Aalto-yliopisto
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Robustness analysis for reinforcement actions in distribution grids (presentation of the results)

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1.11.2023

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Background

- The distribution system operator seeks to protect distribution grids from external hazards
- The aim is to improve grids' reliability and minimize reinforcement costs
- Cost-efficient portfolios of reinforcement actions are computed with Porfolio Decision Analysis (PDA)

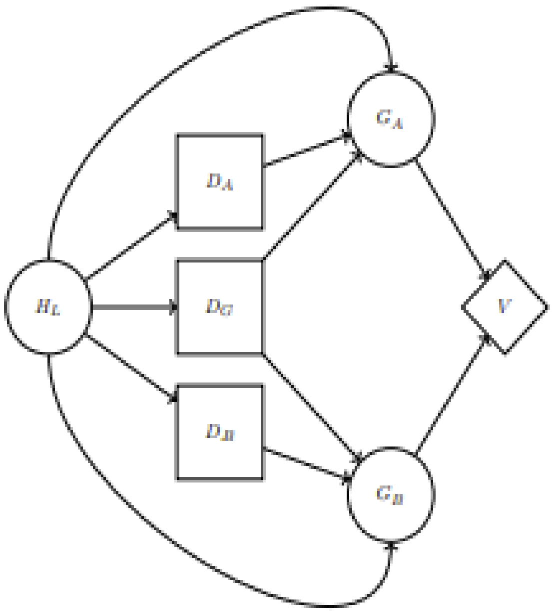
Objective

- There are uncertainties in the model parameters

- Robustness of the selection process
  - What impacts the uncertainties in the model parameters have on the portfolio of optimal reinforcement actions?
- Sensitivity of the reliability
  - How does the reliability of the grid depend on the model parameters of the chosen actions?

Model 1/3

- The problem is represented as an influence diagram
- Case study on two distribution grids
- Python/Julia interface for solving efficient reinforcement actions with different inputs



De La Barra, J., Salo, A. 2023. Selecting combinations of reinforcement actions to improve the reliability of distribution grids in the face of external hazards. ESREL2023.

Model 2/3

- Hazards and reinforcement actions are accounted for by multiplier factors

Hazard	Type	Factors
Weather1	Weather conditions	1.0, 1.0, all
Weather2	Weather conditions	1.4, 1.4, all
Weather5	Weather conditions	3.0, 2.0, all

λ-factor; Increases the failure rate

τ-factor; Increases the reparation time

Number of affected lines in the distribution grid

Model 3/3

Action	Target Hazard	Factors	Price
ST0	Weather, Overload	1.0, 1.0, 0	0
STA	Weather, Overload	0.5, 1.0, 1	200

λ-factor;
Decreases the failure rate

τ-factor, Does not affect the reparation time

Number of affected lines in the distribution grid

Reliability of the system

- Reliability of the grids is characterized trough reliability indices
- SAIDI (System Average Interruption Duration Index)
  - Failure rate, reparation time
- SAIFI (System Average Interruption Frequency Index)
  - Failure rate
- This case study consideres only SAIDI
- The utility function combines and maps SAIDIs of the grids to the interval [0,1]

