CIGRE PARIS 2022

# C2 - Power System Operation and Control

## PS1 - System Control Room Preparedness: Today and in the Future

10352

# Potential and challenges of AI-powered decision support for short-term system operations

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## Motivation

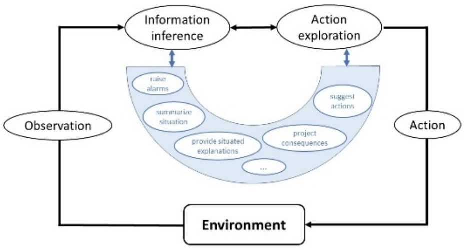
- The complexity to operate the power system is increasing, and the available time to respond to events is decreasing.
- The power system operators are getting overwhelmed with number of tasks and actions to perform during emergencies.
- To timely assist the operators, the AI-powered decision support can be applied to quickly identify and apply optimal actions.

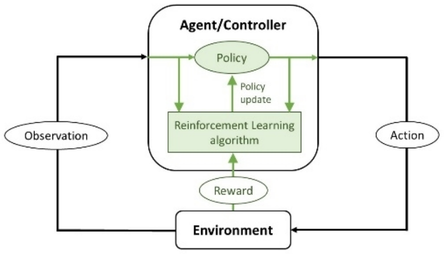
## Approach

- First, an AI and control theory digital framework is proposed to mimic sequential decision making of the operators.
- As a proof of concept of sequential decision making , a real-world AI congestion management use-case at TenneT TSO is presented.
- State-of-the-art and  challenges when applying AI to the power systems problems are identified and elaborated.
- Finally, a cyclic (agile) process approach including enabling capabilities (people, data, and platform pillars) is presented, which aims for efficient development as well as maintenance of AI solutions.

## The operator’s decision-making and AI

- A decision support interface offers the operator a set of functionalities that enable shared knowledge representations and situational awareness over relevant time-horizons and allow for contextual collaborative decision-makings through adapted interactions.
- AI is well-suited to provide some of these functionalities. The general framework of AI and control theory consists of an agent or controller that executes actions in a complex environment and receives feedback from the environment via observations.



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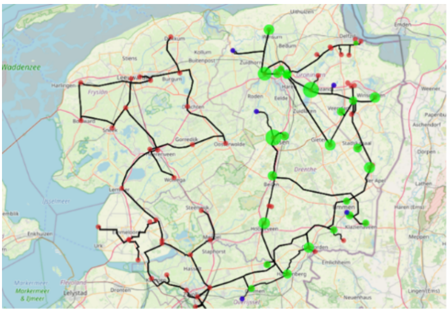
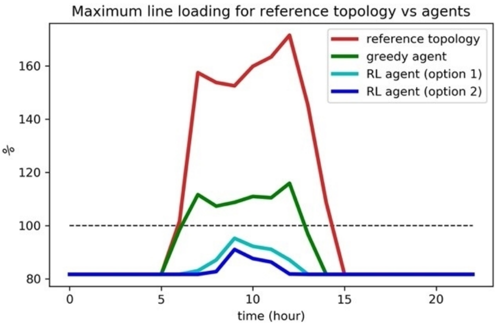
## continued

## A real-world AI congestion management use case at TenneT TSO

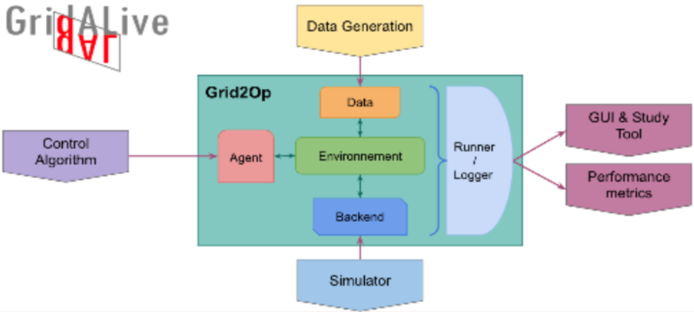
- The use case is focused on a part of the 110 kV grid in the Netherlands that has limited transport capacity and redispatch options (left figure). Large overloads are expected in a near-future scenario when operating the grid in the reference topology (red line in the right figure).
- The green curve depicts the result of the greedy agent in which each timestamp is optimized independently except that the current topology is determined by the sequence of the previous actions. The agent is able to reduce the amount of overload but it is not able to fully mitigate all overloads.
- We demonstrate that in order to solve such a complex problem, topology controllers that provide optimal control actions over a time horizon need to be developed. In the use case, a simple reinforcement learning agent is used (right figure). The RL-agent is able to fully mitigate the overloads.






## State-of-the-art research on sequential decision making applied to congestion management

- RTE TSO and collaborators launched a series of competitions since 2019, the so-called Learning to Run a Power Network (L2RPN) challenge. In each competition the participants need to develop (using the GridAlive framework) controllers that control a power network. The controllers are exposed to realistic (stochastic) production and consumption scenarios, and the remedial actions are subject to real-world network constraints.
- L2RPN provides the first large open-benchmark for solutions to the real-world problem of complex continuous-time network operations, building on previous advances in AI.

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**continued**

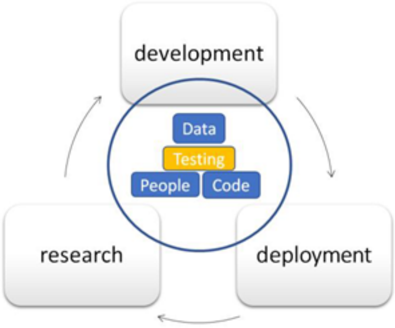
## Research challenges when applying AI to power systems

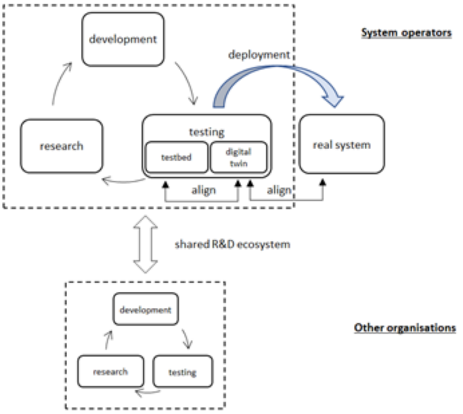
The power system as a critical infrastructure exhibiting unique (cyber-)physical properties subject to significant uncertainty and humans in the loop leads to several challenges

- large observation and action spaces with time scale hierarchies,
- accounting for uncertainties due to model-errors,
- mitigation of low-probability but potentially high-impact events,
- multiple objectives, and trustworthiness.

## Embedding of AI development in system operators

- Often the innovation process still consists of largely independent phases which prevents the virtuous cycle of rapid development/testing/deployment that other sectors have used to good effect.
- To gain the most in the shortest time when developing AI solutions, it is crucial firstly that each company integrates the phases of the innovation process. For that it is necessary develop sufficient capabilities in the people, data, and platform pillars.




## Conclusion

- Adaptation of cutting-edge Artificial Intelligence (AI) technologies in the operational processes is paramount to timely meet the challenges of the energy transition.
- AI solutions applied to power system control demonstrated high potential but also still face substantial challenges. On the one hand, these are methodological challenges related to the unique properties of the power system which require specific research efforts.
- On the other hand, there are organizational challenges stemming from the way that system operators and the surrounding ecosystem need to be re-organized in order to enable rapid development/testing/deployment cycles.