Profitability of Second-Life Lithium-ion Storage Devices for Smart Buildings

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Second-life battery: Definition

First life battery: whenever the capacity goes from 100% to 80% and/or the equivalent series resistance goes from 1 p.u to 2 p.u.

Second-life battery: whenever the capacity goes from 80% down to 66-60% of the starting value.

Second-life battery: Source

Based on the EVs that have been sold last 5 years, from 2020 we will start to have the first samples of second-life batteries (mainly from EVs)

The research question to be adressed is:

From an economic and environmental point of view, does it make sense to collect those exausted batteries and re-use them with lower performances?

Ongoing Project at HEIA-FR

At HEIA-FR we received funds to answer to these questions.

Deliverables:

- Experimental characterization of reduced performances of aged cells;
- Whole LCA comparing first and second life Li-ion cells
- Computation of its profitability for smart-building applications.

PSA, Empa and Aurora's Gird are partners

Preliminary results

We have already computed the preliminary profitability of those second-life scenario batteries for smart building applications.

We took into account a dedicated ageing model of battery, as well as retail and feed-in tariff of Switzerland.

Preliminary results

Hypothesis:

- Retail electricity price of 21 ct of CHF/kWh;
- Feed-in electricity price of 5 ct of CHF/kWh;
- Li-ion second-life BES price equal to 150 CHF per kWh.

Battery Modelling Factors

Non-linearity effects have to be taken into account;

Efficiency of the cell (85%-95%);

Rate capacity effect:

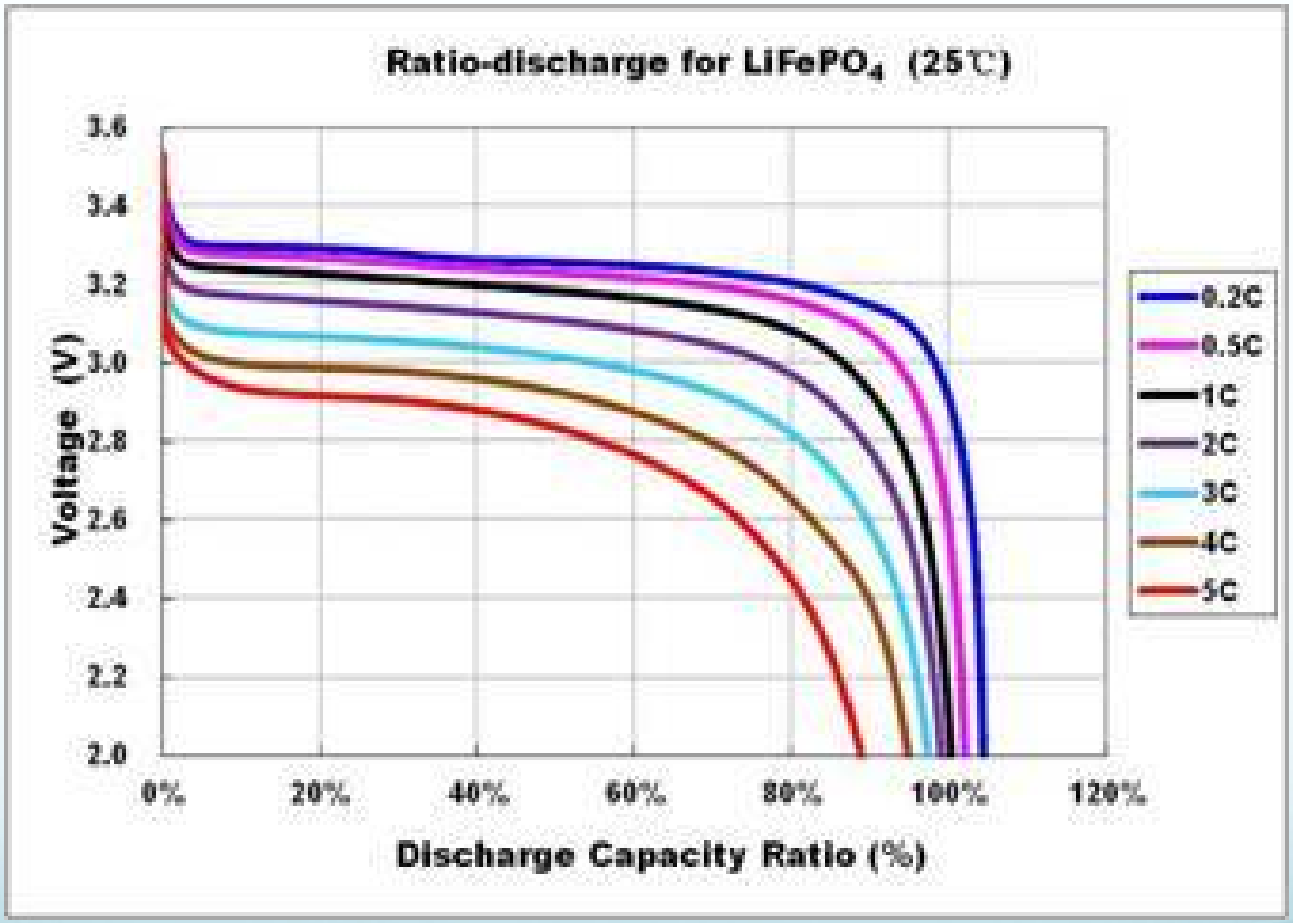
- lower discharge rate >> higher extracted energy
- lower charge rate >> higher stored energy