Robustness of the selection process

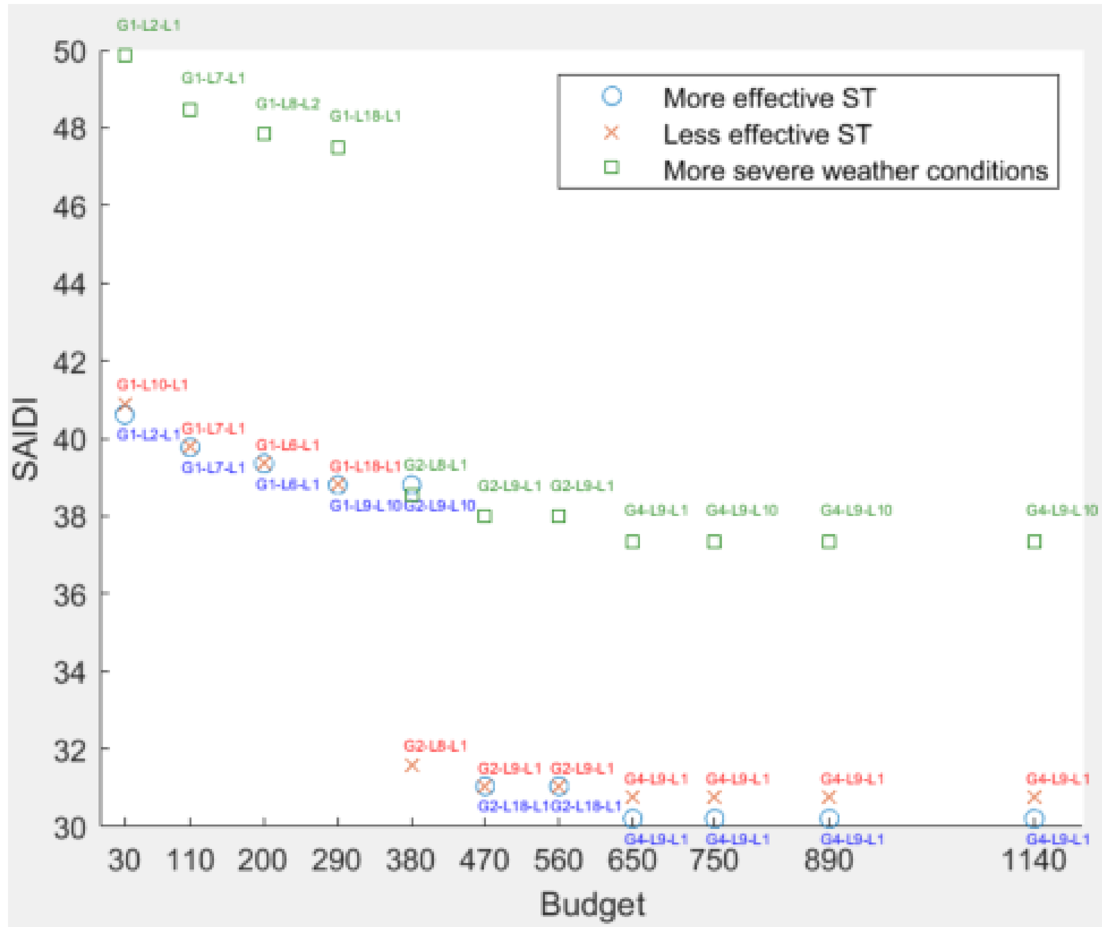
- How the optimal actions change when the model parameters are changed?
- Robust actions for different budget levels are computed
  - 90 iterations overall

Table 6: Step 1 modifications

Action/hazard	target parameter	iterations	factors
ST	λ	20	0.1,0.2,...,2.0
MC	τ	20	0.1,0.2,...,2.0
CS	λ	20	0.1,0.2,...,2.0
Weather	λ	10	1.1,1.2,...,2.0
OL	λ	10	1.1,1.2,...,2.0
CA	λ	10	1.1,1.2,...,2.0

