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Water Solar Electrolysis for Hydrogen Production: Electric Caracterisation

By Romdhane Ben Slama, Nabil BouAzizi, Yassine Hamouda & Saif Eddine Jawadi
University of Gabes, Tunisia

Abstract- The hydrogen production by water electrolysis consumes electric power (much even). To make this process profitable, we exploited two parameters: the origin of the consumed current and the optimization of the power supply. Indeed, the current is renewable origin (photovoltaic). The connection in parallel of the electrolysers with the photovoltaic module made it possible to increase the production of hydrogen while reducing the electric power consumption. In addition, the use of a voltage regulator made it possible to stabilize the voltage and thus to maintain the hydrogen production on a constant level during all the day.

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WATERSOLARELECTROLYSISFORHYDROGENPRODUCTIONELECTRICCARACTERISATION

Strictly as per the compliance and regulations of :

Water Solar Electrolysis for Hydrogen Production: Electric Caracterisation

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Abstract- The hydrogen production by water electrolysis consumes electric power (much even). To make this process profitable, we exploited two parameters: the origin of the consumed current and the optimization of the power supply. Indeed, the current is renewable origin (photovoltaic). The connection in parallel of the electrolysers with the photovoltaic module made it possible to increase the production of hydrogen while reducing the electric power consumption. In addition, the use of a voltage regulator made it possible to stabilize the voltage and thus to maintain the hydrogen production on a constant level during all the day.

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Nomenclature:

I	Electrical current (A)
U	Voltage (V)
P	Power (W)
PCI	Lower heating value (J/kg)
Qv	Flow rate (m^3/s)
V	volume of the test tube (m^3)
t	tube filling time (s)
W	electrical energy (J)
ρ	density of hydrogen (Kg/m^3)
Indices :	
a	absorbed
u	useful
nom	nominal
ab	absorbed

I. Introduction

The production of hydrogen, vector of energy, by electrolysis way interests many authors [1-6]. Their studies relate at the same time, to the production of hydrogen through renewable energies or even the nuclear power, various new materials of electrodes and electrolytes, and even the urine. However, our former publications [7-12] are interested in the choice of nature of electrodes, electrolyte and additive.

In this article, we are interested in the electric characterization of the phenomenon.

Indeed, electrolysis requires a power supply, such as photovoltaic origin.

The couple intensity-voltage of the power is to be determined by the choice of the optimum point according to the characteristic curve of the photovoltaic module and the load. The type of assembly of the electrolysers series or parallel is to be determined. Lastly, the influence of the installation of a voltage regulator makes it possible to stabilize the physical sizes measured with optimal values.

Author α: University of Gabes, ISSAT Gabes Rue Omar Ibn Khattab Gabes Tunisia. e-mail: romdhaneb.slama@gmail.fr

II. Experimental Protocol

A photovoltaic module of 55 Watts used to supply the electrolyser, as well as a standard regulator marks??? and a battery 12 V, 50 AH.

The currents and tension are measured by fixtures in the model, accuracy ± 5 %.

The produced hydrogen flow is given by taking account of the filling time of a test tube of known volume *given*

The calculated sizes are:

- Hydrogen production flow rate: Qv = V/t (m^3/s)

With:

- Absorptive power by the electrolyser: Pa = U.I (W)
- Useful power of the electrolyser: Pu = PCI. Q. p (W)

PCI: lower thermal value of hydrogen (119.910[6] J/Kg)

- ρ: density of hydrogen (0.09 Kg/m^3)
- Consumed electric power: W = Pa . t (J)
- Useful efficiency: η = PCI. (V / (Pa . t)) . ρ (-)
- Consumed electric power per unit of volume:

$$W/V = Pa.\,t / V = Pa/Q \quad (J/cm^3)$$

$$W/V = Pa\,.\,t\,.22{,}4/ V \;(kJ/mol)$$

with: P (W), t (s) and V (cm^3)

Figure 1 : Photo du panneau, batterie, régulateur, charge et électrolyseur.

Figure 1 : Photo of the panel, battery, regulator, load and electrolyser.

III. Power Supply of the Electrolyser Study

With an aim of having a constant hydrogen production, we tried to stabilize the power supply by using the model presented previously while combining the regulator and the battery.

a) Characteristic curve of the photovoltaic module (I=f(U))

While varying the position of the rheostat of the installation relating to the photovoltaic module, according to figure 2, the couple intensity-voltage changes, from where the layout of figure 3.