Ageing associated with DoD;

Ageing associated with discharge C-rate.

Battery Modelling Factors

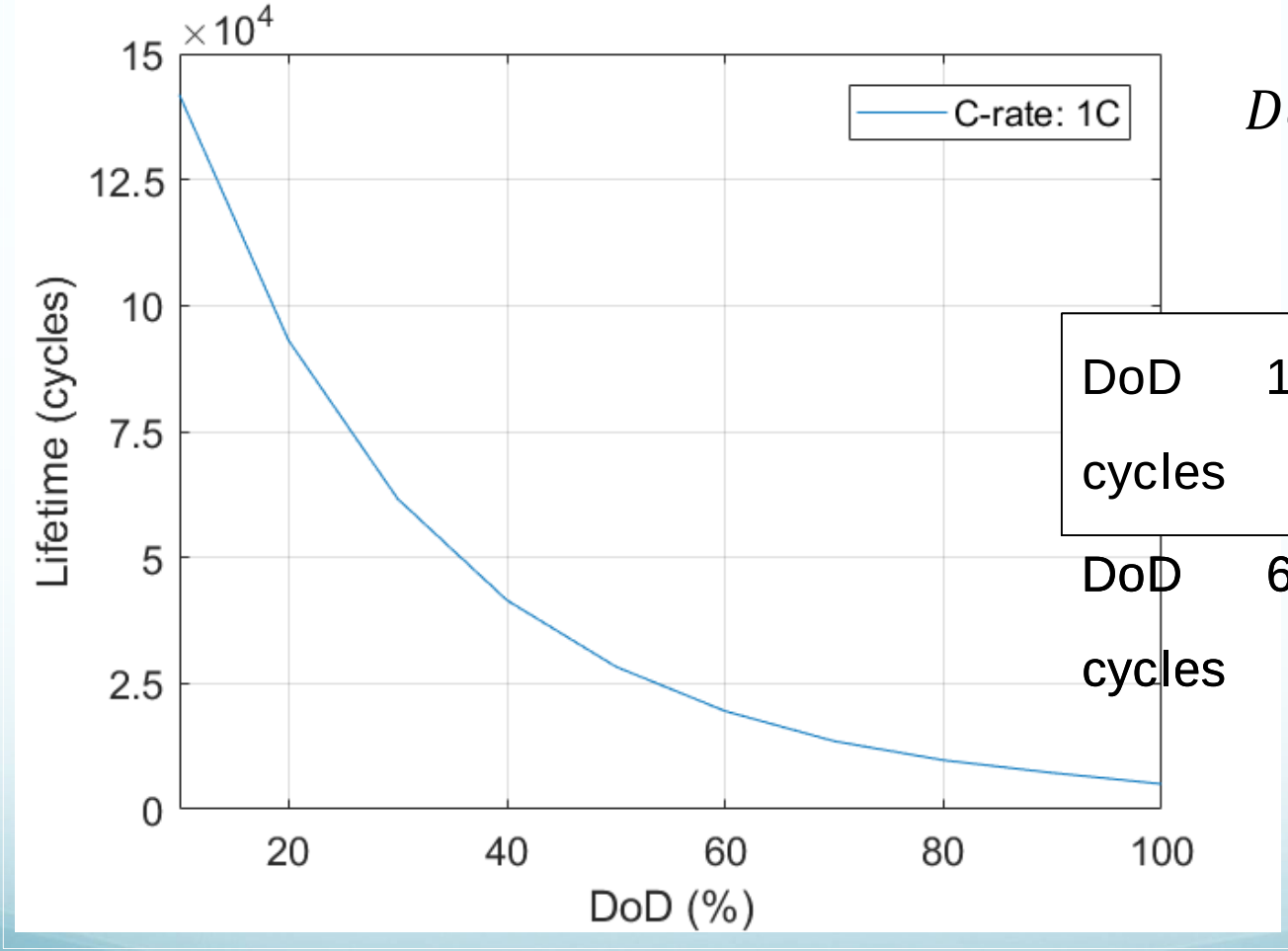
Rate capacity effect



Between 0.2C and 1C there is 6-7% of difference

Battery Modelling Factors

DoD vs Cyclelife, NMC-graphite cell



$$DoD = \frac{E_{DISCH}}{C_N}$$

DoD 100%, 700 cycles

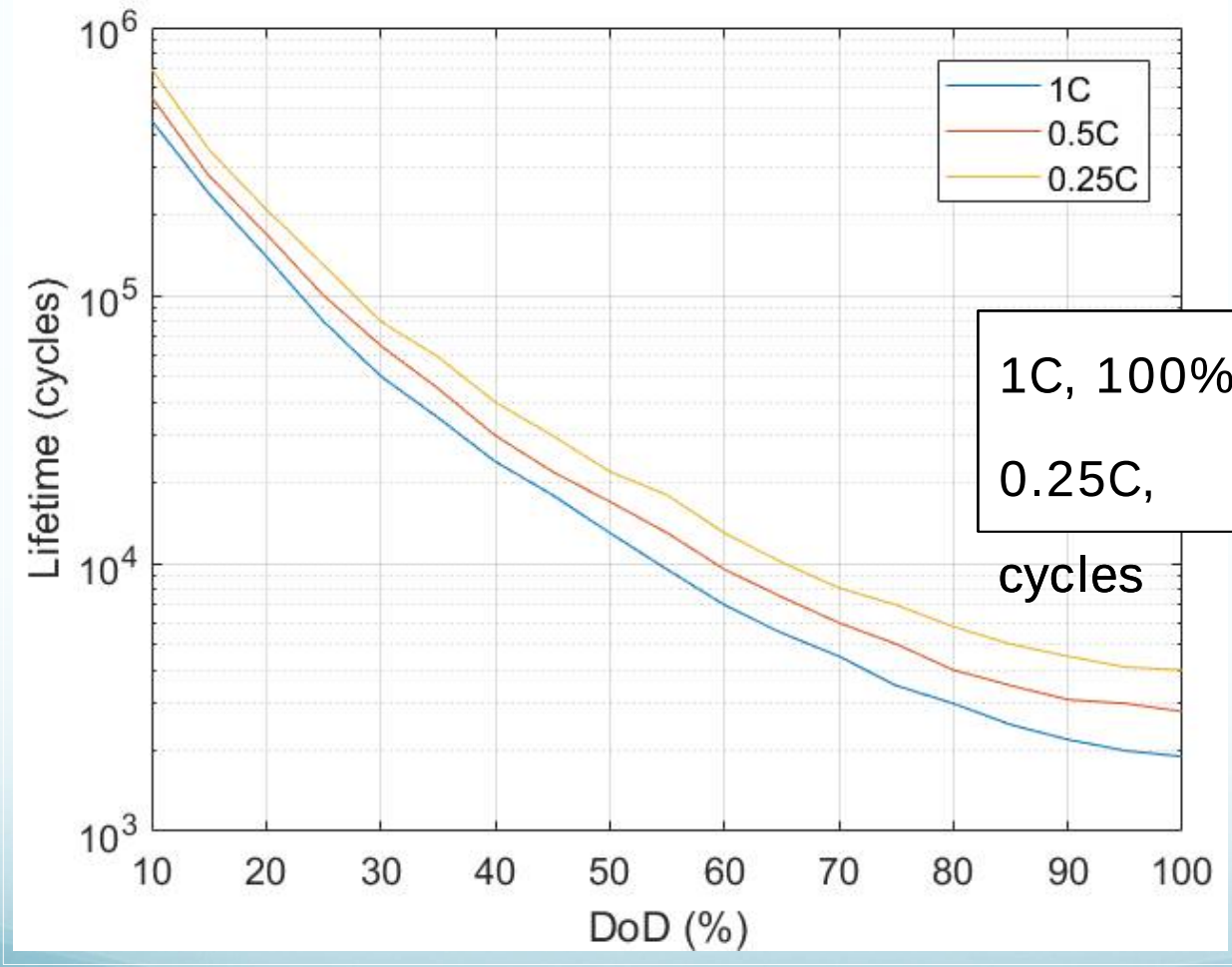
DoD 60%, 2300 cycles

$-E$

B. Xu; A. Oudalov; A. Ulbig; G. Andersson; D. Kirschen, "Modeling of Lithium-Ion Battery Degradation for Cell Life Assessment," in IEEE Transactions on Smart Grid , vol.PP, no.99, pp.1-1.

