Study of the effect of changes in cell output temperature on the net efficiency of solid oxide fuel cell power generation

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ABSTRACT

Solid oxide fuel cell (SOFC) power plants offer a promising pathway toward highly efficient energy conversion compared to conventional systems. This study explores the impact of output temperature variations on system performance through simulation analysis. The results demonstrate that increasing the temperature difference between the fixed input (700 °C) and the cell output significantly enhances net efficiency, while gross efficiency remains relatively stable. At an output temperature of 875 °C, the system achieves a net efficiency approaching 50% and a gross efficiency of approximately 61%. These findings emphasize the critical role of output temperature in determining overall system efficiency and highlight the importance of thermal management in SOFC operation.

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1. INTRODUCTION

Global energy demand continues to increase, creating pressure to develop power generation technologies that combine high efficiency with low emissions. Solid oxide fuel cells (SOFCs) have emerged as one of the most promising solutions because they directly convert chemical energy into electricity through electrochemical reactions at high operating temperatures, achieving efficiencies above 60% [1]–[3]. This makes SOFCs attractive for sustainable energy production and integration into modern power systems.

Despite these advantages, SOFC performance is strongly influenced by thermal management and auxiliary power consumption, particularly the load of forced draft (FD) fans and other balance-of-plant (BoP) components. These auxiliary demands reduce net efficiency, creating a gap between theoretical gross efficiency and practical system performance. Recent studies have emphasized the importance of electrolyte fabrication methods [2] and cathode design strategies to mitigate thermal expansion effects [4], highlighting that material and structural innovations are critical to maintaining efficiency and durability.

Previous works have investigated SOFC efficiency, reforming methods, and thermal management strategies. Ali *et al.* [1] demonstrated the potential of intermediate-temperature reversible SOFCs for distributed-scale energy storage, while Shahsavari *et al.* [2] advanced electrolyte fabrication techniques to improve performance. Ali *et al.* [3] provided a comprehensive review of fuel cell principles, advantages, and limitations, and Shah *et al.* [4] critically examined cathode thermal expansion challenges. However, most analyses focus on gross efficiency, with limited attention to net efficiency as a function of output temperature and auxiliary load.

This paper addresses that gap by quantifying the effect of SOFC output temperature on net efficiency using Cycle Tempo simulation, with explicit consideration of auxiliary power consumption. The novelty lies in linking thermal process parameters to net efficiency outcomes, thereby providing insights beyond conventional gross efficiency studies. The findings have practical significance for designing control strategies, minimizing auxiliary loads, and improving SOFC integration into smart grids and distributed generation systems. By bridging thermodynamics, materials science, and control engineering, this study contributes to advancing SOFC technology as a viable alternative or complement to combined cycle gas turbine (CCGT) systems in the transition toward sustainable and efficient energy generation.

2. LITERATURE STUDY

A literature study on fuel cells shows that their main components are the anode, electrolyte, and cathode. In SOFC, electricity is generated through hydrogen ionization at the anode, producing hydrogen ions and electrons. At the cathode, electrons arriving from the anode facilitate oxygen ionization. The resulting oxygen ions then migrate through the electrolyte to the anode, where they react with hydrogen ions to form water (H_2O) [3]–[5].

According to Li *et al*. [6], SOFCs demonstrate superior electrochemical energy conversion compared to other fuel cell technologies. This advantage is evident in adoption trends, with installed capacity rising from 2.7 MW in 2014 to 27.8 MW in 2018 a nearly tenfold increase in four years. The conversion efficiency of SOFCs is comparable to that of natural gas combined cycle (NGCC) power plants, which combine gas and steam turbines.

In this study, simulations are conducted using an SOFC design concept model to evaluate efficiency under key parameters influencing electricity generation. Li *et al*. [6] emphasizes that achieving high efficiency requires dedicated research, particularly in heat management as part of the balance of plant (BoP) system. A comprehensive BoP study must account for auxiliary systems to ensure optimal performance. Building on prior work, the objective here is to identify and validate, through simulation, the critical parameters affecting SOFC electricity generation and thermal output. Research on commercial SOFC power plants has demonstrated electrical efficiencies of around 60% at rated power [7], while combined heat and power (CHP) systems can achieve efficiencies exceeding 80% [8].

