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MULTI-SOURCE AND MULTI-LEVEL COORDINATION OF ENERGY INTERNET UNDER V2G BASED ON PARTICLE SWARM OPTIMIZATION ALGORITHM

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Abstract. In order to effectively improve the excessive load of microgrid during peak hours of urban electricity consumption, a multi-source and multi-level coordination method of energy Internet under V2G based on particle swarm optimization algorithm was proposed. First, a mathematical model for V2G energy integration in microgrids was developed and a scheduling concept based on a particle-by-particle optimization algorithm was used. Second, an improved PSO algorithm is proposed and experimentally validated, and the experimental results are compared with previous particle swarm optimization algorithms. Experiments have shown that as the number of iterations increases, the value of the objective function decreases and the optimal solution can be obtained until the maximum number of iterations is reached. The iteration speed and power processing cost of the improved PSO algorithm are better than before.The original load curve is the load trough period from 23:00 to 6:00, and two load peaks occur from 12:00 to 14:00 and 19:00 to 22:00. The V2G technology basically realizes the coordinated control of microgrid electric energy and achieves the effect of peaking and valley filling. The improved algorithm has obvious improvement compared with the original power grid state. Conclusion: The application of EV V2G technology can smooth the daily load curve of power grid and coordinate the electric energy of micro-grid to achieve "peak cutting and valley filling", and the effect of this algorithm is more outstanding than the previous algorithm. Finally, the future development direction and suggestions of V2G technology are put forward.The power grid with V2G discharge depth limit has the ability to basically reduce and eliminate the daily peak load, so the technology has broad research space and development prospects.

Key words: V2G technology, Microgrid energy control, Power network peak regulation, Load curve, Particle swarm optimization

1. Introduction. At present, due to the rapid development of the global economy and the increasingly prominent population problem, energy shortage has become an urgent problem to be solved. With the increasingly serious ecological environment problems, saving energy, reducing pollution emission and developing low carbon economy have become an important task of the development of human society.With the diversified application of energy more digital and intelligent, people connect billions of facilities, transmission and consumption of energy production, systems and information through advanced sensors, control and software applications, forming the energy Internet.China is the second largest oil consumer in the world. At a time when there is a shortage of fuel and increasing environmental pollution, the country supports construction to save money and protect the environment. According to the statistics of the Environmental protection department, the carbon dioxide content of automobile exhaust emissions is second only to the carbon emissions of traditional energy processing and energy reuse, accounting for about a quarter of the global total carbon emissions [12]. In the automobile industry, the exhaust emission of traditional fuel vehicles is one of the most important pollution sources. According to the auto sales department, China's auto production and sales have been growing at an annual rate of 1 million since 2000, and the number of cars in China is expected to reach at least 550 million by the middle of the 21st century, which will be at least 38% higher than the number of cars in the United States during the same period. The rapid development of automobile industry not only brings convenience and business opportunities to people, but also aggravates energy shortage and environmental deterioration. In the past, the state has promoted energy conservation, emission reduction, low-carbon economy development, and low-carbon life, and many researchers have dedicated to the development of low-carbon transportation [8]. Those. China's fifth-year plan emphasized the "development of green and low-carbon construction concepts" and included new energy vehicles in the "seven emerging economic strategies". China's new energy industry has

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gradually entered the stage of economic development. With the continuous development of battery technology, compared with fuel vehicles with high pollution and high energy consumption, electric vehicles have attracted more and more attention due to their advantages of energy saving, environmental protection and low noise. Their large-scale application is regarded as an effective way to alleviate energy shortage and air pollution and promote the development of low-carbon economy. Electric vehicles will also be an inevitable trend for the development of the automobile industry in the future [19, 7]. Due to the different priorities considered, the objective functions and constraints of energy Internet scheduling optimization will take various forms, but they can be attributed to non-linear multi-objective planning problems, which can be solved by optimization algorithm, such as genetic algorithm, immune algorithm, particle swarm algorithm, etc.

In recent years, countries around the world have carried out electric vehicle development plans. For example, the United States plans to produce more than 1 million electric vehicles in 2015, Germany plans to increase its domestic electric vehicle ownership to 1 million in 2020, and Denmark plans to gradually replace traditional fuel vehicles with electric vehicles [15, 11].With the rapid development of new energy generation technologies such as renewable energy, energy effici ent and clean fossil fuels, micro-distributed power generation is a gradual way to meet the growing demand for electricity, reduce greenhouse gas emissions and improve energy efficiency. considered. efficiency. Domestic research institutions also began to conduct relevant investigation on electric vehicles. As early as 1995, the Ministry of Science and Technology of China carried out the electric vehicle project of major science and technology industry. Hybrid and pure electric vehicles were already available in China in early 2001. From 2001 to 2005, the national 863 Program set up various special research and development funds for electric vehicles reached 3 billion yuan. The electric vehicle application project launched in Beijing Olympic Games has played a good role in driving and demonstrating the promotion of electric vehicles. In 2009, China launched a demonstration project of “1,000 vehicles in ten cities”, involving 13 cities. First, new energy vehicles, mainly plug-in hybrid vehicles, were promoted and used in public transport. In 2010, 25 cities participated in the demonstration project of “Thousand Cars in Ten cities”, and private electric vehicles were promoted in 6 cities [13]. Compared with traditional algorithms, the Particle Swarm Optimization (PSO) algorithm has advantages such as simplicity, ease of use, fast rotation, and global optimization.

