Chapter 1 : Data Viewer - Intermediate Termed Security Constrained Economic Dispatch LMP

1 Security Constrained Economic Dispatch: A Markov Decision Process Approach with Embedded Stochastic Programming Lizhi Wang is an assistant professor in Industrial and Manufacturing Systems Engineering at Iowa State University.

Transmission line failures constitute a great threat to the electric power system security. We use a Markov decision process MDP approach to model the sequential dispatch decision making process where demand level and transmission line availability change from hour to hour. The action space is defined by the electricity network constraints. Risk of the power system is the loss of transmission lines, which could cause involuntary load shedding or cascading failures. The objective of the model is to minimize the expected long-term discounted cost including generation, load shedding, and cascading failure costs. Policy iteration can be used to solve this model. At the policy improvement step, a stochastic mixed integer linear program is solved to obtain the optimal action. We use a PJM network example to demonstrate the effectiveness of our approach. Article Preview 1 Introduction In a pool-based electricity market, security constrained economic dispatch is the process of allocating generation and transmission resources to serve the system load with low cost and high reliability. The goals of cost efficiency and reliability, however, are oftentimes conflicting. On the one hand, in order to serve the demand most cost efficiently, the capacities of transmission lines and the cheapest generators should be fully utilized. On the other hand, the consideration of reliability would suggest using local generators, which may not be the cheapest but are less dependent on the reliability of transmission lines; a considerable amount of generation and transmission capacities should also be reserved for contingency use. A tradeoff between low cost and high reliability is thus inevitable. Various stochastic criteria have also been proposed. This paper presents another stochastic approach to security constrained economic dispatch, which is able to study some important issues that have not been adequately addressed in the existing literature. First, cascading failures are taken into consideration. Although a rare event, the impact of a cascading failure could be tremendous. The North American blackout, for example, affected 50 million customers and cost billions of dollars Apt et al. A great amount of research has been conducted on modeling, monitoring, and managing the risk of cascading failures see e. We adopt the hidden failure model Chen et al. The advantage of an infinite planning horizon is that the future economic cost of a potential contingency is not underestimated when compared with the immediate reward of taking that risk. Third, the optimal policy from the MDP model provides the optimal dispatch not only for the normal scenario but also for all contingency scenarios. The solution for the normal scenario is the optimal pre-contingency preventive dispatch, whereas the solution for contingency scenarios yields the optimal post-contingency corrective dispatch. Their model has a finite time horizon and transmission constraints are not taken into consideration.

Chapter 2 : Electricity market - Wikipedia

Security constrained economic dispatch is an optimization process that takes account of these factors in selecting the generating units to dispatch to deliver a reliable supply of electricity at the lowest cost possible under given conditions.