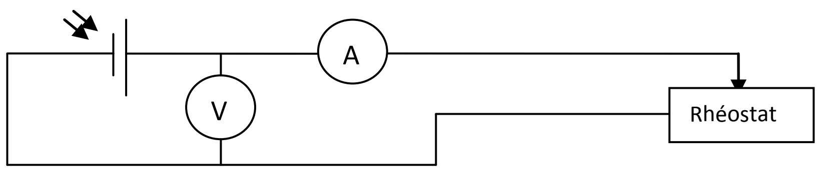

Figure 2 : Synoptic diagram to determine the curve I=f (U) of the photovoltaic module

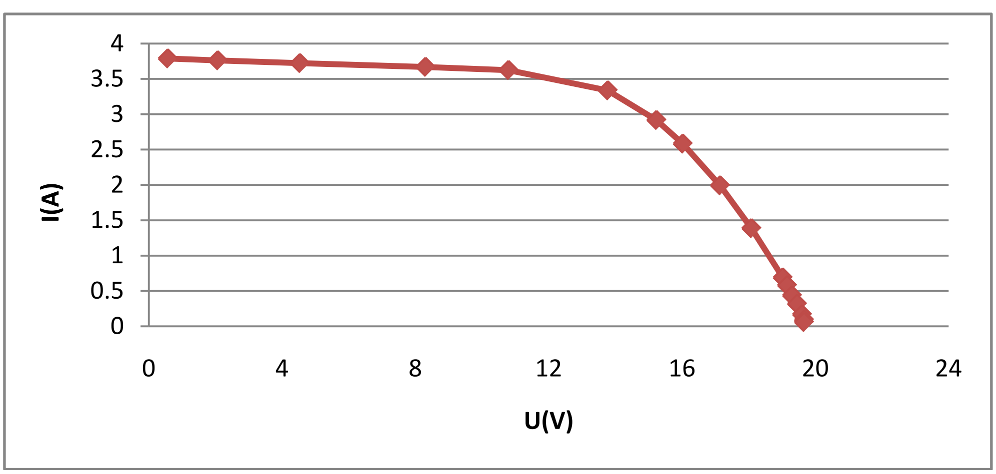

Figure 3 : Characteristic curve of the photovoltaic module (I=f(U))

The curve of figure 3 is made mainly of two parts:

1st part: Zone of operation [between points (0V, 3.A) and (14V, 3.A)]

2nd part: The following part of the curve: the current and the tension are inversely proportional càd that the reduction in the consumed current generates an increase in the tension.

The point of operation (16 V, 2.50A)

b) Characteristic curve of the electrolyser (I=f(U))

The electrolyser can be directly connected with the photovoltaic module or through the regulator connected with the battery. The electrolyte used is the brine of a power station of desalination of water. The rheostat makes it possible to vary the load.

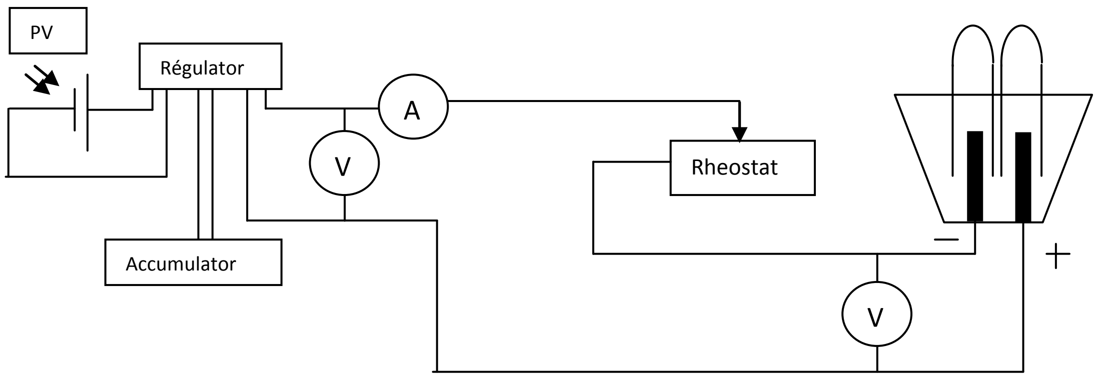

Figure 4 : Synoptic diagram to determine the curve of the electrolyser I=f (U)

