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The Future Control Rooms for Sustainable Power Systems: Current Landscape and Operational Challenges

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Abstract : The electric power system is undergoing significant changes. Thereby, the operation and control are becoming partly modified, more multifaceted and automated, and thereby supplementary operator skills might be required. This paper discusses developing operational challenges in future power system control rooms, posed by the evolving landscape of sustainable power systems, driven in turn by the shift towards electrification and renewable energy sources. A literature review followed by interviews and a comparison to other related domains with similar characteristics, a descriptive analysis was performed from a human factors perspective. Analysis is meant to identify trends, relationships, and challenges. A power control domain taxonomy includes a temporal domain (planning and real-time operation) and three operational domains within the power system (generation, switching and balancing). Within each operational domain, there are different control actions, either in the planning stage or in the real-time operation, that affect the overall operation of the power system. In addition to the temporal dimension, the control domains are divided in space between a multitude of different actors distributed across many different locations. A control room is a central location where different types of information are monitored and controlled, alarms are responded to, and deviations are handled by the control room operators. The operators' competencies, teamwork skills, team shift patterns as well as control system designs are all important factors in ensuring efficient and safe electricity grid management. As the power system evolves with sustainable energy technologies, challenges are found. Questions are raised regarding whether the operators' tacit knowledge, experience and operation skills of today are sufficient to make constructive decisions to solve modified and new control tasks, especially during disturbed operations or abnormalities. Which new skills need to be developed in planning and real-time operation to provide efficient generation and delivery of energy through the system? How should the user interfaces be developed to assist operators in processing the increasing amount of information? Are some skills at risk of being lost when the systems change? How should the physical environment and collaborations between different stakeholders within and outside the control room develop to support operator control? To conclude, the system change will provide many benefits related to electrification and renewable energy sources, but it is important to address the operators' challenges with increasing complexity. The control tasks will be modified, and additional operator skills are needed to perform efficient and safe operations. Also, the whole human-technology-organization system needs to be considered, including the physical environment, the technical aids and the information systems, the operators' physical and mental well-being, as well as the social and organizational systems.

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