3. RESEARCH METHOD

This study investigates the effect of SOFC cell temperature on net system efficiency through a simulation-based approach. A model of an SOFC-based power generation system with a capacity of 100 kWe (AC) were developed to represent distributed-scale applications. The BoP thermal system was integrated to utilize residual heat from electrochemical reactions and exhaust gases, thereby improving overall efficiency. Fuel gas supplied to the anode was set above stoichiometric requirements, leaving at least 10% excess fuel unreacted to ensure stable electrochemical reactions, while cathode air served both as an oxygen source and a thermal stabilizer.

Cycle Tempo software was employed to configure the SOFC power plant concept model. Boundary conditions included steady-state operation, external steam reforming of natural gas, and variable cell output temperatures ranging from 600–1000 °C. The natural gas composition used in the model was CH_4 79%, C_2H_6 13.5%, C_3H_8 3.92%, CO_2 0.64%, and N_2 3.04% [9]. External reforming was selected over internal reforming based on prior studies demonstrating improved stability and separation of chemical and electrochemical processes [10]–[13].

Key parameters included reformer efficiency, pressure drop across BoP components, and auxiliary loads such as FD fan consumption. These values were selected based on published experimental and modeling studies [14]–[18], [12], [13]. Resistance and degradation factors were incorporated to reflect realistic operating conditions, following recent analyses of SOFC performance under methane-rich and low CH_4/H_2O environments [16], [17].

Baseline simulation results were compared with published SOFC performance data to ensure credibility. For example, [1], [15], [18] reported gross efficiencies exceeding 60% under similar operating conditions, which aligns with the baseline outcomes of this study. Auxiliary systems such as FD fans and the external reformer were modeled with explicit power consumption, linking the analysis to control engineering scope. Their operation was treated as controllable subsystems within the BoP, allowing evaluation of their impact on net efficiency.

Finally, sensitivity analyses were conducted by varying input parameters including fuel composition, reformer efficiency, and pressure drop. These variations provided insight into how auxiliary loads and thermal management strategies influence net efficiency, complementing prior studies on temperature distribution and reforming approaches [12], [14], [15].

4. RESULTS AND ANALYSIS

4.1. Parameter model

The conceptual design model of the SOFC power plant used for the simulation is shown in Figure 1. This model uses residual heat from the electrochemical reaction and residual fuel in the SOFC to heat the fuel reforming process (natural gas). Then the exhaust gas is also used to heat the fuel, air, and to produce steam or BoP from the SOFC power plant. The system input consists of fuel, then the reactants air and water vapor. Water vapor, in this system is used for the process of reforming natural gas fuel into simpler materials, namely primarily hydrogen gas which will later be used for the electrochemical process in the SOFC. While the system output is in the form of electrical power and exhaust gas. The remaining exhaust gas from the electrochemical process is burned in the combustion chamber (after burner) to produce higher heat power. In the SOFC system, the remaining reaction fuel is usually made around 5% to 10% to then be burned in the combustion chamber or combustion chamber. While electrical power is the main product as electricity generation. This electrical product is in the form of direct current power with a reaction voltage of around 1 volt in open circuit conditions, while the electric current depends on the number of electrochemical reactions in the fuel cell area. Therefore, in this SOFC power plant, one of the parameters set is the effective cell area of the SOFC.

