EnergyTag

Granular Electricity Accounting:

Paving the Way for India's Clean Energy Future

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Introduction

India's growing energy demand is a critical factor in climate change mitigation efforts, with coal still accounting for 72% of electricity generation. Electricity production that closely matches the demand has grown 223% between 2000-2022. Increasing demand for energy, coupled with the heavy reliance on fossil fuels has driven India's share of global energy-related carbon emissions to 7.4% in 2022, a staggering 182% increase since 2000. As the country strives to meet its net-zero emissions target by 2070, announced at COP26, it faces the complex challenge of balancing economic growth, energy security, and decarbonization goals.

Renewable energy is key to India's decarbonization, with ambitious targets like 500 GW of non-fossil fuel-based energy capacity by 2030. By Sept 2024, India has reached 201 GW of renewable capacity, driven by policy support, investor interest, and growing demand from commercial and industrial (C&I) consumers due to cost competitiveness and clean energy goals. The National Green Hydrogen Mission (NGHM) will further boost renewable deployment, with green hydrogen export as a key focus. Aligning with global standards like the EU's criteria on temporal and geographic correlation, which require matching of clean electricity production and consumption on an hourly basis, is essential for India's export ambitions by 2030.

Despite progress, significant challenges remain, including maintaining grid stability with intermittent renewable sources. Ensuring grid resilience will require overcoming the high costs associated with expanding energy storage, which is essential for balancing supply and demand. For C&I consumers, additional hurdles lie in navigating the complexities of renewable energy sourcing, regulatory issues related to power purchase agreements (PPAs), and the difficulty of making credible environmental claims regarding their renewable energy use.

C&I Consumers' Renewable Energy Procurement in India and Challenges

C&I consumers' renewable energy procurement in India reached 34 GW in Dec 2023, driven by cost advantages over utility tariffs and concentrated in sectors like construction, automotive, and textiles. However, challenges such as delays in network access and different open-access[1] rules and regulations hinder PPAs. Despite these obstacles, initiatives like exemptions on transmission and wheeling fees and provisions for electricity banking[2] have effectively promoted corporate procurement. While these measures have supported direct renewable energy purchases, regulators have increasingly introduced cross-subsidy surcharges (CSS[3]) to recover costs associated with grid balancing and subsidized electricity for domestic and agricultural consumers.

Recent trends indicate a tightening of these supportive policies; for instance, Andhra Pradesh has ended banking, and states like Maharashtra and Haryana have imposed additional surcharges on PPA projects. In Haryana, the Electricity Regulatory Commission has introduced a reliability charge of INR 1.5/kWh (0.018 USD/kWh) on solar PPAs and increased banking charges to the same amount, making direct procurement more expensive.

As these support mechanisms evolve or diminish, the industry moves toward a landscape where the temporal matching of renewable electricity generation with consumption becomes increasingly essential. In particular, if India phases out banking provisions for renewable PPAs, companies would struggle to align renewable generation with consumption. Without banking, they will need to adjust their operations to match the electricity supply or invest in energy storage solutions or more flexible, short-term PPAs. This shift underscores the growing importance of more precise temporal matching of clean electricity generation and consumption and ensures reliable round-the-clock (RTC) supply from clean electricity.

In this context, the Renewable Energy Certificate (REC) system in India serves as a market-based mechanism aimed at supporting Renewable Purchase Obligations (RPO). However, it functions primarily as a compliance tool rather than an effective

[1] That allow consumers to purchase electricity directly from generators or the open market instead of distribution companies.
[2] Electricity banking allows renewable electricity generators to store excess energy in the grid during periods of surplus and withdraw it during times of high demand or low generation.
[3] The cross-subsidy surcharge (CSS) in India is an additional charge levied on large consumers (typically industrial or commercial) who opt to procure electricity through open access (PPA) instead of purchasing it from their local distribution company (DISCOM). This surcharge is meant to compensate DISCOMs for the loss of revenue, as they typically charge higher tariffs to these consumers to subsidize the lower rates offered to residential and agricultural consumers. The surcharge helps maintain the balance of cross-subsidizing electricity tariffs within the state.

environmental attribute tracking system, limiting the choices available to C&I customers for sourcing clean electricity. Additionally, the current system does not facilitate transparent tracking and temporal matching of clean electricity generation and consumption. However, when the demand for granular matching of clean electricity grows, both companies and regulators will need a REC system that can track clean electricity generation at a granular level (e.g. hourly or sub-hourly basis).

