Karlsruhe Institute of Technology

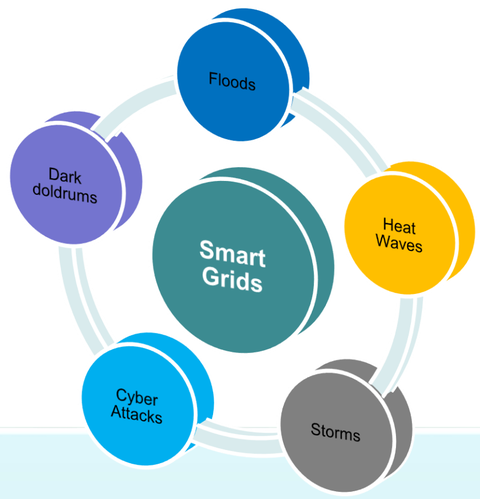
Resilient Cities 2019 10th Anniversary

Continuous and Urban Resilient Power Supply during Critical States

Smart Grids & Critical Infrastructures: Emerging Supply Risks

Dependencies:

- Most critical infrastructures like hospitals or the water supply **depend** on the continuous supply of power
- Power **dependencies will increase further -** potentially in Smart Cities



Risks:

- **Fluctuation** of power generation
- **Climate Change** related risks
- Drastic **change in power consumption** due to
  - climate change,
  - dissemination of new technologies
- **Cyber risks…**

Objectives

Find **system-embedded** controls or management options to…

- …maintain **Security of Supply** as far as possible with regard to **critical services**!
- …enable **continuous** and **fair** power supply of **critical services** in the phase of a degraded state of the power system.

Criticality & Flexibility: Supply Index

- **Criticality** c_l of an infrastructure x_l measures the severity of the consequences a failure has to an urban population – result of a socio-political process and the dynamic features of demand and supply [Ot]
- **Power demand interval** $[P^l_{D,min}, P^l_{D,max}]$ of x_l- power range, where essential services are running.

Supply Index:

$$\mathfrak{si} = \sum_{i \in I} \tilde{c}_i \, q_i\left(\mathfrak{sp}_i, P^i_{D,min}, P^i_{D,max}\right)$$

Resilient Smart Controls Management

- Advanced Metering Infrastructures, Smart Meters
- Energy and Distribution Management System
  - Resilient real-time Controls
  - Smart Contingency Planning, Scheduling

