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A Techno-Economic Evaluation of Using Absorption Chillers in Peak Load Management of Gas Power Stations

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Abstract

This study offers a techno-economic assessment of the role of absorption chillers in managing peak loads at gas power plants. Absorption chillers provide an effective substitute for traditional mechanical cooling by using waste heat for refrigeration, which improves energy efficiency and decreases harmful emissions. The research points out that combining these chillers with combined heat and power systems enhances load management, especially during times of peak demand, by utilizing waste heat or renewable resources like solar energy. The focus is placed on mathematical models that incorporate thermodynamic and economic evaluations to identify optimal operational scenarios and evaluate feasibility. Findings suggest that the effectiveness of absorption chillers is evaluated through the coefficient of performance (COP), which can attain values as high as 0. 77 in ideal scenarios, while normally staying between 0. 5 and 0. 7 in typical situations. The economic analysis indicates that natural gas systems yield internal rates of return (IRR) varying from 40% to 54. 6%, which makes them more financially attractive than hybrid or solar-only systems. Furthermore, absorption chillers can help lessen the dependence on additional peaking power plants during periods of high demand, promoting environmental sustainability while reducing overall operating expenses. In summary, the integration of absorption chillers into gas power stations marks a crucial advancement toward achieving a sustainable energy future, requiring thoughtful design and economic evaluations to optimize the benefits.

Keywords: Absorption chillers, Peak load management, Thermodynamics, Economic feasibility, Renewable energy

تقييم فني واقتصادي لاستخدام المبردات التبريدية في إدارة ذروة الحمل في محطات توليد الكهرباء بالغاز

رعد احمد عبد الكاظم

الملخص:

يهدف البحث إلى تقييم فني واقتصادي لاستخدام المبردات التبريدية في إدارة الذروة في محطات توليد الكهرباء بالغاز. تُعدّ المبردات التبريدية بديلاً فعالًا للمبردات التقليدية التي تعتمد على الطاقة الميكانيكية، حيث تستفيد من الحرارة الناتجة كمصدر للطاقة لتوفير التبريد، مما يعزز كفاءة استخدام الطاقة ويقلل الانبعاثات الضارة. يُظهر البحث أن دمج هذه المبردات مع أنظمة توليد الكهرباء والحرارة المركبة يسهم في تحسين إدارة الأحمال، خاصة خلال فترات الذروة، من خلال استغلال الحرارة المهدرة أو مصادر الطاقة

المتجددة مثل الطاقة الشمسية. كما يسلط البحث الضوء على أهمية النماذج الرياضية التي تعتمد على تحليل الديناميكا الحرارية والاقتصاديات لتحديد أفضل الظروف التشغيلية وتقدير الجدوى الاقتصادية. أظهرت النتائج أن كفاءة المبردات التبريدية تقاس بمؤشر "معامل أداء التبريد(COP) "، والذي يمكن أن يصل إلى 0.77 تحت ظروف مثالية، بينما يتراوح بين 0.5 إلى 0.7 في الظروف العادية. من الناحية الاقتصادية، أظهرت التحليلات أن استخدام الغاز الطبيعي كمصدر للطاقة يحقق عوائد داخلية (IRR) تتراوح بين 40% إلى 54.6%، وهو ما يجعله أكثر جدوى اقتصاديًا مقارنة بالنظم الهجينة أو التي تعتمد فقط على الطاقة الشمسية. بالإضافة إلى ذلك، تسهم المبردات التبريدية في تقليل الاعتماد على محطات الطاقة الإضافية خلال فترات الذروة، مما يدعم الاستدامة البيئية ويقلل من التكلفة التشغيلية الكلية. في الختام، يُعدّ استخدام المبردات التبريدية في محطات الطاقة الغازية خطوة مهمة نحو مستقبل طاقي مستدام، مع ضرورة مراعاة الجدوى الاقتصادية وكفاءة التصميم لضمان تحقيق الفوائد المرجوة.
الكلمات المفتاحية :المبردات التبريدية، إدارة ذروة الحمل، الديناميكا الحرارية، الجدوى الاقتصادية، الطاقة المتجددة .

