ADMM-based fully decentralized Peer to Peer energy trading considering a shared CAES in a local community

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Peer-to-peer (P2P) energy trading markets have emerged locally as a result of the higher usage of renewable energy sources in low-voltage networks. P2P energy trading systems have been increasingly popular in recent years, allowing consumers in residential and industrial types to trade electricity with each other. P2P energy trading has become feasible due to several developments in communication technology and the increased acceptance of renewable energy sources like solar and wind power. In this market, Consumers have been more interested in sharing their extra energy with others to get access to the new market and increase their profit. There are two approaches to P2P energy trading. The centralized approach involves a third-party entity, typically a network operator, that manages the trading platform. This approach offers a reliable option but may pose certain shortcomings such as limited privacy. In contrast, the decentralized approach empowers consumers to transact their surplus energy directly to one another, without requiring the intervention of a centralized authority. Such an approach endows participants with greater flexibility and preserves their privacy. This paper presents a fully decentralized approach for a local P2P energy trading market using the alternating direction method of multipliers (ADMM) algorithm. This paper also considers a compressed air energy storage (CAES) technology to increase flexibility and reduce peak demand. In the following, Numerical studies are carried out for a local community in a distribution network. Simulation results demonstrate how the P2P markets can facilitate the customers to manage their energy in the local community.

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keywords: *Peer to Peer, Energy Transaction, ADMM algorithm, Decentralized approach, CAES.*

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NOMENCLATURE

Acronyms

P2P	Peer to peer
ADMM	Alternative direction method of multipliers
CAES	Compressed air energy storage
RES	Renewable energy sources
LEM	Local energy market
OF	Objective function

Constants and parameters

Obj	Objective function
$U(L_i^t)$	Utility function
P_S^t/P_B^t	Price of electrical energy (buy/sell)
$E_{SG}^t i, E_{BG}^t i$	The amount of sold/bought energy from the grid
$OC_{i,t}^{CAES}$	The operation cost of CAES.
$E_{B/S\_P2Pi,j}^t$	The amount of sold/bought energy in the P2P market
E_{DERi}^t	The amount of energy production from DER
$P_{i,t}^{GEN/COMP}$	The power output/consumed of/by CAES
$V_{i,t}^{INJ/PUMP}$	The amount of air injected/pumped to/from

CAES

$\eta^{INJ/PUMP}$	Injected/pumped power to/from CAES efficiency
$ST^{CAES}_{t,i}$	Stored air in the CAES
HR^{CAES}	Required heat rate of the CAES
l^{Gas}_{t}	The price of the natural gas
$l^{v,t}_{i,j}$	The ADMM multiplayer
$resi^{v,t}_{p,i}$	The ADMM residual value
Obj	Objective function.
$U(L^t_i)$	Utility function.
P^t_S/P^t_B	Price of electrical energy (buy/sell)
$E^t_{SG}i, E^t_{BG}i$	The amount of sold/bought energy from the grid.
$OC^{CAES}_{i,t}$	The operation cost of CAES.

1. INTRODUCTION

A. Motivation

The utilization of renewable energy sources (RES) in the operation of power systems has increased steadily over the past several years. Wind and solar energy have played a larger role in electricity generation compared to other renewable energy sources [1]. The intermittent nature of renewable energy sources creates difficulties for grid stability and management. This has led to the rise of peer-to-peer energy trading as a potentially game-changing strategy for enhancing grid efficiency and facilitating greater use of renewable energy sources. P2P energy trading is a paradigm-shifting technology with the potential to solve some of the most pressing problems that traditional energy markets are currently dealing with. P2P energy trading effectively provides an opportunity for energy customers to create their electricity market and then sell it to other consumers [2]. This can lead to a more decentralized and democratized energy system, where consumers have greater control over their energy choices and can benefit from lower costs and increased efficiency. However, there are still challenges to be addressed, such as regulatory barriers and the need for reliable and secure technology infrastructure. This innovative strategy allows homes and companies to actively engage in the energy production and consumption cycle, giving them control over their energy use and prices [3].