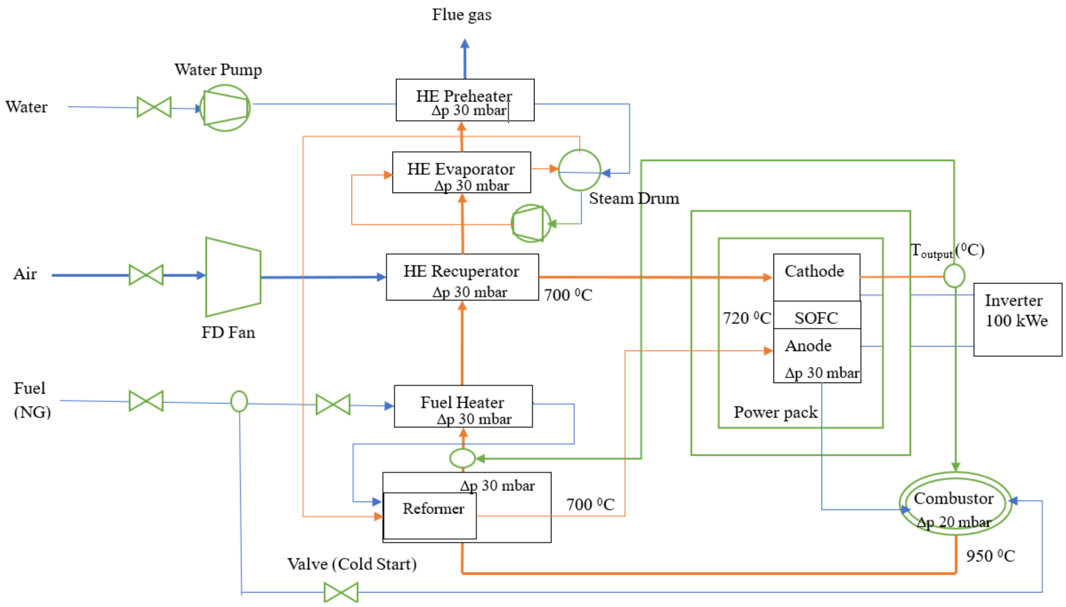

Figure 1. Modeling flowsheet of the conceptual design of the power plant SOFC 100 kWe

The performance test of the SOFC system was conducted at a cell operating temperature of approximately 700 °C [19]. Key parameters include the cell input temperature on both anode and cathode sides, set at 700 °C. For electrolytes using yttrium-stabilized zirconia (YSZ), the operating temperature range of 700–750 °C corresponds to an overall cell resistance of about 4×10^{-5} to 7×10^{-5} Ω·m² [20]. In this model, the resistance was set at 5.9×10^{-5} Ω·m². The combustor, functioning as an afterburner, produces an outlet temperature of 950 °C. Pressure drops across heat exchangers (HE) were minimized (20–50 mbar), while the cell operated at atmospheric pressure (1 bar). Steam reforming was applied with both steam and natural gas input pressures set at 3 bar. Input air was supplied from the environment using an auxiliary fan/blower positioned before the recuperator. All auxiliary power was drawn from the inverter output, which has a waveform conversion efficiency of 0.92. Heat losses in each HE component were relatively small, remaining below 2 kW, while instrumentation and control consumed a fixed 6.5 kWe.

For the BoP system design, the flue gas utilization sequence from the afterburner is first used to heat the reformer. Then, a HE is installed to heat the fuel that goes to the reformer. Then, in the middle, there is an air heater (recuperator). This air is the main reactive material, which requires a large amount of heat per unit time. This air is not only used as a reagent for the electrochemical process in the SOFC but also determines the output heat of the SOFC cell's effective area. Therefore, the heat from the flue gas required to heat this air should have a relatively high temperature. Finally, there is a HE component to generate dry steam for the fuel reformer. Flue gas is also used to generate steam (boiler) and preheat the boiler feedwater. In the boiler and preheater, the temperature of the flue gas exiting the recuperator is slightly above the vaporization temperature of water at relatively low pressure. By using this BoP concept, it is expected that the remaining waste heat released into the flue gas will have a relatively low temperature, but still above the threshold permitted by environmental requirements.

4.2. Simulation and result

Cycle Tempo software was used to simulate the SOFC power plant design as shown in Figure 1, with the outlet temperature varying between 750–875 °C in 25 °C increments. The impact of this temperature change on the overall power plant efficiency was observed, with the results summarized in Table 1 and Figure 2. The gross efficiency remained stable at around 61%, while the net efficiency increased significantly from 29% at 750 °C to 50% at 875 °C.

