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# Efficiency Estimation for Combined Heat and Power Generation based on Characteristics and Engineering Models

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**Extended Abstract**

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**Abstract Summary**

Dispatchable power generation still plays a crucial role in the energy system, and especially combined heat and power (CHP) plants are considered valuable because of both supplies during periods with low renewable infeed. These plants are configured for different applications and exhibit considerable heterogeneity in their characteristics, so a consistent quantification of their key performance indicators is essential for realistic energy foresight studies.

Engineering models are typically applicable only to specific cases, and European public datasets such as German Marktstammdatenregister (MaStR) registry platform and ENTSO-E only provide nameplate capacities, technologies and vintage information. We first combine turbine-level information to the plant level, enabling integrated analyses that capture the interdependence between gas and steam cycles in combined-cycle gas turbines (CCGTs). Based on basic thermodynamic relationships, we derive a series of formulas for thermal efficiencies of CCGT, open-cycle gas turbine (OCGT), steam turbine (ST), and motor-based units.

The formulas also account for vintage and size effects, ensuring consistent estimation across all the units. The parameterization of the formulas consider ST technologies and the generated steam properties, which determine CHP characteristics and are the key drivers of the overall plant efficiency. In the absence of detailed information, a reasonable approximation can be obtained by classifying the unit operator as either a utility or an industrial company together with the GT-to-ST capacity ratio.

This contribution integrates key unit characteristics with engineering models to estimate the efficiencies of CCGT and CHP power plants. We applied the formulas across German power plants using MaStR data. In addition, a closer inspection of the results from multiple perspectives reveals key trends and drivers in the adoption of these technologies in recent decades. The resulting estimates and derived CCGT configurations can be directly

incorporated into energy system models, and the formulas are transferable to generation fleets in other countries.

**Presenting Author Biography**

Jie began his PhD in 2024 in House of Energy, Climate and Finance at University Duisburg-Essen, where his research centers on empirical modeling of energy markets and systems. Prior to this, he worked as mathematical modeler at encoord GmbH, contributing to softwares for integrated energy system analysis. He holds a master's degree in Energy System Analysis from Technical University of Denmark and a bachelor's degree in Renewable Energy Science and Engineering from Chongqing University in China.