B. Relavant Literature

Advanced communication technologies are used in peer-to-peer energy trading to streamline the trade process [4]. Smart grids are a key part of making it easier to keep track of how electricity is distributed, which in turn makes P2P energy trading easier and more efficient. Smart meters are one of the technologies that make peer-to-peer energy sharing possible. Smart meters enable consumers to trade electricity based on current and accurate data, ensuring a fair and transparent trading process, by monitoring energy consumption and production in real-time [5]. Integration of smart grid technology and peer-to-peer energy trading presents an intriguing opportunity to promote renewable energy use, reduce energy costs, and increase consumer participation and control in the energy market [6].

The Internet of Things (IoT) offers an extensive network of interconnected devices that facilitate seamless communication and exchange of valuable data, empowering users to manage their energy consumption [7, 8]. Due to the Internet of Things, devices like smart thermostats can now regulate energy consumption based on real-time data and user preferences. The Internet of Things offers businesses and individuals an excellent opportunity to optimize their energy consumption and contribute to a more sustainable future. For instance, the paper [9] describes a low-cost, open-source P2P energy trading system for a remote community that enables residents to utilize distributed energy resources. Blockchain technology is a recent innovation in the distributed energy markets. This technology is a distributed digital ledger that enables secure and transparent transactions without a central intermediary [10]. Using blockchain-based platforms has enabled secure and transparent P2P energy trading. The privacy preservation of the blockchain ensures that all energy trading activities are accurately recorded and cannot be changed. Finally, blockchain technology has developed novel pathways for peer-to-peer energy trading, resulting in the establishment of a new decentralized approach [11]. By using these advanced communication technologies, P2P energy sharing can be made more secure, efficient, and sustainable.

In terms of centralization, there are two primary methods for P2P energy trading. In the centralized model, a market operator manages all transactions and has access to comprehensive participant data, including demand, generation, and installed capacity [12]. Concerns may come up, though, about the privacy of prosumers if all energy transactions are handled by a single third party like a system operator[13, 14]. To address privacy concerns, a decentralized approach can be used in which transactions happen through a peer-to-peer network, allowing people to trade energy directly with each other without a central middleman. In this approach, users are individual players who can independently control their energy management in a decentralized system. This method can also promote greater market transparency and flexibility [6].

Algorithms like the alternating direction method of multipliers (ADMM) can be used in this method. The ADMM algorithm decomposes the global problem into subproblems, and the final solution is attained by solving the local subproblems iteratively [15, 16]. In this method, only a minimal quantity of information about energy transactions is required to clear the market, which may alleviate privacy concerns [17–19]. ADMM can be used to ensure that energy prices are equitable and the trading process is efficient in the context of P2P energy trading. ADMM permits the system to distribute the computational challenge across multiple nodes. ADMM can facilitate the exchange of information between parties and ensure that energy prices are determined equitably [20]. For instance, to develop a trading method for P2P energy marketplaces, [21] suggests an autonomous optimization strategy using ADMM. The method reveals the energy exchanged values and provides a decentralized learning scheme for adjusting prosumers' cost function parameters. The suggested methods are tested on an IEEE European Low Voltage Test Feeder. The paper [22] suggests a market structure for Local Electricity Markets (LEMs) that includes various Distribution System Operators and allows DSOs to trade between regions while being coordinated by a Local Market Operator. Based on the ADMM algorithm, a unified and autonomous method is suggested in which each DSO plans its own assets in response to market signs to meet flexibility requests from itself or other DSOs.

Game theory is a very useful area of applied mathematics that gives us strong tools for modeling and predicting strategic behavior in a wide range of real-world competitive situations, such as chess, poker, political group building, market buying, and more. By looking at and solving game-theory problems, we can figure out the best moves for each person and see how their moves work together to change the game's result. Overall, game theory gives pros in areas like economics, finance, political science, and computer science useful ideas and ways to think about things [23]. Noncooperative game theory is one of the newer approaches to game theory. It gives a framework for studying competitive situations where players have different goals for how a choice will turn out. With this method, players can improve their objective functions (OF) without coordinating with or communicating with each other. Cooperation must happen in a noncooperative game even though players can't make decisions together. By figuring out the best moves for each player in these cases, game theory can help us understand what will happen [24].