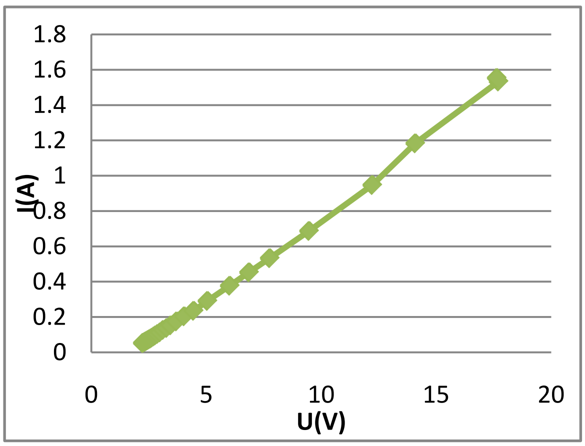

Figure 5 : Curve I=f(U) of the electrolyser connected directly with the photovoltaic module –Al/Cu Electrodes – Water: Rejection of the station of desalination

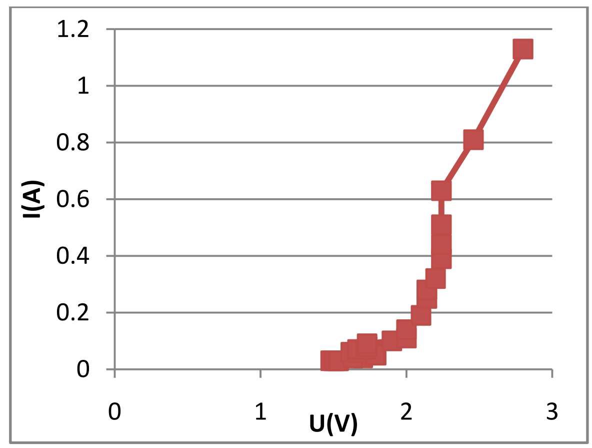

Figure 6 : Curve I=f(U) of the electrolyser connected to the regulator –Al/Cu Electrodes – Water: Rejection of the station of desalination

c) *Point of operation*

According to the figures 7-8 below, it is remarkable that with the regulator, the electrolyser functions in a zone below the nominal zone.

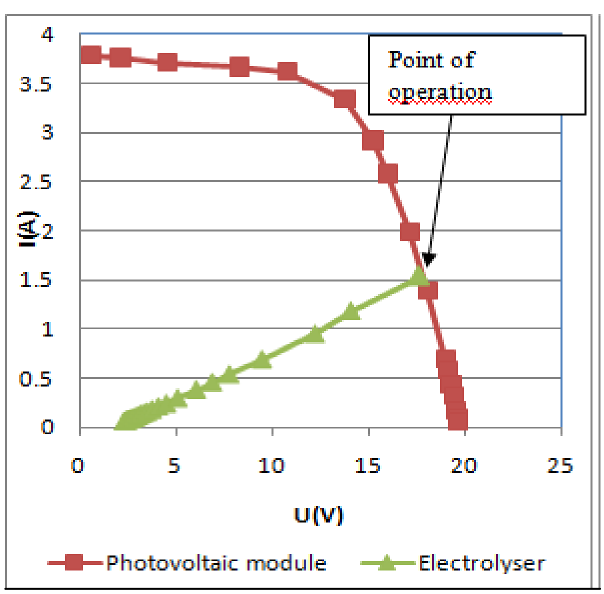

Figure 7 : Graphic determination of the point of operation PV-electrolyser

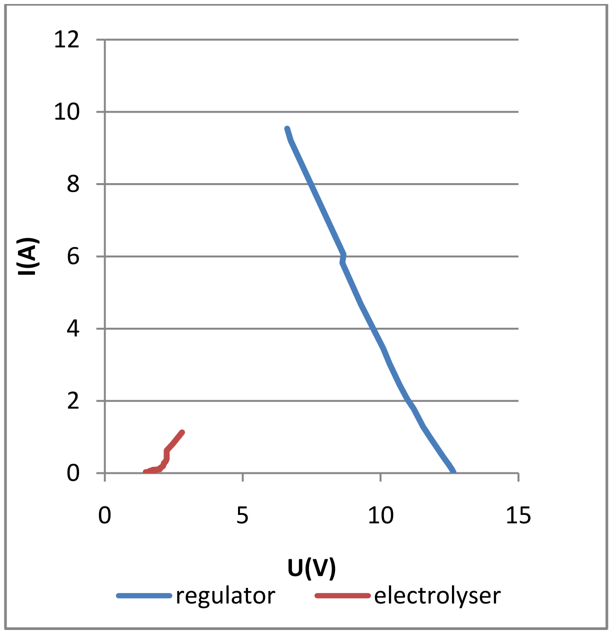

Figure 8 : Graphic determination of the point of operation Regulator-electrolyser

IV. Serial And Parallel Connections of the Electrolysers

To carry out these two experiments, we started by connecting the three electrolysers in parallels then in series.

