“P2P TRADING USING DERs: A HOLISTIC VIEW OF GLOBAL PRACTICES AND PIONEERING EFFORTS IN INDIA”

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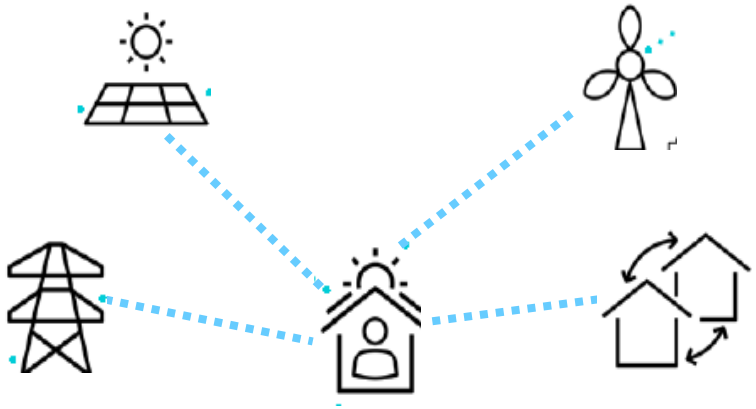
SESSION 7B: DISTRIBUTED GENERATION

Sweta Malik, Shashank Vyas and Alekhya Datta
Electricity & Fuels Division
The Energy & Resources Institute (TERI)
New Delhi, India

Amanda Ahl
Department of Innovation
Tokyo Institute of Technology
Tokyo, Japan

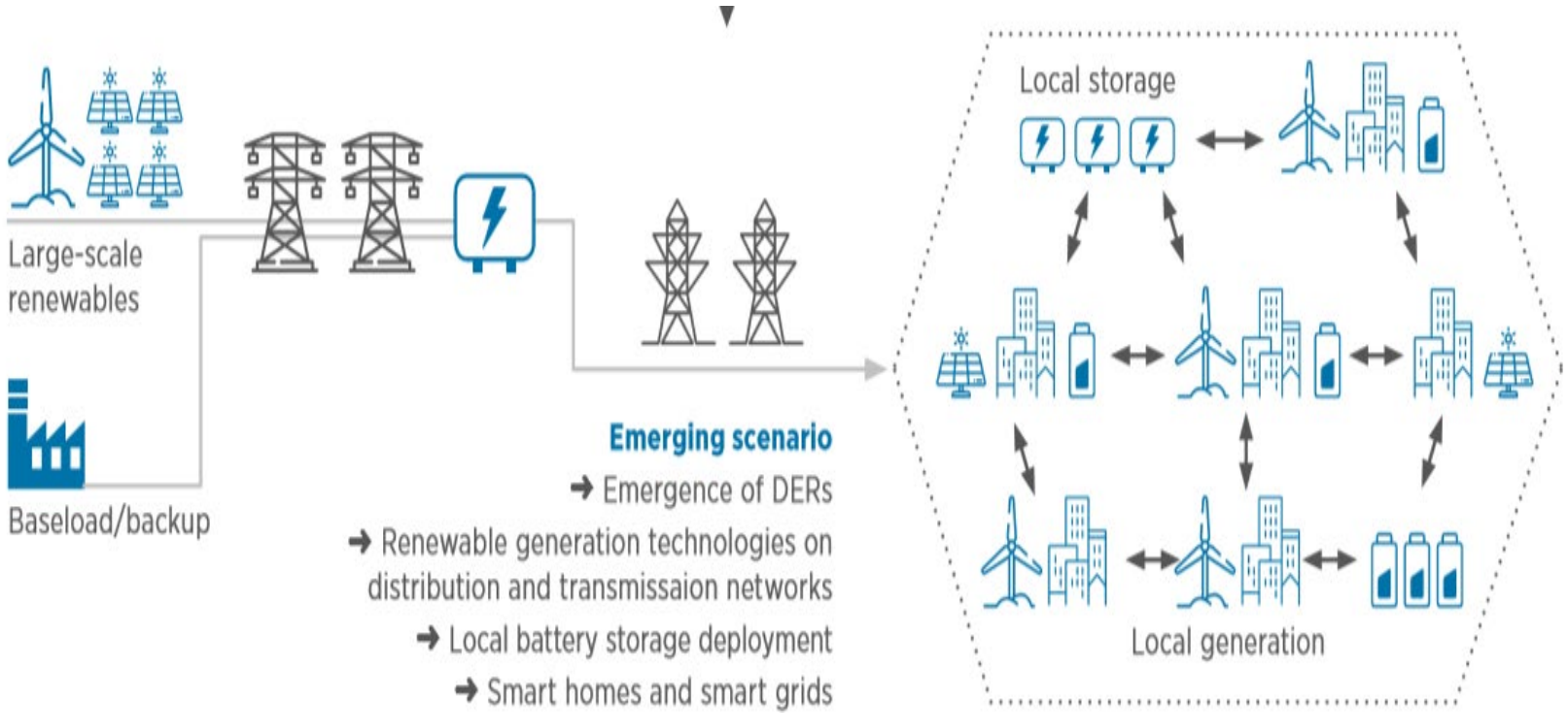
Dynamically changing power system paradigm

