Doctoral School of Information and Biomedical Technologies Polish Academy of Sciences - TIB-PAN

Research domain: Informatyka Techniczna i Telekomunikacja

Topic: 1.4 Uczenie maszynowe – zagadnienia specjalne

Modeling the impact of climate and energy policy on power grids using machine learning: analysis and implementation

Supervisor; contact information

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Scope

In the current dynamic environment, characterized by changing climate conditions and an escalating need to reduce greenhouse gas emissions, the adequate preparation of energy infrastructure has become a vital component of development strategies. The implementation of effective climate and energy policies necessitates not only a thorough analysis of the existing infrastructure but also the flexibility and readiness to adapt to future changes. In this context, this research project explores the mechanisms through which climate and energy policies impact power grids, aiming to better understand how different policy actions can shape the future of energy infrastructure. Focusing on regions (clusters of several counties) in Poland, the project will develop tools to forecast future changes in the energy mix and electricity demand on the electrical infrastructure. With appropriate energy infrastructure, we will be able to effectively adapt to the changing conditions and requirements of climate and energy policies, while simultaneously supporting sustainable development goals and the reduction of greenhouse gas emissions. In this way, the project has the potential to contribute to building a more resilient and sustainable energy system, prepared for future challenges.

In the first step of the research, various climate and energy policy scenarios for regions will be modeled using an advanced regional CGE (ang. Computable General Equilibrium) model. CGE models are a commonly used tool for simulating climate and energy policies [1][2][3]. The simulations will include scenarios tightening of EU climate and energy policies over a 10-year horizon [4][5]. In the next stage of the project, an AI-based model will be developed to examine the impact of climate policy on the changing electricity demand of the power grid and changes in the energy mix for regions, utilizing information obtained from the CGE model. The modeling will involve density mapping of energy grids obtained from maps (comprising high-voltage, medium-voltage networks, etc. [6]), with spatial data taken into account (such as distance from power plants and density of high-voltage networks in neighboring regions),

along with the production of energy-intensive industries. Recurrent neural networks and other machine learning techniques will be utilized for sequential data in spatial domains (Spatial Recurrent Neural Networks) [7].

Requested skills:

- MSc degree in computer sciences telecommunication, quantitative methods or similar discipline,
- Advanced practical knowledge on modeling climate and energy policy
- Practical knowledge of R/Python/Java
- Familiarity with at least one ML tool (e.g. Tensorflow, PyTorch, scikit-learn)
- Advanced Level in English (speaking and writing).

References

1. Weitzel, Matthias i in. „A comprehensive socio-economic assessment of EU climate policy pathways". W: Ecological Economics 204 (2023)
2. Böhringer, Christoph, Thomas F Rutherford i Jan Schneider. „The incidence of CO2 emissions pricing under alternative international market responses: A computable general equilibrium analysis for Germany". W: Energy Economics 101 (2021).
3. Lawrence H Goulder. „Climate change policy's interactions with the tax system". W: Energy Economics 40 (2013)
4. Directive 2021/0211 of the European Parliament and of the Council of 14 July 2021 amending Directive 2003/87/EC establishing a system for greenhouse gas emission allowance trading within the Union, Decision (EU) 2015/1814 concerning the establishment and operation of a market stability reserve for the Union's greenhouse gas emission trading system, and Regulation 2015/757. 2021.
5. Regulation (EU) 2021/1119 of 30 June 2021 establishing the framework for achieving climate neutrality. 2021.
6. https://www.pse.pl/obszary-dzialalnosci/krajowy-system-elektroenergetyczny/plan-sieci-elektroenergetycznej-najwyzszych-napiec
7. Nguyen, Bang LH, et al. "Spatial-temporal recurrent graph neural networks for fault diagnostics in power distribution systems." IEEE Access (2023).
8. He, Yujiang, Janosch Henze, and Bernhard Sick. "Forecasting power grid states for regional energy markets with deep neural networks." 2020 International Joint Conference on Neural Networks (IJCNN). IEEE, 2020.

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