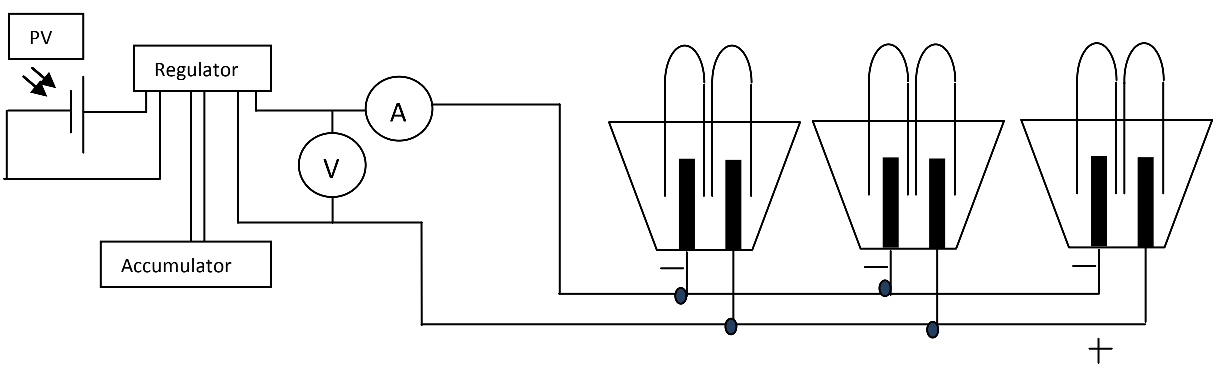

Figure 9 : Parallel connection of the three electrolysers

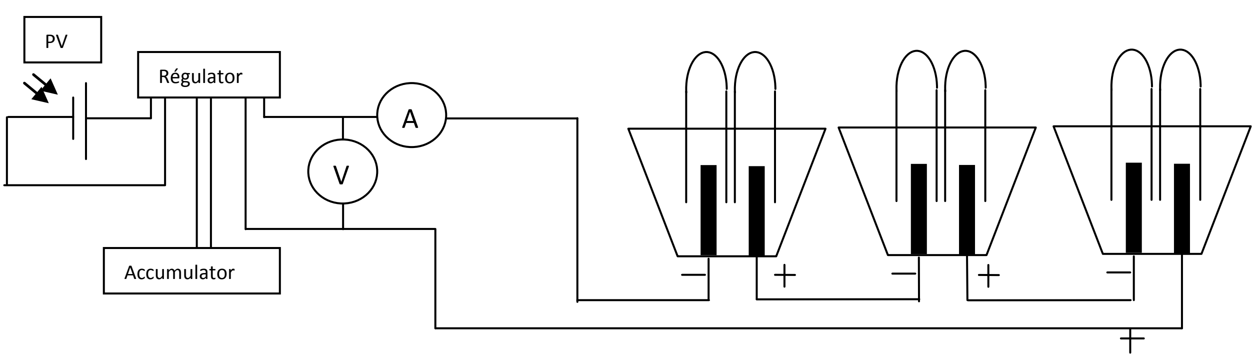

Figure 10 : Serial connection of the three electrolysers

Figure 11 shows that the produced hydrogen flow with the parallel connection is higher than with the serial connection, because with this last the equivalent resistance of the electrolysers is equal to the sum of resistances; on the other hand with the parallel connction the equivalent resistance of the electrolysers is increasingly smaller than the smallest resistance of the electrolysers. Thus, if resistance decreases, the power supply increases and consequently the hydrogen production increases.

