TradeRES

New Markets Design & Models for 100% Renewable Power Systems

Local Markets & Energy Communities

T5.2 Leader: bitUnitor

T5.2 Partners: Imperial College London, LNEG, ISEP, bitUnitor

Final Webinar | November 2024

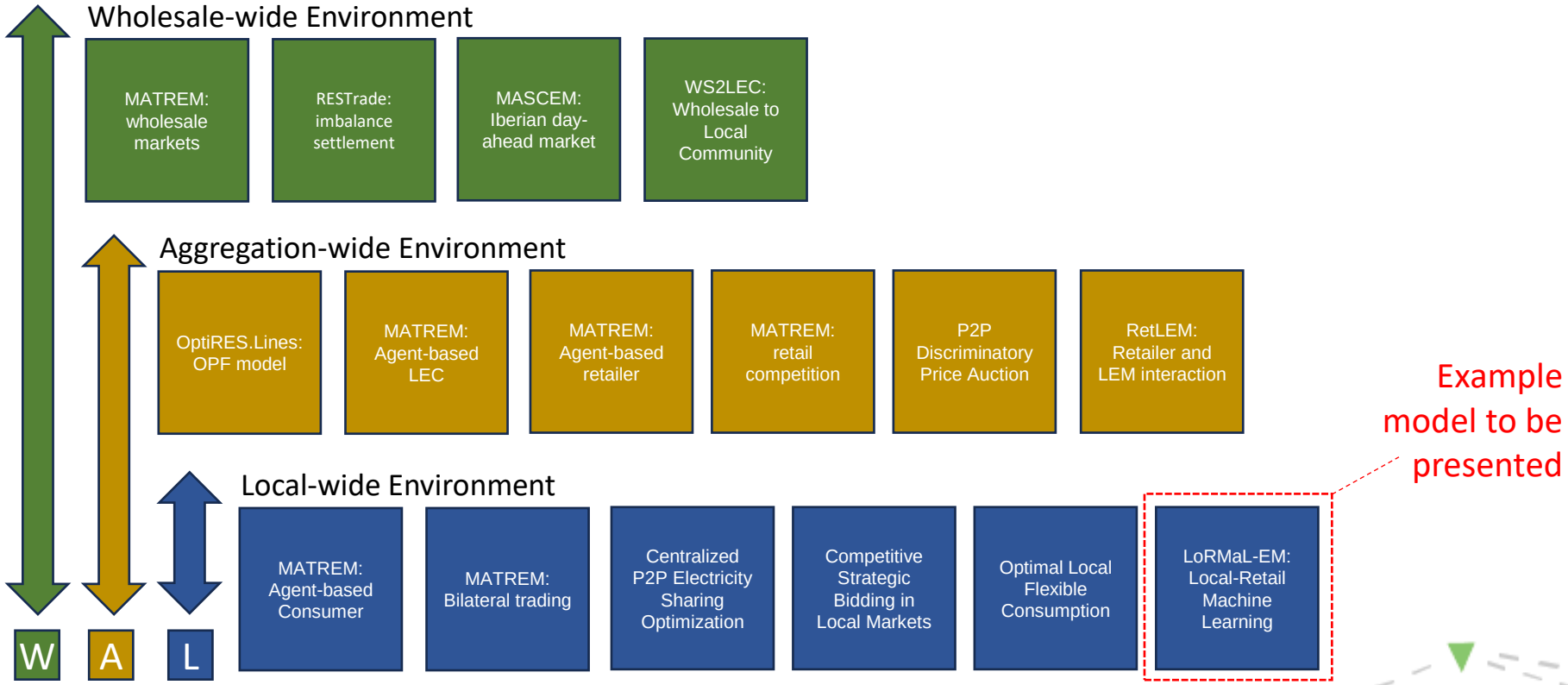
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 864276

Agenda

- Overview
- Features & Methodologies
- Outcomes & Results
- Case study (Local-Retail Machine Learning)
- Blockchain for LEM
- Questions and comments

Local Energy Communities and Markets

- **Review Existing Regulations, Schemes and Models**
- **Introduction of Simulations Environments**
- **Introduction of LMPIs (Local-Market Performance Indicators)**
- **Development of 16 sub-models for examining different aspects**



Optimisation;
Agent-based Modelling;
Game-theoretical Approaches;
Simulation models

Features & Methodologies

Tariff Optimization and Cost Reduction

Features: Optimization techniques to select tariffs; Strategic retail tariffs; Demand response programs to maximize savings and improve competitiveness