Using cooperative game theory, the paper [25] proposes a framework for efficient P2P energy trading in local energy communities (LECs). The proposed algorithm was tested in a LEC with 50 prosumers/consumers, an energy storage system, and 15 charging points for electric vehicles. The results show that using the best priority for each time interval is beneficial, as prosumers make more money and consumers save money on their bills. The proposed framework offers a way for both consumers and prosumers to benefit from the P2P market.

There are different ways to store energy, such as mechanical, electrochemical, electrical, chemical, and thermal. Each of these has its own subcategories. Mechanical storage systems, like CAES, have much lower capital costs than other ways to store energy [26]. They can be used for load shaving, time changing, and seasonal energy storage. The paper looks at CAES technology as a way to store energy on a large scale. CAES technology involves compressing air and storing it in underground caverns or tanks [27, 28]. When energy is needed, the compressed air is released and used to power turbines, generating electricity [29, 30].

Generally, several papers study the P2P energy trading market there is plenty of research about the CAES. But there is only a small amount of paper about utilizing the CAES in the P2P market. the study [31] suggests incorporating a hierarchical day-ahead P2P energy trading model into the industrial water-energy nexus, leveraging a blockchain infrastructure and a continuous double-sided auction market clearing mechanism. The following [32] offers a retailing layer peer-to-peer energy trading system for wind power producers (WPPs). By offering energy consumption to demand response providers (DRPs) in a competitive environment, the framework enables WPPs to increase revenue. The stochastic bilevel optimization model shows how P2P trading may balance energy variations and improve energy transactions. These studies consider the CAES technology in the P2P energy trading framework but our proposed model implements a shared CAES in a local community with P2P energy trading using the ADMM algorithm for a decentralized approach.

C. Contributions

The present study introduces an innovative strategy for peer-to-peer energy exchange within a local community, utilizing a decentralized approach and the ADMM algorithm.

Within this particular framework, individual players known as peers enter a decentralized energy market that empowers customers to trade energy with each other. This paper uses a decentralized approach to make the problem more realistic and preserve the privacy of peers. The present study solves the optimization problem for a local community of six prosumers and a CAES facility. The scheme of the local community is shown in Fig. 1. The proposed approach allows each prosumer to make their own decisions based on their preferences and constraints, while the CAES facility acts as a backup source of energy. This energy storage is built with the investment of every local consumer in a certain place. So this device is shared between peers based on their investment. The results show that using the CAES with a decentralized approach can effectively help the energy management system while preserving the privacy of peers. The proposed model aims to maximize the social welfare of each peer. The study employs an optimization model based on the ADMM algorithm to evaluate the effect of the transactive energy market on consumers' energy management. Furthermore, this framework decreases the dependency of individual players on the upper grid and increases their revenue by providing new energy markets.

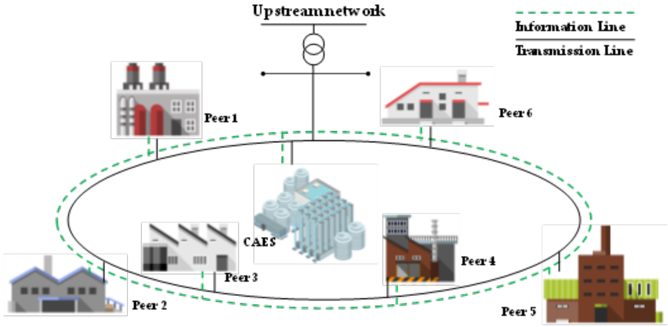

Fig. 1. Local community market scheme with the presence of CAES

The rest of the paper is structured as follows: The system paradigm for the proposed peer-to-peer energy exchange will be presented in Section 2. The results of the simulation will be given in Section 3, and the paper's conclusion will be included in Section 4.

