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Cycle-Life Curves Determination and Modelling of Commercially Available Electric Vehicle Batteries

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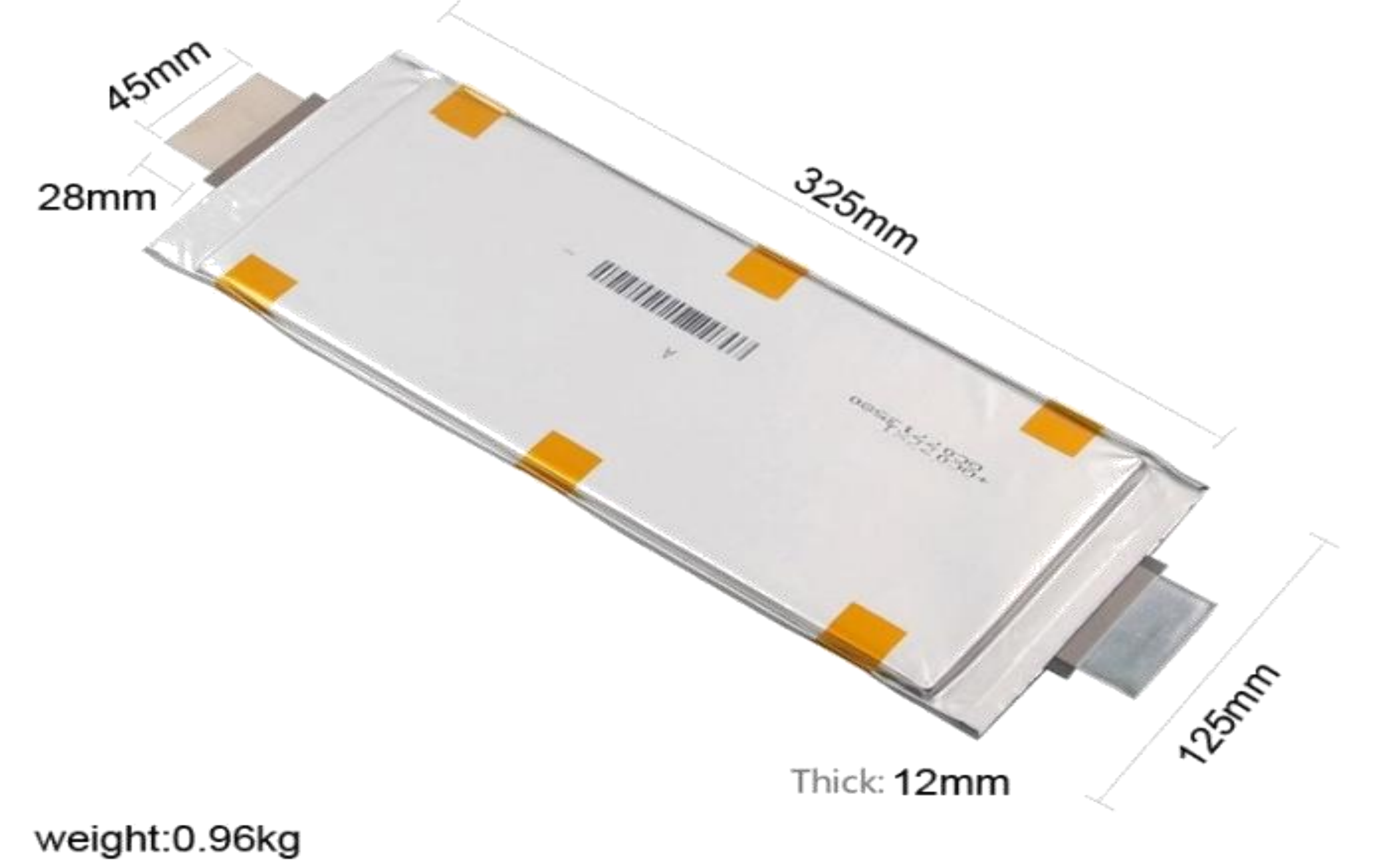
ABSTRACT

