Fachhochschule Nordwestschweiz
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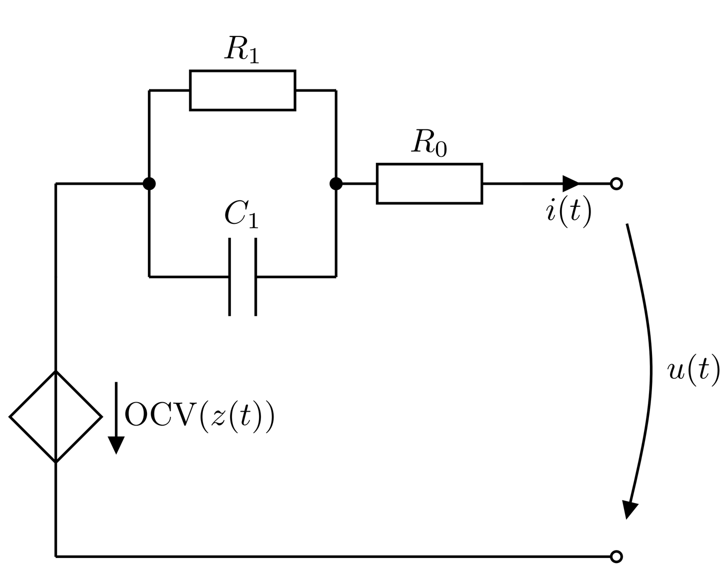
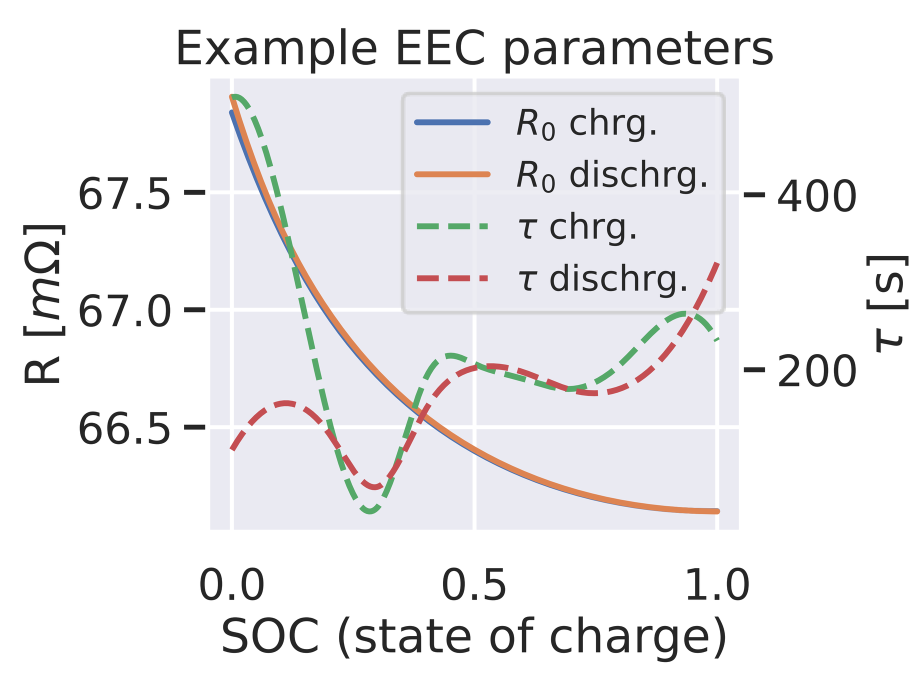
Python based digital twin battery simulator

Along with the worldwide expansion of renewable energies, the need to store self-produced energy is increasing. Considering the wide range of home storage systems, it is difficult to make the right choice. The developed software generates battery models based on physical principles. Using these models and existing consumption curves, it is possible to find the best fitting battery in seconds.

