

**CIGRE Symposium  
Operation and Development of Power Systems in the New Context  
Guilin China, October 2009**

**Closing Session Special Report – Symposium Summary**

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**INTRODUCTION**

The “new context” in this CIGRE Symposium requires the careful use of scarce resources for maximum benefit with minimum associated impact, enabling network managers to link the benefits of competition, regulation and new technologies with the challenges presented by climate change and new sources of generation.

Considering this new context, the objectives of the symposium were to:

1. Assess the changing role of various players in planning, investment and operation.
2. Assess general issues: security of supply economics, energy policy environment.
3. Take into account the experience of twenty years of restructuring the electricity supply industry and the impacts on operation and security of supply.

Key points addressed during the symposium include:

- Many nations across the world are changing their mode of operation to address the new context.
- Generation uncertainty is a significant global challenge.
- Use of merchant lines and the new role of ENTSO E demonstrate the increasing recognition that broader perspectives need to be taken into account when managing cross border energy transfers.
- Valuable to see challenges being experienced in China and to learn from their actions. China expects to have 21% of global energy demand by 2020.
- New techniques are continuing to be developed to manage changing technology and new system designs.
- There is a growing awareness of asset management and the importance of clear risk assessment to justify investments to stakeholders and regulators; and recognition of the challenge for operators to deliver against those risks.
- The rapid growth in wind generation is creating challenges across the world, including China which expects to have 30GW installed by 2020.
- There is a need to improve the link between renewable investment and markets?
- Markets need to address long term societal objectives as well as deliver economic outcomes.

## **OPENING SESSION:** Jean Kowal

### **Intermittent generation, market interdependencies, benchmarking and the importance of customer satisfaction**

- This session highlighted the challenge of the “new context”. Renewables require a different approach to traditional generation. Offshore “supergrids” or distributed automation? There are mixed views on how well incentives are working.
- There appeared to be general acceptance that there is likely to be a need for more rather than less grid investment. Noted that smart grids will not remove the need for grid investment but this may not be well understood by regulators and governments.
- In benchmarking there are different models that complement each other. However, the discussion highlighted the pitfalls of the misuse of benchmarking data and that its main benefit currently is to help businesses improve even though regulators would like to use it for efficiency comparisons amongst similar businesses.
- The presentation on the customer perspective demonstrated the need for clear concise information to build customer satisfaction and stakeholder reputation. There may be a role for CIGRE to bridge the gap in understanding the existing complex technical issues in non technical communities.

## **SESSION 1A: Utility structures, Alain Taccoen**

### **Examples of Utility Structures**

#### Europe

- Long-term development strategy in Spain with the definition of strategic corridors of diverse importance regarding all possible future situations.
- Quality of supply in the new EU regulation (incentive regulation).

#### Australia

- A new step in the development of the electricity market with the introduction of national policies to support sustainable development (Carbon Pollution Reduction Scheme and Renewable Energy Target).

#### China

- A large increase of energy demand including electricity leading to the conclusion *“the old economic developing mode, that is excessive consumption of energy resources and environment pollution must be replaced by resource saving and environment protection mode”*.

#### Brazil

- The new context is a high diversity of players in the transmission sector. Of course, it helped to develop with a good price, the network that needed large investments, but now it implies some difficulties of coordination.

**SESSION 1B: System development**, David Bones  
Transmission planning and investment

Five papers were presented covering issues including:

- Economic cost benefit analysis for transmission augmentation which requires long term modelling of generation expansion and the impact of transmission on that expansion. Such an approach is already used in Sweden, Chile and Australia.
- Transmission planning in Chile where the system operator conducts a four year transmission expansion plan and offers locational marginal prices to provide some certainty for future generation locations.
- A technique for determining a minimum set of load flow cases that provide adequate coverage of critical power system loading conditions rather than focussing on peak demand periods.
- An illustration of how customer interruption costs are calculated and used to evaluate augmentation proposals in Finland.
- Transmission system developments in Jiangsu Province, China which led to fault level issues and how the use of high impedance transformers supplying isolated grids is intended to increase power supply capability.

