3rd NFDI4Energy Conference: Defining Energy Research Data Management Together
Proceedings to the 3rd NFDI4Energy Conference - Extended Abstracts
https://doi.org/10.52825/ocp.v9i.3309

Published: 23 Mar. 2026

Clearing the Conceptual Jungle of Energy Statistics: Definitions for a Decarbonized Power System

Rebecca Hofmann[1,*], Célia Burghardt[1], Michael Memmler[2], Leonhard Gandhi[3], Mirko Schäfer[1], and Anke Weidlich[1]

[1]INATECH, University of Freiburg, Germany
[2]Working Group on Renewable Energy Statistics (AGEE-Stat), Federal Environment Agency, Germany
[3]Fraunhofer ISE, Germany
*Correspondence: Rebecca Hofmann, rebecca.hofmann@inatech.uni-freiburg.de

Abstract. The transition towards a decarbonised, electrified energy system challenges the statistical foundations on which policy, regulation, and research rely. Established indicators such as the renewable energy quota were designed for centralised, fossil-fired power plants, with negligible prosumer activity and limited storage. High shares of variable renewables, increasing rooftop photovoltaic deployment with self-consumption, and diverse storage technologies now fundamentally challenge legacy methods. European legislation has fixed the gross principle and gross inland electricity consumption as the denominator for the renewable energy quota, yet widely cited national indicators deviate systematically from EU-compliant calculations and suffer from double counting in the treatment of pumped hydro storage. To address these ambiguities, we present a *Compendium of Statistical Definitions for Electricity Production and Consumption*. The compendium provides unambiguous definitions, explicit accounting formulas, and references to exact data series and legal sources for key quantities including gross and net electricity production and consumption, self-consumption, storage balance, and the renewable energy quota. We discuss three main implications: the growing statistical importance of prosumer self-consumption, the comparability of renewable energy quotas across methods and jurisdictions, and the need to exclude pumped hydro storage — and, by extension, other storage technologies — from generation accounting to avoid double counting. The compendium provides a reference layer for harmonising heterogeneous datasets, supports machine-readable term definitions compatible with the Open Energy Ontology, and contributes to future-proof energy statistics for high-renewable energy systems.

Keywords: Energy Statistics, Gross Electricity Generation, Pumped Hydro Storage, Renewable Energy Quota, Self-Consumption

1. Introduction

The transition towards a decarbonised, electrified energy system is transforming not only physical infrastructures but also the statistical foundations on which policy, regulation and research rely. Established indicators such as the share of renewable electricity in gross consumption (renewable energy quota) were designed in an era dominated by centralised, fossil fired power plants, negligible prosumer activity and limited storage. Today, high shares of variable renewables, rapidly increasing rooftop photovoltaic (PV) deployment with self consumption, and diverse storage technologies (pumped hydro, batteries, hydrogen) fundamentally challenge the adequacy of these legacy methods. At the same time, European legislation – most notably Directive 2009/28/EC and its recast 2018/2001 – has clearly fixed the gross principle and the use of gross inland electricity consumption as the denominator for the renewable energy quota [1], [2]. Kramer and Maaßen [3] have shown that widely cited German indicators based on net production or network load deviate systematically from the EU compliant quota, and that current German energy balances double count electricity from pumped storage plants. To understand the systematical differences of the used methods it is important to have a common understanding of the operational vocabulary of energy system practice and published statistics. This understanding is important to reconsider current statistical EU guidelines, and derive effective policy for the energy transition.

2. Methods and Results

As a foundation, we have developed a *Compendium of Statistical Definitions for Electricity Production and Consumption*, published as part of the Monitoring Report 2025 by the Expert Commission on the state of the Energy Transition (Germany) [4]. While focusing exclusively on electricity quantities, the compendium provides a dense, cross-referenced framework to address key definitional ambiguities. It lays out the key quantities used in German and European electricity statistics, drawing on and cross-linking the main sources for national energy data:

- The *Working Group on Energy Balances* (AGEB)
- The *Working Group on Renewable Energy Statistics* (AGEE Stat)
- The *Federal Statistical Office* (destatis)
- Eurostat energy statistics
- German Association of Energy and Water Industries (BDEW)
- VGBE (VGBE terms search, only definitions)
- Grid operators' published statistics (ENTSO-E or the SMARD platform of the Federal Network Agency).

For each term – such as gross electricity production, gross electricity consumption, net generation, net consumption, self consumption, storage balance, pumped storage electricity (PSE), and the share of renewables – the compendium provides an unambiguous definition, explicit accounting formula, and references to the exact data series and legal sources.

The first motivation for the compendium is the growing importance of self consumption. BDEW and AGEB statistics define self consumption as electricity produced and used behind the grid connection point (i.e. PV prosumers, industrial on site generators, the railway operator network and closed distribution networks). For 2024, Fraunhofer ISE estimates yearly PV self consumption in Germany already represents 17% of PV generation [5]. As prosumer activity increases, this quantity becomes crucial for network planning (reduced and shifted grid load), for tariff and network charge design (debates on cost reflectivity), and for assessing the real contribution of distributed renewables to decarbonisation. Therefore a coherent statistical assessment of self consumption is highly relevant, ideally supplemented with temporally resolved data as an input for areas like grid planning and operation.