Table 1. Simulation results for various efficiency values due to changes in SOFC Cell output temperature

Temperature output SOFC		750 °C	775 °C	800 °C	825 °C	850 °C	875 °C
Delivered	Apparatus	[kW]	[kW]	[kW]	[kW]	[kW]	[kW]
Absorbed power	Fuel (natural gas)	163.83	163.9	163.96	164.03	164.11	164.19
Gross power	ER-SOFC	100	100	100	100	100	100
Aux. power consumption	FD Fan	46.23	28.96	20.98	16.35	13.31	11.15
	Boiler pump	0	0	0	0	0	0
	Instr_control	6.5	6.5	6.5	6.5	6.5	6.5
	Aux power total	52.74	35.47	27.49	22.85	19.81	17.66
Net power		47.26	64.53	72.51	77.15	80.19	82.34
Efficiencies	Gross	61.04%	61.01%	60.99%	60.96%	60.93%	60.90%
	Net	28.85%	39.37%	44.22%	47.03%	48.86%	50.15%

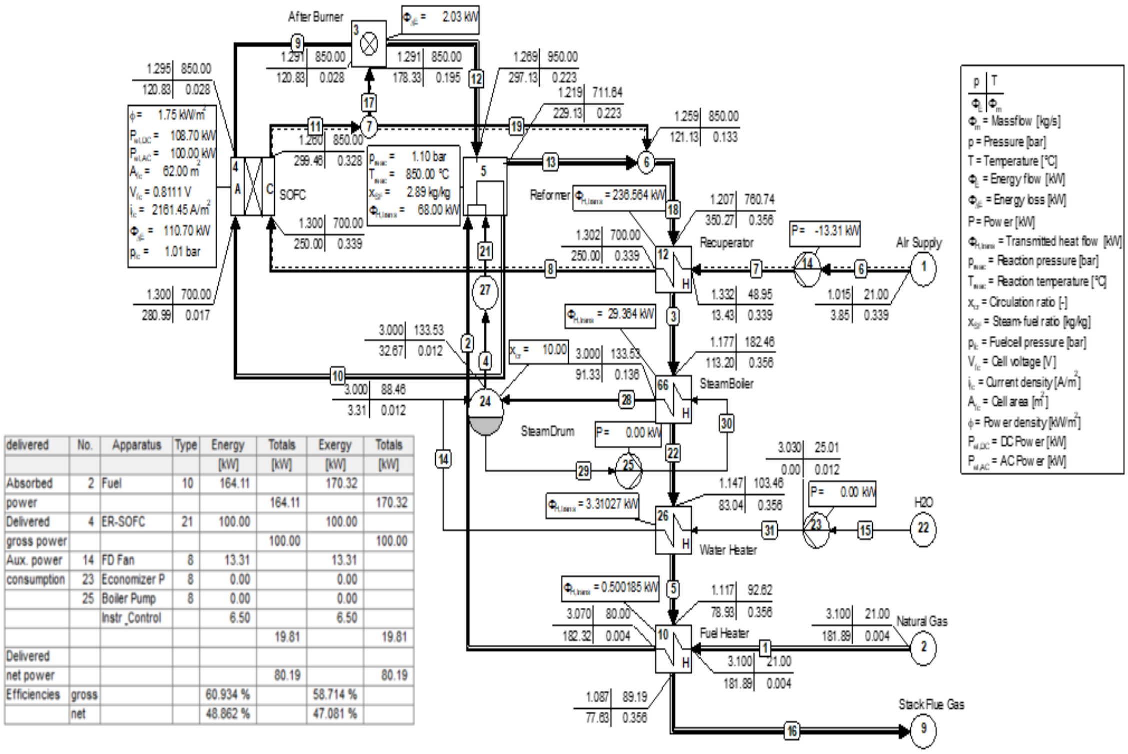

Figure 2. Simulation results for the input-output temperature difference of SOFC Cell 150 °C

An important electrical parameter influencing SOFC performance is cell impedance, which decreases as operating temperature rises [21]–[25], and the effective cell area is set to 62 m². This explains why gross efficiency remains nearly constant: impedance reduction offsets minor thermal losses. In contrast, net efficiency improves because auxiliary loads decline with higher outlet temperatures.

