Electricity Liberalization and Reliability Assurance

- The Japanese and U.S. Approaches through the Transitional Periods –

Kenichi Wada
Researcher, Electric Power & Gas Industry Group
The Institute of Energy Economics, Japan

1. Introduction

Japan as well as the USA or Europe has made progress on market reform in the electricity sector. Emergence of diverse players and expansion of power trade regions were brought about by this reform. In Europe and the USA, unbundling of generation and transmission/distribution sectors has progressed, thereby intensifying electricity trading that interconnects across regions or countries. In Japan, while the system of vertically integrated operation by existing power utilities is being maintained, new players such as Independent Power Producers (IPPs) or Power Producers and Suppliers (PPSs) have entered the market. Depending upon the extent of market share and other influences by these new entrants, assurance of reliability for power supply may require different approaches than in the past.

The major power outages experienced in the northeastern regions of North America and in Italy in 2003 prompted deeper examinations into how the liberalization and assurance of reliability could be implemented in a balanced way. In order to form a reliable electricity market, it is imperative that adequate rules and institutions be established. In particular, for the complex and diversified market structure in today's systems, it will become necessary to clearly define responsibility and authority for each business entity and to operate an integrated system wherein all of the power grid system users are participating and cooperating.

This paper attempts to review the past developments in electricity liberalization both in Japan and the USA, while analyzing in detail the approaches taken by North American Electric Reliability Council (NERC) toward assuring reliability to help extract policy agendas for Japan and identify future directions.

2. Balancing Electricity Liberalization and Reliability

2.1 Progress of Market Liberalization

In the traditional architecture of the power sector, electric power companies forecast demand, develop long-term supply plans, and build up generation and network facilities based on their plan. The recovery of investments required for the construction of the facilities had been ensured in an all-inclusive costing principle, and electric power companies would assure reliability of power supply by carrying out the entire range of demand forecast, development of generation/network facilities, and operation of power grids in an integrated manner.

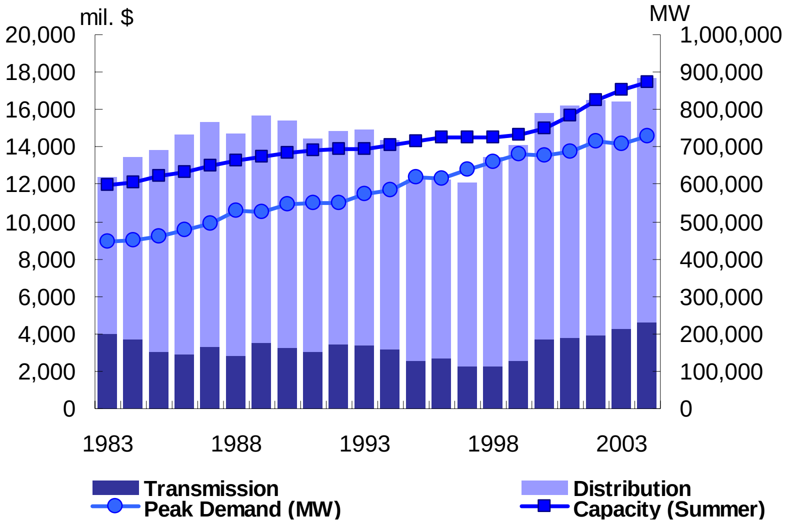
As the market liberalization progresses, however, such an integrated operation has become difficult to maintain, giving rise to growing concerns over assurance of the power system reliability particularly in Europe and the USA. There are three main causes for such concerns. One is an issue of inter-organizational coordination. Events such as unbundling of generation and transmission/distribution sectors as well as emergence of new entrants such as IPPs or PPSs have made coordination necessary among various organizations. Moreover, trading across control areas has raised the importance of cooperation and information exchange among system operators. Secondly, a tendency has arisen where the system reserve capacity fluctuates. Whether it is for power generation or transmission, redundancy allows for a margin in operations. As the principles of market competition work properly, however, excess capacity tends to be curtailed in pursuit of business efficiency. This has made it difficult to develop facilities with a long-term point of view, leading to a reduction in the reserve capacity. Finally, it has become difficult to estimate power flows. This problem is particularly prominent in Europe and the USA where transmission grids are looped or meshed. The foregoing factors intertwine in a compounded manner to make system operation reliable in completive electricity markets.

When decision-making entities are diversified and their relationships become complex, rules to coordinate roles and interests for individual enterprises become necessary. In the USA, planning and operation of bulk power system are often divided where, for instance, a transmission own company carries out planning and investment on the network, whereas a grid operator operates the system. In such a case, problems such as lack of mutual communication, conflict of interests, or planning mismatches are likely to occur. Further, to assure system reliability, back-up power, frequency responsive reserve, and equipment such as a synchronous phase modifier to control voltages must be deployed in preparation for contingencies. To organize entities participating in the bulk power system, rules that clearly stipulate their responsibilities and the functions become necessary.

As electricity liberalization progresses and competition intensifies, a situation arises where facility construction slows down due to growing uncertainty in cost recovery. Figure 2-1 illustrates relationships between the peak electricity demand and the supply capacity in the USA for the last 20 years. It shows that, in late 1990's when uncertainty increased due to the liberalization, the supply capacity did not rise against the steady growth in the peak electricity demand, resulting in a reduced level of reserve capacity.

In addition, as wholesale markets have developed, congestion on the transmission network has increased significantly. The volume of trading grew fast in the late 1990's, while high-voltage transmission lines were expanded only at an annual pace of 0.3%. Investment in transmission capacity has not kept pace with the changes in trading patterns. The number of transactions that failed to materialize due to transmission congestions grew from about 300 cases in 1998 to about 1,500 cases in 2002, according to a report by NERC. The picture of stagnant investment into transmission and distribution facilities in the mid-1990's is also apparent in Figure 2-1 showing historical capital expenditures (in real dollars (2004)) into these areas, which is attributed to one of the causes for the network congestions.

[Figure 2-1] U.S. Capital Investments (Real Dollars) and Peak Electricity Demand



Source: EEI Statistical Yearbook 2004

Furthermore, increased flows across the control areas have made it difficult to control power systems. One of the causes of the blackout in North America and in Italy in 2003 was the failure of the grid operators in adequately regulating complex power flows across areas, states, or countries. Since the grid configuration in Europe and the USA is either a meshed or a looped network, loop flows[1] are prone to occur and, moreover, a failure in a grid has a tendency to cascade into an avalanche of damages. This suggests that system operators need to train their personnel and at the same time to maintain closer communications with other market participants.

2.2 Adequacy and Security

The supply reliability of a power system means the robustness of the grid system as a whole including generators, networks, and loads. A system is considered reliable when power outage occurs less frequently, with shorter duration and in a narrow scope. NERC further defines the supply reliability in terms of two separate notions, i.e. Adequacy and Security. Adequacy refers to the ability of an electric system to supply the aggregate electrical demand and energy requirements of the customers at all times. On the other hand, Security refers to a degree of systemic robustness capable of maintaining the stability, frequency, and voltage of the grid in the event of sudden disturbances caused by incidents such as lightning.

Since electric systems are closely interconnected electrically, an accident could trigger secondary or tertiary accidents, eventually leading to fail the entire power grid. To prevent system collapse, a power grid is designed with a fail-safe structure[2]. In other words, the grid has a

---

1 Power flows that go through outside of a contracted transmission route.

2 Based on the presumption that disruptions could occur due to design defects, equipment failures, or human operational errors, a contrivance designed to minimize damages in the event of such occurrences.

multiplex channel or assured reserve capacity so that it does not significantly affect the overall system even if a contingency occurs, such as the loss of a key generator unit or a transmission line accident (the “N-1 criterion”). This feature therefore requires a broader perspective covering from planning and configuring to operation of a grid in evaluating reliability of power system.

3. Electricity Liberalization and Reliability in the USA

3.1 Founding of NERC

The United States has been steadily developing the framework for a more reliable power system, drawing upon lessons learned from major power outages of the past. While NERC is currently playing a significant role in assuring reliability, the organization itself has been created from a lesson of a power outage. On November 9, 1965, a massive power blackout took place in Northeast U.S. around New York City and could not be restored for as long as 13 hours. Followed by the incident, the utility industry set up NERC as the main reliability organization and has since been paying efforts to voluntarily develop standards and rules to assure system reliability.