Granular electricity accounting can address these challenges by enabling real-time matching of clean electricity generation with consumption. It would allow C&I consumers to better align their clean electricity purchases with their operational needs, incentivizing investments in energy storage, and fostering greater transparency in tracking and certifying clean electricity generation and consumption.

The Hourly Profile of India's Power Grid

The hourly profile of India's power grid reveals a nuanced picture of grid realities, showcasing that the share of clean energy is highly dynamic throughout the day. Although the overall share of clean energy sources is on the rise, the distribution of clean energy fluctuates significantly across different hours.

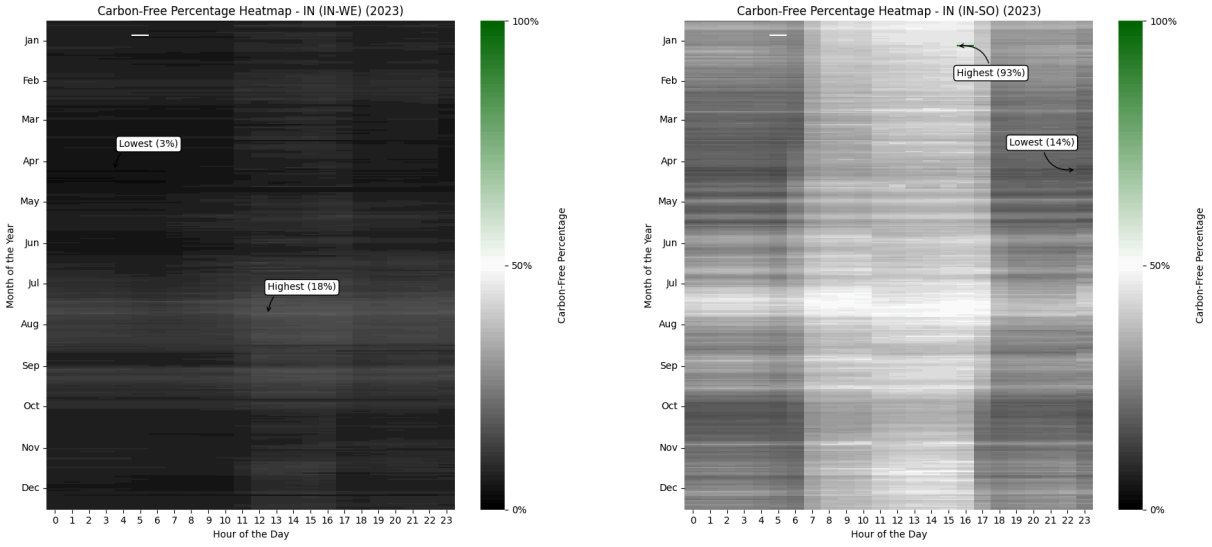

Figure 1: Hourly Carbon-free electricity % in Western Region (IN-WE) and Southern Region (IN-SO). (Source: ElectricityMaps).

Notably, the Southern region of India typically demonstrates a higher share of clean energy compared to the Western region. To adapt to this, companies would need to

closely monitor their electricity usage and align it with periods of higher renewable energy availability, potentially using energy storage solutions to manage demand effectively.

How Granular Electricity Accounting Can Help

Granular electricity accounting is a method of matching clean electricity generation with consumption in the same hour and from a location where the electricity can be delivered. Researchers from Princeton University, McKinsey & Company, and the Technical University of Berlin have found that hourly matching can promote the deployment of advanced clean energy resources and reduce carbon emissions for both buyers and the overall system.

Currently, the use of REC allows consumers to claim renewable energy, such as solar power produced during the day, for the electricity consumption that happens at night. This creates a mismatch in accounting, as the timing of energy generation and consumption doesn't align. While this system has helped promote renewable energy, it doesn't reflect real-time use.

