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AI in Energy Economics

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KI → verständlich: KI + Energie

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Why AI?

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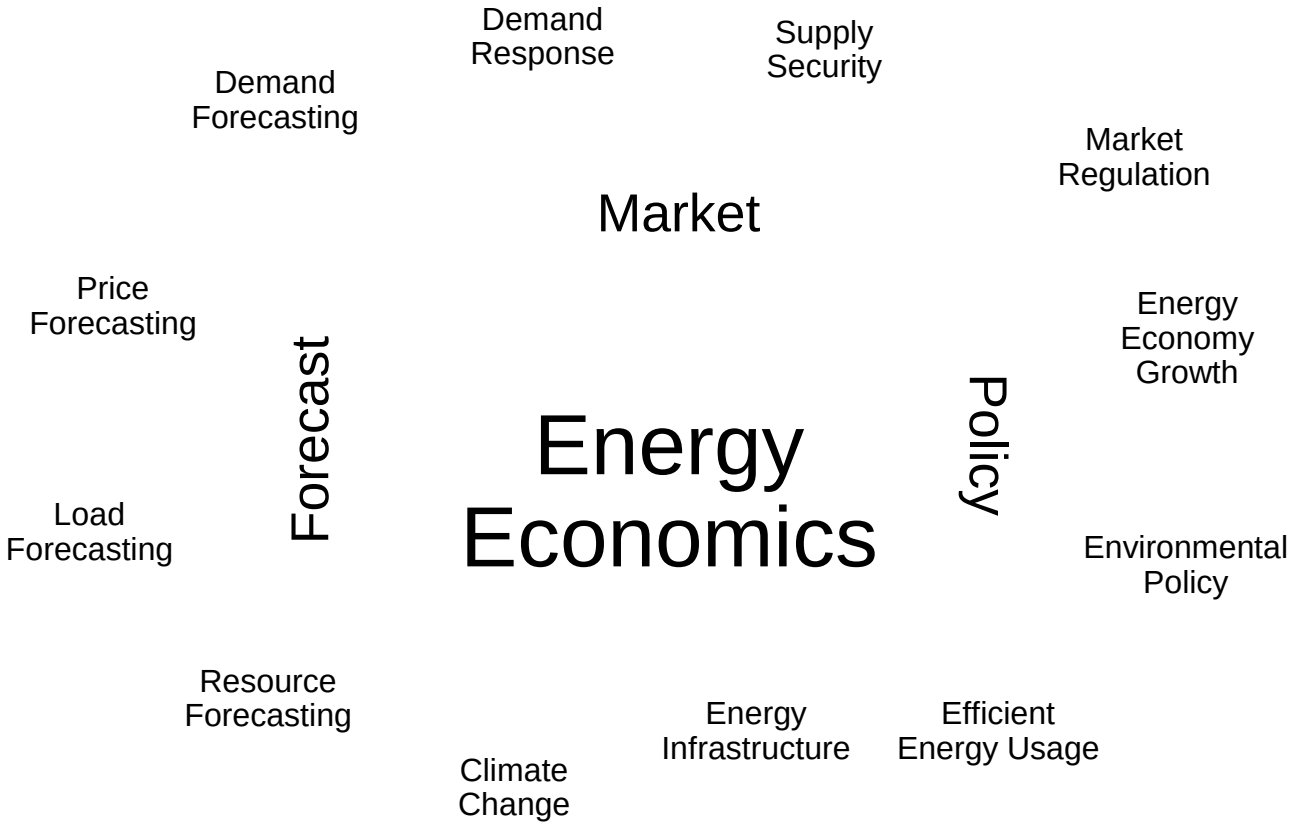
- Very few or no pre-specified assumptions about the functional form of the equation or the statistical distribution of parameters.
- Manage a large amount of structured and unstructured data and make fast forecasts.
- Generate more information for existing processes and automatize processes.
- Proven superiority to conventional methods in many domains.


