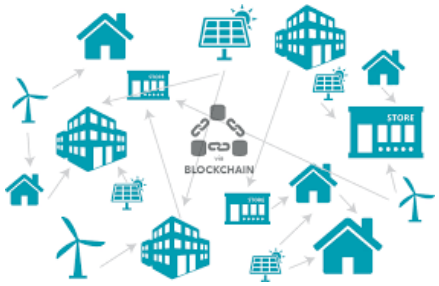
Peer to Peer (P2P) Trading of Rooftop Solar Power on Blockchain in Lucknow, Uttar Pradesh –ISGF Recommendations



Submitted To: **Uttar Pradesh Power Corporation Ltd. (UPPCL)**

Uttar Pradesh
Power Corporation Limited

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India Smart Grid Forum and Power Ledger
CBIP Building, Malcha Marg, New Delhi - 110021

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EXECUTIVE SUMMARY

ISGF implemented a first of its kind pilot project with its technology partner Power Ledger on peer-to-peer (P2P) trading of solar power amongst customers in Uttar Pradesh, India. The main objective of this pilot project was to test the technological feasibility of peer-to-peer (P2P) trading of solar rooftop (RTPV) energy on a blockchain platform at Madhyanchal Vidyut Vitran Nigam Ltd (MVVNL) and its value proposition to MVVNL and their customers in Lucknow City. The P2P platform created an online marketplace where prosumers and consumers could trade electricity, without an intermediary, at the mutually agreed price. The results of the pilot project demonstrated that both prosumers and consumers could benefit by participating in P2P energy trading.

Further, it was demonstrated that there is an opportunity to include a network access charge for the DISCOM within this type of trading environment that will incentivise the DISCOM to promote P2P trading of energy amongst their customers.

Finally, the technical evaluations of the trading platform, meter reading, communication solution, and transactional integration with the billing system were all positive and demonstrated to meet the end-to-end requirements of managing P2P energy trading environment efficiently for MVVNL and UPPCL.

Key recommendations from this pilot project experience are:

i. Extend the P2P platform to more participants both consumers and prosumers
ii. Set the P2P trading rate by UPERC so that the platform is '*set and forget*' for participants, but results in an equitable benefit between the DISCOM rate to buy electricity, and the Net Metering rate to sell electricity to the DISCOM
iii. Incorporate a modest Network Access Charge to the DISCOM to account for costs associated with administration of the program, eg. wheeling charge, transaction fee etc
iv. Extend the program to solarized agricultural feeders under the KUSUM scheme
v. Allow the solar energy traded on the P2P platform to be accounted for meeting the RPO targets of the DISCOM

1 BLOCKCHAIN FOR P2P TRADING

1.1 What is Blockchain?

Blockchain is a modern ground-breaking technology built on a distributed ledger for keeping permanent and tamper-proof (immutable) records of transactional data that has piqued the attention of energy companies, national governments, and academic institutions. Blockchain promises transparent, tamper-proof and secure systems that can enable new business solutions, especially when combined with smart contracts.

1.2 Why is the Blockchain Platform Used for Peer-To-Peer (P2P) Trading?

Blockchain technology is ideal for P2P trading market place as it brings transparency. Blockchain is a digitized, decentralized, distributed ledger that keeps a record of all transactions taking place on a P2P network. All information transferred via blockchain is encrypted and any manipulation with data will be immediately visible and detectable to all other parties and the discrepancy will be known to all. As transactions will be recorded at every step blockchain ensures security, transparency and reliability of the data. This tamper-proof data that does not originate from the utility, will be an important market-enabler.

In P2P trading, individuals generate energy from rooftop solar (RTPV) and share the excess energy (after self-consumption) with other consumers, at a price agreed between prosumer and consumer. Blockchain will allow these transactions to take place on the P2P platform and will store these transactions automatically in encrypted format without the involvement of any third party or energy exchange thereby improving the transparency and reliability of the data and reducing the transaction cost.

2 CONTEXT

Ministry of New and Renewable Energy (MNRE), Government of India has set an ambitious goal of installing 40 GW of solar rooftop (RTPV) power by 2022. As of the end of 2020, India had about 4 GW of RTPV capacity, and it is anticipated that the government will continue to promote solar rooftop program. Solar generation is expected to scale up faster due to the following factors:

a) Cost reduction trajectory of solar PV modules witnessed in the recent past is expected to continue in the coming years while cell efficiency is expected increase
b) Rooftop PV is financially beneficial to most category of electricity consumers
c) Inclination of consumers towards green energy as awareness is raising
d) Consumers will be interested to achieve self-reliance in energy terms
e) Policymakers are already sensitized and have recently notified adoption of gross metering for load >10 kW. This has increased the interest of large customers (>10 kW) for exploring alternative approaches to realize savings on electricity bills from a RTPV investment, including P2P trading of energy from RTPV systems

According to the current trends, the grid will become more interactive. A P2P trading solution is an essential move on the road to a more interactive grid that benefits both customers and prosumers, and the electricity distribution company (DISCOM).

3 OPPORTUNITIES AND SOLUTIONS FOR P2P TRADING

3.1 Opportunities for P2P Trading

The P2P trading model provides an online marketplace where prosumers and consumers can exchange electricity at mutually agreed rates, without the use of an intermediary. Further, P2P trading has the potential to provide following benefits for a DISCOM:

a) **Consumer and prosumer empowerment boosting renewables and flexibility**: P2P trading platforms can provide a marketplace for prosumers to exchange renewable energy produced at a lower cost, facilitating distributed generation deployment. Similarly, P2P trading gives customers more leverage over their energy use and price, increasing system flexibility. P2P trading also enables participants to benefit their local communities by allowing them to absorb renewable energy and gain more from their distributed generation, whether or not storage facilities are used. At the same time, through P2P trading, customers without renewable generation facilities can buy green power directly from local renewable generation.

b) **Balancing and congestion management on the distribution grid through better operation of distributed energy resources:** P2P trading platforms enable better management of decentralised generators by matching local electricity demand and supply. Along with increased local consumption of renewable energy, P2P trading will help reduce investments in generation capacity and transmission infrastructure required to meet peak demand, resulting in lower AT&C losses owing reduced congestion on transmission and distribution networks.

c) **Provision of ancillary services to the main power grid:** The P2P network operators can also allow peers to provide ancillary services to the main grid in addition to allowing P2P transactions, provided if the prosumers deploy energy storage systems. As electric vehicles (EV) rollout is scaling up in UP, the vehicle-to-grid (V2G) technologies will facilitate aggregation of large number of EV batteries and other distributed energy storage systems at prosumer premises as virtual power plant (VPP). The VPPs, which are formed by self-organized consumers, could provide ancillary services to the grid.

3.2 Solutions for P2P Trading

The DISCOM (or a service provider) can promote local generation of solar energy by lending money to customers to create RTPV infrastructure under the OPEX or CAPEX model and creating an end-to-end, fool-proof centralised P2P Trading and Settlement System for commercial settlement of locally generated energy. In order to rollout of such a system, following things are necessary:

a) Software platform for commercial settlement – Metering, Billing, Collection (MBC) systems
b) Established value chain for solar installations
c) Digitalisation - in addition to the physical layer of P2P electricity trading, which requires an electricity network (eg: minigrids, microgrids, DISCOM grids etc.), a virtual or digital layer is required for this business model. An aspect of it is an energy management system (EMS) on the platforms that enable a large number of peers to connect and facilitate P2P trading. To

ensure the power system's efficiency, data from both producers and customers must be obtained and analysed. Smart meters, broadband communication infrastructure, remote control and automation systems (network digitalisation) are thus fundamental enablers of platform-based business models, such as the P2P electricity trading model

d) Smart meter communicating with the blockchain platform
e) Wallet/UPI based payment solution

3.3 Other Opportunities for Blockchain Applications

3.3.1 Electric Mobility in UP

UP has been a major beneficiary under the FAME scheme of Government of India with 139, 000 electric vehicles registered under this scheme. UP's Electric Vehicle Policy 2019 aims to draw over Rs 400 billion in investments across the entire electric mobility ecosystem by 2024, with 50,000 people potentially employed.

Currently, there are 9,997 electric 2-Wheelers, 174,063 electric 3-Wheelers, and 359 electric 4-Wheelers registered in UP, with approximately 210 public charging stations. The projected growth of EVs will open up a lot of possibilities for developing and implementing new technologies, such as blockchain-based EV smart-charging options with a prosumer's rooftop solar plant. Consider a prosumer's neighbour presently charging his EV from the electricity generated in a centralised power plant that is far away. P2P charging will allow this EV owner to buy green electricity from his neighbourhood prosumer to charge his EV.

Various electric vehicle manufacturers, including Toyota Motor Corporation, Hyundai and Tesla, Inc., are undertaking research and development for the incorporation of P2P and Vehicle-to-Grid (V2G) technology, which bodes well for market growth.

3.3.2 Guarantee of Origin (GO) for MSME Sector

A Guarantee of Origin (GO) is a form of Energy Attribute Certificate (EAC) that represents the environmental attributes of one megawatt hour (MWh) of renewable electricity generation. A GO's validity is for 12 months after it is released. Certificates that have not been cancelled within 12 months will immediately expire, and their attributes will flow into the grid, where they will be represented in the residual mix.

GOs are issued in Europe and enable businesses to source renewable energy in the locations that are most important to them. GOs are available in 28 countries in the European Union (EU), plus Norway, Switzerland and Iceland. By European law, each EU member state must have a GO certificate system to track proof of electricity origin, as well as a GO issuing body in charge of developing and enforcing it. When stakeholders refer to the GO market, they are usually referring to the standardised European Energy Certificate System (EECS) GO Market, which currently consists of 21 countries in the European Economic Area (EEA). Several EU countries have national GO systems but have not entered the EECS; the largest of these is the UK's Renewable Energy Guarantees of Origin (REGO) programme, which is operated by OFGEM. In total, 32 countries have GO schemes, including 21 in the EECS and 11 with national schemes.

Recently, the European Union as part of its aim to cut greenhouse gas emissions to net zero by 2050, has also planned to impose **Carbon Border Tax** by 2023 on polluting imported goods including steel, cement and electricity and the list will expand to more sectors. With an estimated 8.9 million Micro, Small and Medium Enterprises (MSME), the state of Uttar Pradesh has the largest share of 14.20

percent MSMEs in India. MSMEs not only play an important role in providing large employment opportunities at comparatively lower capital cost than large industries but also help in industrialization of rural and backward areas, thereby reducing regional imbalances, assuring more equitable distribution of national income and wealth. Carbon Border Tax will have huge impact on MSMEs, which are exporting goods to European countries. MSMEs need to prove that 70 percent of the electricity used for making the products exported to Europe are from renewable energy sources that are exempted from Carbon Border Tax. Blockchain enabled P2P trading will be beneficial for MSMEs as it will facilitate MSMEs to procure renewable energy with immutable Proof of Origin (PoO). GOs can also be issued in India to the MSMEs to showcase that a particular product is produced by using certain percentage of renewable energy. This will help the MSMEs to export goods to the EU countries in future without any challenges.

In the Indian context, GOs are similar to the Renewable Energy Certificate (RECs) which are a market-based instrument to promote renewable energy and facilitate compliance of renewable purchase obligations (RPO). It is aimed at addressing the mismatch between availability of RE resources in state and the requirement of the obligated entities to meet the RPO. RECs issued are of 1 MWh in value, which remains valid for 1095 days from the date of issuance of such certificate.

In addition, blockchain can reduce time to verify invoices and inventory through combining blockchain traceability with goods receivables, purchase orders and invoices. Knowing the authenticity of the product location data, product quality, supplier credentials can greatly help in speeding up the process of supply chain financing. Smart contracts can be leveraged to create, check, and enforce contracts between users, suppliers, clients, and customers.

To ensure on-time payments, product quality, and timely deliveries, tracing a product across the supply chain is critical. Product imaging, videos showing products being loaded, and products tracked using sensors all need traceability. Easy warranty-based product redemption, combined with smart contracts executed on blockchain platforms between retailers, dealers, and OEMs, will boost supply chain performances.

3.4 Use Cases of P2P Trading in Power Sector

Blockchain has attracted the attention of the power industry with its potential to unleash an energy revolution in which both utilities and prosumers will produce and sell electricity. While many blockchain use cases have been proposed for the energy industry, the one gaining the most traction at present is P2P power trading, where owners of small-scale generation can sell excess generation directly to other consumers. Blockchain is a foundational technology that can be used to create new business models and underpin business, economic, and social infrastructure.

The experiences in a range of projects on the application of a blockchain-enabled platform are briefed below:

- **India**

India Smart Grid Forum in collaboration with Power Ledger Australia is already implementing two pilot projects on P2P trading of roof top solar in Lucknow with MVVNL/UPPCL and in Delhi with Tata Power Delhi Distribution Ltd. Details of the Lucknow project are given in the following sections of this project.

- **Australia**

Case studies in Australia include the Renew Nexus project in Fremantle, Western Australia, where the project concluded that by providing a blockchain enabled P2P energy trading marketplace, prosumers and consumers could be incentivised to adjust their behaviour in order to benefit the grid. This was achieved through price signals, leading to greater balance of generation and consumption profiles, resulting in decreased reverse flows of energy in the local distribution network. Further, by providing

more control over the ways in which prosumers could benefit from their investment in DER, participants felt that the P2P trading system would be an incentive to install solar for households that were uncertain about the benefit beyond self-consumption. Additional modelling was undertaken to demonstrate the benefits of including battery storage with a virtual power plant solution, which showed there were potential for benefits to both the battery owners and the distribution network.

- **Thailand**

In Bangkok, Thailand, renewable energy developer BCPG, along with private-public consortium Thai Digital Energy Development are hosting an ongoing trial of the Power Ledger platform where BCPG and Thai utility, the Metropolitan Electricity Authority (MEA) trade rooftop solar power between an international school, apartment complex, shopping centre and dental hospital in Bangkok. The objective of the project is to maximise the renewable energy consumption within the precinct, which is cheaper than grid energy, providing greater income for the solar asset owner BCPG, while reducing electricity costs for participants, which allows for P2P trading in near real-time. Each building is allocated energy from the solar PV systems installed on the roof (some of which are owned by BCPG, who sells the energy to them for a discounted rate) which is transacted through the blockchain platform of Power Ledger. If any building consumes less than the system generates and therefore has surplus of PV energy, they are able to trade that with any other building in the P2P platform.

- **Malaysia**

Power Ledger and SEDA worked together on an 8-month P2P energy trading trial that aimed to demonstrate the ability of the blockchain platform to effectively trade surplus solar energy, with SEDA's goal being to grow the country's RTPV market and advance the deployment of Distributed Energy Resources (DERs) in Malaysia. Power Ledger's platform used interval meter data, provided by Malaysian utility Tenaga Nasional Berhad (TNB), to simulate energy trading patterns between prosumers and consumers across the Malaysian grid. Key takeaways from the project include:

- Balancing of prosumers and consumers is important in reducing excess energy generation
- System Access Charge/Network Charges provide market signal on the commercial viability

Details about several more blockchain projects can be found at: https://www.powerledger.io/clients

4 BENEFITS TO STAKEHOLDERS

4.1 Benefits for Participants – Prosumers and Consumers

i. Freedom for the consumer to choose a supplier of energy (green energy)
ii. Flexibility for customers to trade net energy available at a given time at a better rate (than the net metering or gross metering tariff of the DISCOM) to maximize revenue
iii. Prosumers can monetize their excess solar energy in the same billing cycle
iv. Incentives from DISCOM for participation in Demand Side Management (DSM)
v. Participants can sell their energy at market determined price
vi. As no minimum or maximum capacity for renewable generation is specified in the system, even prosumers with very small sized RTPV systems or very large aggregators can join the P2P trading platform

4.2 Benefits to DISCOMs

i. **RPO fulfilment for DISCOM:** Provided the regulations allow for all rooftop PV generation to be counted towards RPO, regardless of whether it is sold directly to the DISCOM or it is sold to a neighbour, or self-consumed
ii. **Increased generation from rooftop solar reduces the quantity of electricity to be transmitted to local communities which in turn reduces the distribution losses**; as well as defer investment on a system upgrade
iii. **Reduction in the procurement of excess rooftop solar energy from consumers**: By enabling RTPV energy to be traded directly between prosumers and consumers, DISCOMs need not buy the RTPV energy from prosumers under regulated net metering tariffs which are usually higher than the average power purchase cost of the DISCOMs
iv. In the absence of energy storage systems, the prosumer can be encouraged to sell the excess generation of RTPV energy wherever they get the best price through P2P trading, as they would be **unable to manipulate** monthly billing slabs to limit monthly consumption just below higher slabs in this situation (which is one form of tariff arbitrage). Even if a customer continues to minimize monthly consumption by P2P trading to stay below higher tariff slabs in the cost-plus tariff system, such revenue losses can be balanced in the following year in the tariff petition.
v. **Potential new revenue streams for the DISCOM**: DISCOMs can levy wheeling charges and billing and transaction fees for the energy traded on the P2P trading platform within their distribution network
vi. Advocating usage of blockchain-based technologies would ensure a **rapid adoption of smart meters** which eases the metering, billing, and collection (MBC) process with improved efficiency and transparency. A blockchain solution identifying the energy source, at what unit price and any mark-up passed to the consumer would result in more competitive pricing
vii. **Balancing local generation and demand**: DISCOMs can enable prosumers / consumers to discover and coordinate their energy usage through preparation of buy and sell orders to balance the demand and supply within the local community
viii. **Voltage and capacity constraint management:** Promotion and consumption of RTPV energy in local communities can prevent voltage and reverse power flow issues
ix. **Reduction in DISCOM portfolio requirement** results in less procurement of power which in turn creates savings for all consumers, even those who are not part of the P2P trading scheme
x. **Enabling orderly scaling up of Renewable Energy on the grid**

5 P2P PILOT PROJECT IN UTTAR PRADESH

5.1 Power Sector in Uttar Pradesh

Uttar Pradesh (UP), India's most populous state, housed nearly a third of the country's unelectrified population until recently, despite being the fourth largest producer and second largest consumer of electricity. With the introduction of the Pradhan Mantri Sahaj Bijli Har Ghar Yojana (SAUBHAGYA), an additional 8 million customers were connected to the grid during 2017 to 2019. Despite this, the state's per capita electricity consumption is half that of the national average (CEA 2019). Although the SAUBHAGYA scheme added 8 million households in an intensive electrification drive in UP between October 2017 and March 2019, there has been no discernible increase in electricity demand or supply.

As of February 2021, the total installed capacity in UP is 27,309 MW. Thermal-based capacity constitutes about 72 percent of the total capacity, followed by renewable (14 percent), hydro (12 percent), and nuclear (2 percent). To meet the increasing demand, UP has planned capacity addition target of 11,282 MW from own generating stations and allocations from central generating stations, besides sourcing power from private generating stations under Case 1 competitive bidding and renewable energy sources in a phased manner by FY 2022. Renewable capacity is also expected to increase from current level of 14 percent to 19 percent by FY 2022.

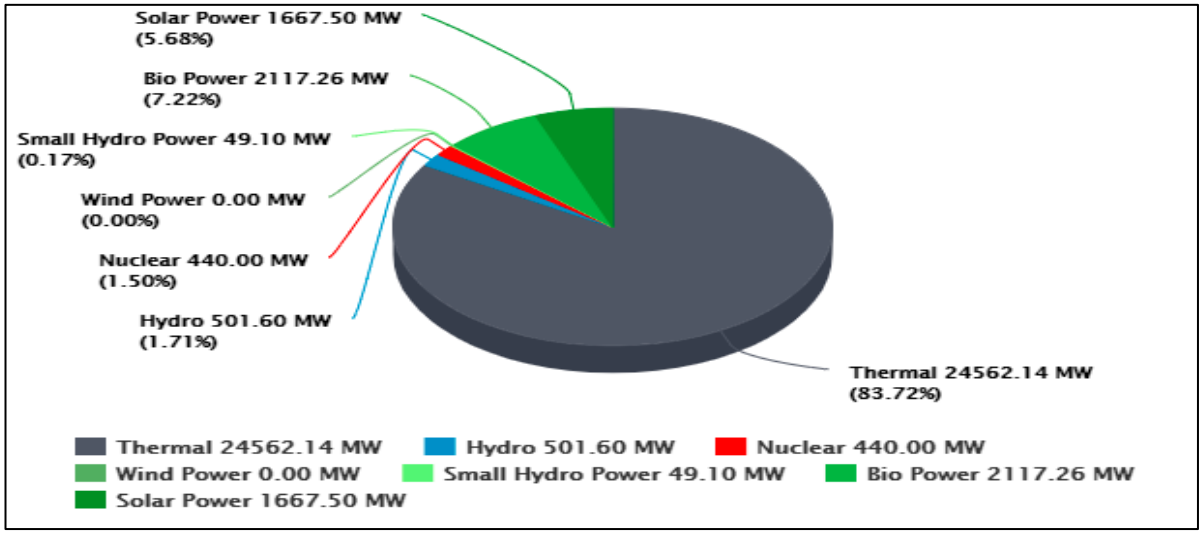


Figure 1: Uttar Pradesh Installed Capacity - Resource Wise

5.2 Project Overview and Objectives

UP is the **first state in India** to launch a pilot project to test the blockchain technology for trading of electricity produced from citizen's RTPV amongst themselves and with other consumers who do not have RTPV. Under the present rules the surplus electricity generated from RTPV can be sold back to the electricity supply company (MVVNL in case of Lucknow) only at the regulated price of Rs 2 per unit (kWh) in UP. The successful outcome of pilot project enabled the prosumers (customers with RTPV) to trade their surplus power produced from RTPV to other customers (peers) at market driven price which is higher than the regulated rate of Rs 2/kWh.

This pilot project is conceived by the Honourable UP Electricity Regulatory Commission (UPERC). The Uttar Pradesh Power Corporation Limited (UPPCL) and its subsidiary Madhyanchal Vidyut Vitran Nigam Limited (MVVNL) are hosting this pilot project in Lucknow. UPERC allowed the pilot project to be implemented under the *regulatory sandbox* approach to test the technical feasibility and customers willingness to participate in such programs. The trading during the pilot phase was undertaken as mock trade – no actual money transactions were involved. But the platform could demonstrate how much the project participants would have gained if there was actual money flow.

The project is implemented by ISGF in collaboration with Power Ledger, Australia. MVVNL and ISGF jointly identified and recruited 12 participants in the pilot project – 9 of them with RTPV and 3 of them net buyers. ISGF installed smart meters in series with the existing revenue meters of MVVNL. The ISGF smart meters (Crystal Power make) are integrated with the blockchain platform of Power Ledger. These meters have 4G SIM cards of Vodafone Idea Ltd. Abjayon Inc., a system integrator has helped in integration of the blockchain platform with UPPCL's billing system. ISGF and Power Ledger

conducted trainings for concerned officials of UPPCL, MVVNL and nodal officers/owners of the identified buildings on the features and functionalities of P2P Platform and the trading procedures.

ISGF also constituted a Blockchain Advisory Committee comprising of following eminent experts who advised on the trading rules and overall project framework:

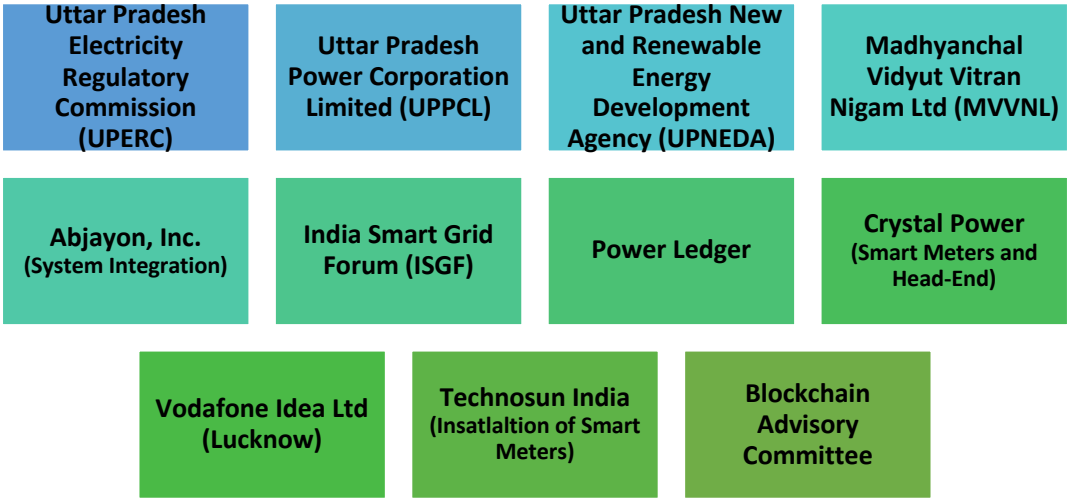
1. **Mr. BP Singh**, Former Member, Delhi Electricity Regulatory Commission
2. **Mr. PK Agarwal**, Former Director, POSOCO
3. **Ms. Mohua Mukherjee**, Ex-World Bank
4. **Prof. Faruk Kazi**, VJTI

There were regular consultations with the Blockchain Advisory Committee at every step and their views and suggestions were incorporated in the project design and implementation. The key objectives of the project were to assist all parties in understanding the nuances of P2P trading such as:

i. To test the technical feasibility of P2P energy trading platform and the and value proposition to MVVNL and their prosumers and consumers
ii. The potential value that can be derived from selling RTPV energy to other buildings within the area
iii. The value of a dynamic energy marketplace where prosumers and consumers can set their buy and sell prices
iv. Test customers willingness to participate in P2P trading programs
v. The optimisation that can occur from utilising different trading models and tariff structures
vi. Provide RTPV owners more flexibility, further incentivizing uptake of DERs in UP
vii. Reduce the financial impact of net metered solar systems on MVVNL
viii. Testing of auto trading logics at customer end which will help in removing manual intervention in the trading - especially with TOD/ TOU tariff regime which was enabled by setting of minimum / maximum dynamic pricing
ix. Support acceleration of deployment of RTPV through cutting edge technology supported market-based mechanisms
x. Provide valuable opportunities to UPPCL to:
    a) Learn how best to implement a network tariff to support the wider rollout of P2P electricity trading
    b) Understand the impacts of P2P trading on the electricity distribution network

5.3 Key Stakeholders

The key stakeholders who are involved in the project are:



5.4 Project Features and Trading Procedure

i. All participants in this pilot project were given a unique ID and Password to access their account on the blockchain platform through internet
ii. A new smart meter was installed in the premises of all prosumers and consumers participating in the project which is sending the import and export of electricity in real-time to the blockchain platform
iii. The blockchain platform is integrated with the Oracle CC&B billing system of UPPCL. Since it was mock trade under the pilot project, each of the project participants were allotted a new customer ID on another instance of the billing system that was integrated with the blockchain platform
iv. The prosumers willing to sell the electricity from their rooftop solar on a daily basis (or even hourly or for every 15 minutes) can quote their offer price and the buyers can place their best bids (the price at which they are prepared to buy) for the same interval on the blockchain platform
v. These buy-sell contracts are executed on blockchain platform which are visible to all participants on the platform and also to MVVNL and UPPCL
vi. The account details – units of electricity exported (sold) and imported (bought) and the money to be paid/received are accessible to all participants on the P2P platform

5.5 Project Implementation Details

In order to prevent service disruptions, ISGF installed smart meters in 12 buildings in series with the existing MVVNL's revenue meters. A local firm, Technosun India Pvt Ltd in Lucknow engaged in RTPV installations helped in installation of the smart meters procured from Crystal Power. Vodafone's 4G SIM cards installed in the smart meters communicate the energy flow data through the Head-End System (HES) of Crystal Power which is integrated with the blockchain platform of Power Ledger. The hardware connectivity diagram before and after installation of new smart meters is depicted below:

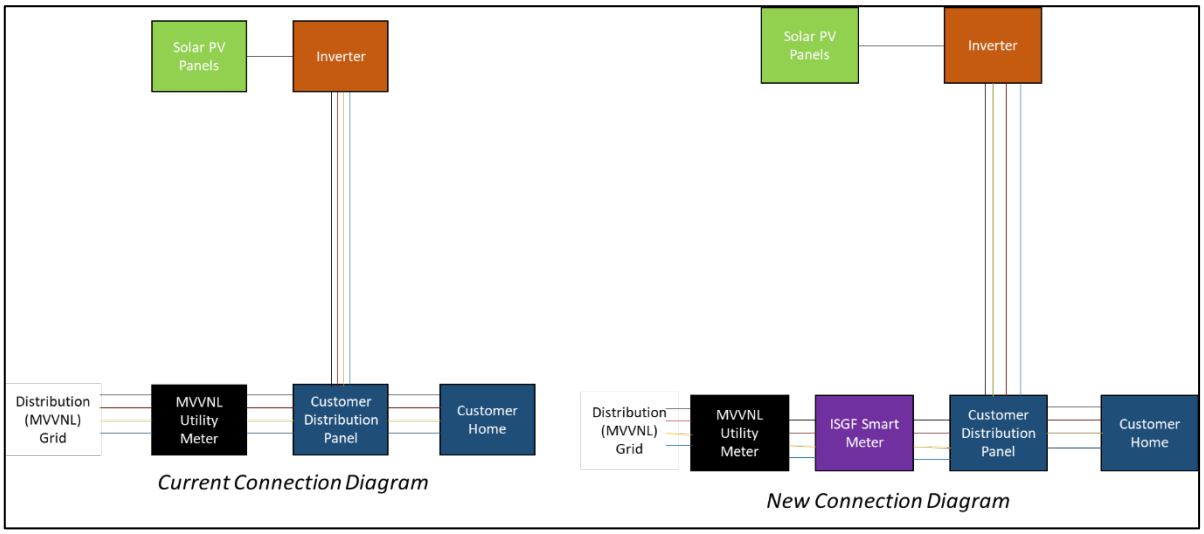


Figure 2: Hardware Connection Diagram

The ISGF team collaborated with Abjayon, Inc to integrate the Power Ledger's blockchain platform with UPPCL's Oracle CC&B billing system. Since only mock trading was involved in this pilot project and not to disturb the ongoing billing process in UPPCL, a separate instance of CC&B environment was created on the cloud.

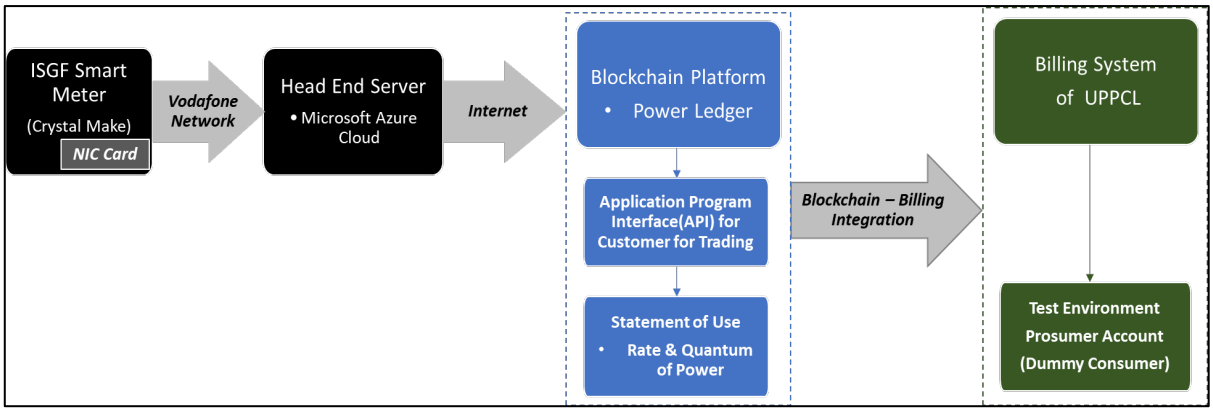


Figure 3: Information Flow Diagram from Meters to Billing System of UPPCL

5.6 P2P Trading Options Experimented

5.6.1 Fixed Price Trading

It ensures P2P trading at a fixed price. This will guarantee each user certainty over the price they will receive for their energy traded through P2P. If no excess energy is available in a P2P network, then the consumer's energy needs will be met by DISCOM. Similarly, if no buyer is available for the P2P then it will be sold back to DISCOM. A diagram visualising the trade can be seen below:

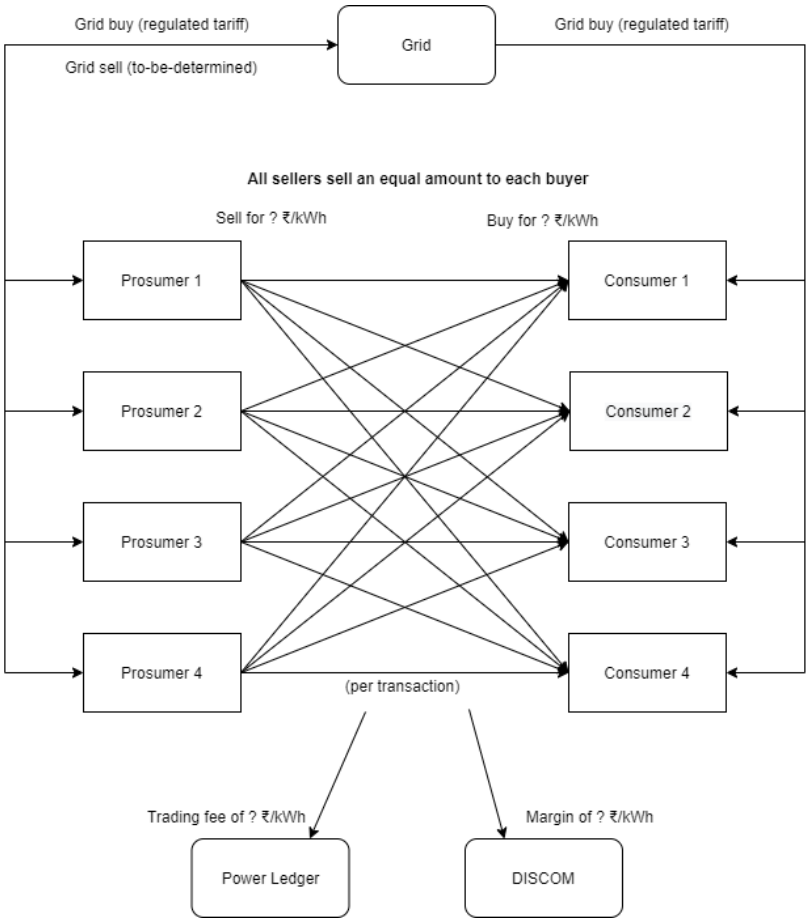


Figure 4: Graphical Representation of Fixed Price Trading Model

5.6.2 Dynamic Price Trading

The dynamic trading option involves prosumers and consumers trading with each other, setting their own prices. There can be numerous ways of finalizing the trade which may be decided as per the regulatory environment/framework. The cleared price can be the highest price being offered by the buyer, the lowest price being offered by the seller, an average of buyer- seller price or market-determined price by any other methodology. A diagram visualising the trade is given below:

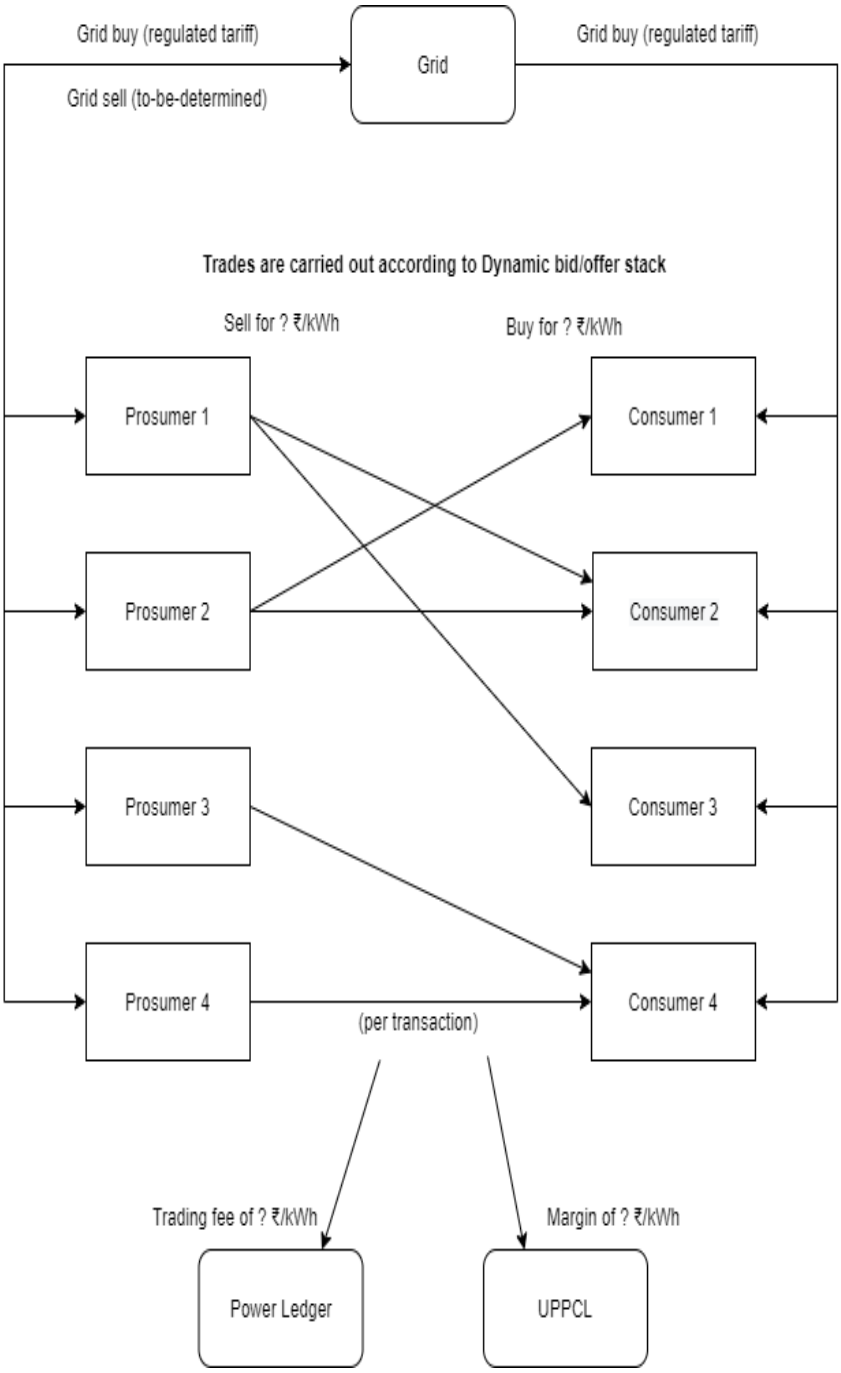


Figure 5: Graphical Representation of Dynamic Price Trading Model

5.6.3 Dynamic Price Trading with Preferential Trading

In this case, the prosumer can also be given a choice to identify its preferred consumer and is termed as preferential trading. This rule allows prosumers to choose a consumer and offer them a percentage of their excess energy at a specific price, or any other mutually negotiated tariff that trade will be carried out before any other trading occurs, meaning that prosumers can choose their preferred off-taker. A diagram visualising the trade is given below (dashed lines indicate a preferential trade, which is carried out before all other P2P trades):

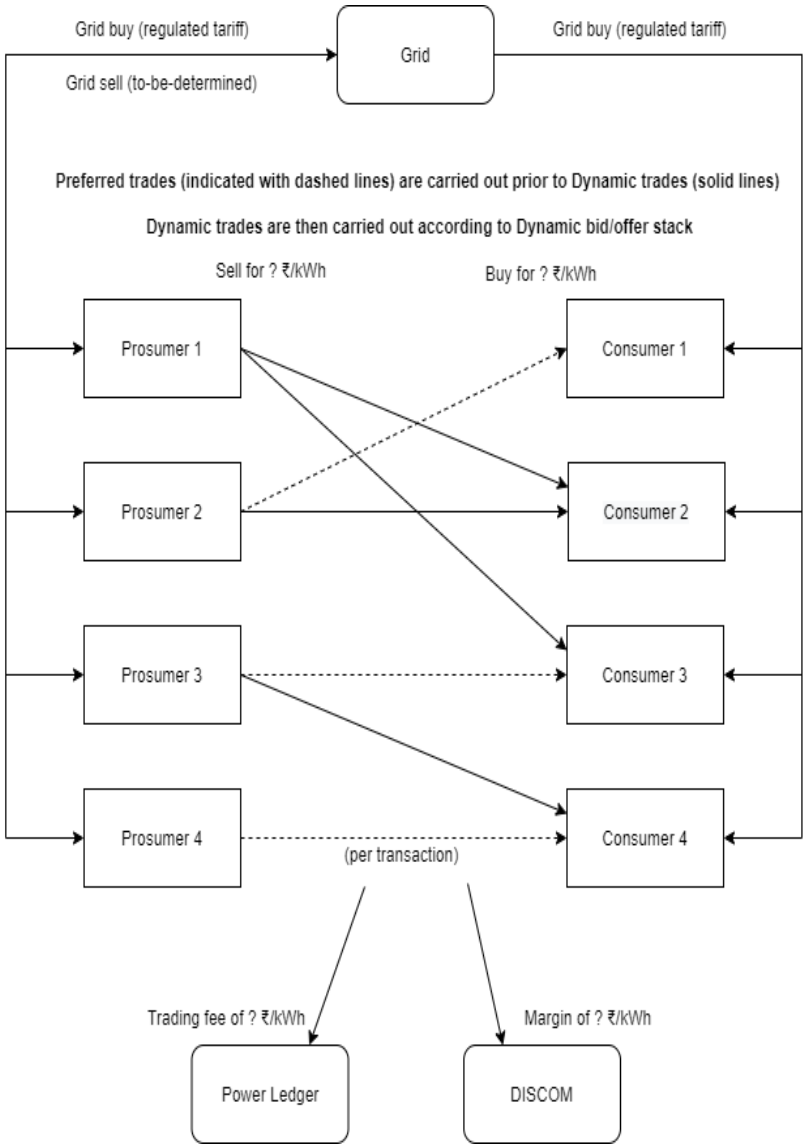


Figure 6: Graphical Representation of Dynamic Price with Preferential Trading Model

5.7 Key Findings

DISCOMs should enhance their metering infrastructure in order to allow energy exchange by installing advanced meters and developing systems for gathering and transmitting metering data to third parties. The availability of individual customer metering data is not only essential for allowing energy trading in energy markets, but it will also benefit all stakeholders in the system. Due to access to granular usage data, DISCOMs will have a much better understanding of the network and what improvements are taking place. Stakeholders may use this information to make better business decisions. This data may also be made accessible to third-party participants and service providers, enabling them to define areas for innovation and business opportunities in the residential sector.

The project went live on 17th December 2020 and the summary of 3 months P2P trading executed on the platform is presented below:

i. **Cumulative Community Sell (without P2P Trading):** 7,694.42 units at a cost of Rs. 14,186.72 at an average rate of **Rs 1.84/kWh**. Even though the feed-in-tariff (FiT) states that the surplus

solar energy fed back into the grid is Rs. 2/kWh; as per our observations, on an average, the real prices reflected is Rs 1.84/kWh. This is the situation for transactions between prosumers and utilities. The prices are too low to be appealing for investments from the perspective of the prosumer/consumer, and thus serve as a barrier to rooftop solar adoption in the state.

ii. **Cumulative Community Buy (without P2P Trading):** 14,402.58 units bought from grid at a cost of Rs. 1,04,660.64 at an average of **Rs. 7.27/kWh**. With an average connected load of 5 kW, the community's energy consumption has been increasingly rising with the arrival of the summer months, as shown by the change in the quantum of energy purchased from the grid during the winter months (Dec 2020 – Jan 2021) vs. the arrival of summer (Feb- March 2021).

iii. **Cumulative P2P Transactions**: 3,532.02 units at a total cost of Rs. 20,280.32 at an average cost of **Rs. 5.74/kWh**. When transactions are P2P, the average price clearly represents the **per unit energy savings of Rs. 1.53** (Rs. 7.27 – Rs. 5.74). With proper accounting and billing, these transactions are safe and secure.

A graphical representation of energy imported and exported both through P2P and distribution grid is shown below.

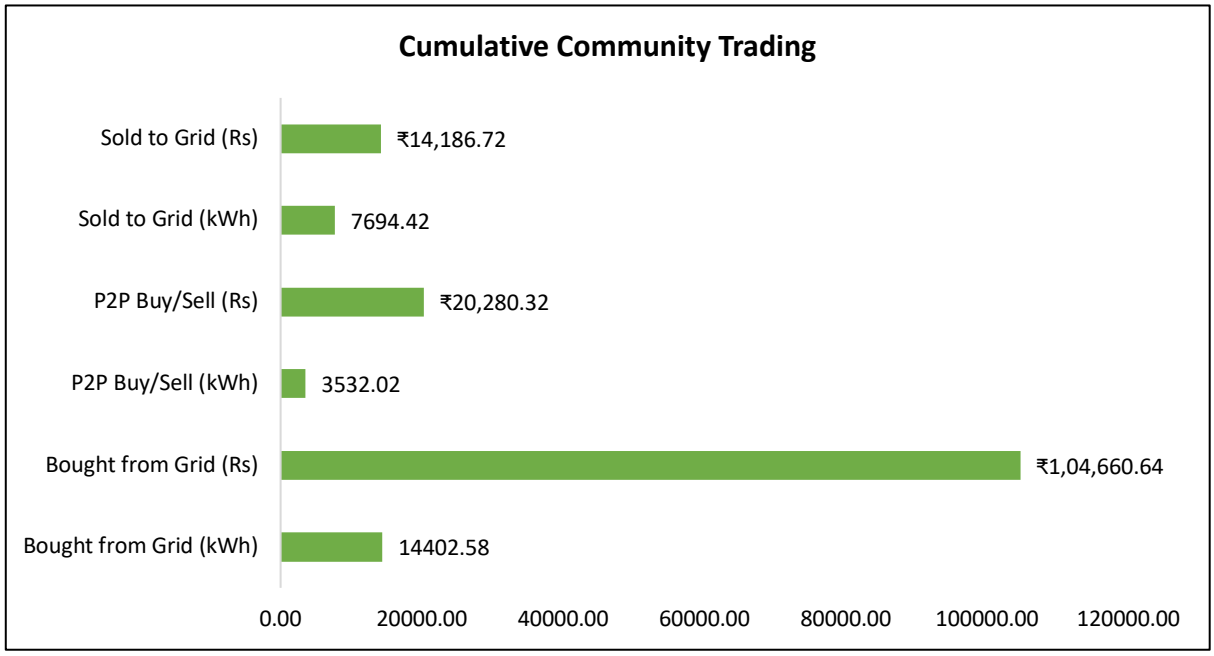


Figure 7: Community Trading Highlights – Cumulative

Based on the results from the dashboard, we have seen an average **grid sell price of Rs. 1.84/kWh**, **grid buy price of Rs. 7.27/kWh**, and **P2P price of Rs. 5.74/kWh**. The graph below depicts the monthly average prices (Rs/kWh).

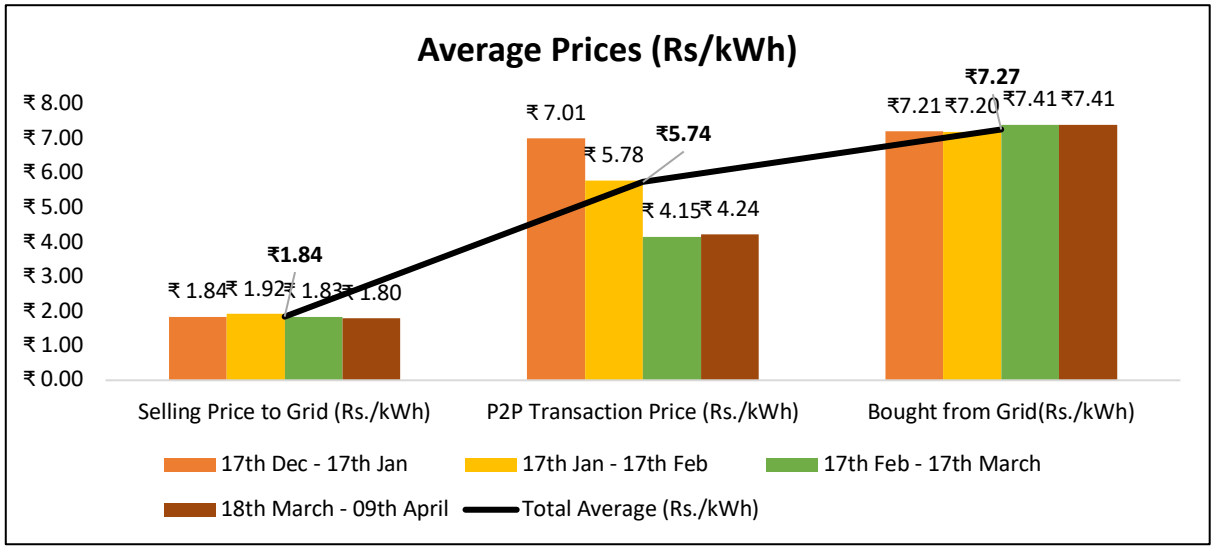


Figure 8: Average Prices (Rs/kWh)

6 RECOMMENDATIONS TO SCALE UP THE PROJECT

With the multitude of schemes and incentives offered by national and state Governments to promote rooftop solar, the number of prosumers and solar generation capacity, are going to increase in near future in Uttar Pradesh. Enabling P2P energy trading would provide a platform for both prosumers and consumers to buy and sell green energy under the rules and regulations that may be defined by the Hon'ble UPERC, enabling them to better recover their costs and increase the share of green energy in the state. It would further help in achieving Sustainable Development Goals 7 ("*Ensure access to affordable, reliable, sustainable and modern energy for all*") that India is committed to.

In view of this, ISGF, in consultation with Power Ledger and the Blockchain Advisory Committee, proposes the following path forward:

1. **P2P Trading Price:** During our interactions with the project participants, it was told by majority of the prosumers/consumers that they do not wish to bid/trade on a daily-basis. Rather, they would opt for fixed price for sale and purchase of RTPV energy, which would give them better clarity on how much higher price they can sell (for a prosumer), and save (for a consumer), if they engage in P2P trading. In view of the project experience, we recommend to keep P2P sale price of RTPV energy at mid-point between the highest commercial tariff and the net-metering feed-in-tariff. These prices may be kept same for a financial year. When tariff regulations are issued, the P2P trading price can also be issued by UPERC.

2. **Charges for the DISCOM**: In theory, the DISCOM revenue will be reduced, if customers are buying electricity from each other. However, the total RTPV energy produced in the state being well below 0.1 percent of the total energy sold by UPPCL, the impact on their revenue will be negligible in the near-term. Since DISCOM's network is used for the power flows and also their IT systems are leveraged for billing and settlement, DISCOMs are eligible for a modest fee which they may term as ***Network Access Charges or Service Charges***. To begin with, we recommend ***10 percent of the sell price of RTPV energy as DISCOM charge*** which may be borne by both - the buyer and seller. For example, in the present scenario, the price to be paid by UPPCL for net export of RTPV energy is Rs 2/kWh to the prosumer, whereas, a commercial consumer pays the tariff of Rs 8.75/kWh (for consumption above 1000 kWh/month)[1]. The midpoint suggested for P2P trade of RTPV is Rs

[1] The gain of Rs.6.75/kWh is being split equally between the buyer, seller, and the DISCOM.

5.38/kWh. ***Applying 10 percent as network access charge on the difference between the selling price and buying price of Rs.6.75/kWh (Rs. 8.75/kWh – Rs. 2/kWh), the net charge amounts to Rs. 0.675/kWh i.e., 67.5 paise/kWh. The proposed change is the equal division of the network charge (34 paise/kWh) between the buyer and seller. After the payment of the network charge by both the buyer and seller, the rate for the buyer is Rs. 5.715/kWh (Rs. 5.385/kWh + Rs. 0.335/kWh), and the seller price is Rs. 5.04/kWh (Rs. 5.38/kWh – Rs. 0.34/kWh).***

With P2P and a Network Access Charge, the DISCOM earns 10% of the gap, and the other two parties – buyer and seller, earns a profit of ~45% each. A simple scenario analysis has been displayed in the table below:

Scenario	Buyer	Seller	Network Access Fee	Discom Revenues (buys at 2/- from seller, sells it at 8.75/- to buyer)
No P2P	-8.75	+2	0	-2 + 8.75=6.75
With P2P but no network access charge	-5.38	+5.37	0	No Earning
With P2P and 10% network access charge	-5.71	+5.04	10% of the gap 0.1*(8.75-2) = 67.5 paise	+0.34+0.34=0.68 per kWh

Therefore, the regulated rates by UPERC could be set up as follows:

Buyer: Buyer pays Rs. 5.38/kWh to Seller and Rs. 0.335/kWh to the DISCOM. ***So, Buyer pays Net Total of Rs. 5.715/kWh purchased through P2P***

Seller: Seller receives Rs. 5.38/kWh from Buyer and pays Rs. 0.34/kWh to the DISCOM. ***Seller receives net total of Rs. 5.04/kWh traded through P2P***

DISCOM receives Rs. 0.34/kWh from seller and Rs.0.335/kWh from buyer. ***So, DISCOM receives Net Total of Rs. 0.675/kWh traded through P2P. This margin is considered sufficient to pay the cost of maintaining the blockchain platform.***

Apart from the above option, UPERC may also declare a fixed fee per unit of energy traded as DISCOM charge which can be divided equally between the buyer and the seller

3. **Achievement of RPO Targets by DISCOMs:** Under Section 86 subsection (1) clause (e) of the Electricity Act 2003, RPOs mandates DISCOMs, open access consumers and captive consumers purchase a portion of their electricity from renewable sources. If all the RTPV energy traded is eligible for RPO of the DISCOM, that is an added benefit for promotion of P2P trading amongst their customers. This will further reduce the DISCOMs obligation to buy Renewable Energy Certificates (REC) from the market to meet RPO.

4. **MVVNL suggested to extend the P2P trading platform to Agricultural Feeders that are being solarized under the KUSUM Scheme[2]:** Under the provisions of the PM-KUSUM program, grid-connected agriculture pumps can be solarized with central and state government's subsidy of 30 percent each and farmer's contribution of 40 percent. The solar capacity allowed is up to two times the pump capacity in kW, and DISCOM would purchase the surplus power. Although agriculture feeders have already been separated, the feeders with mixed loads having irrigation pump (IP) sets for agriculture can also be considered for solarization initially. Feeders may be selected on the basis of load, technical and commercial losses, number of consumers, etc. The solar PV systems installed for the IP sets can be fitted with smart meters and connected to the blockchain platform. However, the IP set customers on agricultural feeders may not be covered under the existing Oracle CC&B billing system of UPPCL with which the blockchain platform is integrated. Those accounts may be ported to the CC&B system by UPPCL.

5. **Regulatory Interventions**: UPERC may issue formal trading rules and regulations. Open access regulations currently limit customer and prosumer involvement in trading to those with 1 MW or more demand. As per existing open access regulations, producers or users must apply to respective State Load Dispatch Centres (SLDC) for permission to wheel traded power on the electricity network. There is no special provision for such P2P sales and purchases. Consequently, there are various types of charges that can be placed on either the seller or the buyer. For P2P trading through blockchain, new clauses must be added to the current regulations, or a separate regulation may be issued.

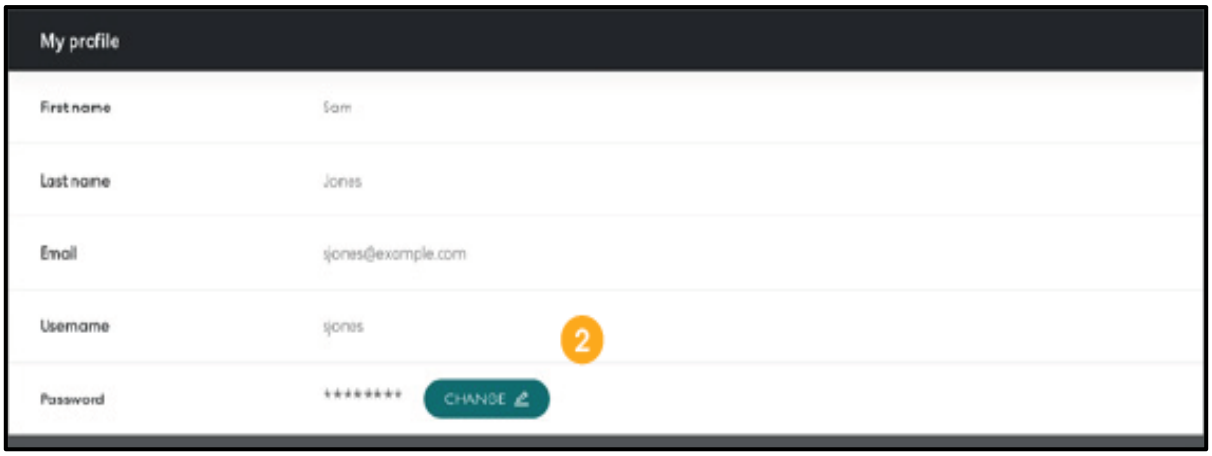
6. **Capacity Building** must be a central component of sector reform implementation. Training is required for all stakeholders, including SLDCs, SERCs, and DISCOMs, as well as for unique customer groups. NGOs and think tanks can help by first explaining the benefits to stakeholders and then providing capacity-building tools to aid change preparation and implementation.

To take the technology beyond the pilot stage in India, a set of regulations and technical specifications must be agreed upon and followed by all stakeholders in the P2P network. To accomplish this, regulators may take the lead in clearly identifying stable regulatory structures with frameworks that facilitate and promote the proliferation of decentralized transaction models based on regulations and beneficial practices observed across the world. As a result, when defining P2P Energy Trading Rules to promote proliferation of RTPV, the most important factor to consider is to strike a good balance between the greater good for all by defining a collection of straight forward, consistent, and equitable regulations.

