# Hybrid Hydrogen Fuel Cell and Solar PV Off-Grid System for Off-Grid Telco Site Project Report

## 26th May 2016


## Solar NRJ Sdn Bhd

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## On Behalf
## MALAYSIAN TECHNICAL STANDARDS FORUM BHD

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## Installation Works

Installation started on 8th December, works involved:

- structure installation for solar panel
- solar panel installation
- control panel installation
- battery installation
- fuel cell installation
- electrolyser installation
- water tank installation
- hydrogen tank installation
- cabelling, wiring and piping installation

Installation duration: 3 weeks.


## Calibration Process

After completion of the installation, calibration process was done to ensure all the system works as per design.

- Programmable Logic Interface/PLC
- Fuel Cell Start-up Process
- Solar System
- Electrolyser Start-up Process
- SCADA System
- Safety System

Calibration: 2 weeks

Basically, programmable logic interface is the heart of our system. PLC will control of the sequence of work for this system such as switching ON/OFF between fuel cell and battery system, electrolyzer turn ON/OFF time, trigger the alarm and others.

## Testing and Commissioning.

Testing and commissioning was done with the DIGI site to ensure the system works based on plan and follow all the specification and standard required. Type of the testing and commissioning that had been done are:

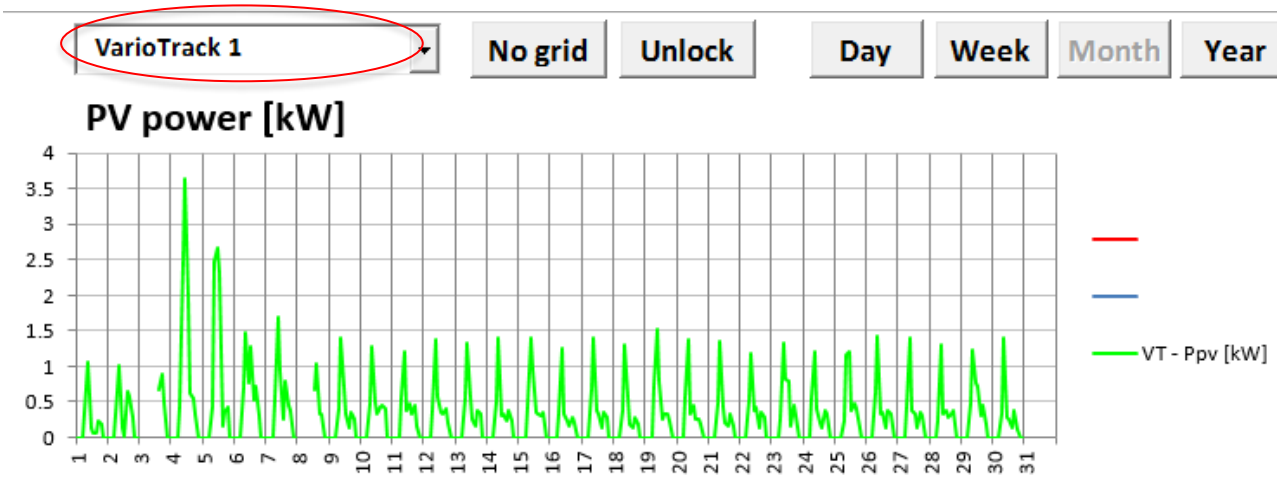
**Appendix**

## Launching Ceremony

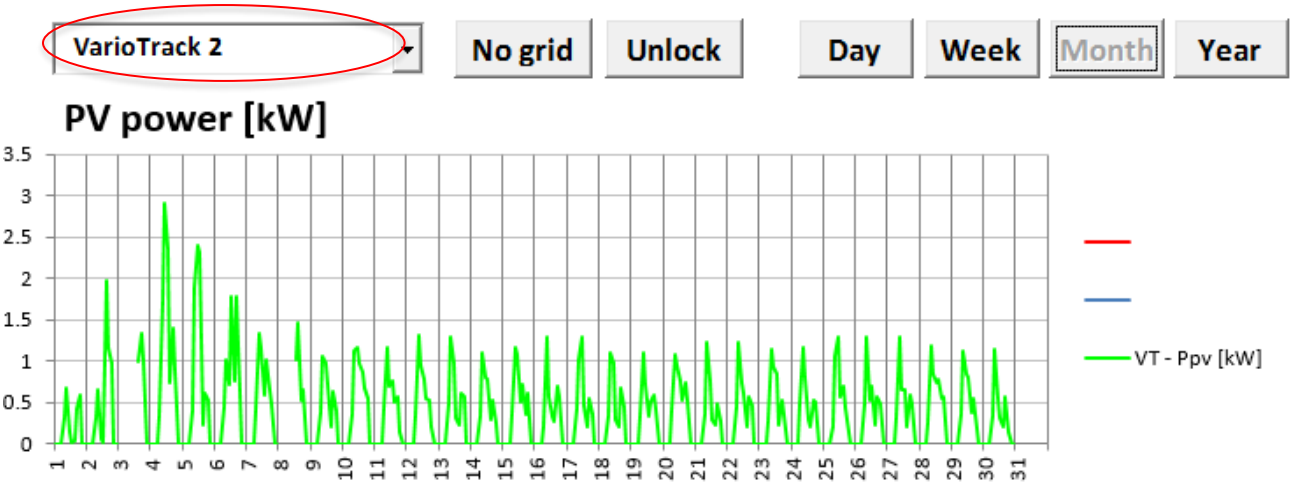
The launch was held on 7 April 2016 at that project site. YBHG DATO' MOHD ALI HANAFIAH MOHD YUNUS officially launched the Proof-of-concept.

## Data Analysis and Performance of the system.

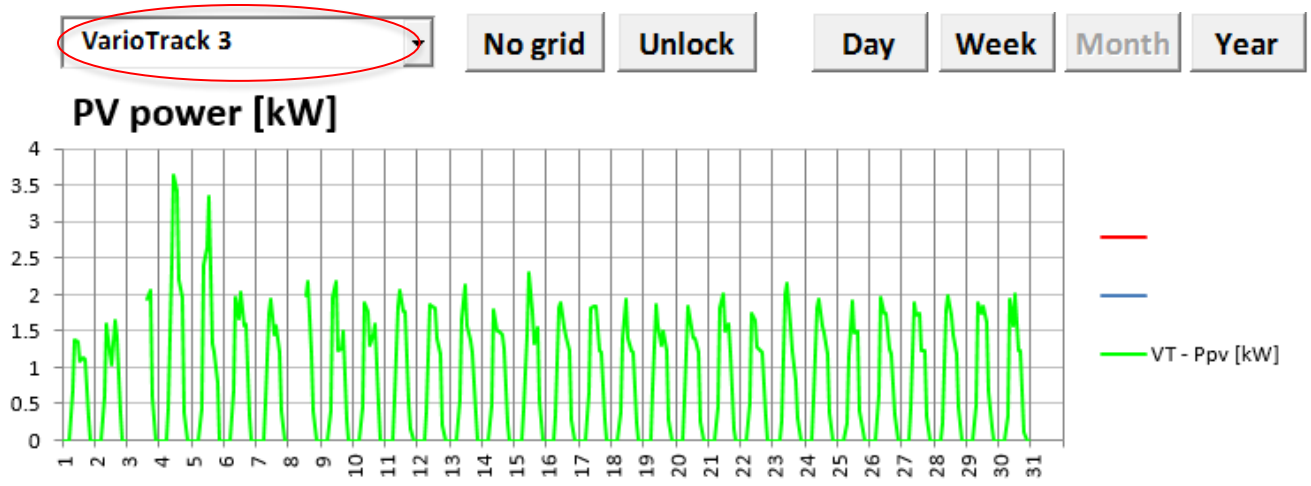
On this section we will discuss regarding of the overall performance of the system based on the data that we collected on April this year. Solar system is divided into 4 section (using four charge controller). Below is the performance of all section for solar system.