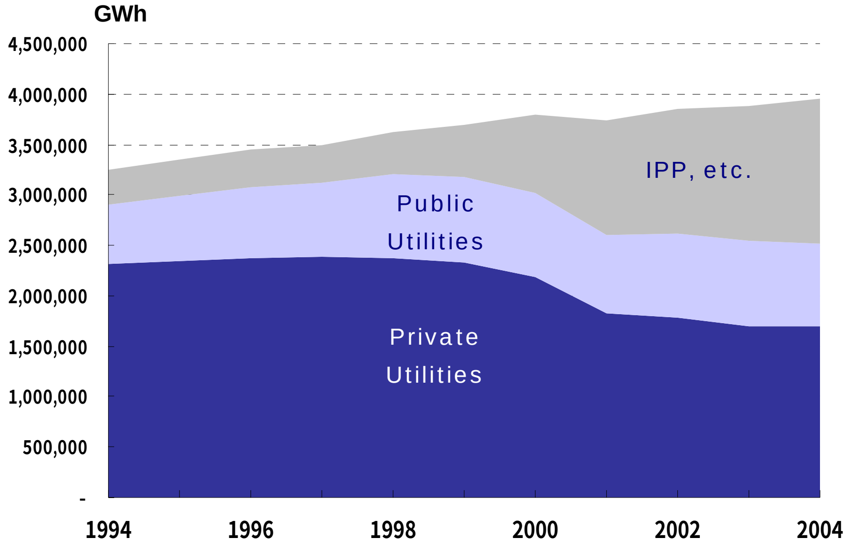
3.2 Reforming the Industry

Electricity deregulation in the USA made a significant step forward in the early 1990’s. During that time, discussions were raised over fair and non-discriminatory access in order to have generation entities (such as IPPs) enter the power generation market and vitalize competition. The Energy Policy Act of 1992 included provisions for open access to power grids and a greater empowerment of Federal Energy Regulatory Committee (FERC) to mandate wheeling services. It paved the way for the emergence of IPPs and promoted competition in the wholesale power markets.

Furthermore, in 1996 FERC issued final rules on “Promoting Wholesale Competition through Open Access Non-discriminatory Transmission Services by Public Utilities; Recovery of Stranded Costs by Public Utilities and Transmission Utilities (Order No. 888)” and “Open Access Same-Time Information System and Standards of Conduct (Order No. 889)”, which together required public utilities to provide non-discriminatory transmission services to others. These orders have transformed the U.S. power utilities by prompting entrance of new players into the market or by establishing Independent System Operators (ISOs).

The structural changes as described in the above have complicated the relationships among transmission owners, generators, and transmission system operators, making it difficult to assure the reliability through the conventional way. This led to FERC’s December 1999 issuance of Order No. 2000 which advanced the formation of Regional Transmission Organizations (RTOs) for operating interstate transmission grids.

[Figure 3-1] U.S. Power Generation by Entities



Source: EEI Statistical Yearbook 2004

In tandem with the federal level reforms retail liberalization was in progress in the state level. As a result, the share of generating facilities owned by IPPs has increased in the late 1990's (see Figure 3-1). On the other hand, investments made by these power producers were largely subject to trends in the wholesale electricity markets. Since the project is always put under rigorous scrutiny, coupled with the uncertainty in the recovery for investments, it has become clear that the securing of adequacy is now a challenge. A report by NERC points out that, while sufficient supply capability would be assured for the period around 2007 to 2008, such assurance would become questionable after 2010 indicating potential supply disruptions depending upon climatic conditions or demand situations.

3.3 The 2003 Blackout in the United States and Canada

The 2003 North America blackout took place on August 14, 2003, affecting large portions of the Midwest, Northeast U.S., and Ontario, Canada and an area with an estimated population of 50 million people and disrupted 61,800 MW of electric load. A joint U.S.-Canada Task Force investigated the incident and issued a final report (the Final Report), which identified the fundamental causes of the outage to be a series of violations of the NERC standards and guidelines. It made recommendations that included a proposal to make reliability standards mandatory and enforceable.

According to the Final Report, the following four main causes for the blackout were identified:

(1) Lack of understanding of the system; FirstEnergy (FE) failed to assess and understand its system conditions, particularly with respect to voltage instability and vulnerability of some areas, and FE did not operate its system with appropriate reliability.

(2) Inadequate situational awareness at FirstEnergy; FE did not ensure system security nor recognize the deteriorating condition of the system. FE's system operators were not adequately trained to maintain reliable operation under emergency conditions.
(3) FE failed to adequately manage tree growth in its transmission rights-of-way.
(4) Failure of the interconnected grid's reliability organization to provide effective real-time diagnostic support; the Midwest ISO lacked communication and procedures for coordinating actions with reliability coordinators of adjacent control areas.

Further, the investigation team identified a number of institutional issues with respect to NERC's reliability standards. The Final Report points out, among others, that NERC has no authority to enforce compliance with the standards, that its policies or guidelines were ambiguous and allowed divergent interpretations, and that NERC was not independent from the industry. Based on these analyses, the Task Force made a total of 46 recommendations, which were classified into four categories given below:

(1) Institutional issues related to reliability; i) Making reliability standards mandatory and enforceable with penalties for non-compliance, ii) actions related to ensuring NERC's independence, and iii) requirements for collection of data needed for grid analyses.
(2) Support and strengthening for NERC's Action Plans adopted on February 10, 2004; i) Clarification of roles, responsibilities, and authorities for related entities, ii) strengthening of voltage control practices, and iii) tightening of communications protocols for emergencies.
(3) Physical and cyber security of North American bulk power systems; i) Actions related to developing and implementing NERC IT standards, ii) developing IT security governance, and iii) actions for maintaining and managing information system health and incident management.
(4) Canadian nuclear power sector; Recommendations for the Canadian Nuclear Safety Commission with respect to emergency response and other related issues.

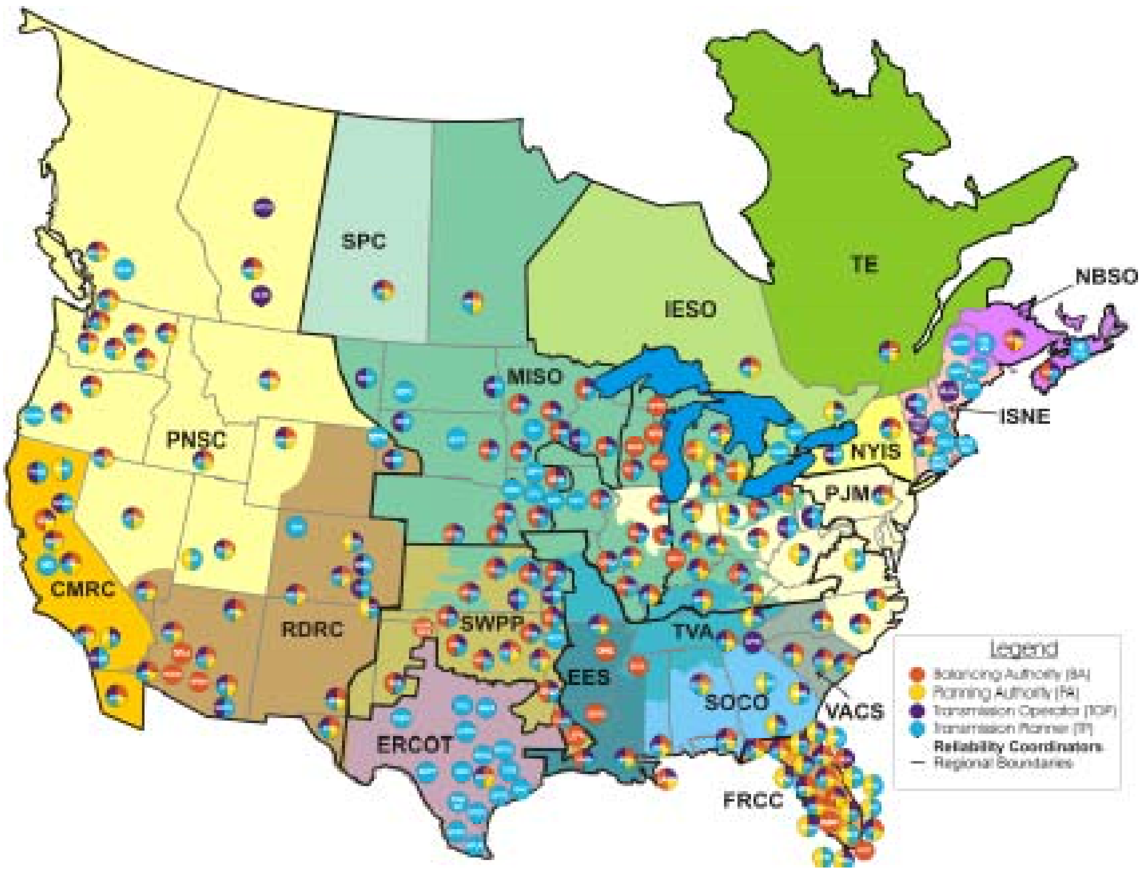
The lessons learned from the major blackout have been reflected into policies such as the Energy Policy Act of 2005 or the new NERC Reliability Standards, providing an opportunity to improve reliability of the North American power systems.

