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Transmission System Reliability Planning

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ABSTRACT: In the past, electrical transmission systems were continuously adding more facilities to their subsystems in order to satisfy the growing customer energy requirements. A utility industry traditionally has relied on a set of deterministic criteria to guide transmission planning. The traditional planning guidelines were based on planner's experience and intuition without a formal and consistent framework for their development. This paper identifies some of the limitations of traditional utility transmission system planning criteria and the possible implications for industrial and commercial customers. This paper presents review and development of transmission system reliability planning criteria based on various research performed by many researchers and scientists and on various historical equipment performance data.

KEYWORDS: Transmission system, reliability, planning, utilities.

INTRODUCTION

The Department's research into a variety of tools that will improve advanced system monitoring, visualization, control, operations, and market structure will ultimately modernize the electricity transmission infrastructure to ease congestion, allow for increases in demand, and provide a greater degree of security. The next generation supervisory control and data acquisition (SCADA) and energy management system (EMS) are being developed. These systems will enable grid operators to react swiftly before a local disturbance can cascade into a larger problem. The systems include the following advances: sensors for measuring system conditions; electric power equipment such as transformers and fault current limiters that regulate power flow; computerized monitoring equipment that enables system operators to "see" the grid in real time and make necessary adjustments; and market mechanisms that promote efficiency and reliability and control systems to protect energy infrastructure. These tools used in concert will increase the safety, reliability and security of the nation's electricity grid. Growing market and an emerging energy competition make the Client becomes more demanding. A power network is mostly reactive. A synchronous generator usually generates active power that is specified by the mechanical power input. The reactive power supplied by the generator is dictated by the network and load requirements. A generator usually does not have any control over it. However the lack of reactive power can cause voltage collapse in a system. It is therefore important to supply/absorb excess reactive power to/from the network. Shunt compensation is one possible approach of providing reactive power support. Requirements for power quality are becoming an important element in contracts for the supply. Regardless of classical solutions, installation of systems improving the quality of energy directly at the Client, energy distributors begin to assemble the reactive power compensation systems in switching substations. Requirements for power quality are becoming an important element in contracts for the supply of energy. This creates a very attractive, but also very demanding market sector. Series capacitors are an economical method of reducing the reactance of high and extra high voltage lines. They produce an improvement in static and dynamic stability, a reduction in voltage drop, and an increase in power transfer capacity. The area of reactive power compensation is gaining increasing importance worldwide. If suitably designed, it is capable of improving voltage quality significantly, meaning that losses in equipment and power systems are reduced, the permissible loading of equipment can be increased, and the over-all stability of system operation improved. Ultimately, energy use and CO_2 emission are reduced. They also provide wide range of automatic capacitor banks with harmonic filters. These equipments are supplied completely assembled and are ready for use. It is only necessary to connect it to the mains with cable of adequate cross section, and to supply the operation signal from a suitable current transformer [1].

PRINCIPLES OF TRANSMISSION PLANNING

In Order 890, the FERC defined nine transmission planning principles whose proper implementation through specific planning procedures and activities would, it concluded, eliminate opportunities for continued discrimination. It defined these principles as follows [3]:

(i) **Coordination:** This principle requires that transmission providers must meet with all of their transmission customers and interconnected neighbors to develop a transmission plan, but without prescribing how often such meetings are to occur, except to note that "customers must be included at the early stages of the development of the transmission plan and not merely given an opportunity to comment on transmission plans that were developed in the first instance without their input," nor to prescribe substantive content, scope, and other features of such plans. However, the FERC clarified that stakeholders are not "co-equals" in the transmission planning process and specifically held that transmission providers are not required to construct transmission proposed by stakeholders. The FERC explained that this principle is intended to "eliminate the potential for undue discrimination in planning by opening appropriate lines of communication between transmission providers, their transmission-providing neighbors, affected state authorities, customers, and other stakeholders."

(ii) **Openness:** This principle requires that "transmission planning meetings be open to all affected parties" except as it may be appropriate where limited subjects are addressed to limit participation to those interested in such subjects and to protect proprietary and confidential data through appropriate confidentiality agreements and other means.

(iii) **Transparency:** This principle requires that transmission providers be required "to disclose to all customers and other stakeholders the basic criteria, assumptions, and data that underlie their transmission system plans" including "the basic methodology, criteria, and processes they use to develop their transmission plans." The FERC explained that information disclosed should be sufficient to permit non-transmission provider stakeholders to "replicate the results of planning studies and thereby reduce the incidence of after-the-fact disputes regarding whether planning has been conducted in an unduly discriminatory fashion."

(iv) **Information Exchange:** This principle requires that transmission customers be given the opportunity to "submit information on their projected loads and resources on a comparable basis as used by transmission providers in planning for their native load." Transmission providers are to develop guidelines and a schedule for submitting this information.

(v) **Comparability:** The FERC requires that each transmission provider "develop a transmission system plan that (1) meets the specific service requests of its transmission customers and (2) otherwise treats similarly-situated customers (e.g., network and retail native load) comparably in transmission system planning." Comparability further requires that "where demand resources are capable of providing the functions assessed in a transmission planning process", "they should be permitted to participate in that process on a comparable basis."

(vi) **Dispute Resolution:** The FERC requires that such a process be provided, noting that its purpose is to provide a means for parties to address substantive and procedural disputes respecting transmission planning without involving the FERC, but further noted that such disputes could be brought before it through an FPA Section 206 complaint.

(vii) **Regional Participation:** This principle requires that each transmission provider is required to coordinate with interconnected systems to: "(1) share system plans to ensure that they are simultaneously feasible and otherwise use consistent assumptions and data and (2) identify system enhancements that could relieve [„significant and recurring" transmission] congestion". The FERC noted approvingly that a number of regional planning efforts were already underway.

(viii) **Economic Planning Studies**: Stating that "planning involves both reliability and economic considerations", the FERC directed that transmission providers are to conduct, at the request of customers or other stakeholders, a

specified number of studies each year which examine the economic desirability of system "upgrades or other investments that could reduce congestion or integrate new resources and loads." Study costs are to be recovered as a ratepayer cost-of-service expense, and additional studies may be requested at the cost of the requestor.

(ix) **Cost Allocation of New Projects:** Explaining that transmission providers and customers cannot be expected to support the construction of new transmission unless the entities responsible for costs are reasonably well identified and support the projects, the FERC added this principle to its initial NOPR proposal. It further noted that the new process would not alter existing, approved cost allocation mechanisms, but would apply only to projects not covered by those mechanisms. It also declined to provide specific guidance on what allocations should be adopted, but rather stated that fairness, acceptance by those affected and the provision of adequate incentives to project development should govern choice of allocation method [2].

TRANSMISSION RELIABILITY TERMINOLOGIES

The terminology below provides definitions of general terms related to NERC and the bulk power system. The Glossary of Terms Used in Reliability Standards offers a more detailed list of definitions, for terminology related to NERC's Standards program and the development of reliability standards [2,3].

Transmission – The transportation of electricity over high-voltage lines and equipment, from generating facilities or other transmission facilities, to a point where it is transformed into voltages usable by customers, and distributed to customers.

Transmission Operator – The person responsible for the operation of the transmission facilities in his or her Transmission Operator Area.

Transmission Planner – One of the regional functions contributing to to the reliable planning and operation of the bulk power system. Transmission Planners are responsible for planning a reliably interconnected bulk power system.

Adequacy – Having sufficient resources to provide customers with a continuous supply of electricity at the proper voltage and frequency, virtually all of the time. "Resources" refers to a combination of electricity generating and transmission facilities, which produce and deliver electricity; and "demand-response" programs, which reduce customer demand for electricity.

Balancing Authority – One of the regional functions contributing to the reliable planning and operation of the bulk power system. The Balancing Authority integrates resource plans ahead of time, and maintains in real time the balance of electricity resources and electricity demand.

Bulk power system – The part of the overall electricity system that includes the generation of electricity and the transmission of electricity over high-voltage transmission lines to distribution companies. This includes power generation facilities, transmission lines, interconnections between neighboring transmission systems, and associated equipment. It does not include the local distribution of the electricity to homes and businesses.

Compliance – The act of adhering to NERC Reliability Standards.

Demand – The amount of electricity required at any given time to meet customer needs.

Demand response – "Changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized." (Definition from U.S. Dept. of Energy).

Demand-side management (DSM) – Programs that encourage customers to use less electricity, or to use it at different times of day, or to allow system operators to interrupt their electricity supply during peak demand times.

Distribution – The local delivery of electricity to customers.

Electricity Reliability Organization (ERO) – The generic name used in the U.S. Energy Policy Act of 2005 to refer to the independent entity that would be given the authority to develop and enforce mandatory reliability standards for the North American bulk power system. NERC was designated as this "electricity reliability organization" by FERC on July 20, 2006. "ERO" refers to NERC's role, but "ERO" is not an official name.

Generating facility – Power plants or other facilities where electricity is produced.

Generation – The process of creating electric energy by transforming other forms of energy into electricity.

Grid – The network of interconnected electricity lines that transport electricity from power plants and other generating facilities to local distribution areas.

Independent System Operator (ISO) – An independent entity that coordinates regional transmission in a manner that is non-discriminatory against any transmission owners, operators or users, and ensures a safe and reliable electric system. Regulated by the US and Canadian governments. The ISO/RTO Council.

Interconnection – (a) A common transmission line connecting two or more electric systems. Interconnections allow electricity to flow between the two systems, and facilitate the sale of electricity between the two regions served by the systems. (b) The synchronized grids in North America: the Eastern Interconnection, Western Interconnection, ERCOT, and Quebec Interconnection.

Penalty – A monetary fine or other action given to a bulk power system user, owner or operator that violated a NERC Reliability Standard.

Planning Coordinator – One of the regional functions that contributes to the reliable planning and operation of the bulk power system. Planning Coordinators are responsible for regional planning including assessing the longer-term reliability of the bulk power system, in coordination with other regions.

Regional Entity – The term 'regional entity' means an entity having enforcement authority pursuant to subsection. A regional entity (RE) is an entity to which NERC has delegated enforcement authority through an agreement approved by FERC. There are eight RE's. The regional entities were formed by the eight North American regional reliability organizations to receive delegated authority and to carry out compliance monitoring and enforcement activities. The regional entities monitor compliance with the standards and impose enforcement actions when violations are identified.

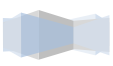
Reliability – In the context of the bulk power system, NERC defines reliability as the ability to meet the electricity needs of end-use customers, even when unexpected equipment failures or other factors reduce the amount of available electricity. NERC breaks down reliability into adequacy and security.

Reliability Coordinator – One of the regional functions contributing to the reliable operation of the bulk power system. The Reliability Coordinator is responsible for the real-time operating reliability of its Reliability Coordinator Area, and coordinates closely with neighboring areas. It has the authority to prevent or mitigate emergency operating situations in real-time and in next-day analysis. All balancing authorities and transmission operators must be within the purview of a reliability coordinator.

Resource Planner – One of the regional functions contributing to the reliable planning and operation of the bulk power system. Resource Planners are responsible for ensuring adequate resources to meet the load in its area.

Security – The ability of the bulk power system to withstand sudden, unexpected disturbances such as short circuits, or unanticipated loss of system elements due to natural or man-made causes.

Self-regulatory or self-regulated – The designation given to a non-governmental entity to which the government has delegated some powers. In NERC's case, United States governmental agencies have delegated to NERC the authority to



implement, and enforce compliance with, Reliability Standards. Although both U.S. and Canadian governmental entities have the power of review and audit of NERC, NERC and the industry have the freedom to write its own rules and standards. This approach allows for greater involvement by those entities directly involved in the operation of the bulk power system, who have detailed knowledge of the industry's operational and technical needs if it is to serve customers as reliably as possible [4].

System operator – System operators are the "airplane pilots of the electricity grids," working at various industry control centers. They monitor and control the electricity network in real time, to maintain its integrity and regulate generating supplies to keep them balanced with customer demand. Balancing authorities, transmission operators, generator operators, and reliability coordinators are all considered system operators.

Violation – The failure to comply, or comply fully, with a NERC Reliability Standard.

Watch List – A list of concerns that might impact negatively on electricity reliability, identified through a NERC Reliability Assessment. The concern might relate to an individual entity or a region [5].

TRANSMISSION PLANNING RELIABILITY CRITERIA

The Alberta Transmission System (ATS) will be planned to meet the Western Electricity Coordinating Council (WECC) Reliability Criteria and more specifically the NERC/WECC Planning Standards contained therein. Specific WECC guides and AESO standards also apply to planning the ATS. The WECC's planning reliability criteria is titled the NERC/WECC Planning Standards as they are the NERC Planning Standards with additional requirements specific to the WECC. Many of the additional requirements result from the long distances between generation and load centers in the WECC as compared with other NERC regions.

The NERC Planning Standards apply to internal systems, while the WECC extensions to the NERC Planning Standards are only applied to external systems by the WECC unless otherwise stated either in the NERC/WECC Reliability Standards or herein.

The goal of the NERC/WECC Planning Standards is to ensure that there is an adequate transmission system where adequate is defined as "The ability of the electric systems to supply the aggregate electrical demand and energy requirements of their customers at all times, taking into account scheduled and reasonably expected unscheduled outages of system elements" [6].

CONCLUSIONS

This paper presents review and development of transmission system reliability planning based on various research performed by many researchers and scientists and on various historical equipment performance data. The principal objective of the paper was to investigate how a number of high-level reliability enhancement strategies can be utilized to promote more dependable applications in the electrical power transmission system.

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