Demand
Response
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Forecasting
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Price
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Economy
Growth
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Economics
Load
Forecasting
Environmental
Policy
Resource
Forecasting
Energy
Infrastructure
Efficient
Energy Usage
Climate
Change

AI in Energy Economics

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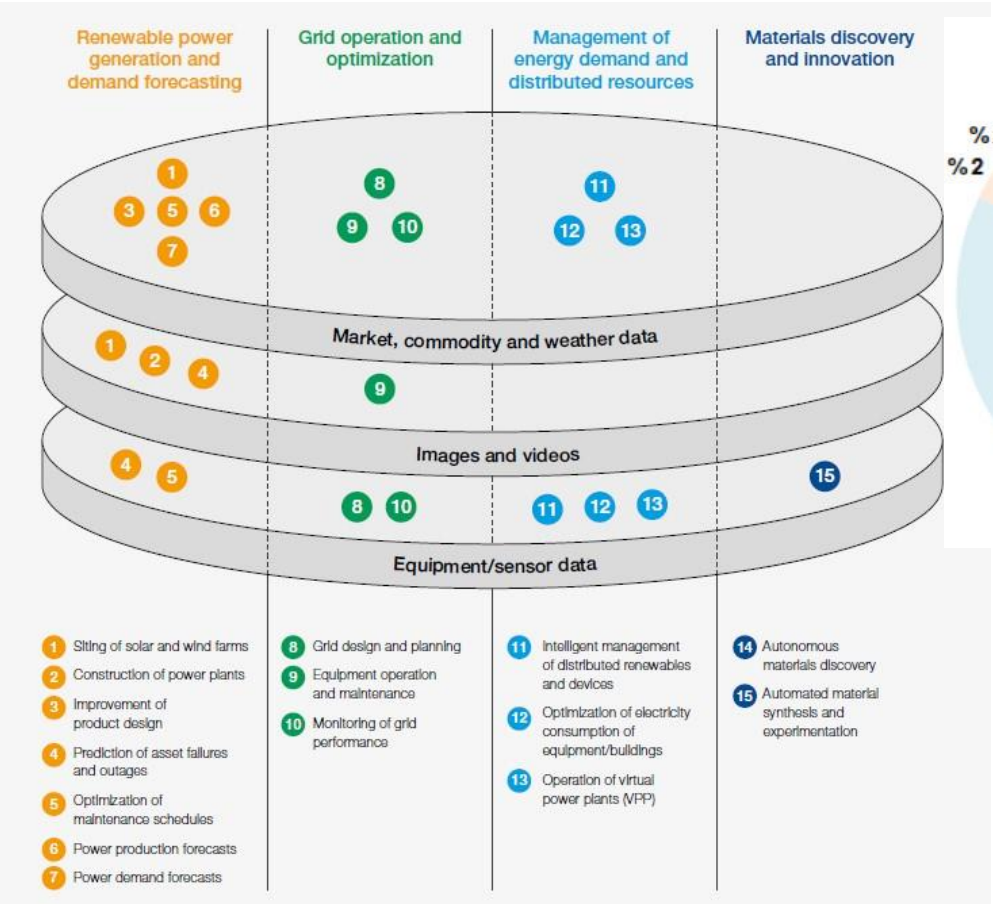
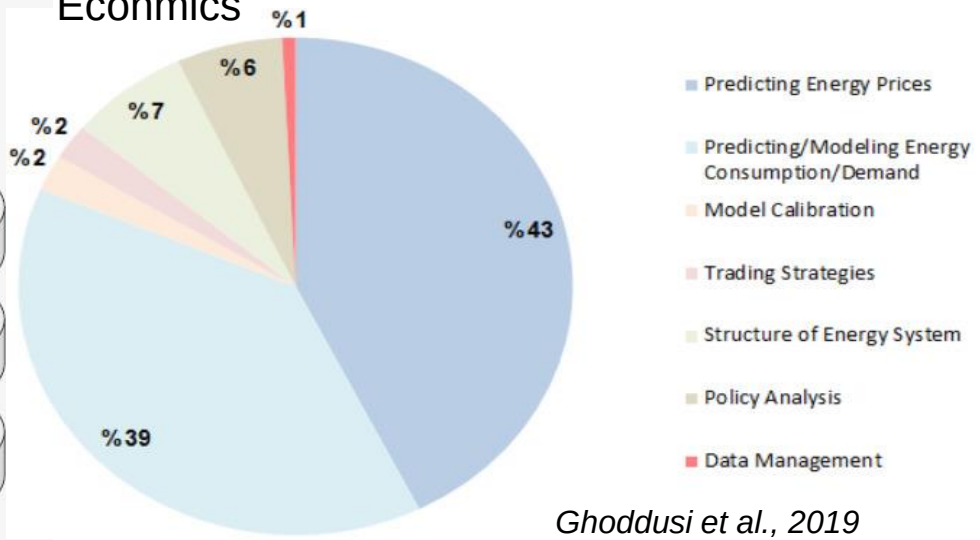
AI supports global energy transition