Changing from centralized system to Decentralized System

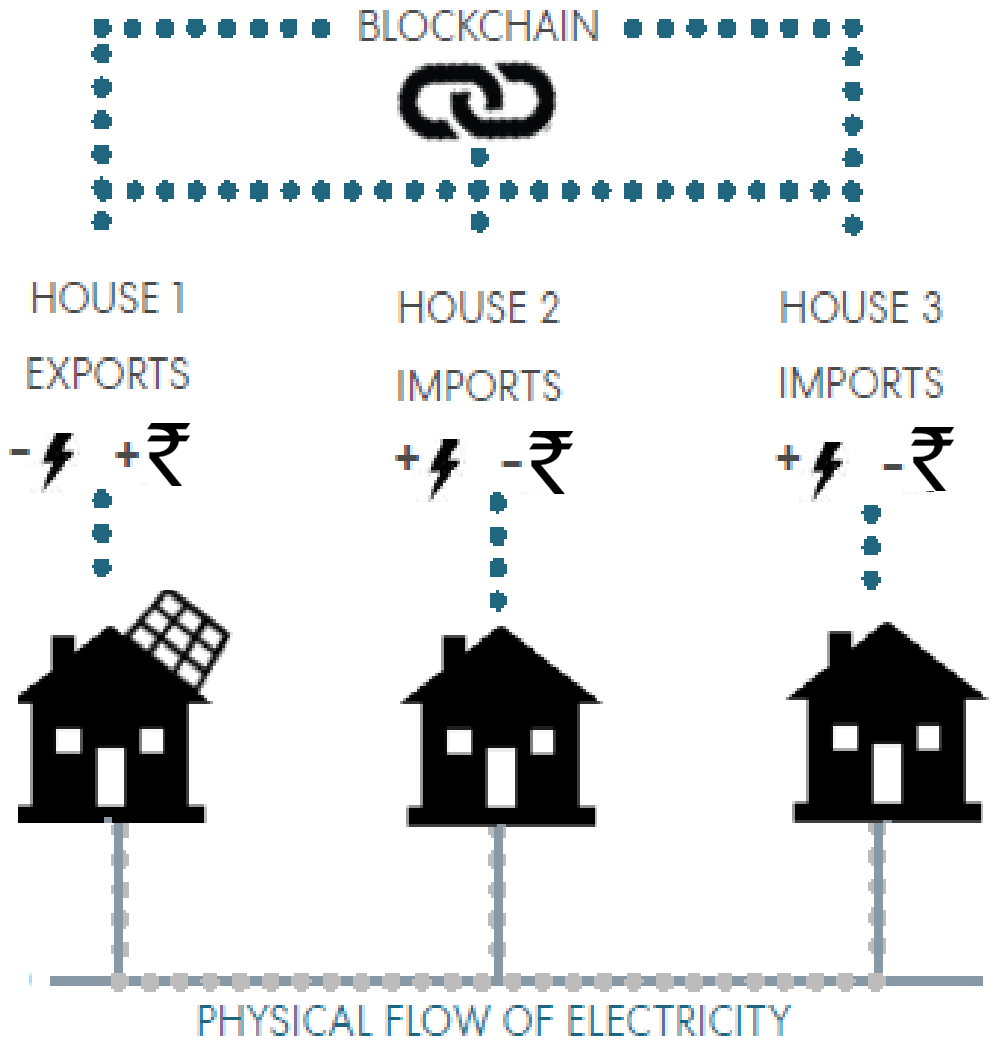


Distributed Energy Resources

- Rooftop Solar
- Electric Vehicles
- Demand Response
- Storage
- Wind

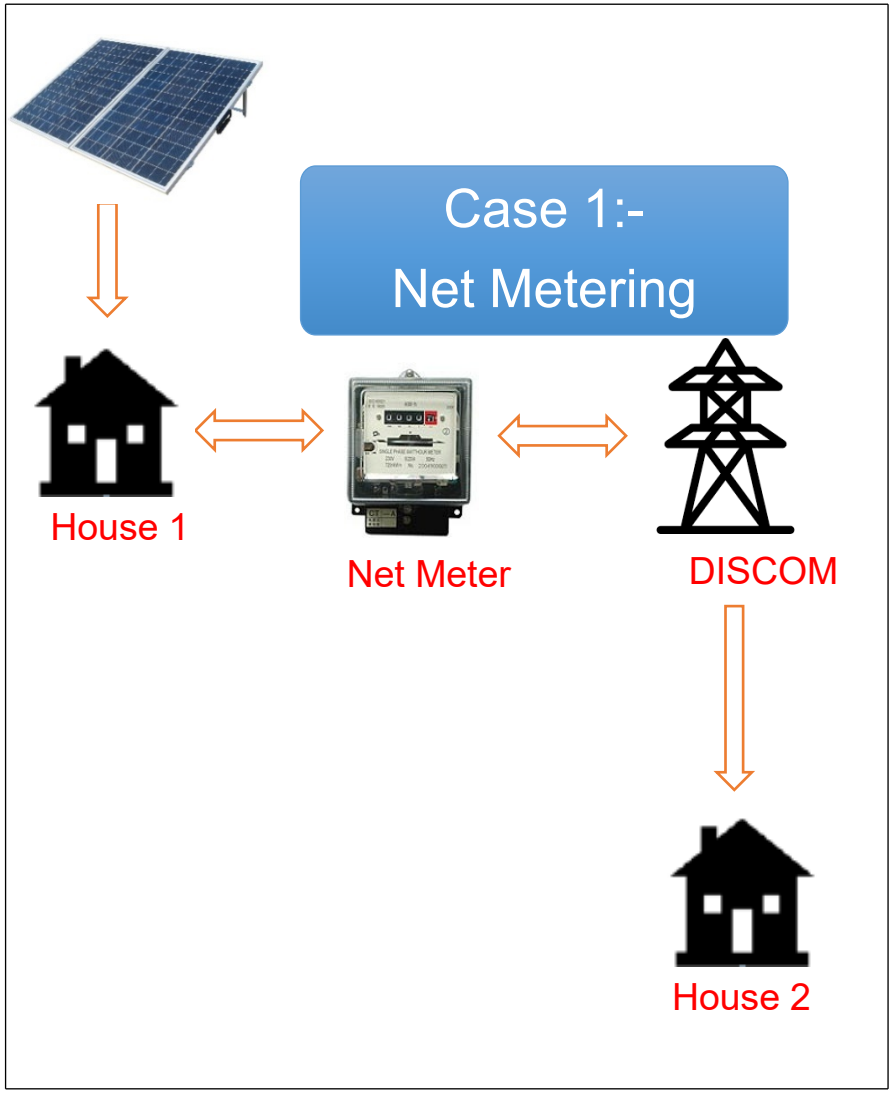


Peer To Peer (P2P) Energy Trading:-



- Enables prosumers to **receive instant payment** from renewable energy
- Customers can buy **cheaper renewable energy**
- **Competitive advantage** for innovative retailers
- **Transparent, secure and instant** electricity transactions by Distributed Ledger Technology
- Better return for excess energy as compared to supplying it to grid.
- Allows for more **informed usage decisions**