2. PROBLEM FORMULATION

This paper considers six prosumers in a local microgrid who have different energy generation and consumption patterns. The study analyzes the impact of their behavior on the overall energy system and proposes a strategy to optimize their energy usage. These peers are interconnected with a low-voltage distribution network and a secure communication link. This paper also considers a shared CAES for increasing the flexibility of the peers. The proposed strategy involves the use of a distributed optimization algorithm that enables prosumers to exchange information and coordinate their energy usage. In this study, the main optimization problem was decomposed with the ADMM algorithm into sub-problems, which were solved by every peer. After every peer solved their optimization problem, a small amount of information about energy transactions was shared among the peers, and the market price was updated. This process continues until convergence is achieved, and the final solution represents an optimal allocation of energy resources among the prosumers while considering their preferences and constraints. The peer-to-peer energy market offers several options for meeting demand: 1) meet the demand by facilitating peer-to-peer exchange within the community; 2) meet the needs of prosumers by utilizing the main grid. 3) Consumers meet their own needs for electricity

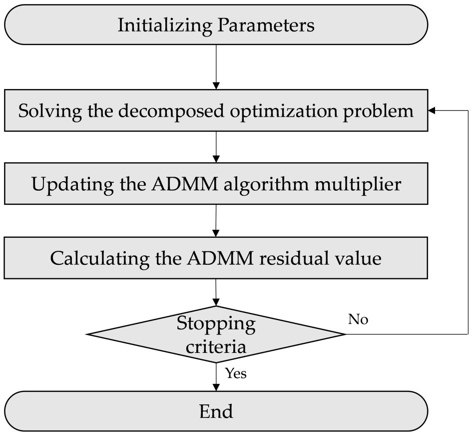

Fig. 2. ADMM-based solving flowchart of the P2P energy trading

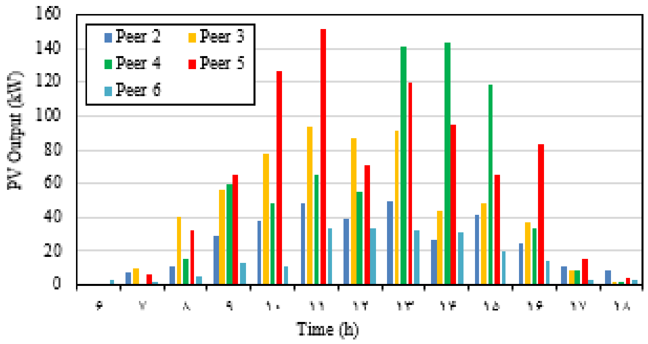

Fig. 3. PV output profile of each peer in the local community market

using green sources. 4) use the CAES unit's energy reserves to meet the demand.

A. Objective function

This study is scheduled for a day with a 24 time slot each on hour intervals that T is the time horizon. Also, we consider n is the number of peers in the P2P market and the set of them is N=1,2,. . . ,n. In this part, a model of the P2P market platform will be made. In the P2P market, each peer attempts to optimize their welfare through load management and energy transaction management. To further facilitate and increase flexibility in optimum energy management, Peers placed in the local market are supplied with CAES. Relationships (1) and (2) show the OF of maximizing welfare.

$$ObjectiveFunction(2) = GHGemissions \tag{1}$$

$$U(L_i^t) = \begin{cases} \alpha_i L_i^t - \beta_i \left(L_i^t\right)^2 L_i^t & < \frac{\alpha_i}{2\beta_i} \\ \frac{\alpha_i{}^2}{2\beta_i} L_i^t & \geq \frac{\alpha_i}{2\beta_i} \end{cases} \tag{2}$$

Relationship (1) shows that the OF consists of three parts. The initial term represents a utility function. The typical formulation of the utility function is depicted in (2) and consists of three primary characteristics. Depending on the unit's energy consumption, various utility outputs are generated. In the first case, the utility function becomes zero when $U(L_{i^t})$=0, demonstrates that units gain no benefit from not consuming energy. In the second