1. Introduction

Energy systems are increasingly important for sustainability and environmental accountability. As populations grow, the demand for energy intensifies, necessitating a shift from fossil fuels to sustainable alternatives. Absorption chillers, which efficiently utilize heat sources, are gaining attention for their compatibility with gas power stations. They not only meet cooling needs but also enhance comprehensive energy management strategies during peak demand.
Absorption chillers differ from conventional compression refrigeration by using thermal energy rather than mechanical work for cooling. This method aligns well with gas power stations that produce waste heat during electricity generation. By harnessing this waste heat, absorption chillers improve overall plant efficiency while satisfying cooling demands, particularly in regions with high temperatures or variable electricity needs.
The use of absorption chillers in gas power stations is part of load management strategies aimed at optimizing supply and demand. Literature on hybrid energy systems ([4]) indicates that integrating renewable and fossil fuel sources can boost operational efficiencies and reduce greenhouse gas emissions. Such setups require advanced energy management approaches that consider economic and thermodynamic factors.
Modeling techniques are essential for assessing the performance of absorption chillers in gas plants. These methods enable detailed analysis of system dynamics under different loads and operational conditions, identifying optimal configurations for thermal and electrical outputs while evaluating economic feasibility. Frameworks utilizing both energetic and exergetic performance metrics are crucial for identifying potential efficiency improvements ([14]).
Economic considerations are significant as countries adopt greener technologies to meet regulatory requirements and public expectations. Evaluating the cost-

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effectiveness of absorption chillers involves comparing initial investments to long-term savings from enhanced efficiencies and reduced emissions.
Incorporating absorption chillers in gas power stations also supports broader peak load management strategies. During surges in electrical demand that exceed generation capacity, these chillers lessen reliance on additional peaking power plants, which often rely on less environmentally friendly fossil fuels.
The transition to sustainable energy solutions requires innovative technologies and a deep understanding of their integration into existing infrastructures. The integration of absorption chillers into gas power stations exemplifies such innovation, merging thermodynamic principles with economic viability to advance sustainability and environmental stewardship.
In conclusion, exploring the relationship between absorption chilling technology and gas power station operations reveals that these integrations signify vital progress toward a resilient energy future aligned with global sustainability goals.

2. Literature Review

2.1. Absorption Chillers

Absorption chillers utilize a heat source for cooling instead of mechanical energy, operating through a thermodynamic cycle involving four main components: evaporator, absorber, generator, and condenser. In the evaporator, a refrigerant—usually a lithium bromide-water mixture—is vaporized at low pressure, absorbing heat to create cooling. This vapor is absorbed by a concentrated lithium bromide solution in the absorber, releasing heat. The mixture is then pumped to the generator, where external heat (from sources like natural gas or solar energy) causes the refrigerant to separate from the solution, allowing the cycle to continue as the lithium bromide solution returns to the absorber.
A key advantage of absorption chillers is their ability to utilize low-grade waste heat from industrial processes, enhancing system efficiency and reducing greenhouse gas emissions compared to conventional mechanical chillers. Findings in [1] indicate that absorption chillers powered by solar energy or natural gas can significantly lower emissions—by 17% to 76% depending on operational parameters.
These systems integrate well with renewable energy frameworks, complementing solar thermal installations by using surplus thermal energy effectively. As detailed in [2], they are being considered for data centers, potentially turning waste heat into cooling resources at lower costs and carbon footprints than electric-driven HVAC systems.

