Risk management for electricity transmission and generation capacity expansion planning

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A set of inter-related mathematical mixed integer optimization models under uncertainty to help the decision making on one of the great and difficult problems in the energy area that European Union is facing today. It consists of the estimation of the timing for clean power generation technologies and electricity free transmission expansion network at a Pan-European level in a long term (e.g., 30-years time horizon). A vast amounts of new generation plants/farms are expected to be built in the medium term future. A substantial part of this new Renewable Energy Sources (RES) generation could probably must be decided in the near future. Mathematical models and algorithms for problem solving to address the environmental challenges under high uncertainty in the main parameters along a large time horizon are essential computerized tools for helping in the decision making on the following items: feasible type and mix of power generation sources, timing for power generation plant/farm site location and dimensions, and timing for location and capacity of new lines in the transmission network. So, the solution should satisfy the electricity demand from main focal points in the European region and optimizing different types of utility criteria at Pan-European level. In an open energy market, the electricity GenCos have a high freedom for organizing and timing the required energy mix to satisfy the EC and National environmental directives while pursuing their own agendas. So, the Pan-European TSOs have no choice but being pro-active (better in a coordinating manner), so, anticipating the transmission network infrastructure strategic decisions on location, quality and timing of the new transmission lines, and expecting that the GenCos will follow. The main characteristics of the models are as follows: First, a framework is introduced for representing the uncertainty in a multistage non-symmetric tree with strategic nodes in the stages (being related to their first periods), and tactical multiperiod scenario graphs up to a modeler-driven stage and tactical scenario two-stage trees along the periods (semesters, years, bi-years, ...), where both structures are rooted with the strategic nodes. Second, the nodes in the tactical scenario trees are so-named tactical ones and, so, the investment on electricity transmission + power generation capacity is assumed to be made at the strategic nodes and the running of the joint electricity transmission + production system for each type of hour in the related periods is made at the tactical nodes. Third, the goal consists of minimizing the PV of the expected investment costs plus operation costs (transmission + production) plus VOLL penalization in the global model, where the strategic and tactical submodels are run interconnected by the so-named linking variables. And, forth, a time stochastic dominance risk averse measure is considered for reducing the risk of negative impact of the proposed solution on low-probability high-profit deteriorated scenarios.