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# Coupling mechanisms and coordinated dispatch strategies for computing-power coordination

**Jianhua Xiao,[1] Fenghua Sun,[2] Shijun Wang,[3] and Longfei Chen[4,*]**

[1]State Key Laboratory of Ecological Safety and Sustainable Development in Arid Lands, Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences, Lanzhou 730000, China

[2]Key Laboratory of Western China's Environmental Systems (Ministry of Education), College of Earth and Environmental Sciences, Lanzhou University, Lanzhou 730000, China

[3]State Grid Gansu Electric Power Company, Lanzhou 730000, China

[4]School of Tropical Agriculture and Forestry, Hainan University, Haikou 570228, China

*Correspondence: chenlongfei_mail@163.com

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**Dear Editor,**

The global artificial intelligence industry has entered a phase of large-scale deployment, with the training and inference of large models driving rapid growth in the electricity demand of computing infrastructure. According to the International Energy Agency, global data center electricity consumption reached 415 TWh in 2024 and is projected to more than double to 945 TWh by 2030.[1] Bass model-based projections further suggest that electricity consumption by China's data center sector will exceed 400 TWh by 2030, accounting for approximately 4% of the nation's total electricity demand.[2] Meanwhile, China is accelerating the development of a renewable energy-dominated power system. By integrating ultra-high-voltage transmission and energy storage technologies, the country could increase its photovoltaic and wind power generation to 15 PWh annually by 2060.[3] However, the intermittent, geographically uneven, and weather-sensitive characteristics of renewable energy sources pose significant challenges to grid flexibility and contribute to wind and solar power curtailment.[4,5] Under the traditional paradigm, the power system functions solely as an energy supplier to computing infrastructure, with little bidirectional interaction between the two. Consequently, it is unable to fully meet the stringent requirements of high-density intelligent computing clusters for power supply reliability and power quality, while also failing to harness the potential of computing loads as controllable demand-side resources. In this context, fostering the deep integration of the new power system and computing infrastructure and establishing coordinated dispatch mechanisms have become central challenges in simultaneously advancing the digital economy and the energy transition.

Computing-power coordination refers to the deep integration and bidirectional interaction between computing infrastructure and the power system across the physical, information, and market layers. Unlike the traditional one-way power supply model, its core objective is to establish a virtuous cycle in which power supports computing and computing, in turn, enhances power system operation. At the physical level, integration serves as the foundation, price, carbon intensity, and available reserve. The dispatch problem is to assign tasks across locations and time so as to reduce electricity cost, renewable curtailment, carbon emissions, and service delay, subject to network capacity, storage and ramping limits, data-transfer latency, cooling constraints, power-quality requirements, and task-deadline constraints. This formulation clarifies why real-time inference is less movable, whereas non-real-time training and offline analysis can be shifted toward renewable-rich periods or regions.

The primary challenge facing computing-power coordinated dispatch is the pronounced spatiotemporal mismatch between computing demand and energy supply. In China, the eastern region concentrates both computing and electricity demand, whereas the northwestern and southwestern regions are rich in wind, solar, and hydropower resources.[6,7] This has created a spatial mismatch characterized by the concentration of computing resources in the east and energy resources in the west. At the same time, renewable energy generation exhibits significant minute-scale and diurnal variability, while many computing services remain constrained by user latency, task deadlines, and service-level agreements. Photovoltaic output may be excessive around midday but constrained at night, and wind output may change within minutes; therefore, hour-scale scheduling must be linked to minute-scale balancing and emergency control. Although the Eastern Data, Western Computing initiative has facilitated the relocation of some computing resources to western regions, insufficient coordination between cross-regional computing dispatch and power dispatch has limited its ability to fully address this structural imbalance. Extreme weather further increases the risk of cascading failure. Heat waves can raise cooling loads and reduce server efficiency, dust storms or low-wind periods can reduce renewable output, and transmission disturbances can simultaneously affect power supply and data-center operation. If computing dispatch, power dispatch, and communication networks are not coordinated, a local power shortage may trigger task migration, network congestion, delayed service completion, and additional electricity demand in backup regions. Data barriers further hinder coordinated dispatch because power dispatch agencies often lack real-time information on dispatchable computing capacity, response rate, task priority, GPU utilization, and queue status, while computing operators lack timely access to renewable forecasts, congestion signals, electricity prices, and emergency constraints. A deeper constraint stems from the inadequacy of market incentive mechanisms. The costs, benefits, and risks of flexibility provision are distributed among grid