Battery Modelling Factors

DoD vs Cyclelife vs Discharge rate, LFPO cell



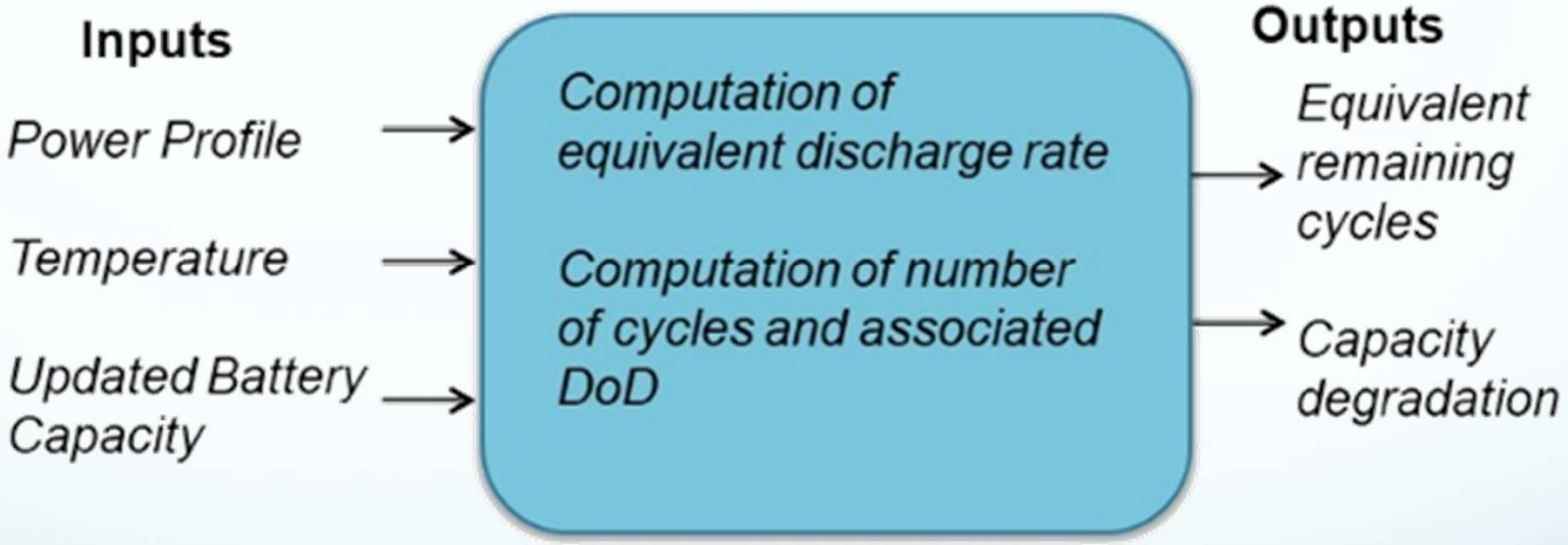
1C, 100%, 1900 cycles

0.25C, 75%, 7000 cycles

Database on ageing of Battery https://www.powertechsystems.eu/fr/home/technique/la-technologie-lithium-fer-phosphate).