Models: MATREM Agent-based Consumer, RetLEM, MATREM Agent-based retailer

Investment in Local RES and Self-Consumption

Features: Optimizing investments in local RES and Flex; Optimal power flow models; Effects of investments in networks

Models: MATREM AB Consumer & LEC, Optimal Local Flex Consumption, OptiRES.Lines

Demand Response and Flexibility

Features: Time-of-Use vs. dynamic tariffs for load management; Centralization of LEMs to increase demand flexibility; flexible consumption to adjust with real-time pricing

Models: MATREM Agent-based Consumer, Optimal Local Flexible Consumption, RetLEM

Peer-to-Peer (P2P) and Bilateral Trading

Features: Bilateral trading protocols; centralized optimization for local P2P transactions, Pay-as-bid model for trading

Models: MATREM Bilateral Trading, Centralized P2P Electricity Sharing Optimization, P2P Discriminatory Price Auction

WS Market and DA Market Participation

Features: Wholesale market interactions; DA trading for communities to leverage broader market participation; Exposure to aggregators to WSM price signals

Models: MASCEM Iberian day-ahead market, WS2LEC

Local Resource Aggregation and Management

Features: Aggregation of local resources; Coordination for strategic behavior; Communities to manage energy collectively; Coordinating local investments

Models: MATREM Agent-based LEC, OptiRES.Lines, MATREM Agent-based retailer

Imbalance Settlement and Cost Computation

Features: Imbalance settlement; Computation of community imbalance quantities and prices for accurate cost allocation and market stability

Models: RESTrade

Strategic Bidding and Auction Mechanisms

Features: Double-sided auction with strategic bidding; Participation in day-ahead and intraday markets, Retail-level pricing and tailored strategies for participation.

Models: Competitive Strategic Bidding in Local Markets; MATREM Agent-based retailer, P2P Discriminatory Price Auction, MATREM wholesale markets, WS2LEC

Outcomes & Results

L A W

Electricity Cost Reduction

Achieves cost savings for consumers and prosumers through optimized tariff selection, local generation, or strategic market participation.

L A W

Enhanced System Flexibility

Increases the ability of the energy system to adapt to fluctuating demand and supply, often by leveraging demand-response programs and flexible consumption options.

L A W

Increased Social Welfare

Improves collective well-being by enhancing equity in pricing, increasing access to renewable energy, and distributing economic benefits more evenly among community members.

L A W

Higher Participation Benefits in Wholesale Markets

Allows LECs and smaller communities to benefit financially from engaging in wholesale and day-ahead markets, typically through aggregated bidding strategies that make participation feasible and profitable.

L A W

Cost Minimization for Prosumers

Reduces expenses for individual prosumers by optimizing energy usage and trading strategies within local or aggregation-wide markets, often through dynamic market mechanisms.

L A W

Reduction in Imbalance Costs

Decreases costs related to energy imbalances by accurately predicting, monitoring, and settling imbalance quantities, helping communities avoid costly imbalance penalties.

L A W

Improved Local Carbon Neutrality

Enhances the sustainability of local communities by increasing reliance on renewable energy sources, reducing carbon footprints, and supporting carbon-neutral goals.

