Interreg - IPA CBC
Italy - Albania - Montenegro
REEHUB PLUS

Date: Friday **10th of December 2021**

Time range: **09:00-16:55**

REEHUB PLUS / 1ST CROSS BORDER EVENT

"SMART CITY OPEN INNOVATION FORUM"

ORGANIZED BY: **BARLETI INSTITUTE FOR RESEARCH AND DEVELOPMENT**

SUPPORTED BY: BRIDGE, UNIVERSITETI BARLETI

Speaker:

Moayad Aloqaily

xAnalytics Inc., and MBZUAI

Relation:

Application of Blockchain in energy Systems

REPUBLIKA E SHQIPËRISË MINISTRIA E INFRASTRUKTURËS DHE ENERGJISË

DiT.N.E.

UCG Univerzitet Crne Gore

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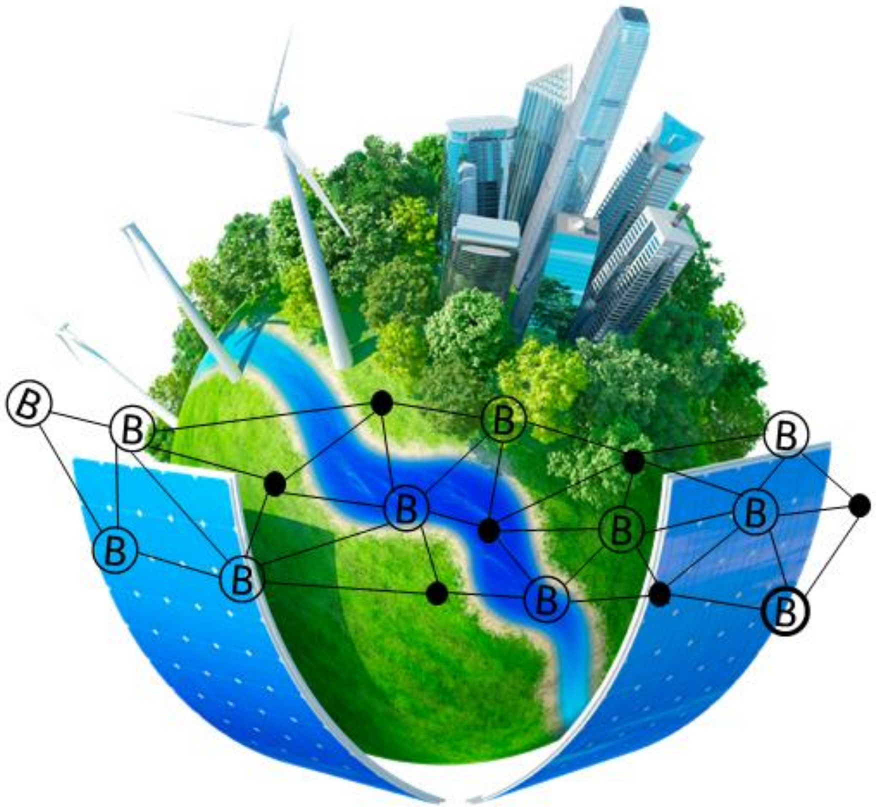
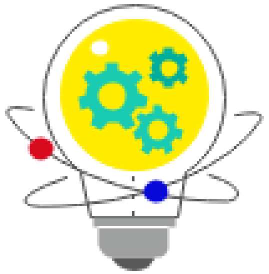
Outline

- Introduction
- Current Energy Systems
- Futuristic Energy Systems
- Blockchain Technology
- Blockchain meets Energy Systems
- Blockchain Supported Peer-to-Peer Energy
  - Trading
  - Sharing
- Open Issues



Introduction

- Our World is suffering!
- Global demand for energy is increasing rapidly
- **Energy Security** concerns emerge as more consumers require more **energy** resources!



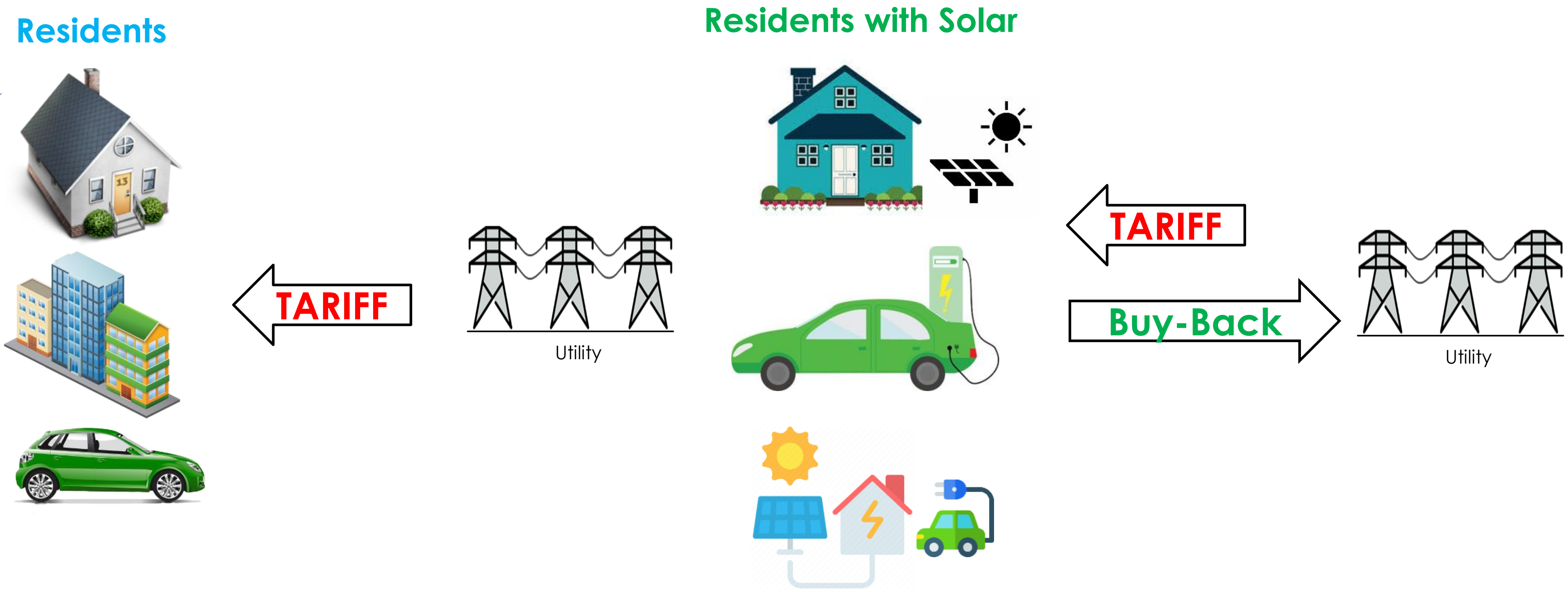
- What is the problem?
  - Population
  - Economic

Demand Increase

Weak and Unbalanced resources

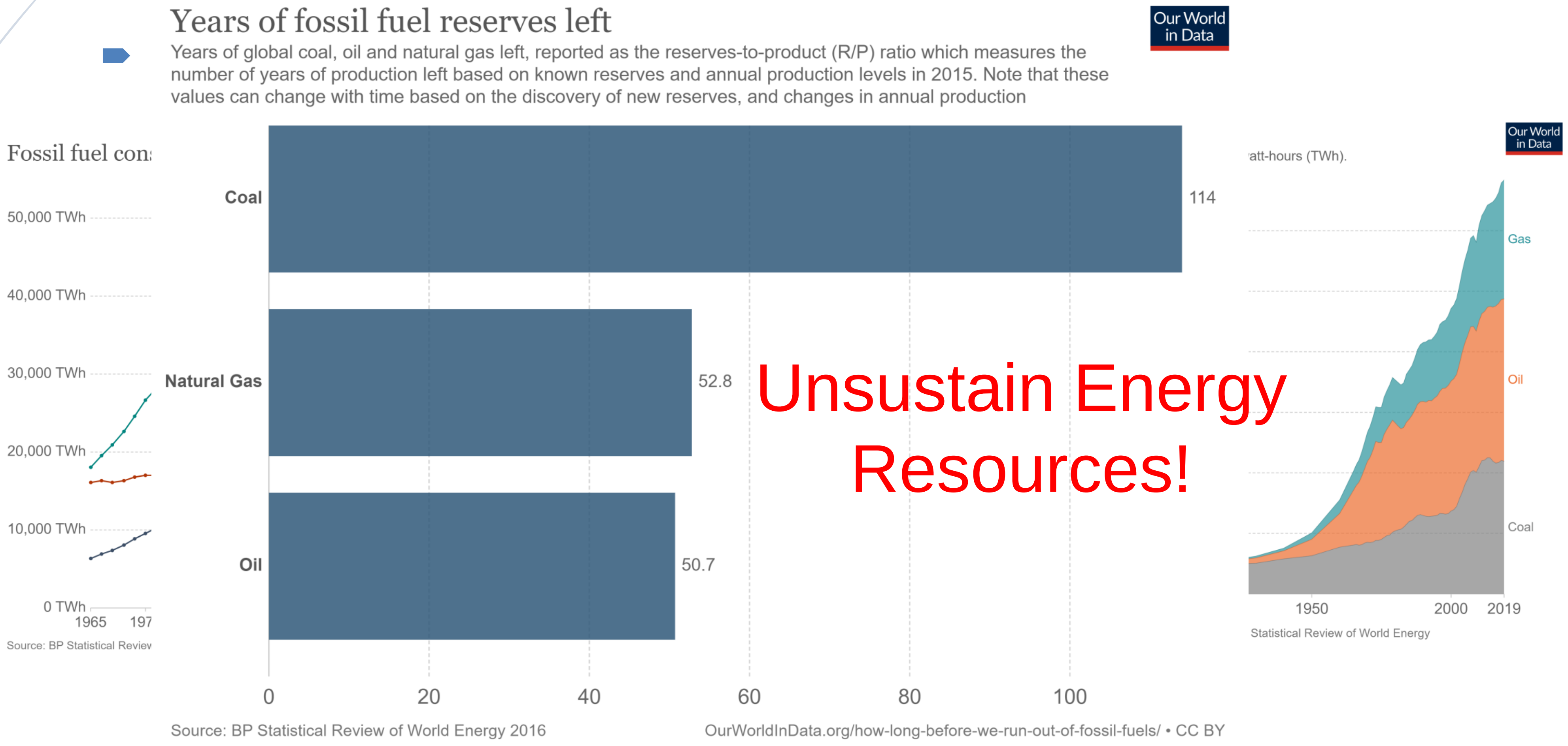
Current Energy Systems

- The common practice is that *consumers* **purchase** electricity from utilities or retailers through fixed tariffs or time-of-use!



Current Energy Systems

When will the world run out of fossil fuels?



Unsustain Energy Resources!

Futuristic Energy Systems

- The integration of **distributed energy resources** into **conventional power system!**

Break the reliance on fossil fuels and incorporate more Futuristic Technologies and natural resources

Smart City
P2P Energy
Smart Grids
Micro-grids
Smart charging

AI
IoT
Blockchain
Big data
5G/6G

Blockchain Technology

- According to Hype Cycle 2020, ***Blockchain*** is almost going to be in every single technology!

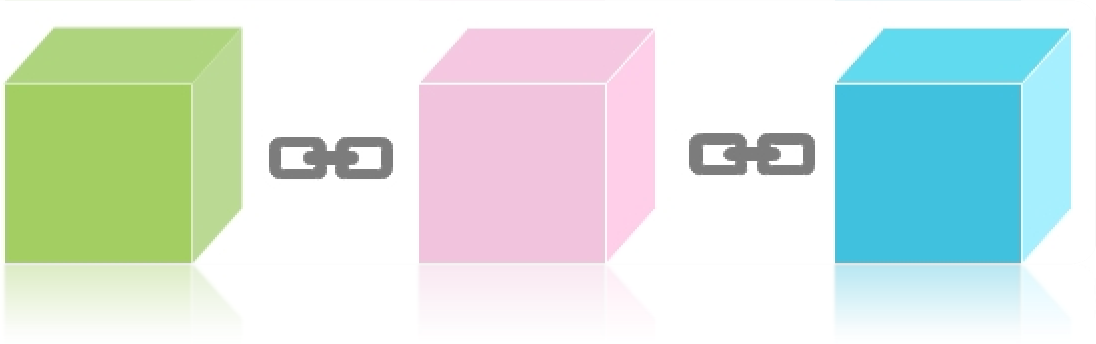
Simple questions:

- **What is BC?**
- **What problems they solve?**
- **How does it work?**
- **Practicality?**

Still Five to 10 Years Away From Transformational Impact

Blockchain: An Overview

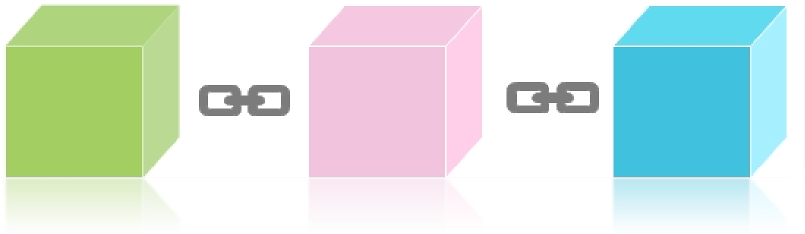
- Chains of BLOCKS that contains Information!