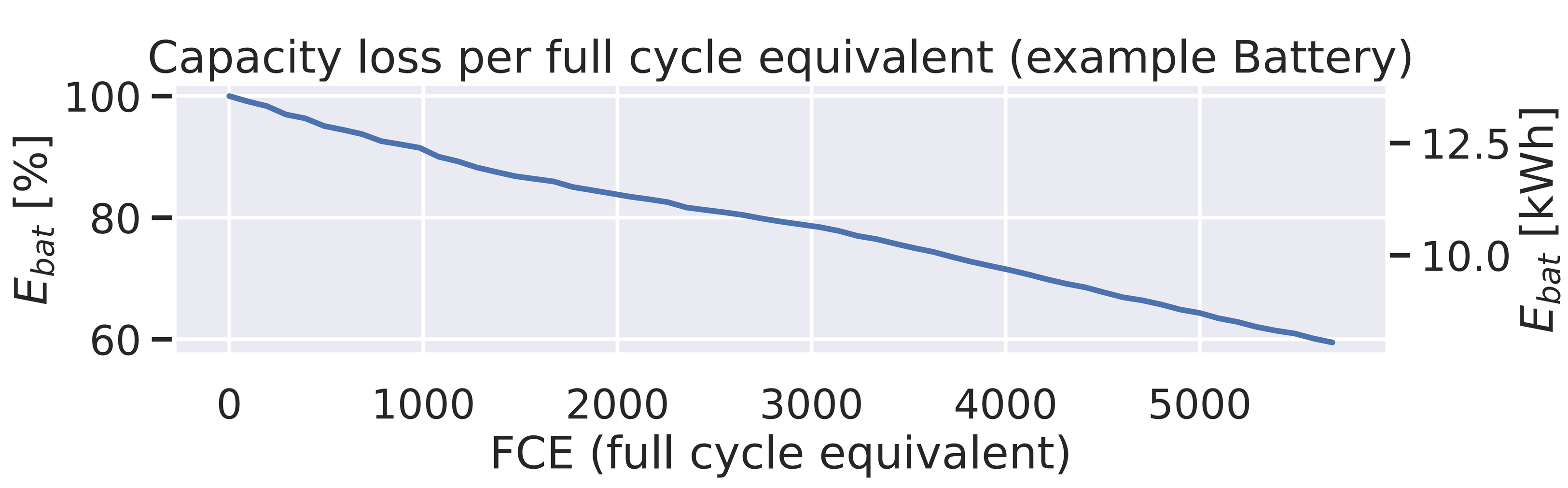
Creation of EEC-models

A virtual battery is stressed (cycling) by physical simulation. Based on the used aging approximation SEI (solid electrolyte interphase), the corresponding layer builds up and causes the battery to lose capacity. Repetitively, after a certain number of stress cycles, the electrical-equivalent-circuit (EEC) parameters will be determined.



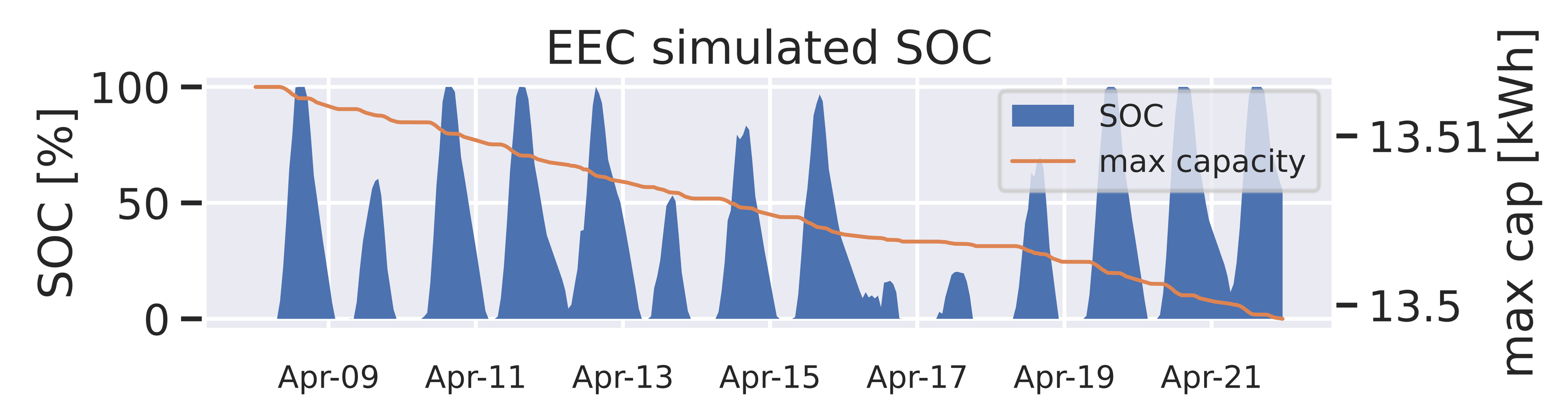


The parameters depend on the voltage jump (R_0) and the voltage recovery (R_1C_1) between an active and rest phase. The plot above shows the parameters of an example battery (13.5 kWh) at 60% SOH (state-of-health). This battery was used for all graphs in this poster. The simulated degradation curve can be found below.



