AI4GriDs

Bundesministerium
Klimaschutz, Umwelt,
Energie, Mobilität,
Innovation und Technologie

FFG
Forschung wirkt.

AI-BASED METHODS FOR OPTIMISING THE OPERATION OF DISTRIBUTION GRIDS

RESEARCH DESIGN

- Development of methods for forecasting and preparation of the requirements for the application of these framework conditions
- Carrying out research into methods used in other companies
- Involvement of other grid operators to validate the results
- Testing of individual methods with two network operators (consortium partners)
- Validation of the developed methods
- Coordination with the external network operators

RESEARCH GOALS

The superordinated goal of the project AI4GriDs is to provide grid operators with the necessary information on how to prepare the data collection within their grids to allow AI methods in both RES-forecasting and grid operation and grid planning

- Catalogue of requirements for the researched and analyzed models to be replicated at DSO level
- Catalogue and description of methods and approaches
- Easy to use forecasting, pre- and post-processing, and validation algorithms

Further objectives

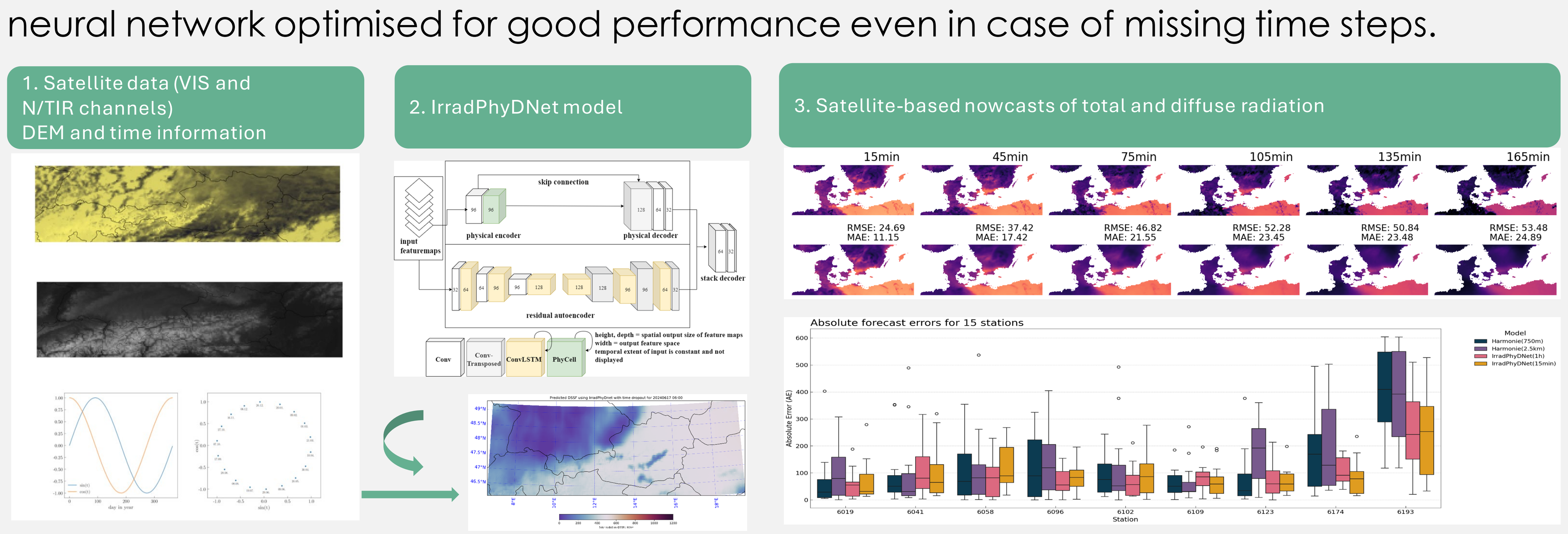
- Curtailment and redispatching of already installed capacities
- Optimized and targeted short-term forecasts of RES for identification of grid congestions
- Optimization (switching) option during operation
- AI-based decision support for optimal distribution grid reinforcement or adaptation such as storage integration
- Identification of the actual RES capacities and impact on the distribution grid reliability

The project will provide the basis for a follow up research project where these methods will be applied in demonstration setting.