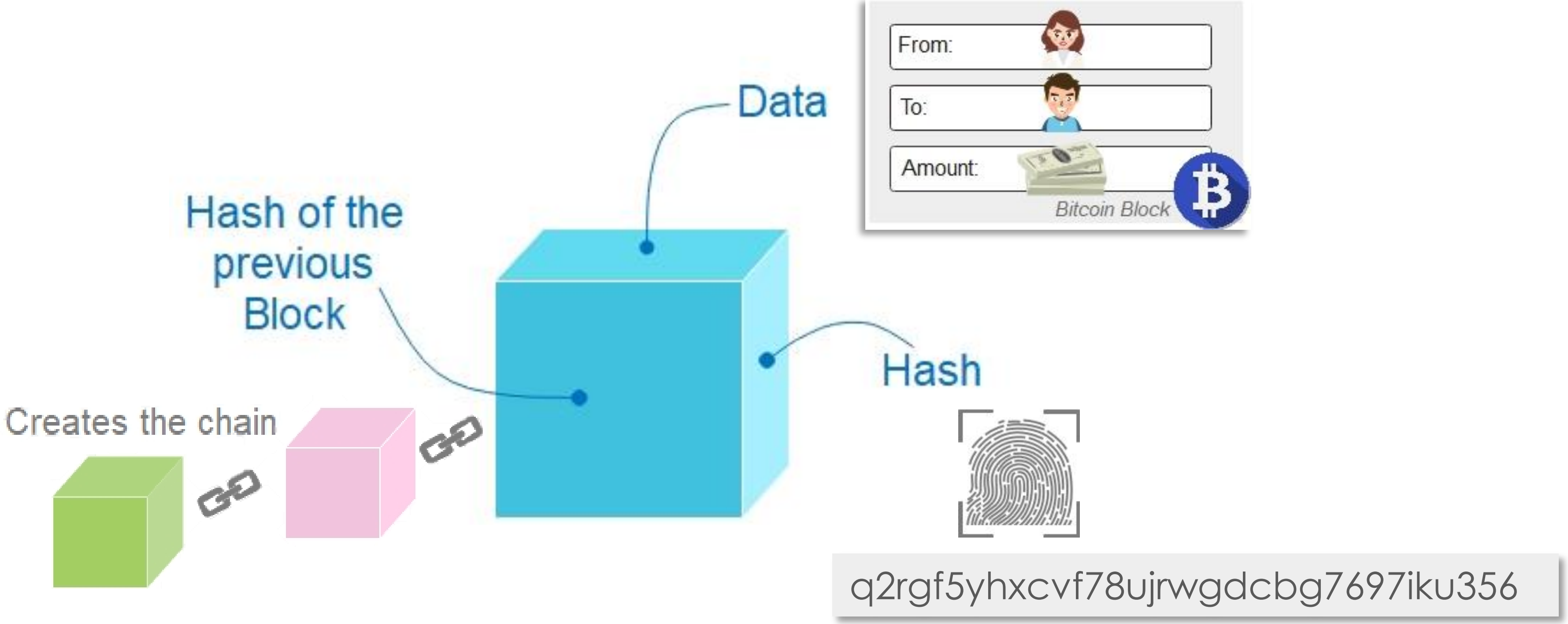


- It's initial inception was to stamp Digital Documents
  - Prevent Documents Tampering
- However, it was not that popular due to many issue
  - Computations and resources
- In 2009, Satoshi has incorporated it with **Bitcoins!**

Blockchain: Basic Concept

- Blockchain → Distrusted Ledger
  - Open to anyone
- It's super unique concept
  - Impossible to change a record's data!

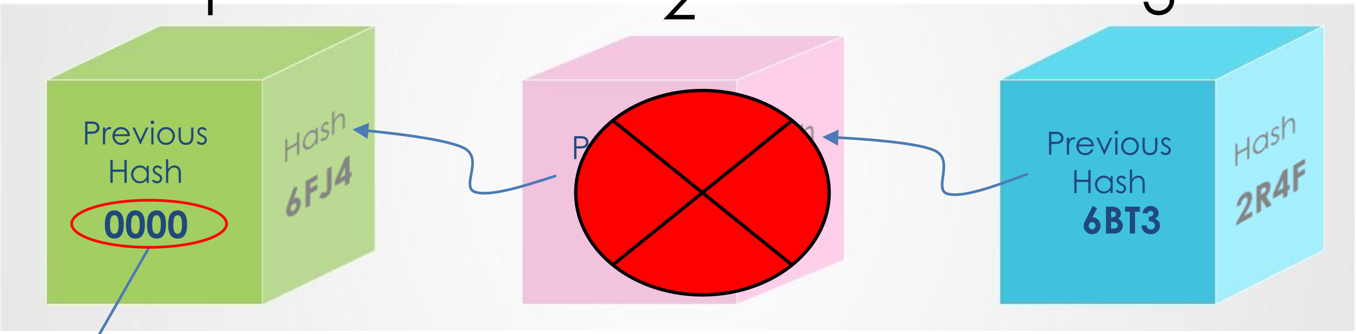




Blockchain: An Example

- How it works on a basic level:

1 2 3



Genesis Block

Proof-of-Work !

10 minutes

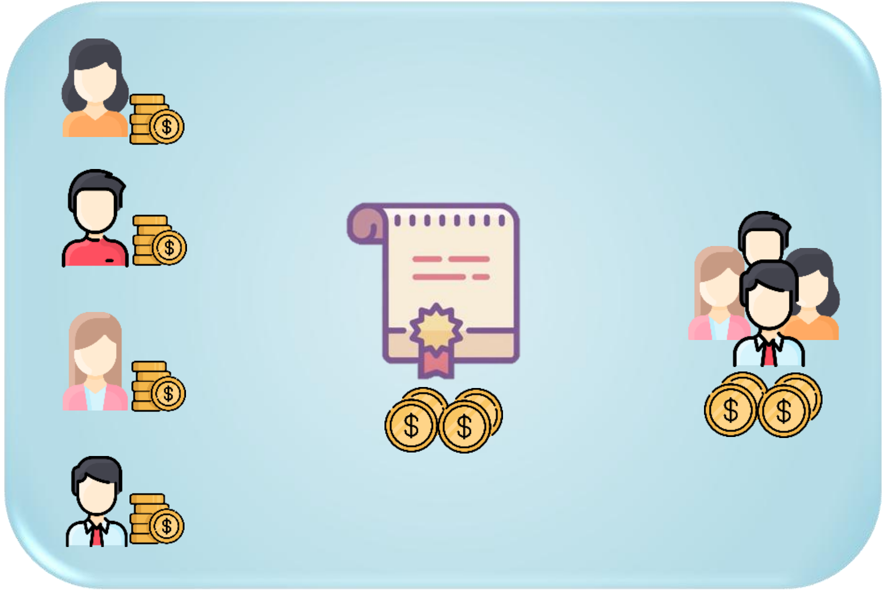
What makes BC secure:
- Not only the hash,
- But also the use of PoW

By being also distributed!

Verified P2P - Consensus

Blockchain: Smart Contracts

- BC is continuously evolving!
- The most used feature with BC is Smart Contracts!
  - Similar to regular contract but digital
- Smart Contracts is basically **a computer program** (referred to as Contract) stored on the Block.
  - Bitcoins - cryptocurrency



Why should trust smart contracts:
- Stored on the top of BC!
- Immutable
- Distributed

Blockchain meets Energy Systems

Japan turns to blockchain for trading extra power

System tracks energy consumption while AI enables users to sell surpluses to other residents

Telangana government collaborates with IIM-Ahmedabad to increase transparency in power sector transactions

- Unsustain energy resources
- Continuous growth
- Natural Resources
- Futuristic technologies

of solar technically
l finds

Blockchain brings trust t
EV charging systems

By The Engineer 16th August 2019 10:27 am

tilities Join
Trading Trial

Power Ledger
trial with KEPC

-enabled P2P

During the trial, KEPCO shared m
Tatsumi Research Lab in Osaka

lated prosumers and consumers at

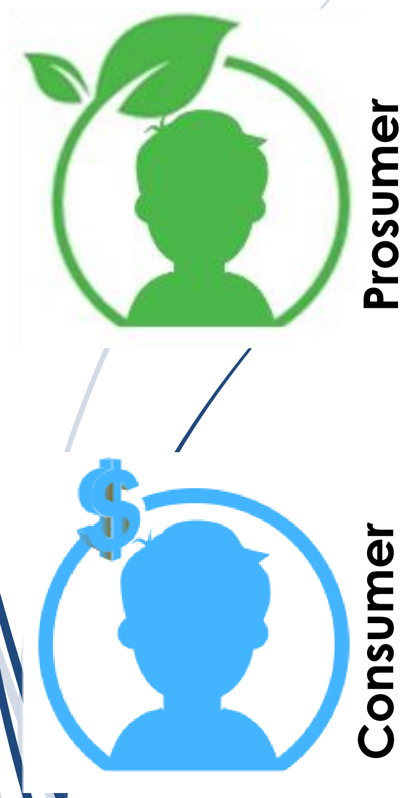
Power Ledger, an platform, has **saved** an average of **USD 424 (AUD 700) per year for its energy consumers** on annual electricity bills and helped solar rooftop system owners double the savings they normally get from their solar plants (Kabessa, 2017).

The New York-based energy start-up Drift, a P2P trading platform, has helped **consumers save 10% of their electricity costs** compared to Con Edison, a local utility in the New York area (CNBC, 2017). To drive down the cost for these consumers, Drift relies on blockchain technology and algorithms to source and trade power.

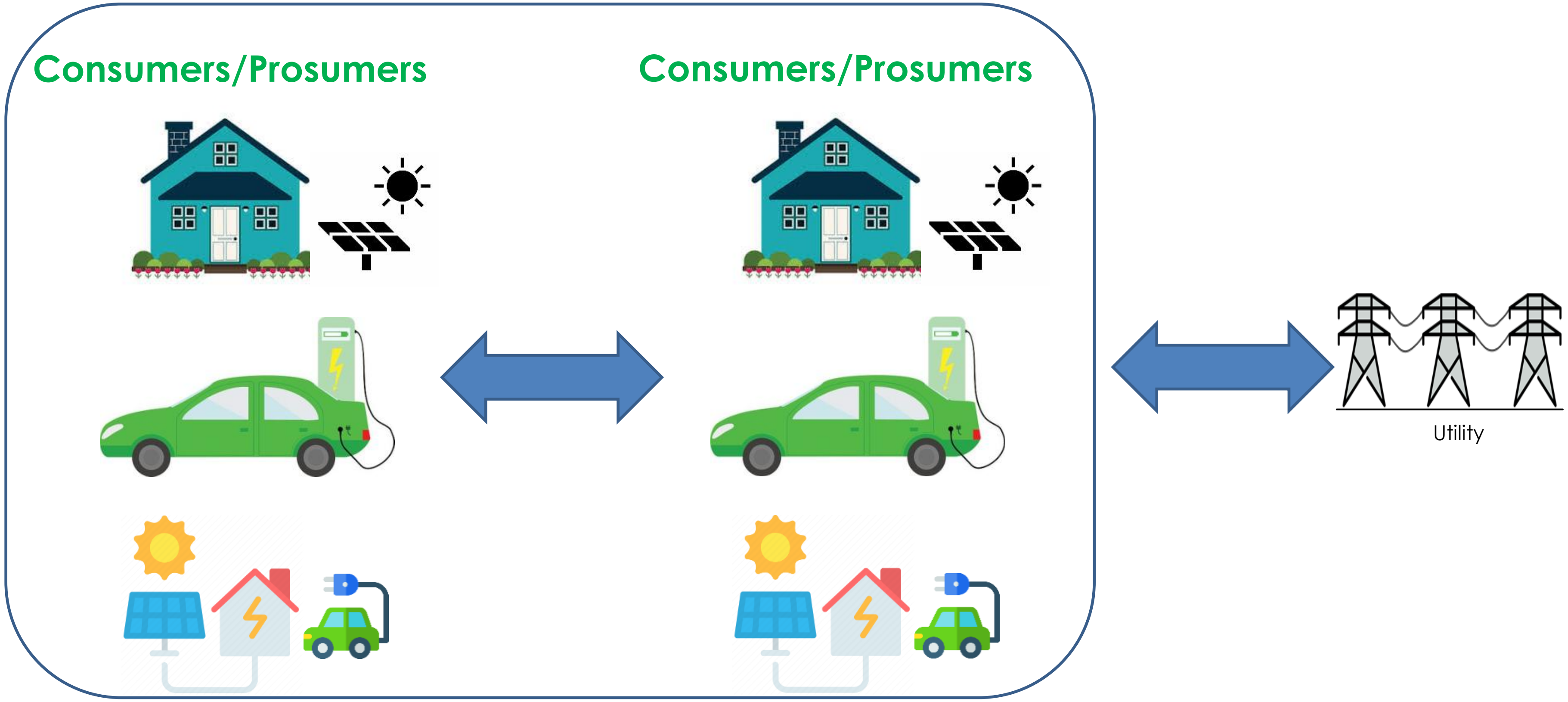
Blockchain In Energy Market Will Hit Record Value USD 11,899 Million By 2024: Zion Market Research

According to the report, the global blockchain in energy market was valued at around USD 208 million in 2017 and is expected to reach appro
2024.

