Performance of methanol fuel cells in alpine environments

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1. Project description

The long-term use of scientific measurement or monitoring equipment on remote alpine sites is often confined to the vicinity of permanent installations or to available mobile energy sources. While combinations of solar panels and rechargeable batteries are readily available, their power output is limited by the surface area of the solar panels (larger battery packs provide more energy but need a large array of solar panels to be recharged within a reasonable amount of time). Additionally, during prolonged periods of unfavourable weather, the solar panels may not be able to compensate the energy needs of the equipment resulting in prematurely drained batteries.

Methanol-based fuel cells are not only small and safe to handle but also provide a fair amount of energy. Teaming fuel cells with solar panels and batteries, therefore, seems to be a sensible approach to a fail-safe power supply for unattended measuring campaigns in remote areas. However, available (civilian) commercial fuel cells are not built for alpine environments where they have to cope with bad weather, temperatures below freezing, low atmospheric pressure and very dry air.

2. Trial run

After the 2018 trial runs a few last tweaks were made to the weatherproof box and its electronics. The now finalized design was then tested inside a climate chamber and out on a field in

Figure 1. Methanol Fuel Cell in its weatherproof aluminium box with the attached auxiliary solar panel on the lower platform of the Sphinx observatory during the crisp February trials (image from 2018).

mid-summer, as a final proof of concept before freezing the schematics and packing for the final trial run (of this prototype) in an alpine environment.

Eventually, the 5-day test run with the military grade methanol-based fuel cell with a nominal power output of 130 W in a weatherproofed aluminium box was carried out at the High Altitude Research Station Jungfraujoch in February 2019. The fuel cell in its housing was placed on the lower platform of the Sphinx observatory (Fig. 1). A 45 W light bulb was used as electrical load to drain the battery and force the fuel cell to recharge. Every 15 minutes a set of 36 operational parameters from the fuel cell was logged. Additionally, the power output of the solar panel and the temperature inside and outside of the aluminium box was logged every minute.

3. Results

During the trials, the fuel cell did not perform according to specifications at all…

The campaign on the Jungfraujoch took place in favorable conditions: Three days of unspoiled sunshine and two days with cloud cover and scattered light snowfall, temperatures constantly below freezing. As it was February, daytime hours were limited to just shy of 10 hours resulting in 38 h of (theoretical) sunshine during the 94 h test run. Accordingly, the solar panel delivered 1400 Wh (2018: 1100 Wh) to the battery. The fuel cell on the other hand, produced only 2300 Wh, which is considerably less than the 3900 Wh from the previous year.

Already during the first night atop the Jungfraujoch it was becoming obvious, that something wasn't right. During daylight hours the solar panel delivered enough power to fuel the light bulb, operate the system and fill the battery to its max capacity. As soon as daylight faded, the light bulb started to drain the battery. Eventually, the fuel cell powered up – as it was supposed to – but it would only deliver an average of 55 W (2018: 85 W), not enough to feed the system, power the light bulb and recharge the battery. Consequentially, the light bulb drained the battery to the point at which the charge controller decided that it needed to disconnect the electrical load to keep the battery from getting permanently damaged. Now the fuel cell was able to recharge the battery once more but as soon as the electrical load was reconnected, the light bulb again used more energy than the fuel cell was able to deliver.

After day two of the trials the light bulb was disconnected during the night, in order to allow the fuel cell to recharge the battery and to enable us to continue with the experiment at dawn the next morning.

Back in the laboratory in Thun, a test run of the fuel cell confirmed its considerably reduced performance. After a thorough inspection, the manufacturer came to the conclusion that the fuel cell had reached its end of life and the reduced performance of the stack was a consequence of normal damage due to wear and tear, which was to be expected after generating energy for (accumulated) 1750 h during a total of 18 months of continuous operation (accumulated).

4. Conclusions

The numerous campaigns at the High Altitude Research Station Jungfraujoch during the last couple of years showed that commercially available (military grade) fuel cells are capable of performing according to specifications even at high altitudes. The stand-alone solution proved to be perfectly suited for continuous unattended operation in alpine environments. By adding a solar panel, the operating time of the fuel cell on one tank of methanol (10 ℓ) was more than doubled.

In the follow-up campaign in 2020 the replacement fuel cell in its finalised weatherproofed box will undergo its maiden trial. As an upgrade to the set-up used in the previous seven years, the light bulb will be replaced by a software controlled electrical load, simulating a worst-case version of the designated use of the system.

Additionally, a second system will be built on the basis of the configuration level of the first at the end of 2019's low temperature test and fitted with a second fuel cell. This system will be ready for high alpine testing at the beginning of 2021.

Collaborating partners / networks

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