AI FORECASTING

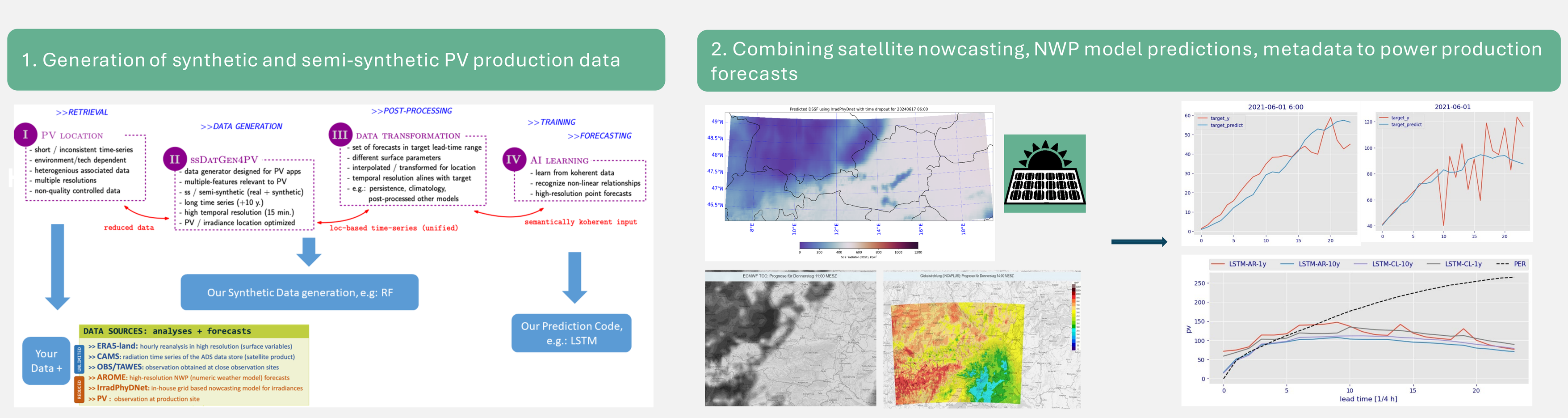
SATELLITE BASED NOWCASTING

Using different satellite products, nowcasts for the next hours are generated with a deep neural network optimised for good performance even in case of missing time steps.

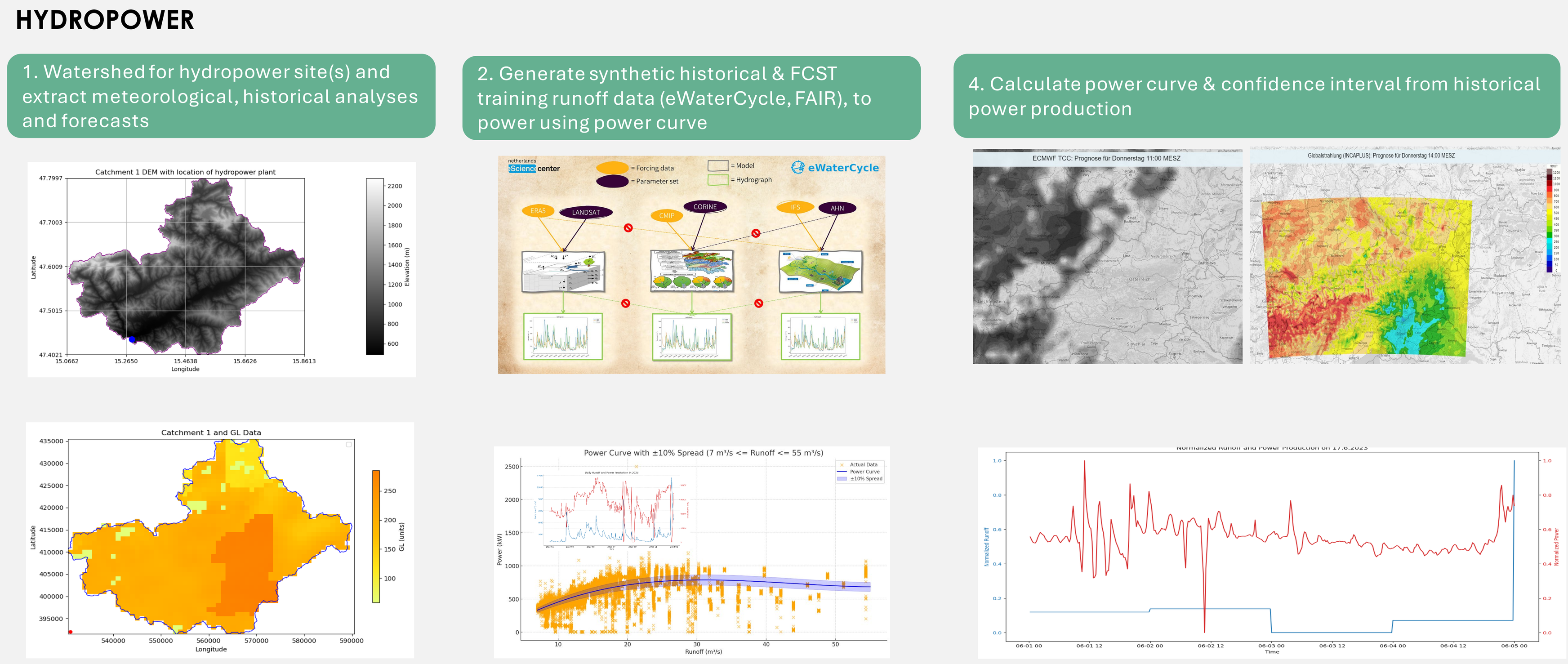


PV PRODUCTION FORECASTS FOR SPARSE HISTORICAL DATA BASE

To generate forecasts for sparse data regions, a multi-step approach is used generating synthetic data, refining them and combining heterogeneous data sources to PV production.



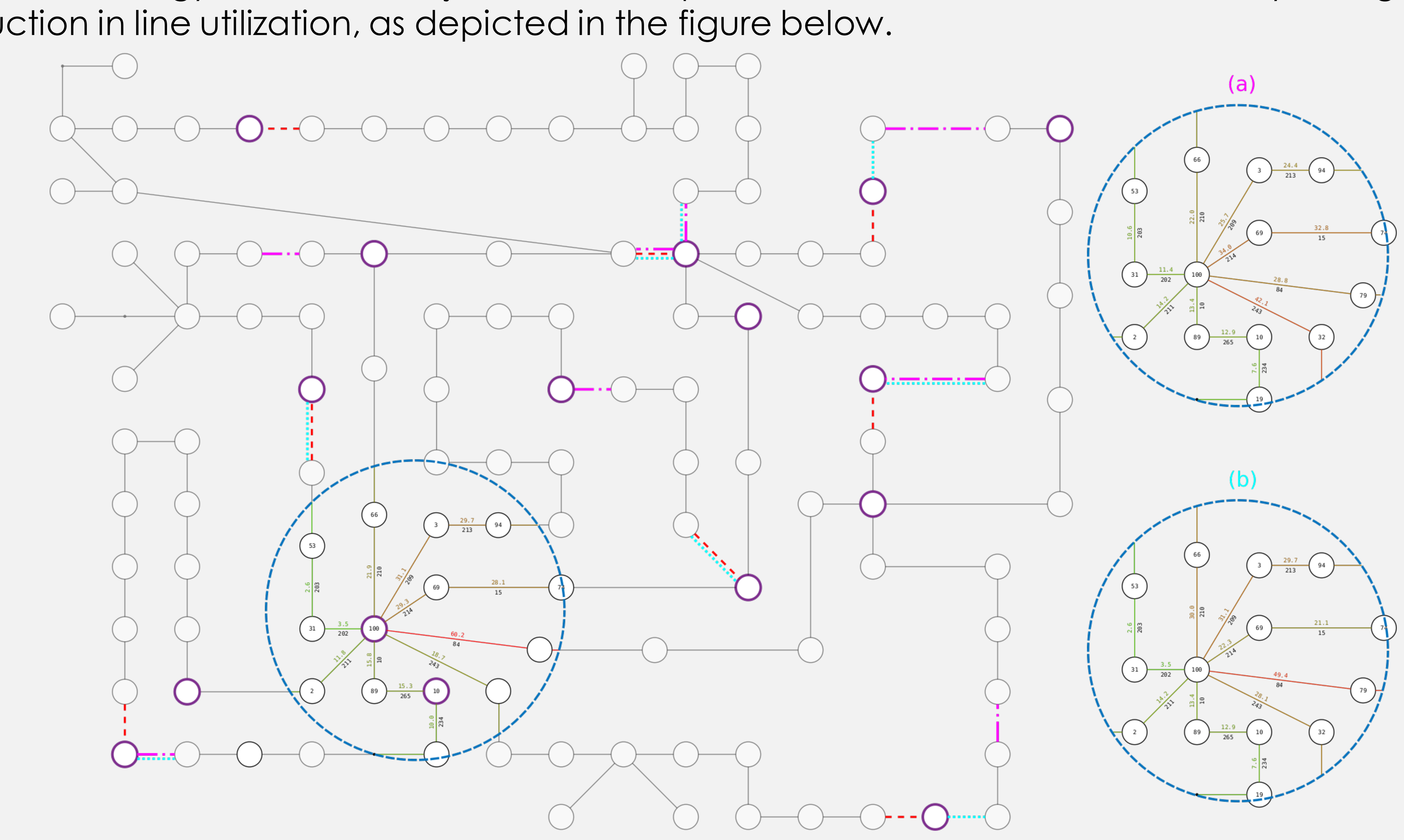
HYDROPOWER



AI GRID PLANNING / STATE ESTIMATION

FIRST USE CASE: Topological Optimization

Optimizing the established grid topology can enhance the resilience and capacity utilization of electrical grids, serving as the initial use-case in this research project. With a focus on topological adjustments within an Austrian medium-voltage distribution grid to reduce line utilization, a digital twin model is employed to simulate and evaluate impacts. The complexity of the task is highlighted by about 500 million potential configurations for the network. To address this challenge two strategies are employed: the first strategy explores the optimal topology across all configurations, achieving an 18.1% reduction in maximum line load compared to the original topology in use. The second strategy confines adjustments to predefined controllable stations, yielding a 10.8% reduction in line utilization, as depicted in the figure below.



The figure depicts the grid topology of the considered network. Red lines mark line split of the default topology in use. Purple nodes indicate controllable stations. Pink lines illustrate line splits indicating the best possible topology, and turquoise lines represent line splits exclusive at controllable stations. Here, Station 100 acts as a feed-in station connected to the high-voltage grid. On the right, a close-up of the region around the feed-in station is shown, emphasizing the decreased line utilization.

These topological changes demonstrate the potential for significant improvements in reducing network strain, boosting resilience, and offering an economical way to manage the grid. This initial use-case paves the way for subsequent research that will incorporate grid dynamics, potentially using a reinforcement learning agent to determine switching operations with high temporal precision. Progressing towards a more dynamic grid also aligns with the second use-case and aims to further refine grid optimization and response strategies.

SECOND USE-CASE: State Estimation

The second use-case in this research project is network state estimation in medium-voltage electrical grids. This task involves integrating and refining loads, feed-ins, and measurement data to accurately depict internal network states. By incorporating existing measurements into the digital twin model, the aim is to improve the accuracy of estimates, even in scenarios with limited data. This aspect of the research is still in progress and remains an ongoing endeavor.

PROJECT HIGHLIGHTS

This project highlights future perspectives on the potential integration of photovoltaic production and hydropower generation forecasts into electrical grid management practices such as topology optimization, in particular when it comes to state estimation. Although the current project does not aim to implement this integration, considering such a fusion represents an innovative and promising direction for enhancing grid management. This theoretical exploration proposes that incorporating predictive data could notably improve the precision of state estimation and the efficiency of topology optimization. Looking forward, merging these approaches could yield significant synergies, offering a compelling avenue for future research to optimize grid performance and reliability.

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