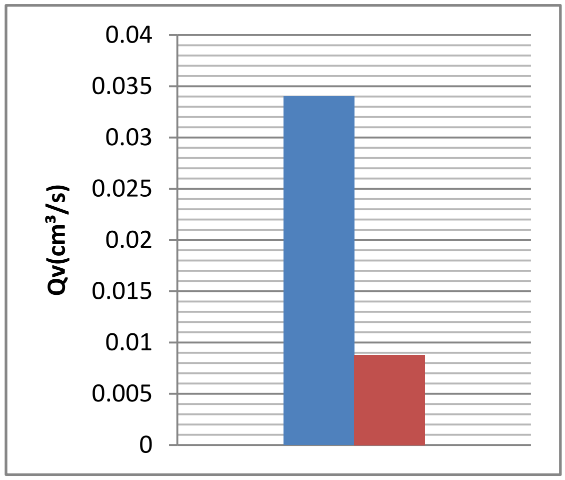

Figure 11 : Produced hydrogen flow by the three electrolysers

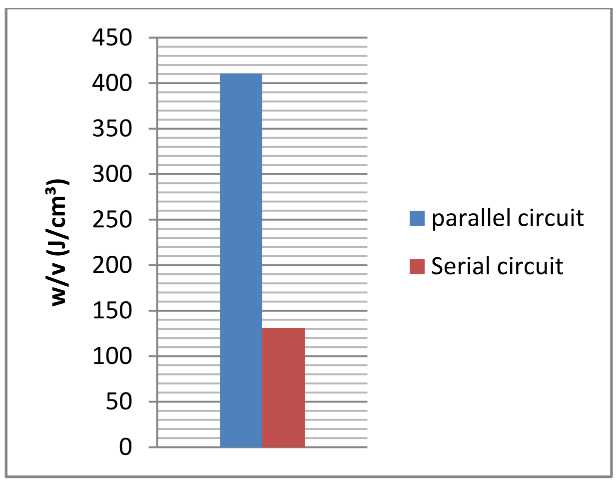

Figure 12 : Specific energy consumption by the three electrolysers

V. Connection Of The Electrolysers Directly To The Module PV And Through The Regulator

To show the effect of the regulator in the stabilization of the supply voltage of the electrolysers and consequently the produced hydrogen flow and the other results of measurement, the two assemblies will be carried out one directly with the module and the other through the regulator.

Various kinds of electrolytes will be tested such as waste water, the water rejections of the distillation station and the Chemical Group of Gabes and the rejection of the therapeutic bath of Metouia Gabes, like the pinks water, the Basilica water and the Kalatous water, without forgetting sea water.

a) Direct connection to the module PV

The electrolysers, assembled in parallel, will be directly connected with the photovoltaic module. The performances of electrolysis are measured: produced hydrogen flow and power consumption.

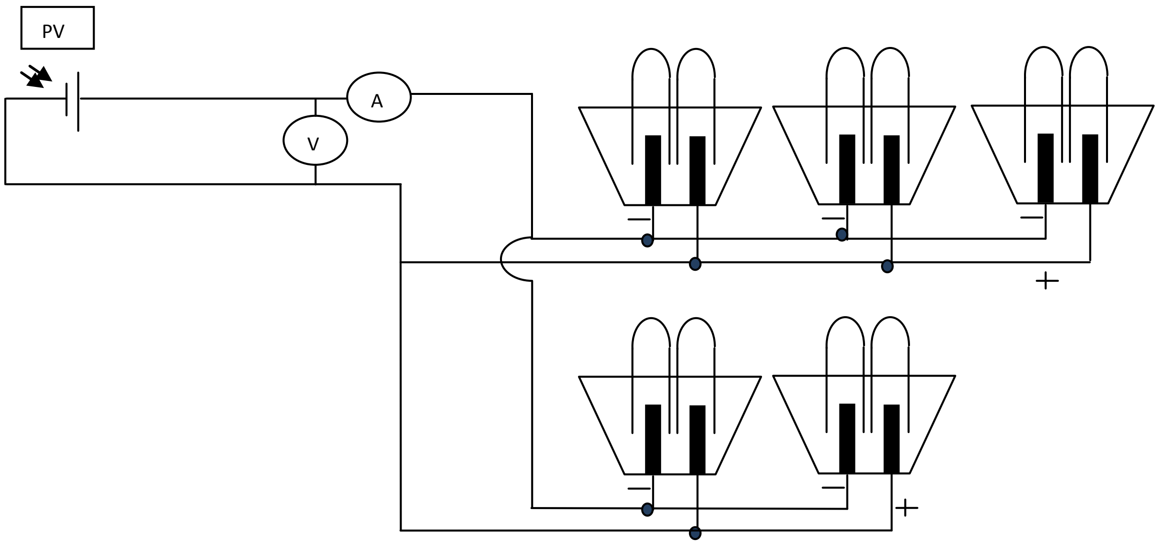

Figure 13 : Synoptic diagram of the parallel assembly of the electrolysers with the PV. Influences of the electrolytes types