2. Literature Review. With the advancement of science and technology, the share of electric vehicles will increase. In the future, many electric vehicles will be connected to the electric power through the distribution of medium and small. These electric vehicles account for most of the total load on the grid, which will have a significant impact on the quality of energy and the safety and stability of the financial grid. Evidence shows that most electric vehicles do not work for most of the day, and using the idle time of the electric batteries will help to make the most of the project. With the rapid development of electric vehicle technology, the number of electric vehicles continues to increase. If many electric vehicles with poor charging ability enter the grid, it will seriously affect the safe and stable operation of the electric grid [3]. This problem worries domestic and foreign scientists. Many countries have studied the management and control of large-scale electric vehicles entering the grid. According to statistics, most electric cars are closed for 90 percent of the day, and the energy storage of electric cars has been decided. The emergence of V2G technology brings solutions to the above problems. The main purpose of V2G is to enable two-way communication between data and power between electric vehicles and the grid. Electric vehicles can leave the grid at higher speeds during peak load times and charge less during low times, so they can even out the system, cutting peaks and filling valleys. Those. Electric vehicle users can find a difference in energy costs, and the grid can save operating costs by reducing resources. Continued research on V2G. Also, smartly connect the electric car to the grid to get the dispatch instructions. Since then, electric vehicles have become part of grid-friendly transportation. The results of the study of electric vehicles participating in the electric frequency network were established abroad. The participation of electric vehicles in the frequency adjustment of the electric power grid is often related to feasibility, economic and management strategies. Although the concepts are different, their main purpose is to provide theoretical support for electric vehicles for high-frequency services [6, 5]. The Particle Swarm Optimization Algorithm is an adaptive technology based on swarm intelligence inspired by artificial life research. The basic understanding of the history of particle flocking comes from studies of the predatory behavior of bird flocks. Researchers have found that birds often suddenly change direction, explosions, their behavior should not be expected, but in all situations, the maximum distance between people. By studying the behavior of similar groups, he discovered that shared information about relationships exists in biological groups, which is advantageous for changing group clusters, which is the basis for building particle swarm algorithms.In this paper, a mathematical model of V2G cooperation in advanced coordination is developed. Based on the planning strategy, a particle-by-particle optimization algorithm is proposed. The experimental results of the two algorithms were compared with MATLAB/Simulink simulation software, and the ability to control the electric vehicle charging and microgrid power output control was analyzed. Experiments show that the value of the objective function decreases with the number of iterations, and the optimal solution is reached when the number of iterations reaches a maximum. The improved PSO algorithm is faster and more efficient. This shows that the particle swarm optimization algorithm is more efficient [2].

3. Research Methods.

3.1. Overview of V2G technology. The main purpose of V2G is to realize the two-way interaction of information and energy between electric vehicles and the power grid. Electric vehicles can discharge to the grid at a higher price when the peak load of the grid is high, and charge at a lower price when the grid trough, so as to smooth the system load and peak filling. Electric vehicle users can also earn the price difference, and the power grid also saves operating costs by reducing the reserve capacity.V2G technology fully embodies the friendly interaction between electric vehicles and smart grid, which is a two-way interaction technology of energy and information. There are many types of electric vehicles and they are very different in nature. Gasoline-electric hybrid electric vehicles have no devices to interact with the grid, so connecting to the grid will have no effect. Only pure electric vehicles and plug-in hybrid electric vehicles interact with the power grid, so V2G technology can be considered. The electric vehicles studied in this essay refer to these two types [1]. Since electric vehicles are idle in most of the day, if the V2G function of electric vehicles is utilized to make the energy flow bidirectional between the vehicle and the microgrid, the electric energy can be stored in the battery to meet its own demand when the load is used, and the grid can be used as a distributed energy storage device during peak load hours. V2G technology can not only reduce the network loss in the transmission process of long-distance high-volume electric energy, but also greatly reduce the thermal power capital needed to be put into the power grid at peak times. Taking advantage of all the changes in the smart grid and electric vehicle battery charging and charging, V2G technology can make the most adjustments to the power grid, smooth the daily load curve of the power grid, and reduce high voltage [4].