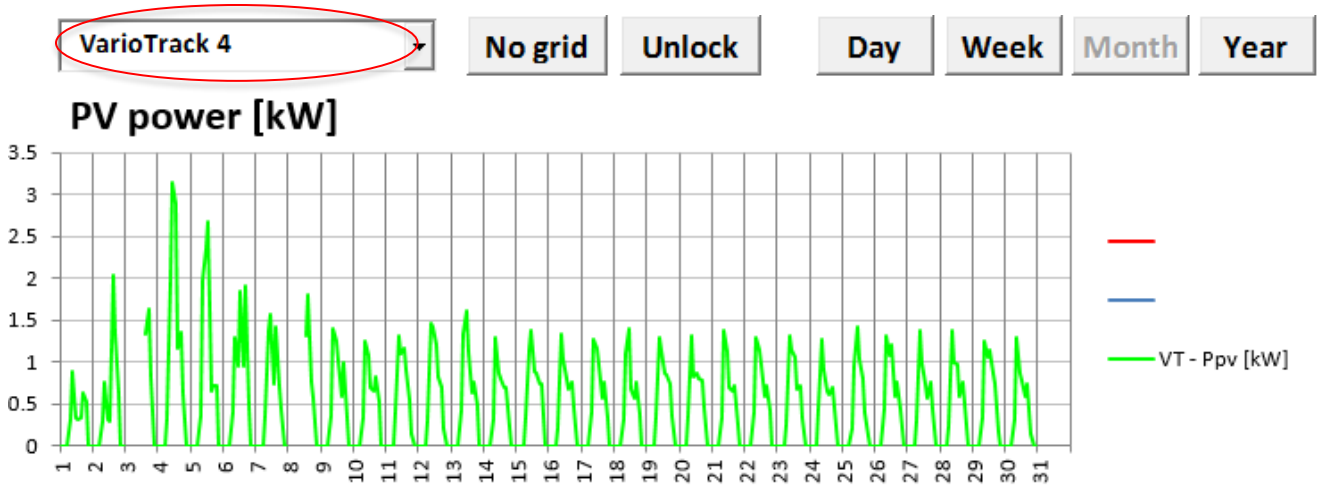

(Section 1 PV Power)



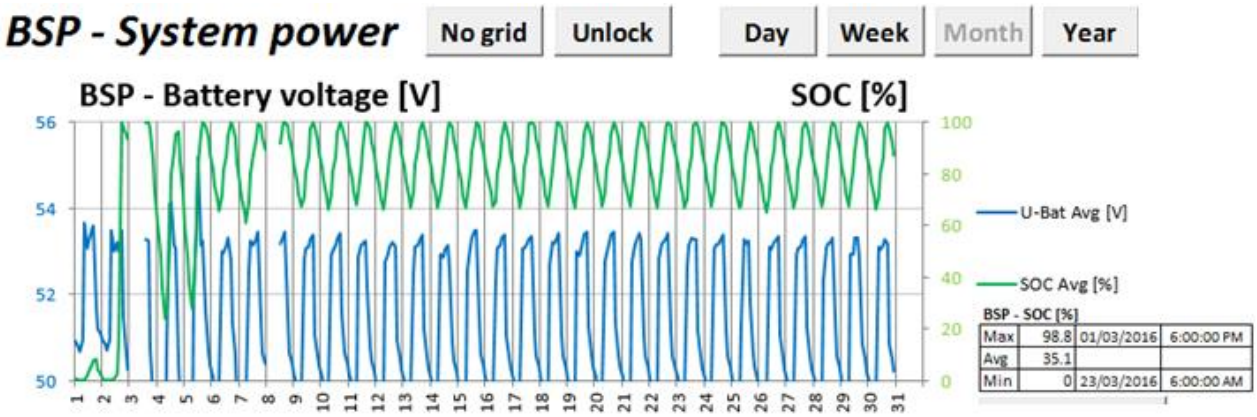

(Section 2 PV Power)




(Section 3 PV Power)




(Section 4 PV Power)