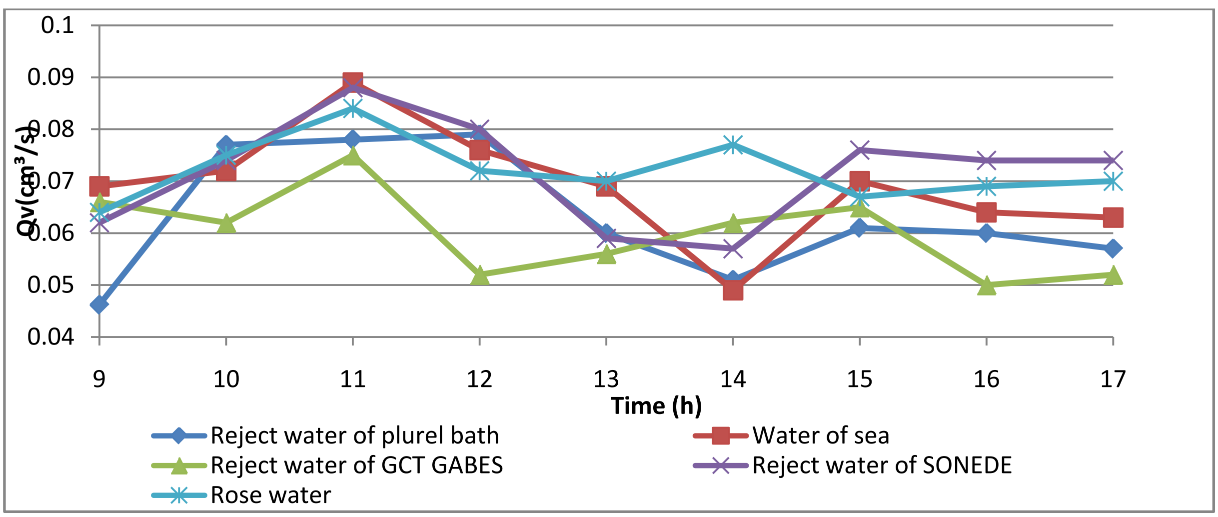

Figure 14 : Variation of the hydrogen flow with the time and the of electrolyte type - salinity 200g/l, Co(+)/Co(-), direct Connection with module PV

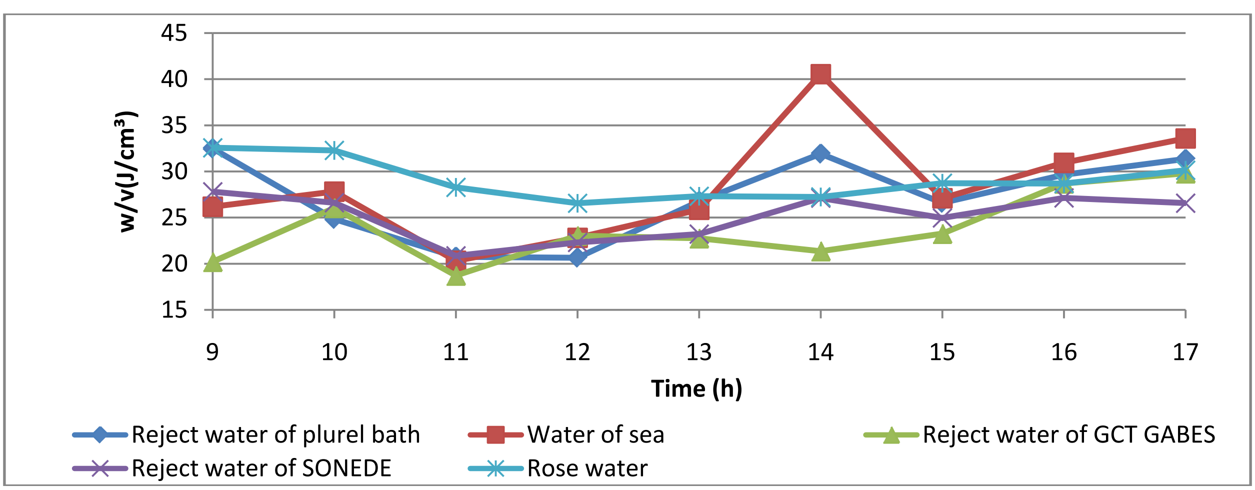

Figure 15 : Variation of the consumed energy with the time and the of electrolyte type - salinity 200g/l, Co(+)/Co(-), direct connection with module PV

The results of produced hydrogen flow and power consumption according to the electrolyte and time are discussed under the effect of the variation of the tension delivered by the module PV, itself due to the variation of solar flux. This will be corrected by the connection through the regulator.

b) Connection to the module PV through the regulator

The electrolysers, always assembled in parallel, will be connected with the photovoltaic module via the regulator. In the same way the performances of electrolysis are measured: produced hydrogen flow and power consumption.