3.2. 2V2G system components and information flow. The V2G system model can be divided into four layers: network layer, parking management layer, smart charging and charging device layer, and vehicle layer.Among them, the bidirectional intelligent charging and discharging device not only interacts with the power grid, but also interacts with the vehicle. The operation of the whole system requires all devices to maintain communication. Figure 3.1 is the schematic diagram of information transmission [20].

3.2.1. Battery management system. Battery management system (BMS) is the main part of electric vehicle, including battery terminal module, central control module and display module. According to the different functions of each component, the BMS can store the power supply and current, the temperature, the state of health (SOC), the consumption state health (SOH), state of energy (SOE) and other pre-calculations and battery information. Fault self-check is carried out by diagnostic algorithm to prevent excessive charging and discharging from damaging vehicle battery, and timely alarm is given when necessary to ensure safe operation. BMS comprehensively monitors battery performance from all aspects, transmits data to charging and discharging devices (EV-PCS) with CAN bus, and then reports it to the background management system to make response strategies, and transmits charging and discharging instructions back to the charging and discharging devices, thus realizing the bidirectional flow of information [10, 16].

3.2.2. Intelligent user terminal. UT in Figure 3.1 is the user terminal, and users can intuitively understand the status information of electric vehicles on the dashboard. The component structure of the device is shown in Figure 3.2. The basic electrical equipment components include display, loudspeaker, card reader, etc. Most of the embedded ARM processors are used in the market, which mainly have wireless data communication module, GPS module and CAN bus interface. When the whole terminal system is installed on the EV, in addition to the bidirectional transmission of comprehensive battery information with the BMS mentioned