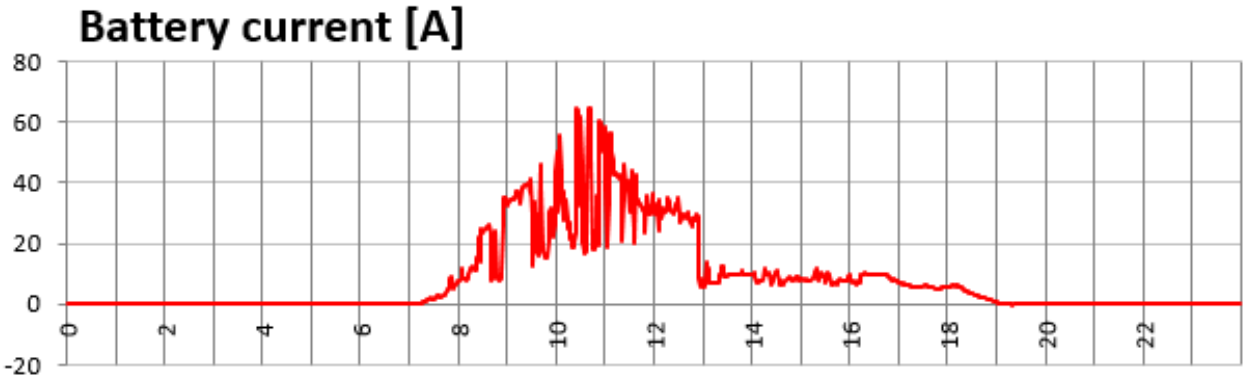



(State of Charge/SoC Battery)

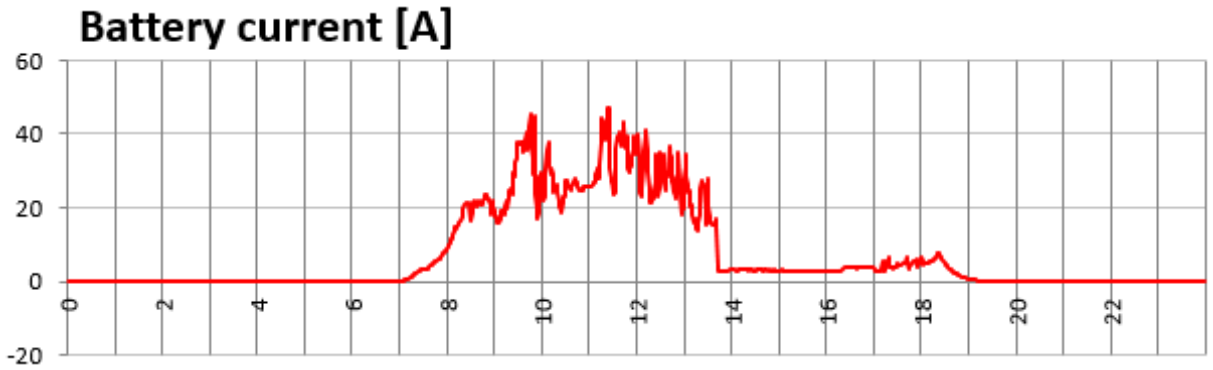
As per graph above you can see performance for each section of the solar system. The capacity of the solar system that we install at each side as 4kWp (total 16kWP). The pv power for each section is depends on state of charge of the batteries. On early on the month/2nd April, the state of charge of the batteries is '0', this is due to some testing that we done to the system. As you can see pv power of each section after that produce more energy to ensure that the batteries state of charge 100% again.

On 4th and 5th April, we try the overall system. At first, we reduce the hydrogen tank into half and the electrolyser will turn "ON" to fill up the hydrogen tank. When the SoC is less than 60%, fuel cell is turn "ON" and supplied the telco. The fuel cell just turn "ON" for couple hours only since the battery SoC reach up so fast to 80%. That's why during that those day the pv power is higher compare to others day (average 3kW for each section) to charge the batteries back. It means, even though the SoC when below 60%, the pv power just consume average 3kW for each section although the maximum can go through 4kW for each section. This is because to make sure battery when above 60%, it just needed average 3kW pv power for each section to charge the battery back.

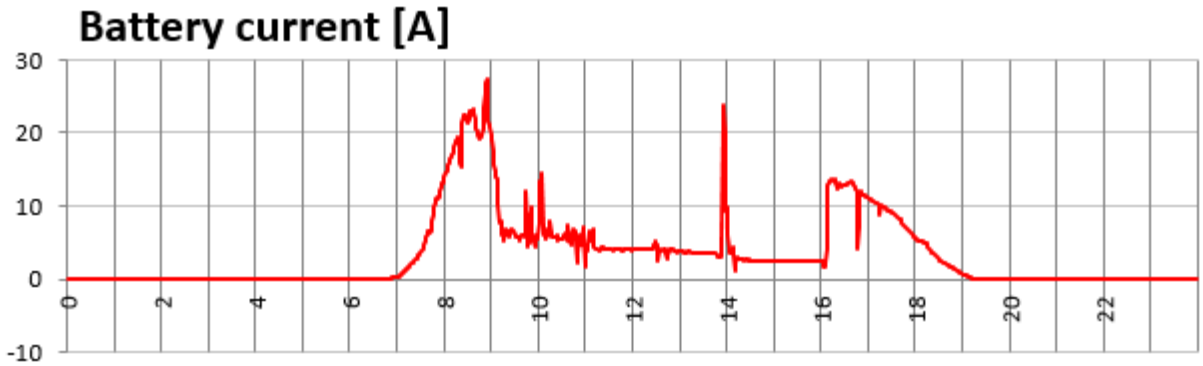
For the rest of the day the pv power almost same (average 1.5kW for each section) and we can see also the SoC of battery never go below than 60% of the batteries. Since never go below than 60% of the SoC, this will not turn "ON" the fuel cell. As you can see on the graph, solar pv performance is not same because of many factors such as orientation of pv modules, shading because of tower itself, solar irradiance and weather.



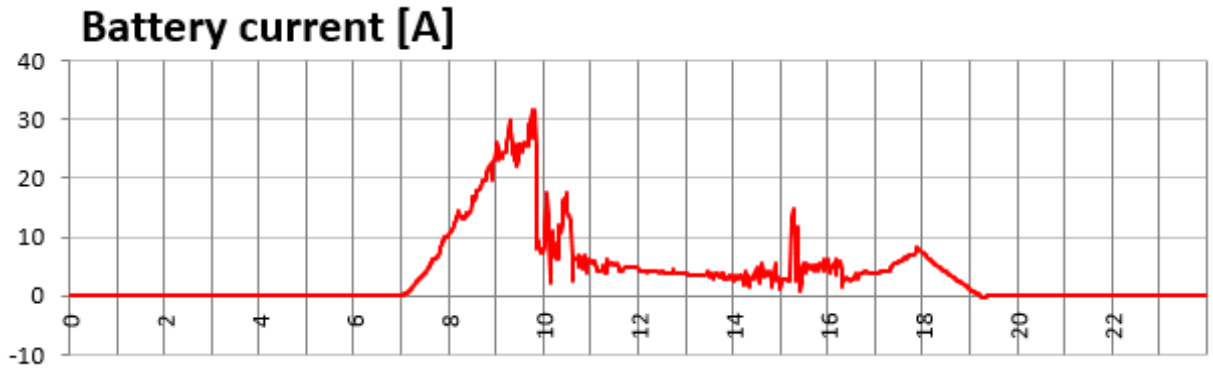

4th April 2016




5th April 2016

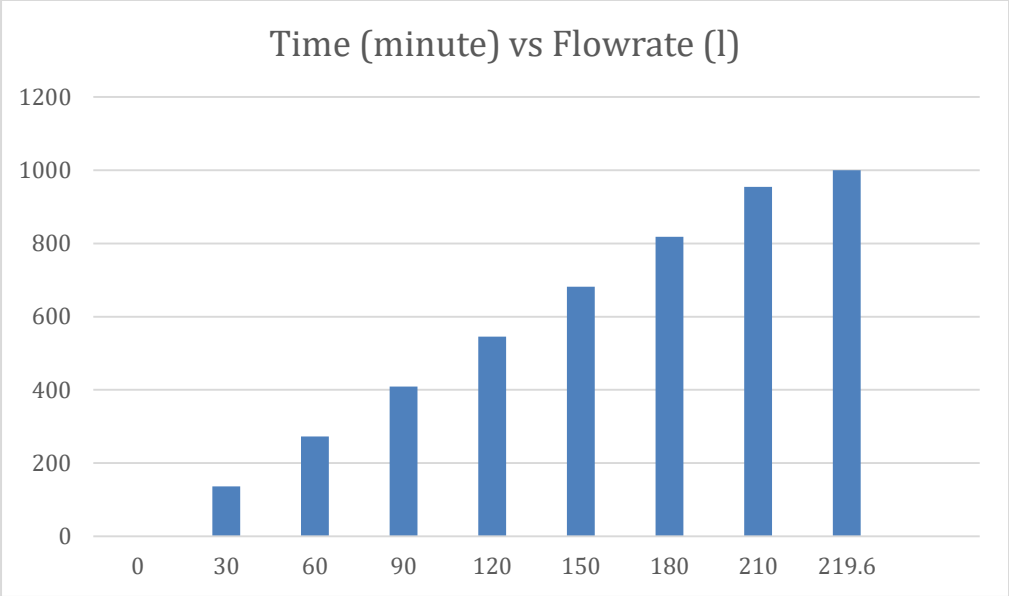



6th April 2016

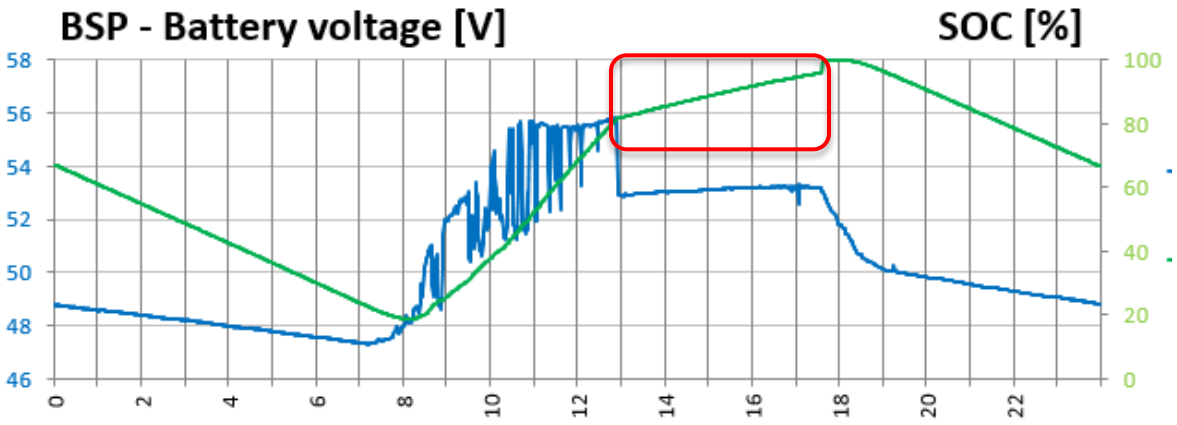



7th April 2016

As per graph above, you can see that since we reduce the gas tank to half, to full up the tank its only takes about average 4 hours on 4th April and average 4 hours on 5th April. On the 6th April onwards, the current consumption for each day is most alike above data. The reason why during that time the current consumption is high is since the electrolyzer is turn "ON" to fill up the tank back. While for the rest of the day, the electrolyzer will not turn "ON" since the tank is already full and the SoC of battery is always more than 60%. We also can see the characteristics for that telco site, every morning around 8.00-9.00a.m the consumption is very high while the rest of the day is just an average value.




Time (minute) vs flowrate (l)




SoC 4th April 2016

As per graph above is the time vs flowrate of the hydrogen to fill the tank. As you can see, time taken is around 3.66 hour/219.6 minutes. As per graph above state of charge (SoC) during 4th April, we can see when state of SoC reach 80%, the electrolyser turn "ON" to refill the tank back. Its take about average 5 hours before the SoC become 100%. As we state before, we reduce the hydrogen gas into half, during that night the system was run by fuel cell. The reason why its takes longer time is because at the same time solar system charging the batteries. At 8.00 a.m until 1.00 p.m as you can see behaviour on charging the battery is constantly linear based on that time, while after that at 1.00 p.m until 6.00 p.m is constantly linear but in not constantly linear as before. This is because during this time the electrolyzer is turn "ON" and at the same time charging the batteries. That's why it's take average 5 hours from SoC 80% to 100% while it's only take 5 hours from SoC 20% to 80%.

## Conclusion

Based on data that we discuss above, we can conclude that the system is working fine based on our preliminary design if we install at the site that consists of 2G and 3G technologies. As per our discussion with Mr Alex Kuik, since this site is for 2G only, we were plan to reduce some of solar panel to ensure the fuel cell will turn “ON”. These work will be done as soon as possible. For future improvement, we were suggest that if we can get at least data for one month monitoring on a power consumption of the telco site for 2G, 2G with 3G and 2G,3G and 4G system. These will help us to design the system more accurate and also maintain the cost at minimum.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