



Abstract:

This report describes the overall experience with the Hydrogen refuelling infrastructure in operation at the Agip service station in Mantova, in Lombardia during the demonstration phase of Zero Regio Project (Nov. 2006 – Nov. 2009).

Particular events which took place at the station and their consequences are described below.

Refuelling data on dispenser are presented and evaluated.

Description of work realised:

The Hydrogen system in the service station area at Valdaro, Mantova, consists of an on-site production facility by Eni (WP3) and a refuelling facility by Sapio (WP4).

In the Hydrogen area of the service station Hydrogen cylinder packs (WP1) are brought from the Sapio production plant and placed in a properly designed storage room. The refuelling equipment will work getting Hydrogen from the back-up supply if the on-site facility is not in operation.

Hydrogen, coming from both sources, was compressed by a diaphragm compressor to reach 370 bar in high pressure cylinders storage. The high pressure cylinders have 1090 Nm<sup>3</sup> capacity. Compressor and high pressure storage were dimensioned to reach 420 bar g, but since the system was not operated at the maximum pressure, the set point was moved, by software, at 370 bar g.

Even if the Hydrogen dispenser have been designed to deliver 350 bar g Hydrogen, and the car fleet, made up of three Panda, designed and tested to be refuelled up to 350 bar and which storage has been dimensioned to provide the proper range at that pressure, they got the permit to be driven with a limit of 200 bar storage pressure, so the refuelling system was operated delivering a smaller amount of Hydrogen at a lower pressure then planned.

The construction phase of the compression, storage and delivery system for Hydrogen within the station in Mantova was completed in July 2007, the opening ceremony took place in September 2007.

After the completion of the construction phase, the testing phase of the refuelling station started.

During the first period the refuelling station was tested by Specialised Engineers. This testing campaign lasted from July 2007 to November 2007. A test tank was used in order to simulate all the possible situation which could occur during the car refuelling.

The regular operation of the station started in November 2007 and lasted until February 2008, except during Christmas Holyday when the operation was interrupted.

Operation stopped in March 2008 because the installation of the SCT-CPO plant required the system purging for safety reasons. The system started up again in July 2008, and was regularly operated till now. So, during these eight months there was only 50% of refuelling station availability. Anyway, during this period the refuelling was available by the provisional refuelling system which was installed inside Sapio production plant.

From September to December 2008 we had regular operation. During this period we had 18 downtime days for scheduled maintenance or repairs of parts. Generally the maintenance stops lasted several days because of spare parts delivery and shipment time, instead the fixing ones required only few hours.

From January to November 15, 2009 we had 38 downtime days for scheduled maintenance or repairs of parts. This downtime was due to the dispenser touch panel failure. The replacement required more than 2 months because the device and software installed were already out of date. Anyway, during this period refuelling was available through the provisional refuel system.

In general we had these kinds of minor incidents:

1. Failure of touch screen;
2. Lost of some date and data of fill history (recovered by car journals);
3. Delay in refreshing screens of plant control system in case of changing status of:
  - a. Production facility by ENI;
  - b. Compressor cooling water system;
  - c. Manual start of compressor;
  - d. Fail of Compressor automatic start.
4. Leakage on:
  - a. Nozzle;
  - b. Valve;
  - c. Check valve vent.

We thought about causes and solutions of these minor incidents:

1. Ambient temperature too hot → replace touch screen.
2. Excess of data traffic on Adsl line → reduction of number of parameters monitored continuously.
3. Probably cables damaged by mice → cables repair or replacement and mouse traps.
4. Use of devices and components → repair or replace.

The system did not occur in incidents causing injury to people or buildings, but some minor faults occurred, which were reported in incident reports (Attached).

The total amount of kg. H<sub>2</sub> delivered in Mantova over complete demonstration time, from September 2007 to November 2009, was 265,19 kg.

Availability averaged over the complete time is 78%, where availability is equal to  $(1 - \text{downtime} / \text{totaltime})$  and downtime means "not in operation because of scheduled maintenance + repairs of parts of the refuelling facilities".

- downtime in hrs = 4272 hrs
- total time in hrs = (from September 2007 to 15th November 2009) = 19344 hrs.

Energy consumption of the refuelling equipment (dispenser, compressor and other utilities related to electricity consumption) was measured to be 10880 kWh. Unfortunately it was not possible to measure the electrical consumption of each component separately. So, the specific energy consumption for refuelled Hydrogen was 41 kWh/H<sub>2</sub> kg, but is not significant.

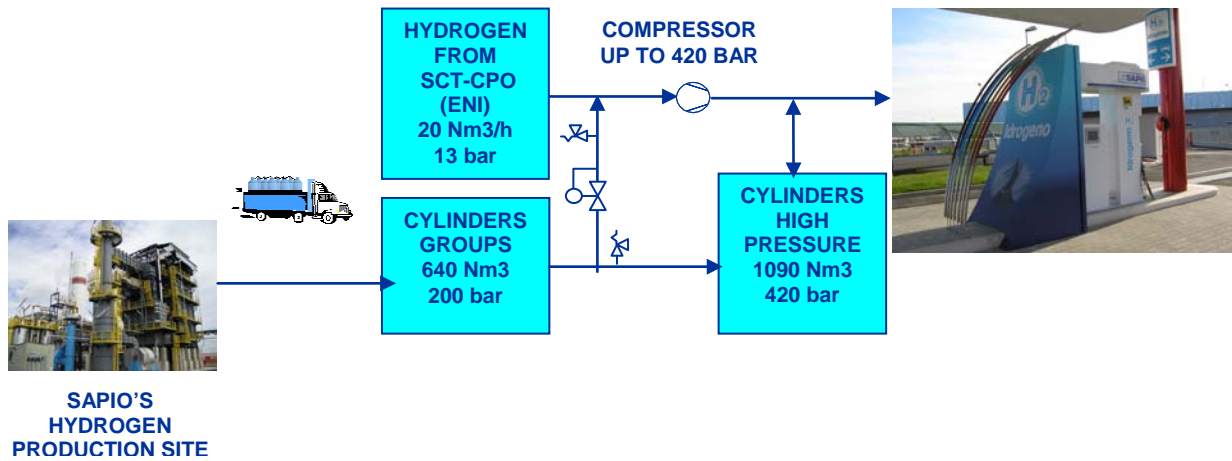


Fig.1: Layout of delivery system to the H<sub>2</sub>GC dispenser in Mantova



Fig.2: Hydrogen dispensers at the Mantova station

YEARS	AVAILABILITY	No. MINOR INCIDENTS
2007	1,0	0
2008	0,6	5
2009	0,9	14
TOTAL	0,8	19

Table 1: Availability of dispenser (for every year and overall)

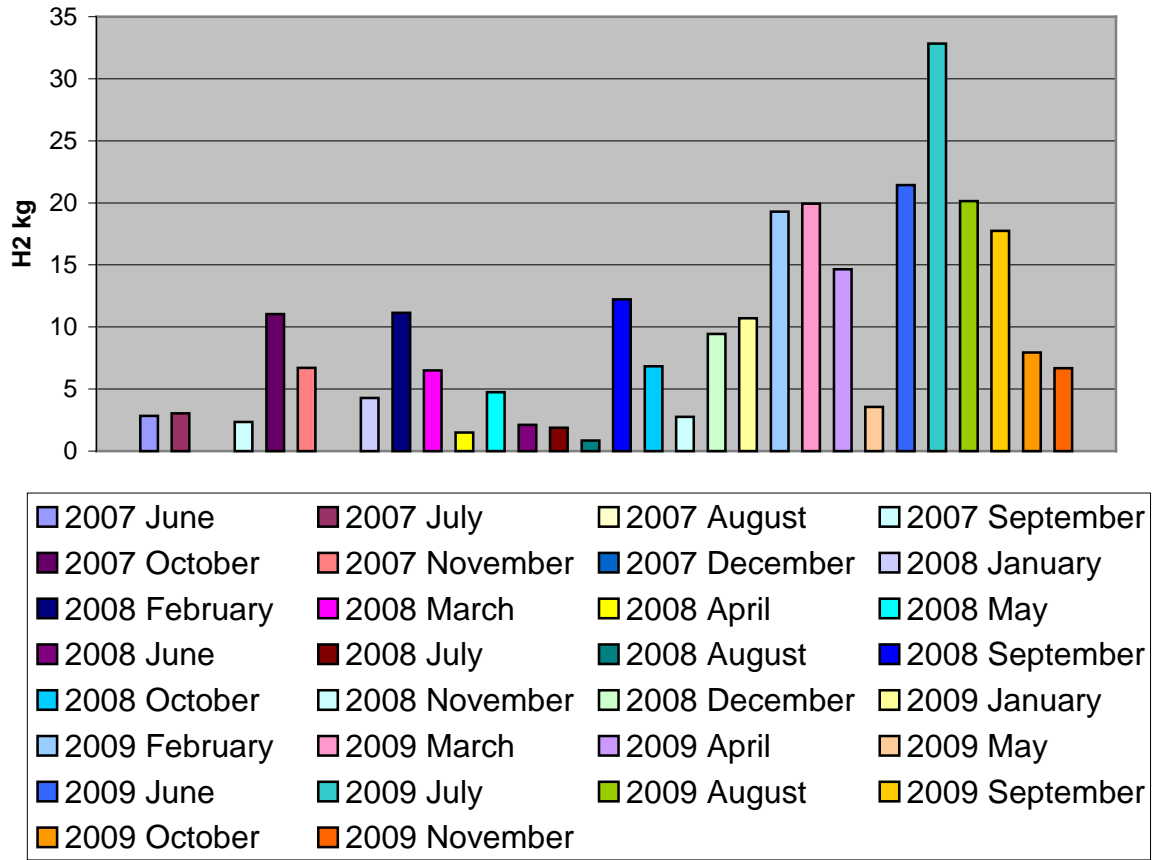


Fig. 3: Amount of Hydrogen refilled at the 350 bar dispenser in Mantova.