Integration of process by-product hydrogen recovery with a fuel cell cogeneration system

Chen, Wan-Da Tsai, Pei-Hong Lai, Wei-Hong Hsu, Zhi-Yin

2025/12/15

Summary

This project utilizes by-product hydrogen generated during manufacturing processes and introduces a low-temperature proton exchange membrane fuel cell (PEMFC) cogeneration system. The previously underutilized hydrogen is converted into electricity and recoverable heat, thereby improving energy efficiency and reducing dependence on external power supply. Through actual operational verification, the electricity produced by this project demonstrated an 85% reduction in carbon emission intensity compared with the emission factor announced by Taipower. This concretely showcases the effectiveness of low-carbon energy applications and serves as an important demonstration case for hydrogen by-product resource utilization and low-carbon transition.

Concrete Actions

1 Introduction of fuel cell technology capable of operating under non-pure hydrogen conditions

This project breaks through the traditional limitation of fuel cells requiring high-purity hydrogen by successfully introducing low-temperature proton exchange membrane fuel cells (PEMFC) capable of tolerating the characteristics of by-product hydrogen from manufacturing processes. This advancement enables fuel cell technology to be directly applied in actual industrial environments, reducing pretreatment complexity and enhancing system practicality. ◦

2 Establishing a fuel cell cogeneration system to enhance energy utilization

The system can simultaneously generate electricity and recoverable heat, effectively converting by-product hydrogen from manufacturing processes into low-carbon energy. This reduces the plant's dependence on external power supply and strengthens overall energy utilization efficiency.

3 Completed actual operational verification to ensure system stability and reliability

After the system was completed, actual operational verification was conducted, accumulating a total of 313 hours of operation and 3,192.6 kWh of electricity generation. During the operation period, the system was able to perform routine start-up and shutdown in accordance with process requirements without causing adverse effects on existing processes, demonstrating strong stability and reliability.

4 The carbon reduction benefits are concrete and quantifiable

The electricity generated by this project has a carbon emission intensity of approximately 0.068 kg-CO_2e/kWh, which represents an 85% reduction compared with Taipower's announced emission factor of 0.474 kg-CO_2e/kWh. The calculation of this carbon reduction benefit does not yet include the contribution from heat recovery.

Conclusion

This project successfully completed the establishment and operational verification of a system integrating by-product hydrogen recovery with a fuel cell cogeneration system. It effectively converted by-product hydrogen from manufacturing processes into usable low-carbon energy, with concrete data demonstrating its energy-saving and carbon-reduction performance. Through actual operational results, the feasibility and stability of fuel cell technology in manufacturing process environments were verified, providing the company with a solid demonstration foundation for low-carbon transition, energy efficiency improvement, and circular energy applications.