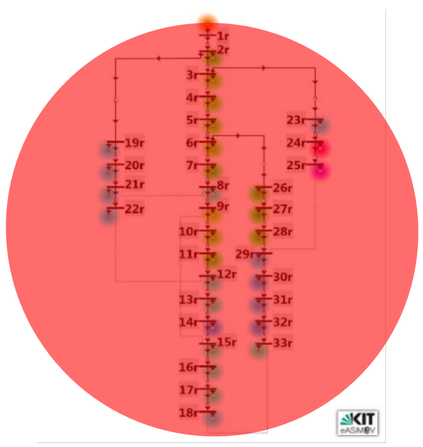
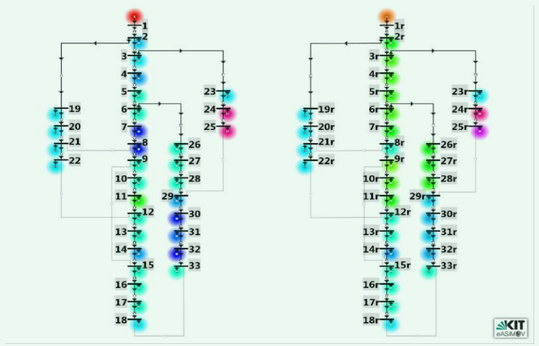
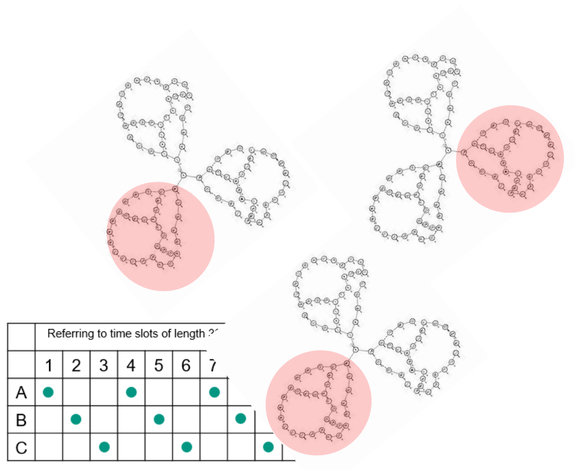
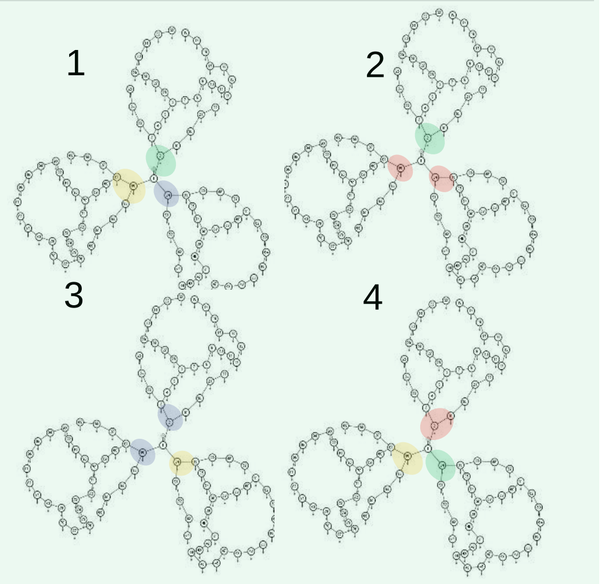
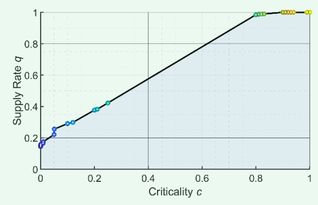
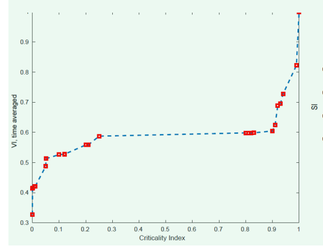
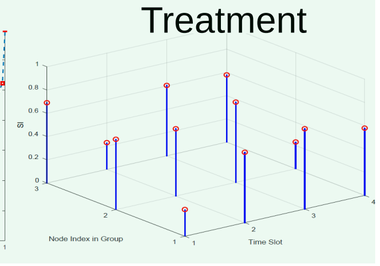
Composite Resilience Supply Metric:

$w_1 \cdot \mathfrak{si} + w_2 \cdot \mathfrak{se} + w_3 \cdot \boldsymbol{\rho}$, $w_1, w_2, w_3 \geq 0$; $w_1 + w_2 + w_3 = 1$,

where $\mathfrak{se}$ is an **efficiency indicator** and $\boldsymbol{\rho}$ **measures fairness** in terms of equal treatment

Methodology & Results

Benchmark-Cases: Blackouts occur, systemically in terms of contingency planning e.g. rolling blackouts – 75 % of current demand

	Blackout	Smart Resilient Control	Rolling Blackout	Smart Resilient Scheduling
				
$\mathfrak{si}$	0	> 0.9	0.66	> 0.9
Fairness	On/Off-Equal Treatment	Monotonicity 	On/Off-Equal Treatment	Monotonicity  Equal Treatment 

[Ot] Ottenburger, S.S., Münzberg, Th., Strittmatter, M. (2018), *Smart Grid Topologies Paving the Way for an Urban Resilient Continuity Management*, International Journal of Information systems for Crisis Response and Management 9 (4), p. 1 – 22, DOI: 10.4018/IJISCRAM.2017100101

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