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However, absorption chillers have limitations, including a lower coefficient of performance (COP) compared to traditional systems, typically ranging from 0.5 to 0.7 under optimal conditions, as noted in [5]. This requires higher energy input relative to output than mechanical systems that achieve COPs above 3.
Initial investment costs are generally higher due to complex designs and materials necessary for high-temperature operation. [1] highlights that while scenarios involving natural gas and solar energy can yield favorable economic returns (IRR between 40% and 54.6%), the upfront capital investment presents a significant barrier.
Operational challenges arise from fluctuating thermal conditions since absorption chillers depend on stable temperature differentials for efficiency throughout varying times and seasons, a challenge noted in studies on performance changes due to solar irradiance ([1]).
In summary, absorption chillers present an innovative approach for efficient cooling using alternative energy sources. Their economic viability hinges on factors such as initial costs and operational efficiencies relative to traditional systems, necessitating careful consideration of design and integration strategies for specific applications like commercial or industrial settings.

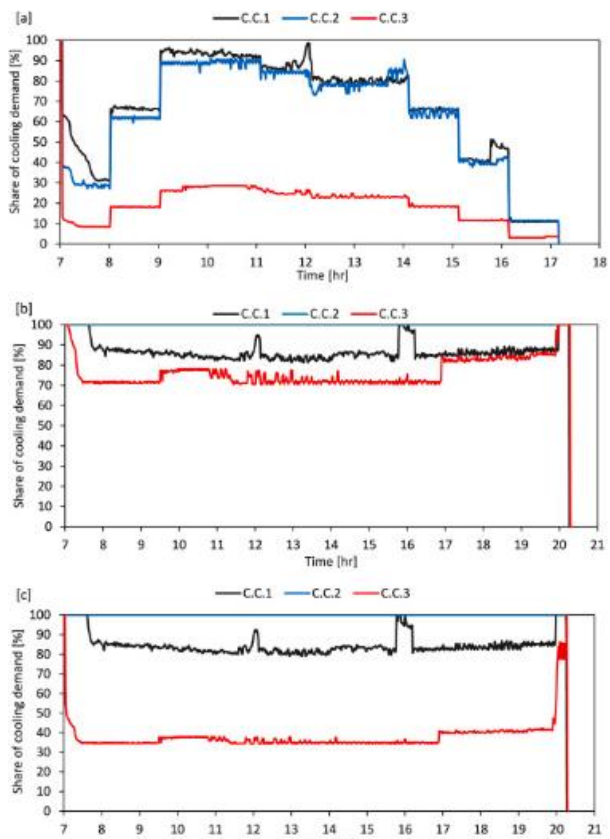

Figure 1: Share of cooling demand supported by absorption chillers powered by [a]

solar energy, [b] natural gas, and [c] solar energy and natural gas. (source: reference [1])

2.2. Load Management

Load management is essential for the stability and efficiency of power systems, particularly in integrating absorption chillers within gas power stations. It involves strategies to align electricity supply with demand, especially during peak consumption periods. Effective load management ensures optimal system function, reduces operational costs, and enhances grid stability by preventing overloads.

In gas power stations with absorption chillers, effective load management is crucial. Incorporating absorption chillers within combined cooling and power systems can significantly reduce peak demand ([4]). This integration meets cooling requirements during high temperatures while decreasing reliance on traditional cooling methods that worsen peak load issues.

Contemporary strategies for effective load management include demand-side management (DSM), which encourages consumers to adjust their energy use based on supply dynamics and pricing signals. By shifting usage from peak to off-peak times—often facilitated through time-of-use (TOU) pricing—the strain on the grid is alleviated, enhancing resource utilization.

Another innovative approach combines energy storage technologies with absorption chillers. Thermal energy storage systems capture excess energy generated during low-demand periods for use during peak hours. This allows gas-powered facilities equipped with absorption chillers to provide cooling and act as a buffer against sudden energy demand spikes by releasing stored chilled water as needed.

Recent advancements in renewable energy integration offer new opportunities for load management. Solar combined cooling systems utilize solar energy for both electricity generation and cooling, reducing dependence on fossil fuels during the summer months when cooling demands rise ([4]). Additionally, fuel cell technology serves as a reliable support system during peak load instances by converting hydrogen back into electricity ([8]).