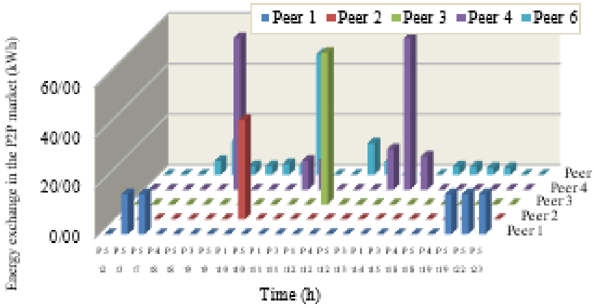

Fig. 4. Energy sold in the P2P market

scenario, a positive non-descending utility function $U'(L_{i^t}) > 0$ encourages consumers to consume more energy until saturation is reached. When the utility function, which indicates the level of customer satisfaction, is saturated $U'^{(L_{i^t})} < 0$, consumers are unwilling to consume more. In addition to the impact of price on energy demand, peer types (residential, industrial, and commercial) have a direct impact on utility function parameters α_i,β_i. Additionally, the weather and market conditions can impact the independent player's energy consumption decisions[14].

B. Power balance constraints

Relation (3) and Equation (4) are used to illustrate the energy balance between incoming and outgoing energy. The left side OF THE (4) is related to the DER energy production, energy bought from P2P and grid, and the generated energy from the storage unit. The right side contains the hourly load demand of customers, energy sold to the grid, and power used in the CAES compressor.

$$E^t_{B\_P2Pi,j} = E^t_{S\_P2Pj,i} \forall t \in T, i \neq j, i,j \in N \tag{3}$$

$$\begin{aligned} E^t_{DERi} + \sum_{\substack{\in N \\ \neq i}} E^t_{B\_P2Pi,j} + E^t_{BGi} + P^{GEN}_{i,t} = L^t_i + E^t_{SGi} + \\ \sum_{\substack{\in N \\ \neq i}} E^t_{S\_P2Pi,j} + P^{COMP}_{i,t} \forall t \in T, i \in N \end{aligned} \tag{4}$$

$$E^t_{BPi,j}, E^t_{SPi,j}, E^t_{BGi}, E^t_{SGi} \geq 0 \forall t \in T, i \in N \tag{5}$$

Inequality (5) demonstrates the energy transaction between peers with upstream grid and internal transactions between the peers are not negative.

C. CAES constraints

The CAES technology is a very unique way to store energy that is based on natural gas turbine generators. The technology works by using a mix of air and natural gas as its working medium. This makes energy production very efficient and reliable. During off-peak times compressors are used to push air to high pressures. The air is then kept in tanks. When there is a lot of energy demand, the stored air is let out to drive an expander, which in turn makes electricity. Compressed air is a very efficient way to store energy, and natural gas can be used as a backup fuel source to improve power output during times of high demand.

$$V^{INJ}_{i,t} = \eta^{INJ} P^{COMP}_{i,t} \forall t \in T, i \in N \tag{6}$$

$$P^{GEN}_{i,t} = \eta^{PUMP} V^{PUMP}_{i,t} \forall t \in T, i \in N \tag{7}$$

$$V^{INJ}_{\min} \leq V^{INJ}_{i,t} \leq V^{INJ}_{\max} \tag{8}$$

$$V_{\min}^{PUMP} \le V_{i,t}^{PUMP} \le V_{\max}^{PUMP} \tag{9}$$

$$ST_{t+1,i}^{CAES} = ST_{t,i}^{CAES} + V_{i,t}^{INJ} - V_{i,t}^{PUMP} i \in N \tag{10}$$

$$OC_{i,t}^{CAES} = \sum_{t\in T} [V_i^C P_{i,t}^{COMP} + (V_i^{EXP} + HR^{CAES}\lambda_t^{Gas})P_{i,t}^{GEN} \tag{11}$$

Equation (6) shows the injected air in the CAES system. This injected air is compressed and stored during off-peak hours and then released to generate electricity during peak demand periods. Constraint (7) displays the power generated by the CAES system during peak times. The air drawn into the chamber and the air injected into storage is dependent on the pressure limits and the size of the valves. These restrictions can be expressed by the expressions (9) and (10), respectively. The stored compressed air in the CAES system in each time block is linked to compressed air and pumped air, which can be written as (10). The operation cost of the CASE is a crucial aspect of the CAES system, as it can have a substantial impact on the system's overall cost-effectiveness and sustainability. It is important to consider the operating cost of the expander when it is discharging and the compressor when it is charging. this cost can differ depending on the type and size of the CAES, and the amount of maintenance that is required.