**SESSION 2A: Market mechanisms**, Colin Ray

Unbundling models, regulated and merchant interconnectors, congestion management, ancillary services and generator trading rights

- Paper 121 - Unbundling models for TSO activities-normative principles and practical application. The main points covered were unbundling rationale and models, issues resulting from unbundling, regulatory complexity, ISO options, EU policy overview, ownership issues, ITO model and international experience. Concluded unbundling essential to ensure proper market functioning and ISO/ITO models involve additional regulatory and incentives issues
- Paper 122 - The role of merchant and regulated interconnections in the European power market. The main points covered were EC milestones 1996-2007, EC 3<sup>rd</sup> energy package, the two types of interconnectors – merchant and regulated, the pros and cons of merchant option, 3<sup>rd</sup> energy package aims to tackle the issues arising from these interconnector options, and merchant vs regulated revenues covering congestion and socio economic welfare.
- Paper 127 - Generation rights trade model and its applications based on energy saving and emission-reducing. The main points covered were generation rights trade model (GRT), fundamental arrangements covering primary and secondary market, co-ordination between matching trade off and bi-lateral transactions, analysis of GRT showing the mechanism and market efficiency and risks.
- Paper 123 - Development of a congestion management scheme in the Netherlands. The main points covered were why congestion management is needed, Dutch high voltage system and congestion areas, wind farm locations in Holland, basic principles of solving congestion, European flows from wind farms in Germany and commercial/physical flows into Holland, future flows across Europe from wind farms, design criteria for congestion management, solutions (market splitting/redispach, auction, access contracts, charging for transit flows, load control) and issues for further consideration (existing rights of access, charges for management of congestion costs).

- Paper 124 - Ancillary Services: updated review of international practices. The main points covered were an explanation of how data gathered on ancillary services, important for system security/reliability, electricity transfers from generation to load, frequency control (primary/secondary), tertiary control (voltage control, black start), methods of procurement (real time, tendering, bi-lateral contracts, mandatory paid/non-paid), providers of ancillary services (generators/demand within control area, generators/demand outside control area, others), methods of instruction (automatic and manual) and methods for monitoring and penalties for non delivery.
- Paper 125 - Ancillary Services in France. The main points covered were institutional arrangements in France for AS's, frequency control and balancing reserve showing levels and response time, voltage control, black start, use of AS's in balancing mechanism, frequency control, tertiary reserve, congestion management, maintaining reserves, specific contracts with distribution network operators and for black start, and the regulatory system covering mandatory and market provision.
- Paper 126 - Ancillary Services: the Brazilian experience. The main points covered were the role of ONS the Brazilian system operator, Brazilian interconnected power system and charts of generation, transmission, distribution/demand, growth in km of transmission lines built over many years, the commercial arrangements, frequency control (primary/secondary), reserve, reactive power, black start, special protection systems, prices based on combination of fixed and variable costs.
- Contribution from China addressing special reporter question 4, main points covered were the restructuring process in 2002 and the AS's assessment criteria, assessment rules, fee standards, monitoring and management system.

## **SESSION 2B: System Development, Olivier Herz**

Europe, Japan, Africa, North America and Australia – planning issues

The session addressed topics related to two areas:

1. Coordination of the power system operation and planning of the interconnected systems, and
2. Transmission planning.

Today's changing operational environment needs to face the following challenges:

1. More interconnections between regions and between countries.
2. Development of the electricity market.
3. Insertion of a large part of renewable generation, specially wind generation.
4. Operational safety of the power system with new materials such as HVDC cables.
5. Obstacles to construct or reinforce the transmission system.

