Scalable Computing: Practice and Experience, ISSN 1895-1767, http://www.scpe.org
© 2024 SCPE. Volume 25, Issues 2, pp. 661–667, DOI 10.12694/scpe.v25i2.2533

STABILITY STUDY OF NEW POWER SYSTEM BASED ON MULTI-INTELLIGENT BODY COLLABORATION

XIANYOU WU, ZHIQIAN YANG, XIN DU, LIANGNIAN LV, AISIKAER,[*] AND YANCHEN YANG[†]

Abstract. Developing, implementing, and maintaining a multi-intelligent body collaboration system necessitates significant investments in finances, time, and expertise. While multi-intelligent body collaboration has the potential to enhance power system stability significantly, it also comes with challenges related to interoperability, security, system complexity, and resource allocation. Resource allocation and training costs can be substantial. Addressing these challenges is crucial to harnessing the full benefits of this approach and ensuring the reliable and efficient operation of power systems. Effective communication and coordination strategies among intelligent agents are integral to maintaining power system stability. Timely information exchange, load balancing, disturbance management, and the integration of AI contribute to a more resilient and adaptive energy grid. As technology advances, refining these strategies will be essential to meet the growing demands of an ever-evolving power landscape. As technology marches forward, it becomes increasingly evident that the refinement of these strategies is paramount. The dynamism of the power landscape, driven by technological advancements and evolving needs, necessitates an agile and adaptable power system. The fusion of multi-intelligent bodies and modern technology stands as a testament to our collective pursuit of a more reliable, efficient, and sustainable energy future. In this ever-evolving landscape, the innovation and enhancement of these strategies are our compass, guiding us toward a brighter and more efficient future.

Key words: Multiintelligence, Sustainability, Power system, Challenges, Communication, Behaviors.

1. Introduction. A stability study of a new power system based on multi-intelligent body collaboration involves assessing the robustness and reliability of this innovative approach to energy management. This system employs multiple intelligent entities that work collaboratively to ensure the stability of the power grid. At its core, this power system harnesses the capabilities of artificial intelligence, machine learning, and advanced control algorithms to manage the intricate balance between power generation, distribution, and consumption. The term "multi-intelligent body collaboration" implies the interaction of various intelligent components, such as smart meters, sensors, control centers, and even consumer devices, in a coordinated manner. One key aspect of this study involves evaluating the system's ability to predict and respond to power demand and supply fluctuations.

The modern power system is a dynamic and complex network that forms the backbone of our modern civilization. It supplies electricity to homes, industries, and institutions, ensuring our daily activities run smoothly. As the electricity demand grows, power systems face increasingly complex challenges. These challenges include the integration of renewable energy sources, the need for improved grid resilience, and the optimization of energy distribution. In this context, a multi-intelligent body collaboration system has emerged as a promising solution to enhance the stability and efficiency of power systems.

While the potential benefits of multi-intelligent body collaboration in power systems are substantial, it is essential to recognize that its implementation is not without challenges. This article delves into the intricacies of this approach, focusing on the key aspects that need to be addressed to exploit its advantages fully. We will explore the challenges related to interoperability, security, system complexity, resource allocation, and the substantial costs associated with training and resource allocation. By understanding and mitigating these challenges, the power industry can harness the full potential of a multi-intelligent body.

2. Objective.

1. To analyze the potential benefits and challenges of implementing multi-intelligent body collaboration in power system stability enhancement

[*]Goldwind Science & Technology Co., Ltd, Beijing, 100176, China (email: aisikaerres1@outlook.com)
[†]State Grid Jibei Electric Power Co., Ltd, Beijing, 100032, China