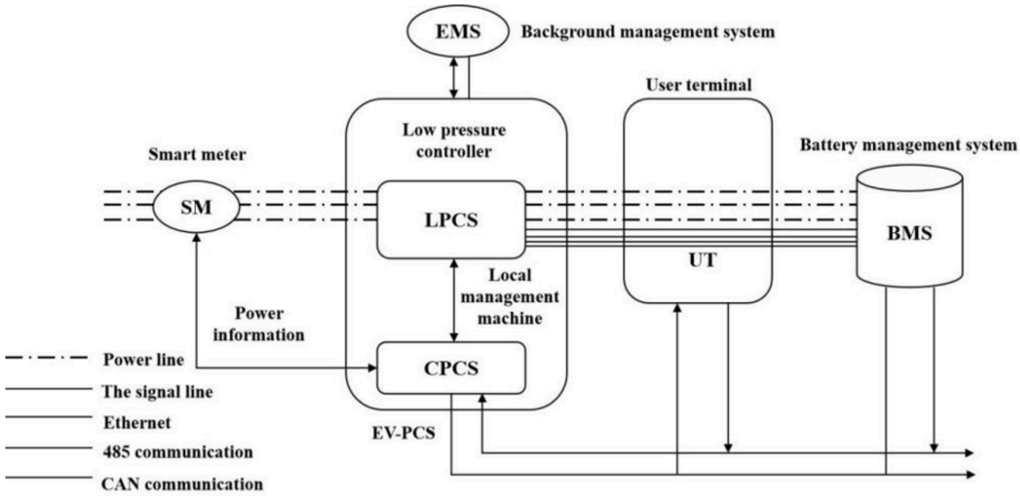

Fig. 3.1: V2G system information flow

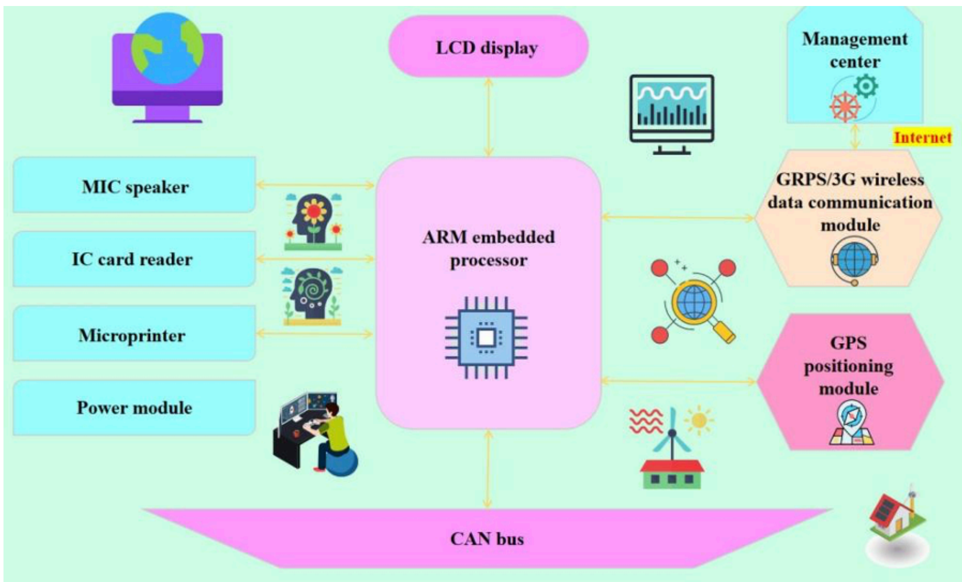

Fig. 3.2: User terminal structure

in Section 3.2.1, the user's instructions can also be transmitted to the corresponding control devices, respectively realizing information interaction. Intelligent user terminal has GPS data reception function to locate the geographical location of the user; It has the wireless communication function and regularly transmits UT statistical information to the background management center. At present, it mainly uses GPRS/3G, a general wireless packet technology, and selects an appropriate network as the channel for remote communication with the outside world [17].

3.2.3. Two-way intelligent charging and discharging device. Intelligent charging and charging system EV-PCS consists of low power controller LPCS and local controller CPCS. At the core of V2G technology, EV-pcs communicate with all major devices.It is bidirectional connected to smart meter SM with RS485 to record electricity information and set parameters. The bidirectional intelligent charging and discharging device receives the charging and discharging instructions from the control center wirelessly. In the charging mode, the execution object is only the vehicle, which is a one-way operation. In the case of V2G mode (peak load of the grid), the SOC set by the user needs to be obtained from UT, which is functionally combined with EMS into a system responsible for determining the charge and discharge strategy, operates bidirectional with BMS, and comes with protection functions such as undervoltage, overvoltage and overcurrent [14].

3.3. V2G peak regulation mode. lV2G participation in power grid peak regulation has faster response speed and higher comprehensive benefit than the traditional mode. At present, the application strategy of V2G technology is mainly studied by using simulation software to predict the power grid load curve, with the purpose of smoothing the curve after electric vehicles enter the network.

3.3.1. Objective function. According to the optimization objective of "peak trimming and valley filling", the control unit of the dispatching center was adjusted to 1h (24 units in total), and the minimum mean square error of the daily load curve was established as the objective function, i.e., Equation (3.1) below:

$$\min F = \sum_{j=1}^{24} \left(P_{Lj} - \frac{\sum_{j=1}^{24} P_{Lj}}{24} - \sum_{i=1}^{n} P_{ij} \right)^2 \tag{3.1}$$

where P_{Lj} is the power load of the grid at time period j; $\frac{\sum_{j=1}^{24} P_{Lj}}{24}$ represents the average daily load power of the grid; n is the number of electric vehicles connected to the power grid; P_{ij} is the total load power of i electric vehicles participating in the grid peak regulation during period j, and the discharge value is positive while the charging value is negative.

3.3.2. Constraints.

1) Power constraint

The charge and discharge power constraint of electric vehicles is expressed in expression (3.2). Generally, the transmission power of the charging line is not allowed to exceed 15 kW. Therefore, the value of $P_{\max}$ in the equation is 15, and the current constraint is mainly considered under this condition. In Formula (3.3) and (3.4), I_{ic} is the charging current; I_{id} is discharge current; I_{iN}, depending on the battery type of different types of electric vehicles, the rating is determined.

$$-P_{\max} \leqslant P_{ij} \leqslant P_{\max} \tag{3.2}$$

$$0 \leqslant I_{ic} \leqslant 1/3 I_{iN} \tag{3.3}$$

$$0 \leqslant I_{id} \leqslant 2 I_{iN} \tag{3.4}$$

Based on the above formula, the power constraints of electric vehicle i at moment j are Equations (3.5), (3.6) and (3.7), where V_{ij} is the rated voltage of vehicle charging (single-phase 220 V, three-phase 380 V).

$$P_{ij\,\min} \leqslant P_{ij} \leqslant P_{ij\,\max} \tag{3.5}$$

$$P_{ij\,\max} = \min\left(15, V_{ij} \cdot 2 I_{iN}\right) \tag{3.6}$$

$$P_{ij\,\min} = \max\left(-15, -V_{ij} \cdot \frac{I_{iN}}{3}\right) \tag{3.7}$$

2) Battery capacity constraints

The user can set the constraint range according to the driving demand, and the following equation (3.8) can be satisfied when the electric vehicle leaves the grid:

$$S_{Oc_{\text{set}}} \leqslant S_{Oc} \leqslant Soc_c \tag{3.8}$$

Where, the charged state of the battery is represented by S_{Oc}, which is defined as the ratio of the remaining capacity of the battery to the capacity Q_{iN} when it is fully charged. $S_{Oc_{\text{set}}}$ is the state of charge constrained by the user on the battery; Soc_c is the full load state.