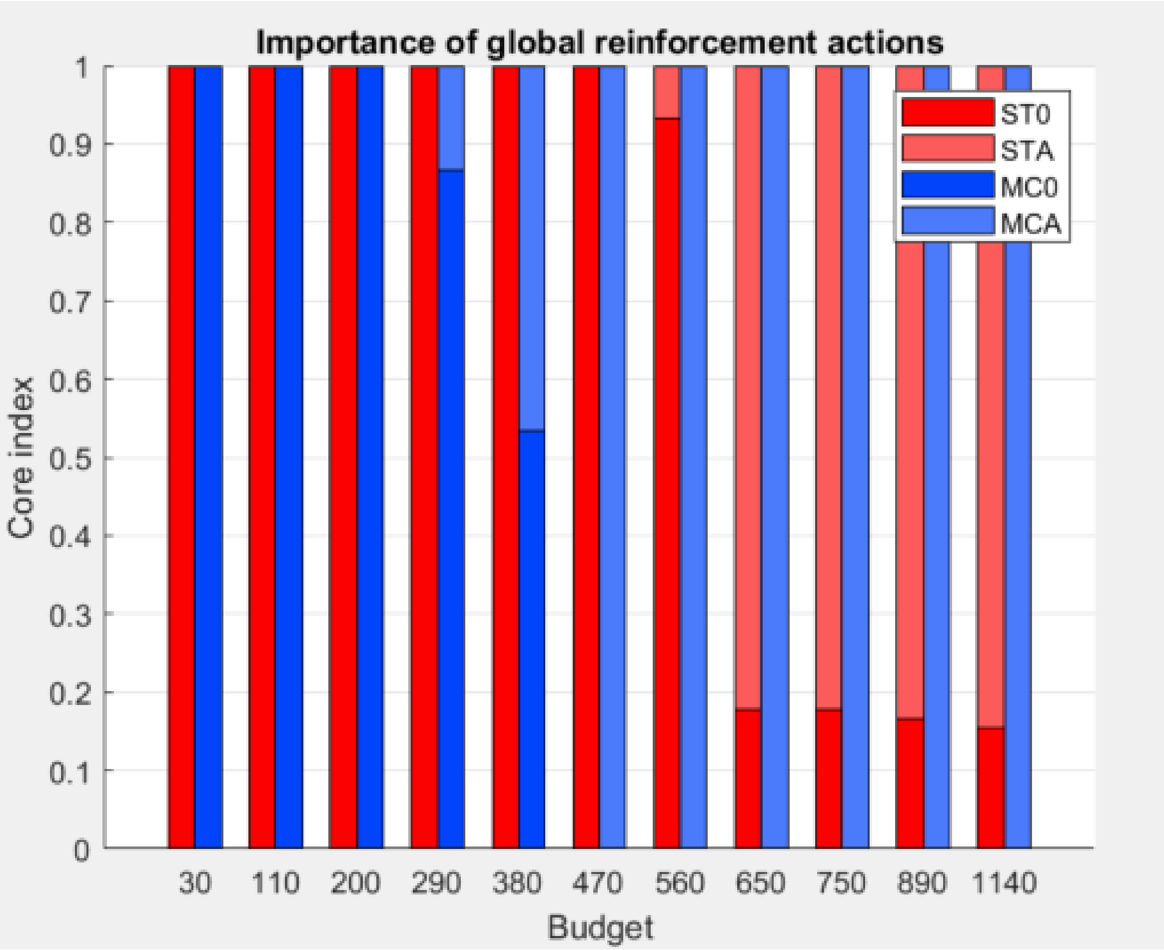
General overview of the results

- Larger budget → more reliable system
- More severe hazards → less reliable system