Net Metering v/s Peer to Peer (P2P) Trading (Power Flow):-

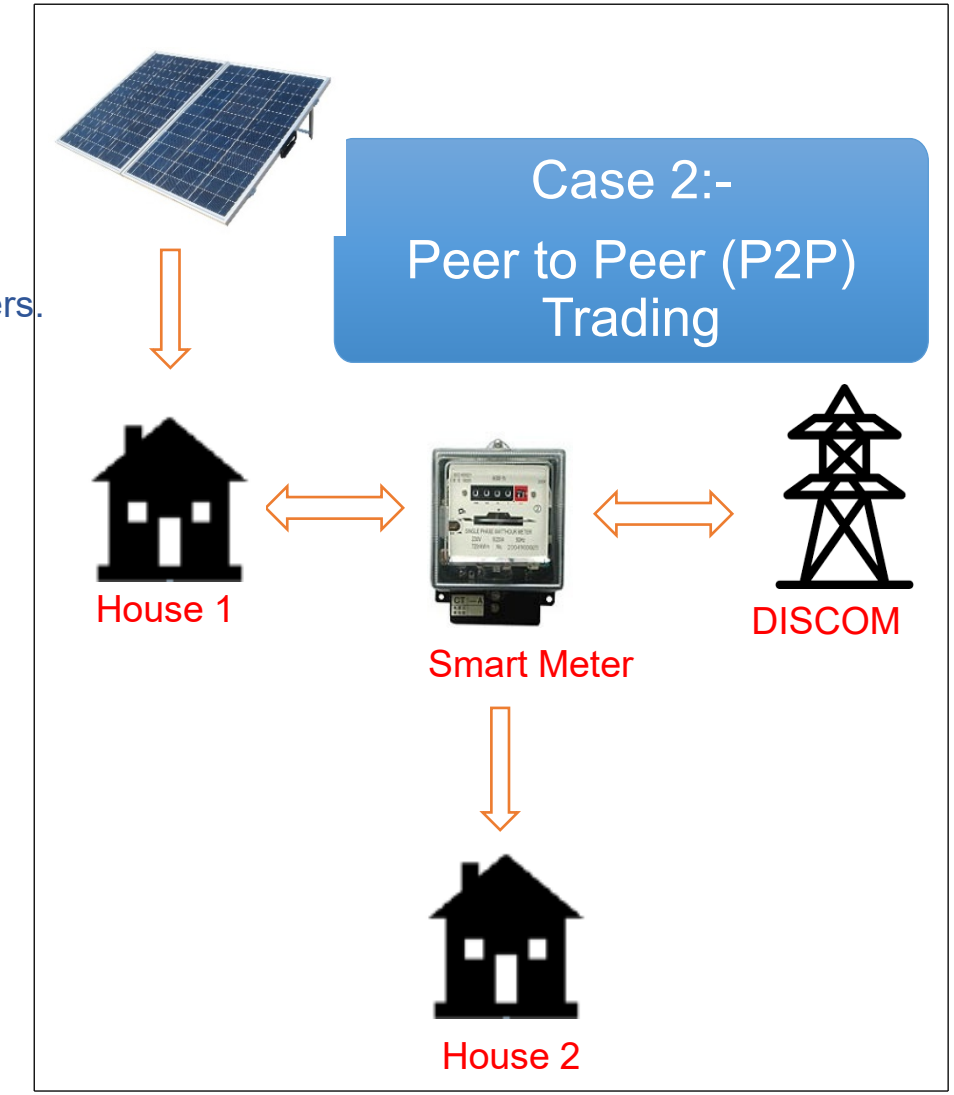


DISCOM:-

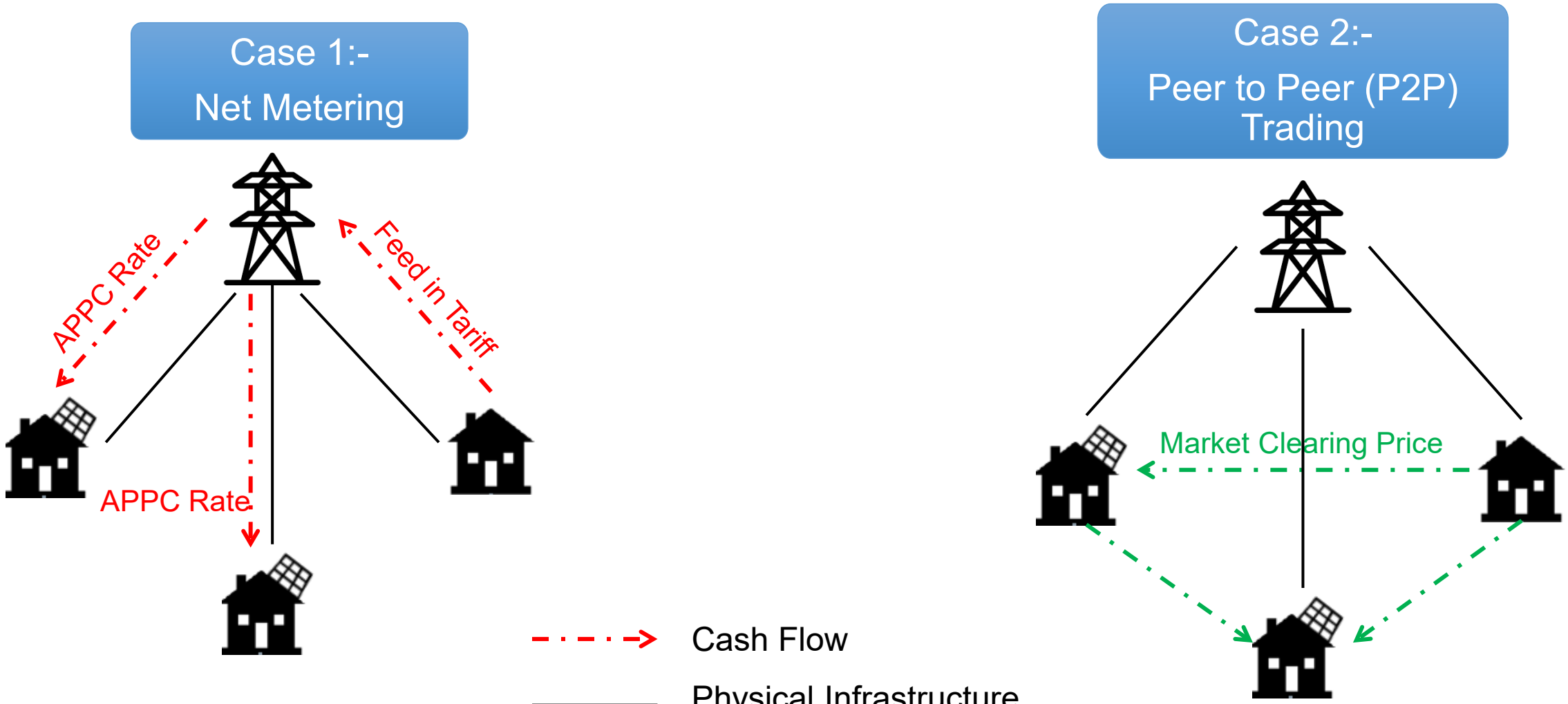
- Low AT&C losses.
- Demand gets completed locally.
- ITransaction fee given by the peers.

Peers:-

- Trade Energy within community.
- Cheaper than Retail tariff.
- Instant Payment and settlement

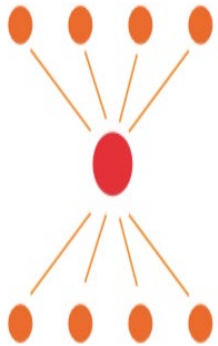


Net Metering v/s Peer to Peer (P2P) Trading (Cash Flow):-



Why Blockchain?

TRADITIONAL MODEL



BLOCKCHAIN MODEL

ethereum

R

Public blockchain

Registration	Smart contract preparation	Blockchain	Manipulation	Costs