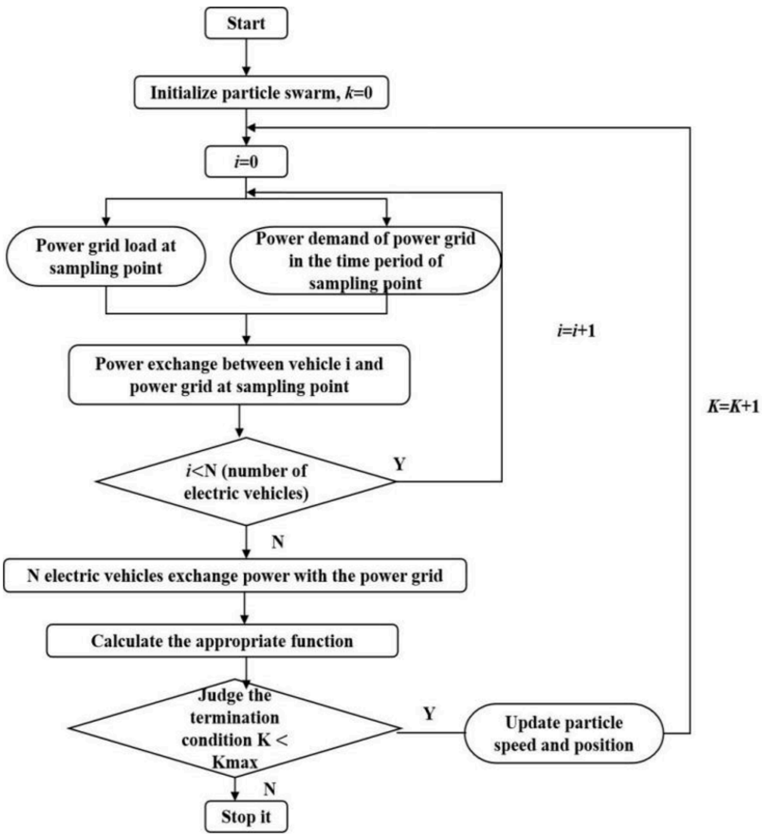

Fig. 3.3: Scheduling strategy flow based on particle swarm optimization algorithm

Considering the service life of the battery, Soc_c is required to be no less than 0.2 and no more than 1. S_{Socij} is the state of charge of vehicle i during the period j, and ΔQ_{ij} is the change of battery capacity during charging and discharging. $Q_{ij\max}$ represents the upper limit of capacity, and $Q_{ij\min}$ represents the lower limit of capacity. Equation (3.9), (3.10), (3.11):

$$Q_{ij\min} \leqslant \Delta Q_{ij} \leqslant Q_{ijmax} \tag{3.9}$$

$$Q_{ij\max} = (S_{\text{Socij}} - S_{\text{Socmin}})\, Q_{iN} \tag{3.10}$$

$$Q_{ij\min} = (S_{\text{Socij}} - S_{\text{Socmax}})\, Q_{iN} \tag{3.11}$$

3.4. Improved particle swarm optimization algorithm. ParticleSwarmOptimization (PSO) or swarm foraging algorithm was first proposed by J. Kennedy and RK Eberhart. It is a modified version of a good genetic algorithm. The world's best results have been achieved by implementing a random process, which has the advantages of fast rotation, high accuracy and ease of use. The different models developed in this letter are electric cars, and there are many uncertainties. The solution of the objective function is the minimum cost, and the particle-by-particle optimization algorithm can be used. As shown in Figure 3.3, the improvement in EV scheduling based on the particle swarm optimization algorithm is derived from the following two factors [9].

3.4.1. Inertia weight of particles. In the general search of the PSO algorithm, a larger inertia weight is suitable for the global search in the first stage of the iteration, while a small body inertia is useful for the local search in the later stage. To achieve a balance between the two, a line of weight reduction (LDIW) is

Table 4.1: Daily load of power network

Time period	Power /kW	Time period	Power /kW	Time period	Power /kW
1	66	9	78	17	83
2	66	10	90	18	97
3	64	11	88	19	103
4	67	12	102	20	92
5	68	13	102	21	103
6	67	14	97	22	93
7	74	15	83	23	71
8	79	16	80	24	68

proposed as shown in the following equation (3.12).

$$\omega=\omega_{\max}-\left(\omega_{\max}-\omega_{\min}\right)\frac{K}{K_{\max}} \tag{3.12}$$

where K is the number of iterations; $K_{\max}$ is the set maximum number of iterations; $\omega_{\max}$ is the maximum inertia weight; $\omega_{\min}$ is the minimum inertia weight. With the increase of the number of iterations K, the inertia weight ω gradually decreases.