P2P Energy - Concept



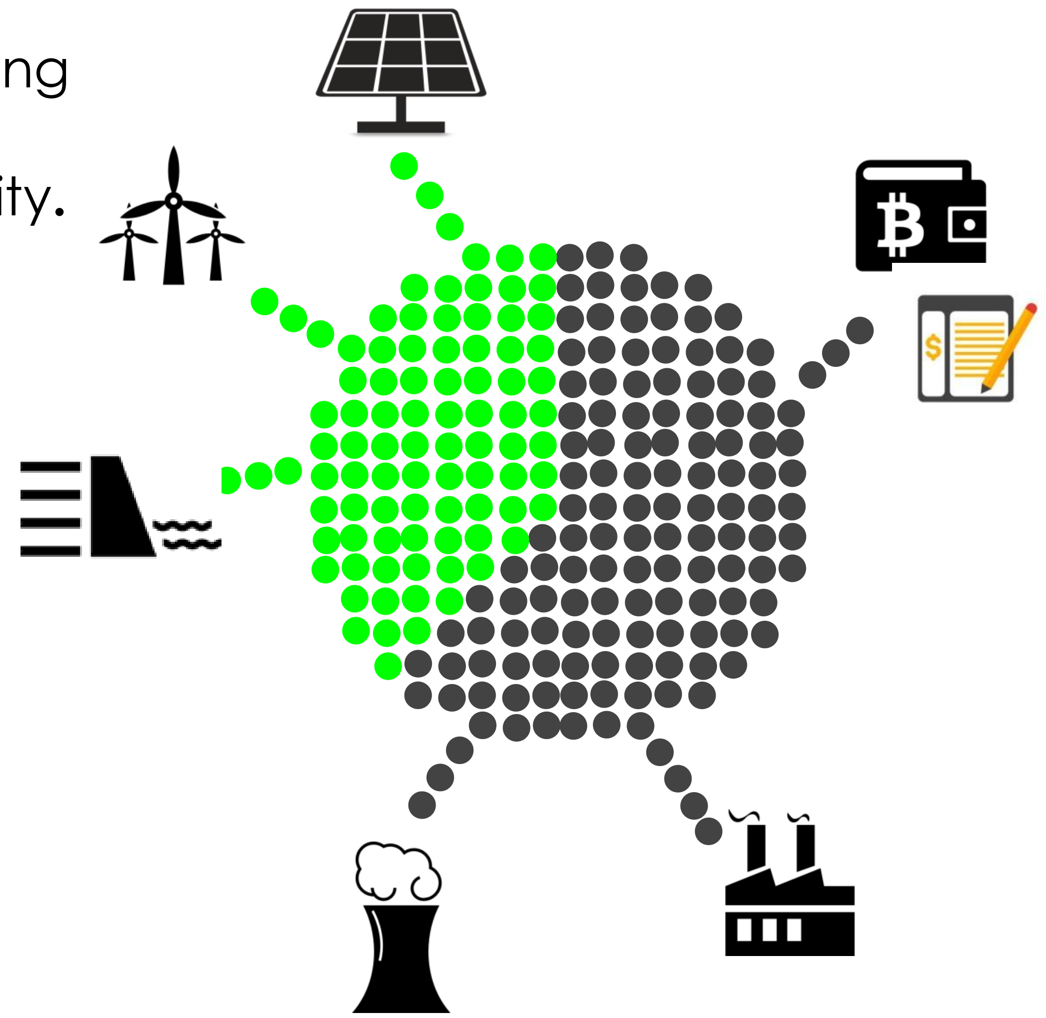
- A new business model, where consumers and producers (prosumers) trade electricity directly, without the need for an intermediary.



Blockchain meets Renewable Energy Systems

The basic and inter-related goals of employing blockchain in Renewable Energy systems:

- Eliminate the need for a central authority.
- Eliminate central points of failure.
- Enable trust among peers.
- Create better consensus
- Sustainable source of Energy
- Reduce the need of fossil fuel

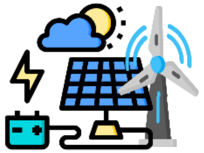


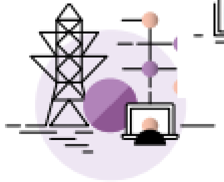
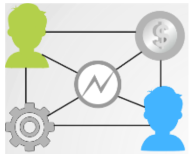
Create free market economy of energy !

Moving towards P2P Energy

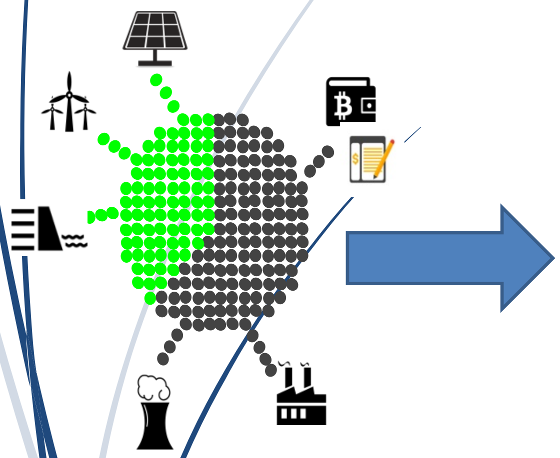
- Benefit of moving towards P2P Energy:
  - Renewable energy becomes accessible to induvial
  - Increasing renewable deployment
  - Empowering prosumers/consumers
  - Balancing and congestion management
  - Energy-as-a-Service Concept
  - Resilient to outages
  - Reduce operation costs

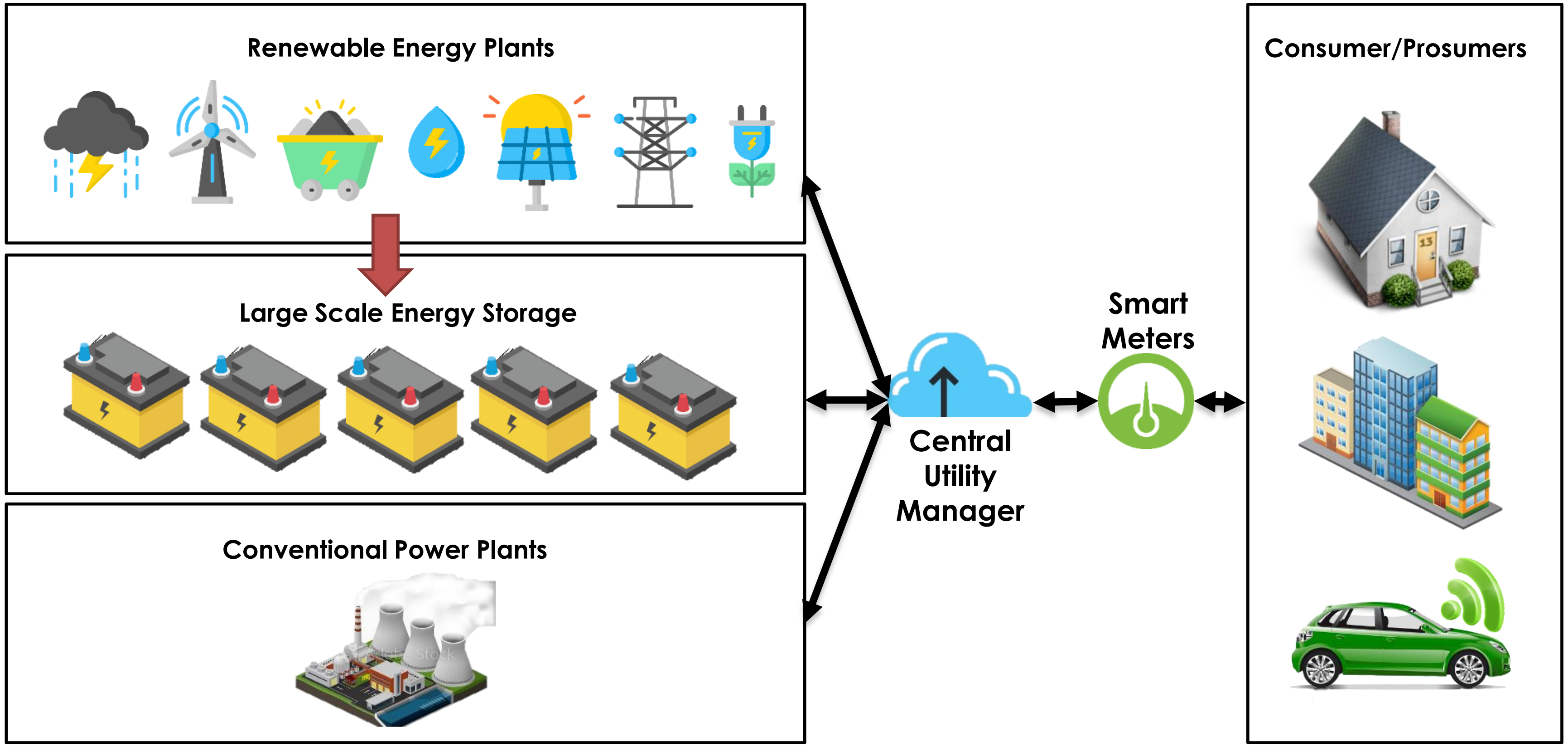




Future Energy Architecture

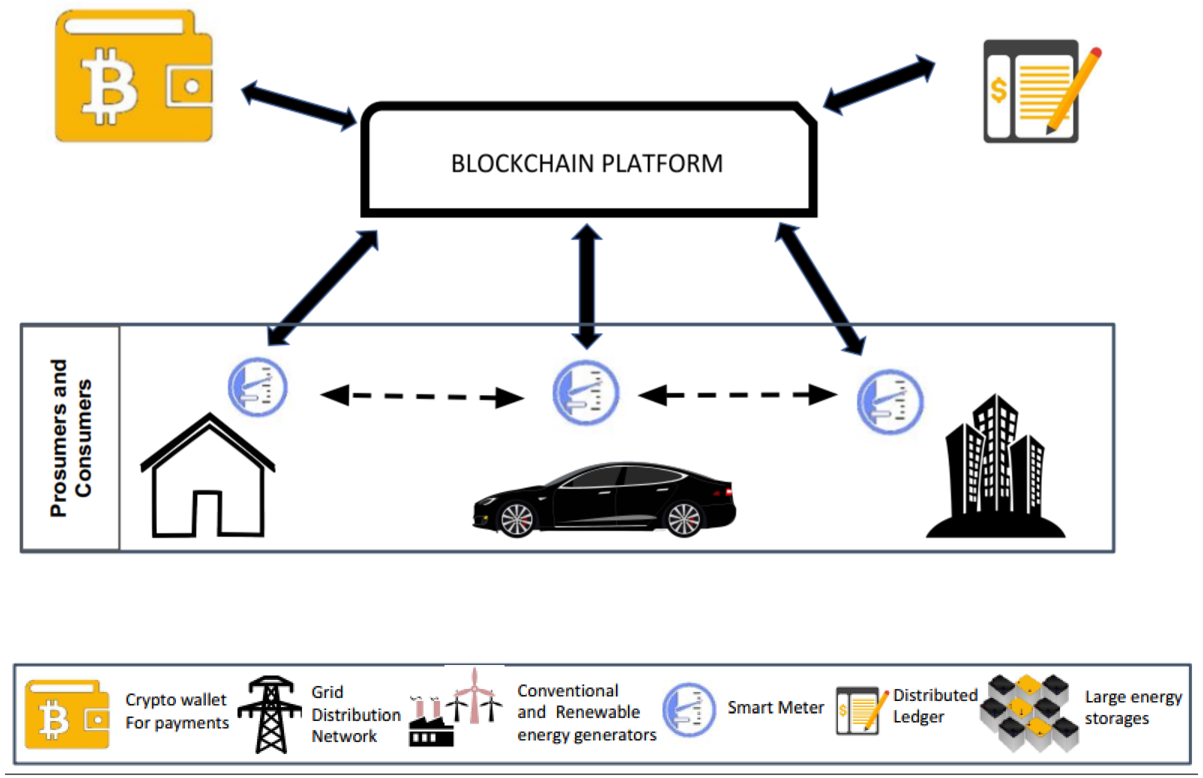




How can we Trade/Share energy? How convenient will it be?