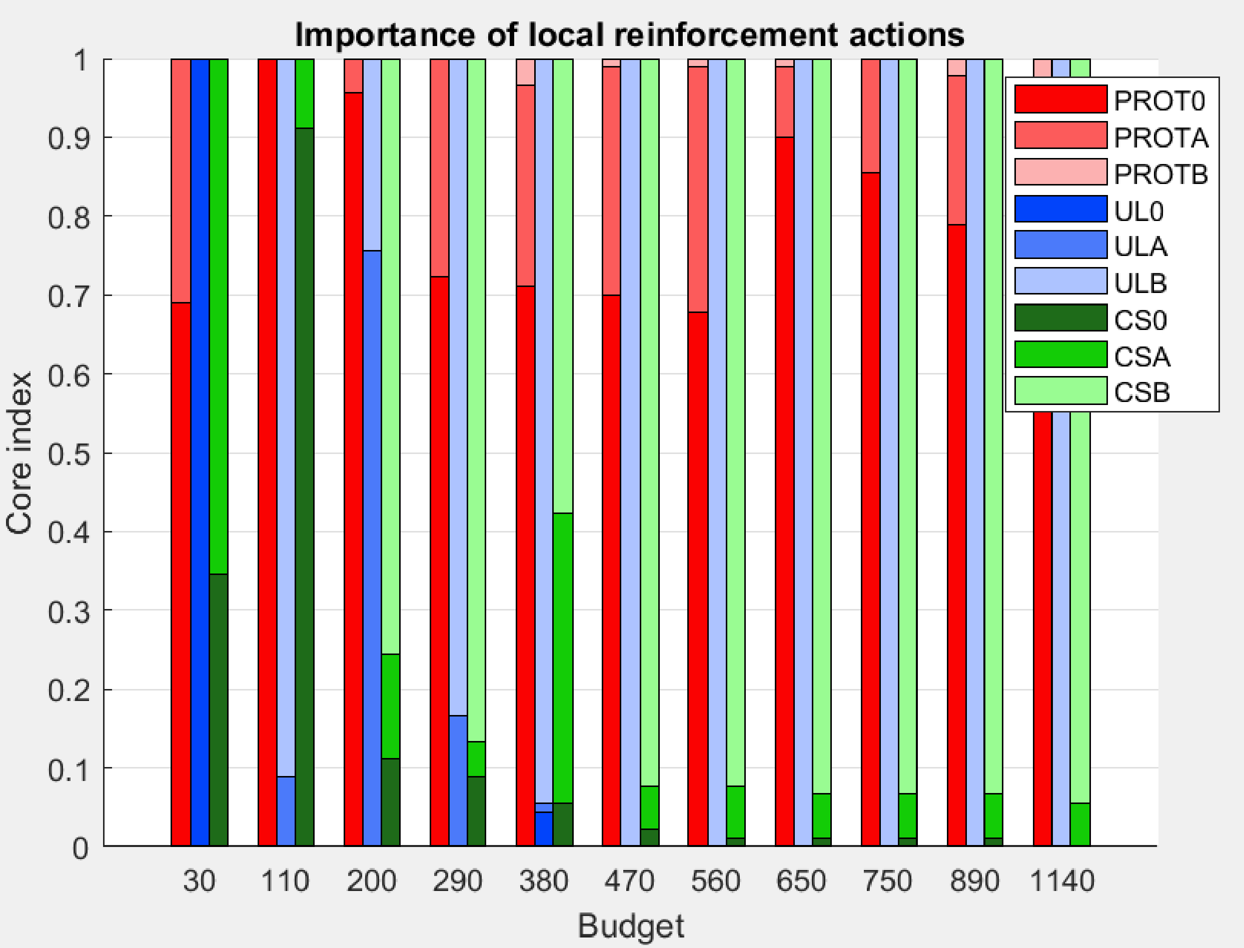
Robust global actions

- Core index indicates the percentage of times the action was selected in the optimal portfolio
- MCA is more important than STA



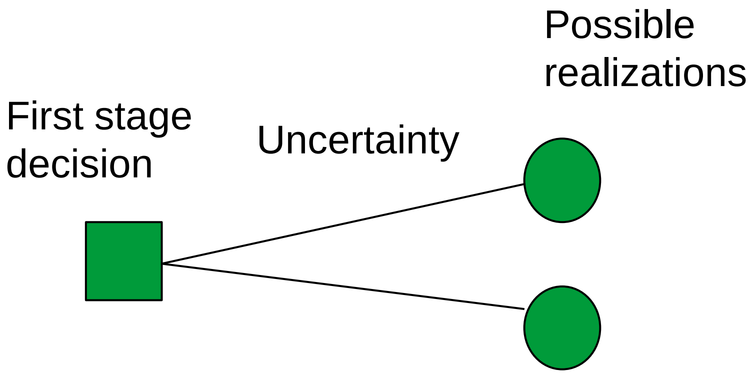
Robust local actions

- Protective devices are not widely used
- More expensive underground line and communication system is preferred



