H2SusBuild (NMP2-LA-2008-214395)

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COOPERATION
NMP2-LA-2008-214395

- **General Overview**
  - «Development of a clean and energy self-sustained building in the vision of integrating H_2 economy with renewable energy sources»
  - 1/10/2008 – 30/9/2012, 48 months
  - Total budget: 9.915.627,00 € – EC contribution: 6.699.755,00 €
  - Collaborative Project (Large-scale integrating project)
  - Consortium comprises 18 partners: D'Appolonia, NTUA, SCAME, IKERLAN, IDROGEN2, SEAE, IVW, CIRCOMP, ACCIONA, ICI, CATATOR, USTAN, CRES, SKANSKA, UNSTUDIO, DECSOFT, CAVE, DNV

- The project's objective was to develop an **intelligent, self-sustained and zero CO_2 emission hybrid energy system (RES-H2 system)** to cover electrical and thermal energy needs of either residential/commercial buildings or districts of buildings:
  - By RES availability, the primary energy harvested is directly used to cover contingent loads
  - By excess RES availability, the excess energy is converted to gaseous H_2 to be used as energy storage medium
  - By RES shortage, the stored H_2 is applied as a green fuel to cover the building's electrical and thermal energy demand through
    - combined heat and power generation by means of fuel cells
    - additional heat production by means of direct combustion

- **At system level**
  - *Design of the RES-H2 hybrid energy system*
  - *Development of a techno-economical simulation tool to facilitate the design and sizing of similar RES-H_2 systems*
  - *Integration of all components in one operational RES-H2 hybrid energy system (full-scale demonstrator covering the energy needs of a small building)*
  - *Development of an effective Energy Management and Control System building on optimised operational strategies*
  - *Installation of a Safety and Protection System to guarantee safety in the building*
  - *Assessment of applicability as well as economic viability of the proposed RES-H2 hybrid energy system in the building sector*

- **At technologies/components level**
  - *Improved water electrolyser technology, to render it compatible with domestic environments by working particularly on safety and on reducing overall system's dimensions and cost*
  - *Reduction of weight and cost of pressurized hydrogen storage technologies by:*
    - *the development of lightweight composite pressure vessels for hydrogen gas storage in buildings*
    - *the development of a low cost and high production capacity manufacturing process based on Ring Winding*
  - *Development of domestic heating technologies based on hydrogen combustion*
  - *Further development of low temperature Solid Oxide Fuel Cell technology*
  - *Design and development of a 20 kWe and 20 kWth micro-CHP unit based on PEM Fuel Cells*

- **Project milestones**
  - *M1: Beta version SW Tool*

    A simulation tool with GUI able to conceptually design the RES-H_2 system
  - *M2: Small-scale pilot RES-H_2 plant ready for testing*

    Integration of small-scale components (electrolyser, PEM FC, H_2 distribution grid and storage, energy management and control system, safety and protection system) in a single reduced scale plant working in design conditions
  - *M3: Full-scale components prototypes ready and tested*

    Full-scale components tested individually and ready for shipping to demo building for integration
  - *M4: Full-scale RES-H_2 plant ready for testing*

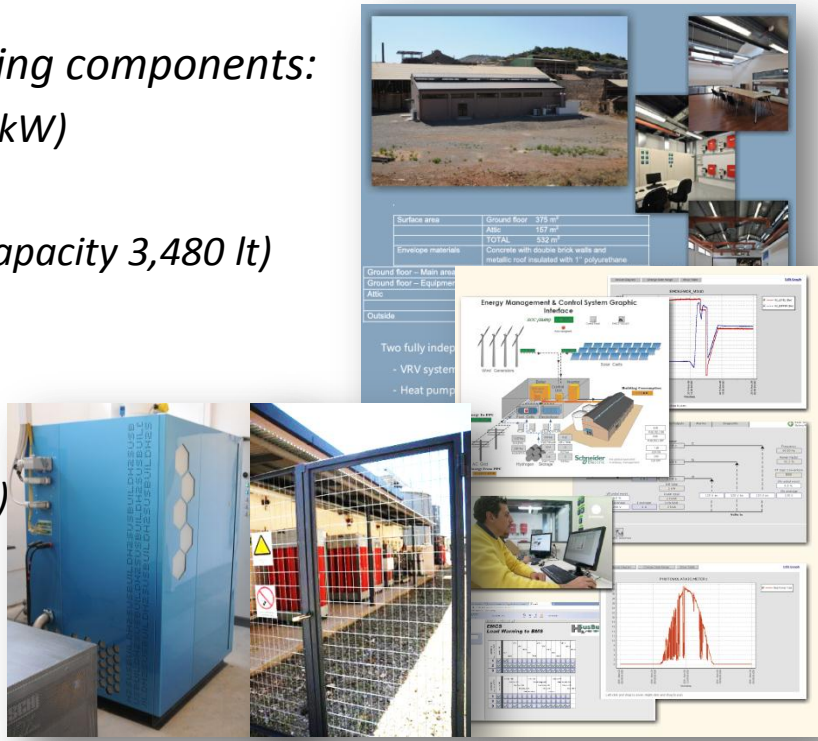
    RES-H2 plant integrated and working in design conditions in the demo building
  - *M5: Final version SW Tool*

