G-SCOP
SCIENCES POUR LA CONCEPTION, L'OPTIMISATION ET LA PRODUCTION

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Titre de la thèse : Battery usage optimization to increase their usage duration in first and second life and rationalize energetic consumption

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Description du sujet :

- Context

Batteries are in the center of our modern society. They are present in our communication devices (telephones, laptops, tablets, etc.), booming in our means of transport (car, bicycle, electric scooters, etc.), and allowing energy to be stored produced by renewable energy sources... Batteries contribute to our independence from fossil energy. However, their environmental impact is significant. "Among the different phases of the battery life cycle, the end of life highlights different issues" including environmental ones. Efficient use of these batteries throughout their life cycle is a major challenge with high economic and environmental potential.

In addition, electric vehicles are booming (+146% increase in electric car registrations in one year). These vehicles may correspond to rental vehicles, captive fleets (fleet of maintenance services, delivery companies, etc.) or private vehicles. The new usage studied such as the use of electric cars as a reserve of green energy [3], or the strong commitments of the French government [5] in this area can only contribute to increase this trend.

Efficient usage of electric car batteries is therefore crucial. Propose schedules that optimize the charge / discharge cycles and periods of non-use of these batteries would allow a better usage and increase the duration of the first life of these batteries while increasing the possibilities of reuse. In addition, this could allow substantial savings in energy consumption, savings that have an environmental and financial interest.

- Aims and objectives

The objective of this thesis is to propose planification tools for the cycles of use (charge/discharge and use/non-use) of the batteries of electric vehicles and more particularly of

the vehicles of captive fleet by taking into account the degradation profiles, the profiles and conditions of use, the batteries health state, the different types of charge and their impacts as well as user preferences in order to increase the life of the batteries and optimize energy consumption.

- Proposed mode of research / methodology

This thesis will take place in 5 main stages:

- In order to identify relevant objectives and constraints, a study and appropriation of indicators and tools from the literature on the profiles and usage conditions of batteries, on degradation profiles and on health status indicators, in particular in connection with the possibility of reuse ([7], [8], [1]), will be conducted.
- A study on planning methods, focusing in particular on those taking into account the health of equipment [6] and on those considering a circular economy context [4] will be carried out. A study on the modeling of user profiles in optimization [9] will be conducted jointly.
- Proposals for integration into model planning models, battery usage conditions and profiles as well as user profiles and preferences will be made.
- Several problems of planning battery use cycles will be studied in order to consider increasing levels of complexity (usage profile, state of health curves, impact of charging modes on aging, degradation profiles, operating conditions, user profiles and preferences).
- Planning methods will be proposed, implemented and tested on instances of the literature.

- Expected research contribution

This thesis aims to propose and implement planning methods that will address several scientific issues:

- Modeling of the constraints representing the cycle of usage and the consumption of the batteries.
- Modeling of user preferences and usage conditions of the batteries (schedules, types of the next tour…).
- Defining the objective functions and selection of the relevant constraints.
- Solving the corresponding problem with optimization methods.
- Propose efficient planning methods.

The proposal of planning methods taking into account these different elements constitutes a real originality which, to our knowledge, has not yet been studied in the literature.
The results obtained will be published in international conferences and journals of rank A.
This interdisciplinary thesis subject is part of the Circular project (CDT) [2]. It aims at increasing the quality of the second life for batteries by a better management of their first life. Indeed, optimized management of usage cycles and charging cycles would help increase the battery reuse. In addition, an optimization or rationalization of the usage cycles (charge/discharge, use/non-use) could allow a better diversification of uses and substantial savings in energy consumption.

- Work plan

Classically, this thesis will begin with a bibliographical study. This bibliographical study will be conducted according to two axes. On the one hand, the study will focus on the articles making it possible to identify the characteristics and the constraints of the use of the batteries (profiles of degradation, various types of load, profiles of use, curves of state of health, impact of

charging modes on ageing, etc.). On the other hand, the study will focus on planning, modeling and consideration of user preferences.
Based on this bibliographic study, the objectives and constraints related to energy consumption, battery life and the opportunity for these batteries to have a second life will be identified and prioritized.
Different usage cycle planning problems (charge/discharge and use/non-use) will be modeled. Complexity studies will be conducted. Several exact, heuristic and hybrid or Constraint Programming type methods will be proposed, implemented and tested on instances that can be generated.
The proposed methods will be based on classical and advanced operational research tools (mathematical programming, development of heuristics, constraint propagation, complexity).

- Bibliography

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