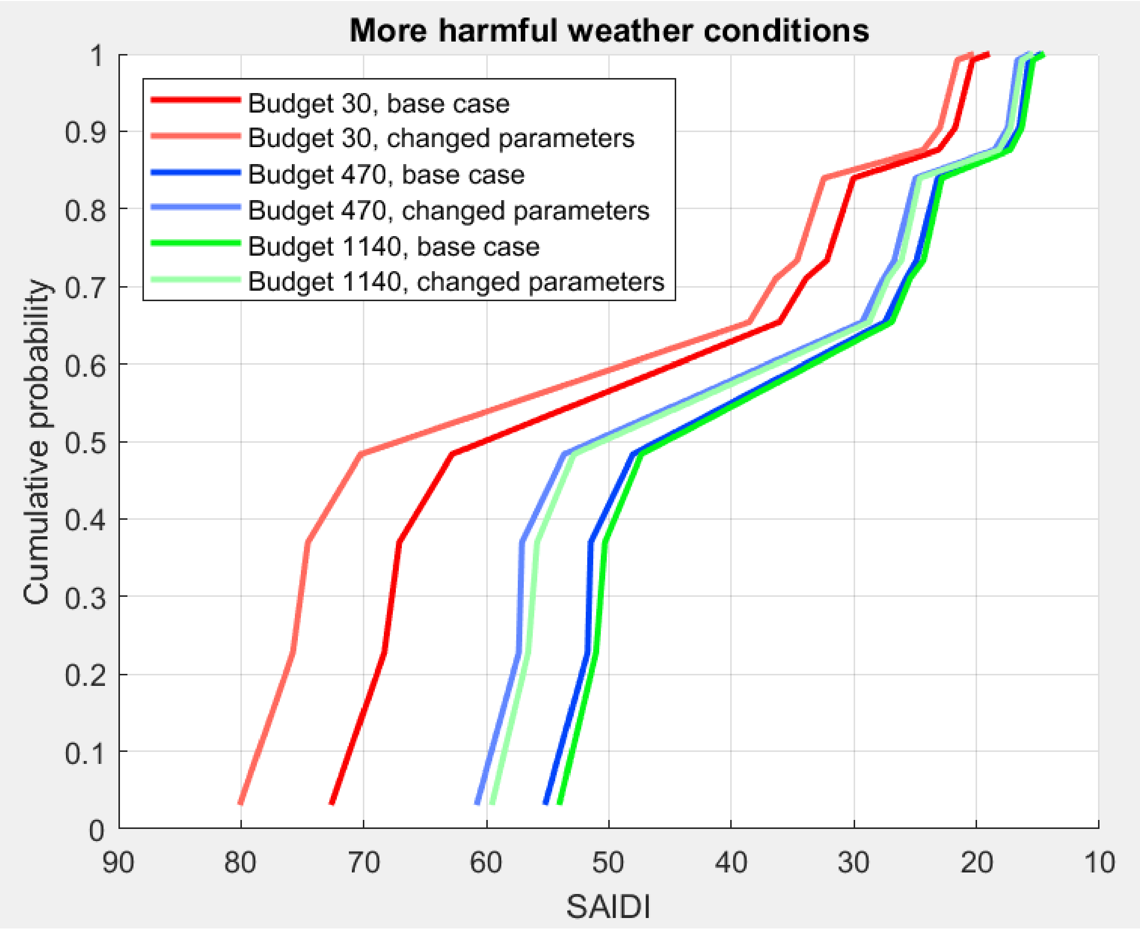
Sensitivity of the reliability

- The first stage decision is made based on known information
- Effectiveness of the actions or severity of the hazards can vary
- How does the reliability of the system change after the change in effectiveness?