Anonymous Free access	Public structure enables wide variety of applications Users can trade with all users	Decentralised data storage & verification performed by P2P network	No ex-post revisions possible	Higher operating costs No operator fees

Private blockchain

Registration	Smart contract preparation	Blockchain	Manipulation	Costs
Invitation-based Know-your-customer controls	Contracts are made between customers through operator's platform	Centralised data storage & verification performed by operator	Ex-post revisions possible(e.g. in the case of legal dispute)	Lower operating costs Operator fees

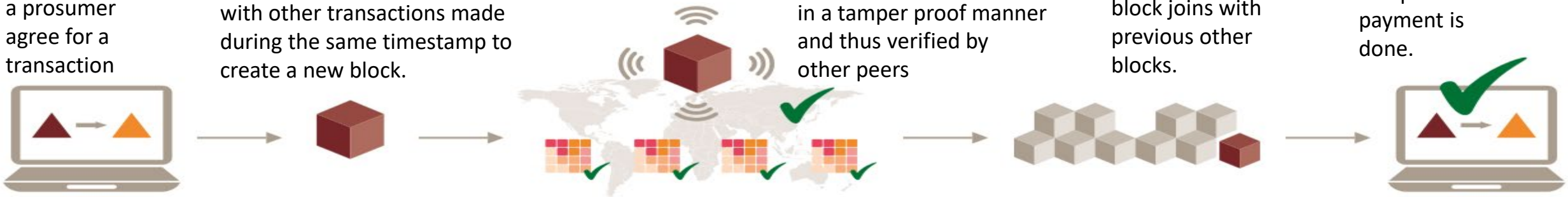
A consumer and a prosumer agree for a transaction

The transaction is combined with other transactions made during the same timestamp to create a new block.