A second motivation is the comparability of renewable energy quotas across calculation methods and jurisdictions. Kramer and Maaßen demonstrate that approaches based on quantities like public net production stand in contrast to the gross principle mandated by the European Commission, and can result in higher renewable shares for the same year. For Germany 2023, for instance, AGEB reports a gross domestic electricity consumption of

520.5 TWh including, and 515.1 TWh excluding pumped hydro storage; the corresponding renewable energy quota thus is 52.9% and 53.4%, respectively. By clarifying and formalising these variants and their intended use, the compendium enables transparent recalculation of indicators and avoids the mixing of denominators criticised for instance in [3]. The compendium's consistent definition chain, from gross electricity production through net electricity production to net electricity consumption, allows to quantify the gross/net divergence and clearer discuss the influences from power plant own consumption versus estimation of prosumer and storage terms.

Third, the compendium clarifies the treatment of pumped storage electricity and, by extension, other storage technologies. In the German energy balance, pumped hydro storage is still counted as part of gross electricity production, even though it represents the release of previously stored electricity, not new primary generation. This methodological decision implies double counting in both production and consumption: the energy appears once when it is first generated and stored, and again when it is discharged. As of now, Eurostat and the EU Renewable Energy Directive explicitly state that electricity from pumped storage using previously pumped water must not be counted as renewable generation. However, electricity from storage should not be accounted for as generation in general to avoid double counting, especially considering the increase in storage capacity. Further, in a future energy system based on renewable energies storage will mainly charge with renewable electricity, leading to inaccurate accounting under the current directive. It is therefore important to distinguish between storage input, storage output, and storage losses, implying the usage of gross electricity production and consumption excluding pumped hydro storage for the renewable energy quota and related indicators. This approach eliminates double counting for pumped hydro and is immediately generalisable to batteries and power to hydrogen systems, which will play an increasingly important role in high renewable energy systems. With this increasing role, however, it is essential to balance and report the energy provided by electricity storage systems in order to obtain a comprehensive picture of the electricity supply.

3. Conclusion

For energy system research, the compendium has three main implications. First, it provides a reference layer against which heterogeneous datasets and indicators can be mapped, to improve interoperability between national statistics, TSO data, and research datasets. The compendium can serve as a basis for machine readable term definitions for instance from the Open Energy Ontology [6]. This enables automated checks such as whether pumped hydro storage has been excluded from renewable generation, whether PV self consumption has been consistently added to both renewable production and consumption, or whether reported gross and net balances are consistent when storage and network losses are taken into account. Second, it makes the methodological choices behind headline indicators like the renewable energy quota explicit for energy analytics. Third, it contributes to future proof energy statistics in a world of high renewable shares, prosumers, and storage, by treating these elements not as marginal corrections but integral parts of the energy system.

Data Availability Statement

The compendium of statistical definitions is published as part of the Monitoring Report 2025 [4]. The data sources referenced therein are publicly available through the respective organisations (AGEB, AGEE-Stat, destatis, Eurostat, BDEW, VGBE, ENTSO-E, SMARD).

Underlying and Related Material

The full compendium of definitions is available in the Monitoring Report 2025 of the Expert Commission on the state of the Energy Transition [4].

Author Contributions

Conceptualization R.H., C.B., A.W.; methodology R.H., C.B., M.M., L.G.; writing – original draft R.H., C.B., M.S.; writing – review & editing R.H., C.B., M.S., M.M., L.G.; supervision A.W., M.S.

Competing Interests

The authors declare that they have no competing interests.

Funding

M.S. and A.W. would like to thank the German Federal Government, the German State Governments, and the Joint Science Conference (GWK) for their funding and support as part of the NFDI4Energy consortium. Funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – 501865131.

References

[1] European Commission, *Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (Text with EEA relevance)*, 2009.

[2] European Commission, *Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast) (Text with EEA relevance.)* 2018.

[3] W. Kramer and U. Maaßen, "Das Bruttoprinzip ist europäische Vorgabe – Unterschiedliche Berechnungsmethoden schaffen Verwirrung bei der EE-Quote", *Energiewirtschaftliche Tagesfragen*, vol. 72, no. 4, pp. 45–47, 2022.

[4] Andreas Löschel, Veronika Grimm, Felix Matthes, Anke Weidlich, *Monitoringbericht*, Expertenkommission zum Energiewende-Monitoring, 2025.

[5] Tobias Reuther, Verena Fluri, Hannah Nolte, Christoph Kost, *Wissenschaftliche Analysen zu ausgewählten Aspekten der Statistik erneuerbarer Energien und zur Unterstützung der Arbeitsgruppe Erneuerbare Energien-Statistik*, Federal Environment Agency, Climate Change 61/2025, 2025. DOI: https://doi.org/10.60810/openumwelt-7685.

[6] M. Booshehri et al., "Introducing the open energy ontology: Enhancing data interpretation and interfacing in energy systems analysis", *Energy and AI*, vol. 5, p. 100 074, 2021. DOI: https://doi.org/10.1016/j.egyai.2021.100074.