# ENGINEERING RESILIENCE TO POWER OUTAGES

**Eric RIGAUD** [1], Anouck ADROT[2], Frank FIEDRICH[3], Thomas MÜNZBERG[4],Wolfgang RASKOB[4], Frank SCHULTMANN[5], Marcus WIENS[5]

[1] MINES ParisTech, PSL Research University, CRC, Centre de recherche sur les risques et les crises, CS 10207 rue Claude Daunesse 06904 Sophia Antipolis Cedex, France

[1] eric.rigaud@mines-paristech.fr / +334 93 95 74 86

[2] Paris-Dauphine University, PSL Research University, Dauphine Recherches en Management DRM UMR CNRS 7088 Place du Maréchal Delattre de Tassigny, 75116 Paris Cedex

[2] anouck.adrot@dauphine.fr/ +33144054045

[3] Wuppertal University, Institute for Public Safety and Emergency Management, Gaussstr. 20, 42119 Wuppertal, Germany

[3] fiedrich@uni-wuppertal.de / +49 202 31713280

[4] Karlsruhe Institute of Technology (KIT), Institute for Nuclear and Energy Technologies Hermann-von-Helmholtz Platz 1, 76344 Eggenstein-Leopoldshafen, Germany

[4] thomas.muenzberg@kit.edu, wolfgang.raskob@kit.edu

[5] Karlsruhe Institute of Technology (KIT), Institute for Industrial Production (IIP) Hertzstraße 16, 76187 Karlsruhe, Germany

[5] frank.schultmann@kit.edu, marcus.wiens@kit.edu

## SUMMARY

The aim of the proposed paper is to apply resilience engineering thinking to power outages in the prospect of a definition of power blackout. This definition will support the development of a simulator based on a multi agent system and a guideline dedicated to the assessment and the enhancement of systems resilience to power outages.

Resilience engineering thinking refers to a new way to describe the dynamics of systems coping with threats and associated safety management system development. This approach aims to consider, among other, systems adaptive capacity to both anticipated and unanticipated situations and to support the development of associated safety management systems.

Power blackout refers to a short or long term loss of the electric power to a geographic area. Consequences of power outage depend, among other factors, on the duration of the loss of power and on the number of people and assets affected within the geographic area. As critical infrastructures are strongly interdependent, power outages can be a consequence and/ or a cause of other threats and consequently be part of a systemic crisis and disaster. However, the consequences of power blackouts have been persistently underestimated risks.

Applying resilience engineering thinking to power outages implies the definition of a four dimensional model. The first dimension refers to the system adaptive capacities to respond and recover to the occurrence of unwanted situations in general and to power outages in particular. The second dimension is related to the functions that support the improvement of adaptive capacities before and after occurrence of a threat. The third dimension refers to the diversity and the complexity of power outages threats. The fourth dimension concerns the short and long terms adaptive processes that stem from the reaction of the system to the occurrence of a power outage.

The design of this model will consider, among other factors, intrinsic properties of power outages (speed of onset, duration, area affected, etc.), systems connectivity and their potential escalation and propagation, adaptation processes to known situations and surprises, learning, monitoring and anticipating support functions, respond process and associated human and group dimensions.

The paper will be structured in three parts. The first part is dedicated to the presentation of power outage

threats. The second part is related the presentation of the theoretical background of the model. The third and final part presents the model proposed.

## RELEVANCE TO "MANAGING RESILIENCE, LEARNING TO BE ADAPTABLE AND PROACTIVE IN AN UNPREDICTABLE WORLD"

The proposed paper contributes to the topics of the symposium by i) putting into perspective different approaches of socio-technical systems and communities' resilience, ii) defining a model that supports the analysis and improvement of systems' capabilities to respond and recover from the adverse and complex effects of power outages. The proposed model, by taking into account the diversity of power outages as well as the characteristics and adaptive capacity of systems involved in power outages will support the definition of the fundamentals of power outages resilience management.

## SIGNIFICANCE/TAKEAWAY: HOW DOES THE PROPOSAL ADVANCE OUR ABILITY TO CREATE AND SUSTAIN RESILIENCE?

Definition of a model of system resilience to power outage is a preliminary step for defining the system resilience to power outage management, to design associated assessment and improvement methods and to develop a multi-agent system simulator. The model will support the performance of studies of power outages with integrating different dimensions of resilience management. Both, the simulator and method will concretely support the improvement of system resilience to power outages.

The set-up of a system-resilience-model to power outage is an essential element of a holistic approach to resilience management. In addition, the system oriented approach, as well as the multi-agent simulator, will improve the assessment of complex risk structures and enhance the system resilience. The model will support the performance of studies of power outages by integrating different dimensions of resilience management.

## REFERENCES

Boin A., Comfort L. K., Demchak C., 2010. The rise of resilience, in Comfort L.K., Boin A., Demchak C.C., (eds.), Designing resilience, preparing for extreme events, University of Pittsburgh Press.

Hollnagel E., 2011. Prologue: The Scope of Resilience Engineering, in Hollnagel E., Pariès J., Woods D. D. and Wreathall J., Resilience Engineering in Practice. Ashgate Studies in Resilience Engineering.

Münzberg T., Wiens M., Schultmann F., Dynamic-spatial Vulnerability Assessments: A Methodical Review for Decision Support in Emergency Planning for Power Outages, Humanitarian Technology: Science, Systems and Global Impact 2014, HumTech2014, Procedia Engineering, Volume 78, 2014, Pages 78–87

Woods D. D., 2006. Essential Characteristics of Resilience, in Hollnagel E., Woods D., Leveson N., Resilience Engineering: Concepts and Precepts, Ashgate.