The data block is stored in decentralized network in a tamper proof manner and thus verified by other peers

The verified block joins with previous other blocks.

Transaction is completed and payment is done.



Source:- PwC

Smart Contracts & Energy Tokens:-

- Rules/algorithms which can signal the system
- Initiate certain transactions
- Payments in the microgrid between peers
- Manage Grid Congestion
- Balance between supply and Demand
- Network Flows

Agent Bidding Strategies

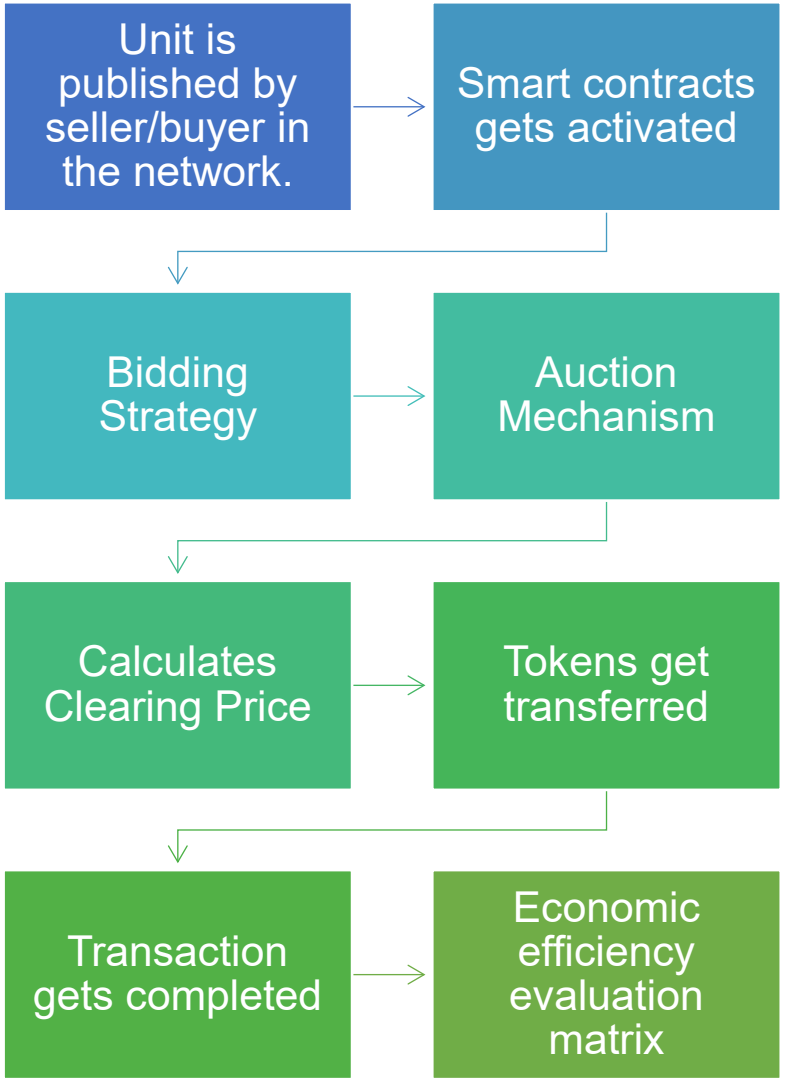
- Random Bidding Strategy
- Preference Bidding Strategy

Auction Mechanism

- Discriminatory k-DA
- Uniform k-DA

Economic Efficiency Evaluation Matrix

- Percentage of kWh Sold
- Percentage of kWh Bought
- Percentage of Household cleared



1. Auction Mechanism:-

Discriminatory k-Double Auction

- C – Consumers and C_p - Asking Price
  P – Prosumers and P_p - Selling Price
- Asking Price – Ascending order
  Selling Price - Descending order
- The trading will happen only when the buying price is always greater than or equal to the selling price ($C_p \geq P_p$)

$$P = kC_p + (1-k)\, P_p$$

- This process is entirely discriminatory as the "P" i.e. trading price is always between every winning prosumers-consumer pair.

Uniform k-Double Auction

- C_y – Consumers and C_{py} - Asking Price
  P_y – Prosumers and P_{py} - Selling Price
- Asking Price – Ascending order
  Selling Price - Descending order
- Here, all the winning consumers and prosumers trade at a common clearing price.
- Next, "Y" is considered as the largest breakdown index taking the Yth consumer and prosumers.

$$P = k\, Cpy + (1-k)\, Ppy$$

- Therefore, we get a distinct per unit transaction trading price for all winning consumer and prosumers at each 30 minute interval.