4.3. Result analysis

The simulation results demonstrate that variations in SOFC cell outlet temperature have distinct impacts on gross and net efficiency. Gross efficiency remains relatively stable around 61%, with only a slight decrease as outlet temperature increases. This stability can be attributed to the intrinsic electrochemical conversion process, where impedance reduction at higher temperatures offsets minor losses. In contrast, net efficiency improves significantly, rising from approximately 29% at 750 °C to about 50% at 875 °C, see Figure 3. The improvement is primarily driven by the reduction in auxiliary power consumption, particularly from the FD fan. At lower outlet temperatures, the FD fan requires up to 46 kWe to supply cooling air, whereas at higher temperatures the demand decreases to around 11 kWe, thereby reducing auxiliary load and enhancing net efficiency.

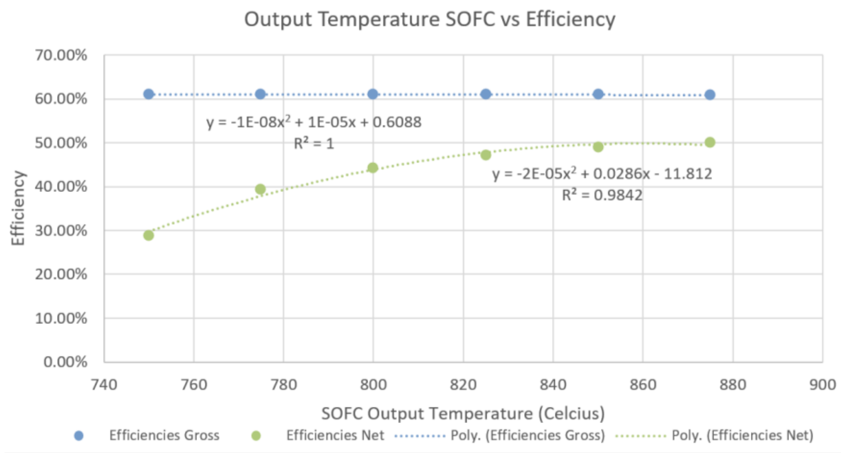

Figure 3. Efficiency vs SOFC output temperature

These findings are consistent with prior studies reporting that SOFC efficiency is strongly influenced by operating temperature and auxiliary system dynamics. For example, Sugihara and Iwai [14] highlighted the role of gas flow and temperature distribution in determining SOFC performance, while [15], [18] emphasized the challenges of methane reforming and its impact on efficiency. Compared to commercial benchmarks, the simulated gross efficiency aligns with reported values for SOFC systems exceeding 60% [1], [3], and the net efficiency improvement underscores the importance of auxiliary load management, which is often overlooked in conventional analyses. When compared with NGCC plants, which typically achieve net efficiencies of 55–60%, the SOFC system demonstrates competitive performance, particularly in distributed generation contexts.

From an engineering perspective, the FD fan emerges as the dominant auxiliary consumer. Its consumption must be minimized through advanced control strategies. Integration of SOFC systems into smart grids or distributed generation networks will require dynamic load management and BoP optimization. Furthermore, the findings suggest that SOFC systems can benefit from internet of things (IoT)-based monitoring and adaptive control to balance thermal stability with auxiliary consumption.

It is important to acknowledge the limitations of this study. The results are derived from Cycle Tempo simulations, which rely on steady-state assumptions and may oversimplify real-world dynamics. Experimental validation is necessary to confirm the observed trends, particularly regarding auxiliary load behavior at varying temperatures. Additionally, the model does not account for degradation mechanisms or transient performance, which are critical for long-term operation.

Future research should therefore focus on experimental validation of the simulation outcomes, development of dynamic control strategies for auxiliary systems, and integration of SOFC models with IoT-based monitoring platforms. Such efforts will enhance the reliability of SOFC systems and support their adoption as viable alternatives or complements to NGCC plants in the transition toward sustainable energy generation.

5. CONCLUSION

The study concludes that SOFC outlet temperature has a minimal effect on gross efficiency, which remains stable at about 61%, but a significant impact on net efficiency, which rises from 29% at 750 °C to 50% at 875 °C due to reduced auxiliary power consumption, especially from the FD fan. These results highlight the importance of auxiliary load management in improving real system performance and show that SOFCs can achieve competitive efficiency compared to NGCC plants. As the findings are based on steady-state simulations, future work should include experimental validation and dynamic control strategies to ensure applicability under real operating conditions.