Granular electricity accounting helps correct this issue by matching renewable generation more closely with actual consumption, ensuring a more accurate and reliable carbon accounting system. Thus, it aligns green electricity markets with grid realities, ensures real-time renewable energy use, and improves grid stability.

India’s Current Landscape: Already a Granularity Frontrunner?

As India embarks on its journey toward deep decarbonization of its energy sector, granular electricity accounting emerges as a vital step forward. While this concept may seem novel, its foundational elements are already present in existing policy frameworks. For example, India's power market already operates on a 15-minute block settlement system, providing a strong foundation for granular electricity accounting. A new market segment - The Green Term Ahead Market (G-TAM) enables short-term trading of renewable energy, through 15-minute time blocks. Initiatives like Firm and Dispatchable Renewable Energy (FDRE) which ensures continuous and reliable electricity from renewable energy sources and aims to overcome the intermittent nature of renewable energy generation, and the National

Smart Grid Mission which supports the deployment of smart meters help precise energy tracking.

This article explores how these initiatives form the bedrock of a granular electricity accounting system, why it's essential and advantageous for India to move in this direction, and how global experiences demonstrate its potential.

Let's explore India's current landscape that supports granularity in detail below.

1. **15-Minute settlement period for electricity in India:** India's adoption of a sub-hourly settlement system, which divides the day into 96 (15-minute) blocks for recording and settling energy exchanges, positions the country ahead of many others, which have typically adopted an hourly settlement model. This sub-hourly settlement system helps maintain grid discipline by adjusting the price of electricity based on real-time supply-demand conditions and the grid frequency. Indian PPAs currently require 15-minute interval matching between consumption and generation on a day-ahead basis, reflecting a step towards more frequent and precise matching mechanisms. This granular matching creates important incentives to create PPAs that match demand with green supply.
2. **Green Term Ahead Market (GTAM):** Launched in August 2020 by the Central Electricity Regulatory Commission (CERC), the GTAM provides a platform for renewable energy generators to sell power in the short term without long-term PPAs. The GTAM facilitates the physical delivery of green power, promoting transparency and efficiency in trading. The introduction of Green Intraday Contracts and Day Ahead Contingency Contracts further enhances India's capabilities in granular electricity accounting. These contracts facilitate bidding on a 15-minute time-block basis, allowing participants to adjust their energy procurement in real time based on immediate supply and demand conditions. By enabling more precise scheduling and allocation of green power, these contracts support the integration of renewable energy sources into the grid while enhancing operational flexibility for both consumers and suppliers.
3. **Firm and Dispatchable Renewable Energy (FDRE):** FDRE, introduced as a successor to India's Round-the-Clock (RTC) contracts, represents a crucial evolution in clean electricity procurement. It guarantees a consistent electricity supply backed by energy storage, closely matching the needs of the off-taker. The inaugural FDRE tender concluded in November 2023 with SJVN for 1,500 MW, highlighting the market's readiness for this innovative approach.

FDRE's focus on aligning generation with real-time demand on an hourly basis supports the shift towards accurate, time-based tracking of clean electricity.

4. **Smart Metering under the National Smart Grid Mission**: The National Smart Grid Mission (NSGM) and The Smart Meter National Programme (SMNP) are actively promoting the deployment of smart meters, which are essential for granular accounting. Energy Efficiency Services Limited (EESL) - a government-owned enterprise has installed over 3.5 million smart meters in the states of Uttar Pradesh, Delhi, Haryana, Bihar, Rajasthan, and Andaman. Smart meters, with their ability to measure and communicate consumption in real time, provide a foundation for more precise electricity tracking. By integrating these meters into the grid, India can leverage real-time consumption data to match it with real-time renewable generation.

5. **Leading organizations adopting 24/7 carbon-free energy:** India's leading renewable energy developer Greenko is developing a platform that will deliver dispatchable 24/7- carbon-free energy of over 100 TWh across India. Greenko is a signatory to the UN's 24/7 Carbon-free Energy Compact. RE100 member company Shree Cement Ltd recently committed to source 24/7 carbon-free electricity and become a founding partner of Climate Group's 24/7 Carbon-Free Coalition. The company is exploring battery energy storage and pumped hydro energy storage for an uninterrupted 24/7 carbon-free electricity supply for its operations in India.