K Value [0,1]	Condition
1	P is equal to the Asking Price If $C_p \geq P_{p,}$ the prosumers increases a utility of $C_p - P_p$ as the prosumers received additional than the estimated price.
0.5	It sets the "P" at precisely between the buying price and the selling price. None of the party escalates more utility than the other.
0	P is equal to the Selling Price. If $C_p \geq P_{p,}$ the consumer increases a utility of $C_p - P_p$ as the consumer trades at a lower than anticipated price.

2. Economic Efficiency Evaluation Matrix:-

Percentage of kWh Sold

$$\frac{Total\ Energy\ Traded}{Total\ Energy\ supplied\ for\ sales}$$

- The percentage of kWh sold assesses consumption of total supply from the sellers perspective.
- The higher the ratio, the higher sellers excess PV outputs.

Percentage of kWh Bought

$$\frac{Total\ Energy\ Traded}{Total\ Energy\ demanded\ for\ purchase}$$

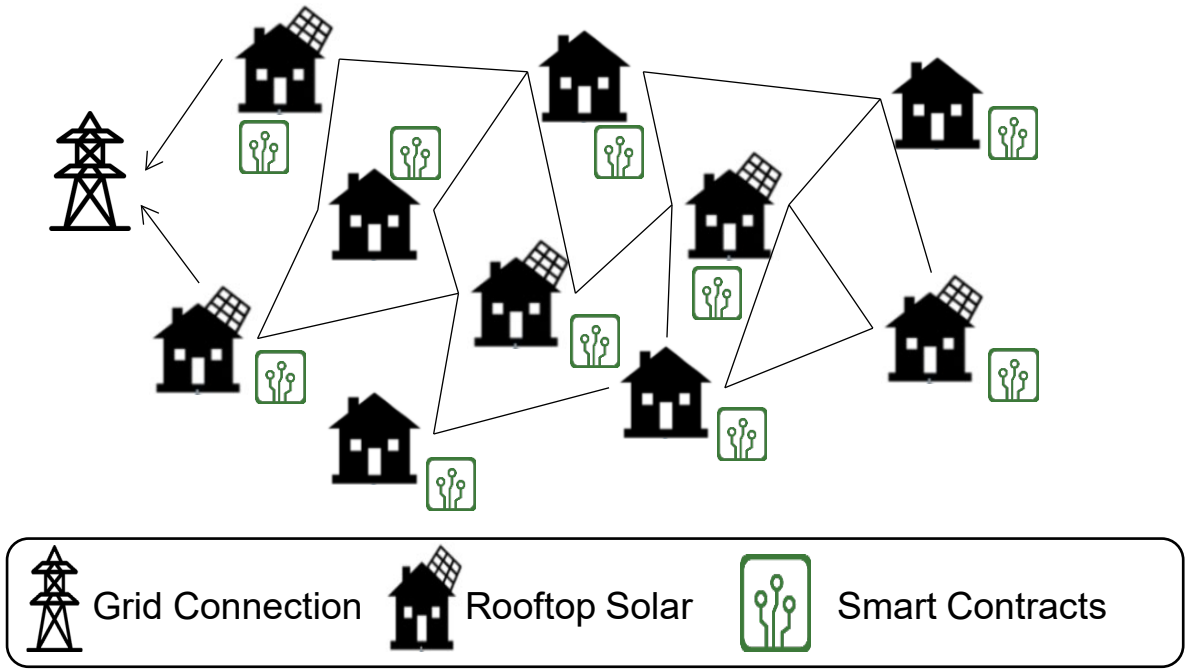
- The percentage of kWh bought evaluates fulfillment of total demand from buyers perspective.
- The higher the ratio, the higher buyers demands are met.

Percentage of Households Cleared

$$\frac{Total\ peers\ whose\ demand\ \&\ supply\ is\ met}{Total\ Number\ of\ peers}$$

- The percentage of households quantifies fulfillment of the amount of buyer and seller contracts submitted at each hourly auction interval.
- The higher the ratio of household cleared, the higher the number if participants satisfied within the microgrid.