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REFERENCES

[1] Z. Song, C. Xu, J. Liao, J. Ye, Z. Li, and W. Hong, "Numerical modeling of reversible solid oxide cells and optimization of the interconnector structure," *Journal of Solid State Electrochemistry*, vol. 29, no. 12, pp. 5055–5078, Dec. 2025, doi: 10.1007/s10008-025-06336-8.

[2] E. Shahsavari, M. Jafari, F. Yadollahi Farsani, N. Ekraminezhad, M. Ranjbar, and H. Salamati, "Fabrication of YSZ electrolyte layers using thermally assisted slurry spin coating method for IT-SOFC application," *Monatshefte fur Chemie*, vol. 153, no. 2, pp. 183–192, 2022, doi: 10.1007/s00706-021-02884-7.

[3] A. B. M. Ali, A. K. Nemah, Y. A. Al Bahadli, and Ehsan kianfar, "Principles and performance and types, advantages and disadvantages of fuel cells: A review," *Case Studies in Chemical and Environmental Engineering*, vol. 10, p. 100920, Dec. 2024, doi: 10.1016/j.cscee.2024.100920.

[4] N. Shah, X. Xu, J. Love, H. Wang, Z. Zhu, and L. Ge, "Mitigating thermal expansion effects in solid oxide fuel cell cathodes: A critical review," *Journal of Power Sources*, vol. 599, p. 234211, Apr. 2024, doi: 10.1016/j.jpowsour.2024.234211.

[5] F. Y. Farsani, M. Jafari, E. Shahsavari, H. Shakeripour, and H. Salamati, "Investigation of structural, electrical and electrochemical properties of La0.6Sr0.4Fe0.8Mn0.2O3-δ as an intermediate temperature solid oxide fuel cell cathode," *International Journal of Hydrogen Energy*, vol. 45, no. 15, pp. 8915–8929, Mar. 2020, doi: 10.1016/j.ijhydene.2020.01.030.

[6] M. Li *et al.*, "A Comprehensive Review of Thermal Management in Solid Oxide Fuel Cells: Focus on Burners, Heat Exchangers, and Strategies," *Energies*, vol. 17, no. 5, p. 1005, Feb. 2024, doi: 10.3390/en17051005.

[7] M. Gandiglio, P. Marocco, A. Nieminen, M. Santarelli, and J. Kiviaho, "Energy and environmental performance from field operation of commercial-scale SOFC systems," *International Journal of Hydrogen Energy*, vol. 85, pp. 997–1009, Oct. 2024, doi: 10.1016/j.ijhydene.2024.08.332.

[8] J. Li *et al.*, "Advancements in Solid Oxide Fuel Cell Technology: Bridging Performance Gaps for Enhanced Environmental Sustainability," *Advanced Energy and Sustainability Research*, vol. 5, no. 11, Nov. 2024, doi: 10.1002/aesr.202400132.

[9] Y. Khan and P. K. Singh, "Thermo-Economic and Environmental Analysis of a SOFC-Based Novel Power Generation System Formed with Gas Turbine and Modified Organic Flash Rankine Cycle," *Arabian Journal for Science and Engineering*, vol. 51, no. 3, pp. 2941–2955, Feb. 2025, doi: 10.1007/s13369-025-10193-y.

[10] M. Zhang *et al.*, "Recent Advances in Methanol Steam Reforming Catalysts for Hydrogen Production," *Catalysts*, vol. 15, no. 1, p. 36, Jan. 2025, doi: 10.3390/catal15010036.

[11] E. A. Liese and R. S. Gemmen, "Performance comparison of internal reforming against external reforming in a Solid Oxide Fuel Cell, gas turbine hybrid system," *Journal of Engineering for Gas Turbines and Power*, vol. 127, no. 1, pp. 86–90, Jan. 2005, doi: 10.1115/1.1788689.

[12] M. Höber *et al.*, "Holistic approach to design, test, and optimize stand-alone sofc-reformer systems," *Processes*, vol. 9, no. 2, pp. 1–28, Feb. 2021, doi: 10.3390/pr9020348.

