Using metamodels for conducting large-scale scenario analyses: The case of security of electricity supply

Themenbereich: (7) Energiesystem- und Klimamodellierung

Jan PRIESMANN[1(1)], Lars NOLTING[(2)], Aaron PRAKTIKNJO[(1)]

[(1)]Lehrstuhl für Energiesystemökonomik, E.ON Energy Research Center, RWTH Aachen University

(2)Tennet TSO GmbH

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Motivation and central question

With the increasing share of intermittent supply from renewable energy sources, probabilistic simulation models are gaining importance for the assessment of security of electricity supply in the European electricity system. However, probabilistic simulation models with high temporal resolution are time-demanding and computationally intense, which represents a barrier to performing comprehensive analyses covering a wide range of possible scenarios. Metamodeling has been described as a potential solution to this dilemma (Siebertz et al., 2010). Metamodeling simulates the behavior of system models by learning the relationship between the model input and output data. Using Design of Experiment (DoE) approaches, the set of Simulations that is required to train the model is selected (cf. Figure 1).

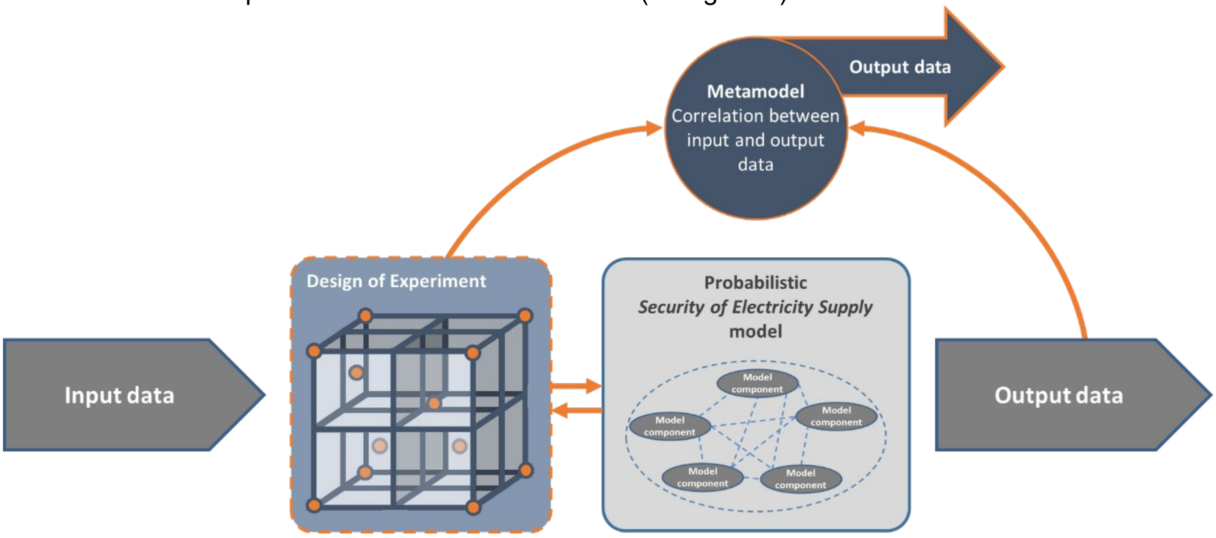

Figure 1: Schematic representation of the basic principle of metamodeling for the case of security of electricity supply assessment.

The aim of this paper is to reduce complexity in the assessment of security of electricity supply by using metamodels for predicting the stochastic key indicators 'Loss of Load Probability' (LoLP), Loss of Load Expectation' (LoLE) and 'Expected Energy not Served' (EEnS) (for more information on the indicators, thee e.g. ACER, 2020). For this purpose, we implement different metamodels and subsequently evaluate these. The specific research questions addressed in this work are the following:

- To what extent does metamodeling help to avoid the conventional modeling process and thus reduce runtime in security of supply assessments?
- At what cost? Does the accuracy of the model remain sufficiently accurate?
- Which type of metamodel suits best the assessment of security of electricity supply?

Methodical approach

The methodological structure of this paper is divided into three main sections. Frist the scenarios are defined by selecting input data for different scenarios. The goal is to account for the uncertainty in the

[1] Mathieustr. 10, 52074 Aachen, Germany, +49 241 80 49897, jan.priesmann@eonerc.rwth-aachen.de, Web

different dimensions of the input data set by using a large scenario range. The number of input-output relations is then reduced based on DoE. In the second step, the supporting points in the design space are simulated using the probabilistic simulation model. In the final step, three types of metamodels are trained and tested on the generated input-output relations. The modeling approaches applied are Logistic Regression (Logit), Feed-Forward Neural Network (Feed-Forward NN), and Long Short-Term Memory Neural Network (LSTM NN).

Results and conclusions

For assessing the accuracy, the three metamodels are applied to a test dataset with 262,800 input-output relations, representing one full scenario with 30 weather years and 8,760 hours. Figure 2 shows the resulting distributions for the LoLE using the original probabilistic model and the three metamodels. One LoLE is calculated for every weather year, therefore, the distributions consist of 30 data points.

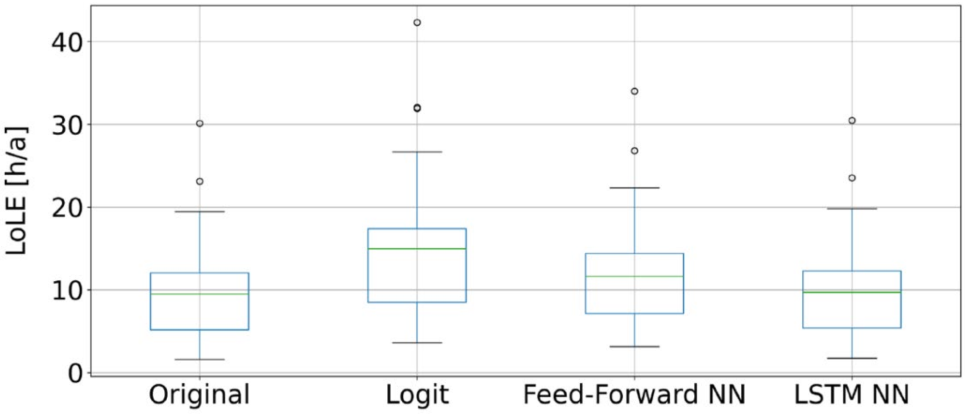

Figure 2: Comparison of the distribution of results for the LoLE in the scenario with 30 weather years.

We find that complex metamodels can better represent the nonlinear behavior of the underlying probabilistic model. Metamodels based on neural networks are able to approximate the original model with high accuracy. At the same time, the metamodels are capable to simulate a new scenario (based on 30 weather years) in a few seconds, instead of 4 hours as before with the probabilistic model.

References

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