ARTIPHYCTION
Project full title: **Fully artificial photo-electrochemical device for low temperature hydrogen production** Contract no.: **303435** Reference call.: **FCH-JU 2011** Start date of contract: **01/05/2012** Finish date of contract: **31/10/2015** Duration: **42 months**

Main achieved results:

Concept and Objective	Final Result
Targeted minimum efficiency exceeding 5% solar energy to hydrogen heating value Antenna systems at the anode and the cathode will be tailored in order to exploit higher energy photons (e.g. wavelengths below 600 nm) at the anode, where the water-splitting occurs, and the lower-energy ones (wavelengths above 600 nm) at the cathode where proton reduction takes place. Model calculations, presented in the impact section, show that this concept has the potential to exceed 10% conversion efficiencies, which would offset the competition of combined commercial photovoltaic panels and water electrolysers.	Efficiency target partially (40% - 60%) achieved: • The best results with a CoPi-catalysed Mo-doped $BiVO_4$ photo-anode and a Co NPs-based cathodic electro-catalyst in the Final Artiphyction prototype show a potential of 3% overall sunlight into hydrogen conversion efficiency. However, due to mass-transfer and kinetics limitations phenomena (bubbles formation and accumulation in the electrodes surface) the performance decrease up to about 2% during long-term operation. • This paves the way to full achievement of the ambitious goal of the project by: more engineering efforts on reactor design to improve fluidodynamics (although already 4 different versions of prototype device have already evolved during the Artiphyction project); and a further optimization on electroactive materials. • Detailed modelling data are pointing at the way to go with the measured performances and show that 10% conversion is quite compatible with thermodynamic calculations but requires the development of appropriate electrocatalytic micro- and nano-structures.
The prospected system durability will exceed 10.000 h lifetime. The final prototype will be tested for at least 1000 h in the last six months of the project.	Life testing achieved in 100 %: The final prototype module of 5 PEC-PV units has been tested for 1000h and a limited reduction of efficiency (less than 5%) has been observed when operating at a 2% STH efficiency. Indeed, a trade-off between STH efficiency and stable operation has been pointed out (see D6.3) in order to maintain the stability with the prospective durability of 10.000 h.
To disclose wide potential application opportunities, the above targets must be reached without using expensive noble metals or materials and via assembling techniques amenable for mass production.	No use of noble metals achieved at 100%: • Attention have been addressed mostly on the anode water-splitting side of the cell were noble metal catalysts are not present. The synthesis techniques adopted for $BiVO_4$ and Co-based catalysts are amenable for mass production and were actually used to manufacture the final Artiphyction prototype.
The system can be modular and reach whatever production goal in the range from 100 W for domestic use (ca. 3 g/h H_2 equivalent) up to 100 kW (ca. 3 kg/h H_2 equivalent) for commercial use. By the end of the project a proof-of-concept prototype for domestic use (3 g/h H_2 equivalent) will be engineered, assembled and tested.	100 W (ca. 3 g/h H_2 equivalent) partially achieved at ~ 33%: • Special attention was paid on manufacture a modular system. The final ARTIPHYCTION prototype is composed of 20 modules, each of them with 5 PEC-PV units that can be assembled to reach different total areas. The original module surface area has been achieved. However, even though the system was proved to be able to operate at 3% of STH efficiency, a strategic decision was taken in favour of the prototype stability. Hence, a half of the possible PV cells were used in the system, since in this case the stability would prevails (with a 5% of margin) although the activity of the PEC cells would decrease of 25%. Therefore, the maximum overall H_2 production of the prototype is slightly higher than 1 g/h.