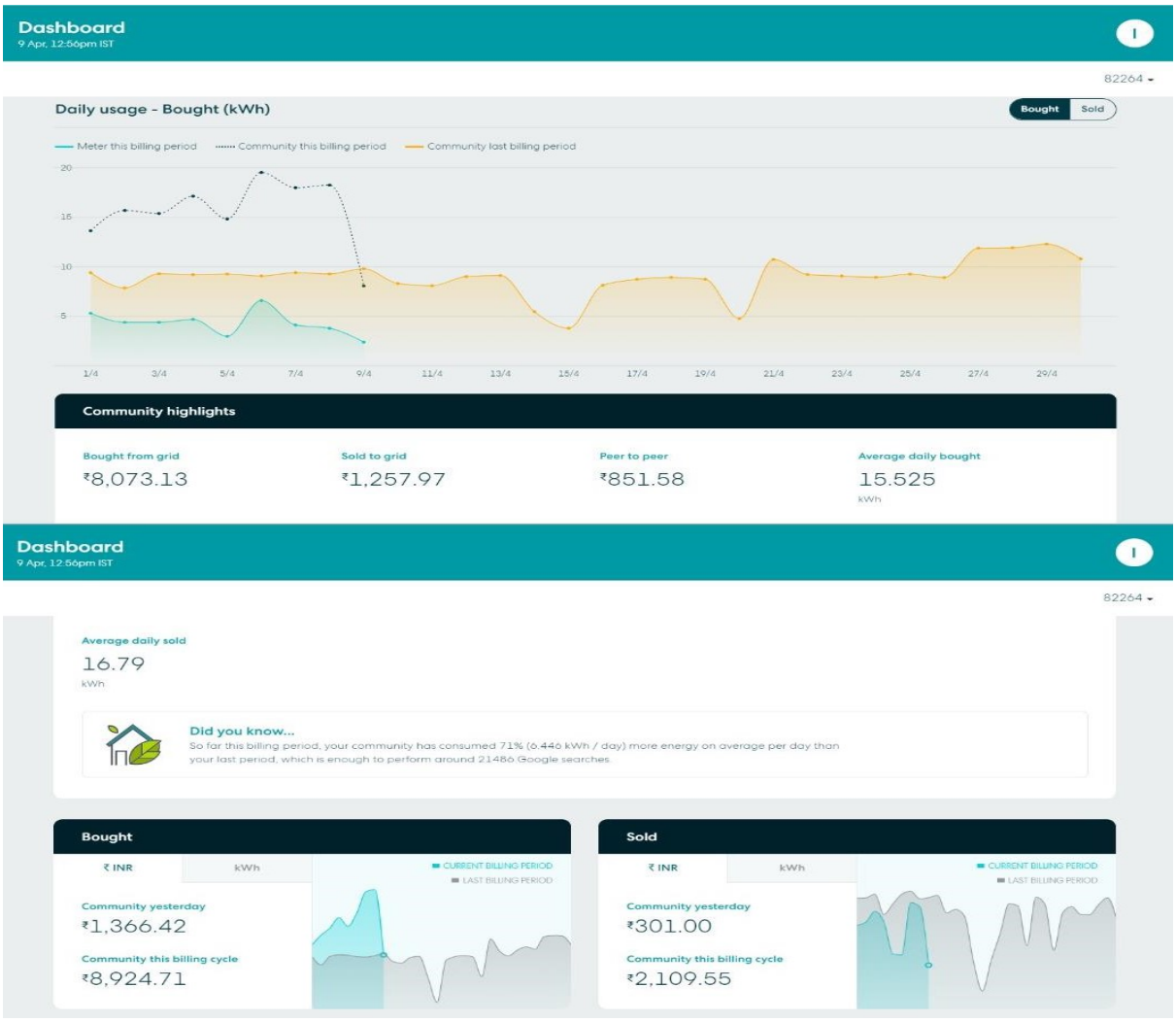
[2] Ministry of New and Renewable Energy (MNRE) has launched the Pradhan Mantri Kisan Urja Suraksha evem Utthan Mahabhiyan (PM KUSUM) Scheme for farmers for installation of solar pumps and grid connected solar and other renewable power plants in the country. The scheme aims to add solar and other renewable capacity of 25,750 MW by 2022 with total central financial support of Rs. 34,422 Crore including service charges to the implementing agencies. (https://bit.ly/3m3FFcC). MNRE has decided to include feeder level solarization under Component-C of the PM-KUSUM program.

APPENDIX A - TRADING PLATFORM SNAPSHOTS FOR P2P TRANSACTIONS

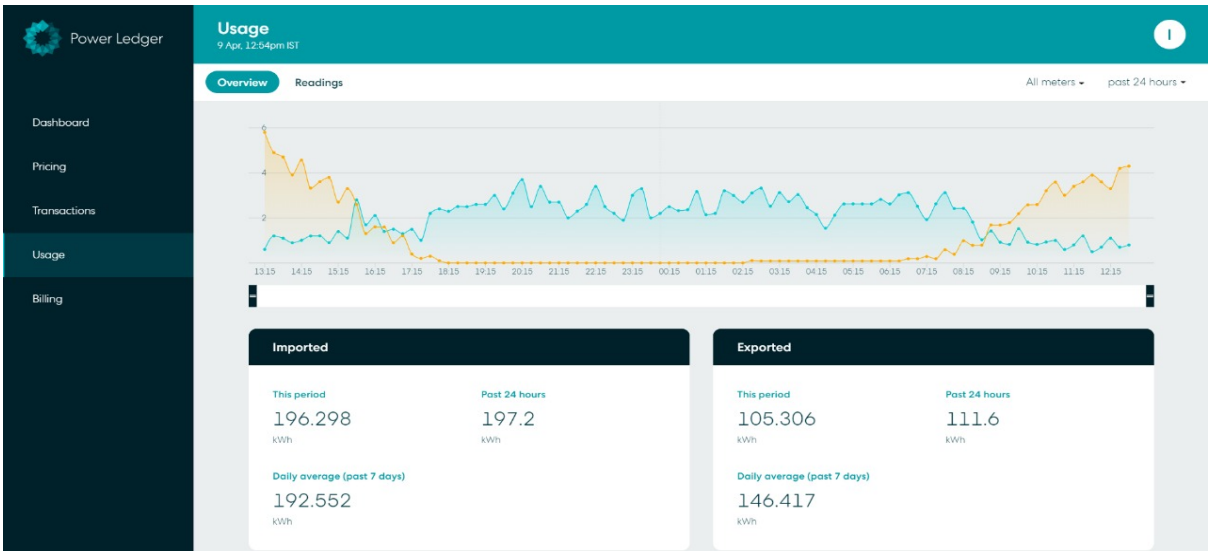
A unique ID and Password will be created for every Consumer and Prosumer. Using the credentials, the participants can login to the dashboard of the blockchain platform.



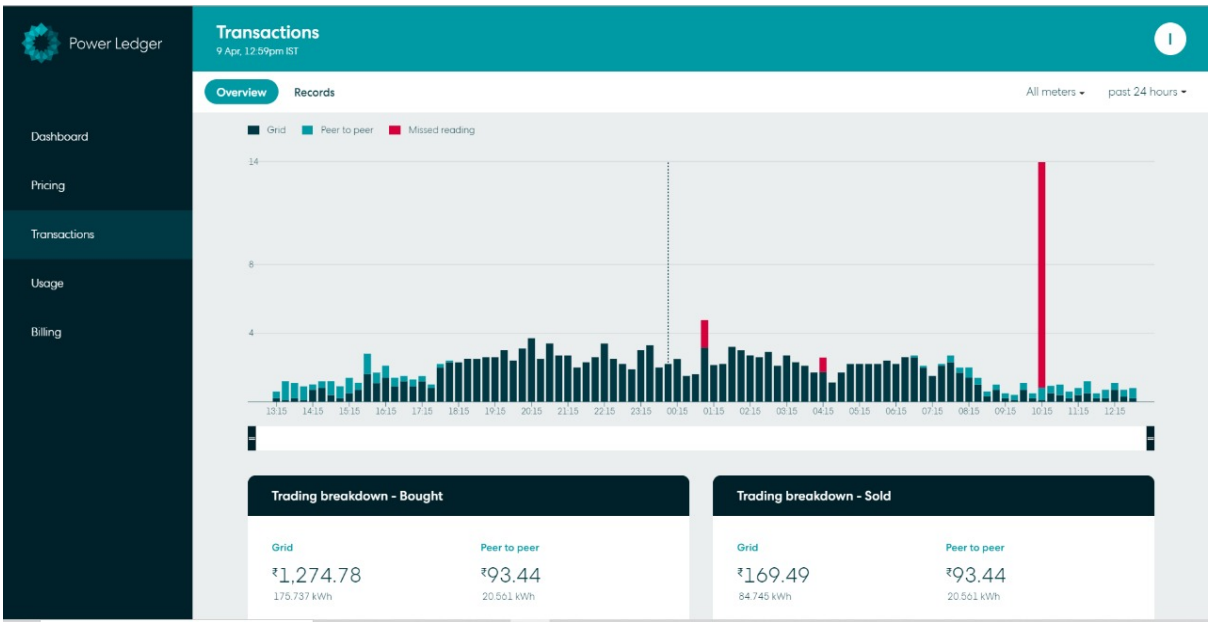
Consumers and Prosumers can view their performance highlights in terms of daily average energy bought and sold along with the community daily average energy traded. This will give the participants a better view of their current position and encourage users to utilize green energy more.



Consumers and Prosumers can check their daily usage with Import and Export.



All transactions with the Grid and P2P can be explored by Consumers and Prosumers.