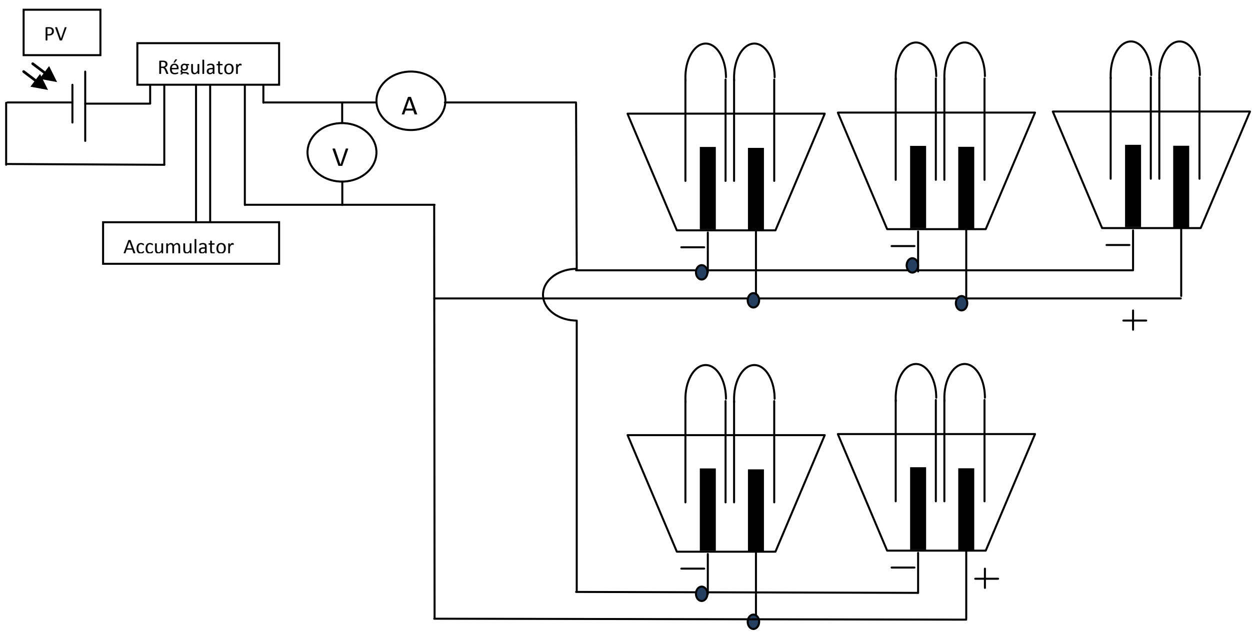

Figure 16 : Synoptic diagram of the parallel assembly of the electrolysers with the regulator. Influences of the electrolytes types