4. Approaches Taken by NERC

4.1 Reliability Functional Model

In the past, U.S. power utilities also operated in a similar manner as in Japan where vertically integrated entities took charge of supply and demand adjustments in the respective control areas and coordination with adjacent areas. Consequently, the traditional NERC's guidelines reflected such market structures. Beginning in the early 1990's, as the restructuring of the electric utility industry began to progress, the previous NERC Operating Policies based on the traditional market structure started to deviate from the reality. To address this situation, the NERC Operating Committee formed a Task Force in 1999. The Task Force listed all the tasks for the organizations performing the reliability functions. While the original plan was to assign these listed tasks to respective organizations, it did not work well because control areas themselves were changing their functions and there were a variety of newly emerging entities such as RTOs and ISOs. Realizing that there was no longer an operating organization that could provide a "standard", the Task Force decided to build a framework called a "Functional Model" consisting of the functions that ensure reliability. Embracing all forms of organizations including traditional, vertically-integrated entities, RTOs, and ISOs, the Model defines roles and responsibilities not just for transmission owners or grid operators but also for generators or load serving entities, and calls for all entities participating in a bulk power system to perform certain roles in assuring the system reliability as a whole.

[Figure 4-1] Status of "Functional Model" Certification



Source: NERC Website

Figure 4-1 illustrates the status of certification for various entities, wherein those certified as Balancing Authority are marked in red, Planning Authority in yellow, Transmission Operator in dark blue, and Transmission Planner in blue (for functions of each responsible entity, see Table 4-1). It can be seen from the illustration that when an entity performs two or more functions, it is certified for each of them.

The Model specifies 17 basic functions related to assureing reliability. To enable consistent and stable operations of transmission power grids regardless of institutional frameworks, responsible entities corresponding to respective functions and the relationships between the functions are defined, thereby providing a basic framework for NERC's Reliability Standards.

The main functions and responsible entities are grouped into three broader categories of: (i) Standard Functions [Standards Development, Compliance Monitoring], (ii) Reliability Service Functions [Operating Reliability, Planning Reliability, Interchange, Balancing, Transmission Service], and (iii) Planning and Operating Functions [Transmission Ownership, Transmission Operations, Transmission Planning, Generator Ownership, Generator Operations, Resource Planning, Load-Serving, Purchasing-Selling, Distribution]. Table 4-1 shows identities of major entities and their functions as set forth in the NERC Reliability Standards, showing their relationships that generally correspond to the Model as described above.

It may be said that NERC's Functional Model has presented a new framework by shifting the basis of reliability maintenance from organizations to functions, so that reliability could be maintained for the system as a whole.

4.2 NERC Reliability Standards

NERC's Reliability Standards (Version 0) was adopted on February 8th, 2005, and took effect on April 1st, 2005. In February 2006, thirteen new standards were adopted and three existing ones revised. There are 102 approved standards as of March 2006.

While the provisions of the Reliability Standards cover a wide range of activities from normal grid operations to emergency measures, they are all provided under two sets of guiding principles, i.e. Reliability and Market Interface Principles (see Table 4-2 for details). What made it necessary for the two principles to be laid out together was the recognition that "bulk electric power system reliability and electricity markets are inseparable and mutually interdependent".

The new NERC Reliability Standards feature objectivity, transparency, and effectiveness. Since the Final Report concluded that "some of the policies or guidelines are inexact, non-specific, or lacking in detail, allowing divergent interpretations among reliability councils, control areas, and reliability coordinators", it was intended to develop objective and measurable compliance criteria. Standards development process is stipulated in detail so that they are formulated through a transparent and fair process. Moreover, as the Energy Policy Act of 2005 has made the Reliability Standards legally binding, effectiveness is ensured. The following sections examine these three features one by one.

[Table 4-1] Major Entities and Their Functions

Major Entities and Their Functions
Balancing Authority
Responsible for integrating resource plans ahead of time, maintaining load-interchange-generation balance within a Balancing Authority Area, and supporting Interconnection Frequency in real time.
Planning Authority
Coordinates and integrates transmission facility and service plans, resource plans, and protection systems.
Purchasing-Selling Entity
Purchases or sells, and takes title to, energy, capacity, and Interconnected Operations Services. Purchasing-Selling Entities may be affiliated or unaffiliated merchants and may or may not own generating facilities.
Regional Reliability Organization
Ensures that a defined area of the Bulk Electric System is reliable, adequate and secure, and can serve as the Compliance Monitor.
Reliability Coordinator
Responsible for the reliable operation of the Bulk Electric System, with authority to support adjacent transmission systems that need close coordination, and acts to prevent or mitigate emergency operating situations from the wider purview it has.
Reserve Sharing Group
Two or more Balancing Authorities that form a group to collectively maintain, allocate, and supply operating reserves required for each Balancing Authority's use in recovering from contingencies within the group.
Resource Planner
Develops a long-term (generally one year and beyond) plan for the resource adequacy of specific loads (customer demand and energy requirements) within a Planning Authority Area.
Transmission Operator
Responsible for the reliability of its local transmission system, and operates or directs the operations of the transmission facilities.
Transmission Owner
Owns and maintains transmission facilities.
Transmission Planner
Develops a long-term (generally one year and beyond) plan for the reliability (adequacy) of the interconnected bulk electric transmission systems within its portion of the Planning Authority Area.
Transmission Service Provider
Administers the transmission tariff and provides transmission service to Transmission Customers under applicable transmission service agreements.
Distribution Provider
Provides and operates the "wires" between the transmission system and the end-use customer. For those end-use customers who are served at transmission voltages, the Transmission Owner also serves as the Distribution Service Provider. Thus, the Distribution Service Provider is not defined by a specific voltage, but rather as performing the Distribution function at any voltage.

Source: NERC "Reliability Standards for the Bulk Electric Systems of North America"

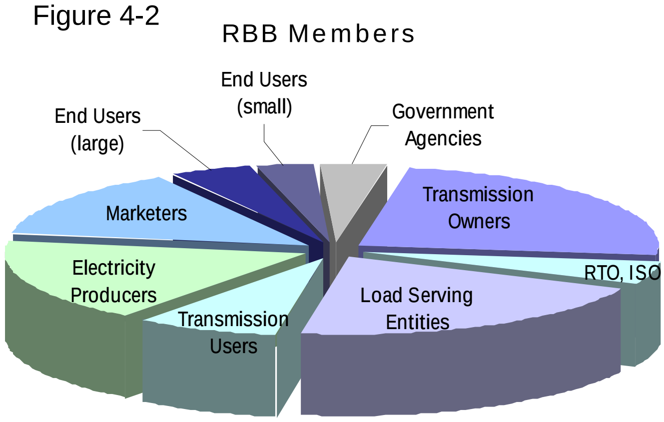
4.2.1 Transparency

For developing reliability standards, the NERC Reliability Standard Process Manual establishes the consensus development process for approval, revision, reaffirmation, and withdrawal of such standards. The process is generally based on the procedures of the American National Standard Institute (ANSI) and other standards-setting organization in the U.S. and Canada. One of its main characteristics is the open and transparent decision making process which allows by all stakeholders to participate.

For example, any person who is directly and materially affected by the reliability of the North American bulk electric systems is allowed to request a reliability standard be developed or modified, and has a right to express an opinion during the development or review processes. The initial step for any proposed standard is a solicitation for public comments, and the same step is taken later again for a completed draft standard.

While the final approval for a proposed standard is decided through ballot, this process is also designed to allow all interested parties to participate. The group having the voting right is called the Registered Ballot Body (RBB) and comprises members from all nine segments as illustrated in Figure 4-2, according to the NERC Reliability Standard Process Manual. A ballot pool to participate in the consensus development process is established for each of the standards action, consisting of members of the RBB who are interested in that particular action and whose voting results will decide adoption of the standards action in discussion.

Figure 4-2



Source: "NERC Reliability Functional Model" Version 2

As described above, the Reliability Standard Process Manual provides for a fair and transparent process as illustrated in Figure 4-3, covering all related entities such as government agencies, grid operators, transmission owners, market participants and others in developing reliability.