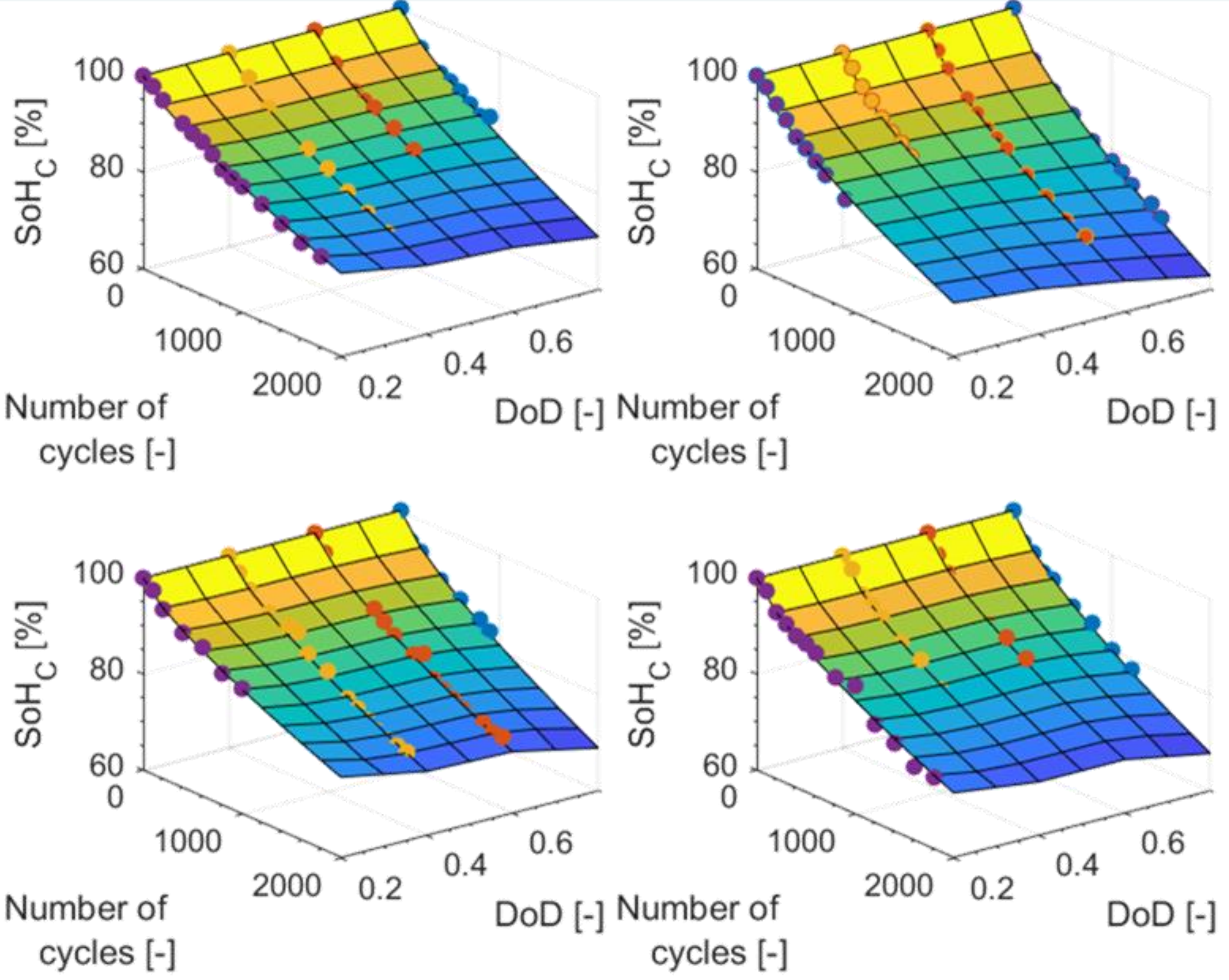
In recent decades, there has been a growing concern about the trend of global emissions, and in particular those of the transport sector. In this context, the electric vehicle is a promising technology, with some barriers still to be overcome. Among these deficiencies everything related to storage technology is found. In this sense, lithium-ion batteries are one of the options to be considered, although it is necessary to continuously monitor the state of health. Cycle life vs DoD curves are very useful for characterizing profitability in any application that considers battery storage, as well as life cycle optimization studies. Cycle life refers to the number of charge-discharge cycles that a battery can provide before performance decreases to an extent that it cannot perform the required functions (e.g., 80% compared to a fresh one in electromobility applications). In this paper, a model for calculating the Cycle Life vs DoD curves is proposed, applied to a commercially available electric vehicle, the Renault Zoe. Modelling results show R squared coefficient of determinations above 0.9890.

CYCLE AGING MODEL



$$SoH_C = 100 - a_C \cdot (DoD, C.T) \cdot N^{bc(C,T)}$$

It can be seen that temperature is a key factor when comes to degradation of the battery, but C-Rate has the greatest influence.