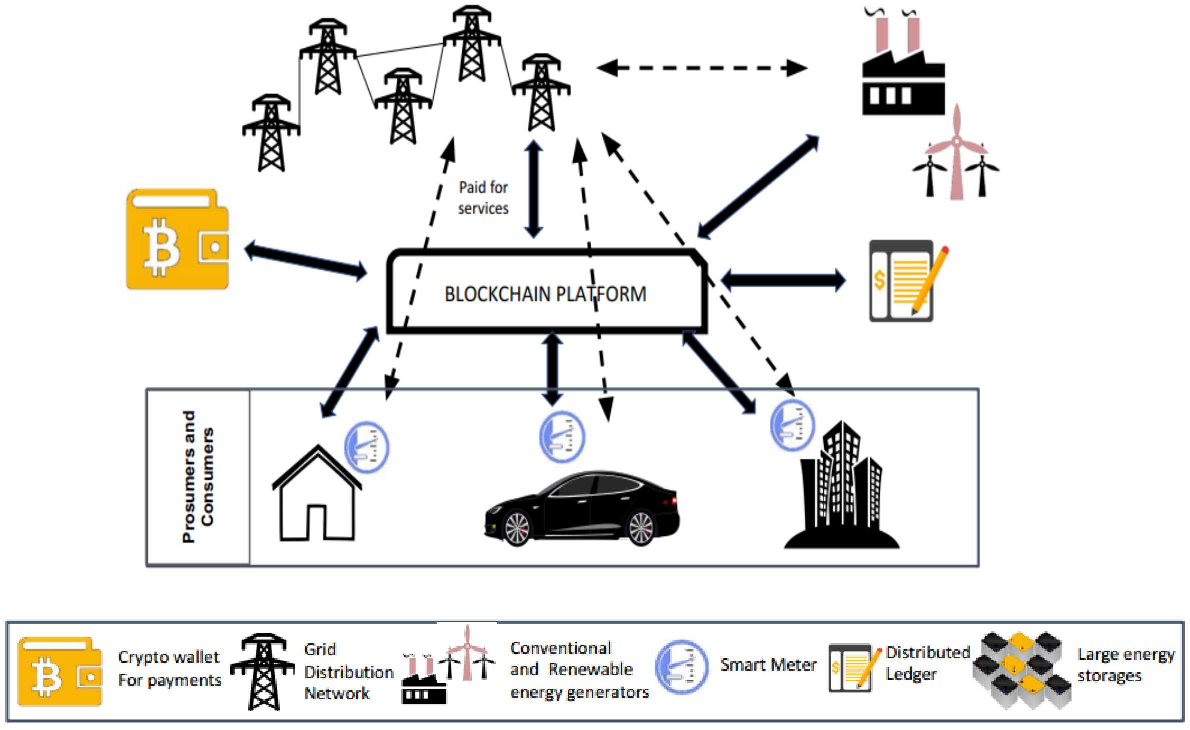
Potential Systems (1/3)

- **Infrastructure-based P2P Energy Trading**



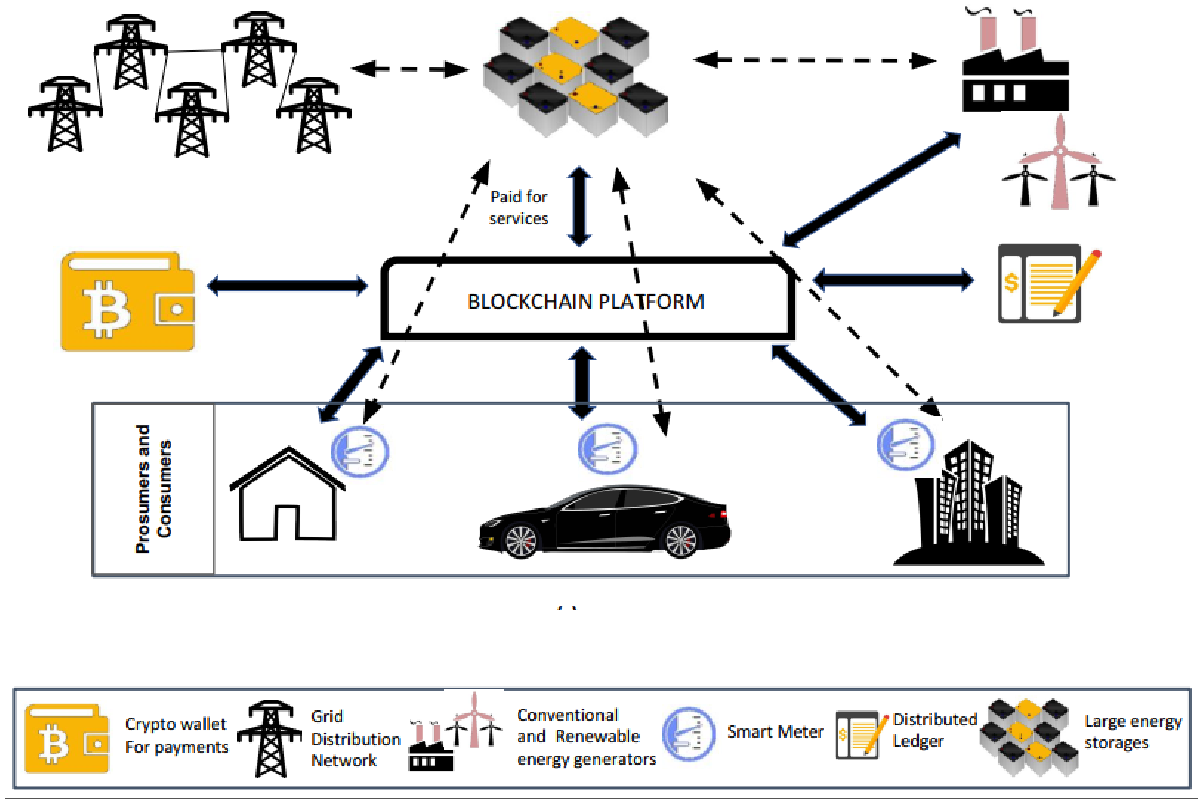
Potential Systems (2/3)

- **Ad hoc P2P Energy Trading**

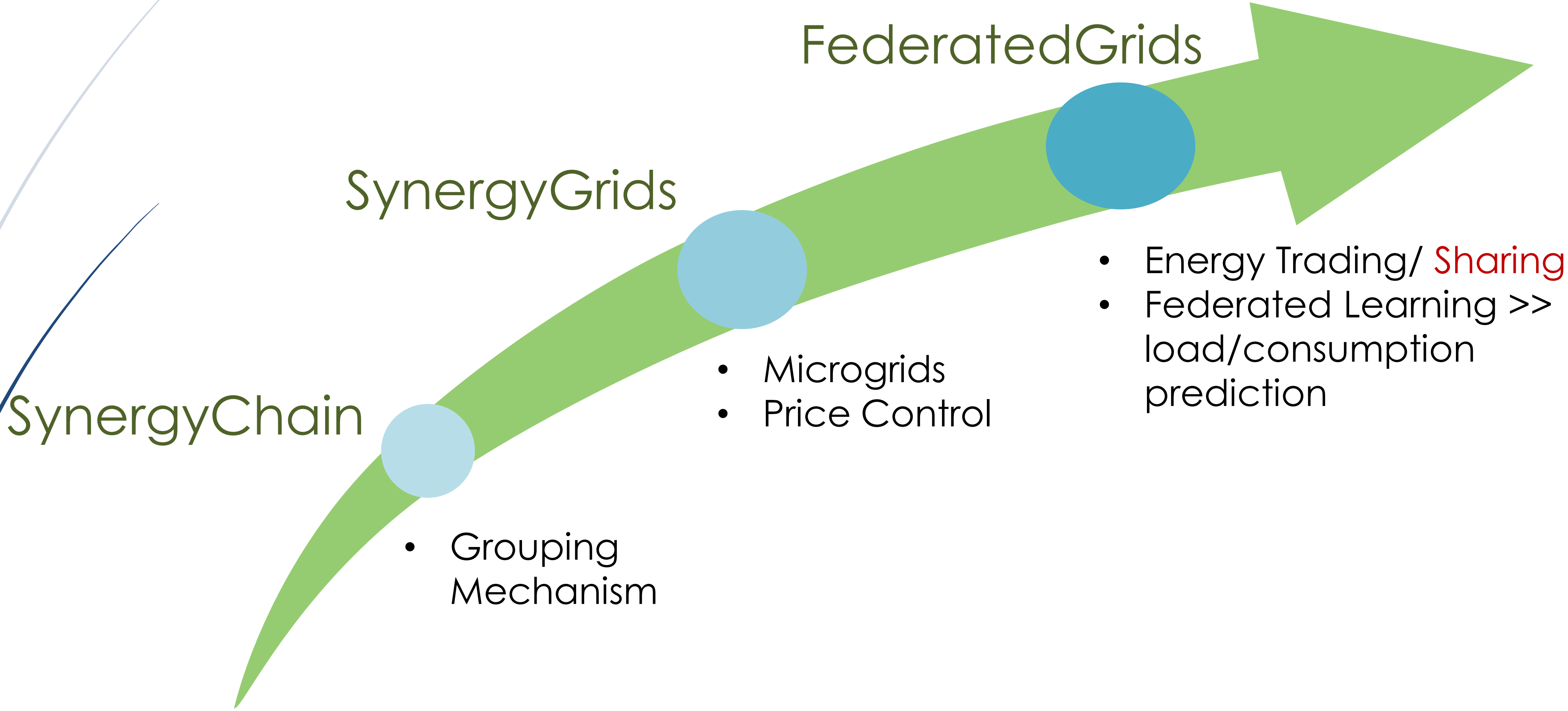


Potential Systems (3/3)

- **Large Scale Energy Storage Based Trading**

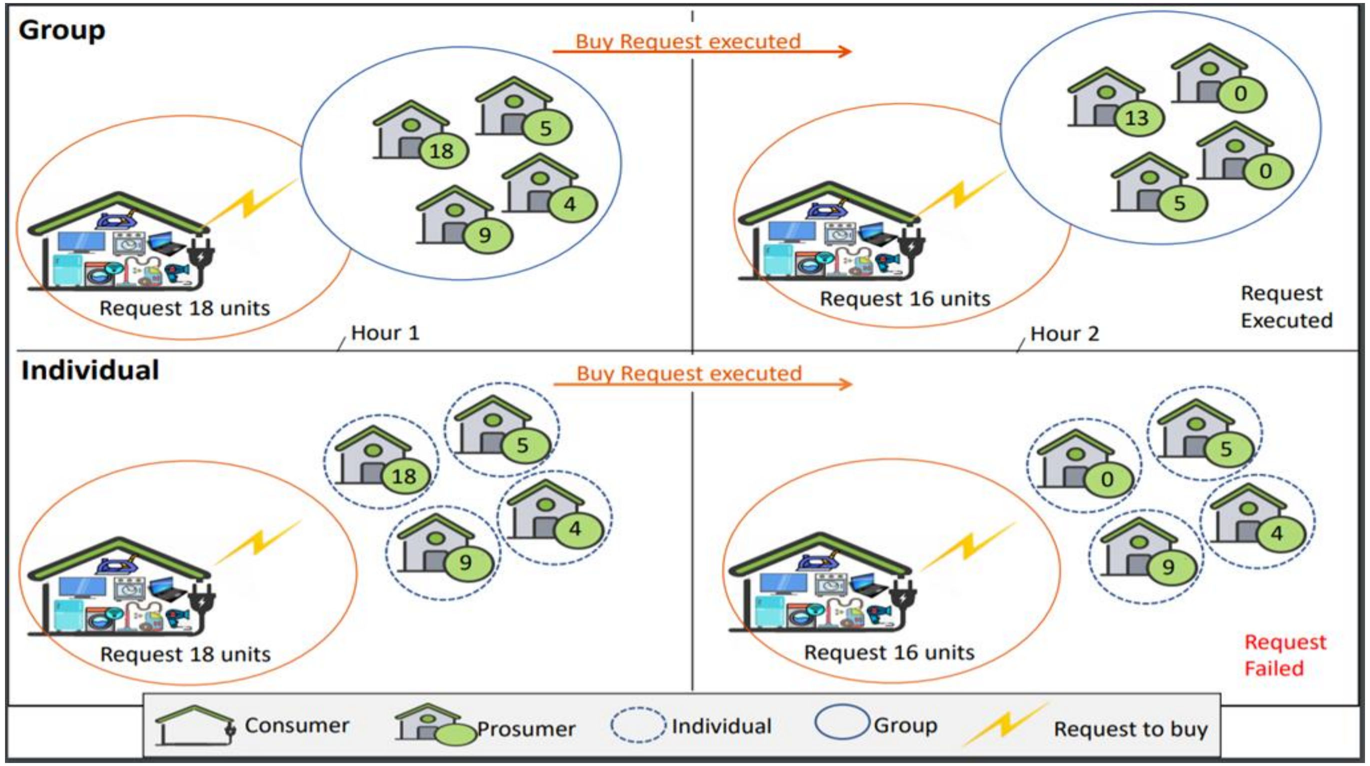


Evolution of Future Energy Systems



SynergyChain

- An example scenario depicting efficacy of prosumer management



SynergyChain

- The idea is to create prosumer ***community grouping***, located in different geographical area, to allow efficient energy trading among local members.
- A heuristic-based grouping algorithm, and also grouping-goal for cluster creation is defined for improvement in profits.
- Blockchain is used for better scalability and decentralization.
- Smart Contract will be implemented.