Prototype for Blockchain based P2P trading:-

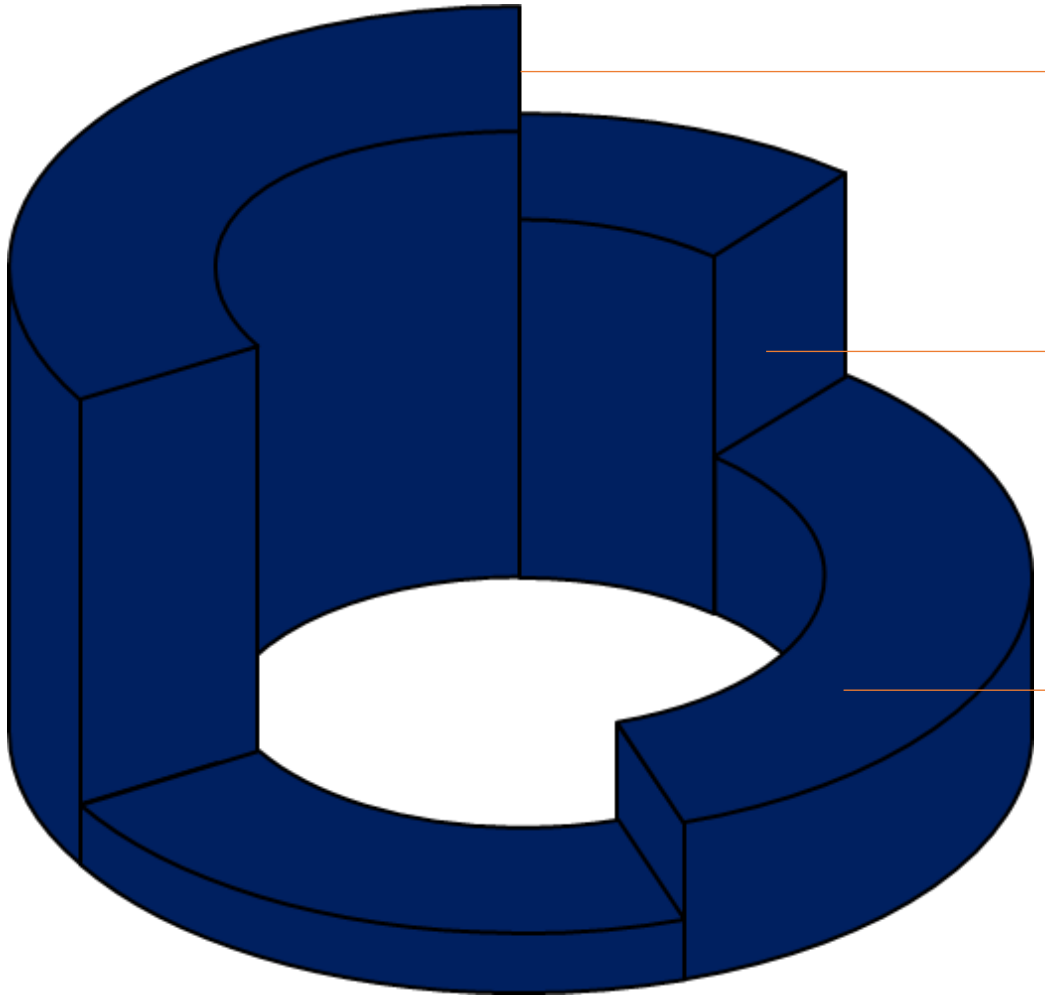


Proof of Concept (PoC)	Simulink Model of 10 Households	5 Prosumers and 5 Consumers
1 Unit of Energy = 1 Token	Smart Meters measure the energy produced and consumed	Hyperledger Sawtooth 1.x – DLT Platform
Node-JS 8.x (web application back-end)	Python/ C/ C++ (Smart-Contracts)	Web Based Application for Prosumers, Consumers & DISCOMs

Policy Recommendations:-

- Regulations for P2P energy trading may be considered at CERC-level. UPERC had included P2P energy trading in their solar rooftop regulations, however, there is no clear indication for implementation.
- National-level technical standards for P2P energy trading platforms (including open-source) could be formulated, which comes under cyber security.
- Regulators may ask utilities to set up pilot projects based upon P2P trading.
- Changes may be required in the business model of utilities keeping P2P energy trading in-mind.

Future Work:-



- 3. Implementing Pilot Project (along-with a distribution utility) on the findings of Proof of concept.
- 2. More distributed Energy resources such as Battery Energy Storage and Electric Vehicles shall also be included in the Proof of Concept (PoC)
- 1. The proof of Concept shall include group of households with different ratio of consumers and prosumers.