

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. Therefore, teaming fuel cells

with solar panels and batteries 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 somewhat troubled 2020 trial run the electrical load was completely redesigned.

The new electrical load is now controlled by a rather quaint but reliable analogue timer switch, simulating a worst-case version of the designated primary use of the system. The electrical load was designed to represent chatty traffic on a radio relay varying power



Figure 1. Methanol Fuel Cell in its weatherproof aluminium box with the attached auxiliary solar panel on the lower platform of the Sphinx observatory halfway through the February trials.

demand between 15 and 100 W over a period of 8 hours, followed by 16 hours of “radio silence” and restarting the cycle afterwards.

The 5-day test run with the military grade methanol-based fuel cell with a nominal (sea level) power output of 130 W in a weatherproofed aluminium box was carried out on the High Altitude Research Station Jungfrauoch in February 2022. The fuel cell in its housing was placed on top of the new electrical load on the lower platform of the Sphinx observatory (Fig. 1). During operation every 15 minutes a set of 36 operational parameters from the fuel cell was logged and stored online. Additionally, the power output of the solar panel, the power demand of the electrical load and the temperature inside and outside of the aluminium box was logged locally every minute.

3. Results

During the trials, the fuel cell did perform according to specifications, eventually.

The campaign on the Jungfrauoch took place in changeable conditions: Team and equipment were greeted by a massive snowstorm which lasted until Tuesday morning, preventing the setting up of the solar panel. While Tuesday had a bit of everything in store, Wednesday was all about sunshine, followed by passing clouds for the remainder of the week. As it was February, daytime hours were just under 11 hours resulting in 33 h of (theoretical) sunshine during the 72.5 h of the test run with the solar panel in operation. Accordingly, the (new) solar panel delivered 1460 Wh (2021: 930 Wh) to the battery. The fuel cell on the other hand, produced just 540 Wh, which was mainly a by-product of trying to prevent the stack from freezing.

The electrical load required on average just shy of 40 W during the 24 h of simulated radio chatter resulting in 960 Wh. In earlier years a 45 W lightbulb was used as the electrical load, demanding about 3.3 kWh in total during a 72.5 h test run. While the latter approach certainly put considerable pressure on the fuel cell, it wasn't exactly a realistic use case. The former, on the other hand, while

definitively closer to a real-life use case might just be a tad on the easy side.

However, this meant that the fuel cell had more than enough time to cool and was repeatedly forced to fire itself up to prevent the stack from freezing. It did so a total of 24 times.

Solar panel and fuel cell delivered 2 kWh to the battery while the electrical load used 960 Wh. This means that the system itself required 1.04 kWh to operate, which translates to roughly 14 W of stand-by consumption of the base system (e.g., modem, fans, inverters...).

These results, however, have to be taken with (at least) a grain of salt. The storm on Monday, with temperatures down to -30 °C, quickly forced the fuel cell to fire itself up to prevent the stack from freezing. But since the trial runs always start with a fully charged buffer battery, there was nowhere to go with the surplus energy, resulting in an error and, subsequently, leading to an automatic shut-down. Manual resets obviously couldn't remedy the problem, so it was decided to halt the trial run and move the system indoors until the storm had passed. While necessary, this led to a poorly defined system status for the reboot on Tuesday morning.

4. Conclusions

The numerous campaigns at the High Altitude Research Station Jungfrauoch 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 2023 the second fuel cell in its own, slightly different weatherproofed box will repeat its full-length maiden trial.

Collaborating partners / networks

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