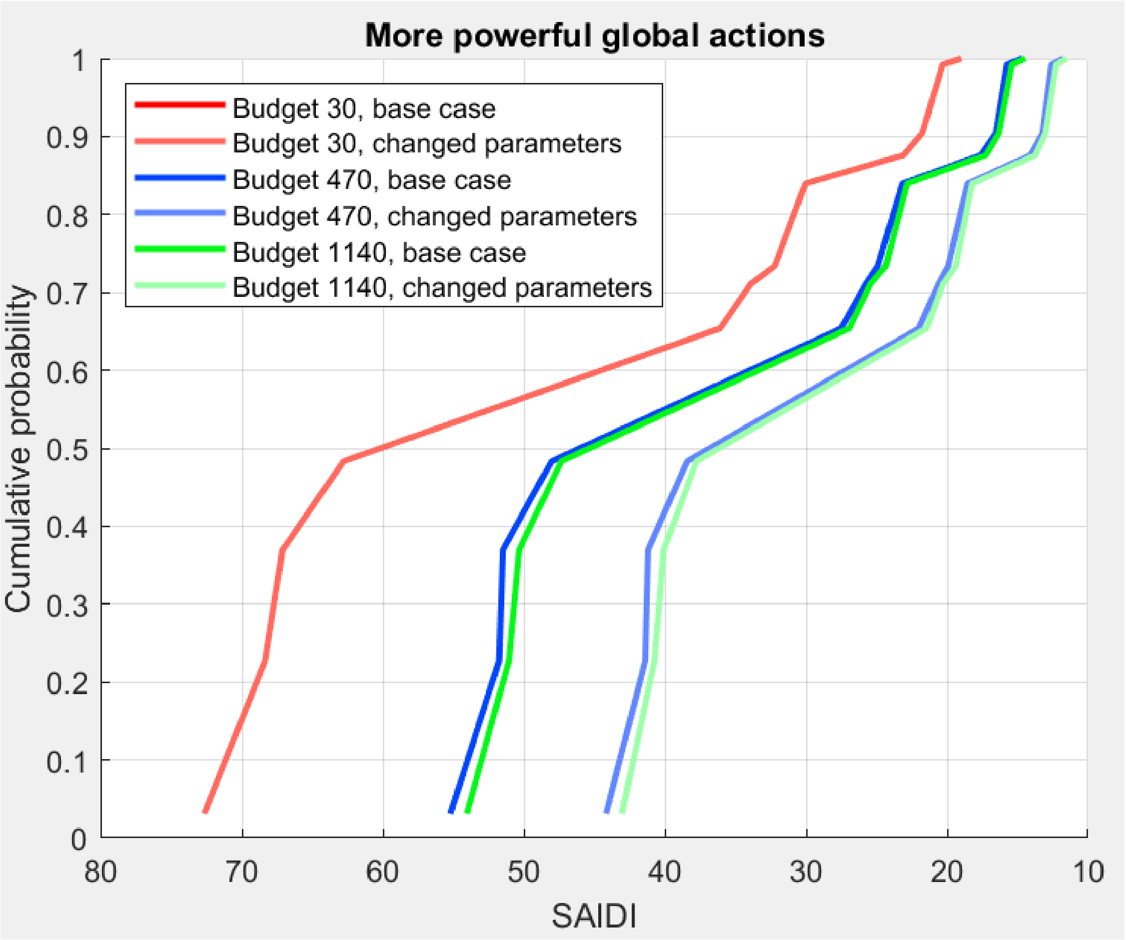
Change in weather conditions

- 20% more harmful weather conditions
- The difference in the reliability is the biggest with the most severe scenarios



Change in global actions

- 20% more effective global actions
- The lowest budget does not use global actions
- The change in the reliability is approximately 20%



Conclusions

- The DSO can benefit from sensitivity and robustness analysis
  - It is possible to identify robust actions that are used almost always even though parameters vary
  - Some actions can be abandoned if they are rarely used; might make the analysis more efficient
  - It is possible to determine those parameters that impact the reliability most
  - Confidence intervals help the DSO identify worst-case scenarios