- Paper 131 introduced the newly founded Coreso (Coordination of Electricity System Operators) centre shared by French and Belgian power transmission system operators (TSOs), joined later by UK's National Grid. Coreso does nationwide analysis and provides operational suggestions to the relevant TSOs. Coreso is open to other TSOs. Three participants introduced their experiences of coordinating operation works. They all agree that it's very important to enhance the coordination among TSOs for improving the security of interconnected systems in open markets. Coreso's experience is successful and can be extended.
- Paper 132 introduced another neutral organization, ESCJ (Electric Power System Council of Japan), which is responsible for ensuring the fairness and the transparency of interregional transmission systems planning and operations among utilities.

Independent academic experts play a very important role in decision making for reinforcement of interconnection lines.

- Paper 133 provided a way to evaluate combinations of expansion plans for interconnected transmission and regional transmission on the basis of calculating transmission congestion costs.
- Paper 134 gave a brief on the situation of the power sector in Africa, especially energy reserves and power deficits faced nowadays and it presents the five development strategies proposed by UPDEA (Union of Producers, Transporters and Distributors of Electric Power in Africa).
- Paper 135 discussed a very specific and practical issue. The author focuses on the effects of generation dispatch on transmission system planning. Three types of dispatch are mentioned: economic dispatch, stressed dispatch and flat dispatch. The paper shows that different generation dispatches result in different transmission planning solutions. After comparison of the three generation dispatches through case studies, the paper concludes that stressed dispatch should be better. Some participants presented their experience. The stressed dispatch is widely used in North America because of NERC requirements. In Chile, the base case is starting from economic dispatch and is reexamined with the study of stressed dispatch. The question on how to consider the effects of wind power on economic dispatch is indeed a problem that we have to face today. Maybe economic dispatch can take into consideration the effects of environment costs or other factors, which will need a lot of work?
- Paper 136 proposes a methodology for optimizing generation contracts and discusses issues on efficient transmission investments. There is a need for more research to evaluate the effectiveness of the timing and the scale of new generation investments by transmission planners to get an effective transmission investment.

### **SESSION 3A: Market Mechanisms**, Albert Di Caprio Grid Codes, connection rules and adequacy

The session addressed the issues of the interrelationships of markets and grid codes and more specifically the balance between market driven objectives and regulator driven objectives.

The authors provided views on drivers, barriers and models for incentivising a variety of objectives including distributed generation, wind and 'global social' objectives.

The symposium discussion included the need to recognise when a regulation or a market rule changes from "fulfilling a justified need", to becoming a perverse driver that hurts rather than helps "the common good".

Examples cited were: the possibility that drivers to reduce carbon could drive out generation resources needed to sustain transmission grid reliability, or conversely the drive to fill short term political expediencies at the expense of long term social needs.

The very definition of today's industry objectives was debated. What constitutes generation adequacy in today's electric power industry – in today's world? Can and should multi national solutions and optimisations be used? What constitutes optimisation?

For CIGRE, our discussion of measuring the success or failure of today's regulations and market rules indicates a need for continuing to closely monitor market trends and market impacts in an objective and independent fashion, particularly as we transition from local to global paradigms.

**SESSION 3B: System Analysis**, David Bones on behalf of W. Xiaochem  
Reliability, transient stability and inter-area coordination

Five papers were accepted for this session and all were presented. The papers covered a range of power system analysis topics:

- Paper 151 discussed the application of a technique known as Probabilistic Safe Assessment to assess the security of the power system in Finland and its variation with system conditions. Through discussion we learned of the techniques employed in Finland to gather the failure statistics necessary to support this analysis.
- Paper 153 describes power system stability analysis software developed at the Czech Technical University in Prague. This application was developed in Matlab and is specifically designed to assess the stability implications of connection of large amounts of distributed generation into distribution network. Through discussion we learned that researchers have found that there is significant variety in distribution network topology and design which makes it difficult to make general conclusions which would apply to all distribution networks.
- Paper 154 described a technique developed in Korea which utilised an Optimal Power Flow to optimise inter-area interchanges while maintaining small signal stability.
- Paper 156 described reliability studies that have been undertaken in China to assess the impact on reliability of a proposed UHVDC connection. An 800kV UHVDC link with a power transmission capacity of 6.4GW is proposed to transmit power from hydro generation in the west to demand centres in the east. The paper reports the results of non-sequential monte-carlo studies performed to assess the impact on the reliability of the power system of this proposed UHVDC connection. The studies showed that the inclusion of the UHVDC link did not significantly change the reliability of the East China Power Grid. Through discussion we explored how sensitivity studies were used to test the impact of the UHVDC connection being less reliable than designed.
- Paper 157 presented the results of a reliability assessment of the Brazilian Power System, conducted using a state enumeration technique. Through discussion we learned that the reliability of border transformers was a significant factor in the overall power system reliability. Paper 157 and 156 provide a good contrast of two different applications of tools and techniques for assessing Power System Reliability.

**SESSION 4A: Asset Management** Eric Rijks  
Developing and developed world, existing and new risk assessment

The international development of standards for Asset Management is felt to be very useful for the implementation of asset management processes within electricity transmission companies.

Risk management and how risk management should be incorporated in the decision making processes of an asset manager are still subject to much discussion. While some feel that impacts of possible events are the key factor in the investment decisions on assets, others feel that leaving the probability of the events out of the considerations means a loss of key information for the decisions.

Risk management methodologies for asset management of electricity transmission infrastructures are developing. In our discussions we have seen that qualitative risk assessment, based on engineering judgement can be useful, but that the increasing regulatory and financial scrutiny of asset investment plans require a more quantitative, scientific risk management methodology in the future.

## **SESSION 4B: System Security, Ben Li**

Risk assessment, security indices and use of wide area SCADA/EMS

This session dealt with system security, more specifically, transmission system security.

System security is one of the key components in ensuring reliable power supply to end-use customers. Following market liberalisation in many countries with increased cross-boundary trades, transmission systems are operated closer to their limits than ever before.

Transmission system security under the deregulated regime is of growing concern.

With new technology, methods to assess transmission system security near real-time also break new grounds. The papers presented in this session touched on some of the innovative ideas.

Four papers related to system security were presented in this session. These papers dealt with the following topics:

- Security indices as indicators of system security.
- Risk assessment of transient voltage instability to aid decisions in SVC investment.
- Risk assessment for operations in the Portuguese transmission system using a probabilistic approach to assessing contingencies.
- Wide area IP-based EMS/SCADA system - its flexibility for grid operational structure reform under deregulation environment.

Four questions were posted on the CIGRE web site prior to the Symposium. Following the presentations, the audience participated actively in discussion, asked additional questions, and freely exchanged views on:

- Risk taking consequence, and trade-offs between deterministic and probabilistic approaches in selecting contingencies for security analyses.
- Practical use of security indices and risk assessment indices for operator actions.
- Latest development in Dynamic Security Analysis tool to aid operator decisions.
- Concept of virtual system control centers – primary and backup, using IP-based network and web-based information system.

It is expected that with technology advancing so rapidly, the industry may see further breakthroughs and new developments in the near future. An update may be appropriate at the next CIGRE Session or Symposium.

## **SESSION 5A: Sustainability, Environment and Integration, Juan Fran Alonso**

Sustainability in distribution and transmission, energy saving dispatch, energy policy and wind power challenges

Three papers were presented on sustainability (with paper 181 from Finland), the environment (with paper 185 from China and France) and wind integration (with paper 187 from China) described in brief below:

- Paper 181 from Finland introduced sustainability as a fundamental objective in distribution - presented as a new dimension in addition to the reliability and profitability objectives normally considered. A theoretical model integrating the valuation of sustainability performance criteria was presented, with the expectation of evolving it into a tool that can be practically applied. Discussion included some interventions mentioning practical examples of sustainability integration as well as commenting on how regulation should include this topic.
- Paper 185 from China and France has presented implementation and experience of eco-design by a multinational firm of power equipment, explaining practices according

to IEC standards as well as the participation of eco-design experts in all different production units involved. A tool for designing products and services was presented, as well as practical cases.

- Paper 187 from China exposed Wind Integration in China, with the challenges for the power system, mainly concerning operation problems, power balance capability, reactive control and stability. Interventions from the audience pointed towards LVRT capability requirements and retribution systems, enabling additional information from the authors. Finally, some reflections on the organisational challenges, especially the cooperative relationships between the TSOs and the wind generators so that technical challenges are better tackled, were made.

### **SESSION 5B: System Control, Joachim Vanzetta**

Automatic voltage control, dc and offshore wind, system monitoring and fault diagnosis

Six very interesting papers were presented about the operation and development of power systems. A Chinese and Korean paper presented new approaches of automatic voltage control systems. Another Korean paper presented the Wide Area Monitoring System (WAMS) architecture of the Korean Power System. Furthermore, alarming and expert systems for fault diagnosis in power systems were described. One major current challenge of the wind power integration is the grid to offshore wind farm connection. Therefore paper 192 described a coordinated control of a multi-terminal HVDC transmission system for offshore wind farms. Next is a brief summary of the session:

- Paper 191 “A Novel Automatic Voltage Control on Large Power System” described a coordinated automatic voltage control system used in a large power system, installed at the Jiangsu Electric Power Company. A three-level hierarchical control structure was presented. The automatic voltage regulators (AVR), installed on every generator, are overlaid by a decentralized area control scheme (secondary voltage control), finally the tertiary level realizes a global control. The online optimal power flow (OPF) algorithm is supplemented by a dynamic security assessment (DSA) tool, which includes an early warning procedure.
- One major challenge of the wind power integration is the grid to offshore wind farm connection. Paper 192 “Coordinated Control of a Multi-Terminal HVDC Transmission System for Integrating Large Offshore Wind Farms” described a coordinated control of a multi-terminal HVDC transmission system for offshore wind farms. Simulations of a four-terminal DC system for connecting two offshore wind farms to two different onshore AC networks were presented. The simulations showed the system’s performance during wind speed and power variations. Furthermore the system behaviour after a disturbance, the tripping of a wind farm, was analyzed. Until now there are no experiences of multi-terminal HVDC transmission systems in operation.
- Paper 193 “Application of Electric Power Alarming and Coordinated Control System in Jiangsu Power Grid” described a system for the identification of critical system states. The presented Electric Power Alarming and Coordinated Control System (EACCS) is installed at Jiangsu Electric Power Company and consists of real-time early warning, decision-making and coordinated control systems for security and stability. Examples of the successful operation during hurricane events were described.
- Paper 194 “Korean Wide-Area Monitoring System for Maintaining Real time Voltage stability of Metropolitan Region in Korea Using PMU measurements” described the Wide Area Monitoring System (WAMS) architecture of the Korean Power System. The ongoing analysis concerning the optimal location and amount of Phasor Measurement Units

(PMUs) to be installed were described. Four PMUs are already installed and in the following years 100 PMUs are going to be installed. Furthermore a voltage stability index algorithm (WAVI), as an indicator for voltage instability, was introduced.

- In Paper 195 “Coordinated Voltage Control between CVC (Continuous Voltage Control) and DVC (Discrete Voltage Control) to Enhance Voltage Stability in Jeju Power System” a coordinated voltage control system for voltage and reactive power management of the Korean island power system Jeju was described. By coordination of generators and switch shunt devices, reactive power reserve of generators is reserved for emergency situations. To verify the performance of the system, simulations results were presented.
- Paper 196 “An Improved Association Rules Mining Algorithm in Fault Diagnosis Expert System of Power System” presented an expert system for fault diagnosis in power systems. The results of the expert system were tested and verified by use cases. Until now there are no operational experiences.