[Table 4-2] Reliability Principles and Market Interface Principles

Reliability Principles
1. Interconnected bulk electric systems shall be planned and operated in a coordinated manner to perform reliably under normal and abnormal conditions as defined in the NERC Standards.
2. The frequency and voltage of interconnected bulk electric systems shall be controlled within defined limits through the balancing of real and reactive power supply and demand.
3. Information necessary for the planning and operation of interconnected bulk electric systems shall be made available to those entities responsible for planning and operating the systems reliably.
4. Plans for emergency operation and system restoration of interconnected bulk electric systems shall be developed, coordinated, maintained and implemented.
5. Facilities for communication, monitoring, and control shall be provided, used, and maintained for the reliability of interconnected bulk electric systems.
6. Personnel responsible for planning and operating interconnected bulk electric systems shall be trained, qualified, and have the responsibility and authority to implement actions.
7. The security of the interconnected bulk electric systems shall be assessed, monitored, and maintained on a wide-area basis.
Market Interface Principles
1. The planning and operation of bulk electric systems shall recognize that reliability is an essential requirement of a robust North American economy.
2. An Organization Standard shall not give any market participant an unfair competitive advantage.
3. An Organization Standard shall neither mandate nor prohibit any specific market structure.
4. An Organization Standard shall not preclude market solutions to achieving compliance with that standard.
5. An Organization Standard shall not require the public disclosure of commercially sensitive information. All market participants shall have equal opportunity to access commercially non-sensitive information that is required for compliance with reliability standards.

[Figure 4-3] Reliability Standards Development Process

4.2.2 Objectivity

In the past, the NERC policies and guidelines merely provided for an outline of reliability requirements, often leaving the actual operation to grid operators. As the market structure transformed and the electricity trade diversified, however, more specific, objective, and explicit reliability standards are needed.

The NERC Reliability Standards set forth responsibility and technical requirements for each of the entities defined in the Functional Model and comprise 14 functional categories.

When a lack of a particular requirement seriously undermines the system reliability, the requirement is approved as an item of the Reliability Standards; the structure of the standards are mutually exclusive and collectively exhaustive.

[Table 4-3] The Reliability Standard Template

Elements of a NERC Reliability Standard	
A.	Introduction (Title, Number, Purpose, Applicability, Effective Date)
B.	Requirements (Action Standards, Procedures, etc.)
C.	Measure(s)
D.	Compliance (Compliance Monitoring Responsibility, Data Retention, Levels of Non-Compliance, etc.)
E.	Regional Differences
Version History	

Source: "Reliability Standards for the Bulk Electric Systems of North America"

Each reliability standards clearly defines its purpose, applicability, requirements, compliance elements and other elements in as systematic way according to the Reliability Standard Template given in Table 4-3, with respective explanations as follows:

The "Purpose" in A explicitly states what outcome will be achieved by the adoption of the standard.

The "Requirements" in B describe technical, performance, and preparedness requirements necessary for system reliability. Each requirement identifies what entity is responsible and what action is to be performed by each entity.

The "Measure(s)" in C are used to assess performance and outcomes of the requirements stated above. Each measure identifies to whom the measure applies and the expected level of performance to demonstrate compliance. This part of the standard reflects the basic concept of the new Reliability Standards that each standard must be explicit, practical, and as objective as is practical.

The "Compliance" in D describes the compliance monitoring process together with the information on the entity responsible for monitoring compliance, measurement data retention requirements, as well as the threshold levels of non-compliance for each measure.

The "Regional Differences" in E are provided so that regional situations could be flexibly reflected in a standard.

There are four different types of reliability standards, each with a distinct approach to measurement as described below:

(i) "Technical standards" related to the provision, maintenance, operation, or state of electric systems containing measures of physical parameters.

(ii) "Performance standards" related to the actions of entities and measures of the results, or the nature of the performance of such actions.

(iii) "Preparedness standards" related to the actions of entities to be prepared for contingencies.

(iv) "Organization certification standards" to define the essential capabilities to perform reliability functions.

As described above, all standards are defined in an objective as well as measurable manner, stipulating the roles, scope of responsibilities, and the method of mutual cooperation for each entity comprehensibly, coherently, objectively and in detail.

4.2.3 Effectiveness

The previous NERC Reliability Standards were voluntary provisions without legal backing. Therefore, even in case a deviation from the standard was identified, it merely caused a warning being sent to the parties concerned and penalty could not be imposed. Such a status had been perceived as a problem even before the 2003 blackout, and NERC had tried to develop a NERC Compliance Enforcement Program or to lobby a legally enforceable reliability standard bill through Congress. Nevertheless, the compliance in the utility industry remained of a voluntary nature. After the revelation that the root causes of the 2003 blackout were violations of the reliability provisions, however, voices calling for legally enforceable reliability standards grew even stronger.

On August 8, 2005, the Energy Policy Act of 2005 was signed by President Bush and came into force. The law includes a provision to newly establish an Electric Reliability Organization (ERO) for enhancing the reliability of the North American bulk power systems. The law mandates that the ERO develop legally enforceable reliability standards and that a non-compliant entity could be penalized. It is now planned to transform NERC into the ERO with a target timing in the summer of 2006, and on September 1, 2005, FERC made a public announcement on the "Rules on the Certification of an Electric Reliability Organization; and the procedures for the establishment, approval, and enforcement of mandatory electric reliability standards" (Docket No. RM05-30-000), which was finalized on February 2, 2006 through a public hearing process.

In summary, the following provisions are incorporated in the Rules:

- Criteria that an entity must satisfy to qualify to be the ERO;
- Procedures under which the ERO may propose new or modified Reliability Standards for Commission review;
- A process for timely resolution of any conflict between a Reliability Standard and a FERC-approved tariff or order;
- the process for resolution of an inconsistency between a state action and a Reliability Standard;
- Regulations pertaining to the funding of the ERO;
- Procedures governing an enforcement action by the ERO, a Regional Entity or the FERC;
- Criteria under which the ERO may delegate authority to a Regional Entity for the purpose of enforcing Reliability Standards;
- Regulations governing the issuance of periodic reliability reports by the ERO that assess the reliability and adequacy of the Bulk Power Systems in North America; and
- Procedures for the establishment of Regional Advisory Bodies.

The envisaged transition of NERC into the ERO with strengthened independence and the ability to make reliability standards mandatory and enforceable with penalties for non-compliance will ensure the future effectiveness of reliability maintenance policies.

4.3 Outline of the NERC Reliability Standards

The provisions in the new NERC Reliability Standards are made to reflect the Final Report recommendations to a substantial degree. Table 4-4 summarizes the reliability functions and responsible entities laid out in the Reliability Standards in a matrix form. The functions comprise 14 categories with their brief explanations given in the following sections.

4.3.1 Resource and Demand Balancing:

These are standards related to real time balancing control operations (or ancillary services) mainly applicable to the Balancing Authority. Ancillary services refer to various kinds of supporting activities for stable operation of an interconnected power system and include services such as frequency response, disturbance control, or supply of reactive power, for which a need has arisen to newly define and stipulate because a diverse range of entities have started using the transmission service. The standards under this category stipulate items such as allowable deviation from the scheduled frequency, time error correction standards, disturbance control procedures, and calculation methods related to Automatic Generation Control (AGC) while taking the conditions of neighboring areas that are electrically synchronized to the interconnection into consideration.

4.3.2 Critical Infrastructure Protection:

Standards related to entities responsible for reporting disturbances or unusual occurrences, suspected or determined to be caused by sabotage and to organizations (governmental agencies, regulatory bodies) for such reporting.

4.3.3 Communications:

Since exchange and sharing of operating information with adjacent control areas are required to accurately monitor the status of the interconnection, telecommunication facilities are considered an important tool to maintain reliability. The standards under this category include provisions for the required information system and connection procedures, procedures to enable continued system operation during the loss of telecommunications facilities, emergency response measures, and communicating paths among related entities.

4.3.4 Emergency Preparedness and Operations:

According to the Final Report, "if manual or automatic load-shedding of 1,500 MW had implemented within the Ohio grid area, the blackout of such a magnitude exceeding 60,000 MW could have been averted." The standards under this category covering emergency preparedness and responses include, provisions for obtaining emergency assistance from adjacent balancing areas, provisions for ensuring a system Blackstart Capability[3] as a part of System Restoration Plans (SPR), provisions for inter-organization communication and coordination, procedures and authorities for Load Shedding Plans to forcibly shed load in the event of insufficient generation or transmission capacity. There are also provisions for reporting procedures in the event of disruptions or unusual occurrences in the system and a method for minimizing the likelihood of similar events in the future.

4.3.5 Facilities Designs, Connections and Maintenance:

When facilities are interconnected within a system or between systems, it is necessary to ensure the entire system remains coordinated by integrating performance levels of various equipment, their system requirements, and other elements. Targeting mainly facility owners such as a Generator Owner or Transmission Owner, the standards under this category include provisions for applicable requirements when integrating new facilities, and rating standards for electrical facilities. There is also included a provision for a vegetation management program to prevent transmission lines from contacting with vegetation and related outages.