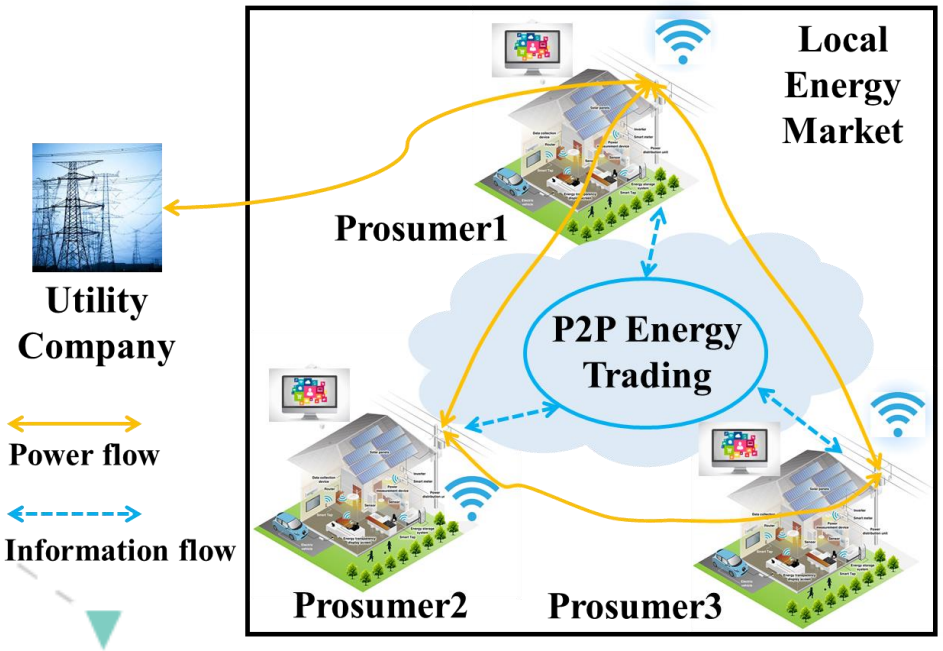
L A W

Effective Market Competition

Establishes a competitive environment that promotes fair pricing and resource allocation by encouraging suppliers to offer competitive tariffs and services.

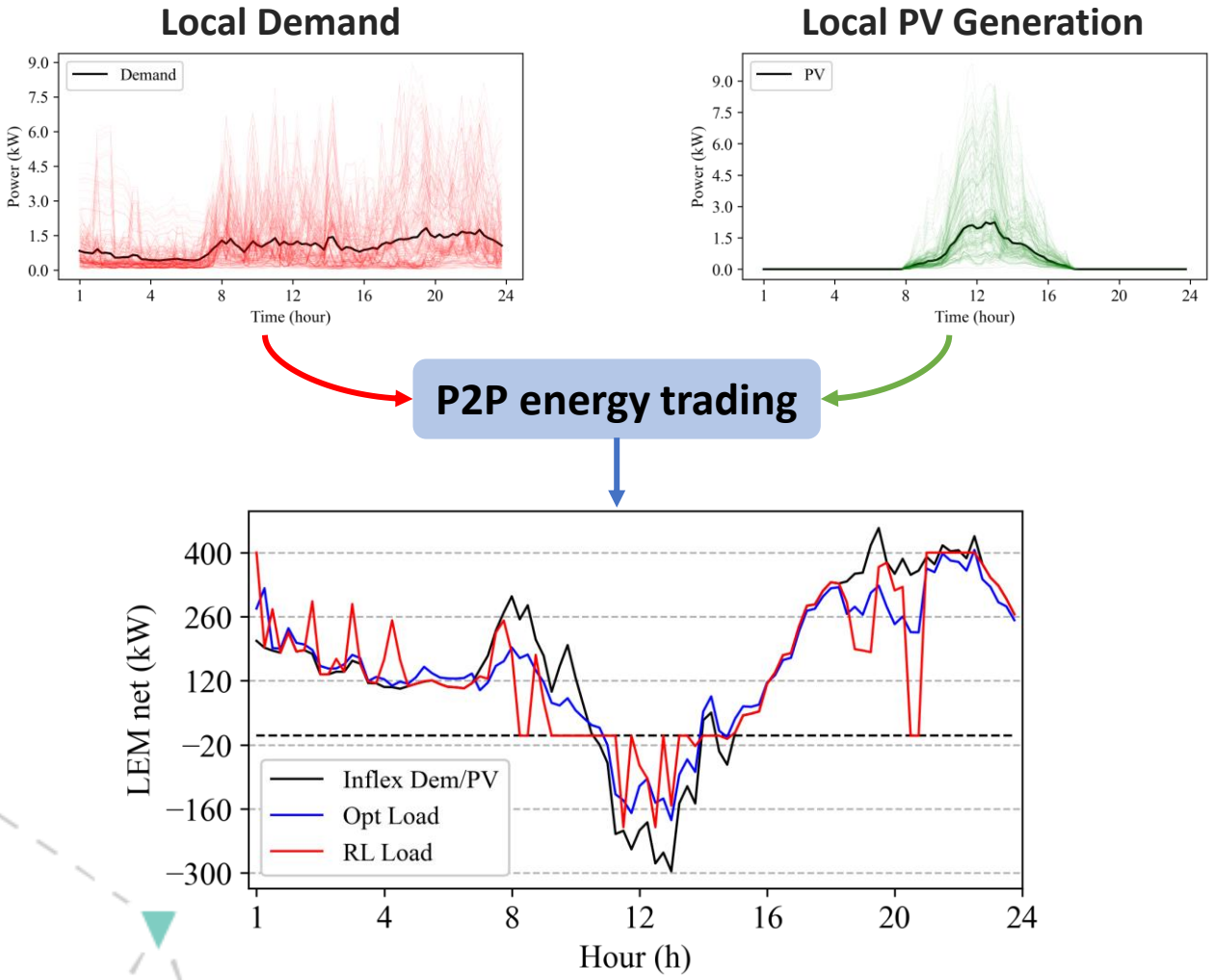
P2P Energy Trading

Peer-to-Peer (P2P) energy trading has emerged as a new market paradigm that enables direct and autonomous energy trading among prosumers within a local distribution level.



