TECHNO-ECONOMIC ANALYSIS OF SOLAR-ASSISTED INTEGRATED ENERGY OPTIMIZATION SYSTEM FOR STEEL MAKING PLANTS LOCATED IN RAS AL-KHAIR INDUSTRIAL CITY

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Overview

Steelmaking process is considered extremely energy-intensive and carbon-dependent processes. Electric Arc Furnace (EAF) is the most electricity consumer in the whole process that counts for approximately 35% of the total required energy. In addition to its huge energy consumption, it was estimated that the emissions from global steel production represented 7–9% of direct emissions generated by fossil fuels. The use of solar energy to power such systems may save a large amount of electrical energy. This paper evaluates on grid integrated energy supply using a techno-economic analysis. The purpose of this paper is to exploit the results achieved in the analysis to develop viable recommendations in utilizing solar energy to power such extensive energy consumption equipment in steelmaking plant to establish tangible economic benefits from applying such technology. The results show that on grid solar thermal system is economically feasible with over 100 GWh electrical energy annual saving that resulted in a plant operating cost saving of $5 MM/year of 0.34 million ton/year of liquid steel production plant. Also, the system ensures a carbon emissions reduction of 15% and PBP of 8 years.

Method

In order to provide a consistent baseline for comparison with the traditional energizing process, Table 1 shows the basis assumptions for the selected operation characteristics under analysis. This factory is selected to be located in Ras Alkhair industrial city, Saudi Arabia.

Table 1: Case Study Main Operating Parameters

Characteristic	Description	Unit
Capacity	340000	Ton
Power transformer	100	MVA
The specific energy consumption	359	Kwh/ton
Annual average of direct normal irradiance (DNI)	1900	Kwh/m2/year

Technical Assessment Result

The applied off-gas data for the process design (mass flow and temperature) are examine. The fluctuation in mass flow and temperature of the off-gas between melting and charging (0:18–0:22) are obvious. During melting temperature, peaks of 1400 °C are reached. During charging the off-gas temperature decreases rapidly to 250 °C before the melting of the second scrap bucket starts (0:18–0:22). When the EAF lid is closed and the electric arc ignites the off-gas temperature increases dramatically again to 800 °C. As off-gas quenching is required in the reference plant off-gas waste heat will be just extracted at temperatures above 600 °C. About 600 °C is chosen to definitely ensure the mitigation of dioxin formation via de novo +synthesis. [13,14] Consequently, a waste heat extraction is potential to provide the system with its required energy in order to achieve the economical and environmental accomplishments.

Payback Period Analysis

The economic analysis results show that the PBP for the energy optimization system is 8 years, demonstrating that the system will result in great environmental protection as well as utilizing free sources of energy. Table 3 summarizes the cost of components, total investments, and annual saving for the system. The result illustrates that the PBP results is directly impacted by the changing of electricity rates. As the electricity rate increases, the PBPs decrease.

Table 2: PBP at electricity rate of $0.048/kW h.

Parameter	**Rate**	**Unit**
Inflation Rate	4%	-
Discount Rate	3%	-
Total Investment Cost	40,000,000	$

Total Annual Saving	5,000,000	$
Payback Period	8	Year

Net Present Value Analysis

The results from this analysis shows that the NPV for the system is $ 83,093,922 indicating that the system is feasible at the given electricity rate. The models demonstrate that the NPV becomes positive, indicating feasibility, at the electricity rate of $0.048/kW h. The analyses by both NPV and PBP methodologies show that the system is economically viable and environmentally friendly in the eastern province of Saudi Arabia.

Conclusions

The economic analyses using both PBP and NPV methods revealed that the solar thermal electric arc furnace and energy optimization system is economically feasible and environmentally friendly for steel industry. Moreover, the technical analysis reveals that the wasted heat and the solar thermal energy is sufficient to power the whole system. The eastern province of Saudi Arabia where most of the factories are located will benefit by applying such system in different highly temperature-based industries. However, the analytical results show that the energy optimization system is feasible and economically viable. The (PBP) for the system is 8 years. Furthermore, A solar-assisted integrated energy optimization system for EAF steelmaking was presented. Main process aspects are discussed using solar thermal energy, off gas data of steelmaking plant with a usable waste heat potential of 14.7 MWth. The system will achieve 100 GWh electrical energy saving annually and 15% reduction in estimated carbon emissions. Moreover, the system ensures 24 hours operation without interruption, full operation during maintenance times and Control automation system for energy supply management.

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