Rejuvenation of Fuel Cells

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During the execution of baseline tests on two µCHP units in the Sapphire project, malfunctions in the logging system caused a series of unscheduled shutdowns due to the crash of the computers controlling the systems; the µCHP systems experienced repeated emergency stops, after each of which laboratory personnel restarted them after some hours.
After over 3000 hours of testing, data logs indicated that stack voltages, while erratic, experienced a long-term recovery correlated with the frequency of emergency stops. Data analysis with techniques developed within Sapphire indicates that this recovery was due to an increase in catalytic activity, most likely on the cathodic side [1]. A second 3000-hour test campaign on both systems confirmed the ability of emergency stops to rejuvenate the fuel cells.

The results were surprising, since start/stops are usually associated to severe voltage degradation [2], but the data indicates that appropriately executed shutdowns can be beneficial for cell performance. The exact mechanism of the rejuvenation process is not identified yet, but the two µCHP systems investigated in Sapphire showed respectively record-low degradation rates (-0.2 µV/h) and sustained rejuvenation rates (4 µV/h) over 3000 hours, as shown in Figure 1.

The potential of cell rejuvenation for the automotive sector will be investigated in project Giantleap, which focuses on fuel-cell buses with a high degree of hybridisation with batteries. This high hybridisation gives a significant freedom to the control system to implement rejuvenation cycles on the fuel cells. A major concern is whether the rejuvenation cycles can be implemented in an automotive setting, and whether they could promote other secondary degradation mechanisms, e.g. membrane degradation.

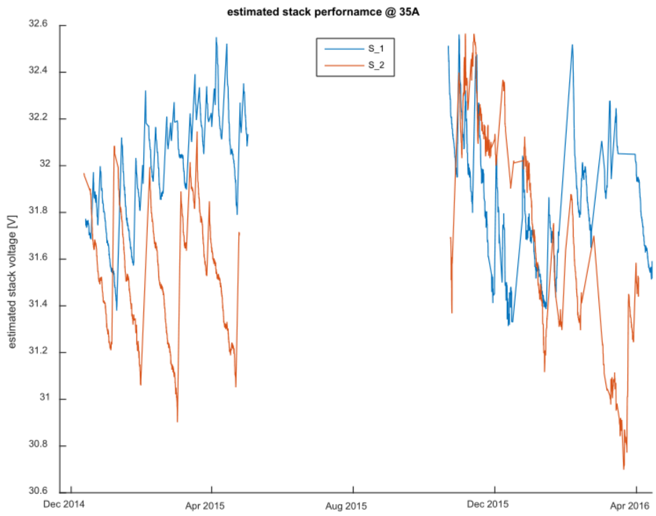

Figure 1 Stack voltage of two µCHP systems subject to repeated shutdowns over two 3000-hour test runs. The first run showed a degradation rate of -0.2 µV/h (system 2, orange) and a rejuvenation rate of 4 µV/h (system 1, blue). The second run confirmed the phenomenon with periods of repeated shutdowns and periods of steady operation.

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REFERENCES

1. J. Tjønnås, F. Zenith, I. J. Halvorsen, *Report on the advantages of PHM-aware control*, deliverable 7.3, Sapphire project.
2. D. Bezmalinović and F. Barbir, *Analysis of Degradation Mechanisms*, deliverable 5.1, Sapphire project.