SynergyChain- Learning Module

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  groupi
- Group d hence
  the sa
- A sma ecision.
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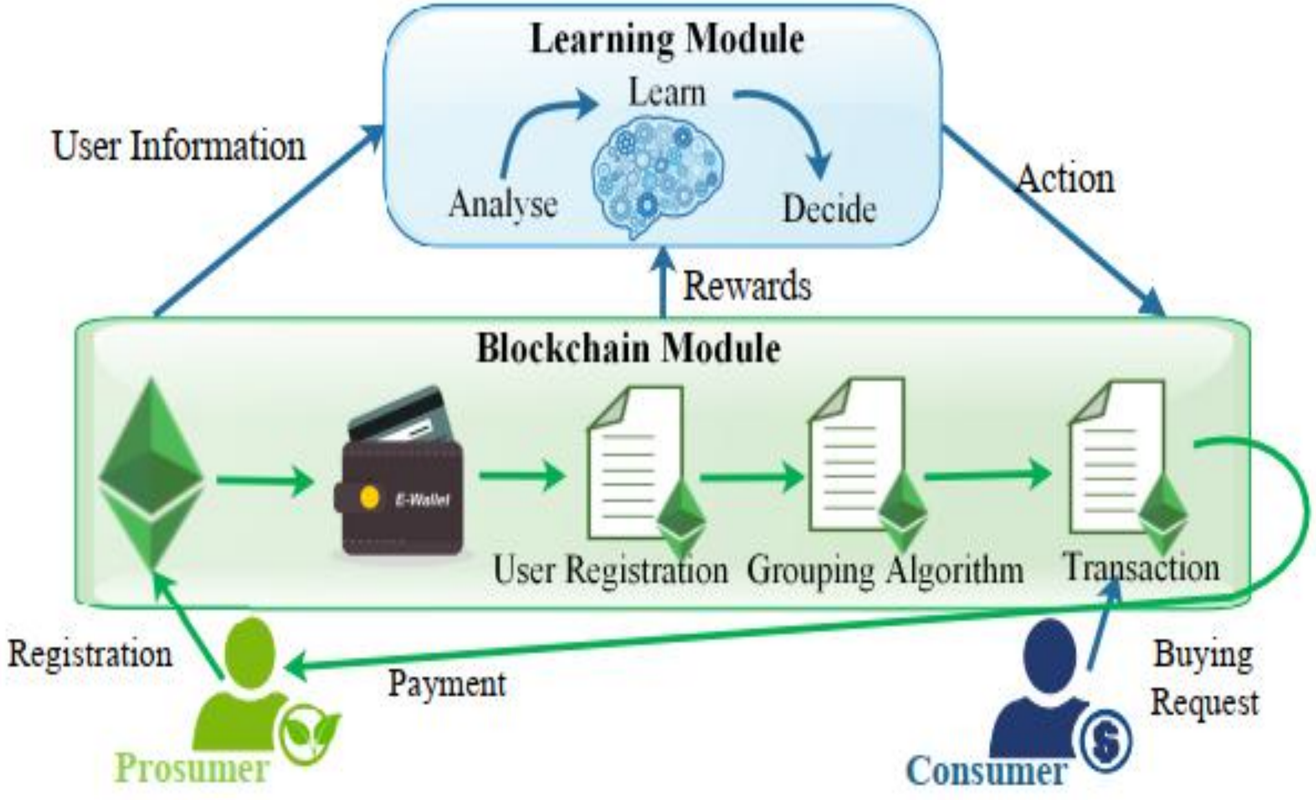
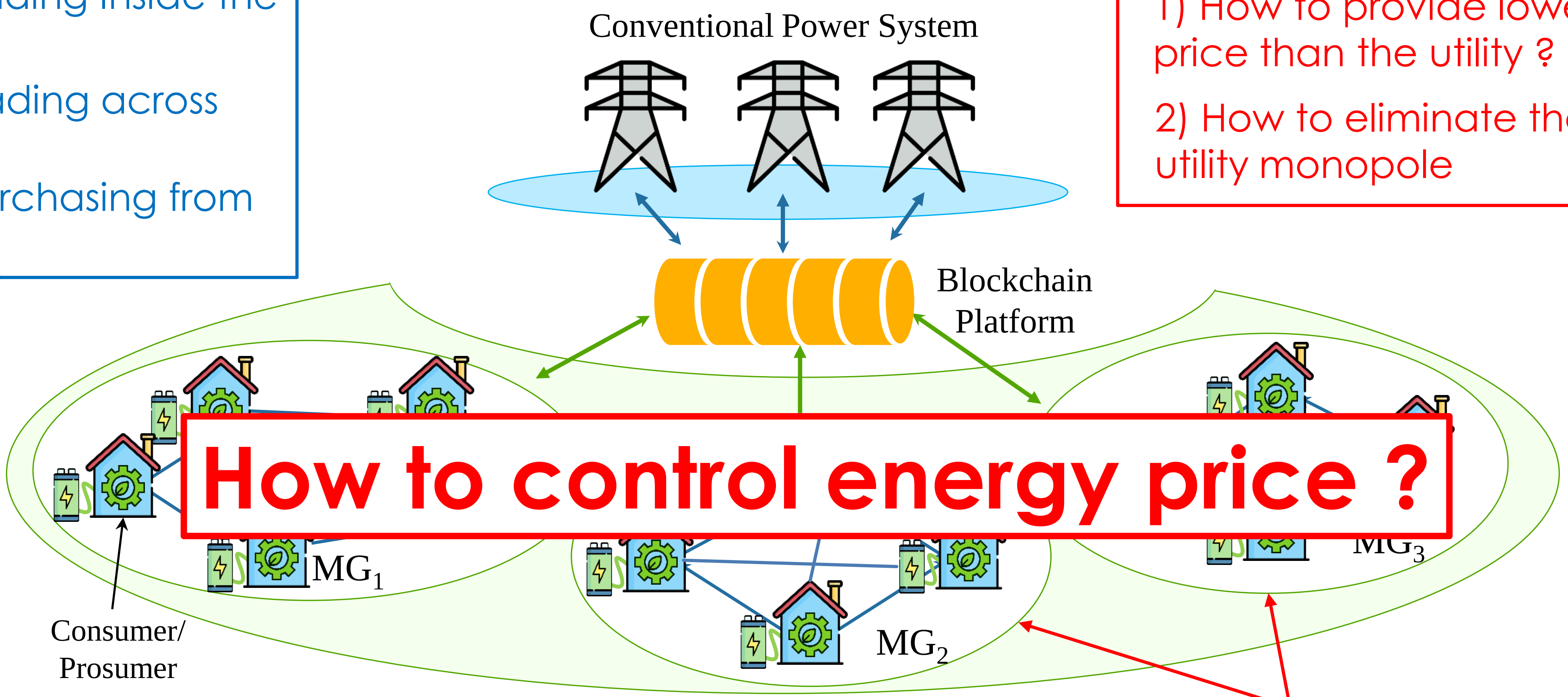


SynergyGrids

1) Energy Trading Inside the microgrid
2) Energy Trading across Microgrids
3) Energy purchasing from utility

1) How to provide lower price than the utility ?
2) How to eliminate the utility monopole



How to control energy price ?

Microgrid

SynergyGrids – Price Control

- Pricing technique that takes into account the total available energy, the usage, the distance between consumer and prosumer
- The proposed model
  - Utilizes the Hourly energy data set,
  - Reduces the load over the utility grid,
  - Increases the sale of prosumers.
- Target:
  - Reduce the price in comparison to utility grid energy prices.
  - Minimize the total energy cost of the consumer.

$$\mathbf{Price}_{\mathbf{inside\_Microgrid}} \leq \mathbf{Price}_{\mathbf{between\_Microgrid}} \leq \mathbf{Price}_{\mathbf{utility}}$$

SynergyGrids – Price Control

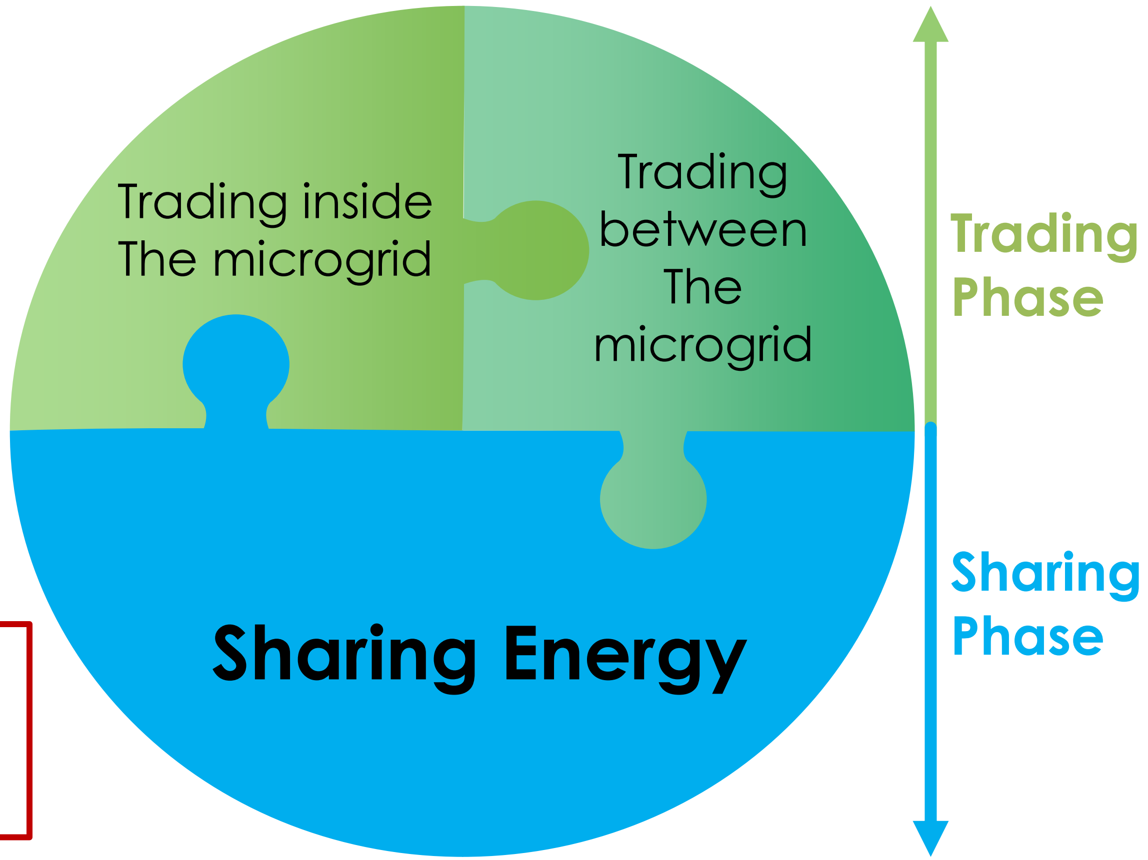
- Smart contracts task:
  - Self-triggering capability,
  - Designed for devising transactions between entities,
  - Reducing the demand from the main grid.
- Matching mechanism that takes into account energy requirements and matches buyers with the sellers
- Decreasing utility load: advantage for low energy areas