Technological innovations enhance load management through improved analytics. Advanced modeling techniques allow operators to more accurately forecast electricity consumption patterns, facilitating informed decision-making regarding resource allocation ahead of expected peaks.

Implementing hybrid systems that combine thermal and electrical resources complements these strategies. Tri-generation hubs featuring photovoltaic panels alongside gas turbines demonstrate how optimized microgrid setups can meet varying electrical and thermal needs without increasing peak loads ([9]).

Moreover, smart grid technologies are set to transform load management practices by providing real-time insights into consumption patterns linked to generation capabilities. Smart meters give consumers immediate feedback on usage, along with dynamic pricing models that encourage participation in load balancing initiatives.

In summary, efficient load management is vital for maintaining the reliability and performance of power systems with absorption chillers in gas power stations. By integrating DSM techniques, innovative storage solutions, hybrid systems, predictive analytics, and smart grid technologies, utilities can effectively navigate complex demand scenarios while ensuring optimal operational effectiveness.

2.3. Modeling Techniques

Modeling techniques for absorption chillers in gas power stations rely on both thermodynamic and economic frameworks, essential for assessing their performance in energy systems. Thermodynamic modeling simulates the operational dynamics of absorption chillers under various conditions, integrating equations addressing mass, energy, and species conservation. Dynamic models for lithium bromide absorption chillers illustrate this, capturing heat transfer across components such as generators and condensers ([6] p. 16-20).

The complexity of absorption chillers necessitates careful consideration of factors like flow rates and temperatures associated with supplied steam and chilled water. The lengthy transient times due to significant thermal mass highlight the need for dynamic modeling to accurately predict system behavior ([6] p. 16-20). This involves using specific heat transfer coefficients based on established correlations, enhancing precision in determining local heat transfer coefficients within generator tubes ([6] p. 16-20). Additionally, two-phase flow pressure drop correlations help establish steam characteristics along the generator tube bundle.

Economic modeling frameworks are crucial for evaluating the feasibility of integrating absorption chillers into gas power stations. These frameworks utilize thermo-economic indicators to assess performance from cost and environmental perspectives. By combining traditional economic analyses with thermodynamic principles, these methods address inefficiencies from irreversibilities in energy conversion processes ([12]). Exergy analysis paired with economic metrics reveals how energy losses translate into financial liabilities and affect environmental sustainability.

Multi-criteria optimization approaches are beneficial for evaluating absorption chiller performance. Examining systems through various sustainability metrics—such as exergy efficiency—enables engineers to develop reliable assessments guiding design choices ([12]). This approach underscores that relying on single-performance metrics may yield misleading conclusions; therefore, a broader spectrum of criteria should inform performance optimization strategies.

Economic modeling often includes life-cycle assessments (LCA) alongside techno-economic evaluations, providing insights into the carbon footprint and financial implications of different chiller designs. Integrating thermo-environmental methodologies enhances analysis accuracy by allocating environmental burdens across energy system components ([12]), facilitating informed resource distribution and technology selection.

Computational tools like Matlab or EES aid in constructing thermodynamic models, allowing extensive simulations validated against experimental data. Research has modeled ammonia-water absorption machines to accurately predict coefficients of performance (COP) under specific operational parameters ([10] p. 6-9, [7]). Such predictive abilities are crucial for optimizing chiller operations while maintaining efficiency.

In summary, effective modeling techniques combining thermodynamic simulations and economic analyses are vital for understanding the dynamics of integrating absorption chillers into gas power stations, offering insights into operational efficiency and economic viability.

3. Methodology

3.1. Thermodynamic Evaluation

The thermodynamic assessment of absorption chillers in gas power stations involves a comprehensive model development process that integrates the principles of mass, energy, and species conservation. Essential components of an absorption chiller—such as the generator, evaporator, absorber, and condenser—are conceptualized as part of a dynamic system that accurately reflects the transient thermal behaviors inherent to this technology. The performance of absorption chillers is significantly influenced by the flow rates and temperatures associated with the supplied steam and chilled water, making it crucial to take these factors into account for precise predictions of operational efficiency.