D. ADMM algorithm implementation

The ADMM algorithm is particularly well suited for solving difficult optimization problems with complex constraints, which standard optimization methods can be unable to handle. This method divides the original issue into a group of subproblems that can be tackled more effectively. The essential novelty of the ADMM approach is the introduction of auxiliary variables, which allow for the transformation of the original problem into an equivalent form that is more likely to the main optimization model. By introducing these auxiliary variables, the issue may be divided into two parts: one involving the original variables and one involving the auxiliary variables. The ADMM algorithm then tries to optimize the subproblems and update the ADMM multiplier (auxiliary variables) in a coordinated manner until the residual value become less than a small value. In this paper, the ADMM algorithm decomposes the main problem, including OF (1) and constraint (3), by adding the squared norm of the interconnecting constraint (3) multiplied by the penalty parameter $\rho_t^{(v,i)}$. The new decomposition OF is shown by (12).

$$\mathrm{Obj}_{\mathrm{i}}^{\mathrm{v}} = \max \sum_{t\in T} \left[\begin{array}{l} \mathrm{U(L_i^t)} + \mathrm{P_S^t E_{SGi}^t} - \mathrm{P_B^t E_{BGi}^t} - \sum\limits_{\substack{\in N\\ \neq i}} \lambda_{j,i}^{v,t} \mathrm{E_{B\_P2Pi,j}^{v,t}} + \\ \lambda_{i,j}^{v,t} \sum\limits_{\substack{\in N\\ \neq i}} \mathrm{E_{S\_P2Pi,j}^{v,t}} \\ -\frac{\rho_{P,i}^{v,t}}{2} \left[\sum\limits_{\substack{\in N\\ \neq i}} (\mathrm{E_{BPi,j}^t} - \widehat{\mathrm{E}}_{\mathrm{SPj,i}}^{\mathrm{t}})^2 + \sum\limits_{\substack{\in N\\ \neq i}} (\mathrm{E_{SPi,j}^t} - \widehat{\mathrm{E}}_{\mathrm{BPj,i}}^{\mathrm{t}})^2 \right] \\ -\mathrm{OC_{i,t}^{CAES}} \end{array} \right] \tag{12}$$

$$\lambda_{i,j}^{v+1,t} = \lambda_{i,j}^{v,t} + \mathrm{r_{P,i}^{v,t}} \left[\sum_{\substack{\mathrm{jN}\\ \mathrm{ji}}} \mathrm{E_{B\_P2Pj,i}^{v,t}} - \sum_{\substack{\mathrm{jN}\\ \mathrm{ji}}} \mathrm{E_{S\_P2Pi,j}^{v,t}} \right] \forall t \in T, i \in N \tag{13}$$

$$resi_{P,i}^{v,t} = \sum_{\substack{\in N\\ \neq i}} E_{B\_P2Pj,i}^{v,t} - \sum_{\substack{\in N\\ \neq i}} E_{S\_P2Pi,j}^{v,t} \forall t \in T, i \in N \tag{14}$$