- Enhance coordination of prosumers' PV production and demand side flexibility, such as storage and electric vehicles.
- Balance local demand and generation, reduce aggregated demand peaks.
- Reduce energy customers' dependence on incumbent retailers.
- Form local trading and reduce energy costs.
- Avoid the distribution network reinforcement.

LoRMaL-EM: Dataset and Case Study



Local community aggregated net profiles of 250 households for Optimization and AI-driven approaches.

EU Residential Community Dataset:

- 250 households
- 250 demand, 200 PV, 150 Storage units

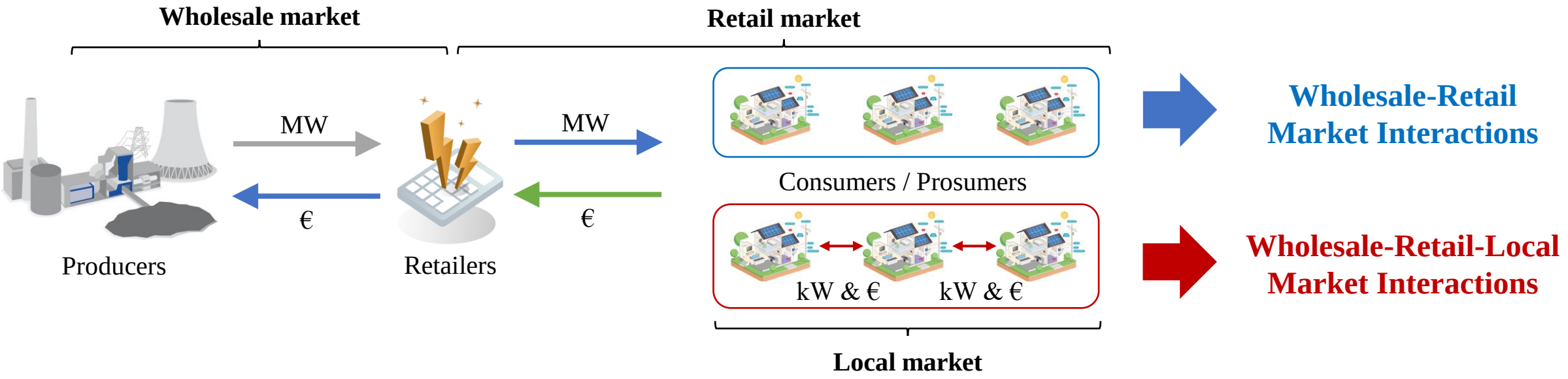
Case Study:

- More peak demand reductions at night.
- More PV absorptions at midday.
- Lower energy costs (2,527€).

