PRODUCTIVITY RESEARCH NOTES 2624

# What Is Electricity Output?

*Beyond Kilowatt-Hours*

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November 25, 2026

## KEY MESSAGE

*Electricity is measured in kilowatt-hours, but electricity supply, as an output in national accounts, is a composite economic product. The electricity system not only generates electric energy but also transfers it across space and time, provides supply capacity, and balances supply and demand. Electricity storage illustrates the distinction particularly clearly: it reduces the physical quantity of electricity over a complete cycle while potentially increasing its economic value. Meaningful productivity measurement requires distinguishing physical measurement boundaries, the accounting of internal transactions, and the goods and services that constitute electricity-system output.*

## WHY THIS MATTERS

Electricity appears to be one of the easiest products to measure, given its common physical unit. Yet electricity supply is not merely the delivery of energy actually consumed; it also entails maintaining the ability to deliver electricity whenever and wherever it is needed. Moreover, the transition from vertically integrated utilities to disaggregated electricity systems makes previously internal activities visible as market transactions. What should remain invariant to such organizational changes, and what should be separately recognized as output?

## CONCEPT: PHYSICAL AND ACCOUNTING BOUNDARIES

International energy statistics distinguish gross electricity generation from net generation, the latter excluding electricity consumed by generating auxiliaries and losses in main generator transformers (United Nations 2018). Abstracting from electricity storage, further deductions for network losses and substation own use yield electricity delivered to users. These physical measurement boundaries are distinct from the accounting treatment of transactions within the electricity industry. When purchased electricity is resold, a transaction-gross measure counts the same electricity at successive transaction stages, whereas a transaction-net measure eliminates internal electricity trades from both output and intermediate input. Under the former, measured output may increase even when generation and deliveries remain unchanged. The latter makes aggregate electricity volume independent of the number of transaction stages.

## CONCEPT: ELECTRICITY SUPPLY AS A COMPOSITE PRODUCT

The electricity system provides a range of economically distinct products. Generation converts other forms of energy into electricity; transmission and distribution transfer electricity across space; storage transfers it across time; and retail and trading facilitate transactions. Capacity provision ensures the availability of resources to meet future demand, while balancing and ancillary services support the continuous operation of the system. The emergence of capacity and balancing markets makes some of these services separately observable and priced. Their underlying functions, however, largely predate the markets themselves. A change in market arrangements need not represent the creation of a new economic service. Generation also carries environmental attributes, which may be favorable, such as low emissions, or adverse, such as the

land-use and landscape impacts of large-scale solar installations. Two electricity systems delivering the same annual quantity of electricity may nevertheless differ in availability, flexibility, reliability, and environmental performance. The figure summarizes these three dimensions of electricity output measurement.

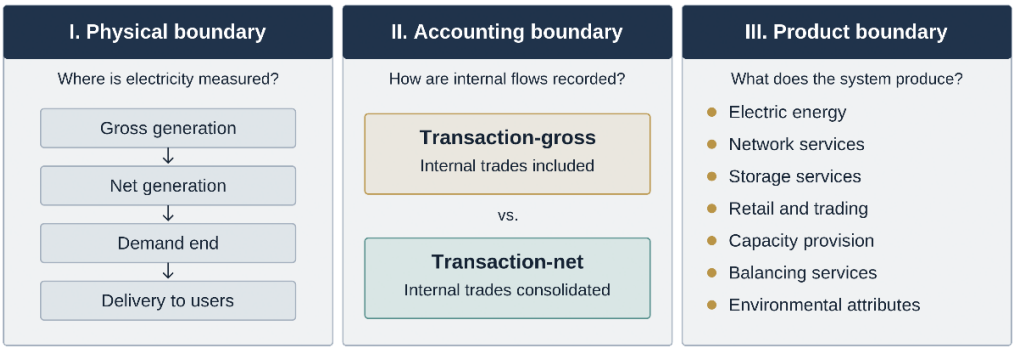


*Figure. Three Dimensions of Electricity Output Measurement*
Source: Authors' elaboration.
Note: Demand end denotes electricity after network losses, before substation own use.

## ILLUSTRATION: ELECTRICITY STORAGE

Pumped-storage hydropower and batteries illustrate the distinction between physical and economic output. Over a complete storage cycle, charging 100 MWh at USD 50/MWh and discharging 80 MWh at USD 150/MWh entails a physical loss of 20 MWh, yet output value exceeds electricity input cost by USD 7,000. Like transmission, storage can create economic value despite physical losses. While charging electricity should be netted against discharged electricity for aggregate physical measurement, storage warrants separate output and input accounts for productivity analysis, including any capacity and balancing services it provides.

## MEASUREMENT CONSIDERATIONS

An extended electricity account would distinguish electric energy from the services associated with its supply, while reconciling physical flows with monetary transactions. It requires activity-level accounts and price-weighted quantity indices to aggregate heterogeneous outputs. Even for electric energy itself, substantial price differences across hours of the day and seasons raise a further question of how to construct annual quantity indices. Not all separately identified services should be added to the value of electricity supplied, as some constitute intermediate inputs into other electricity-system activities. Environmental attributes, favorable or adverse, may not be fully reflected in observed prices and may require additional valuation. Policy-related levies and subsidies, such as those associated with feed-in tariffs, raise separate valuation issues rather than necessarily representing additional output. Without appropriate adjustment, resources used to improve reliability, flexibility, or environmental performance may appear only as higher inputs, understating productivity growth, while unrecorded environmental costs may overstate it.

## IMPLICATIONS

**01**
Physical electricity volumes and economic output are distinct concepts. Both require consistent measurement boundaries.

**02**
Electricity-system reforms can alter recorded transactions and outputs without changing underlying production.

**03**
Productivity measurement requires an extended electricity account that identifies distinct outputs without double counting.

## REFERENCES

United Nations (2018). *International Recommendations for Energy Statistics (IRES)*. New York: United Nations.

*This note is part of the Productivity Research Notes series, examining key issues in productivity and economic performance in Asia. The views expressed are those of the author(s). Inquiries may be directed to sankenoffice@info.keio.ac.jp.*

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