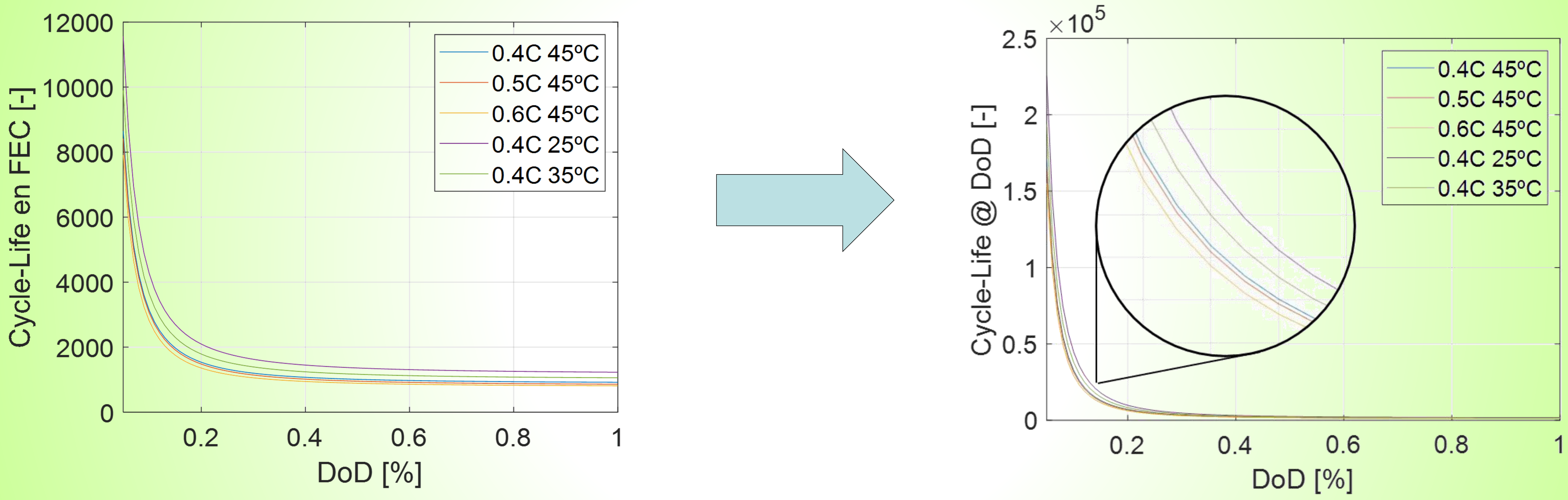


Capacity degradation for a) 25C 0.3786 C, b) 45C 0.3786 C c) 25C 0.4812 C d) 25C 0.6710 C.

SIMULATION RESULTS – CYCLE LIFE vs DoD

$$CL\ [FEC] = a(C,T) \cdot DoD^{b(C,T)} + c(C,T)$$

$$CL\ [N\ @\ DoD] = \frac{CL\ [FEC]}{DoD}$$



Cycle-Life adjusts studied, a) expressed in FECs and b) expressed in number of cycles @ DoD.

$$CL\ [N\ @\ DoD] = a(C,T) \cdot DoD^{b(C,T)} + c(C,T)$$

C_{Ch}	T	FEC				N @ DoD			
		a	***b***	***c***	R^2	***a***	***b***	***c***	R^2
0,4C	25 ºC	55,18	-1,749	1175	0,9934	178,6	-2,382	1559	0,9997
	35 ºC	45,82	-1,758	1012	0,9925	146,2	-2,397	1384	0,9996
	45 ºC	36,88	1,786	883,4	0,9904	117,9	-2,424	1242	0,9995
0,5C	45 ºC	38,26	-1,766	823,2	0,9900	110,6	-2,438	1190	0,9995
0,6C	45 ºC	31,03	-1,815	781,3	0,9890	96,8	-2,461	1125	0,9996

CONCLUSIONS

Battery degradation is one of the main problems of energy storage, in automotive applications as well as in stationary applications. Knowing the rate of degradation of a battery under a known working cycle is necessary for technology general deployment and performance improvement, as well as life cycle assessment since the usage optimization improves life cycle. Therefore, research on how to maximize batteries' lifetime is being encouraged. Concerning electric vehicles, people do want to know, as accurately as possible, how often they will need to replace the batteries installed in their vehicles. For this purpose, it is necessary to directly monitor, or indirectly estimate, the state of health.

In this context, with the aid of this paper, and the lifetime model here presented, the trade-off between working current and temperature in batteries applications can be correctly assessed.

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