DESTINATION EARTH

ML Demonstrator Energy Systems

DLR Institute of Networked Energy Systems | AARHUS UNIVERSITY | Renewables Grid Initiative

Avoiding complex and lengthy optimization problems with ML

- Energy systems simulations can be computationally expensive when scaling to large systems or handling high-dimensional relationships.
- Machine learning can speed up energy system models by replacing traditional solution methods with more efficient architectures.
- Once trained, ML models can provide near-instant predictions of optimal solutions, bypassing the need for iterative solvers and enabling more scalable and adaptive energy system operations.

Data and Tools

High-resolution climate simulations from DestinE's Climate Digital Twin

Our Demonstrator combines information from DestinE's Climate DT with state-of-the-art energy systems modeling and AI to support planning and operation of a climate-proof European power system.

State-of-the-art energy system data and open-source energy systems modeling

PyPSA

The ML model will be trained and validated with power system simulations following the lines of the European Resources Adequacy Assessment, implemented in PyPSA.

Advanced machine leanring with physics-informed neural networks

The core of the ML Demonstrator is a Physics-Informed Neural Network designed for energy system optimization under uncertainty and tailored to reflect the physical and topological characteristics of the European electricity grid (see figure on the right).

Physics-Informed Neural Network, especially designed to handle the complex, dynamic nature of power systems with a high penetration of renewable energy sources; Its special setup ensures the both accuracy and physical consistency of the predictions and allows for a fast and reliable simulation of power flows and generator dispatch. [figure credit: Chen Li, FIAS]

Interactive scenario exploration

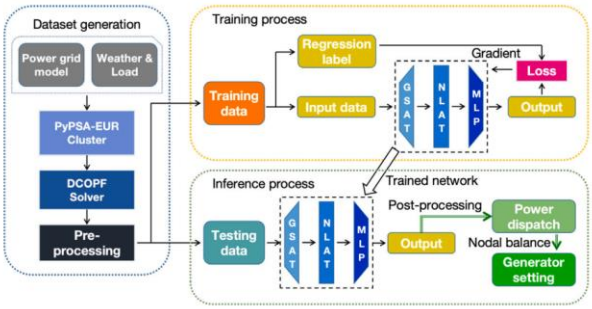
Our Demonstrator aims for an interactive user experience. By integrating data from the Climate Digital Twin and the Data Lake, the ML Demonstrator will turn data into real-time, actionable insights through:

- **Data Conversion:**
  Convert climate variables from the Climate DT into power system variables.
- **Data Management and Processing:**
  Facilitated via the DestinE Data Lake and the Digital Service Platform, ensuring seamless integration between the Data Lake, the ML model, and end-users.
- **User Interface:**
  An interactive dashboard that allows users to interact with the system. Users can input scenarios, receive real-time alerts, and visualize optimized power flows, grid stability metrics, and resource adequacy assessments.
- **Interactive "What-if" Exploration:**
  The user interface allows iterative adjustment of parameters. Users immediately see the implications of their adjustments, facilitating iterative exploration and refinement of strategies.

Stakeholder engagement and co-design

The technical design of the Demonstrator, including the testing and validation approach, is defined in close callobaration and exchange with user through:

- Bilateral face-to-face meetings
- Knowledge sharing and dissemination activities
- Workshops and webinars



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