Discussion

Hugh Rudnick & Rodrigo Palma (Universidad Católica de Chile, Santiago, Chile). The transmission network planning is a subject of growing importance in the deregulated electric sector environment where many countries are operating. Competing generators interested in the transmission capacity to access their customers are also concerned that the network expands in such a way that their share of the total cost is minimized. Whether a central regulator or a monopoly transmission company determine network planning or it is resolved through market oriented mechanisms, the need is for tools to optimally and dynamically tackle the problem. The authors contribute with techniques to solve the static network problem. We would be interested in learning how they have modeled and managed the following problems.

- Investment alternatives. For each candidate transmission path there could be different investment alternatives to consider (voltage levels, number of circuits, transmission towers, etc.), each with a different cost, increasing the size of the problem. How is it handled in your algorithm?

- Logical constraints at the bus level. A decision to use a higher voltage transmission line may imply the inclusion of transformers at its ends, depending on the decisions made in other lines connected to the same buses. Is it not merely a radial problem, but meshed interactions appear. The substations and transmission line investment decisions intermingle at the bus level. How do you manage this problem?

- Operations in a predominantly hydro generation system. The transmission network usage may vary considerably in a system where water availability drastically changes patterns of hydro generation. The need is there to simulate different operating scenarios for each year, either in a stochastic manner or through the use of typical hydrological conditions. Which alternative do you use?

- Security and reliability considerations. Requirements for security (n-1 criteria) and reliability of the transmission system need to be modeled in any network planning effort. How have you included them in the operational and investment subproblems?

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G. C. Oliveira, A. P. C. Costa and S. Binato: The authors thank Mr. Rudnick and Mr. Palma for their comments. Investment alternatives are considered as distinct binary decision variables, each one of them corresponding to an equipment (line or transformer), for each voltage level, with its associated cost and maximum number of possible additions. In case of a circuit candidate on right-of-way (i,j) with $n_{ij} > 1$ possible additions, $x_{ij}$ is written as the sum of $n_{ij}$ binary variables $x_{ij}^k$, and a linear constraint of the form “sum of these variables is less or equal to one” is imposed to the investment subproblem. By this scheme, we avoid having to explicitly deal with more binary variables during the solution, since at most one of these variables will be nonzero, expressing the number of circuits added on each candidate right-of-way. For each such right-of-way, the cost coefficients are given by $c_{ij} = k_i c_j$.

Regarding the question concerning logical constraints, they are built independently of the order in which they can be added and also of the “meshed interactions”, and only when possible. For the Brazilian case study, one can introduce for example the following linear constraint which enforces that when adding the 248-247 transformer, either the 248-251 or 248-250 or the 248-211 lines should also be added:

$x_{248-247} \leq x_{248-251} + x_{248-250} + x_{248-211}$

For each of these lines, another linear constraint can be enforced: for example, we can write:

$x_{248-251} \leq x_{248-248} + x_{250-248} + x_{211-248}$

For many circuits-in-series situations, take for example lines 210-60, 60-54 and 54-53. In order to enforce the all must be added simultaneously (if ever), the following linear constraints are required:

$2 \ x_{210-60} \leq x_{54-60} + x_{53-54}$

$2 \ x_{54-60} \leq x_{310-60} + x_{53-54}$

$2 \ x_{53-54} \leq x_{54-60} + x_{210-60}$

Presently, we have not yet considered different operating scenarios. The extension of the decomposition approach to stochastic optimization is straightforward, and has been applied to other expansion problems such as interconnected power systems capacity planning [1]. The operating subproblem becomes a linear stochastic optimization problem, which should provide to the investment subproblem the reliability of the given trial expansion plan and also the Benders cuts. Different operating scenarios can be considered in the operation subproblem, by using typical hydrological conditions.

Finally, security constraints can also be incorporated by applying a security constrained linear dispatch formulation to the operation subproblem [2]. Again, the decomposition approach can be used to solve the operation subproblem as shown in reference [2], at the expense of increasing the computational effort.

References


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