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A SMART AND SUSTAINABLE CLOSED-LOOP SUPPLY CHAIN SCHEDULING MODEL FOR REMANUFACTURING

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ABSTRACT

Remanufacturing is recognized as a value retention strategy to reduce material depletion and global warming, while sustainability is a human goal to achieve economic development in a harmonious and environmentally conscious manner, as well as responsibly, regarding communities. Integrating these concepts requires smart systems that provide the information to support decision-making processes and achieve a balance of economic, environmental, and social benefits.

Smart sustainable remanufacturing emerges as integrating sustainability objectives into remanufacturing through the support of smart systems. This study integrates this manufacturing paradigm into an optimization model supported by a machine learning predictive model for performing closed-loop supply chain (CLSC) operations scheduling. The process involves maximizing economic benefits and minimizing negative environmental and social consequences, while determining the optimal time for recovering used products, but also calculating the ideal batch size for each recovery period and establishing the most efficient processing sequence for every batch. All while leveraging a predictive machine learning model to forecast battery lifespans and mitigate inefficiencies related to return rate uncertainties.

A case study illustrating a conceptual remanufacturing CLSC system for electric vehicle batteries in Quebec serves as the basis for evaluating the proposed model's effectiveness. The process starts by modeling the charging capacity of each battery throughout its charging cycles, starting at the vehicle registration date. A predictive model, which had been previously trained using experimental data obtained from real batteries, receives randomly generated simulation data as input for establishing the lifespan. With the progression of each period, the predictive model is updated and retrained using the data and results gathered from the previous period's performance to improve it.

As a result, a decision-making tool is introduced to optimize the sustainable performance of the system. This also enables the evaluation of different implementation alternatives from the early stages of adoption through its operation, thanks to the simulation of various scenarios that contribute to a more informed and effective decision-making process.