Case	Strategy	Cost (€)
Optimisation	Static	2,625
AI-driven	**Dynamic**	**2,527**

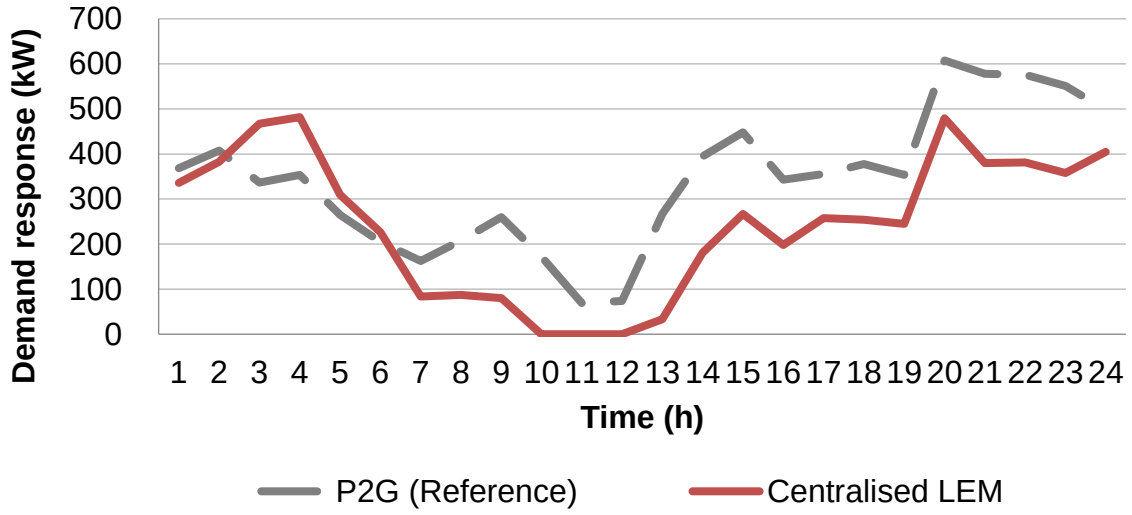
RetLEM: Model Overview

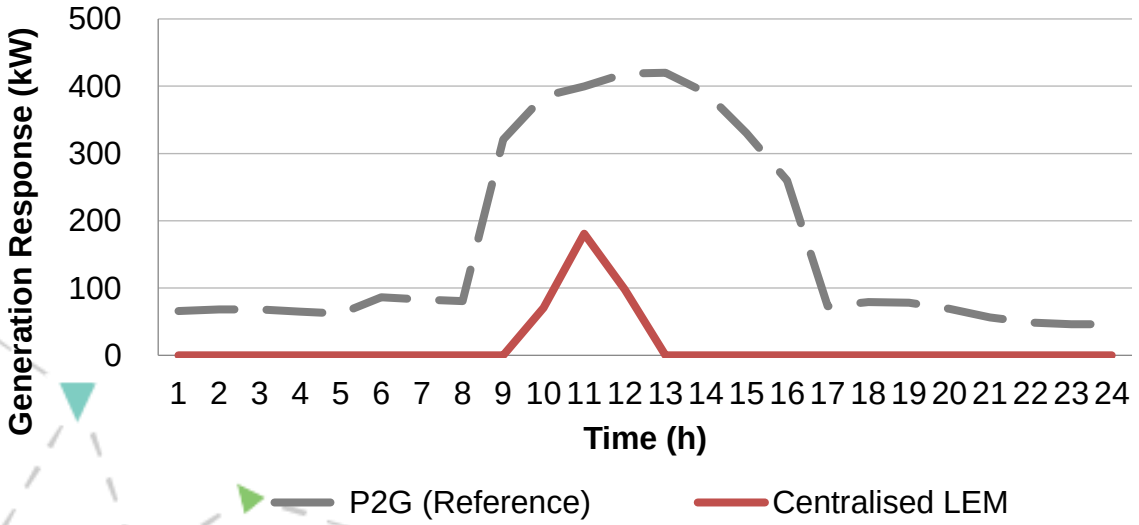
A comprehensive market design to capture the dynamic interactions between the wholesale market, retail market, and local market – through a tri-level optimisation approach.



- Upper level: market operator collects all bids and offers and solves a **centralised market clearing algorithm**.
- Middle level: retailers announce **strategic retail pricing scheme** to maximise their retail profits.
- Lower level: all consumers and prosumers make **local trading activities** to reduce their energy bills.

RetLEM: Community Response





P2G: peer to grid – no local trading. LEM: local energy market.

The introduction of LEM reduces the dependence of end-customers on upstream electricity market.