FederatedGrids

- After the trading phase
- All buyer's requests are fulfilled
- Prosumers with excess energy left

Excess energy can be shared with prosumers not able to afford energy

Advantage:
➔ Prosumer satisfaction
➔ Less storage charges

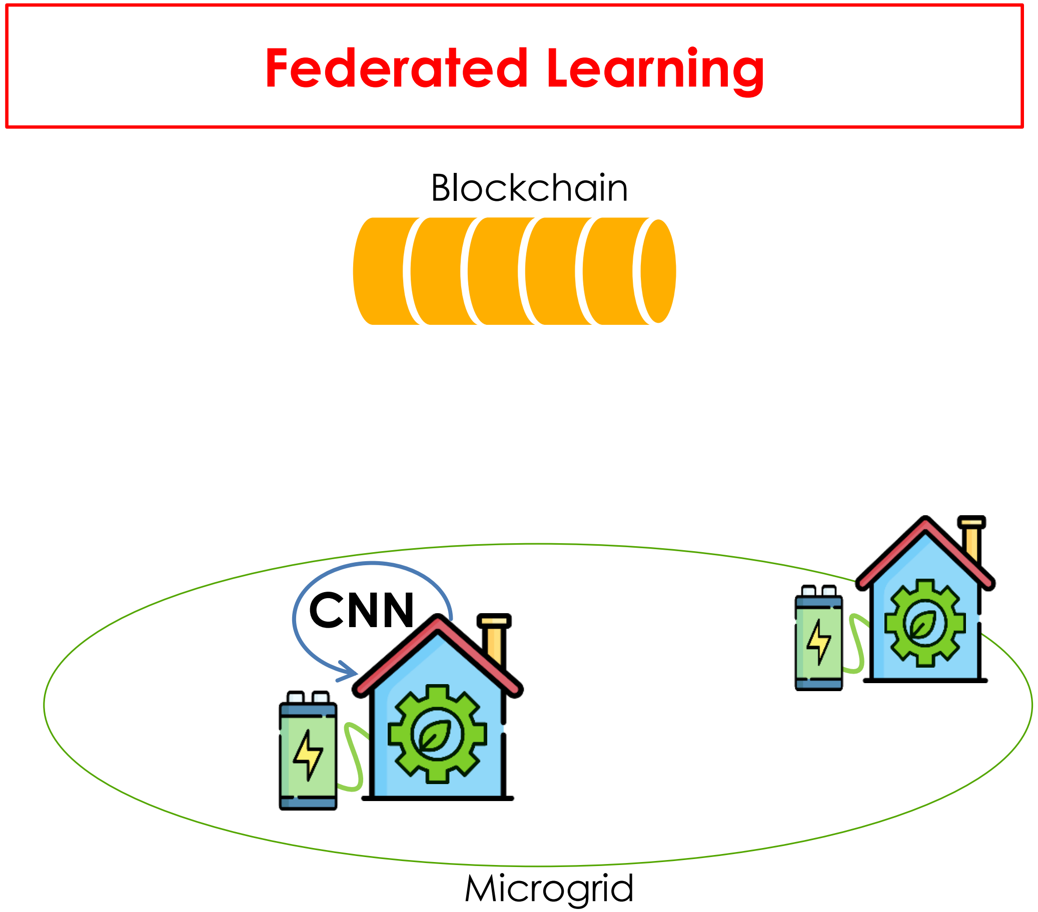


FederatedGrids – Energy Sharing

- Two different aspects:
  - Energy sharing between peers: rest of consumers do not have funds to buy energy and weren't able to participate in the energy trading phase.
  - Energy resource sharing: producers share the batteries of other participants' to store their surplus energy allowing to reduce the extra storage cost.
- At the end of trading phase: Eligible consumers sends the sharing request:
  - Sharing inside the microgrid
  - Sharing across microgrids

FederatedGrids- Learning Model

- Target: Predicating the global system load (energy demand and energy generation)
- Make decisions related to the sharing phase: Prosumers ➔ share energy ?
- Using Blockchain-assisted Federated Learning
- Prosumers: share energy in exchange for future benefits and advantages



Example 3: FederatedGrids- Learning Model

- Target: Predicating the global system load (energy demand and energy generation)
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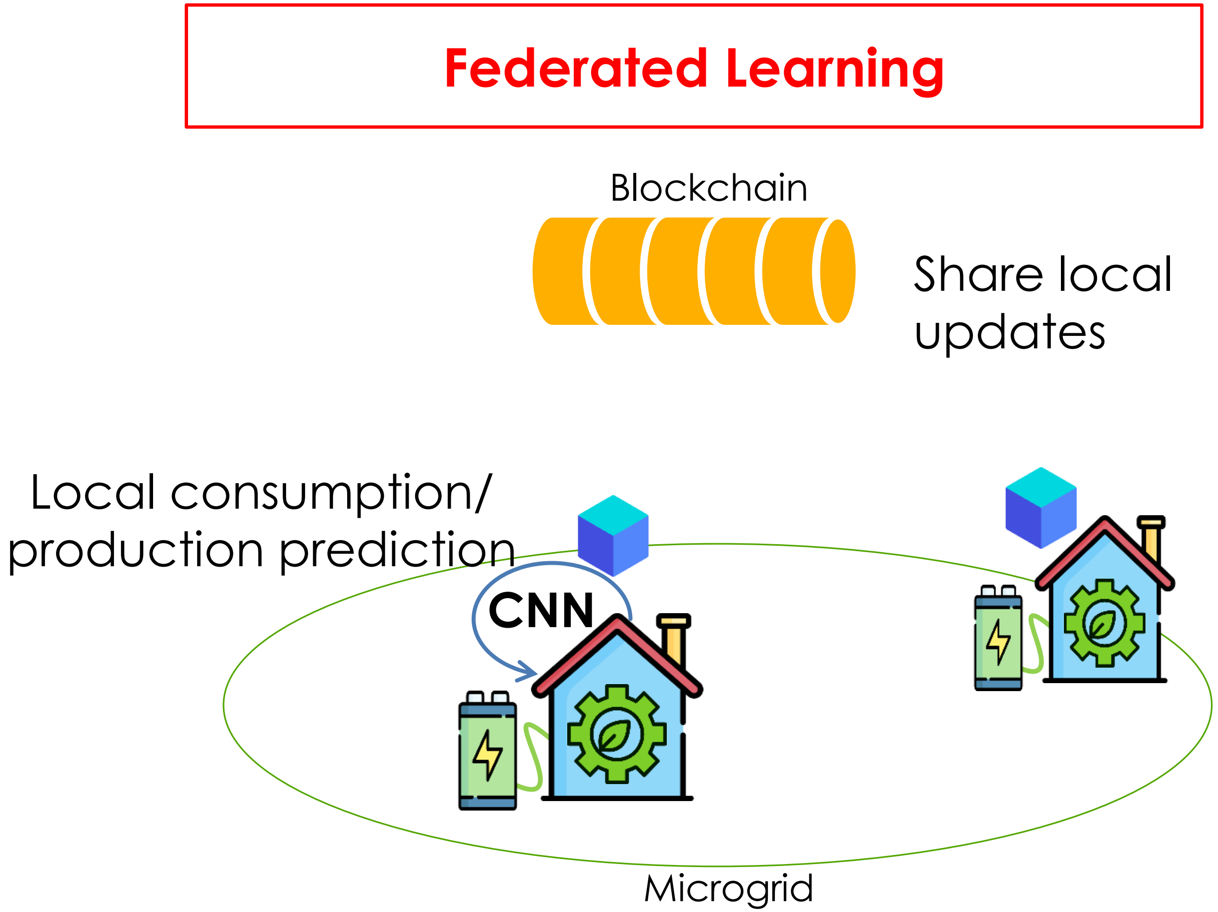

Example 3: FederatedGrids- Learning Model

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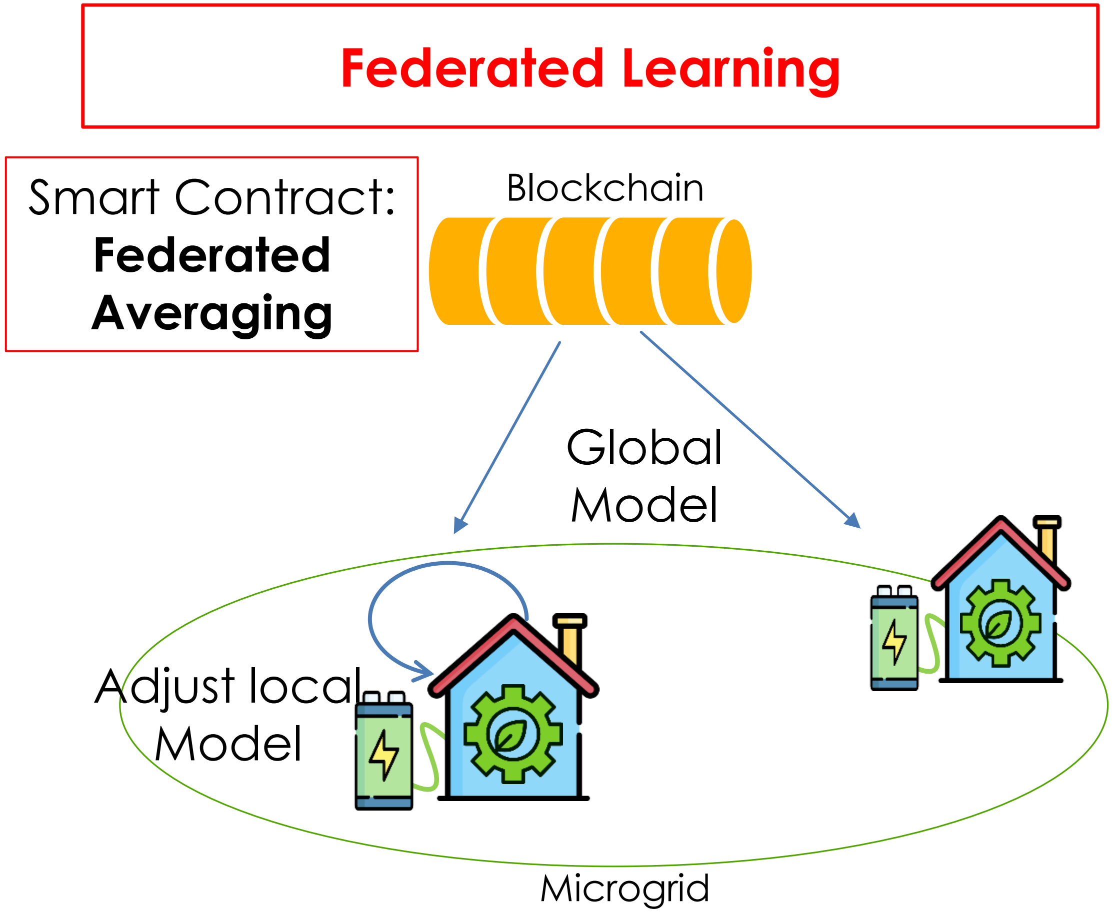


Tools Used: Overview

Evaluation: Experimental Setup

Prototype system is based on the following assumptions:

- A participant is either a prosumer or a consumer in each time step.
- A consumer is either a one able to buy energy or the one without available resource to cover energy buying requirements.
- The microgrid to microgrid trading cost is defined at the beginning of each time step.

Evaluation: Experimental Setup

- Dataset: Hourly Energy Consumption data-set: 4years of electrical consumption, generation, pricing, and weather data for Spain
- It contains two major pieces of information needed for the proposed model for each time stamp:
  - The energy generated by reusable energy resources such as wind and solar energy
  - the data for energy demand.
- Part of a project from the Open Weather API to study the impact of the weather conditions on renewable1
- Jhana,Nicholas.“HourlyEnergyDemandGenerationandWeather.”Kaggle,10 Oct.2019,www.kaggle.com/nicholasjhana/energy-consumption-generation-prices-and-weather.

Evaluation: Experimental Setup – Price Control – Trading Phase

- 5 Microgrids
- 300 prosumers.
- 500 consumer energy requests are sent to evaluate the system.
- Microgrid 1 has higher amount of energy generated and utilized
- Microgrid 5 has large energy generated to energy utilization difference.
- The prosumers have different energy source type.