The program added in Equation (3.12) can adaptively update the inertia coefficient. Select $\omega_{\max}=2, \omega_{\min}=0.1, K_{\max}=300$.

3.4.2. Particle renewal rate. The situation of vehicles exchanging loads with the grid in 24 periods of a day is studied. Therefore, the dimension is 24, the number of initial population $m=100$, and the position of particle i is expressed as $X_i=\left(X_{i1}, X_{i2}, \ldots, X_{i24}\right), i=(1,2, \ldots, 100)$. During operation, its “flight” speed is also n-dimensional vector $V_i=(Vi1, Vi2, \ldots, Vi24), i=(1,2, \ldots, 100)$, and other speed parameters are set as $V_{\min}=-0.5, V_{\max}=0.5$ according to experience.

Particle swarm optimization algorithm updates particle velocity according to equation (3.13), where $x_i(k)$ is the position information of particle i, $p_i(k)$ represents individual extreme position of particle i, and $g_i(k)$ represents global extreme position.

$$v_i(k+1)=\omega v_i(k)+c_1 r_1\left(p_i(k)-x_i(k)\right)+c_2 r_2\left(g_i(k)-x_i(k)\right) \tag{3.13}$$

In the speed update of the improved PSO, the speed of the last two times is weighted as the new speed. The main program is as follows:

$$\begin{gathered}
[gbf i]=\min(pbf) \\
gbx_pso=pbx(i,:) \\
Gbf_pso=[Gbf_psogbf] \\
Gbx=[Gbx; gbx_{pso}] \\
v3(i,:)=(1-\text{ alf })*\left(\begin{array}{c}
w * v2(i,:)+c1 * \operatorname{rand} *(pbx(i,:)-P(i,:)) \\
+c2 * \operatorname{rand}(\operatorname{gbx} \operatorname{pso}-P(i,:))
\end{array}\right)+alf^* v1(i,:)
\end{gathered} \tag{3.14}$$

4. Result Analysis. The daily load curve of a building is used for simulation verification. The data are shown in Table 4.1, and Pav=83kW is obtained. For convenience of calculation, it is assumed that 2000 electric vehicles of the same model are connected to the power grid, and the driving power consumption is all 8kW. The rated capacity of the battery is 40kW · h, and the maximum allowable charging and discharging power is 15kW. The initial charging state of the electric vehicle entering the station is 0.8, and the minimum charging state of the outbound station required by the user is 0.9.

Table 4.2: Load exchange between electric vehicles and the grid

Time period	PSO	Improved PSO	Time period	PSO	Improved PSO	Time period	PSO	Improved PSO
1	3.9506	3.9967	9	7.4067	9.1229	17	8.9158	3.0122
2	6.7125	7.7567	10	-3.5161	-0.6706	18	-5.7265	-6.8803
3	7.6103	8.2171	11	-1.1951	-1.2442	19	-12.5054	-14.0272
4	9.6999	7.8026	12	-8.8.94	-11.5440	20	-6.0450	-0.3861
5	8.0242	7.9079	13	-8.1237	-11.4422	21	-5.8577	-11.3175
6	7.7998	8.3182	14	-9.1048	-3.6391	22	-2.4955	-1.4643
7	8.1648	7.6256	15	10.6419	9.3059	23	4.8398	18.4147
8	7.5815	7.2512	16	6.5271	9.0763	24	13.3846	19.6704

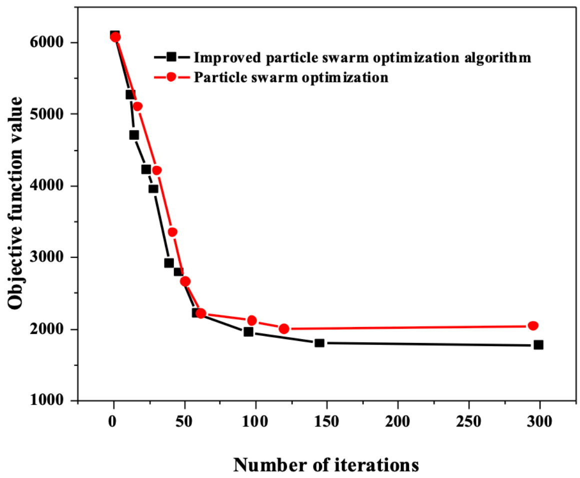

Fig. 4.1: Variation curve of objective function value with the number of iterations