4.3.6 Interchange Scheduling and Coordination:

This category includes various standards for interchange transactions, and in particular congestion management procedures based on a process called tagging. As interchange transactions become more dynamic over a wider expanse of areas, power flows become more complex. These standards ensure that transactions are identified by tagging so that efficient congestion management

[3] The capability for a generating unit or station to go from a shutdown condition to an operating condition delivering electric power without assistance from the electric system.

is achieved and the interchange transaction information is shared by all entities.

[Table 4-4] Outline of NERC Reliability Standards

	Regional Reliability Organization	Balancing Authority	Reliability Coordinator	Planning Authority	Transmission Service Provider	Transmission Planner	Transmission Operator	Transmission Owner	Resource Planner	Generation Operator	Generation Owner	Load - Serving Entity	Purchasing - Selling Entities	Distribution Provider
Resource and Demand Balancing		●	●				●			●		●		
Critical Infrastructure Protection		●					●			●		●		
Communications		●	●				●							
Emergency Preparedness and Operations	●	●	●				●			●	●	●		
Facilities Designs, Connections, and Maintenance	●		●	●		●		●						●
Interchange Scheduling and Coordination		●	●		●		●						●	
Interconnection Reliability Operations and Coordination	●	●	●		●		●	●		●	●	●		
Modeling, Data, and Analysis	●			●	●	●		●	●		●	●		
Personnel Performance, Training and Qualifications		●	●				●							
Protection and Control	●	●					●	●		●	●	●		●
Transmission Operations		●	●	●	●		●			●		●	●	●
Transmission Planning	●			●		●					●			
Voltage and Reactive Control		●					●			●			●	
Cyber Security														

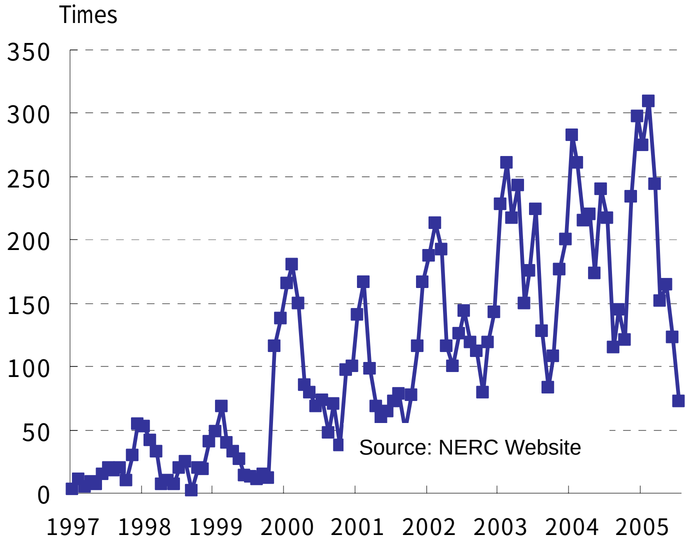
Source: NERC "Reliability Standards for the Bulk Electric Systems of North America"

4.3.7 Interconnection Reliability Operations and Coordination:

These are standards mainly targeted at Reliability Coordinators with an aim of ensuring reliability of interconnected systems. These standards stipulate action standards, authorities, functions, and required facilities for Reliability Coordinators so that the reliability of bulk electric systems can be assured while continuously monitoring conditions not only within the Reliability Coordinator's own area but also neighboring areas. Provisions also include parameters to monitor that may have significant impacts upon the Reliability Coordinator Area and neighboring Reliability Coordinator Areas, or actions such as redispatch or load shedding to mitigate a critical situation.

One of such standards, IRO-006-0, stipulates that the Reliability Coordinator must direct its Balancing Authorities and Transmission Operators to return the transmission system to within its Interconnection Reliability Operating Limits as soon as possible, but no later than 30 minutes, taking actions such as reconfiguration, redispatch, or load shedding through the Transmission Loading Relief (TLR) procedure until relief requested by the TLR process is achieved.

[Figure 4-4] TLR Invocations (Level 2 or Above)



The TLR is one of the congestion management procedures and, when urgently required, could be invoked to shed load to relieve congestion at the initiative of the Transmission Operator. The TLR procedures have six levels starting from the lightest action of Level 1 (Notification of a potential overload condition) to Level 6 (Emergency Procedures). A Transmission Loading Relief Procedure Log is maintained and posted on the NERC website.

Figure 4-4 shows a historical trend for the number of requests to invoke TLR Level 2 or above, where it was 305 times in 1998 but increased year by year to 2,397 times in 2005. This indicates the growing number of cases in which transmission grids are operated near the limits of their transmission capacities and, as pointed out in Chapter 2.1, illustrates the lack of adequacy in the North American network facilities.

4.3.8 Modeling, Data, and Analysis:

The Regional Reliability Organizations are responsible for collecting relevant data and performing simulations based on system models to analyze the system reliability. Since such data are collected from a variety of related organizations, consistency is required for the data collection or calculation methodologies. The standards under this category include provisions for calculation methods for Total Transfer Capability (TTC) and Available Transfer Capability (ATC), Capacity Benefit Margin (CBM), Transmission Reliability Margin (TRM), effects of Demand-Side Management (DSM) and related parameters. Data consistency in the interconnected transmission system, simulation, and Direct Control Load Management (DCLM) is also specified.

4.3.9 Personnel Performance, Training, and Qualifications:

The increasing number of cases where the grids are operated near the limits, growing complexity in the system operations due to institutional reasons, and advanced use of high technology facilities are calling for operating personnel to have sufficient knowledge and skills. The standards in this category include provisions for certification requirement, responsibility and authority of operating personnel in organizations such as Transmission Operator and Balancing Authority as well as the requirement for a coordinated training program to maintain and improve human resources in the operating entities.

4.3.10 Protection and Control:

Since the operation of protective relays is a crucial measure in preventing the cascading outage, the standards under this category include provisions for equipment and procedures for system protection and control. Performance requirement, maintenance and inspection procedures for equipment used in the system protection programs such as Underfrequency Load Shedding (UFLS), Undervoltage Load Shedding (UVLS), and Special Protection System (SPS) are also stipulated together with the implementation procedures.

4.3.11 Transmission Operations:

For advance examination of the transmission reliability or preparations for potential contingencies, effectiveness must be assured based on a specified work flow. The standards under this category include provisions for the information management and system monitoring method during normal operating conditions, the command structure for responding to contingencies, as well as reporting requirements, response, and corrective actions in the event of violations of the Interconnection Reliability Operating Limit (IROL) and System Operating Limit (SOL).

4.3.12 Transmission Planning:

In this section, system performance standards are defined for conditions at each phase of normal operating, scheduled outages, single outage, multiple outages, and extreme events. The Planning Authority and Transmission Planner are required to periodically assess and review specified performance requirements in line with the system development or upgrading plans for the future. It is also stipulated that, for assessing the overall reliability (Adequacy and Security) of the interconnected bulk electric systems, each Regional Reliability Organization is required to provide NERC with system data and system performance information.

4.3.13 Voltage and Reactive Control:

Being one of the standards related to ancillary services, this standard requires each Generator Operator, Transmission Operator, and Purchasing-Selling Entity to ensure voltage levels, reactive power flows, and reactive resources are monitored, controlled, and maintained within limits in real time to protect equipment and the reliable operation of the Interconnection.

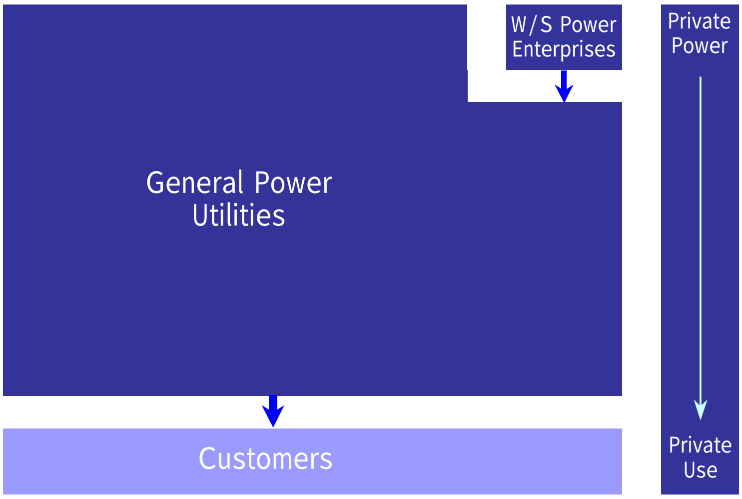
4.3.14 Cyber Security:

The September 11, terrorist attacks triggered a heightened crisis awareness of potential terrorist attacks on electronic equipment and communication networks that are crucial to the operation of the interconnected bulk electric systems, including hardware, software, and data bases. Since cyber terrorism could render profound damages to the system, standards have been developed to reduce risks to the reliability of the bulk electric systems caused by any compromise of critical cyber assets. NERC is now developing standards and procedures for the identification and certification of applicable.