    A reliable simulation tool with GUI ready for the design and dimensioning of similar RES-H_2 systems
  - *M6: Full-scale RES-H_2 plant performance demonstrated*

    Data about system performance and safety

- **Approach for performing project activities**
  - *Activities were categorized as Research, Demonstration and Other in a modular manner*
  - *Research activities involved design, modeling and simulation following in-house procedures*
  - *Research activities at technologies/components level was carried out within first 18 months of project development*
  - *Demonstration activities involved **full-scale system development and installation in a real demonstrator building***
  - *Identification of risks and possible contingency plans to ensure project progress was carried out on a continuous basis*

- **Technical Accomplishments and Progress**
  - *All project objectives and milestones have been achieved*
  - *The RES-H_2 energy system has been successfully designed, installed and is currently operational in a medium-sized (525 m^2) office building in Lavrion Technological and Cultural Park, Lavrion, Greece*
  - *The RES-H_2 energy system consists of the following components:*
    - *Thin-film PVs (46.8 kW) and downwind WTs (36 kW)*
    - *Water electrolysis unit (22.3 kW)*
    - *H_2 distribution grid and storage vessels (water capacity 3,480 lt)*
    - *Micro-CHP PEM Fuel Cell (20 kWel and 20 kWth)*
    - *H_2 burner within condensing boiler (60 kWth)*
    - *Heat Recovery System (HRS)*
    - *Energy Management and Control System (EMCS)*
    - *Safety and Protection system (SPS)*



- H2SusBuild directly correlates with the following FCH JU Application Areas
  - AA2: Sustainable hydrogen production and distribution
  - AA3: Stationary Power Generation and Combined Heat & Power (CHP)

MAIP Targets AA2: Production and Distribution			Target 2015	Target 2020	Achieved by H2SusBuild
Production	*Decentralized*	*Electrolysis from renewable electricity*	*1.5 t/day 68% efficiency*	*3.0 t/day 70% efficiency*	*≅8.5 kg/day 52% efficiency*
		Total installed production capacity (from renewable)	*-*	*460 t/day*	*≅ 8.5 kg/day*
Stationary storage (of H2 from renewable electricity)	*Decentralized (above ground)*	*Compressed*	*5.0 t*	*10.0 t*	≅ 61 kg

2. Alignment to MAIP/AIP

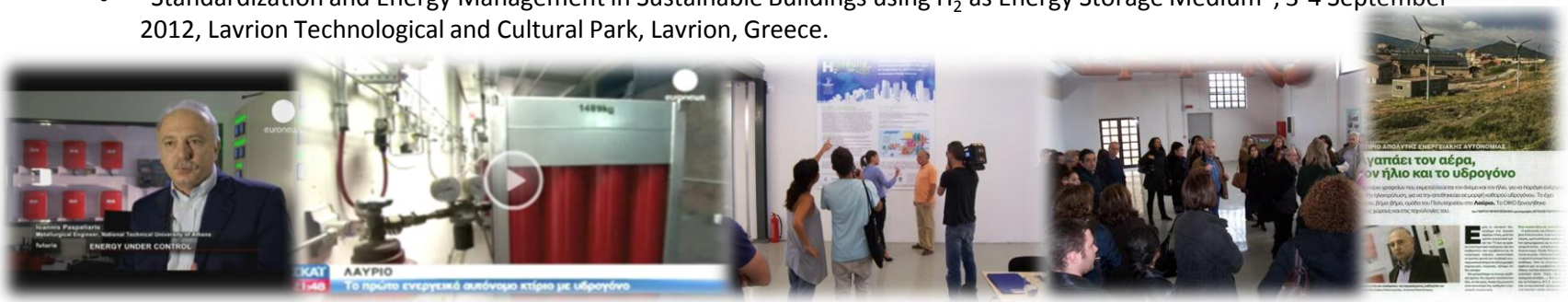
MAIP Targets AA3: Stationary Power Generation and CHP		Target 2015	Target 2020	Achieved by H2SusBuild
Small Scale - Domestic *1 - 5 kWe*	*Single home residential CHP system*	*35% - 45% electrical efficiency* *75% - 85% total efficiency* *1000 units*	*40% - 50% electrical* *80% - 90% total* *2000 €/kW* *20000 units*	*≅50% electrical* *≅75% total* 1 PEM unit
Small Scale - Commercial *5 – 50 kWe*	*Commercial CHP system*	*55%+ electrical efficiency* *85%+ total efficiency* *4000 €/kW* *100+ units*	*60%+ electrical* *90%+ total* *4000 €/kW* *50000 units*	*≅46% electrical* *≅90% total* 1 prototype PEM unit

