Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 99 (2016) 285 – 291

Energy Procedia

10th International Renewable Energy Storage Conference, IRES 2016, 15-17 March 2016, Düsseldorf, Germany

Development and Evaluation of a Battery Lifetime Extending Charging Algorithm for an Electric Vehicle Fleet

Fabian Rücker[a,b,]*, Ilka Bremer[a,b], Sebastian Linden, Julia Badeda[a,b], Dirk Uwe Sauer[a,b,c]

[a]*Institute for Power Generation and Storage Systems (PGS), E.ON Energy Research Center RWTH Aachen University, Mathieustr. 10, 52074 Aachen, Deutschland*
[b]*Institut für Stromrichtertechnik und Elektrische Antriebe (ISEA), RWTH Aachen University, Jägerstr. 17/19, 52066 Aachen, Deutschland*
[c]*Jülich Aachen Research Alliance, JARA Energy, Deutschland*

Abstract

Electric vehicle (EV) lifetime strongly depends on the intensity of battery degradation. In this study simulation models, which include battery ageing mechanisms were used to benchmark these influences on total depreciation during one charging process. A nonlinear programming algorithm was used to optimize EV charging for a fleet. An energy price signal was included and the total operational costs for EV charging were minimized. It can be shown, that the interior point algorithm evaluates the optimal solution to charge every single vehicle to the necessary capacity for the operation and obeys the load restriction at the charging location. This is shown for a case study incorporating twentytwo EVs for delivery services.

© 2016 Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
Peer-review under responsibility of EUROSOLAR - The European Association for Renewable Energy

Keywords: electric vehicle charging; lithium battery ageing

* Corresponding author. Tel.: +49-241-8049366; fax: +49-241-80649366 .
E-mail address: fabian.ruecker@isea.rwth-aachen.de

1876-6102 © 2016 Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
Peer-review under responsibility of EUROSOLAR - The European Association for Renewable Energy
doi:10.1016/j.egypro.2016.10.118

1. Introduction

Electro mobility is one important contribution towards Germany's energy political goal of decreased carbon dioxide emissions. Electric vehicles (EVs) are now operated both in private and commercial use, however the commercial use is currently focused [1], especially to accelerate the market introduction of EVs. The lifetime of EVs is strongly related to the intensity of the battery pack degradation when a replacement of the pack at its end of life is not considered. In addition, the purchase and operation of the traction battery pack in EVs has the biggest proportion of the investment cost.

Todays research highlights mechanisms that shorten the lifetime of lithium-ion battery cells [2, 3]. Smart charging strategies based on Nash equilibrium [6], machine learning approaches for fast solving of complex non-linear approaches [7] and various charging concepts [5] have been investigated.

In this paper a lithium-ion ageing model parametrized on thorough cell ageing test matrixes was included into an optimization algorithm to develop and analyse battery lifetime extending charging algorithms. The optimization model is specifically designed to be used for vehicle fleet operation as it takes the load restrictions of the charging location into account and has a relatively short runtime. It is presented here using an input data set generated from field tests.

2. Model

The model for optimized traction battery charging, which was implemented for this study describes the scenario of the charging process for a large fleet of EVs. The model is flexible in terms of EV battery technology parameters, charging location parameters and fleet usage profiles. In Table 1 the input parameters are listed.

The total cost of the charging process can be separated into the cost for electricity C_{kWh} and the depreciation cost $C_{calendaric}$ due to calendaric ageing. The estimation of optimized battery charging is only possible if the major degradation mechanisms are described and validated by an ageing model. The model development and parametrization for a high power pouch cell was done at cell level and was published in [3]. The authors exemplify ageing factors for lithium-ion high power pouch cells with a nominal capacity of 6 Ah and a nominal voltage of 3.6 V. The anode of the pouch cell consisted of hard carbon and the cathode of $LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$ (NMC) as active material. The authors developed a lifetime prediction model based on extended accelerated ageing test data. The cycle lifetime of the cell, cycled between 60 % and 80 %, was shown to be 30,000 equivalent full cycles (end-of-life-criterion (EOLC): 70 %). The ageing of the cell due to cycling is therefore neglected in the optimization. The calendaric ageing of the cell shows the expected dependencies on its temperature and state of charge (SOC). High cell voltages determine high SOCs, result in higher mechanical stress for the materials and subsequently lead to a shorter battery lifetime [2]. Elevated temperatures and a high SOC diminish the battery lifetime due to a capacity fade over time. Lifetime estimation includes a definition for the operational limitation, the EOLC, which was defined here to be 80 % of the initial capacity. In [3] the authors fitted mathematical functionalities for the capacity fade of the cell due to calendaric ageing. The function used in this paper for the capacity fade is

$$\frac{C(t)}{C_{init}} = 1 + c_a \cdot c_V^{\frac{V-V_0}{\Delta V}} \cdot c_T^{\frac{T-T_0}{\Delta T}} \cdot \sqrt{t}, \quad (1)$$

where $c_a = -0.0064$, $c_V = 1.1484$, $c_T = 1.5479$, $T_0 = 25°C$, $V_0 = 3.5\,V$, $\Delta V = 0.1\,V$, $\Delta T = 10°C$ and t is given in weeks.

For $\frac{C(t)}{C_{init}} = 0.8$ (EOLC) equation (1) yields the lifetime L in weeks of the cell at voltage V and temperature T.

$$L = \left(-\frac{0.2}{c_a \cdot c_V^{\frac{V-V_0}{\Delta V}} \cdot c_T^{\frac{T-T_0}{\Delta T}}} \right)^2 \quad (2)$$

Download English Version:

https://daneshyari.com/en/article/5446680

Download Persian Version:

https://daneshyari.com/article/5446680

Daneshyari.com