   As per the International Energy Agency (IEA) when companies set more granular energy goals – such as matching their electricity demand hourly, rather than annually, it can stimulate the deployment of additional clean energy capacity to the grid, and support the wider portfolio of flexible electricity generation technologies needed for net zero transitions in the power sector.

   The IEA modeling case study for India and Indonesia in 2030 evaluates the impacts of corporate clean electricity sourcing strategies on power systems. It compares different clean electricity goals, specifically annual and hourly matching portfolios, assessing their effects on system costs, fuel costs, operating expenses, and peak contributions. The study finds that annual matching portfolios provide lower system value[4] compared to the cost of standard grid supply. In contrast, hourly matching portfolios yield significantly higher system value, potentially exceeding the costs for serving corporate loads, indicating that more granular procurement strategies can enhance

[4] In this context, "system value" is a comprehensive measure of how effectively a corporate clean electricity sourcing strategy enhances the overall performance, cost-effectiveness, and reliability of the power system while facilitating the transition to net-zero emissions.

economic benefits and system efficiency reducing the burden of renewable integration on ratepayers.

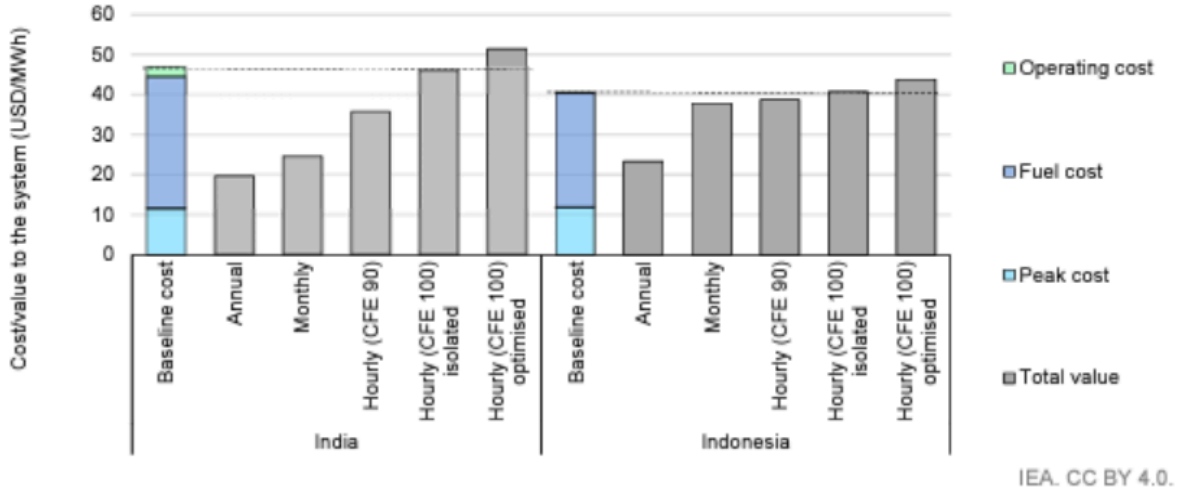

Figure 2: System costs and value contribution in India and Indonesia, 2030. (Source: IEA).