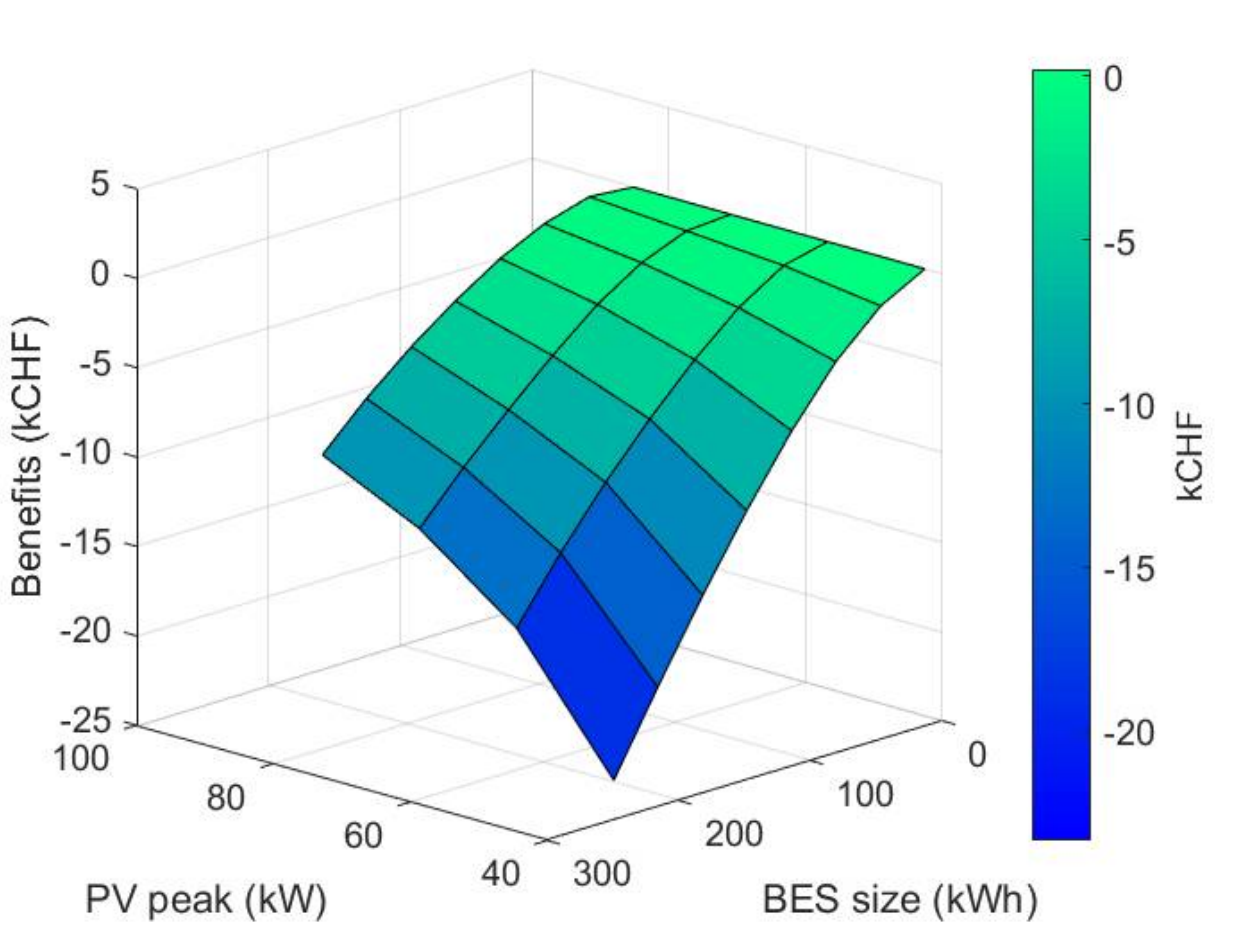
Battery Ageing Model

Structure of the battery ageing model



Preliminary results

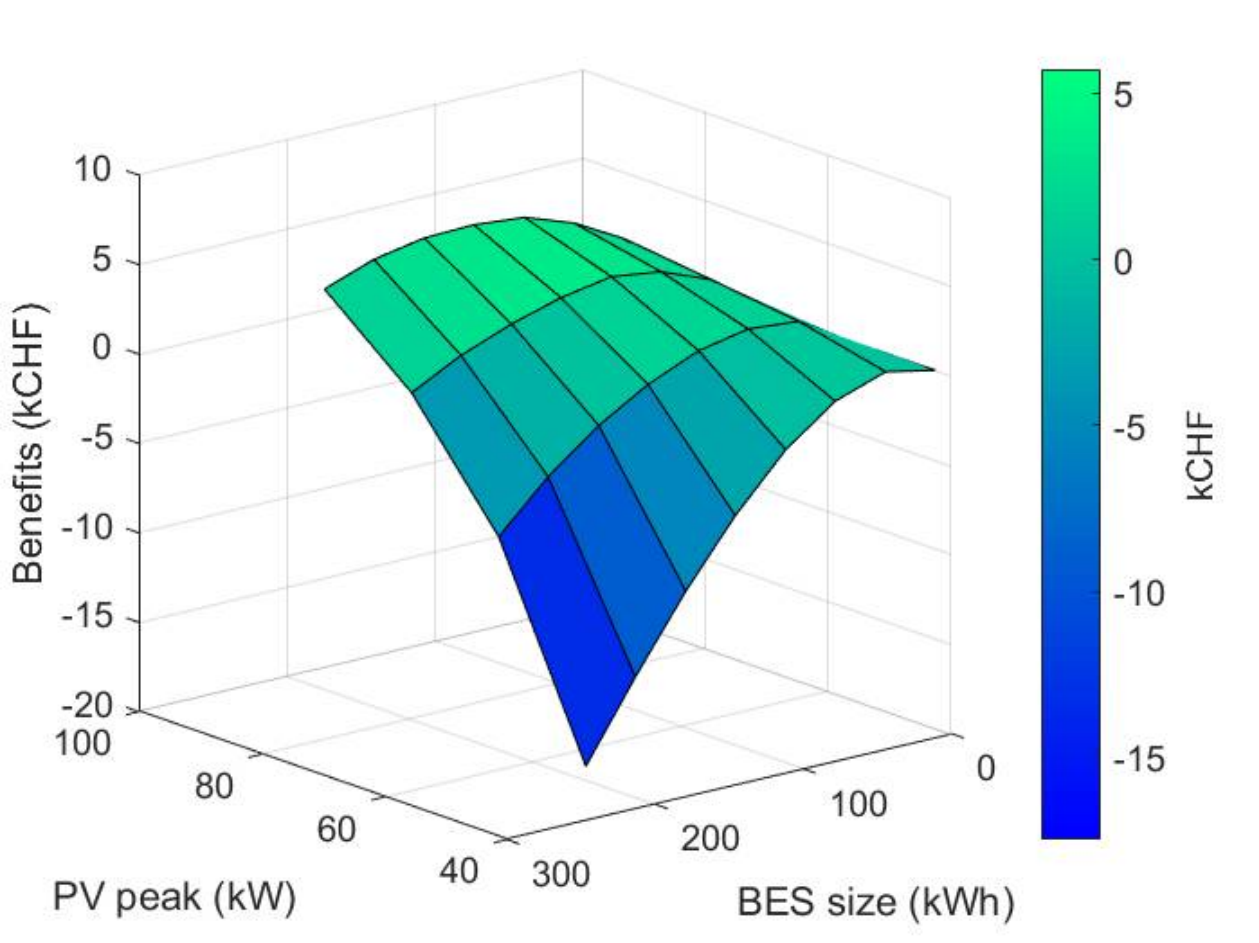
Benefits vs Battery Size vs PV Peak Power



5 years second-life battery

Preliminary results

Benefits vs Battery Size vs PV Peak Power



5 years second-life battery + 3 years of third-life thanks to our ageing management

Conclusion and Outlooks

Second-life batteries are not profitable during the declared 5 years of nominal life;

Third-life, namely 3 years after the second-life involve an economic benefit (up to 25% of the investment cost);

We have to manage the usage of the BES for minimizing its ageing, increasing the lifetime and consequently the benefit.

Thank you for your attention

Institute for Applied Research into Energy Systems (ENERGY)
University of Applied Science in Fribourg, Switzerland

Is ageing really so important?

The majority of Home Energy Storage devices are not profitable with the current price.