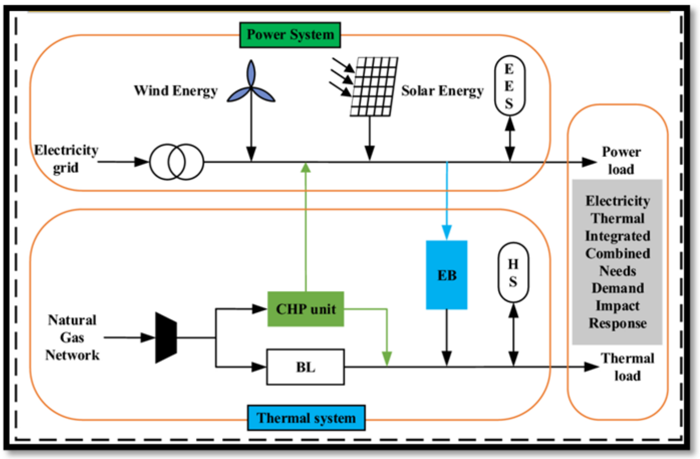

Fig. 3.1: Structure of combined and thermal energy system

2. To develop a comprehensive model of the new power system integrating multi-intelligent bodies
3. To evaluate the impact of different intelligent agent behaviors on power system stability under various operating conditions and disturbances
4. To identify the effectiveness of communication and coordination strategies among intelligent agents in maintaining power system stability

3. Methodology. This study mainly uses a secondary qualitative data collection method to gather information related to the work on a new power system based on multi-intelligent body collaboration. Furthermore, the study should assess the economic viability of implementing such a system [2]. The secondary data collection method must be statistical and theoretical, and it can easily give information related to the topic. Additionally, it is essential to evaluate the financial feasibility of putting such a system into practice.

3.1. Identify the benefits and challenges of implementing multi-intelligent body collaboration in power system stability. Various potential challenges and benefits are available, and smart grid implication is one of the most influencing challenges. Along with that, there are high investment costs, privacy, operational complexity, and maintaining security; these types of issues might be considered potential challenges [1]. Multi-intelligent body collaboration in power system stability enhancement offers numerous benefits. Firstly, it can leverage the combined capabilities of multiple intelligent agents, such as AI algorithms and control systems, to swiftly detect and respond to stability threats. This can lead to faster fault identification and corrective actions, minimizing disruptions [3]. There are various benefits also available, such as a smart grid that is connected with efficient transmission of electricity.

The above-mentioned Figure 3.1 indicates that this study is mainly focusing on the "wind energy (WT), solar energy (PV), gas turbine (MT), electric heat boiler (EB), gas boiler (BL), energy storage battery (EES), heat storage tank (HS)", and it is demanding on the side-electric energy heat machine [4]. Additionally, collaboration among various intelligent components allows for enhanced prediction accuracy. By integrating data from diverse sources, like sensors, weather forecasts, and load patterns, the system can make more informed decisions, leading to improved stability and reduced risk of blackouts. However, this approach also presents challenges. Interoperability among different intelligent components is a critical hurdle [5]. Ensuring seamless communication and coordination between AI agents, control systems, and human operators requires sophisticated integration techniques and standardization protocols. Data security and privacy are another concern. Collaborative systems involve sharing sensitive operational data among different intelligent agents. Protecting information from unauthorized access or cyber-attacks demands robust cyber security measures.

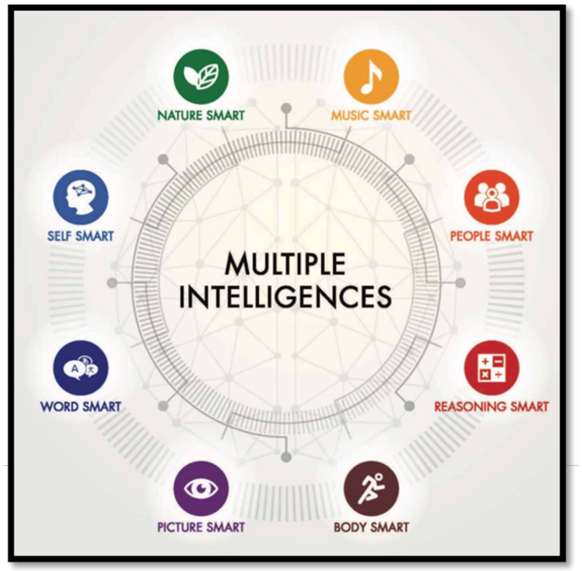

Fig. 3.2: Processes for using Multi Intelligences

3.2. Develop a model of the new power system integrating multi-intelligent bodies. The model powering system is a combination of analyzing and studying behaviors and performance of the power system. In an era marked by rapid technological advancements and the increasing demand for sustainable energy solutions, the development of a comprehensive model for a new power system that integrates multi-intelligent bodies has garnered significant attention [6]. This study explores the key components and benefits of such a system, highlighting its potential to revolutionize the way we generate, distribute, and consume energy. There are various sources and power systems available, and those are:

