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Carbon Market Risk Analysis & Defense based on Hybrid Simulation - a Perspective from Cyber Physical Social Systems in Energy

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Abstract

Smart grids are a complex cyber–physical system by their very nature, and this has impacted the way energy is generated, transported and consumed. With the rapid evolution of the power system, multi-domain impacts should be considered, such as non-electrical-energy systems (such as wind, solar, hydro, thermal and hydrogen), non-energy systems (such as weather, climate and transportation), and social behaviors (such as regulation, investment, trading and consumption behaviors). The tighter coupling among wide-area information, energy systems and social elements has prompted the relevant research to extend from Cyber Physical Systems in Power (CPSP) to Cyber Physical Social Systems in Energy (CPSSE).

Nowadays, climate change has become the core challenge for the sustainable development of human society, and reducing greenhouse gas emissions from anthropic activities has become more and more urgent. Among all the policy options, carbon market using the “cap-and-trade” model has been widely recognized. Currently, 35 countries, 15 states or provinces, and 7 cities around the world have launched carbon markets. China has also implemented pilot carbon markets since 2011 and officially launched the national carbon market on Dec. 19, 2017. Being energy and emission-intensive, power systems have the responsibility to undertake the emission reduction mission, and power companies are the major players in carbon market. The fast development of the carbon market will have a significant impact on the planning and operation of the energy and power system.

To address the above-mentioned challenges, our research team expands the research perspective of energy and power systems to the carbon market. Under the framework of CPSSE, the cross-domain integrations in information acquisition, knowledge extraction and decision support are analyzed, the feedback control strategies based on sand table simulation are studied. Firstly, the relationship between climate constraints and the carbon market is discussed, and the status-quo of China’s carbon market is introduced. Secondly, the mechanism of carbon market risk is elaborated from a regulatory perspective, the carbon market risk analysis and control practices in recent years are reviewed. Furthermore, a multi-line risk defense framework of carbon market is proposed by defining key features such as "disturbance occurrence", "parameter violation" and "market malfunction" and the coordinated control optimization method under this framework is discussed. Finally, the problem of carbon market risk prevention and control is mathematically formulated. Sand-table simulation and risk quantitative analysis technologies are suggested to be further investigated to support carbon market risk analysis and control.