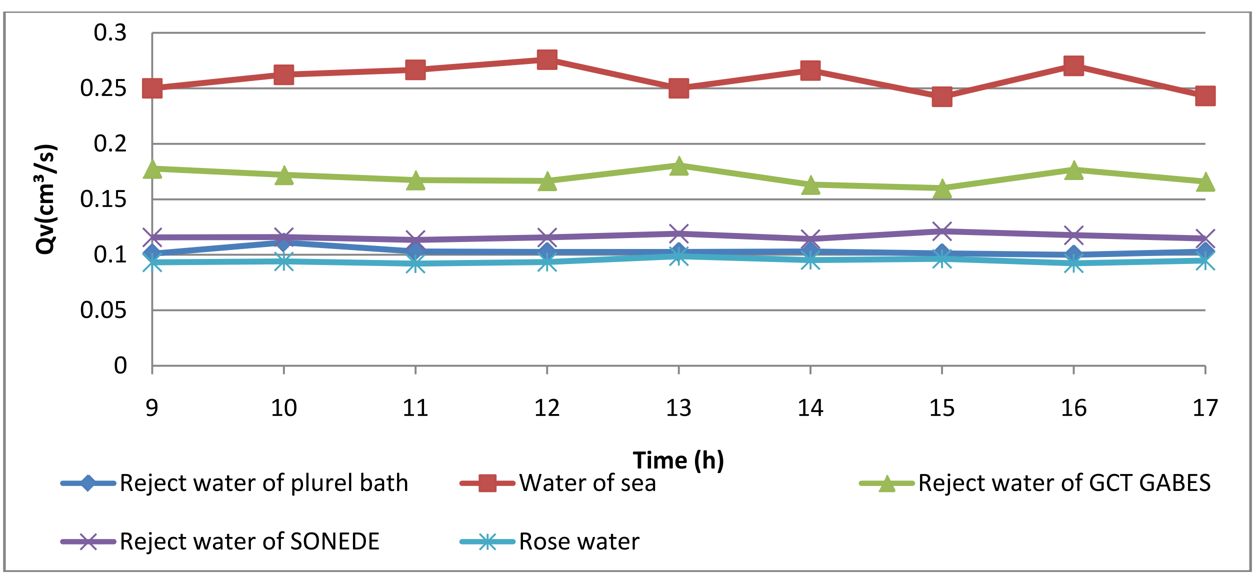

Figure 17 : Variation of the hydrogen flow with the time and the of electrolyte type - salinity 200g/l, Co(+)/Co(-). Connection with the regulator

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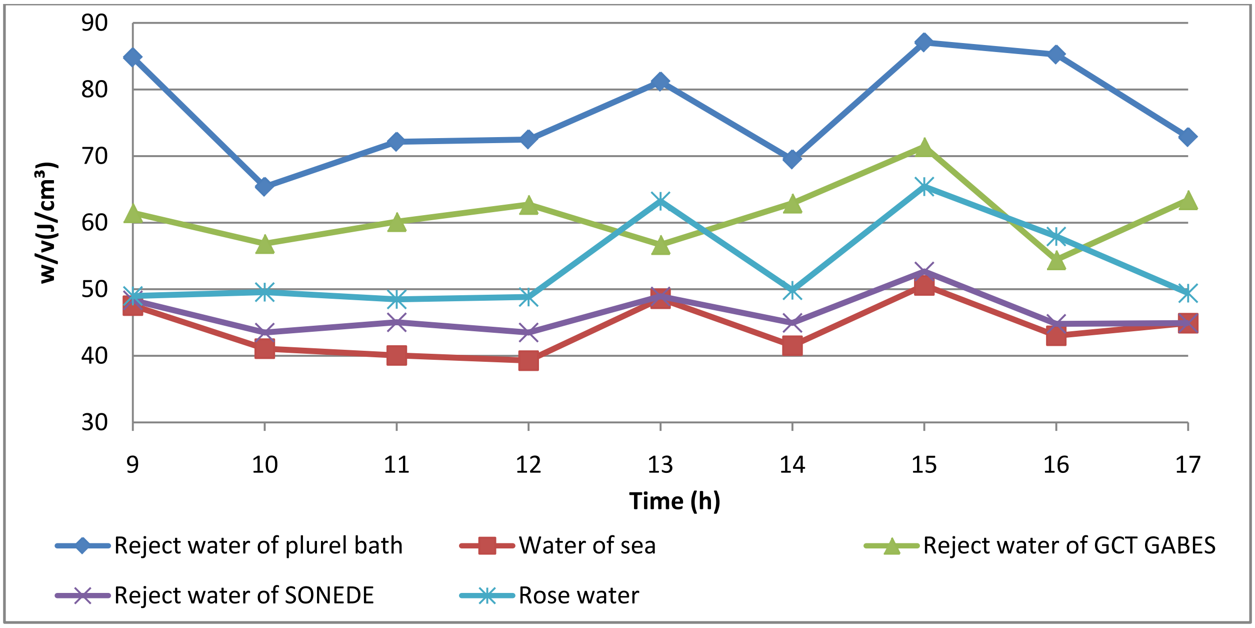

Figure 18 : Variation of the consumed energy with the time and the of electrolyte type - salinity 200g/l, Co(+)/Co(-). Connection with the regulato

For two figures 17 and 18, the uniformity of the curves according to the electrolyte type is due to the presence of the regulator, without which, the fluctuation of the solar radiation would disturb the supply voltage.

The produced hydrogen flow is better for sea water, follow-up of the rejection water of a phosphate treatment plant, brine of desalination. The result is reversed for the specific consumption of energy. What is beneficial.

VI. Conclusion

For the water electrolysis, one recommends the assembly of the electrolysers in parallel, which induces a better hydrogen production. Indeed, the supply voltage is independent of the number of electrolysers, contrary to the serial connection.

The coupling of the electrolysers to module PV must be done at the optimal operation point (high couple tension-current).

The connection of the voltage regulator between the module and the electrolysers makes it possible to stabilize the supply voltage and consequently the performances of electrolysis (flow of produced hydrogen and consumed electric power).

The good choice of the electrolyte type makes it possible to maximize the hydrogen production and to minimize electric consumption. Among those studied in this article, the sea water proves to be interesting.

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