Integration of Renewable Energy Sources. The new power system model emphasizes the integration of renewable energy sources, such as solar, wind, hydro, and geothermal power. These sources offer a sustainable alternative to traditional fossil fuels, reducing greenhouse gas emissions and mitigating climate change [7].

Advanced Smart Grid Infrastructure. Smart grid infrastructure is an electricity network it is used in various technologies, and it helps to monitor and manage those sources that help to fulfill the demand for electricity for users. Smart grids enable real-time communication and coordination between various energy generation and consumption points, optimizing energy distribution and load management [8]. The incorporation of a smart grid infrastructure forms the backbone of the multi-intelligent body-integrated power system.

Decentralized Energy Generation. The new model shifts from centralized power generation to decentralized systems. This approach empowers individual households, businesses, and communities to generate their energy using renewable sources, contributing to energy self-sufficiency and grid resilience [9].

Developing a comprehensive model for a new power system that integrates multi-intelligent bodies holds immense promise for transforming our energy landscape. This theory was developed by Howard Gardner in the year 1983 to leave the concept of traditional intelligence and introduce the world to multiple intelligence processes 12]. This model leverages the power of renewable energy sources, advanced technology, data analytics, and distributed AI to create a more sustainable, efficient, and resilient energy infrastructure.

4. Evaluate the impact of different intelligent agent behaviors on power system stability. Various impacts are available from different intelligence and power system stability; along with that, Voltage stability is the main contrast that impacts electric system operation. The impact of different intelligent agent behaviors on power system stability is a complex topic that requires careful analysis [10]. Intelligent agents can play a significant role in enhancing the stability of power systems under various operating conditions and disturbances. These agents can include advanced control algorithms, machine learning models, and optimization

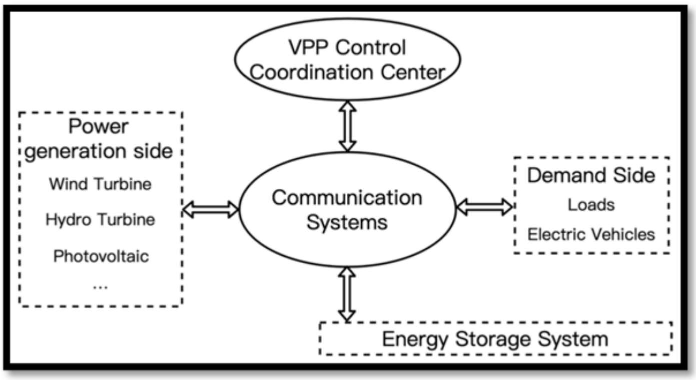

Fig. 4.1: Communication system in renewable energy sources

techniques. Voltage fluctuations might cause voltage stability, which can happen in equipment failures and power outages [11]. One central area where intelligent agents impact is load forecasting and demand response. By accurately predicting future load patterns and adjusting demand accordingly, agents can help maintain a balanced supply-demand relationship, reducing the likelihood of instability caused by sudden load changes.

4.1. Analyze the effectiveness of communication and coordination strategies in maintaining power system stability. There is a strong connection available for making good communication, and it plays a significant role in "conveying information for ensuring a stable supply of electricity". Effective communication and coordination strategies among intelligent agents play a pivotal role in maintaining power system stability [12]. In today's complex and interconnected energy landscape, where power generation, distribution, and consumption are constantly evolving, the need for seamless information exchange and collaboration cannot be overstated. Firstly, clear communication is crucial for timely decision-making and response. Secondly, effective coordination among agents ensures a balanced load distribution [13]. Furthermore, coordination enhances resilience against disturbances.

Incorporating machine learning and AI techniques into communication and coordination strategies further enhances their effectiveness. These technologies enable agents to predict potential instability based on historical data and emerging patterns. By proactively addressing these concerns, the power system can avoid instability triggers before they occur. However, challenges do exist. Ensuring interoperability among diverse intelligent agents, which may be developed by different manufacturers or for different purposes, requires standardized communication protocols [14]. Cyber security measures are also paramount to protect against malicious attacks that could exploit communication vulnerabilities.

5. Results. In the above-mentioned figure 4.1, it is showing the most significant issue in the power grid design and operation are frequency stability and control. There are various processes have been introduced to incorporate this process [15]. When it comes to power reserves, each specification is unique and requires a certain amount of reserve to handle any deviations in power. It's important to keep these reserves available to ensure smooth operations and prevent any disruptions. When it comes to balancing supply and demand in the energy market, the key lies in controlling the output of dispatch able generating units. This is where most of the work is done, ensuring that energy is being produced and distributed in the most efficient and effective way possible [16].

It's a complex process, but one that's absolutely essential to keeping the lights on and the world running smoothly. Moreover, the collaborative nature of these intelligent bodies ensured efficient energy distribution and load balancing. By continuously exchanging data and making informed decisions, the system optimizes energy flow, minimizes wastage, and enables the integration of renewable energy sources at a larger scale [20]. This not only enhances environmental sustainability but also mitigates the challenges posed by fluctuating power generation.

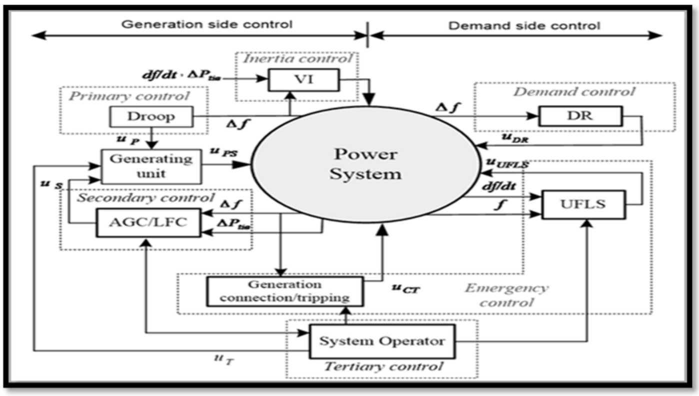

Fig. 5.1: Frequency stability and control smart grid in power system

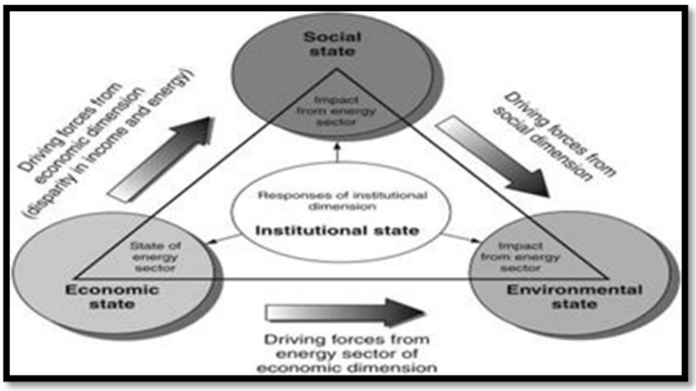

Fig. 5.2: Sustainable energy transaction

The result of a stability study conducted on a novel power system based on multi-intelligent body collaboration yields insights into its potential for revolutionizing energy networks, as mentioned above. This innovative approach leverages advanced technologies like artificial intelligence, machine learning, and interconnected devices to enhance system stability and reliability [17]. The maximum number of people are facing sustainable energy resource issues due to greenhouse gas emissions and global climate change. The stability study shows that integrating multiple intelligent entities, such as smart grids, IoT devices, and predictive analytics, contributes to real-time monitoring, fault detection, and adaptive control. These issues mainly happened because "fossil fuels led by coal, natural gas, and oil contributed 61.3% of global electricity generation in the year 2020". This synergy reduces the risk of cascading failures and blackout events, improving the overall resilience of the power system [18]. Energy plays a crucial role in all nations' progress and sustainable development. It is widely recognized as one of the most important factors determining the pace at which a country grows and develops.

Without adequate energy resources, it would be impossible for economies to thrive and for people to lead comfortable lives. Therefore, it is essential to prioritize energy policies and investments to ensure a brighter future for all [19]. Sustainability is a crucial aspect of the global energy transition. All dimensions of sustainability must be taken into consideration while formulating and implementing policies, planning, operating, and dispatching energy resources for both generation and consumption. Only then can we ensure a sustainable future for generations [21]. As data flows between various components, providing robust encryption and intrusion detection systems is imperative to prevent potential cyber threats that could compromise the system's reliability and security. For a long time, energy did not seriously factor in sustainable development. However, sustainable development and sustainability issues now play a central role in energy and electricity by anchoring the evolution of the sustainable development paradigm. We must continue prioritizing sustainability in the energy sector to ensure a better future.

6. Conclusion. In conclusion, the stability study of a power system based on multi-intelligent body collaboration is a comprehensive assessment of this innovative approach's technical, operational, and economic aspects. It examines how the synergy between various intelligent entities can enhance grid stability, adaptability, and efficiency. By addressing challenges related to prediction accuracy, communication, resilience, and cost-effectiveness, this study paves the way for a more resilient and responsive energy infrastructure. The distributed nature of intelligent entities allows for real-time data collection and analysis, enabling proactive adjustments to prevent disruptions. This can lead to more efficient load management, reduced downtime, and enhanced grid stability. Moreover, the stability study would delve into these intelligent bodies' communication protocols and data-sharing mechanisms. Efficient data exchange is crucial for quick decision-making and coordinated actions. It's important to ensure that the communication network is robust, secure, and capable of handling the vast amounts of data generated by the system.

The future of power systems lies in the continued development and integration of multi-intelligent body collaboration. Future directions in this field include further advancements in artificial intelligence, the deployment of more sophisticated IoT devices, and the incorporation of advanced predictive analytics. These innovations will improve grid stability, adaptability, and sustainability. Additionally, research should focus on creating standardized protocols and frameworks that facilitate seamless interoperability among various intelligent agents. As the energy landscape evolves, power systems will need to adapt continuously, and multi-intelligent body collaboration will play a pivotal role in ensuring a reliable and efficient energy distribution network for the future.

Fundings. This work is funded by the Science and Technology Project of SGCC (Research on Wind Generator Transient Voltage Optimal Control Technology in Weak Power Grid) (4000-202214067A-1-1-ZN).

REFERENCES

[1] A. Adeyemi, M. Yan, M. Shahidehpour, C. Botero, A. V. Guerra, N. Gurung, L. C. Zhang, and A. Paaso, *Blockchain technology applications in power distribution systems*, The Electricity Journal, 33 (2020), p. 106817.

[2] T. Ahmad, R. Madonski, D. Zhang, C. Huang, and A. Mujeeb, *Data-driven probabilistic machine learning in sustainable smart energy/smart energy systems: Key developments, challenges, and future research opportunities in the context of smart grid paradigm*, Renewable and Sustainable Energy Reviews, 160 (2022), p. 112128.

[3] F. E. Aliabadi, K. Agbossou, S. Kelouwani, N. Henao, and S. S. Hosseini, *Coordination of smart home energy management systems in neighborhood areas: A systematic review*, IEEE Access, 9 (2021), pp. 36417–36443.

[4] T. Darwish, G. K. Kurt, H. Yanikomeroglu, G. Senarath, and P. Zhu, *A vision of self-evolving network management for future intelligent vertical hetnet*, IEEE Wireless Communications, 28 (2021), pp. 96–105.

[5] D. Faquir, N. Chouliaras, V. Sofia, K. Olga, and L. Maglaras, *Cybersecurity in smart grids, challenges and solutions*, AIMS Electronics and Electrical Engineering, 5 (2021), pp. 24–37.

[6] Y. Feng et al., *Research of finite-time event-triggered control for high-speed train under switching topology*, Journal of Applied Science and Engineering, 26 (2022), pp. 933–940.

[7] A. Goudarzi, F. Ghayoor, M. Waseem, S. Fahad, and I. Traore, *A survey on iot-enabled smart grids: Emerging, applications, challenges, and outlook*, Energies, 15 (2022), p. 6984.

[8] B. Guo, Y. Liu, S. Liu, Z. Yu, and X. Zhou, *Crowdhmt: crowd intelligence with the deep fusion of human, machine, and iot*, IEEE Internet of Things Journal, 9 (2022), pp. 24822–24842.

[9] J. He, Y. Li, H. Li, H. Tong, Z. Yuan, X. Yang, and W. Huang, *Application of game theory in integrated energy system systems: a review*, Ieee Access, 8 (2020), pp. 93380–93397.

[10] M. A. Khan, N. Kumar, S. A. H. Mohsan, W. U. Khan, M. M. Nasralla, M. H. Alsharif, J. Żywiołek, and I. Ullah, *Swarm of uavs for network management in 6g: A technical review*, IEEE Transactions on Network and Service Management, (2022).

[11] J. Le, G. Qi, L. Zhao, and R. Jin, *Research on a control strategy for a distributed economic dispatch system in an active distribution network, considering communication packet loss*, Electronics, 11 (2022), p. 3288.

[12] S. Li, Y. Jia, F. Yang, Q. Qin, H. Gao, and Y. Zhou, *Collaborative decision-making method for multi-uav based on multiagent reinforcement learning*, IEEE Access, 10 (2022), pp. 91385–91396.

[13] Y. Liu, X. Liu, X. Mu, T. Hou, J. Xu, M. Di Renzo, and N. Al-Dhahir, *Reconfigurable intelligent surfaces: Principles and opportunities*, IEEE communications surveys & tutorials, 23 (2021), pp. 1546–1577.

[14] O. P. Mahela, M. Khosravy, N. Gupta, B. Khan, H. H. Alhelou, R. Mahla, N. Patel, and P. Siano, *Comprehensive overview of multi-agent systems for controlling smart grids*, CSEE Journal of Power and Energy Systems, 8 (2020), pp. 115–131.

[15] M. B. Mollah, J. Zhao, D. Niyato, Y. L. Guan, C. Yuen, S. Sun, K.-Y. Lam, and L. H. Koh, *Blockchain for the internet of vehicles towards intelligent transportation systems: A survey*, IEEE Internet of Things Journal, 8 (2020), pp. 4157–4185.

[16] L. Qian, P. Yang, M. Xiao, O. A. Dobre, M. Di Renzo, J. Li, Z. Han, Q. Yi, and J. Zhao, *Distributed learning for wireless communications: Methods, applications and challenges*, IEEE Journal of Selected Topics in Signal Processing, 16 (2022), pp. 326–342.

[17] M. H. Shawon, S. Muyeen, A. Ghosh, S. M. Islam, and M. S. Baptista, *Multi-agent systems in ict enabled smart grid: A status update on technology framework and applications*, Ieee Access, 7 (2019), pp. 97959–97973.

[18] K. Tazi, F. M. Abbou, and F. Abdi, *Multi-agent system for microgrids: design, optimization and performance*, Artificial Intelligence Review, 53 (2020), pp. 1233–1292.

[19] W. Tushar, C. Yuen, T. K. Saha, T. Morstyn, A. C. Chapman, M. J. E. Alam, S. Hanif, and H. V. Poor, *Peer-to-peer energy systems for connected communities: A review of recent advances and emerging challenges*, Applied energy, 282 (2021), p. 116131.

[20] X. Wang, J. Li, Z. Ning, Q. Song, L. Guo, S. Guo, and M. S. Obaidat, *Wireless powered mobile edge computing networks: A survey*, ACM Computing Surveys, (2023).

[21] P. Zhang, H. Xue, and S. Gao, *Multi-agent fault-tolerant control based on distributed adaptive consensus*, Ieee Access, 7 (2019), pp. 135882–135895.

Edited by: Sathishkumar V E
Special issue on: Scalability and Sustainability in Distributed Sensor Networks
Received: Aug 23, 2023
Accepted: Feb 13, 2024