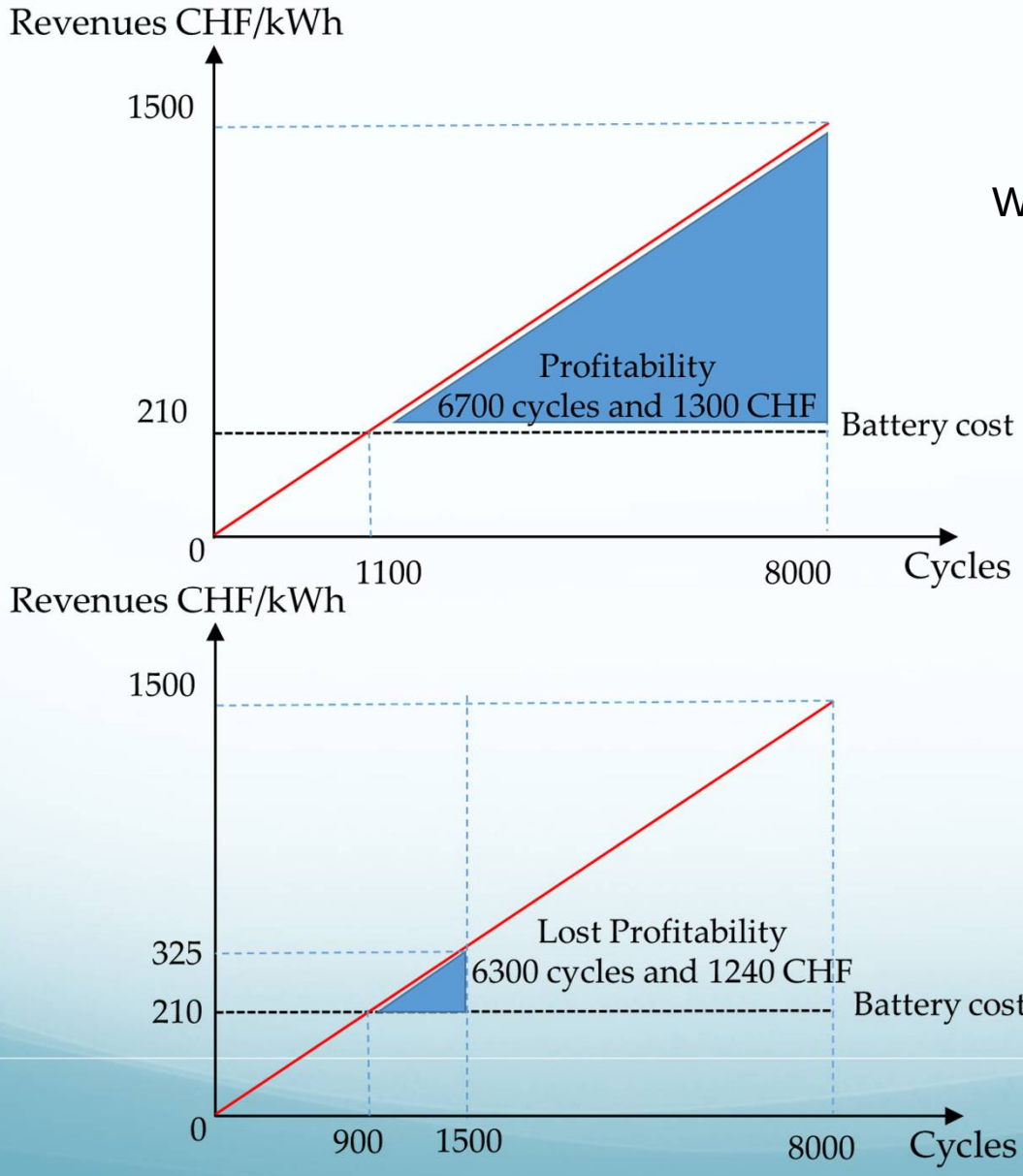
Example:

6.3 kWh, 3.3 kW, Li-ion NMC, efficiency 95%, Cycle life 8000 cycles at DoD=80%;

installation cost 9000 Eur

Cost per kWh= 0.24 Eur

Is ageing really so important?



With Ageing Aware Software:
1300 CHF benefit/kWh

8000 cycles

Without Ageing Aware Software:
120 CHF benefit/kWh

1500 cycles