

# Guest Editorial

## Introduction to the Special Section on Planning and Operation of Transmission Grid with Applications to Smart Grid—From Concept to Implementation

This special section addresses the challenges and opportunities for the development of a transmission grid with applications to smart grid and brings together the most recent advances from concept to implementation in the field of transmission operation, control, and planning worldwide.

The special section covers the design and planning of operation and communication systems of smart transmission grids; state estimation of smart transmission grids; smart voltage and power flow control as well as generalized power network management; wind generation and emission constrained dispatching for smart grids; smart demand as power grid services; wide area monitoring, control as well as emergency control.

### **Design and Planning of Operation and Communication Systems of Smart Transmission Grid**

The paper entitled “Conceptual Design and the Future Development for Operation Smart System in China Southern Power Grid” presents the current status of the technical supporting systems in the control centers and substations of China Southern Power Grid (CSG). A new conceptual model of next generation system, named Operation Smart System (OS2) is proposed. It is believed that the research and development of OS2 will significantly benefit the grid operation of CSG.

The paper entitled “Smart Grid Infrastructure Using a Hybrid Network Architecture” proposes a digital system for condition monitoring, diagnosis and supervisory control that can be applied to smart grids. The system is based on hybrid network architecture, consisting of a Wired Infrastructure, a Wireless Sensor Network (WSN) and a Power Line Communications (PLC). The basic characteristics are: a) easy/low cost implementation, b) easy to set up by user, c) easy implementation of redundant routines (security), d) portability/versatility, and e) open system.

### **State Estimation of Smart Transmission Grid**

The paper entitled “Analog-Digital Power System State Estimation Based on Information Theory—Part I: Theory” proposes a novel method of power system state estimation that makes use of information theory to calculate an accurate real-time power system model from a set of analogue and digital measurements.

The merit of the paper is that it proposed minimum-information-loss (MIL) method, which seamlessly unifies the maximum a posteriori estimation of both analogue and digital quantities such as bus voltages and switch statuses. In fact, the well-known weighted least-square (WLS) estimation is just a special case of the comprehensive MIL state estimation.

The paper entitled “Analog-Digital Power System State Estimation Based on Information Theory—Part II: Implementation and Application” shows the implementation and validation of an accurate real time power system MIL model from a set of analog and digital measurements. The performance of the MIL method is evaluated on the IEEE test system as well as two real-life test systems. The MIL method would be very useful in the framework of smart grids.

### **Smart Power Flow, Voltage Control, as Well as Generalized Power Grid Control**

The paper entitled “Power Flow Controlling Devices as a Smart and Independent Grid Investment for Flexible Grid Operations: Belgian Case Study” describes the Belgian case for different stages of the grid management: investment, planning, scheduling and operations using power flow controlling devices, including practical aspects. Two technologies such as the traditional phase shifting transformer and voltage source converter HVDC are considered in the study.

The paper entitled “Optimal Voltage Control of PJM Smart Transmission Grid: Study, Implementation, and Evaluation” discusses the smart voltage control method for PJM Interconnection who operates the largest synchronized transmission system in North America where one the system-wide voltage control performance requirements both pre- and post contingency are considered.

The paper entitled “Managements of Generalized Congestions” proposes a new concept of generalized congestions to describe the factors affecting both the competition level and the efficiency of power markets. This paper analyzes generalized congestions, market power, and generalized market power in many aspects including taxonomy, evaluation indexes, control measures, and the corresponding research methods.

### **Operation of Smart Transmission Grid With Wind Generation and Emission Constrains**

The paper entitled “Wind Power Dispatch Supporting Technologies and Its Implementation” considers the challenges of

Chinese wind power generation and introduces a framework and four key supporting technologies for the proposed wind power dispatch system. The despatching system has already been put into operation in the Northwest Grid of China and the performance of the proposed system in the Northwest Grid of China is demonstrated.

The paper entitled “Emission-Concerned Wind-EV Coordination on the Transmission Grid Side With Network Constraints: Concept and Case Study” presents a study of emission-concerned wind–electric vehicle (EV) coordination at the transmission grid level. The basic idea is that an aggregator model representing a cluster of controllable EVs is coordinated with large-scale wind power generation at the transmission grid level.

### **Smart Demand as System Control Services of Smart Transmission Grid**

The paper entitled “Economical Regulation Power Through Load Shifting With Smart Energy Appliances” considers the technical and economical feasibility of the introduction of automated demand response from domestic smart appliances in a European setting as a means of a significant amount of regulating power. The study shows that classical load shifting of washing appliances creates sufficient value in the day-ahead market to justify investments in smart energy control services while cooling appliances create significant value on the balance market.

The paper entitled “Smart Demand for Frequency Regulation: Experimental Results” presents the results of field experiments using demand as a frequency controlled reserve (DFCR) on appliances with programmable thermostats. The tests show that a population of refrigerators is able to deliver frequency reserves approximately equal to their average power consumption, electric space heaters are able to provide frequency reserves of over 90% their maximum power consumption in certain weather conditions.

### **Wide Area Monitoring, Control, as Well as Emergency Control of Smart Transmission Grid**

The paper entitled “Wide Area Inter-Area Oscillation Monitoring Using Fast Nonlinear Estimation Algorithm” presents the results of the development of Smart Grid transmission network applications in the Great Britain (GB) power system. The core of this novel application is a fast nonlinear algorithm for the

real-time estimation of the dominant inter-area oscillation mode based on the Newton-Type Algorithm (NTA).

The paper entitled “Smart Technologies in Emergency Control of Russia’s Unified Energy System” shows the distinctive features of the Unified Energy System (UES) of Russia and presents the current emergency control system. A modern approach to monitoring, forecasting, and control is suggested and some artificial intelligence applications for development of emergency control in the UES of Russia are presented with new smart measurement, communication and control tools, information, and computer technologies.

### ACKNOWLEDGMENT

The guest editorial board would like to thank the IEEE Power and Energy Society, the authors for their contributions to this special section, and the reviewers for their valuable comments and suggestions. Special thanks to Dr. Mohammad Shahidehpour, Editor-In-Chief of the IEEE TRANSACTIONS ON SMART GRID, and Ms. Cheryl Koster, IEEE PES Publications Administrator, for their timely help and support.

Xiao-Ping Zhang, *Guest Editor-in-Chief*  
University of Birmingham  
Birmingham, U.K.

Ronnie Belmans, *Guest Editor*  
Katholieke Universiteit Leuven  
Leuven, Belgium

Daniel Kirschen, *Guest Editor*  
University of Washington  
Seattle, WA USA

David Sun, *Guest Editor*  
Alstom Grid  
Seattle, WA USA

Ebrahim Vaahedi, *Guest Editor*  
BC Hydro  
Vancouver, Canada

Yusheng Xue, *Guest Editor*  
State Grid EPRI  
Nanjing, China