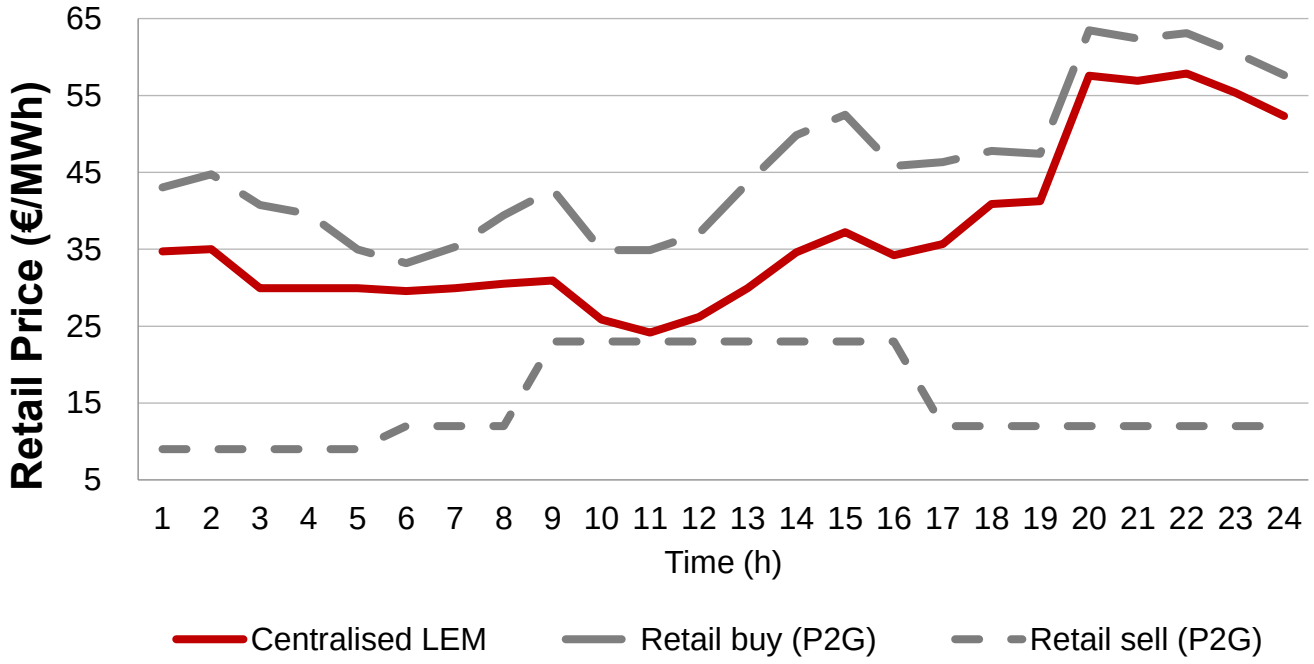
Peer to Grid (P2G) Market – dash grey line

- All consumers have to buy electricity from the upstream retailer.
- All prosumers have to sell electricity to the upstream retailer.

Local Energy Market (LEM) – solid red line

- Demand and generation can be balanced locally.
- Only the remaining deficit or surplus will be traded with the upstream retailer.

RetLEM: Retail Pricing and Business Case



Market	Profit of Retailer (€)	Utility of Local Demand (€)	Profit of Local Generation (€)
Peer-to-grid	220.85	99.97	5.80
Peer-to-peer	**94.64**	**187.88**	**86.27**

The introduction of LEM reduces retailer's market power and increases customers' social welfare.

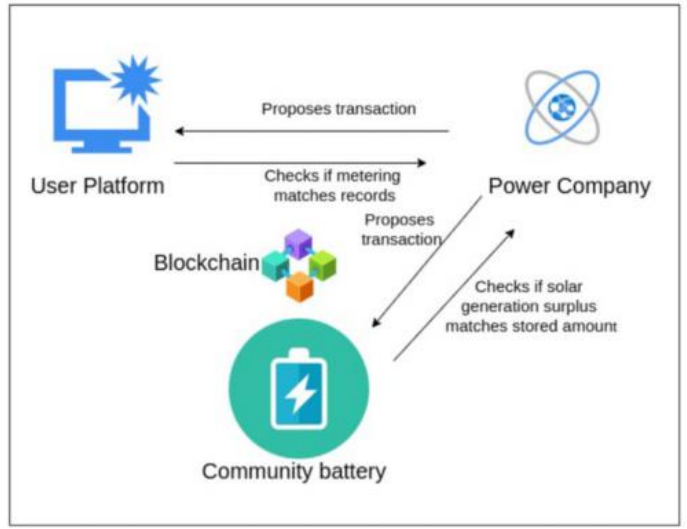
Strategic Retail Pricing:

- The local market pricing is designed between the low retail sell price and the high retail but price.
- Retailer loses its profit due to the less business cases from end customers.
- Local demand increases its utility due to the lower local market price w.r.t. the high retail buy price.
- Local generation increases its profit due to the higher local market price w.r.t. the low retail sell price.

- Link to Dashboard: https://traderes-bc-app-mcmq7hsjpbhxudmvbve7hv.streamlit.app/
- Link to GitHub repository: https://github.com/ocatak/TradeRES-BC-Portal/

Blockchain for LEC

- We have developed a Blockchain-based energy trading system for LEC
- The system is designed to demonstrate secure, transparent, and efficient energy trading.
- Utilizing Ethereum blockchain technology, this project introduces two main smart contracts: "EnergyExchange" and "EnergyToken"
- These contracts facilitate the production, consumption, and trading of energy tokens within a decentralized framework
- Energy consumption and PV data from Portugal (LNEG)



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Questions or Comments?

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More information at: https://traderes.eu/

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