the function values.

Numerical results for an example will be presented and compared with deterministic (expected value) solutions.