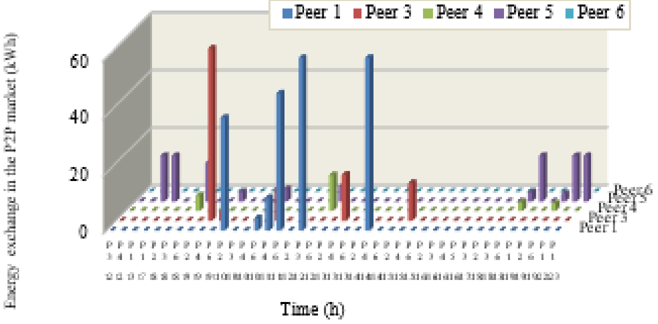

Fig. 5. Energy bought in the P2P market

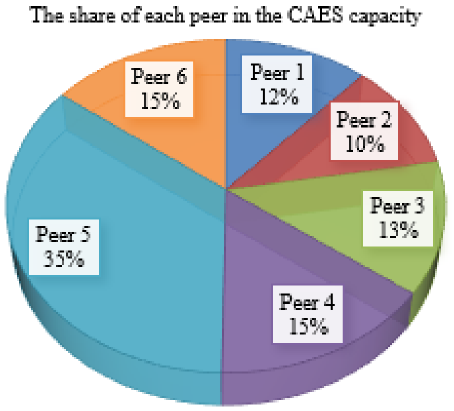

Fig. 6. The share of each customer in the local shared CAES.

Constraint (3)-(11) involves the distributed optimization model in which numerous peers collaborate to discover the best solution. As shown in Fig. 2 each peer solves its own optimization problem and calculates the results. The ADMM multiplier is then updated using equation (13), and the optimization problem is performed using the new ADMM multipliers in the following iteration. This method is repeated until a stopping requirement is achieved. This criterion is achieved when the residual value $resi_t{}^{(}v,i)$becomes less than ϵ, which is the convergence rate of the algorithm.

3. RESULTS AND ANALYSIS

This paper presents a decentralized approach for a local P2P energy trading market using the ADMM algorithm and CAES technology to increase flexibility and customer welfare. The proposed approach enables peers to trade energy locally, reducing the reliance on the upstream grid and promoting renewable energy use. As shown in Fig. 1 the presented local community consists of six prosumers who can trade energy with each other. This approach not only provides a more sustainable and cost-effective solution for energy distribution but also fosters a sense of community and collaboration among the prosumers. Furthermore, it can potentially lead to the creation of microgrids that are more resilient and reliable during power outages. In this paper, all of the peers are equipped wit photovoltaic energy generation systems except peer 1. The PV-generated energy depends on the weather conditions and the orientation of the PV panels, which can vary throughout the day and across different seasons. In the local community, peers are close to each other and the energy loss between them is near to zero. the generated energy by each peer is shown in Fig. 3. This figure shows that the participants have different PV generations. For example, peer 5 has more energy generation from the PV system. Every peer that is equipped with PV generation has the possibility to use this energy to meet the demand or sell it to the upper grid and share it in the P2P market. In fact, every peer is an independent player that tries to maximize social welfare. So this player decides whether to participate in the P2P market or not. In this paper, all peers are equipped with the CAES. This storage lets the peers charge the energy at a lower price and use it at a higher price of electrical energy but all of the peers do not own the separate CAES. Every participant cooperates in installing the CAES energy storage with different shares as shown in Fig. 4. So they can use this storage system base on their shares. Practically every peer has a virtual CAES on his own site. Characteristics of the CAES are adopted from [33].

A. Simulation Results

The proposed model is carried out on GAMS (version 24.9.1) and solved using Mixed-Integer Nonlinear Programming. (MINLP). The model operates 24 hours a day, with each period lasting an hour. All procedure takes about 38 seconds, excluding the time it takes for peers to communicate with one another. This paper considers six prosumers in a local microgrid who have different energy generation and consumption patterns. This study aims to analyze the effectiveness of a proposed energy management algorithm that optimizes the energy flow among the prosumers in the local community. In this paper, every customer takes control of the energy system and tries to maximize social welfare. The simulation results show that the peers participating in this market are willing to trade their extra energy production in the P2P market, as shown in Fig. 4. The results also indicate that the proposed P2P market model can improve the economic efficiency of the microgrid by reducing the total energy cost and increasing the utilization rate of renewable energy sources. In the following, Fig. 5 shows the energy bought from every customer in the P2P market. By comparing these two figures it can be concluded that every customer responds to the other customer's requests and the P2P market activate between the peers. In this model, every peer has a share of the virtual CAES. The share of each peer is shown in Fig. 6. In this paper every individual peer tries to solve its own optimization problem based on the energy consumption, generation, and energy price. As shown in Fig.7 based on the electricity price, all peers modify the charging and discharging time. The peers who act as a buyer supply a portion of their demands from CAES when the price is high and compressed the air in the storage at hours with the low market price. In the following, the demanded load is shown in Fig. 8. The load profile of each customer is different base on the peer's size By employing the ADMM algorithm on this model in each iteration, the multipliers update based on the previous results until the difference between bought and sold energy in this market is less than ϵ. and these results show the convergence of the employed algorithm in the P2P market. In the current study, the model reaches the stopping condition after two iterations.