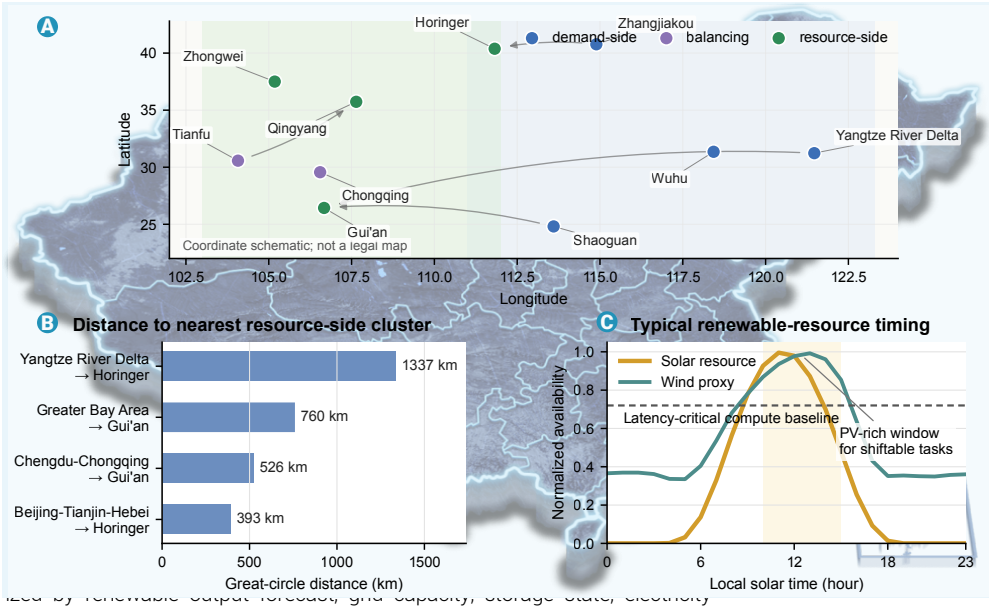



**Figure 1. Spatial and temporal mismatch in computing-power coordination in China** (A) Coordinate schematic of the ten national data-center clusters under the East Data, West Computing layout. Cluster coordinates are approximate representative centres and are used only for analytical visualization. (B) Great-circle distances from major demand-side computing regions to the nearest resource-side cluster. (C) Mean 2024 diurnal solar resource and wind-speed-derived wind proxy.

operators, renewable generators, data-center operators, cloud customers, and end users, yet current settlement rules do not fully compensate computing operators for service-quality risk or reward them for carbon reduction and curtailment avoidance. Moreover, the linkage among green electricity trading, carbon trading, and computing dispatch remains underdeveloped, and unified standards for dispatchability assessment, data interfaces, response verification, and power-quality management are not yet fully established. This mismatch is summarized in Figure 1.

The key to addressing these challenges lies in establishing an integrated coordinated dispatch mechanism for the source-grid-load-storage-computing system, thereby enabling global optimization across the power and computing systems. At the system level, a four-tier coordinated dispatch framework should be established, covering the national, regional, provincial, and park levels. At the national level, the overall allocation of cross-regional computing and power resources should be coordinated; at the regional level, coordinated dispatch of computing and power resources across provinces should be managed; at the provincial level, each province should formulate its own coordinated dispatch plan; and at the park level, refined dispatch of data centers, local renewable energy, energy storage, cooling systems, and backup power should be implemented. At the dispatch strategy level, computing tasks should be classified by latency tolerance and computational performance requirements. Real-time tasks, such as online inference and financial transactions, should be given priority in power supply and supported by the local grid or dedicated storage to ensure second-to-minute response. Near-real-time tasks, such as data preprocessing and model fine-tuning, can adjust operating schedules within hourly windows according to renewable output and electricity prices. Non-real-time tasks, such as large-model training and offline analysis, can be adjusted on daily or weekly horizons and scheduled during periods of peak renewable generation or low grid load. Dispatch decisions should jointly evaluate energy-side metrics, including electricity cost, curtailment reduction, carbon intensity, reserve margin, ramping pressure, and outage risk, and computing-side metrics, including task completion time, GPU utilization, queue length, data-transfer delay, service-level compliance, and revenue loss caused by interruption or migration. Data are the core foundation of coordinated dispatch. A data-sharing platform with unified standards and interface specifications should enable real-time interaction between power-system and computing-system data, while privacy-preserving computation and federated learning can support trustworthy data sharing without exposing sensitive commercial information. For extreme-weather scenarios, the same platform should trigger emergency schedules that reserve local backup capacity for real-time tasks and migrate only those tasks whose data-transfer delay and service contract allow relocation. Market-based incentives are the fundamental driving force. The ancillary service market should incorporate computing loads into peak shaving, frequency regulation, and reserve provision, with compensation linked to verified response, service quality impacts, and risk allocation. Bundled trading products for green electricity plus computing, carbon-value settlement, and contracts for emergency flexibility can transmit both environmental value and reliability value to participating market entities.

China has initiated pilot projects for computing-power coordination at national computing hub nodes in regions such as Inner Mongolia, Gansu, and Qinghai, giving rise to a range of replicable implementation models. The Horinger cluster in Inner Mongolia has established the country's first data center supplied through direct green electricity delivery, with green electricity accounting for 86% of its total power consumption and an annual electricity supply of 790 million kWh. The Qingyang cluster in Gansu has adopted an integrated source-grid-load-storage model, achieving a data center power usage effectiveness of less than 1.20 and reducing carbon dioxide emissions by approximately 250,000 tons annually. These pilots show that green-electricity procurement, renewable-resource co-location, storage-supported park operation, and efficient cooling can connect conceptual dispatch strategies to practice. They also reveal that computing-power coordination remains at an early stage. Real-time data interfaces, flexible-load verification, service-quality settlement, benefit distribution, and risk sharing have not yet been standardized. To move from pilot demonstration to scalable dispatch, computing infrastructure should be incorporated into power-sector planning, renewable energy bases and computing parks should be planned jointly, and technical standards should define dispatchable computing capacity, response time, data interfaces, power-quality requirements, emergency coordination, and settlement rules. Thus, the policy lesson is not simply to build more western data centers, but to make their flexibility observable, verifiable, and tradable. Such measures would allow computing resources to function not only as large electricity consumers, but also as flexible, low-carbon resources for the new power system.

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## AUTHOR CONTRIBUTIONS

All authors contributed to the manuscript and approved the final version.

## DECLARATION OF INTERESTS

The authors declare no competing interests.

## DATA AND MATERIALS AVAILABILITY

The data supporting Figure 1 are derived from public policy information released by the National Development and Reform Commission and public NASA POWER hourly data for 2024. The cluster coordinates are approximate representative centres, and the distance values and normalized diurnal curves were calculated by the authors. No third-party images or map basemaps were reused. The source data used to draw Figure 1 are provided with the revision package.