ISOTOPES FOR HYDROGEN ENERGY –Towards the understanding of the specifics of reactions involved in the Hydrogen Fuel Cell integrated system using Steady-State Isotope Transient Kinetic Analysis – "Proof-of-concept" for a hydrogen fuel cell power station/ RomHyIso

Operation 2.1.2: *„ Complex research projects fostering the participation of high-level international experts*

CONTRACT NO: 119/02.06.2010
BENEFICIARY: NATIONAL INSTITUTE FOR RESEARCH AND DEVELOPMENT FOR CRYOGENIC AND ISOTOPIC TECHNOLOGIES– ICIT Rm. Valcea
SMIS-CSNR CODE: 12013
ID PROJECT: 538
TOTAL VALUE:
ERDF – 4,470,346.80 lei
STATE BUDGET – 915,613.20 lei

CONTEXT

Growing concerns about the effect of greenhouse gases and the depletion of available fossil fuel resources, have motivated worldwide interest in development of new energy technology solutions. In addition to the ongoing effort to find new and effective renewable energy sources, defining a new energy "carrier" to completely remove the carbon from this chain is vital for eliminating the main problems of the world economy.

Creating a sustainable energy chain, that starts from the power source to the consumer, in which the hydrogen is the focus of energy transport and storage, with superior efficiency, cost and reliability comparable to present technologies, is one of the main elements in this area. The core technology on which is based the hydrogen energy is the fuel cell -a device that converts the chemical energy stored in hydrogen into electricity.

In this context, ***the project "ISOTOPES FOR HYDROGEN ENERGY" project aimed to identify the realistic mechanism of physical and chemical processes which occur within the main components of a hydrogen integrated power system*** *– with a* ***hydrogen processor*** *by methane*

*catalytic steam reforming and with **hydrogen fuel cell**, by implementing a new experimental approach, based on the use of isotopic labeled compounds.*

The project is considered to be part of a national and international effort, and the proposed and achieved results will contribute to an enhanced in-situ knowledge of the processes within an integrate power system, knowledge which is seen to be the key of a better approach for designing and finding optimized technological solutions.

OBJECTIVES

*The project was designed to run on two parallel phases with obvious links in terms of results and design data. A first exploratory research phase based on **a new investigation method(SSITKA**) that uses stable isotopes as tracers is applied to investigate the kinetics of catalytic PEM fuel cells redox processes and the hydrogen generator reforming reaction. The second phase was planned to bring a validation of the experimental results obtained before but also to have a practical application of the research, so **a laboratory-scale demonstrative model for a hydrogen processor, coupled with a PEMFC stack**, with a power of about 1kW, was designed and developed.*

In essence, the main objective of the project was the design and implementation of a "Proof-of-concept" for an integrated power station, laboratory-scale, based on a hydrogen processor - PEM fuel cell system.

The main scientific objectives defined and fulfilled by achieving this project took into account: the preparation of the experimental and theoretical conditions for the Steady-State Isotope Transient Kinetic Analysis - SSITKA; experimental and simulation studies for hydrogen production via catalytic steam reforming of methane; in-situ investigations, modeling and implementation of SSITKA experiments for the catalytic processes that occur in the PEM fuel cells anode and cathode; experimental investigation of proton transfer mechanism in the polymer membrane of the fuel cell using isotopic tracers; integration and implementation of a "proof-of-concept" for a hydrogen-based power station that uses natural gas as primary fuel and hydrogen as energy carrier; Testing and demonstration.

It should be noted that all these goals are related to the implementation of the new SSITKA investigation methodology for the processes taking place in the PEM fuel cell and in the catalytic reforming process.

