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Enabling Batch Process Flexibility Through Electricity Market Interfaces in Steel Production

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The transition to sustainable steel production necessitates innovative strategies for managing electricity demand in energy-intensive batch processes. Unlike large-scale continuous operations, small and medium-sized enterprises (SMEs) in steel manufacturing—such as specialized foundries and long product rolling mills—face unique challenges due to smaller batch sizes, greater product complexity, and the necessity for highly flexible scheduling. These companies must dynamically adapt to volatile energy markets while maintaining production efficiency and competitiveness.

This paper presents a conceptual framework tailored to SMEs for integrating electricity market signals into production planning and execution, enabling real-time demand response and load shifting. By leveraging scientific models for forecasting, optimization, and real-time analysis, the proposed software modules enable flexible production planning (e.g. day-ahead scheduling) and dynamic adaptation to fluctuating electricity prices and grid conditions. Special emphasis is placed on application-oriented interfaces that connect the production level and the energy market. These interfaces allow for multi-level reaction strategies, ranging from real-time adjustments to daily and weekly planning horizons, ensuring effective demand response and load shifting.

By aligning energy consumption with market signals, reducing production costs, and improving sustainability, the developed architecture enhances the economic viability of process flexibility; exemplarily conceptualized in a joint project with industrial facilities –foundry and long production. This research underscores the transformative potential of digitalization and market-driven energy optimization in the steel industry. By demonstrating practical applications in real-world production environments, it lays the foundation for scalable solutions that balance economic efficiency with ecological responsibility.

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