CYPRESS

CYPRESS: Report D1.1 describing the selected performance metrics

Task 1.1 - Project Report

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Contents

Executive Summary

This document is the first deliverable of the "*Cyber-Physical Risk of the bulk Electric Energy Supply System*" (CYPRESS) project.

The CYPRESS project aims at developing novel knowledge, methods and tools needed to help ensure the security of supply through the transmission grid, while accounting for the specific nature of cyber-threats and integrating them into a coherent probabilistic risk management approach. It is articulated along three research themes, aiming to develop: i) novel models and benchmarks for computer simulation and laboratory testing of the cyber-physical electric power system security of supply, ii) techniques for assessing the cyber-physical security of electric energy supply, and iii) techniques for enhancing the cyber-physical security of electric energy supply. The project scope falls entirely within the category of "fundamental research" within the meaning of Regulation (EU) No 651/2014 because it is experimental and theoretical work undertaken essentially with a view to acquire new knowledge on the foundations of phenomena or observable facts. The project is not intended to develop commercial tools.

The work presented in this document has been performed in the frame of CYPRESS WP1, titled "*Criteria and benchmarks for cyber-physical risk management*". The objective of CYPRESS WP1 is to generalize and adapt the concepts currently used in reliability management of electric power and energy systems so that they can correctly cover the cyber-threats from various system wide control and communication layers. The document is the outcome of task 1.1, seeking to develop relevant performance metrics to quantify the overall level of cyber-security, resilience and reliability of a bulk electric power system and to quantify how these properties decompose over the different subsystems, such as national transmission grids, generation systems, and lower voltage distribution grid.

As task 1.1 was the first activity in the CYPRESS project, the need to first establish a common understanding of the basic concepts in electrical energy physical and cyber systems, and to share bibliographic resources, became apparent. Rather than achieving this shared understanding implicitly, the onset of this report first provides essential background on electric power systems (Chapter 2) and communication networks (Chapter 3), as well as the conceptual definitions of reliability, resilience and cyber-security (Chapter 4). The report subsequently introduces relevant reliability and resilience metrics that are presently used by the electric power system stakeholders as well as prominent proposals from the scientific literature (Chapter 5) and relevant cyber-security metrics (Chapter 6). It must be noted that the focus has been placed on the clear introduction of such metrics, and on establishing their relevance for the research scope of the CYPRESS project. The applicability of these metrics over different subsystems (*e.g.*, national transmission grids, lower voltage distribution grids, *etc.*) is also presented. Defining the precise decomposition approach for such metrics is a topic that has to be followed up at a latter stage, and while precisely developing the proposed methodologies

for cyber-physical risk assessment and risk management in electric power systems.

Author contributions

Table 1 lists all the authors that have contributed to this report. Efthymios Karangelos[1] wrote chapter 1, co-wrote chapters 2, 4 and 5 and is the main editor of the report. Klaas Thoelen took the lead in writing Chapter 3, proof-read the entire document and provided related feedback for improvements and corrections. Farshid Faghihi co-wrote chapters chapters 2 and 5. Frédéric Sabot co-wrote chapters chapters 2 and 5. He also contributed to the discussions for all power system-related parts, and reviewed the whole document. Dave Singelée and Volkan Guler wrote chapter 4 and co-wrote 6. Jonathan Francart provided inputs to chapters 4 and 6. Pierre Henneaux and Hakan Ergun reviewed the entire document and provided feedback.

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