EXPERIMENTAL APPROACH

The project highlighted a new approach for investigation the physical and chemical processes which occur in the main components of the technological chain of a hydrogen power station, being analyzed two major components: a hydrogen processor using catalytic steam reforming of natural gas and a proton exchange membrane fuel cell. The use of stable isotope tracers as a new investigation tool – Steady-State Isotope Transient Kinetic Analysis- was first applied and developed in the '80s, but it potential was not fully brought into play. SSITKA analysis is considered to be an ideally suited method to investigate the gas- surface processes, especially the ones driven by the catalysts, like the ones from the reforming reactors or from the PEM fuel cells.

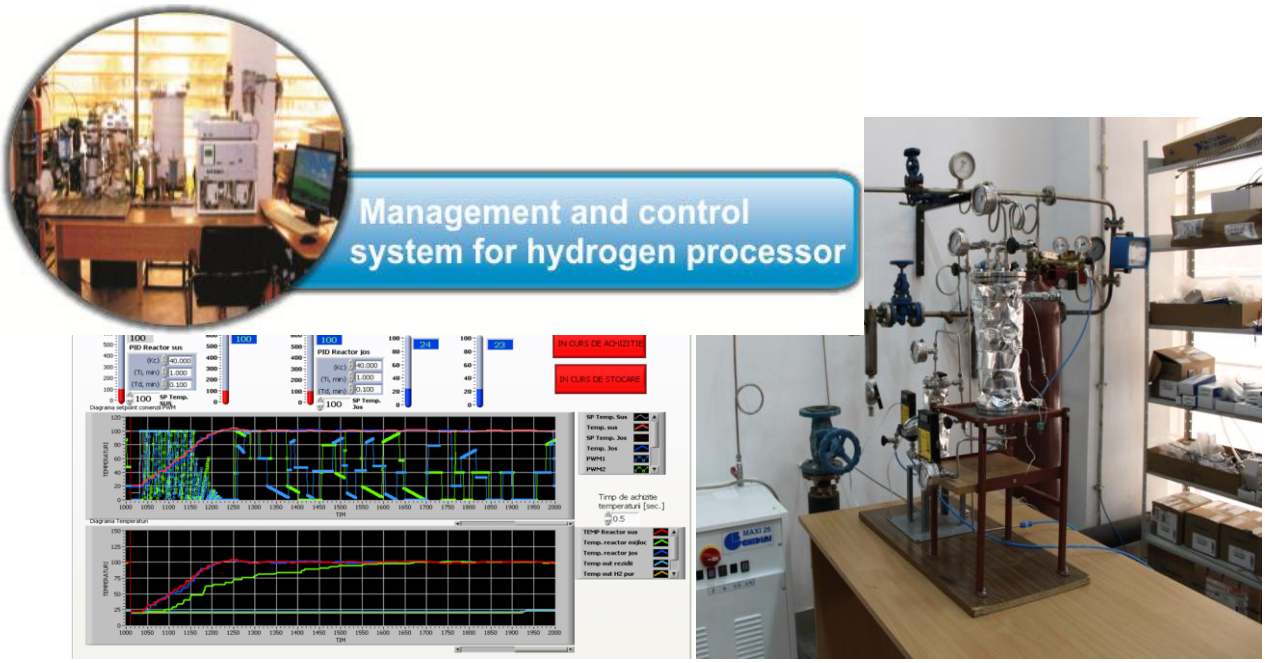
EXPERIMENTAL RESULTS

During the 24 months of the project , the activities have evolved from the design and building of the SSITKA experimental setup to the design, development and testing of the integrated power station based on hydrogen processor and fuel cell assembly, the final target.