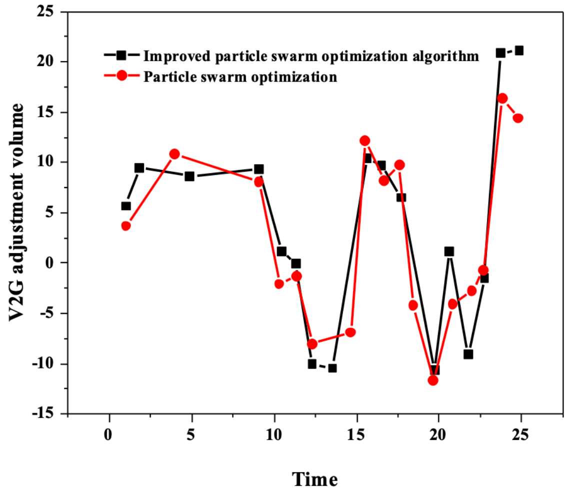

Fig. 4.2: V2G adjustment volume

According to the information in Table 4.1, based on the above mathematical model and the constraints, MATLAB simulation program is used to verify the accuracy of the results of the simple particle swarm optimization algorithm, and create the particle swarm optimization algorithm that is mentioned in this article. . follow. Those. The generated data is shown in Table 4.2 and the curves are shown in Figures 4.1 and 4.2.

Figure 4.1 shows that as the number of iterations increases, the value of the objective function decreases until the number of iterations reaches a maximum, and an agreement can be reached received. The iteration speed and fitness rate of the improved PSO algorithm are better than before. The values of the V2G rules in Figure 4.2 are put into the network, and the maximum rules of the two algorithms are compared as shown in Figure 4.3.

As can be seen from Figure 4.3, the load trough period of the original load curve is from 23:00 to 6:00, while two load peaks occur from 12:00 to 14:00 and 19:00 to 22:00. The simulation results show that V2G technology basically realizes the coordinated control of microgrid electric energy, and achieves the effect of peaking and valley filling. The improved algorithm is significantly improved compared with the original grid state, indicating that the algorithm is superior to the basic particle swarm optimization algorithm. The daily load curve can be replaced by a constant load curve, which is of great benefit to power distributors and reduces the price of electricity at the same time. It brings convenience to users [18].

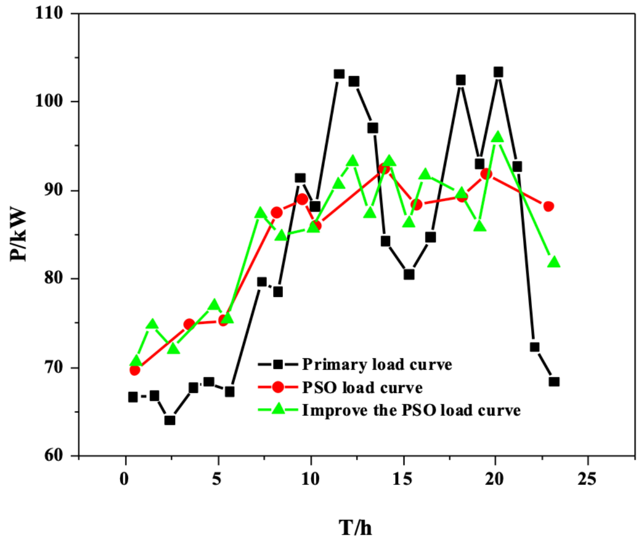

Fig. 4.3: V2G participating peak load regulation curve of power grid

5. Conclusion. In this essay,we fully demonstrates that the use of V2G can reduce the power grid load peak demand for generator sets, using the improved particle swarm optimization algorithm can achieve this point of view. The integration of electric vehicles into the power grid through V2G technology is not only beneficial to the distribution network in terms of power grid support, stability and load regulation, but also beneficial to the popularization of energy storage. However, improper V2G function management poses risks to the vehicle's built-in energy storage and requires setting discharge speed and depth to extend battery life.The improved PSO algorithm has better iteration speed and fitness function values. The original load curve is the load valley period from 23:00 to 6:00,12:00∼14:00 and 19:0019:00∼22:00. V2G technology basically realizes the coordinated control of microgrid power, and realizes the effect of peak value and filling valley. The improved algorithm has a significant improvement over the original grid state. A power grid with V2G discharge depth limit has the ability to reduce and eliminate the peak daily load essentially, so this technology has great research space and development prospect in the future.The existing research results show that V2G technology still has great potential for development, and the future research can focus on the specific implementation method of V2G technology, and the new business model suitable for V2G. V2G pilot projects can first be established in small-scale microgrids to expand their scale and extend them to the whole large power grid.

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REFERENCES

[1] M. H. Alabdullah and M. A. Abido, *Microgrid energy management using deep q-network reinforcement learning*, Alexandria Engineering Journal, 61 (2022), pp. 9069–9078.

[2] M. Azeroual, Y. Boujoudar, L. E. Iysaouy, A. Aljarbouh, M. Fayaz, M. S. Qureshi, F. Rabbi, and H. E. Markhi, *Energy management and control system for microgrid based wind-pv-battery using multi-agent systems*, Wind Engineering, 46 (2022), pp. 1247–1263.

