Indian solar's digital leap

The next phase of India's clean energy buildout will be defined not only by installed capacity but by how well renewables are integrated to provide flexibility. Digital coordination, market access, and transactional integrity will matter as much as gigawatts deployed. Digitalizing energy is fundamental for promoting solar adoption, ensuring that surplus solar generation is utilized, and enabling distributed assets to play an active role in grid operations, say Shantanu Roy and Saptak Ghosh of India's Center for Study of Science, Technology and Policy (CSTEP).

India's solar generation capacity has expanded remarkably, but the systems governing energy exchange have not kept pace. Rooftop solar accounts for roughly 17% of India's installed solar capacity of 135 GW, but most of this generation remains locked within net-metering or gross-metering frameworks. Similarly, plants in India's agricultural solar PM-KUSUM program are locked into power purchase agreements (PPAs) with electricity distribution companies (DISCOMs) that prioritize developers over farmers.

While these mechanisms have helped scale distributed solar, they still offer limited price discovery and no dynamic signals reflecting time, location, or grid conditions. This means that surplus midday solar often has little economic value beyond bill offset, even as evening demand peaks continue to rely on fossil-fuel-based generation.

Photo: Harvinder Chandigarh/Wikimedia Commons

A small floating solar power plant has been installed on the man-made Dhanas Lake in Chandigarh, India.

Time-of-day tariffs are being introduced, but they are mostly static and fail to reflect local supply–demand dynamics, weakening incentives for distributed resources to align with local grid conditions.

In a PV-dominant system, power must function as a time- and location-sensitive product. This is enabled by peer-to-peer energy trading, by permitting direct electricity exchange between producers and consumers based on proximity, timing, and demand, while the grid ensures physical delivery and reliability. Distributed and decentralized solar owners can sell surplus power locally, communities can balance internal demand, and consumers can gain access to cleaner and potentially cheaper electricity.

These models enable real-time price discovery, activate distributed assets as market participants, and improve the economics of storage needed for system flexibility.

Missing layer

India's power sector is currently exploring digital public infrastructure applications through the emerging concept of the India Energy Stack, with policy signalling and stewardship from the Ministry of Power. The aim is for the system to create a unified digital foundation for identification, smart metering, consent-based data sharing, settlement, and grid coordination based on shared standards rather than fragmented utility-specific platforms. It builds on India's well-established Aadhaar digital identity system and its unified payments interface – a national digital payment system unique to India.

The Beckn protocol, a system originally developed for digital commerce, also presents a compelling model for India's decentralized energy markets. It defines how buyers and sellers discover each other and transact in an open, interoperable environment.

When applied to electricity, Beckn allows surplus solar and flexibility services to be published as discoverable digital services. Rooftop solar and PM-KUSUM owners, battery operators, and community energy systems can broadcast offers specifying location, time window, capacity, and price. Buyers such as electric vehicle charging operators or commercial consumers can dynamically align their needs with these offers based on proximity and grid constraints.

Since Beckn is protocol-based, it can be used by multiple platforms and service providers, enabling open and competitive markets, innovation without grid fragmentation, and regulatory supervision.

Blockchain technology is increasingly relevant in energy markets as it enables reliable record-keeping and automated settlement. It can be embedded into Beckn to build trust, enable settlement, and ensure auditability. In distributed solar and peer-to-peer trading, blockchain operates as a digital trust layer that supports transparent, reliable transactions.

Blockchain-based systems can facilitate tamper-proof and auditable recording of solar energy transactions, with smart contracts seamlessly executing settlements once predefined conditions such as delivery, time window, and price are met. This supports granular accounting by time of use, location, and source, which is essential in electricity markets where value varies.

An Indian prosumer with rooftop solar and battery storage could operate as a flexible micro power plant, storing midday surplus and discharging during evening peaks to serve nearby demand. Beckn-based discovery makes this flexibility visible to buyers, such as hotels or offices, with offers being defined by capacity, duration, and price.

New opportunities

Peer-to-peer trading and digital energy markets are not intended to replace DISCOMs. They instead create opportunities for utilities to transition into new roles as market operators, system integrators, and validators focused on network management, reliability, and settlement. Regulators should focus on enabling innovation without impairing grid stability. Regulatory sandboxes and city-scale pilots can allow new models to be tested before rollout.

Digital energy markets can strengthen energy equity, build resilience through local balancing, and accelerate renewable integration by ensuring surplus solar generation is efficiently utilized. India has already demonstrated its ability to build national-scale digital infrastructure. Extending these principles to the power sector can unlock the next phase of the energy transition, allowing distributed assets to act as a coordinated national resource – one transaction at a time. pv

Saptak Ghosh and Shantanu Roy

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About the authors

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