To create a robust thermodynamic model, a transient analysis is employed that includes complex heat transfer phenomena across the various components of the chiller. This approach necessitates the use of specific heat transfer coefficients tailored for different modes of heat transfer relevant to each component. Importantly, the condensation process within horizontal tubes is modeled based on established frameworks such as those proposed by Dobson and Chato. Their research clarifies how to categorize condensation flows into distinct regimes—namely annular, stratified-wavy, and stratified—thereby facilitating more accurate

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calculations of local heat transfer coefficients.

In developing an effective model, integrating pressure drop correlations associated with two-phase flow is essential for accurately determining temperature and pressure conditions throughout the generator tube bundle. By combining these advanced correlations with mass and energy conservation equations specific to each component within the absorption chiller system—especially four shell-and-tube heat exchangers—the resulting model distinguishes itself from existing literature by effectively capturing both steady-state and transient behaviors.

Data collection for validating this model is critical to ensuring its reliability. Experimental data obtained from various configurations of absorption chillers serves as a benchmark for comparison against model predictions. For instance, research has shown that thermodynamic modeling can improve key performance indicators such as the coefficient of performance (COP) through practical data applications (as noted in [7]). Validation results generally correspond well with established values found in literature across diverse operational scenarios.

Beyond empirical data collection, sensitivity analyses are conducted to explore how variations in operational parameters affect performance metrics like COP. For example, changes in input temperatures or pressures can lead to significant shifts in cooling efficiency (referencing [5]). This ongoing adjustment process not only allows operators to enhance system efficiency but also assists in identifying optimal operating conditions that maximize cooling output while minimizing energy consumption.

Moreover, integrating economic assessments with thermodynamic evaluations provides a clearer understanding of the feasibility of implementing such systems within gas power stations compared to conventional refrigeration methods. By combining cost analysis with thermodynamic evaluations—as illustrated in [11]—the economic implications become evident; utilizing waste heat to drive absorption chillers not only improves thermal efficiency but could also lead to substantial long-term savings.

Model development requires iterative refinement grounded in both theoretical principles and practical observations gathered during testing phases. It is through this meticulous validation process that predictive accuracy is enhanced across various operating scenarios typical within gas power stations using absorption chilling technology.

Component	**heat load before system analysis (kWh)**	**heat load after system analysis (kWh)**
Evaporator	9.46	9.88
Absorber	19.13	16.83

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Generator	19.62	17.36
Condenser	9.95	10.41
COP	0.4821	0.569

Table 1: Heat loads of main parts in absorption chiller and system COP, before and after sensitivity analysis (Based on Experimental Data). (source: reference [5])

3.2. Economic Evaluation

Economic assessments of absorption chillers in gas power stations require a thorough examination that combines a cost-benefit analysis (CBA) with a sensitivity assessment of critical parameters. The CBA is particularly essential for gauging the profitability and feasibility of integrating absorption cooling technologies within energy systems. This methodology typically entails juxtaposing total anticipated costs against projected benefits throughout the system's lifespan, equipping stakeholders with the necessary insights to make sound investment and operational decisions.

When evaluating absorption chillers, it is imperative to account for all pertinent costs, which encompass initial capital outlays, operational expenses, maintenance fees, and any prospective decommissioning costs. For example, as illustrated in [1], various scenarios revealed differing internal rates of return (IRR) contingent on technology choices and fuel sources. It was found that absorption chillers powered by natural gas yielded higher IRR figures compared to hybrid or exclusively solar-driven systems. This underscores the significant impact that the choice of energy source has on economic results.