[3] H. Goldstein, *What v2g tells us about evs and the grid: Vehicle-to-grid technology adds another layer of complexity to the electric-vehicle transition*, IEEE Spectrum, 59 (2022), pp. 2–2.

[4] R. Jabeur, Y. Boujoudar, M. Azeroual, A. Aljarbouh, and N. Ouaaline, *Microgrid energy management system for smart home using multi-agent system*, International Journal of Electrical and Computer Engineering, 12 (2022), pp. 1153–1160.

[5] M. Kermani, P. Chen, L. Göransson, and M. Bongiorno, *A comprehensive optimal energy control in interconnected microgrids through multiport converter under n- 1 criterion and demand response program*, Renewable Energy, 199 (2022), pp. 957–976.

[6] M. S. Mastoi, S. Zhuang, H. M. Munir, M. Haris, M. Hassan, M. Alqarni, and B. Alamri, *A study of charging-dispatch strategies and vehicle-to-grid technologies for electric vehicles in distribution networks*, Energy Reports, 9 (2023), pp. 1777–1806.

[7] S. Moalem, R. M. Ahari, and G. Shahgholian, *Long-term demand forecasting in electrical energy supply chain of espidan ironstone industry using deep learning and extreme learning machine*, Journal of Intelligent Procedures in Electrical Technology, 13 (2022), pp. 1–20.

[8] S. Mohseni, R. Khalid, and A. C. Brent, *Metaheuristic-based isolated microgrid sizing and uncertainty quantification considering evs as shiftable loads*, Energy Reports, 8 (2022), pp. 11288–11308.

[9] S. Panda, S. Mohanty, P. K. Rout, and B. K. Sahu, *A conceptual review on transformation of micro-grid to virtual power plant: Issues, modeling, solutions, and future prospects*, International Journal of Energy Research, 46 (2022), pp. 7021–7054.

[10] M. S. Rafaq, B. A. Basit, S. A. Q. Mohammed, and J.-W. Jung, *A comprehensive state-of-the-art review of power conditioning systems for energy storage systems: Topology and control applications in power systems*, IET Renewable Power Generation, 16 (2022), pp. 1971–1991.

[11] M. S. Sadabadi, M. Sharifzadeh, M. Mehrasa, H. Karimi, and K. Al-Haddad, *Decoupled dq current control of grid-tied packed e-cell inverters in vehicle-to-grid technologies*, IEEE Transactions on Industrial Electronics, 70 (2022), pp. 1356–1366.

[12] S. Safiullah, A. Rahman, S. A. Lone, S. S. Hussain, and T. S. Ustun, *Robust frequency–voltage stabilization scheme for multi-area power systems incorporated with evs and renewable generations using ai based modified disturbance rejection controller*, Energy Reports, 8 (2022), pp. 12186–12202.

[13] D. Song, *A review of v2g technology applications and impact on the grid*, International Core Journal of Engineering, 8 (2022), pp. 640–645.

[14] P. Wang, W. Yuan, C. Su, Y. Wu, L. Lu, D. Yan, and Z. Wu, *Short-term optimal scheduling of cascade hydropower plants shaving peak load for multiple power grids*, Renewable Energy, 184 (2022), pp. 68–79.

[15] Z. Wang, P. Jochem, H. Ü. Yilmaz, and L. Xu, *Integrating vehicle-to-grid technology into energy system models: Novel methods and their impact on greenhouse gas emissions*, Journal of Industrial Ecology, 26 (2022), pp. 392–405.

[16] T. Wei, X. Chu, D. Yang, and H. Ma, *Power balance control of res integrated power system by deep reinforcement learning with optimized utilization rate of renewable energy*, Energy Reports, 8 (2022), pp. 544–553.

[17] H. Zhang, *Key technologies and development challenges of high-proportion renewable energy power systems*, Highlights in Science, Engineering and Technology, 29 (2023), pp. 137–142.

[18] Z. Zhang, C. Dou, D. Yue, Y. Zhang, B. Zhang, and Z. Zhang, *Event-triggered hybrid voltage regulation with required bess sizing in high-pv-penetration networks*, IEEE Transactions on Smart Grid, 13 (2022), pp. 2614–2626.

[19] K. Zhou, Z. Zhang, L. Liu, and S. Yang, *Energy storage resources management: Planning, operation, and business model*, Frontiers of Engineering Management, 9 (2022), pp. 373–391.

[20] K. Zuo and L. Wu, *Enhanced power and energy coordination for batteries under the real-time closed-loop, distributed microgrid control*, IEEE Transactions on Sustainable Energy, 13 (2022), pp. 2027–2040.

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