Evaluation: Energy Load

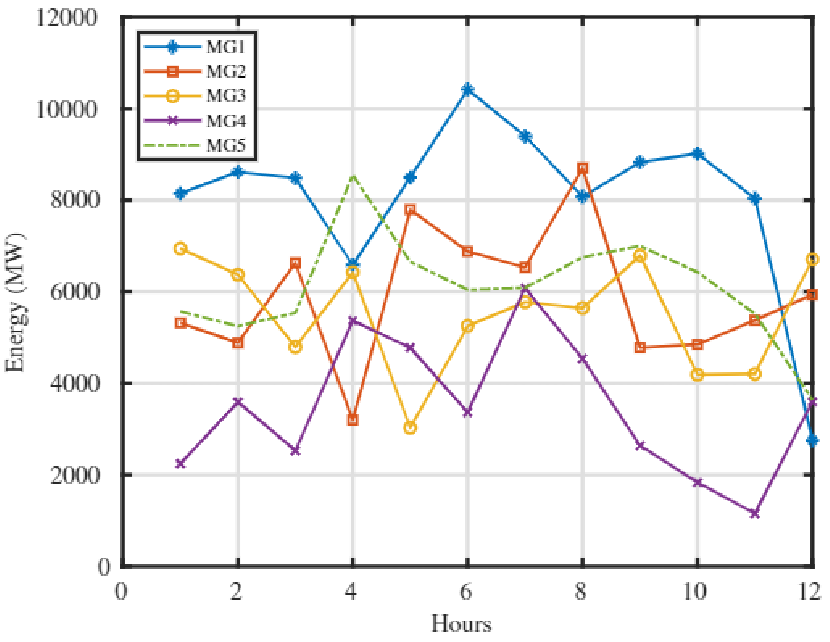


Fig. Energy Load of each microgrid.

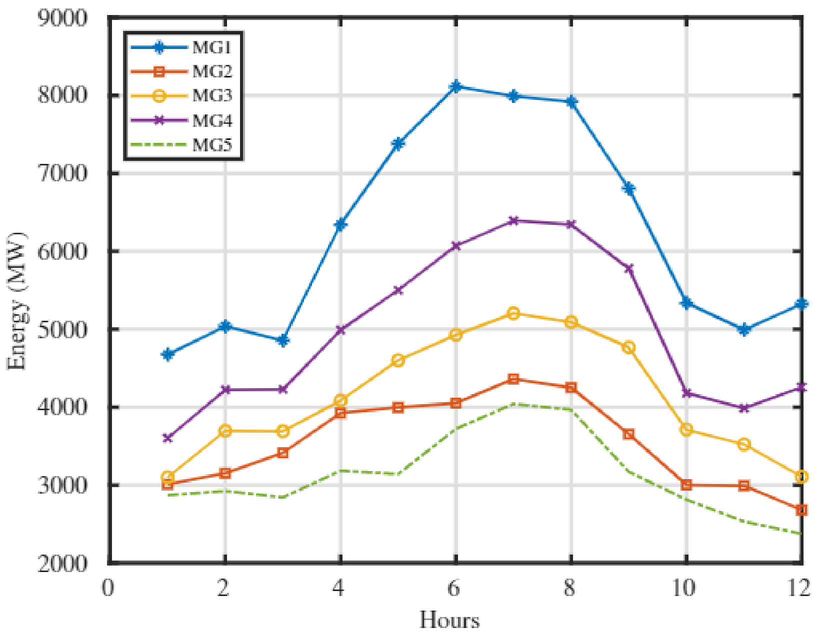


Fig. Energy generation of each micro-grid.

Evaluation: Trading Phase - Price Control

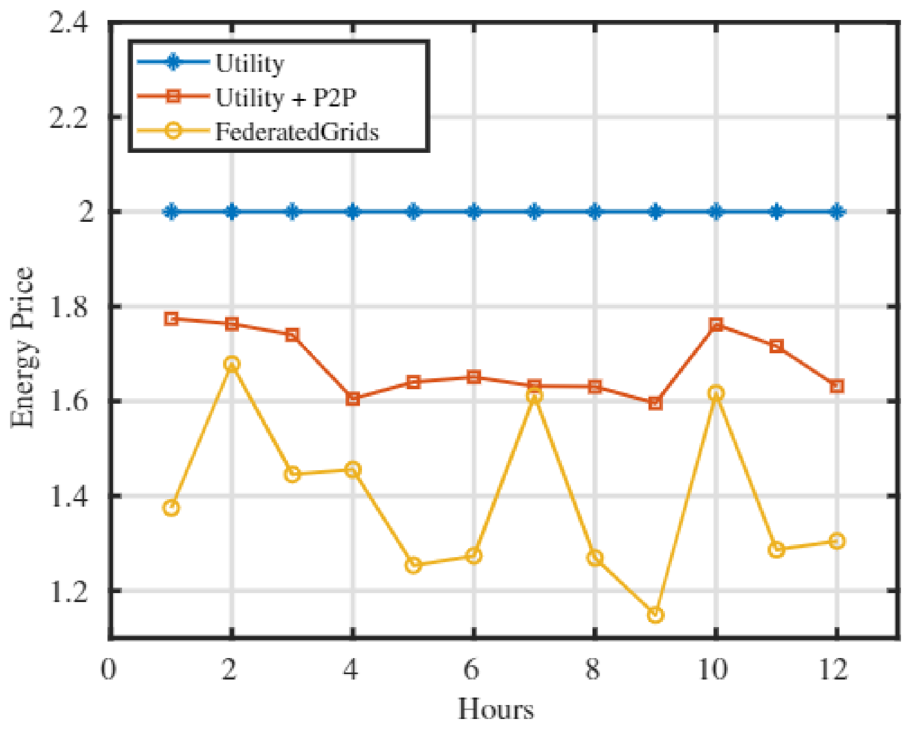


Fig. Average energy price with 5 microgrids.

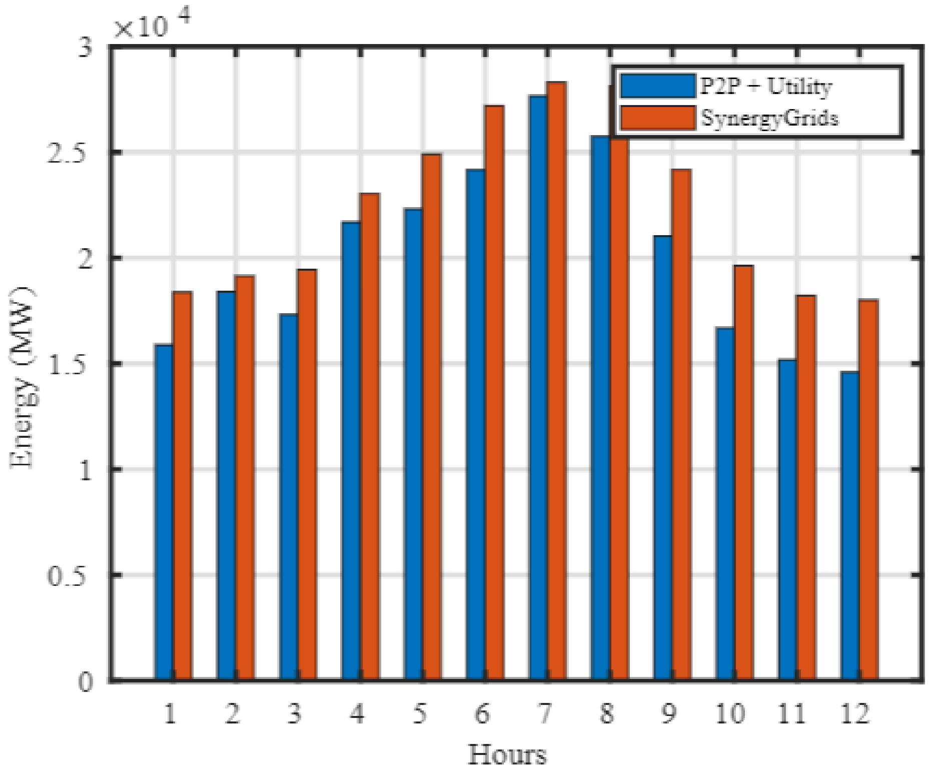


Fig. Total energy sale with 5 micro-grids.

Evaluation: Trading Phase – Price Control

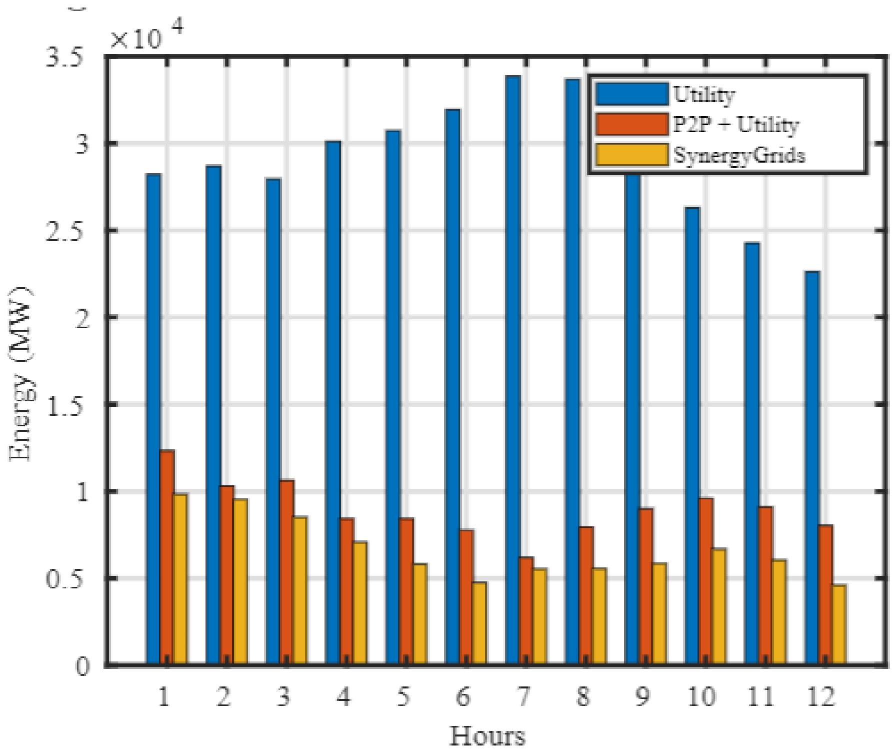


Fig. ' Energy load over utility with 5 microgrids.

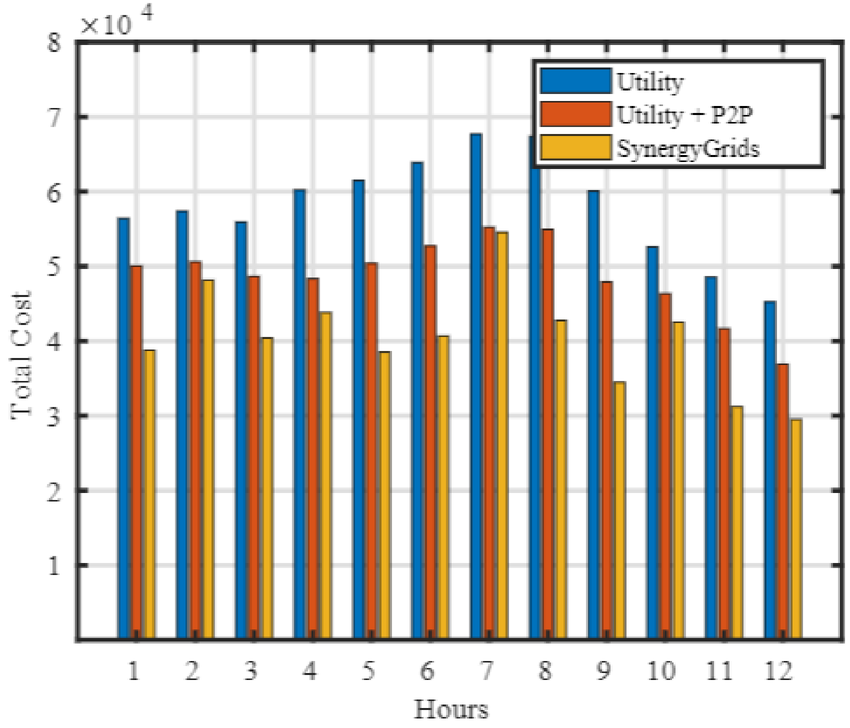
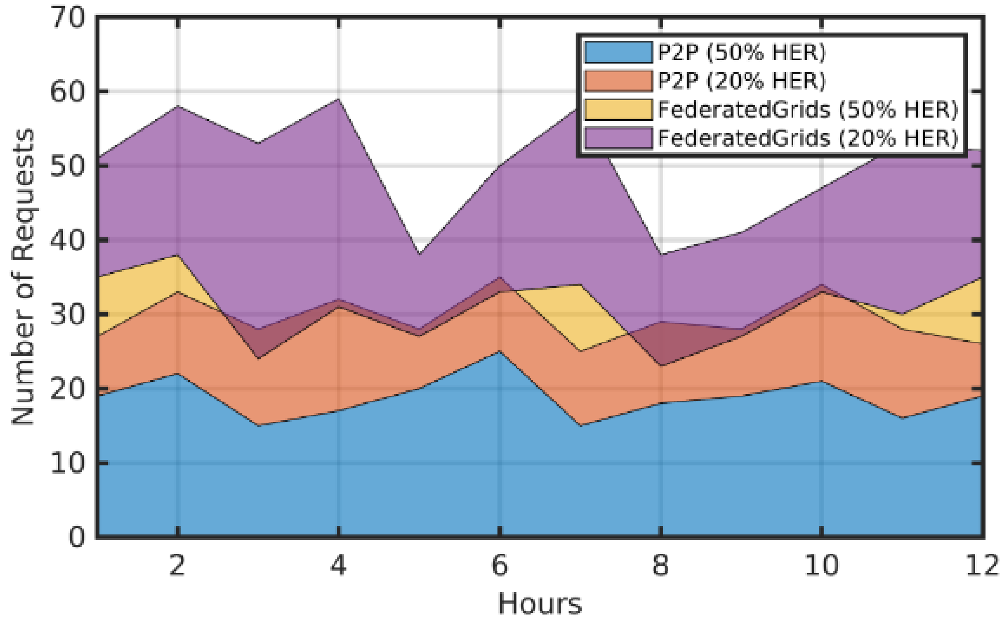


Fig. Total consumer cost with 5 microgrids.