Additionally, net present value (NPV) emerges as another vital metric within this evaluation schema. According to [13], fine-tuning parameters such as the efficiency of the solution heat exchanger can lead to substantial annual savings—potentially up to $70,000—which positively affects NPV. Likewise, the research indicated that strategic modifications could enhance economic function by 9.95% through reducing exergy loss while simultaneously lowering operational expenses.

The sensitivity analysis complements the CBA by investigating how fluctuations in key input variables influence overall performance and financial viability. As detailed in [5], factors such as solution concentration, generator temperature, and pressure significantly shape both the system’s coefficient of performance (COP) and financial viability indicators like payback period and NPV. The findings from this study suggest that even slight adjustments in optimizing the system can yield considerable performance gains; for instance, raising generator temperature was

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shown to improve COP while decreasing related costs.
Moreover, external market dynamics play a crucial role in sensitivity analyses; variations in fuel prices can substantially alter the economic outlook for absorption chillers. When evaluations incorporate natural gas pricing—as referenced in [5]—the cost-effectiveness of projects can shift dramatically based on prevailing market conditions and energy sourcing strategies.
Incorporating thermoeconomic principles further sharpens these evaluations by aligning thermodynamic efficiency with economic performance metrics. Utilizing techniques such as multi-objective optimization—as noted in [13]—research indicates that refining an absorption chiller network not only enhances thermodynamic efficiency but also yields significant economic advantages through reduced operating costs.
In conclusion, grasping both CBA frameworks and sensitivity analyses constitutes a foundational element in executing a comprehensive economic assessment for absorption chillers within gas power stations. Insights gleaned from existing literature highlight the importance of choosing optimal operating conditions while being mindful of fluctuating market factors that affect both operational efficacy and financial results.

4. Results and Discussion

4.1. Performance Metrics of Absorption Chillers

Absorption chillers are evaluated based on unique performance indicators, particularly in gas power stations. A key metric is the coefficient of performance (COP), which is the ratio of cooling output to energy input. Research shows that peak COP can reach approximately 0.77 under ideal conditions, highlighting their efficiency in converting thermal energy into cooling ([1]). This efficiency is crucial during high demand periods, allowing for effective cooling with minimal energy use.
Another significant metric is the seasonal coefficient of performance (SCOP), which varies with operational conditions throughout the year. Studies report SCOP values around 0.52, suggesting lower efficiency during off-peak times or when operating outside standard parameters ([1]). This decrease in SCOP indicates that absorption chillers perform well under certain conditions but face challenges from environmental factors like solar radiation and temperature fluctuations.
Exergy analysis also plays a vital role in evaluating these systems. Exergy measures the useful work extractable from a thermal system, emphasizing the importance of maximizing exergy efficiency to optimize both thermal and

electrical resource use. Aligning exergy optimization with economic factors has been shown to enhance overall system viability ([3] p. 1-5), improving cooling effectiveness while minimizing waste and promoting sustainability.
External factors, such as load management strategies at gas power stations, directly impact absorption chiller performance. Effective load management improves operational efficiency by utilizing these systems during peak energy demand and favorable pricing periods. Simulations indicate that integrating absorption chillers with thermal storage enhances synchronization between generation and consumption, effectively capturing excess thermal outputs ([6] p. 31-35).
The integration of absorption chillers with alternative heat sources, like solar energy or natural gas, further boosts performance metrics due to more stable operating conditions, especially during daylight hours ([1]). These hybrid systems significantly reduce greenhouse gas emissions while maintaining competitive performance standards.
Real-world applications demonstrate that absorbent solutions, such as lithium bromide-water, have excellent thermodynamic properties suited for various climates. Research suggests selecting appropriate refrigerants based on local climate characteristics optimizes operational efficiency and informs future design improvements.
Understanding these performance metrics allows stakeholders to make informed decisions regarding investments in absorption chiller technology within gas power stations, considering potential returns against traditional mechanical compression systems.

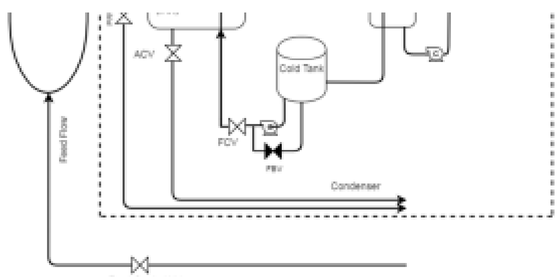

Figure 2: Schematic of an IPWR connected to a two-tank sensible heat thermal energy storage system, charging mode (source: reference [6])

4.2. Economic Viability Assessment Results

The financial viability evaluation of absorption chillers within gas power stations uncovers significant insights into their operational efficiency and cost-effectiveness. Findings from a variety of studies, including assessments of multiple operational scenarios, highlight how the arrangement and energy sources greatly affect the economic performance of these systems. For example, absorption chillers powered by natural gas exhibit remarkable internal rates of return (IRR) ranging from 40% to 54.6%. In contrast, hybrid systems that utilize both solar and gas show IRR values between 12% and 16.9%. Solar-only systems fall behind, presenting IRR figures as low as 5.6%, indicating a less favorable investment outlook for those relying solely on solar energy sources, as noted by Rodríguez-Toscano ([1]).

Further examination reveals that the net present value (NPV) associated with natural gas usage can be two to three times greater than that of hybrid models, and ten to thirty-six times higher than systems relying on solar collectors alone. This substantial disparity highlights the economic benefits linked to using natural gas as the main energy source for absorption chillers compared to alternative methods. The structure of capital costs is a key factor; for instance, when solar collectors represent a hefty portion—up to 58%—of total capital expenses, financial risks increase due to the necessity for additional equipment like pumps and piping.

In another study focused on a single-effect absorption chiller network in an industrial setting, optimization strategies were employed to enhance economic performance by reducing annual costs while boosting energy and exergy efficiency ([13]). Adjustments made to cooling water temperatures had significant effects: lowering inlet temperatures substantially increased performance coefficients while cutting overall operational expenses by roughly $70,000 annually under optimized conditions.

Moreover, various research efforts reveal that enhancing the efficiency of solution heat exchangers correlates positively with improved system performance metrics and notable reductions in operating costs—resulting in annual savings that could reach approximately $60,000 ([13]). These insights underline how targeted investments in component efficiencies can not only elevate thermodynamic performance but also lead to positive economic results.

Another critical element impacting economic viability is the fuel cost related to operation. Research indicates that if natural gas prices surpass $0.07 per cubic meter without subsidies, projects may lose their cost-effective advantage; however, at subsidized rates around $0.04 per cubic meter, projects can achieve acceptable payback periods of about nine years ([5]). Conversely, altering the pricing structure shows that increased input costs can significantly affect project feasibility evaluations.

In summary, an integrated approach that merges effective thermodynamic assessments with thorough economic analyses offers a holistic view of the financial dynamics surrounding absorption chillers within gas power stations. This comprehensive analysis emphasizes the importance for decision-makers to balance initial capital investments against long-term operational savings while taking into account market factors such as fuel prices and technology efficiencies.

4.3. Implications for Peak Load Management Strategy

The incorporation of absorption chillers into gas power stations significantly enhances peak load management strategies. These chillers optimize energy resource utilization during high-demand periods, which is crucial for grid stability and reducing operational expenses. By integrating absorption chillers with combined heat and power (CHP) systems or tri-generation energy hubs, operators can respond flexibly to fluctuating energy demands, thus improving load management.

Absorption chillers utilize low-grade waste heat or renewable energy sources, like natural gas, for cooling, making them well-suited for existing gas power frameworks. This approach increases overall system efficiency and helps lower greenhouse gas emissions. Studies on trigeneration systems demonstrate these advantages when absorption chillers are employed ([4]). Demand-side management (DSM) strategies utilizing absorption cooling can yield economic benefits by alleviating peak load pressures on the electrical grid and reducing reliance on fossil fuel-powered peaker plants.