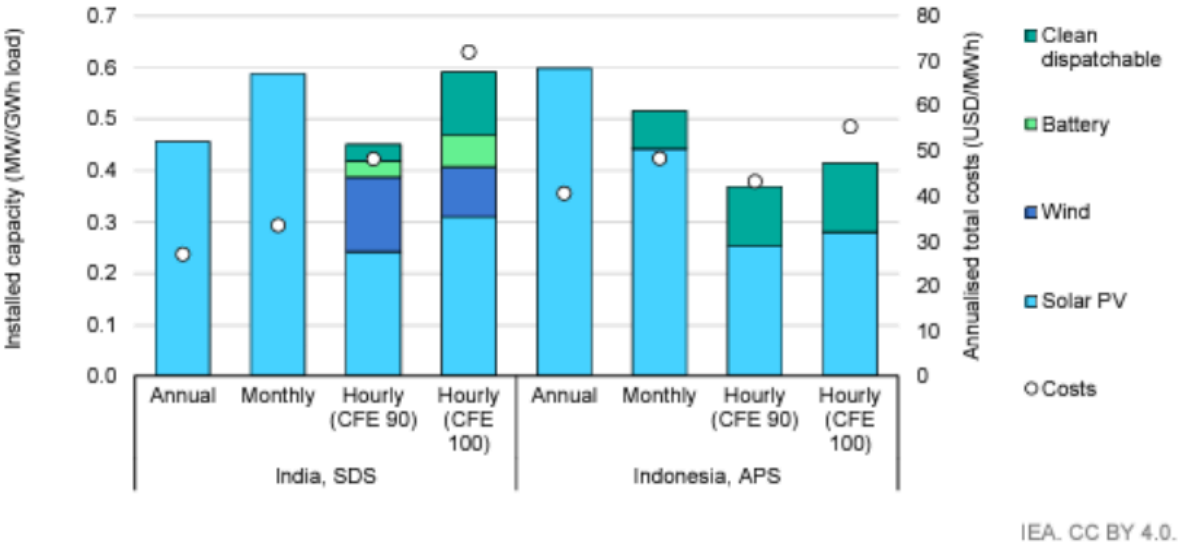

Figure 3: Procurement portfolios and procurement cost for annual and hourly demand matching in India and Indonesia, 2030. (Source: IEA).

Global Programs Supporting Granular Electricity Accounting

India is not alone in this shift towards granular electricity accounting. International initiatives highlight the growing importance of real-time energy and carbon accounting, reflecting a global consensus on the need for precision in tracking clean energy consumption.

Green Hydrogen and Temporal Matching Requirement

Granular Electricity Accounting is becoming essential for the production of **green hydrogen** globally. For hydrogen to be considered truly green, it must be produced using renewable energy in real-time, not just through annual or monthly averages of energy use. This precision ensures that hydrogen production does not rely on grid electricity from fossil fuels at any given moment, thus maintaining its low-emission integrity. Globally, both the United States and the European Union (EU) have set requirements for hourly matching of clean electricity in hydrogen production to certify it as low-emission. The EU further requires that green hydrogen is produced using renewable electricity generation which meets the 'additionality' requirement - requiring hydrogen producers to source electricity via PPA with new and unsupported renewable electricity generation capacity.

In the context of international trade, particularly with the EU, compliance with the green hydrogen certification requirement, and the Carbon Border Adjustment Mechanism (CBAM) is critical. The CBAM mandates that imported goods, including hydrogen, meet strict carbon emission standards. As the EU aims to regulate carbon emissions associated with high-emission sectors, including hydrogen, India must adopt granular electricity accounting practices to track and verify the renewable electricity used in hydrogen production, and additionality requirements. With this, India can position itself as a global leader in green hydrogen and similar products, ensuring that its hydrogen production meets the highest environmental standards and can compete in international markets.

And India can lead in this space. Recently, AM Green Group- a Greenko Group venture has taken the final investment decision (FID) for setting up a 1.3 GW renewable hydrogen-to-ammonia plant in the state of Andhra Pradesh, India. The project will source electricity from 4.5 GW hybrid renewable energy projects (solar and wind) and has already secured 25 years of PPAs with the NTPC equivalent to 50% of its total requirement. The plant has been pre-certified as compliant with the EU's strict granular accounting rules on green hydrogen (i.e. Renewable Fuels of Non-Biological Origin (RFNBO)).

The EU's Granular Guarantees of Origin

In Europe, the European Commission's new renewable energy law supports the rollout of granular Guarantees of Origin (GOs). By allowing energy consumers to track when and where renewable energy is generated, the EU aims to foster transparency and drive investment in renewable energy during periods of lower generation. A similar system will be helpful for a transparent and accountable renewable energy market in India, as it encourages grid operators and consumers to use clean energy in real time, avoiding reliance on fossil fuels.