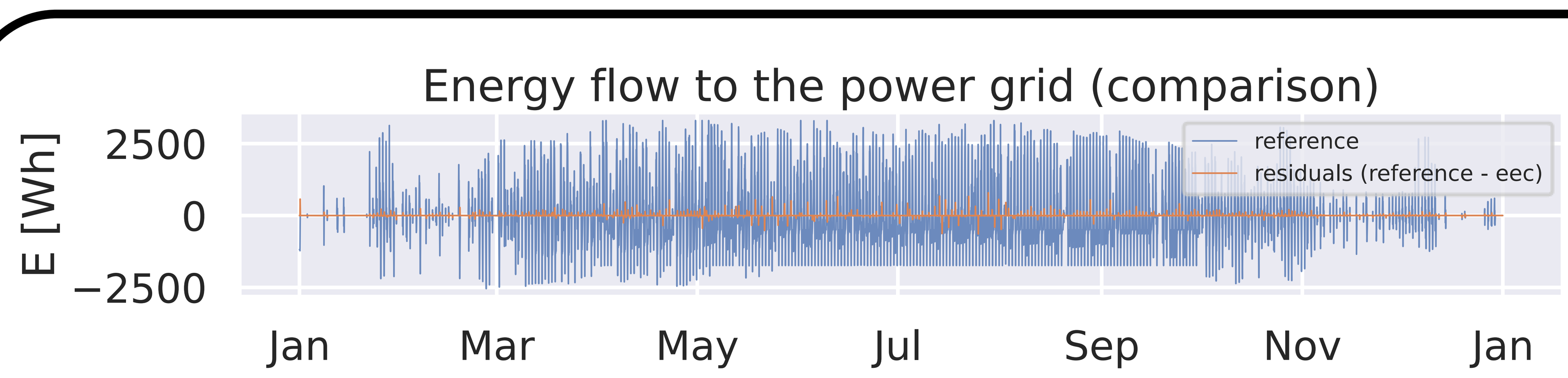
Simulating EEC-models

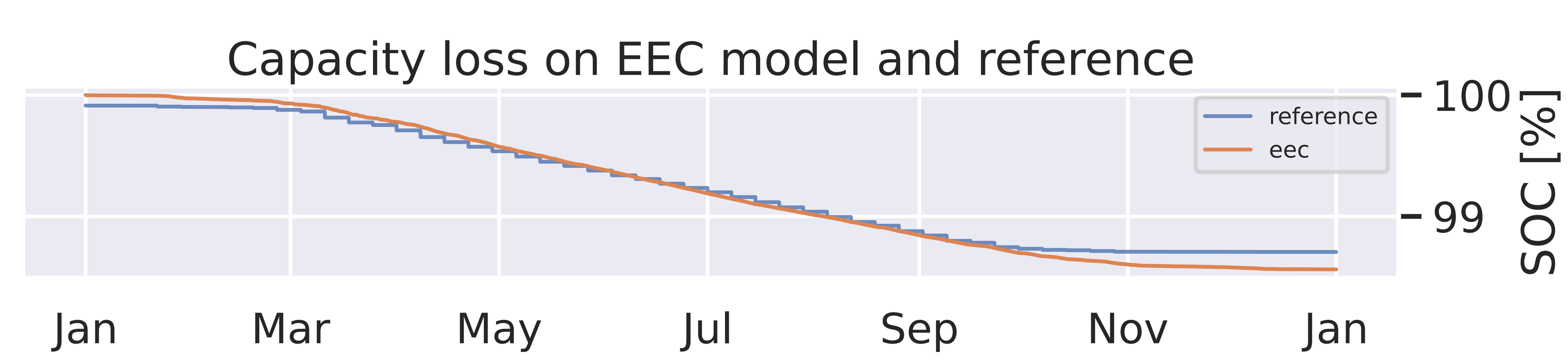
An EEC model is treated exactly like electrotechnical components and is used to determine the energy, battery losses and terminal voltage. Test simulations were carried out for various locations and consumers in Switzerland. EEC-simulation results for a single-family house in Basel with PV (4.3 kWp) can be found below. The orange part of the following plot shows the influence of the battery on the sampled data. PV overproduction (positive) and grid purchases (negative) are decreased by the battery.



The results can now be used to estimate the best fitting battery for a given household. For this purpose, different key-performance-indicators (KPI's) were defined, which can be formed from the simulation output. Since the simulation with EEC is enormously fast (<1s per yearly dataset), a very large amount of data with many locations and consumption curves could be simulated.

Another project of the FHNW is concerned with the bundling of the resulting data by means of machine learning in order to be able to provide an even faster battery recommendation in a web service.





The two plots compare the EEC simulation of the Basel household with a physical simulation performed in the same way. The deviation of the energy flow (1.5 %) and the capacity loss (0.14 % of the initial capacity) are in line with expectations. Small differences of the EEC are negligible considering the more than 10'000 times faster computation time (>3h vs <1s).

According to current information, the tool will soon be integrated into a web service and hopefully help make the world a little greener.

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References: