# Different ways of Electrolyser Power Supply

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**Abstract.** The aim of this paper is to describe and show the results of measurements made on the hydrogen accumulation system, whose main part is the low-temperature PEM electrolyser type Hogen GC600. Electrolyser was supplied in two ways. First way was from the distribution network 230/400V and second one from the photovoltaic (PV) panels. Measurements were carried out in different operating modes of electrolyser. The results should serve to better understanding of hydrogen storage system (electrolyser) functionality and increase its efficiency.

## 1 Introduction

From the previous measurements on hydrogen storage system has been the overall efficiency set on 23%. As the least efficient point of storage system in which one could be increased the efficiency, appears to the electrolyser with efficiency ranging from 19 to 27%, depending on the time of its operation and especially the frequency of the switching losses arise due to the necessary warming up and pressuring prior to the delivery of hydrogen to the vessels or metal hydrides. This type of electrolyser produces very high purity hydrogen (99.9999%), which is particularly suitable for diagnostic purposes. The module (s) Nexa fuel cell used in the system requires hydrogen purity "only" 99.99%. From the previous measurements on storage system also implies that there are certain gaps manifested undesirable operating states of a system control system whose elimination is expected to further increase efficiency. Currently therefore is more detailed traffic analysis of the entire system. The aim is to optimize it in such a way that the aforementioned operating conditions will be completely eliminated. The choice between the vessels and metal-hydrides will also need to be resolved. For a deeper analysis of the problem and better understanding how the storage system works were done new measurements when the electrolyser was supplied from the grid 230/400V and from the PV panels.

## 2 Electrolyser supplied from the grid 230/400V

During all-day measurement was tested several modes of electrolyser operation in which it could be effectively operated. The evaluation should show which of the selected mode will be most economical (with the lowest power consumption). Analysis results of the measured data should help to identify such a working mode in

which the electrolyser operates with minimal energy losses and thus with the highest efficiency.

**Tab. 1** Electrolyser supplied from the grid 230/400V

| Electrolyser status | Time | Amount of produced $H_2$ | Power consumption | Total power consumption |
|---|---|---|---|---|
| | min | liter | Wh | Wh |
| warming up | 9:57 | 0 | 71 | 465 |
| Pressuring | 3:05 | 0 | 34 | |
| $H_2$ production | 60:00 | 36.9 | 360 | |
| standby mode | 30:00 | 0 | 63 | 241 |
| warming up | 0 | 0 | 0 | |
| Pressuring | 0 | 0 | 0 | |
| $H_2$ production | 30:00 | 19.43 | 178 | |
| Shutdown mode | 30:00 | 0 | 0 | 221 |
| warming up | 1:05 | 0 | 2 | |
| Pressuring | 3:00 | 0 | 30 | |
| $H_2$ production | 30:00 | 19.45 | 189 | |
| Shutdown mode | 60:00 | 0 | 0 | 227 |
| warming up | 2:00 | 0 | 8 | |
| Pressuring | 3:05 | 0 | 31 | |
| $H_2$ production | 30:00 | 19.12 | 188 | |

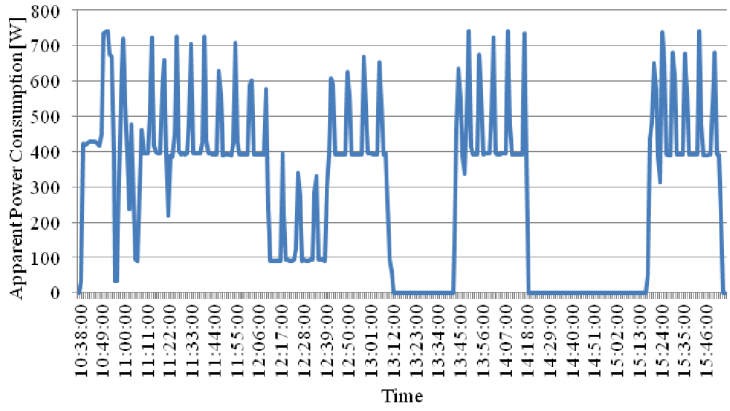


**Fig. 1** Apparent Power Consumption

Electrolyser was operated in "Standby mode", which means that is always ready to produce hydrogen (electrodes are continuously heated and maintains a constant pressure of hydrogen). In "Shutdown mode" is electrolyser completely disconnected from the power supply (hydrogen is not produced and electrodes cool down to ambient temperature). During the measurements were subtracted values of consumption, quantity of produced hydrogen and times necessity for these modes.

According to the values listed in Table. 1 the most economical mode seems to be a "Shutdown Mode (30:00 min)" then compared with the "Shutdown Mode (60:00min)" heats up the electrodes about one minute less.
During the measurement (in 13th minute) was recorded power outage which can be seen in the graph in Fig. 1 and 2. However, this did not affect the results concerning the modes of the electrolyser. Fig. 2 shows the progress and the amount of hydrogen produced in different examined modes.

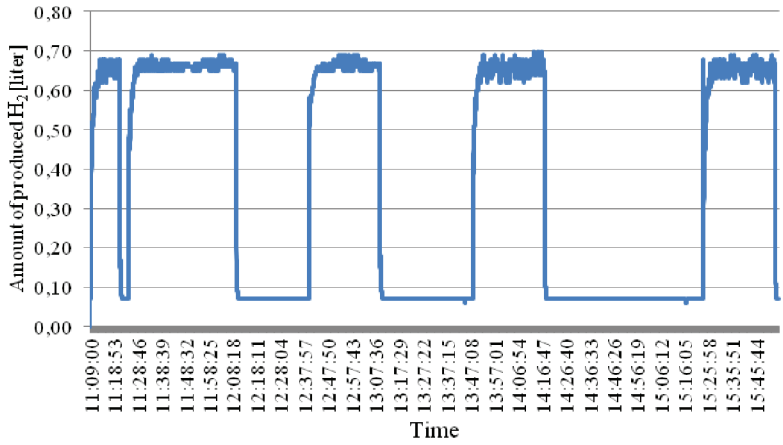


**Fig. 2** Amount of produced hydrogen

## 3 Electrolyser supplied from the photovoltaic panels

Measurement on electrolyser powered from the PV panels was carried out in the autumn month of October. Although solar activity in this time of year is lower than in the summer months, the intensity of radiation panels (see Fig. 3) was sufficient to cover electrolyser consumption.

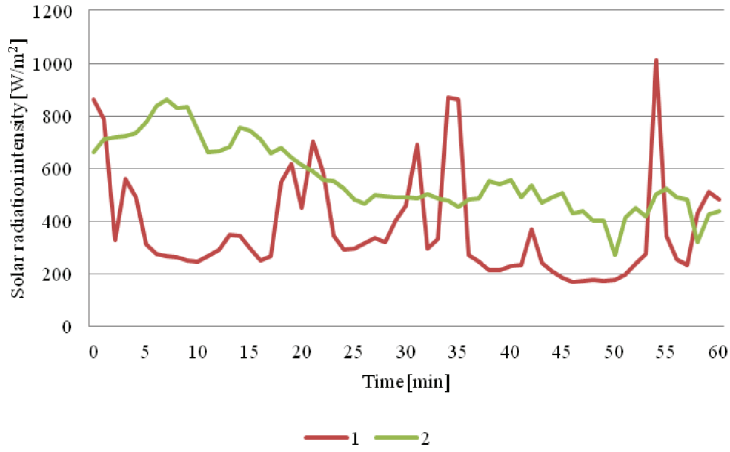


**Fig. 3** Solar radiation intensity
* (1 – Standby mode (11-12 am), 2 – Shutdown mode (1-2pm))

The device was as in the case of supply from the grid operated at different times of hydrogen production in the Standby and Shutdown mode. By using Datalogger were recorded voltage and current on polycrystalline PV panels Schott Poly165, Sunny Island Charger, Sunny Island 4282 and electrolyser Hogen GC600.

**Tab. 2** Solar radiation intensity *

| Solar radiation intensity [W/m$^2$] | 1 | 2 |
|---|---|---|
| average | 372.2 | 562.7 |
| min. | 170 | 270 |
| max. | 1012 | 860 |

## 3.1 Standby mode

**Tab. 3** Intermittent operation

| | Mode | Amount of produced $H_2$ [liter] | Power consumption [Wh] |
|---|---|---|---|
| 25 | start and $H_2$ supply | 16.01 | 245 |
| 1 | standby | 0 | 0.89 |
| 5 | $H_2$ supply | 2.33 | 42.11 |
| 2 | standby | 0 | 1.71 |
| 5 | $H_2$ supply | 3.09 | 35.25 |
| 3 | standby | 0 | 4.68 |
| 5 | $H_2$ supply | 3.18 | 39.51 |
| 4 | standby | 0 | 5.62 |
| 5 | $H_2$ supply | 3.42 | 37.6 |
| 5 | standby | 0 | 6.71 |
| 10 | $H_2$ supply | 6.43 | 79.14 |
| 10 | standby | 0 | 17.48 |

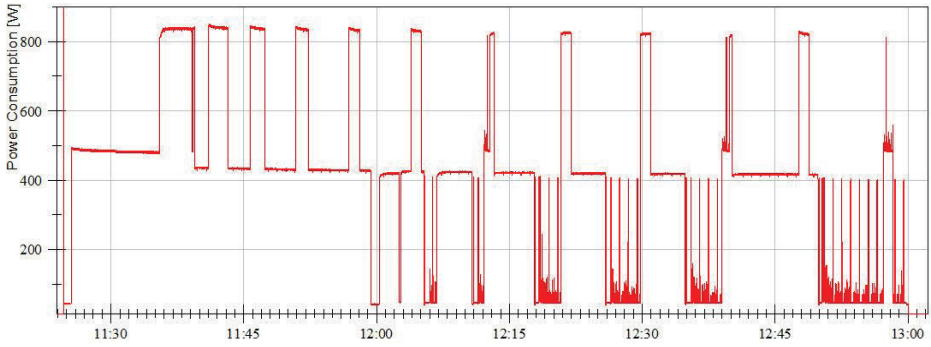


**Fig. 4** Power Consumption - Standby mode

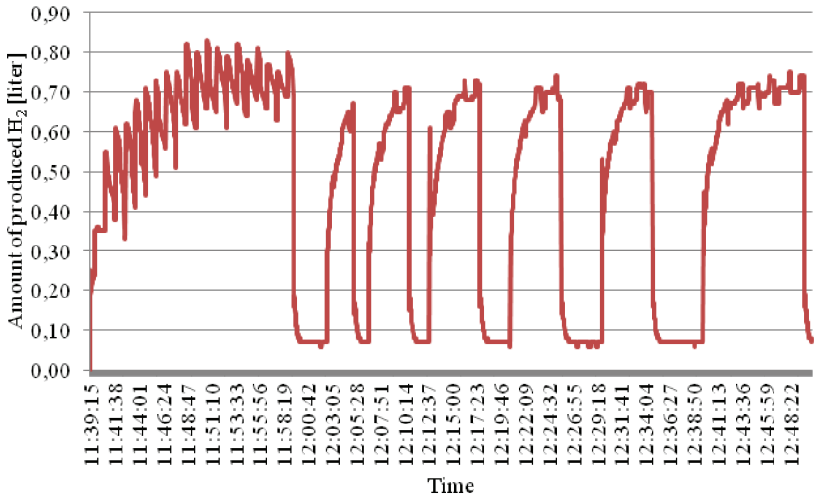


**Fig. 5** Amount of produced $H_2$ - Standby mode

## 3.2 Shutdown mode

**Tab. 4** Intermittent operation

| Time [min] | Mode | Amount of produced $H_2$ [liter] | Time [min]** | Power consumption [Wh] |
|---|---|---|---|---|
| 10 | start and $H_2$ supply | 6.92 | - | 133.18 |
| 1 | shutdown | 0 | 0 | 0 |
| 5 | $H_2$ supply | 1.3 | 2:35 | 41.22 |
| 2 | shutdown | 0 | 0 | 0 |
| 5 | $H_2$ supply | 1.07 | 3:00 | 41.15 |
| 3 | shutdown | 0 | 0 | 0 |
| 5 | $H_2$ supply | 1.02 | 3:05 | 35.57 |
| 4 | shutdown | 0 | 0 | 0 |
| 5 | $H_2$ supply | 1.01 | 3:05 | 41.94 |
| 5 | shutdown | 0 | 0 | 0 |
| 10 | $H_2$ supply | 4.88 | 3:20 | 88.88 |

** Required to warming up and pressurize before $H_2$ delivery

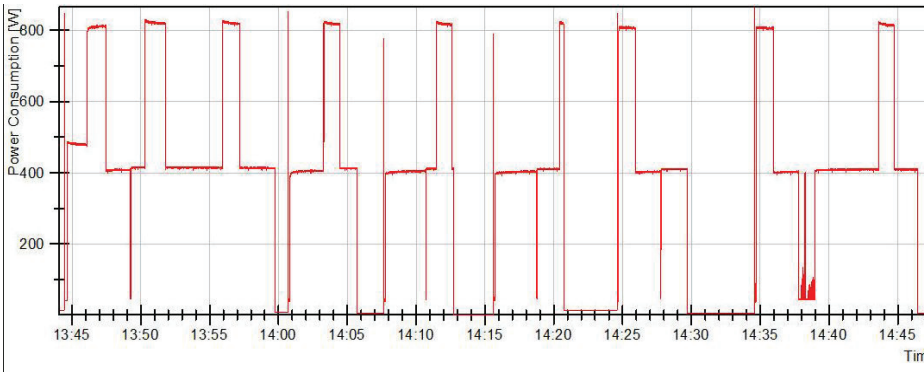


**Fig. 6** Power Consumption – Shutdown mode

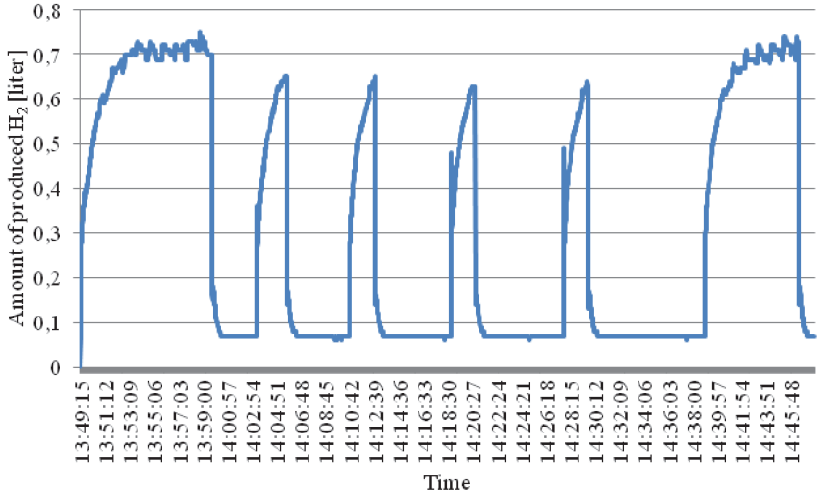


**Fig. 7** Amount of produced $H_2$ – Shutdown mode

## 4 Conclusion

When comparing the two modes from Tab. 2 and 3 we find that in Standby mode will produce a liter of hydrogen times more than in Shutdown mode and only with a slightly higher consumption. One of the main reasons is that when you go to the electrolyser Shutdown mode it tends to cool to ambient temperature. It will cause that after turn on have to re-warm up electrodes and subsequently pressurise hydrogen to a selected pressure, causing the largest losses. Similar measurements will be repeated in the near future, so that theory could be confirmed or clarified.

## Acknowledgement

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## References

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