World Economic Forum, BloombergNEF and Deutsche Energie-Agentur, 2021

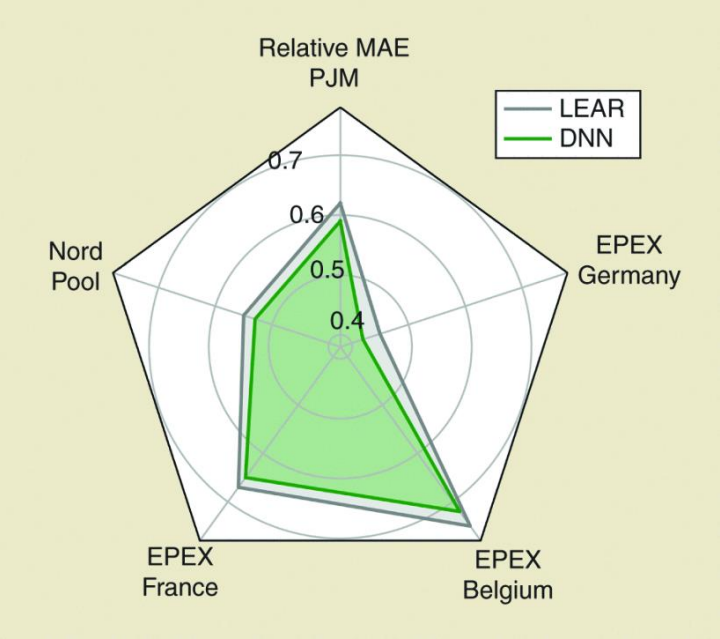
Applications of Machine Learning in Energy Econmics



Ghoddusi et al., 2019

- AI has a large number of applications in energy economics.
- The most significant contribution has been achieved in forecasting industries.
- There are huge potentials of AI to be unlocked.

AI Supports Market Operations



A radar plot of the relative mean absolute errors (rMAEs) for the LASSO-estimated autoregressive (LEAR) and deep neural network (DNN) models using two-year test periods from five power markets, including Pennsylvania–New Jersey–Maryland (PJM) Interconnection, European Power Exchange (EPEX) of Germany, Belgium, and France, and the Nord Pool (Jędrzejewski et al., 2022).

The AI-based technique (DNN) outperforms the advanced time series based technique (LEAR) and achieves lower errors for all markets.

AI-based methods outperform the conventional methods for electricity price forecasting. This is a fundamental input to energy companies' decision-making mechanisms at the corporate level, saving them the costs of over-/under-contracting.

AI Supports Policy Makers And Sustainability

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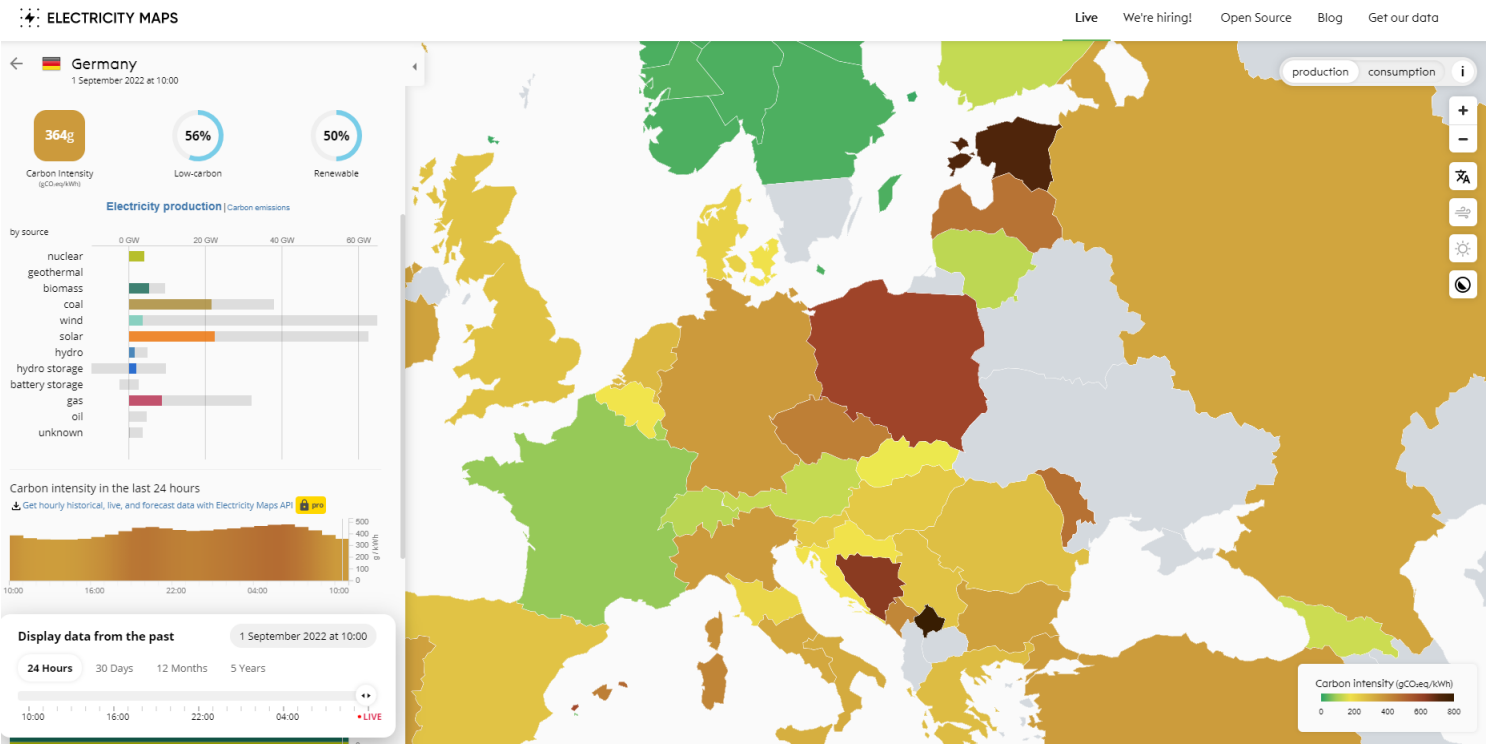

*AI-based [Electricity Maps](): *

- Covering 90+ countries
- *Hourly carbon accounting, including estimation and forecasting*

AI enables the automated establishment of databases under different domains. The granular carbon accounting, e.g., allows estimating the carbon intensity for smart consumption, supports demand response, and measures the impacts of decarbonization projects in the long term.

Meta Studies for Solar Forecasting

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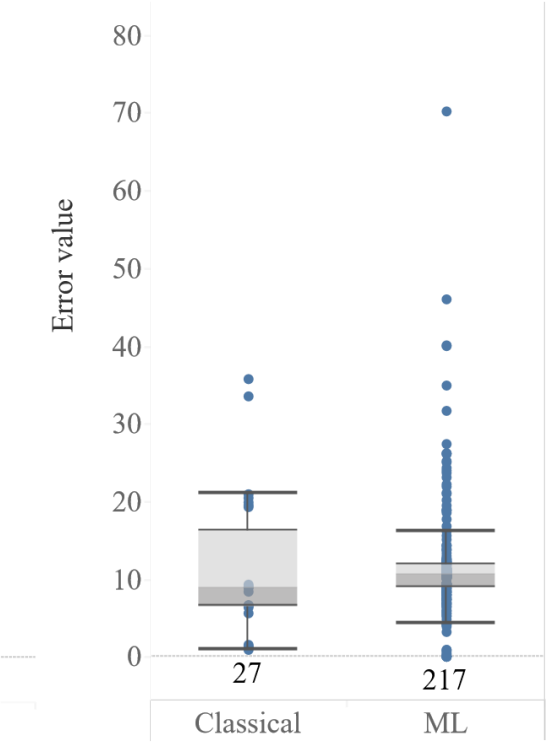
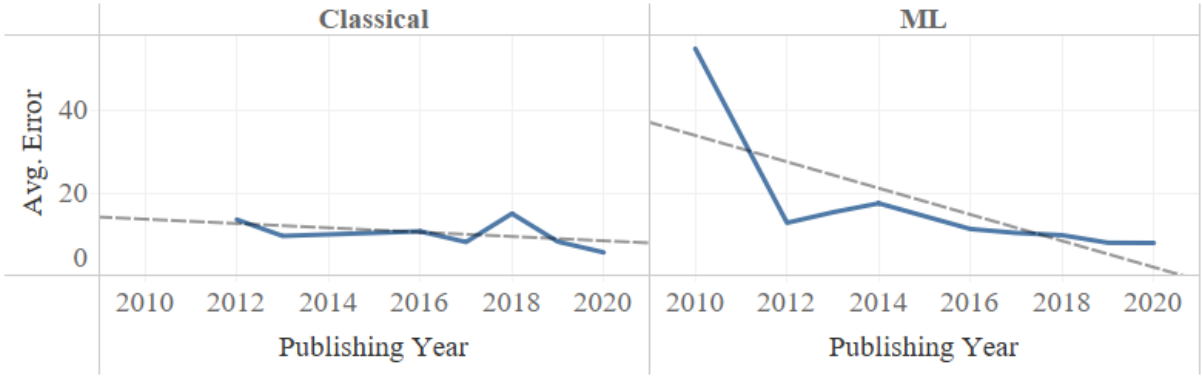
- Two of my team‘s recent studies perform meta-analysis (i.e. extensive quantitative analyses of literature) on solar forecasting
  - Nguyen, T.N. and Müsgens, F., 2022. What drives the accuracy of PV output forecasts?. Applied Energy, 323, p.119603 (Nguyen and Müsgens, 2022a).
  - Nguyen, T.N. and Müsgens, F., 2022. A Meta-Analysis of Solar Forecasting Based on Skill Score. arXiv preprint arXiv:2208.10536 (Nguyen and Müsgens, 2022b).
- Both analyse how various factors influence forecast quality (but differ in data and methodology)
- Relevant today: Both include whether a forecast is done with AI

AI Supports Energy Transition



Note: Classical includes time series and regression models; ML: machine learning models; The lower the error, the better. Data show long test sets (>365 days) which we consider more representative



Our database of 1,136 observations from 180 studies on solar energy forecasting confirms:

- *based on RMSE, MAE, and MAPE, AI-based methods are not yet superior to classical methods*
- *but it has much steeper progress curve*

Source: Nguyen and Müsgens, 2022a

AI has a leading role in enhancing the accuracy of renewable energy forecasts in the long run

Current Advances of AI In Forecasting

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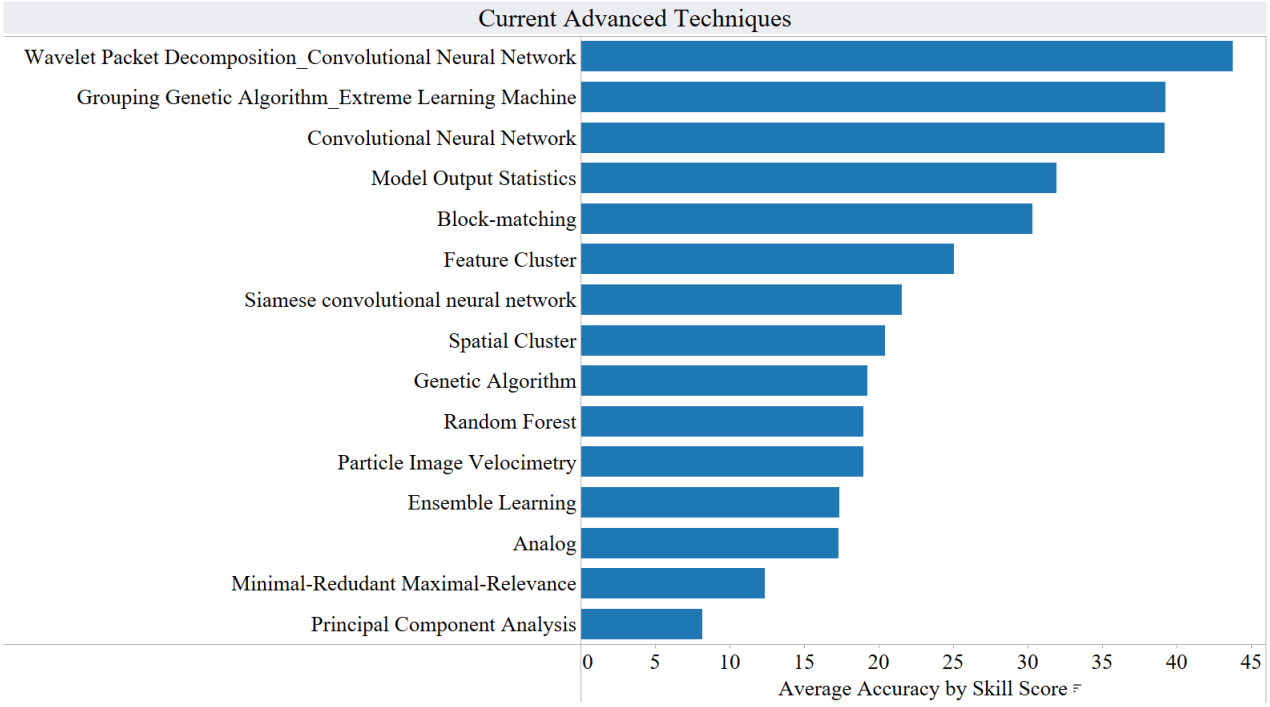

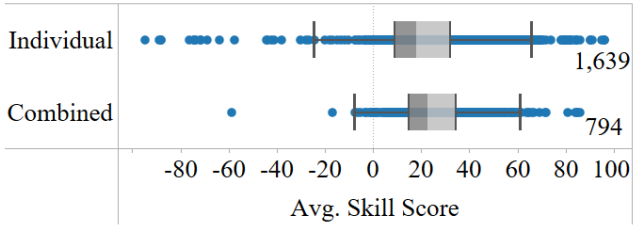

Note: The higher the skill score, the better.

Our study on another database of 4,758 observations from 188 papers on solar forecasting based on skill score metrics shows the importance of AI techniques in feature engineering and selection.

The study also shows the most effective AI and machine learning techniques observed in the literature.

In the future, we would see more combinations of methods, where AI techniques can be used to further enhance the performance of both classical and advanced forecast methods.

Source: Nguyen and Müsgens, 2022b

Challenges and Outlook of AI in Energy Economics

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Challenges

- Fear of black boxes
- Conservative stakeholders stick with time-proven methods.
- Outdated infrastructure and large transition costs
- Carbon footprint usually higher for the technologies involved in an AI pipeline.

Outlook

- Explainable AI is gaining more focus.
- Increasing number of case studies showing the superiority of AI techniques will motivate the transition from conventional to state-of-the-art techniques.
- The fast increment in the computing power will enable AI to yield more practical values and make up for its costs.

Vielen Dank für die Aufmerksamkeit!

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