Implementing time-of-use (TOU) pricing models alongside these technologies encourages consumers to shift their electricity consumption and cooling needs to off-peak hours. This strategy smooths out demand curves, ensuring that energy generation aligns with consumption patterns while easing the burden on the electrical grid and generation facilities. Research indicates that deploying absorption chillers with TOU pricing can lower operational costs and optimize asset utilization ([9]).

The economic feasibility of adopting absorption chillers largely depends on the choice of heat sources. Using natural gas reduces initial investment compared to solar-driven systems and mitigates logistical challenges associated with solar collector setups ([1]). In regions where natural gas is abundant and inexpensive, absorption chilling technology proves to be an economically viable solution for enhancing cooling capabilities and managing peak loads.

Incorporating thermal storage solutions with absorption chillers further enhances flexibility to meet varying demand levels throughout the day. This combination allows excess capacity generated during off-peak hours or from renewable sources—such as wind or solar—to be stored and utilized during peak demand periods.

Moreover, policy initiatives should promote infrastructure upgrades that facilitate the deployment of absorption chilling technology within existing energy frameworks. Fostering a regulatory environment supportive of innovation in

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cooling technologies, including incentives for new constructions or retrofitting older plants, can make improved peak load management more achievable.

In summary, integrating absorption chillers into gas power stations offers significant economic and environmental benefits for peak load scenarios, highlighting the importance of these systems in sustainable energy infrastructure investments.

5. Conclusion

The integration of absorption chillers in gas power stations offers a strategic approach to enhancing energy efficiency and sustainability in electricity generation. This technology utilizes waste heat from power generation, reducing greenhouse gas emissions while improving operational efficacy. As global cooling demands rise, particularly in warmer regions, the importance of absorption chillers is becoming more prominent. They enable power stations to utilize surplus thermal energy that would otherwise be wasted, contributing to a sustainable energy landscape.

Gas power facilities are often designed with peak load demands in mind. Absorption chillers provide additional cooling capacity during these peak times without significantly increasing fuel consumption. This capability is crucial for managing load fluctuations effectively and ensuring energy production aligns with demand, as highlighted by the need for strong load management strategies ([4]). By incorporating these systems, gas power plants can alleviate peak load challenges and reduce dependence on traditional cooling methods that typically involve higher operational costs and emissions.

Economically, the long-term benefits of absorption chillers merit consideration, despite initial investment costs. Savings from reduced energy consumption and lower operating expenses can offset upfront costs. Economic evaluations should include direct financial impacts and ancillary advantages such as better environmental performance and improved stakeholder perceptions regarding sustainability ([12]). These considerations are increasingly relevant amid the global push for decarbonization and regulatory frameworks promoting clean energy solutions.

Thermodynamic analyses reveal that absorption chillers can significantly improve the efficiency of gas power stations by optimizing thermal loads and enhancing system integration ([12]). This methodology shows how these systems effectively capture waste heat and convert it into valuable cooling, highlighting their role in hybrid energy frameworks that combine renewable resources with fossil fuels.

Absorption chillers also contribute positively to broader sustainability goals related to social and environmental impacts ([12]). Utilizing waste heat reduces reliance on fossil fuels and lowers carbon emissions associated with electricity generation, addressing growing pressures from regulations and public advocacy for environmentally responsible practices.

Furthermore, deploying absorption chillers aligns with global sustainable development goals, particularly those outlined by the United Nations Sustainable Development Goal 7. By facilitating access to affordable and clean energy while promoting economic growth across sectors like healthcare and education, gas power plants employing this technology can drive societal progress.

Looking forward, continued innovation will enhance the capabilities of absorption chillers along with advancements in digital monitoring and control systems, ensuring optimal performance under varying loads and maximizing economic returns throughout their operational lifespan. Integrating this technology signifies a shift towards more sustainable practices in gas-powered electricity generation, merging economic viability with ecological responsibility.

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