[13] M. Höber *et al.*, "Experimental identification of the impact of direct internal and external methane reforming on SOFC by detailed online monitoring and supporting measurements," *Journal of Power Sources*, vol. 581, p. 233449, Oct. 2023, doi: 10.1016/j.jpowsour.2023.233449.

[14] S. Sugihara and H. Iwai, "Experimental investigation of temperature distribution of planar solid oxide fuel cell: Effects of gas flow, power generation, and direct internal reforming," *International Journal of Hydrogen Energy*, vol. 45, no. 46, pp. 25227–25239, Sep. 2020, doi: 10.1016/j.ijhydene.2020.06.033.

[15] L. Fan, C. Li, P. V. Aravind, W. Cai, M. Han, and N. Brandon, "Methane reforming in solid oxide fuel cells: Challenges and strategies," *Journal of Power Sources*, vol. 538, p. 231573, Aug. 2022, doi: 10.1016/j.jpowsour.2022.231573.

[16] S. Muto and H. Watanabe, "Atomic scale understanding of the role of Ni/XSZ interface in internal reforming SOFC in low CH4/H2O environment," *International Journal of Hydrogen Energy*, vol. 71, pp. 811–819, Jun. 2024, doi: 10.1016/j.ijhydene.2024.05.269.

[17] C. Lin, F. Kerscher, S. Herrmann, B. Steinrücken, and H. Spliethoff, "Analysis on temperature uniformity in methane-rich internal reforming solid oxide fuel cells (SOFCs)," *International Journal of Hydrogen Energy*, vol. 57, pp. 769–788, Feb. 2024, doi: 10.1016/j.ijhydene.2024.01.071.

[18] L. Fan *et al.*, "Advances on methane reforming in solid oxide fuel cells," *Renewable and Sustainable Energy Reviews*, vol. 166, p. 112646, Sep. 2022, doi: 10.1016/j.rser.2022.112646.

[19] H. Kim *et al.*, "Characterization of direct-ammonia solid oxide fuel cells (DA-SOFCs) at 650–750 °C in a single-repeating unit stack: Effects of metallic components and residual ammonia," *International Journal of Hydrogen Energy*, vol. 68, pp. 1312–1321, May 2024, doi: 10.1016/j.ijhydene.2024.04.250.

[20] D. Sikstrom and V. Thangadurai, "A tutorial review on solid oxide fuel cells: fundamentals, materials, and applications," *Ionics*, vol. 32, no. 1, pp. 5–30, Jan. 2024, doi: 10.1007/s11581-024-05824-7.

[21] J. Nisar, G. Kaur, S. Giddey, S. Bhargava, and L. Jones, "Cathode Materials for Intermediate Temperature Solid Oxide Fuel Cells," *Fuels*, vol. 5, no. 4, pp. 805–824, Nov. 2024, doi: 10.3390/fuels5040045.

[22] F. Liu *et al*., "Status and prospects of electrode materials for symmetrical solid oxide fuel cells: a concise review," *Ionics*, vol. 31, no. 5, pp. 3877–3894, May 2025, doi: 10.1007/s11581-025-06182-8.
[23] J.-D. Liang, L. Hong, P. C. Wu, and S. S. Shy, "A Simple Pressurized SOFC Test Rig for Measurements of Cell Performance, Impedance, and Various Overvoltages," *ECS Transactions*, vol. 68, no. 1, pp. 2179–2188, Jun. 2015, doi: 10.1149/06801.2179ecst.
[24] S. Vecino-Mantilla and M. Lo Faro, "Exsolved perovskites for reliable SOFCs fed with dry biogas," *International Journal of Hydrogen Energy*, vol. 95, pp. 1151–1157, Dec. 2024, doi: 10.1016/j.ijhydene.2024.04.326.
[25] D. D. Le, H. L. Nguyen, S. Yu, H. H. Le, and T. D. Hoang, "Progress and outlook of solid oxide fuel cell technology for stationary power generation applications," *Frontiers in Energy Research*, vol. 13, Sep. 2025, doi: 10.3389/fenrg.2025.1650696.

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