In the following, Fig. 7 shows the stored energy in the CAES as a central shared energy storage system. The CAES can be used as an effective solution for storing excess energy and meeting peak demand in the grid. To further facilitate comparison, the cost of electricity is displayed in Fig. 7. CAES stored energy at a lower price and generate energy from compressed air at a higher price of electricity. Moreover, Fig. 8 shows the modeling results for each prosumer's demand at each stage, which is based on the number of users, the energy produced by RES, and the price of energy.

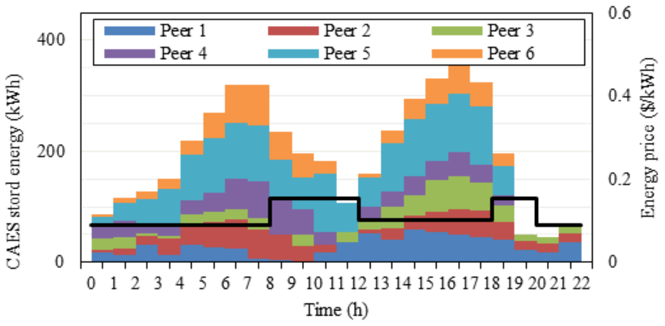

Fig. 7. Energy stored in the CAES and electrical energy price

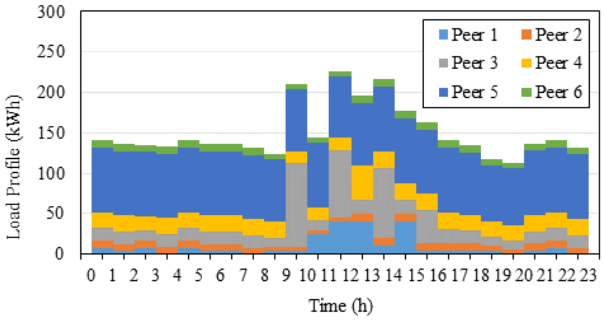

Fig. 8. Load profile of the industrial peers participating in the P2P market

4. CONCLUSION

This paper introduces a peer-to-peer energy market within a local community, utilizing a decentralized approach and the ADMM algorithm. It uses a decentralized approach to make the problem more realistic and preserve the privacy of peers. The proposed model aims to maximize the social welfare of each peer and evaluate the effect of the transactive energy market on consumers' energy management. It decreases the dependency of individual players on the upper grid and increases their revenue by providing new energy markets. The ADMM algorithm is used to solve the optimization problem of the proposed model, which enables each peer to make decisions independently while ensuring the convergence of the market. This approach can potentially lead to a more sustainable and efficient energy system, as well as promote local economic development. This paper also considers a shared CAES for increasing the flexibility of the peers. CAES technology uses air and natural gas as the working medium to compress air and discharge it to generate electricity. The MINLP model was used to simulate the entire market system. The paper outcomes demonstrated the suggested model's success in encouraging peers to limit their intake during peak times. Also, the results show that peers cooperate with each other by participating in the P2P market and increase their welfare by sharing the excess energy in local community infrastructure. The paper outcomes demonstrated the suggested model's success in encouraging peers to limit their intake during peak times. Also, the results show that peers cooperate with each other by participating in the P2P market and increase their welfare by sharing the excess energy in local community infrastructure

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