Power Ledger
Transactions
9 Apr, 12.59pm IST
Overview
Records
All meters
past 24 hours
Dashboard
Pricing
Transactions
Usage
Billing
Grid
Peer to peer
Missed reading
Trading breakdown - Bought
Grid
₹1,274.78
175.737 kWh
Peer to peer
₹93.44
20.561 kWh
Trading breakdown - Sold
Grid
₹169.49
84.745 kWh
Peer to peer
₹93.44
20.561 kWh

APPENDIX B – SNAPSHOTS FROM POWER LEDGER'S BLOCKCHAIN PLATFORM

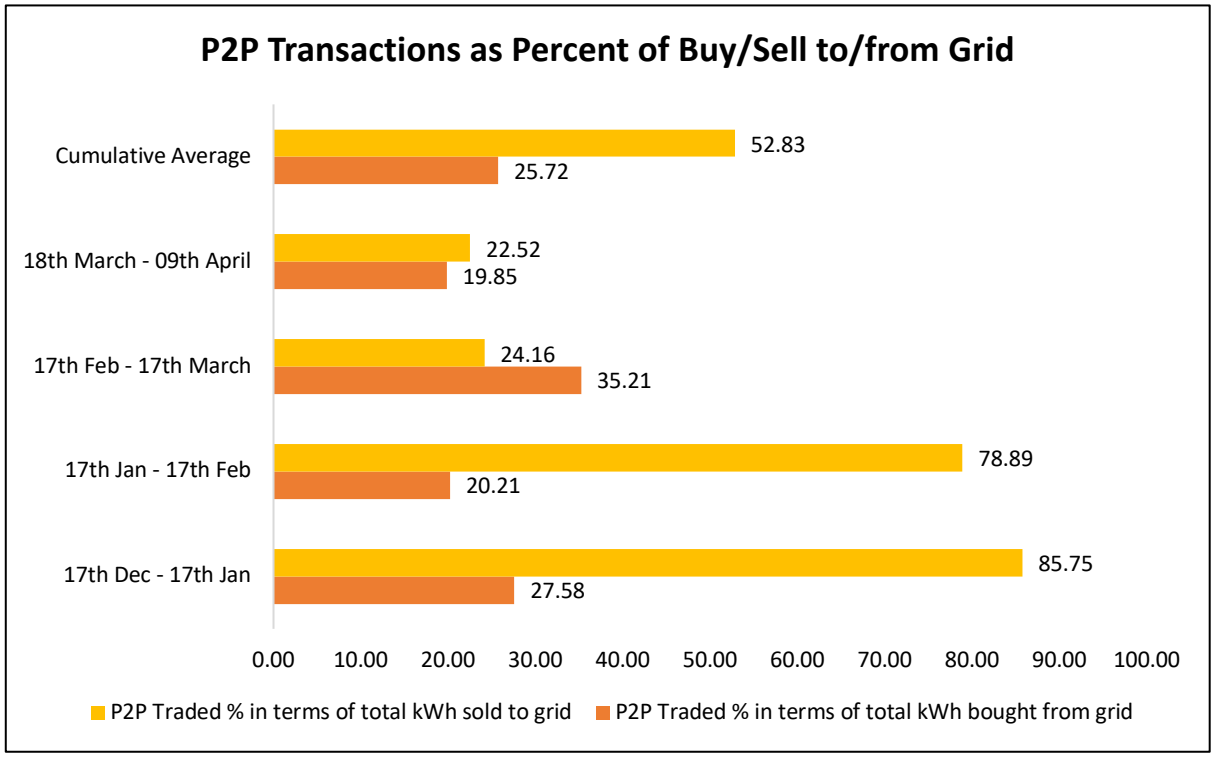


Figure 9: P2P Transactions as Percent of Buy/Sell to/from Grid

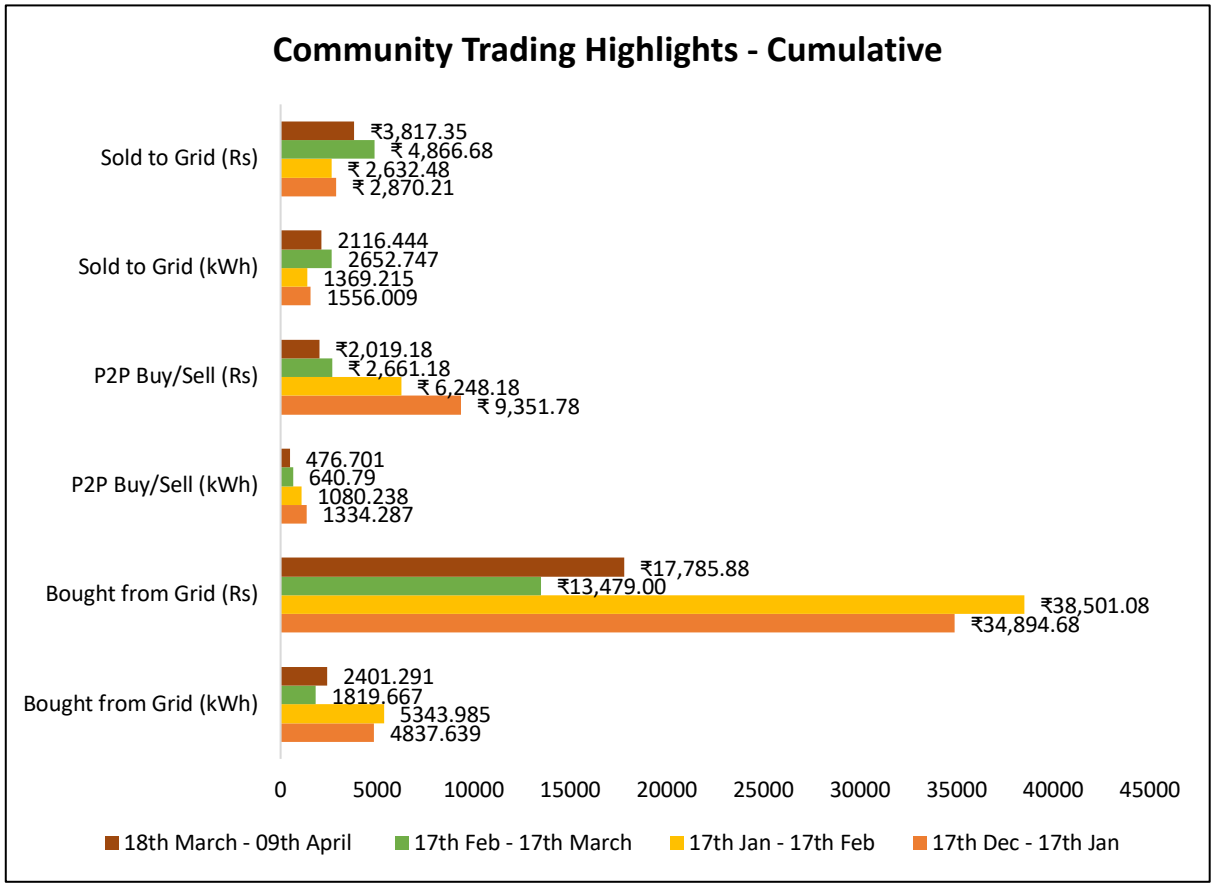


Figure 10: Community Trading Highlights – Monthly (Dec 2020 – March 2021)

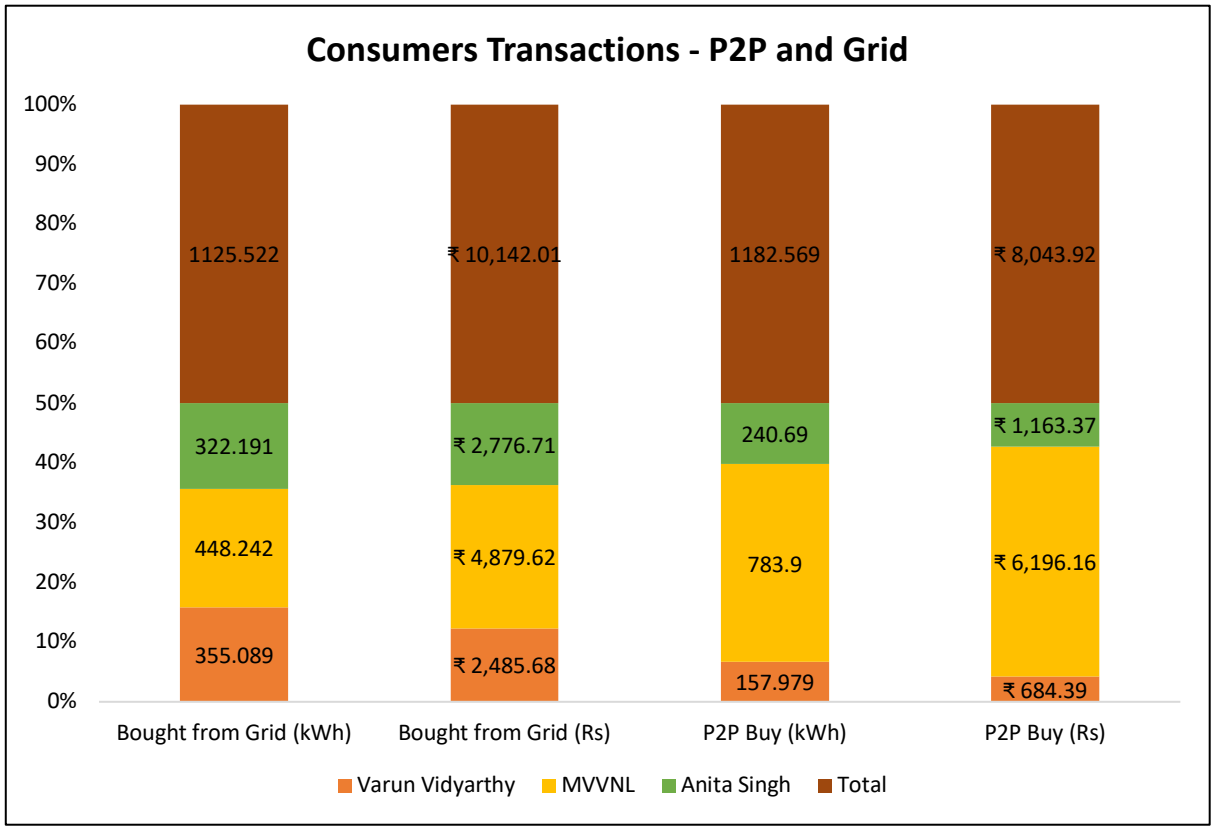


Figure 11: Consumer Transactions - P2P and Grid