CIGRE Study Committee D2

PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP

WG D2.56	**Name of Convenor:** Qinglai Guo (CHINA) **E-mail address**: guoqinglai@tsinghua.edu.cn	
Strategic Directions #[2]: 1	**Sustainable Development Goal #[3]: 9**	
The WG applies to distribution networks: ☒ **Yes /** ☐ **No**		
Potential Benefit of WG work #[4] : 4		
Title of the Group: Interdependence and Security of Cyber-Physical Power System (CPPS)		

Scope, deliverables and proposed time schedule of the WG:

Background:

With the extensive deployment of advanced technologies and applications that systematically interconnect centralized and distributed controllers, sensors, physical devices, and various stakeholders involved in many processes, the future smart grid is extending its functionality by allowing a two-way flow of both electricity and information. Modern power systems heavily rely on communications and computer infrastructures for their sensing, protection, control, and real-time operation, hence qualifying power systems as typical CPPS, which changes the way we interact with the physical world and power world. The disturbance, failure, or attack inside the cyber part will definitely jeopardize the physical power system operation. The modelling, operation, and control of power systems should therefore consider the interdependence between cyber and physical systems.

These new features will also arouse challenges and research interests. The existing methodologies are mainly focusing on the physical side or the cyber side respectively and have not paid enough attention to the interdependence and interaction of the two parts. As the interdependence between the physical side and cyber side gets stronger, the secure operation of power system increasingly relies on cybersecurity. To reach a better understanding of the interdependence and security of cyber-physical power systems, this working group is proposed to focus on the CPPS's concept, development of new technologies and algorithms for the integrated cyber-physical power system modelling and analysis, secure and reliable operation, and resilient control of CPPS.

Moreover, as an important component of cyber-physical systems, digital twin (DT) is an integrated multi-physics, multi-scale, probabilistic simulation of a system that uses high-precision physical models, real-time data, etc. For precise large-scale real-time simulation and pre-decision-making of complex CPPSs, digital twin (DT) toward CPPSs should also be considered in this working group.

Since this is a new perspective of power systems, this working group will rely on experts which are familiar with the systemic approach and, when necessary, will be in contact with other working groups to ask for information related to their specific topics.

Scope:

The proposed plan is for a 3-year working group, with the goal of producing reports documenting current practices and significant innovations, organizing conferences, panel sessions and special issues on publications. The working group will:

1. Issue CIGRE technical reports phase by phase after the start of the working group and review the current status of CPPS, identifying ongoing significant R&D efforts and potential gaps. The objective of these reports is to serve as a reference for CIGRE members in the field about the latest development and improve the understanding of the emerging CPPS technologies.
2. Investigate the worldwide blackouts with cyber-physical coupling failures causing by natural hazards and cyberattacks over the decades, identify the mechanism of the cyber-physical interdependence and the increased risk associated with this interdependence.
3. Review hierarchical architecture of the communication networks and their corresponding measurement/control services for power grids of different utilities. Exploring the interdependence between communication networks and power grids.
4. Explore the current different methodologies for modelling and interdependence analysis in CPPSs, identify the scenarios they apply to and figure out how to improve their versatility.
5. Identify and discuss the application of digital twin (DT) in high-precision real-time simulation and pre-decision-making of CPPSs, especially for simulation of hierarchical communication networks. Defining step by step methodology to expand the deployment of DT regards to the reinforcement of interdependence and security of CPPS.
6. Identify the current cyber-attack incidents and potential cyber threats of power systems. Verifying security issues to ensure the effective application of DT in the simulation of CPPS in the face of various types of cyber threats.
7. Identify the current resilience enhancements techniques for modern power systems considering cyber-physical interdependences, especially in the face of natural hazards and cyberattacks.
8. Benchmark standard cases for cyber-physical system (CPS) in power systems. The standard system will serve as the test-bed on coordinated calculation and assessment of static and dynamic characteristics of CPPS in a power system application scenario. Further novel methods and theories could be tested with these system settings.