History[edit] One early introduction of energy market concepts and privatization to electric power systems took place in Chile in the early s, in parallel with other market-oriented reforms associated with the Chicago Boys. The Chilean model was generally perceived as successful in bringing rationality and transparency to power pricing. Argentina improved on the Chilean model by imposing strict limits on market concentration and by improving the structure of payments to units held in reserve to assure system reliability. One of the principal purposes of the introduction of market concepts in Argentina was to privatize existing generation assets which had fallen into disrepair under the government-owned monopoly, resulting in frequent service interruptions and to attract capital needed for rehabilitation of those assets and for system expansion. The World Bank was active in introducing a variety of hybrid markets in other Latin American nations, including Peru, Brazil, and Colombia, during the s, with limited success. Tabors, and Roger E. Bohn published a book entitled, "Spot Pricing of Electricity. The locational marginal prices then emerged as the shadow prices for relaxing the load limit at each location. A key event for electricity markets occurred in when the UK government under Margaret Thatcher privatised the UK electricity supply industry. The process followed by the British was then used as a model or at least a catalyst for the restructuring of several other Commonwealth countries, notably the National Electricity Markets of Australia and New Zealand and the Alberta Electricity Market in Canada. In the United States the traditional vertically integrated electric utility model with a transmission system designed to serve its own customers worked extremely well for decades. As dependence on a reliable supply of electricity grew and electricity was transported over increasingly greater distances, wide area synchronous grid interconnections developed. Transactions were relatively few and generally scheduled well in advance. However, in the last decade of the 20th century, some US policy makers and academics asserted that the electric power industry would ultimately experience deregulation and independent system operators ISOs and regional transmission organizations RTOs were established. They were conceived as the way to handle the vastly increased number of transactions that take place in a competitive environment. About a dozen states decided to deregulate but some pulled back following the California electricity crisis of and In different deregulation processes the institutions and market designs were often very different but many of the underlying concepts were the same. The role of the wholesale market is to allow trading between generators, retailers and other financial intermediaries both for short-term delivery of electricity see spot price and for future delivery periods see forward price. Some states exempt non investor-owned utilities from some aspects of deregulation such as customer choice of supplier. For example, some of the New England states exempt municipal lighting plants from several aspects of deregulation and these municipal utilities do not have to allow customers to purchase from competitive suppliers. Municipal utilities in these states can also opt to function as vertically-integrated utilities and operate generation assets both inside and outside of their service area to supply their utility customers as well as sell output to the market. Nature of the market[edit] Electricity is by its nature difficult to store and has to be available on demand. Consequently, unlike other products, it is not possible, under normal operating conditions, to keep it in stock, ration it or have customers queue for it. Furthermore, demand and supply vary continuously. There is therefore a physical requirement for a controlling agency, the transmission system operator , to coordinate the dispatch of generating units to meet the expected demand of the system across the transmission grid. If there is a mismatch between supply and demand the generators speed up or slow down causing the system frequency either 50 or 60 hertz to increase or decrease. If the frequency falls outside a predetermined range the system operator will act to add or remove either generation or load. The proportion of electricity lost in transmission and the level of congestion on any particular branch of the network will influence the economic dispatch of the generation units. Markets may extend beyond national boundaries. Please update this article to reflect recent events or newly available information. March A wholesale electricity market exists when competing generators offer their electricity output to retailers. The retailers then re-price the electricity and take it to market. While wholesale pricing used to be the exclusive domain of large retail suppliers, increasingly markets like New England are beginning to open up to end-users. Large end-users seeking to cut out unnecessary overhead in their energy costs are beginning to recognize the advantages inherent in such a purchasing move. Consumers buying electricity directly from generators is a relatively recent phenomenon. For an economically efficient electricity wholesale market to flourish it is essential that a number of criteria are met, namely the existence of a coordinated spot market that has "bid-based, security-constrained, economic dispatch with nodal prices". The theoretical prices of electricity at each node on the network is a calculated " shadow price ", in which it is assumed that one additional kilowatt-hour is demanded at the node in question, and the hypothetical incremental cost to the system that would result from the optimized redispatch of available units establishes the hypothetical production cost of the hypothetical kilowatt-hour. In practice, the LMP algorithm described above is run, incorporating a security-constrained, least-cost dispatch calculation see below with supply based on the generators that submitted offers in the day-ahead market, and demand based on bids from load-serving entities draining supplies at the nodes in question. While in theory the LMP concepts are useful and not evidently subject to manipulation, in practice system operators have substantial discretion over LMP results through the ability to classify units as running in "out-of-merit dispatch", which are thereby excluded from the LMP calculation. In most systems, units that are dispatched to provide reactive power to support transmission grids are declared to be "out-of-merit" even though these are typically the same units that are located in constrained areas and would otherwise result in scarcity signals. System operators also normally bring units online to hold as "spinning-reserve" to protect against sudden outages or unexpectedly rapid ramps in demand, and declare them "out-of-merit". The result is often a substantial reduction in clearing price at a time when increasing demand would otherwise result in escalating prices. Researchers have noted that a variety of factors, including energy price caps set well below the putative scarcity value of energy, the effect of "out-of-merit" dispatch, the use of techniques such as voltage reductions during scarcity periods with no corresponding scarcity price signal , etc. The consequence is that prices paid to suppliers in the "market" are substantially below the levels required to stimulate new entry. The markets have therefore been useful in bringing efficiencies to short-term system operations and dispatch, but have been a failure in what was advertised as a principal benefit: In LMP markets, where constraints exist on a transmission network, there is a need for more expensive generation to be dispatched on the downstream side of the constraint. Prices on either side of the constraint separate giving rise to congestion pricing and constraint rentals. A constraint can be caused when a particular branch of a network reaches its thermal limit or when a potential overload will occur due to a contingent event e. The latter is referred to as a security constraint. Transmission systems are operated to allow for continuity of supply even if a contingent event, like the loss of a line, were to occur. This is known as a security constrained system. Some systems take marginal losses into account. The prices in the real-time market are determined by the LMP algorithm described above, balancing supply from available units. This process is carried out for each 5-minute, half-hour or hour depending on the market interval at each node on the transmission grid. The hypothetical redispatch calculation that determines the LMP must respect security constraints and the redispatch calculation must leave sufficient margin to maintain system stability in the event of an unplanned outage anywhere on the system. This results in a spot market with "bid-based, security-constrained, economic dispatch with nodal prices". Since the introduction of the market, New Zealand has experienced shortages in and , high prices all through and even higher prices and the risk of a severe shortage in as of April These problems arose because New Zealand is at risk from drought due to its high proportion of electricity generated from hydro.