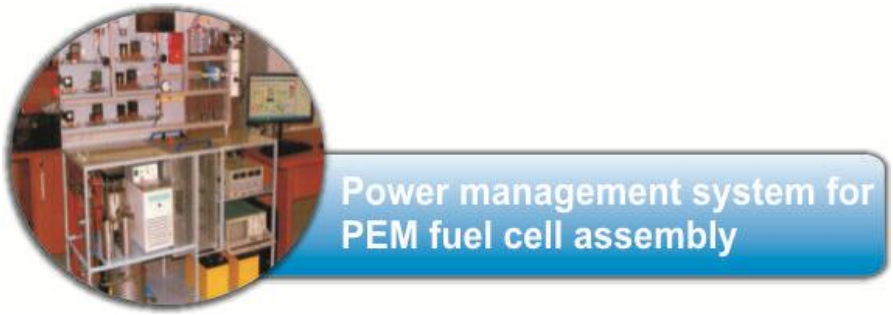
The main tangible results of the project are:

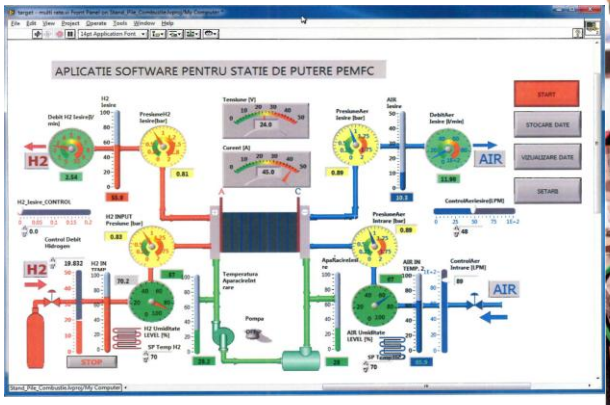
- SSITKA set-up with a high degree of versatility in terms of its further use for many types of applications that involve kinetics investigations for the catalyzed surface reactions.

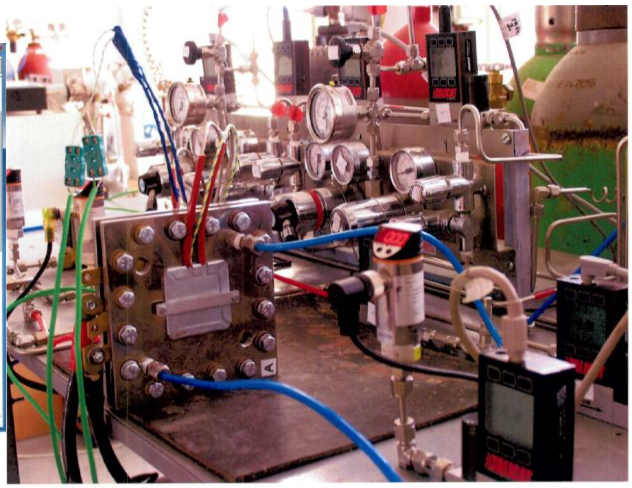
- Experimental model for a compact hydrogen processor using catalytic reforming of methane and onsite purification of hydrogen by Pd membranes.
- Management and control system for the hydrogen processor that supply the RomHyIso power station.



- Management system for power and for heat & water for RomHyIso fuel cell assembly







These overall results, of the RomHyIso project activities were doubled by additional research results: comparative studies between testing and demonstration in order to compared to the performance of similar systems; reports of experiments and functional tests based on hydrogen power station; codes and operating procedures for setting up the main parameters that influence the long-term performance; a final test report for the " proof of concept" of the power station.

FOLLOW-UP

The project highlights a new approach to investigate the physical and chemical phenomena occurring in the technological chain components of a hydrogen power station. This approach is considered to be completely innovative and the results had a strong impact on hydrogen energy research and also on technological development activities in Romania.
Meanwhile, the new implemented investigation methodology has proved to have a much wider application into hydrogen energy area, opening therefore a strong specialization for the research group at National Center for Hydrogen and Fuel Cell Ramnicu Valcea.
The resulted hydrogen integrated small power unit development line, have opened new skills for the research team of the NCHFC, which created the basis for further improvements and extending towards technology transfer to high-tech SME.
Therefore, the project outcome established a strong milestone onto the road on which Romania will become an important and trustful partner for the entire community which is working to bring hydrogen into the light of new European energy.