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 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 runs

With increasingly higher temperatures during summer months, optimisation of the air flow inside the aluminium box were becoming necessary. In a first step, the weatherproofed box was

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.

augmented with an air duct to meet the exhaust of the fuel cell and to guide the hot vapours directly to the outside. Before packing and shipping the system to the Sphinx observatory, it had to pass a series of performance tests in its new configuration in warmer conditions and at moderate altitudes (500 m.a.s.l.) which took place in August 2017.

Eventually, a 5-day test run with the military grade methanol-based fuel cell with a nominal power output of 130W in a weatherproofed aluminium box was carried out on the High Altitude Research Station Jungfraujoch in February 2018. 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, and a direct consequence of 2017's mystery of the lost 1000 Wh, the power output of the solar panel was logged every 10 seconds.

3. Results

During the trials, the fuel cell performed according to specifications.

The campaign on the Jungfraujoch took place in perfect conditions: Five days of unspoiled sunshine with temperatures constantly considerably below freezing. As it was February, daytime hours were limited to just shy of 10 hours (as opposed to 15 h in May) resulting in 36 h of sunshine during the 92 h test run (55.5 h during 91 h in May 2017). Accordingly, the solar panel produced "only" 1000 Wh (2017: 1500 Wh) and the fuel cell 3900 Wh (2017: 3000 Wh). Since it was considerably colder than during the previous year's campaign, the fuel cell had to switch to the anti-freeze mode during idle times more frequently in order to prevent permanent damage to its stack. Thus, having to produce additional 400 Wh of energy (relative to 2017) to meet the increased on-site power required.

4. Conclusions

The numerous campaigns at the High Altitude Research Station Jungfraujoch during the last couple of years showed that commercially available fuel cells are capable of performing according to specifications even at high altitudes. The stand-alone solution which was the centre point of this year's tests 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.

For the follow-up campaign(s) in 2019 the design of the weatherproofed box will be finalised and the interplay of the components further optimised. Additionally, a second system will be built on the basis of the configuration level of the first system at the end of the low temperature tests taking place in February 2019.

Collaborating partners / networks

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