5. Policy Development in Japan

Approximately ten years have elapsed since the electricity liberalization began in Japan. Before the liberalization, the Japanese electricity utility industry had a relatively simple structure focused mainly on public interests, as shown in Figure 5-1. After the 1995 amendments to the Electricity Utility Law, however, such a framework has been undergoing changes. The following sections attempt to review the past developments of the electricity liberalization from the viewpoints of diversifying utility business players and the development of rules supporting such entities.

[Figure 5-1] Japanese Electricity Utility Industry Prior to 1995



5.1 The 1995 Amendment to the Electricity Utility Law

As a result of deliberations in the Electricity Utility Industry Council that started in March 1994, sweeping changes were made to the Electricity Utility Law in April 1995 for the first time in 31 years. The revised law introduced a program of "Special Electric Utilities" that were allowed to engage in retail electricity business utilizing power sources such as co-generation near the consumption points. Furthermore, to promote efficiency in business operations through market principles, licensing requirement for entry to wholesale electricity business was in principle abolished, and new entry to the generation sector was expanded by introducing IPPs.

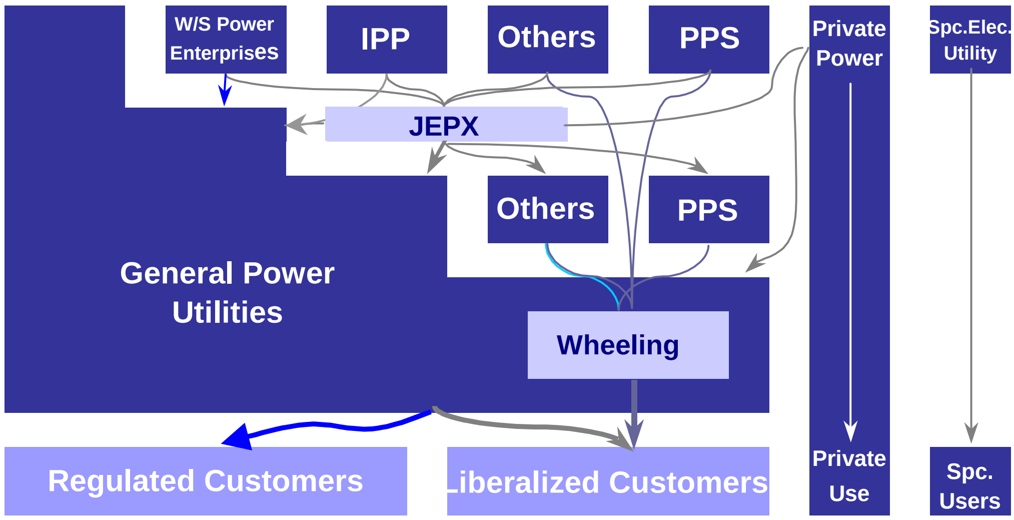
5.2 The 1999 Amendment to the Electricity Utility Law

Based on discussions about how to realize the public interests such as long-term stability or reliability assurance in energy supply and to introduce market principles in a balanced manner, amendments were made to the Electricity Utility Law in May 1999 (implemented in March 2000) to bring about (i) partial liberalization of the retail market, (ii) creation of Power Producer and Supplier (PPS), and (iii) introduction of wheeling service rules. In the liberalization of electricity retailing, a specific class of large-lot customers (special high-voltage customers who receive electricity at voltages 20kV or higher, and in principle use more than 2 MW of electricity) was liberalized for retail, such customers accounting for approximately 30% of General Power Utilities' customers. The PPS was devised to encourage new entrants into the liberalized market. As a result of these changes, new entry into the electricity generation and retail sectors was now allowed without any entry licensing requirements, supply obligations, and tariff regulations. The rules for access to transmission networks (the wheeling service rules) were established so that the new entrants and GPUs with their own transmission facilities could compete on an equal footing. At the same time, a concept of “Cross-area Wheeling Service Contract” was introduced with associated transmission charges being levied each time supply areas were straddled, which resulted in the so-called “pancaking problem”.

5.3 The 2003 Amendment to the Electricity Utility Law

In the amendments to the Electricity Utility Law enforced in June 2003, the liberalized portion of the retail market was enlarged, and the establishment of the Japan Electric Power Exchange (JEPX) and the Electric Power System Council of Japan (ESCJ) was determined. Furthermore, the wheeling service system was revised so that cross-area transmission charges were abolished and integrated into uniform connection charges, thereby solving the pancaking problem. As a result of these reforms, structure of the Japanese electricity industry now appears as shown in Figure 5-2, depicting the diversified power utility entities and the increased complexity in power trades achieved in the past ten years and making a remarkable contrast with the picture given in Figure 5-1.

[Figure 5-2] Japanese Electricity Utility Industry After 2003



5.4 The Electric Power System Council of Japan (ESCJ)

After implementation of electricity retailing liberalization in 2000 and as a growing number of entities started using the power grids, the transmission and distribution networks strengthened its character as the “public goods” to be accessed not only by GPUs but also by many other entities. Under this circumstance, a report entitled “The Framework of Desirable Future for Electricity Industry” was submitted in February 2003, and subsequently an interim report entitled “The Detailed Design for Desirable Future Electricity Industry” was compiled by the Electricity Industry Committee in December 2003, which together organized the establishment of a neutral organization for supporting electricity transmission and distribution services, along with governance for such an organization, scope of its function and responsibility, codes of conduct for its officers and personnel, and the rules to be established by the organization.

While the electricity transmission and distribution sectors traditionally had been operated by GPUs under voluntary rules, upon the revision of the Electricity Utility Law, various rules were set forth for an organization to support electricity transmission and distribution services. In accordance with the provisions of Article 94 of the Law, which stipulate that "basic guidelines concerning the electricity transmission and distribution services" be developed, the Rules of ESCJ have been established. The Rules are made up of four parts, i) "Rules of System Development" concerning policy, system securities, and coordinating process, ii) "Rules of Power System Operation" concerning grid operations, load-dispatching instructions, and utilization of interconnection line, iii) "Rules for System Interconnection" specifying technical requirements and work procedures related to the grid access, and iv) "Rules of Information Publication" concerning the scope and procedures for publicizing information such as available transmission capacity. The rules are developed or revised in fair manner by a 13-member Rule-Making Committee consisting of four neutral members, three representatives from GPUs, three representatives from PPSs, and three representatives from wholesale and private power producers.

5.5 Framework for maintaining Reliability

Under the current framework, the responsibility for maintaining reliability is held by GPUs, whereas the ESCJ is charged with rule-making and supervision of the system and the government will monitor ultimate reliability (Adequacy) through annual supply plans.

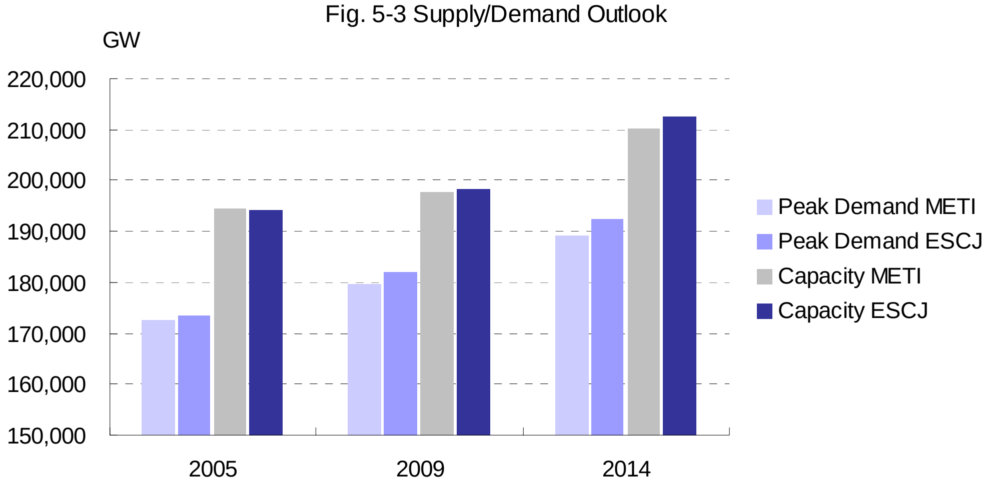
While the structure of Japan's electricity industry has shifted from the one illustrated in Figure 5-1 to the one in Figure 5-2, there has been no change in that the responsibility of maintaining supply reliability is still held by the GPUs. In this arrangement, GPUs are mandated to secure supply capability including generation capacity and balancing capability required in the course of grid operation, and bear the supply obligation to the regulated portion of retail sector customers as well as ultimate supply assurance to the liberalized portion of the retail sector as the last resort supplier.

Work concerning communication and coordination for interconnection lines straddling franchised areas of the GPUs is carried out by the ESCJ. The ESCJ also performs functions such as communication and coordination required for transactions arranged in the JEPX, wide-area transactions straddling franchised areas, and congestion management, as well as formulation of construction plans for inter-regional interconnection lines.

The long-term planning (Adequacy) for capacity building is assessed by the government and by the ESCJ. According to the provisions in Article 29 of the Electricity Utility Law, each of the ten GPUs and two Wholesale Electric Power Enterprises must file with Minister of Economy, Trade and Industry an individual 10-year plan for power supply and demand by the end of every fiscal year. The plans thus submitted by the entities are then compiled by the Electricity Infrastructure Division of the Agency for Natural Resources and Energy (ANRE), and published as "Electricity Supply Plans" at the end of the fiscal year. The ESCJ also develops a "Supply Reliability Assessment

Report[4]" in accordance with Chapter 9 of the Rules of ESCJ.

Fig. 5-3 Supply/Demand Outlook



Sources: METI "Electricity Supply Plans FY2005", ESCJ "Supply Reliability Assessment Report FY2005"

Figure 5-3 shows a summary of the results of electricity supply/demand assessments for the next ten years published by ANREI and ESCJ, where there are little differences between the two assessing bodies who have equally concluded that the supply reliability should be adequate for both short-term and long-term outlook. However, these assessments only dealt with adequacy for generating facilities, leaving out detailed examination of transmission and distribution facilities. As the adequacy assessment for the grid is substantially affected by technical factors, often resulting in different conclusions depending on the geographical relationship with the power plants or grid configurations, enhancement in this area will be a future challenge.

[Table 5-1] Frameworks of Reliability Maintenance in Japan and the USA

	Japan	USA
Reliability Organization	**ESCJ**	**NERC**
Reliability Rules	**Rules of ESCJ**	**Reliability Standards for the Bulk Electric Systems of North America**
Rules Established	**September 2004**	**April 2005**
Reliability Responsibility	**GPUs**	**Shared among organizations**
Reliability Assessment Report	**・Supply Reliability Assessment Report (ESCJ)** **・Electricity Supply Plans (METI)**	**・Long-Term Assessments** **・Summer Assessments** **・Winter Assessments**
Issues	**Elimination of assymetricity among organizations**	**Coordination among various organizations**

4 While the "Supply Reliability Assessment Report" by ESCJ includes data for PPSs, the METI report omits them.

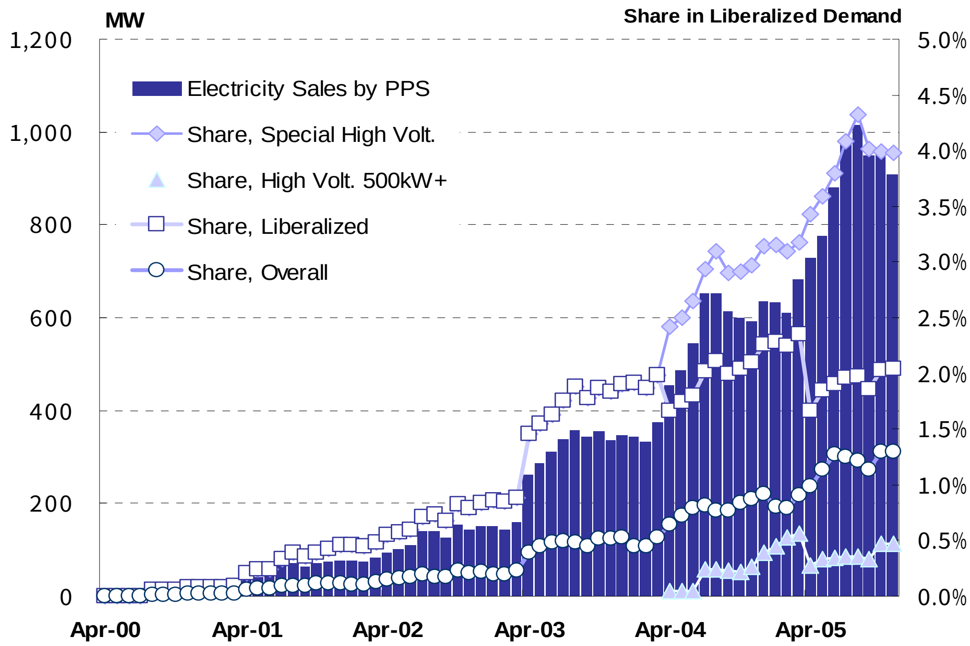
Table 5-1 compares the frameworks for maintaining reliability between Japan and the USA. While issues and challenges may differ between them, there are similarities in both nations' approaches where a neutral organization is formed for securing reliability and to build an electricity market with the use of reliability standards and rules.

6. Issues for the Future

6.1 Security

Japan has until today enjoyed a high degree of supply reliability. This has been enabled by factors such as relatively larger capital investments for reliability maintenance compared to many other countries and a clear-cut supply responsibility that allowed smooth communications, and so on. While the structure of GPUs taking unilateral responsibility for assuring supply security is still unchanged today, rearrangement of the framework for reliability could become necessary depending upon the development in the future market structure.

[Figure 6-1] Electricity Sales by PPSs and Market Share



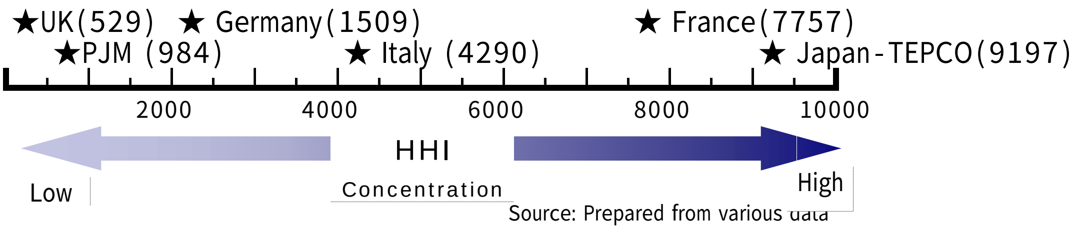
Source: Prepared from METI "Provisional Report on Overall Electricity Demand", etc.

Figure 6-1 shows the development of electricity sales by PPSs and their market share since 2000 indicating two facts; for one thing, the market share for PPSs is increasing, and for another, their overall share is still low at 2% or so. To look at this situation from another viewpoint, Figure 6-2 can be given. This chart shows the degree of market concentration based on a measure called HHI (Herfindahl-Hirschman Index)[5], where it is evident that in Japan GPUs have the lion's share in the

[5] HHI (Herfindahl-Hirschman Index) is a measure of concentration in a specific market and is defined as the sum of the squares of

highly concentrated electricity market. By contrast, the market concentration is low in electricity markets in the U.K. or PJM Interconnection in the USA. While it is hard to expect the Japanese electricity market to immediately transform itself into the form like PJM, if the market structure continues to change as the market share of new entrants grows, corresponding could become necessary.

[Figure 6-2] Degree of Market Concentration



Source: Prepared from various data

One of the conceivable options for dealing with the above situation is introduction of ancillary services (see Sections 4.3.1 and 4.3.13) into the market. Recently, an argument is emerging that ancillary services should be put to market mechanisms so that equitable cost sharing is achieved. Currently, in the area of ancillary services in Japan, only those concerning frequency control are defined and its cost is recovered by the wheeling charge inclusively.

From now on, however, it may be needed to broaden discussions on whether it is rational to put ancillary services to market mechanisms from the viewpoint of grid reliability, acceleration of competitive market formation, or equitable cost sharing.

In such discussions, it is also necessary to keep in mind that the concept of ancillary services embraces various types of services. There is a type of service such as regulation for which a multiple number of competing service providers are considered preferable, or services that are more suitable for a single provider for the entire system like blackstart service.

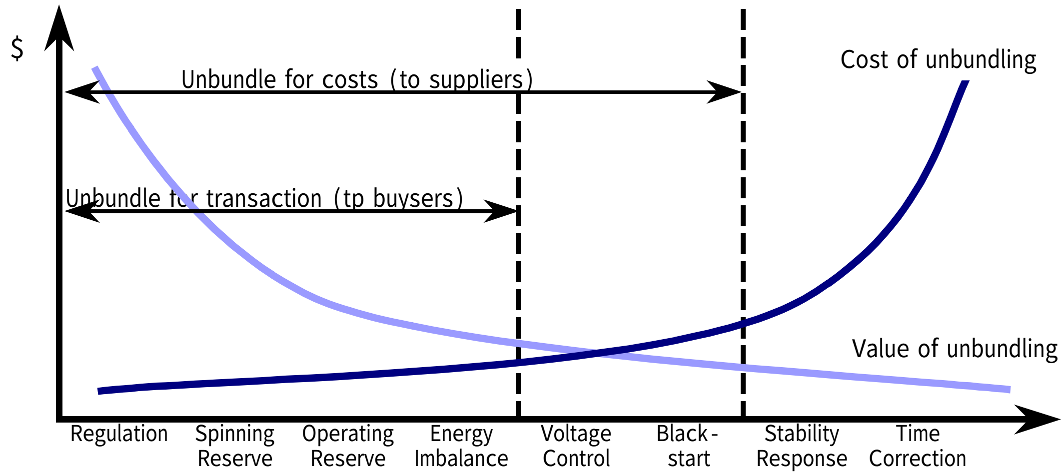
Figure 6-3 shows various types of ancillary services and their cost. In this chart, the "Unbundle for costs (to suppliers)" refers to a range of services in which it is possible to specify service providers as well as customers and to recover cost even after unbundling. The "Unbundle for transaction (to buyers)" refers to a range of services for which a market mechanism is considered to work even after taking expenses for cost recovery and other factors into consideration. However, it is noted here that even in the USA as a pioneer in putting ancillary services to market mechanisms, there are a number of areas where unified understanding has not been formed as yet concerning measurement methods, pricing, or method of cost defrayal. In the regulation service, for instance, there still is a lack of common understanding on issues such as cost structure of generating entities (thermal efficiency, indirect expense, opportunity cost, etc.), performance measurement (time

---

market shares of each individual firm. HHI is obtained by the formula $HHI = \sum_{i=1}^{n} S_i^2$, where S_i is the market share of firm i.

intervals, interpretation of AGC signals, performance specifications, etc.), and the methodology of pricing for individual customers. How to establish clear rules for those elements remains to be seen.

[Figure 6-3] Various Ancillary Services and Cost



Source: Brendan Kirby "Ancillary Service Conference" Proceedings

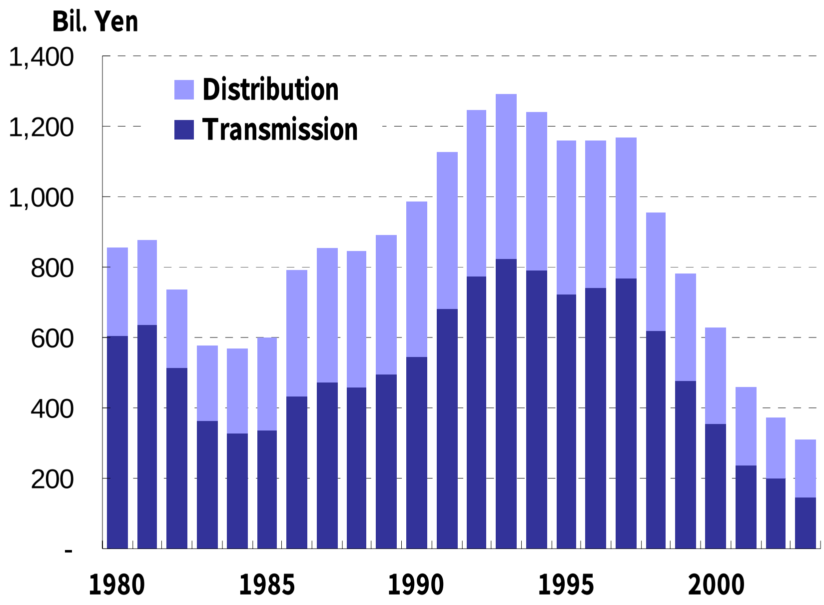
6.2 Adequacy

As competition intensifies and cost cutting pressure heightens, incentives to curtail capital investment as much as possible and to utilize existing facilities increase. Further, there is a possibility of increased congestion among interconnection lines due to rising demand for the transmission service created by liberalization. Institutional measures to ensure incentives to form network facilities will become a future issue.

As shown in Figure 6-4, the Japanese investment into transmission and distribution networks has been rapidly falling since the early 1990's because power companies searched for a move to secure financial resources in order to cut electricity rate by reducing capital expenditures in response to progress of. Even with such a sharp decline in the investment flow, there currently is little perception that the reserve level in transmission capacity is lacking. However, if such trend continues, some measures could become necessary to ensure incentives for investing in these facilities.

Furthermore, the manner of the interconnections utilization and their construction cost could become a major issue in the future. Because of past efforts by the GPUs to develop and enhance the network, adequacy is secured within their franchised areas. However, when cross-area transactions increase as encouraged by the elimination of the pancaking problem, the issue of under-capacity for interconnection lines will come to light. While the ESCJ is supposed to develop specific plans for expansion of interconnection lines according to the rule of "Coordinating Process of Interconnection Planning" as provided in the Rules of ESCJ, there still is no rule as to how the cost burden should be borne, leaving the issue of consensus building unsolved.

[Figure 6-4] Transmission/Distribution Investments in Japan



Source: "*Denkijigyō Binran FY2005*"

7. Conclusion

It is indispensable to have appropriately designed rules for the formation of a well-functioning market. In Japanese, competition is simply defined as "an act of contest for defeating others or winning superiority" (*Kōjien*). However, the word "competition" in English is usually defined as "seeking or endeavoring to gain what another is endeavoring to gain at the same time, usually under or as if under fair or equitable rules and circumstances" (*Webster's Third New International Dictionary*). In other words, there is an underlying perception that without appropriate rules competition does not work out and means for regulating the market cannot exist. In a period of institutional transition such as now, the existence of objective and effective rules established through a transparent process is particularly important.

Contact: report@tky.ieej.or.jp

[Bibliography]

1. Hiroshi Asano, Kenji Okada, Ikuo Kurihara, Haruhito Taniguchi, Naofumi Watanabe [2003], "Denryoku Jiyūkato Keitō Mondai", *Denryoku Jiyūkano Seidosekkei* compiled by Tsuruhiko Nanbu, University of Tokyo Press
2. Teizo Anayama [2005], *Denryoku Sangyōno Keizaigaku*, NTT Publishing Company
3. Junichi Ogasawara [2005], "Nichi-Bei-Ou Ni Okeru Denryokushijō Jiyūkano Shinten Jōkyōto Sono Hyōka", *Enerugī Keizai*, August, pp21-36
4. Junichi Ogasawara [2005], "Jigyōhō Taikeito Shinraidoijini Tsuite (Sono 1)", *Natsource Japan Letter*, July 2005
5. Junichi Ogasawara [2005], "Jigyōhō Taikeito Shinraidoijini Tsuite (Sono 2)", *Natsource Japan Letter*, August 2005
6. Electricity & Gas Industry Division, Agency for Natural Resources and Energy, Nuclear and Industrial Safety Agency [2005], *2005 Nenban Denki Jigyōhōno Kaisetsu*
7. Chen Luonan [2001], "Kyōkyū Shinraidoto Denryoku Setsubi Keisei", *Denryoku Jiyūkato Gijutsu Kaihatsu* compiled by Ryūichi Yokoyama, Tokyo Denki University Press
8. Toshiyuki Hayashi [2004], "Denryoku Shisutemuno Antei Unyōto Kyōkyū Shinraido", *Denryoku Jiyūkano Keizaigaku* coauthored by Tatsuo Hatta/Makoto Tanaka, Toyo Keizai Inc.
9. Makoto Yano [2005]、 *Shitsuno Jidaino Shisutemu Kaikaku*, Iwanami Shoten
10. Brendan Kirby and Eric Hirst [2002], "Reliability Management and Oversight", *National Transmission Grid Study Issue Papers*, U.S. Department of Energy, May 2002
11. David R. Nevius and Ellen P. Vancko [2005], "Ensuring a Reliable North American Electric System in a Competitive Marketplace," *Issue Papers on Reliability and Competition*, August 2005
12. Diana L. Moss [2004], "Competition or Reliability in Electricity? What the Coming Policy Shift Means for Restructuring", *The Electricity Journal* 17(2), 11-28
13. IEA [2005], *Learning from the blackouts*, OECD/IEA, Paris.
14. NERC, [2005], *NERC Reliability Standards Process Manual version 4.0*
15. NERC, [2003], *NERC Reliability Functional Model, Function Definitions and Responsible Entities version 2*
16. Robert J. Thomas [2005], "Managing Relationships Between Electric Power Industry Restructuring and Grid Reliability," *Issue Papers on Reliability and Competition*, August 2005
17. U.S.-Canada Power System Outage Task Force, [2004], *Final Report on the August 14, 2003 Blackout in the United States and Canada: Causes and Recommendations*