Reliability Studies in Information and Communication Technology(ICT)-dominated Power Systems

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Challenges and objectives

- Integration of distributed renewable energy resources, growing number of electric vehicles, demand-side management programs, generation-side management as well as remote switching require moving toward a smart distribution system.
- A smart distribution can be achieved by the deployment of Information and Communication Technologies (ICTs) into the distribution system. Such a system can be considered as a Cyber-Physical Distribution System (CPDS).
- The failure of these ICTs can deteriorate the operation of the power system. Accordingly, the impacts of the failure of ICTs are essential to be studied during the evaluation of the reliability of a CPDS .

Research tasks

- Determining the interdependencies between the cyber and power systems.
- Providing methodologies to capture the impact of these interdependencies on the operation and consequently the reliability of the system.
- Quantifying the impact of failure of ICTs on the reliability of the whole system.

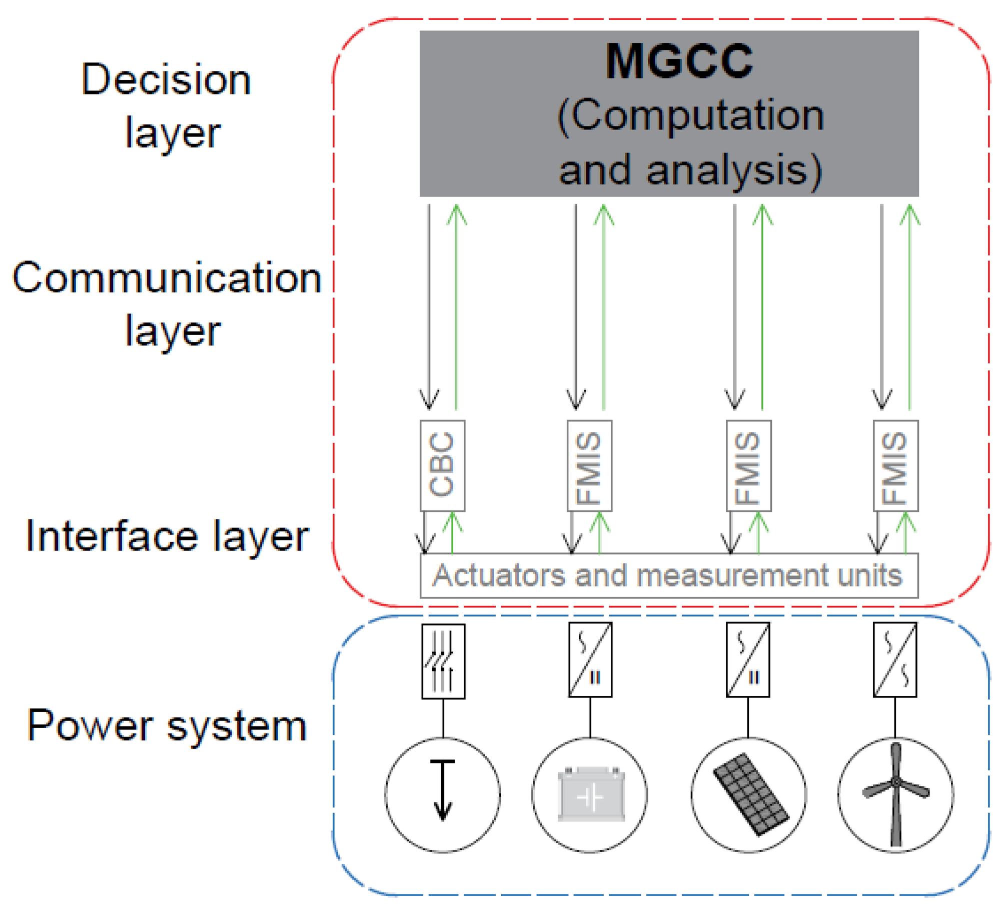
Approach

- The related interdependencies are modeled as direct and indirect interdependencies.
- Markov model and Monte Carlo simulation are mostly used for the components and modelling the failure and repair processes.
- Optimization models are developed for the operation of the system.

Significant Results

- The relevant interdependencies has been modeled in which, for example, the impact of failure of circuit breaker controller on the loss of load has been investigated. The result shows that failure of circuit breaker controller does not have a great impact on the loss of load. However, the load shedding strategy employed by a microgrid operator, depends on the availability of energy storage systems, might impact the reliability of the system.
- A detailed model of Photo-Voltaic (PV) unit has been developed that can capture the impact of individual component failure inside the PV unit.
- The result, so far, shows that the failure of ICTs has a great Impact on the operation and long-term reliability of a microgrid and should be considered during its design phase. Extending this to a smart distribution system is necessary to quantify the impact of ICTs' failure and to help the designers as well as the system operators of a distribution system.

Illustration



This figure shows the Information flow in a Cyber-Physical Microgrid. Failure of each component in cyber system has a different impact on the relevant components in the power system. These failures might cause the failure of a power system component directly, or they might impact the power system operation indirectly.

Mode of Operation	Sub-mode	Time period	Prob.	Cause [%]		
				Power system failure	Cyber system failure	Common
Grid-connected	Healthy (M_{10})	8611.4	0.983	-	-	-
	Emergency (M_{11})	6.2	0.0007			
Island Mode	Healthy (M_{20})	15.1	0.0017	90.0	9.89	0.098
	Emergency (M_{21})	71.3	0.008			
	Shutdown* (M_{22})	16.01	0.0018			
Shutdown (M_3)	-	33.6	0.00380	87.21	12.75	0.038

Results of the microgrid operation modes due to failures in the both power and cyber systems, showing time periods, probability of occurrences, and causes. Shutdown mode, indicated by *, is a result of the lack of generation in the microgrid because of any reason.