Evaluation: Experimental Setup – Sharing Phase

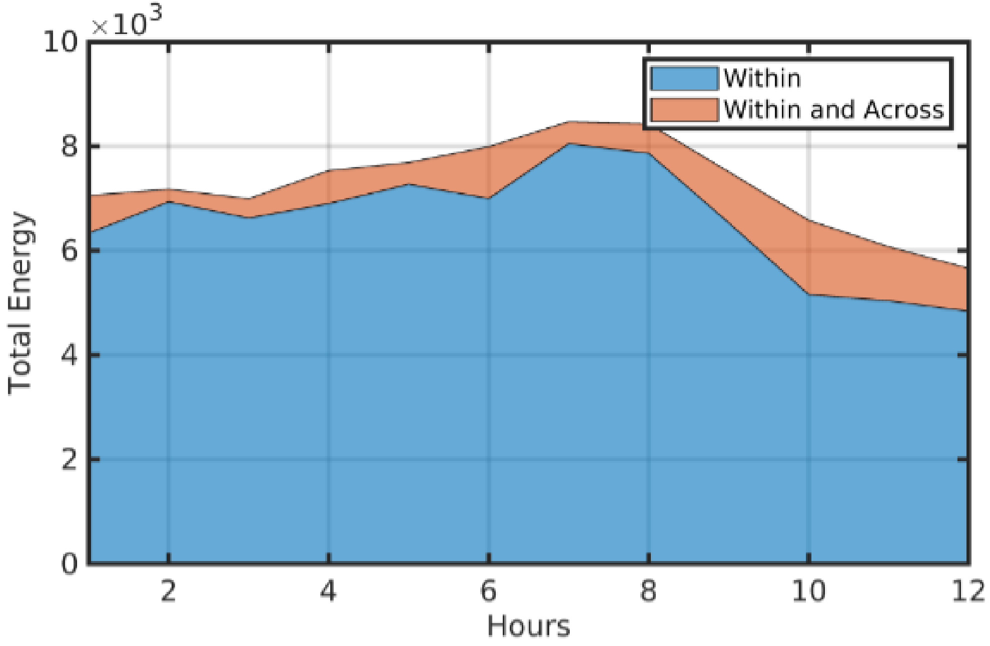
- 5 Microgrids
- 100 prosumers.
- 300 consumer
- A consumer is either a one able to buy energy or the one without available resource to cover energy buying requirements.

Evaluation: Energy Sharing – Covered Requests

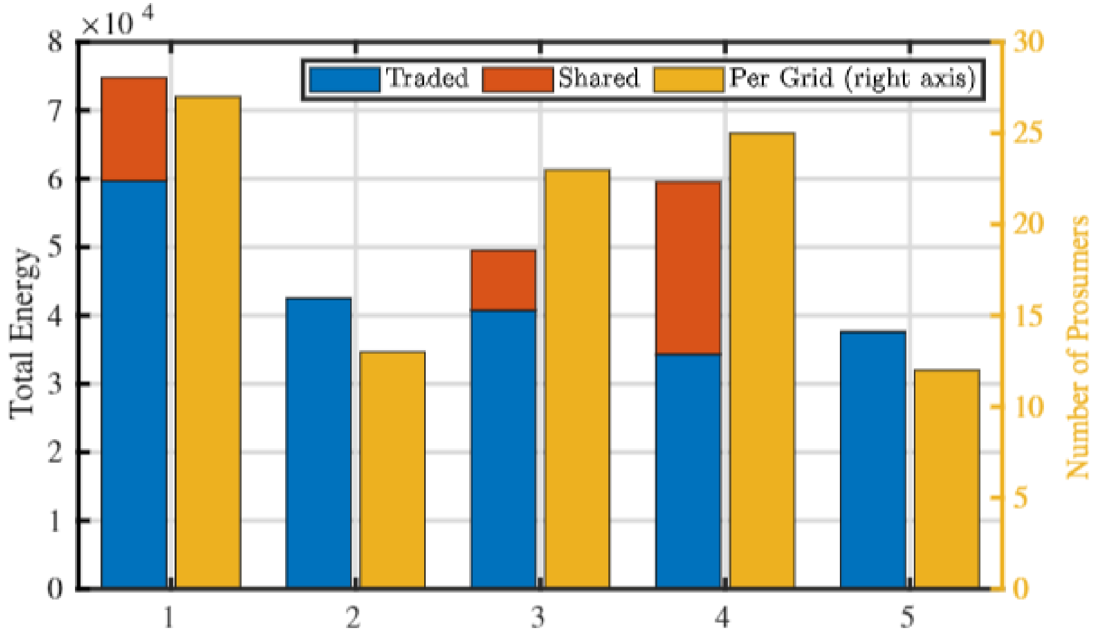


Covered energy share request with small and large requests

Evaluation: Energy Sharing – Covered Requests

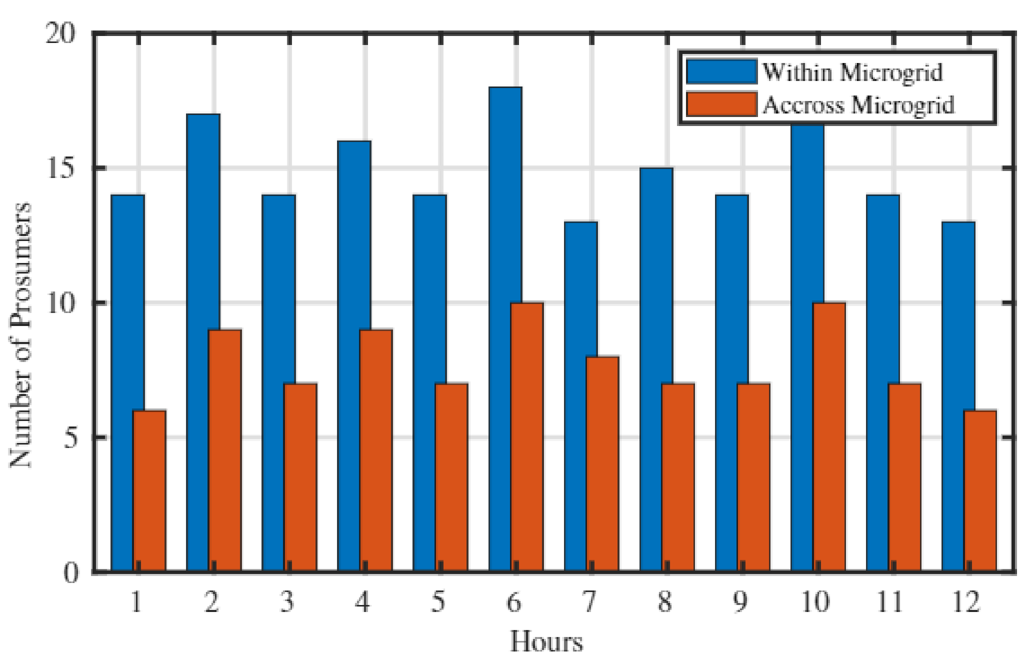


Energy shared within and across microgrid

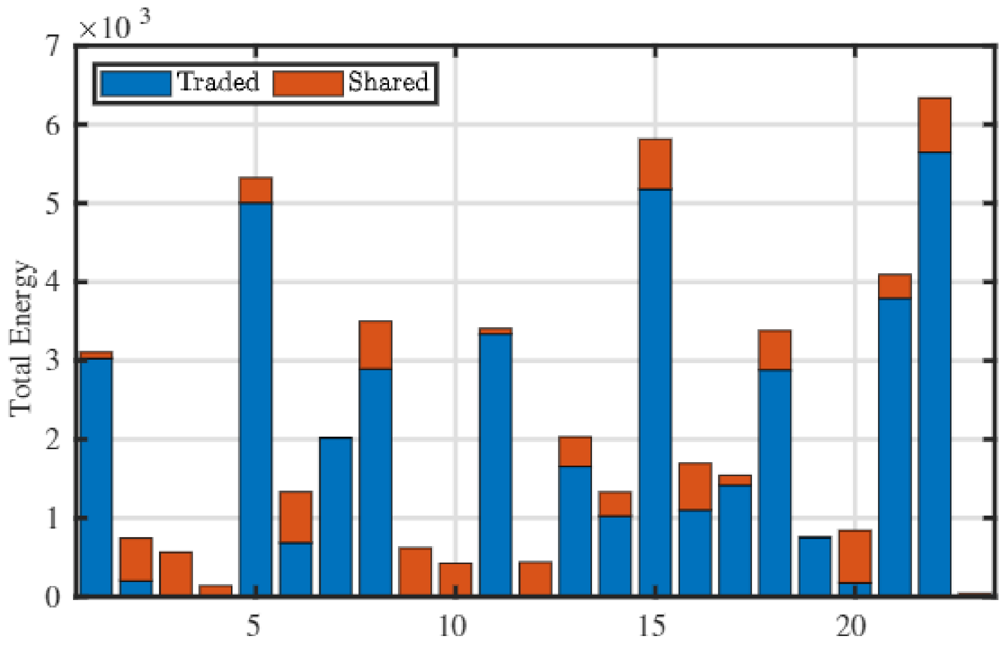


Energy shared and traded by each microgrid

Evaluation: Energy Sharing – Covered Requests



Prosumer sharing energy inside grid and between microgrids



Total Energy shared and traded per prosumer for grid 3

Open Issues

- Efficient utilization of energy generation.
- Energy costs concept - EnergyTokenz.
- Emerging market.
- Off-chain data!
- Depend on weather and atmospherically condition.
- Community adoption.
- Government investment in such models.
- Integrational and interoperability issues.

Peer-review publications

- Ali, F. S., Aloqaily, M., Alfandi, O., and Ozkasap, O. (2020). Cyberphysical blockchain-enabled peer-to-peer energy trading. **IEEE Computer**, 53(9):56–65.
- Ali, F., Aloqaily, M., Ozkasap, O., and Bouachir, O. (2020c). Synergychain: Blockchain-assisted adaptive cyberphysical p2p energy trading. **IEEE Transactions on Industrial Informatics**.
- Ali, F., Aloqaily, M., Ozkasap, O., and Bouachir, O. (2020b).Federatedgrids: A hybrid peer-to-peer blockchain-assisted energy trade and share. **IEEE Transaction on Parallel and Distributed Systems**.
- Ali, F., Aloqaily, M., Ozkasap, O., and Bouachir, O. (2020a).Blockchain-assisted decentralized virtual prosumer grouping for p2p energy trading. In 21ST IEEE International Symposium on a World Of Wireless, Mobile And Multimedia Networks (**IEEE WOWMOM**). IEEE.
- Perk, B., Bayraktaroglu, C., Dogu, E. D., Ali, F. S., and O. Ozkasap (2020). Joulin: Blockchain-based p2p energy trading using smart contracts. In IEEE Symposium on Computers and Communications (**ISCC 2020**).IEEE.

Thank you

Questions!

We are hiring!

- Students and collaborators who feels interested:
  - Many recognized international labs are working on this research
  - Joint Project– Fund Available.