Joint work with other SCs: Liaison experts from SC C1 will be invited.

Remarks:

Cyber-physical system (CPS) (National Science Foundation, 2006)

Cyber-physical systems (CPS) are engineered systems that are built from, and depend upon, the seamless integration of computational algorithms and physical components. Advances in CPS will enable capability, adaptability, scalability, resiliency, safety, security, and usability that will far exceed the simple embedded systems of today.

Cyber-Physical Power System (CPPS) (Institute of Electrical and Electronics Engineers, 2020)

The traditional power systems with physical equipment as a core element are more integrated with information and communication technology, which evolves into the Cyber-Physical Power System (CPPS). The CPPS consists of a physical system tightly integrated with cyber systems

(control, computing, and communication functions) and allows the two-way flows of electricity and information for enabling smart grid technologies. **Deliverables:** ☒ Technical Brochure and Executive Summary in Electra ☒ Electra Report ☐ Future Connections ☐ CSE ☒ Tutorial ☐ Webinar **Time Schedule**: start: Jan 2022 **Final Report**: Dec 2024
Approval by Technical Council Chairman: **Date**: January 18th, 2022

Notes: [1] Working Group (WG) or Joint WG (JWG), [2] See attached Table 1, [3]See attached Table 2 and CIGRE reference Paper: Sustainability – at the heart of CIGRE's work. [4] See attached Table 3

Table 1: Strategic directions of the Technical Council

1	The electrical power system of the future reinforcing the End-to-End nature of CIGRE: respond to speed of changes in the industry by preparing and disseminating state-of-the-art technological advances
2	Making the best use of the existing systems
3	Focus on the environment and sustainability (in case the WG shows a direct contribution to at least one SDG)
4	Preparation of material readable for non-technical audience

Table 2: Environmental requirements and sustainable development goals

	CIGRE selected the 7 SDGs that are the most relevant to CIGRE. In case the WG work refers to other SDGs or do not address any specific SDG, it will be quoted 0.
0	Other SDGs or not applied
7	**SDG 7: Affordable and clean energy** Increase share of renewable energy; e.g. expand infrastructure for supplying sustainable energy services; ensure universal access to affordable, reliable, and modern energy services; energy efficiency; facilitate access to clean energy research and technology
9	**SDG 9: Industry, innovation and infrastructure** Facilitate sustainable infrastructure development; facilitate technological and technical support
11	**SDG 11: Sustainable cities and communities** Increase attention on sustainable and resilient buildings utilizing local (raw) materials, power for electric vehicles, strengthening long-line transmission and distribution systems to import necessary power to cities, developing micro-grids to reinforce the sustainable nature of cities; protect and safeguard the world's cultural and natural heritage; reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and waste management
12	**SDG 12: Responsible consumption and production** E.g. Promote public procurement practices that are sustainable; address reducing use of SF6 and promote alternatives, encourage companies to adopt sustainable practices and to integrate sustainability information into their reporting cycle, address inefficient fossil-fuel subsidies that encourage wasteful consumption
13	**SDG 13: Climate action** E.g. Increase share of renewable or other CO_2-free energy; energy efficiency; expand infrastructure for supplying sustainable energy; strengthen resilience and adaptive capacity to climate-related hazards and natural disasters; integrate climate change measures into national policies, strategies and planning; improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning
14	**SDG 14: Life below water** E.g. Effects of offshore windfarms; effects of submarine cables on sea-life
15	**SDG 15: Life on land** E.g. Attention for vegetation management; bird collisions; integration of substations and lines into the landscape

Table 3: Potential benefit of work

1	Commercial, business, social and economic benefits for industry or the community can be identified as a direct result of this work
2	Existing or future high interest in the work from a wide range of stakeholders
3	Work is likely to contribute to new or revised industry standards or with other long term interest for the Electric Power Industry
4	State-of-the-art or innovative solutions or new technical directions
5	Guide or survey related to existing techniques; or an update on past work or previous Technical Brochures
6	Work likely to contribute to improved safety.