Australia (Guarantee of Origin) Bill 2024

The Australian Government has introduced the Future Made in Australia (Guarantee of Origin) Bill 2024, along with supporting legislation, to establish a Guarantee of Origin (GO) scheme. This scheme will track and verify emissions for hydrogen and other products made in Australia, providing a framework for renewable electricity certification, including hourly certificates. The 2024-25 Budget allocated $32.2 million to expedite the scheme's initial focus on renewable hydrogen and expand into green metals and low-carbon liquid fuels, building on the $38.2 million from the previous budget to establish the GO scheme. Similar to Australia's budget allocations, India should allocate sufficient funding to enhance its REC framework for granular electricity accounting.

The United States Federal 24/7 CFE Goals

The US federal government has committed to sourcing at least 50% of the electricity for its operations from carbon-free sources on a 24/7 basis by 2030. With more than 300,000 buildings and 600,000 vehicles, the U.S. Government is the nation's largest energy consumer. By aligning energy consumption with clean energy generation every hour, the US is setting a benchmark for global decarbonization efforts. India's ambitions to adopt similar granular frameworks could position the country as a leader in real-time electricity accounting.

The Road Ahead: Scaling Granular Electricity Accounting in India

To fully implement granular electricity accounting in India, certain challenges and opportunities must be addressed:

1. **Scaling Smart Meter Infrastructure and data availability:** Phase-wise deployment of smart metering across large industrial electricity consumers followed by smaller companies, and finally to the general public will be helpful for timely deployment and real-time electricity tracking. A significant number of smart meters are deployed under the Smart Meter National Programme (SMNP), but there is a need to accelerate wider deployment across states. Achieving this will provide the data backbone necessary for granular electricity accounting, allowing consumers and DISCOMs to match generation and consumption in real time. Access to the granular electricity consumption data is also an issue for consumers. Some large industrial electricity consumers have smart meters installed, however access to data is limited or unavailable, and when it is available it is stored for as little as 3 months with DISCOMs. Providing consistent access to granular electricity data is crucial to match generation and consumption for credible clean energy consumption claims.

2. **Incentivizing Renewable Generation During Low Supply Hours**: Granular electricity accounting provides incentives to increase renewable generation during low-supply hours[5] through pricing signals. This is where energy storage technologies, like batteries, come into play. As per the National Electricity Plan (NEP) 2023, the energy storage capacity requirement in India is projected to be 411.4 GWh in the year 2031-32. However, there are challenges such as high initial capital expenditure, a longer gestation period of storage projects, etc. While storage solutions are still expensive, India's growing investment in FDRE supply models and grid upgrades will help overcome this barrier in the meantime.

3. **Adopting 24/7 Carbon-Free Energy Goals**: By adopting a national-level goal similar to the US federal government's targets, India could send a powerful signal to investors and policymakers. Voluntary 24/7 carbon-free energy goals by companies can further drive change in the electricity market. Together it can boost India's clean energy transition forward.

4. **Integrating Granular Certificates (GCs) into the Indian Renewable Energy Certificate (REC) system:** GC represents the next frontier in electricity

[5] For solar energy, low-supply hours typically occur during the evening and nighttime when sunlight is not available. For wind energy, it might happen during periods of low wind speeds, which can vary throughout the day and season.

accounting by introducing precise time-stamped certifications that align energy consumption with renewable energy generation on an hourly or even sub-hourly basis. Since India already operates on 15-minute settlement periods, implementing Granular Certificates would allow for the alignment of renewable energy generation and consumption on this granular time scale. Unlike current RECs, which aggregate energy generation over extended periods, Granular Certificates ensure a more immediate match between consumption and actual renewable generation. This reduces discrepancies and enhances the transparency of energy claims. The Central Electricity Regulatory Commission (CERC) in conjunction with the State Electricity Regulatory Commission (SERC) and other stakeholders must explore granular time-stamped REC system development in India.

Granular electricity accounting represents an opportunity for India to enhance transparency, improve grid efficiency, accelerate decarbonization, and leverage its renewable resource advantage. While the country has already laid the groundwork through 15-minute electricity settlement, GTAM, FDRE supply, and smart metering initiatives, moving toward hourly and sub-hourly accounting will take these efforts to the next level. By aligning with global trends and integrating advanced technologies, India can set the stage for a cleaner, more sustainable energy future.