- **Training and Education**
  - Training and demonstration activities have been performed at the H2SusBuild site for various audiences (technicians, private companies interested in RES-H2 implementations, domestic and foreign government officials, educational and scientific institutions)

- **Safety, Regulations, Codes and Standards**
  - H2SusBuild demonstration site was designed and constructed based on a combination of US, European and national codes and regulations due to lack of uniform regulation, norms and standards among European countries regarding H2 installations
  - The project has produced a design guidelines document gathering experience from design, installation and operation activities to be used as possible reference for future applications

- **Dissemination & public awareness**
  - Participation in international events and conferences (H_2 Implementing Agreement 2008, BSEC Turkey 2010, EeB PPP Belgium 2010, ICH2P Greece 2011)
  - Web, TV and radio broadcasts (Euronews-Futuris, TV5-Mediterraneo, SKAI TV, ERT)
  - Publications in magazines and newspapers (Realnews, Kathimerini, OIKO magazine)
  - Website maintenance and update

- **Publications/workshops**
  - I. Paspaliaris, M. Taxiarchou, A. Peppas, P.G. Benardos, S. Carosio, G. Urbano, A. Monero, R. De Laurentiis, "Implementation of a hybrid energy system combining RES and H_2 in an office building in Lavrion Greece", Proceedings of the International Conference on Hydrogen Production (ICH2P-2011), 19 - 22 June 2011, Thessaloniki, Greece.
  - I. Paspaliaris, M. Taxiarchou, A. Peppas, P.G. Benardos, S. Carosio, G. Urbano, A. Monero, R. De Laurentiis, "Application of a hybrid energy system combining RES and H_2 in an office building in Lavrion Greece", submitted for publication, International Conference on Renewable Energies and Power Quality (ICREPQ'13), 20 - 22 March 2013, Bilbao, Spain.
  - "Standardization and Energy Management in Sustainable Buildings using H_2 as Energy Storage Medium", 3-4 September 2012, Lavrion Technological and Cultural Park, Lavrion, Greece.



- **Technology Transfer / Collaborations**
  - *H2SusBuild interfaces with a new FP7 project titled "Autonomous Management System Developed for Building and District levels" (AMBASSADOR, FP7-NMP, 314175) focusing on real-time configurable building and district energy management and information systems (DEMIS)*
  - *The developed RES-H_2 system is also included in proposals submitted for the FP7-2013-NMP call*

- **Project Future Perspectives**
  - Proposed future research approach
    - H2SusBuild demonstration site will continue operation to further investigate optimized energy management scenarios and synergistic operation strategies between RES and H_2 technologies
    - Existing system infrastructure (water electrolyser, micro-CHP PEM Fuel Cell, prototype H_2 Burner) can be used to further elaborate on real-world operation characteristics and integration requirements for residential applications

- **Project Future Perspectives**
  - The developed RES-H_2 hybrid energy system can be used as a full-scale research, development and testing facility of:
    - H_2 production, storage and consumption technologies
    - Energy management systems
  - Existing demonstration site presents a great opportunity to attract interested parties such as:
    - State or Regional authorities
    - Scientific institutions
    - Private companies

    for direct knowledge exchange, consultancy and joint initiatives
  - Contribute to standardization activities at system level for residential buildings or districts of buildings in order to promote growth of target market

- **Project Future Perspectives**
  - Possible contribution to the future FCH JU Programme
    - The H2SusBuild demonstration site existing infrastructure can actively contribute to two out of four FCH JU Programme application areas:
      - AA2: Sustainable hydrogen production and distribution
      - AA3: Stationary Power Generation and Combined Heat & Power (CHP)
    - Furthermore, it is technically feasible to modify and upgrade the existing infrastructure in order to contribute to the rest of FCH JU Programme application areas

Technological park of
National Technical University of Athens
Lavrion, Greece

Project useful references

- **H2SusBuild project website**
  http://www.h2susbuild.ntua.gr/