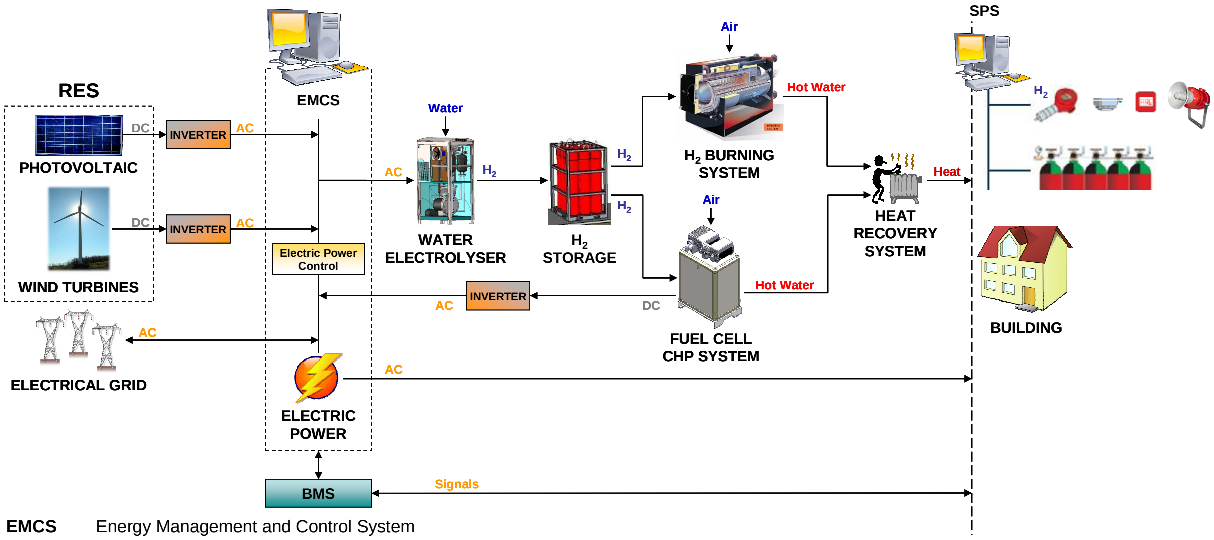
Publishable summary

Project context

More than 40% of the total energy consumed in the EU is used to cover the needs for heating, cooling and electricity of buildings. As the major part of this energy is produced from combustion of fossil fuels such as oil and natural gas, both the EU community and the buildings sector are highly dependent on imported fossil fuels. Moreover, the buildings sector is also a major contributor to greenhouse gas (GHG) emissions. To address energy- and climate-related issues, the EC has set the objectives of reducing greenhouse gas emissions by 20%, increasing the share of renewables in the EU's energy mix to 20%, and achieving the 20% energy efficiency target by 2020. Accordingly, the trend in the buildings sector is to move towards using Renewable Energy Sources (RES) to cover buildings' basic energy needs, thus moving away from fossil fuel-based energy sources. However, a proper way to balance the intermittent nature of RES must be researched and consolidated to ensure the continuous operation of energy systems based on RES.

The H2SusBuild Project objectives

The concept behind the H_2SusBuild Project was to develop a self-sustainable and zero-CO_2-emission hybrid energy system, in which the storage of hydrogen provides for the energy supply in case of energy shortage from RES, thus compensating their intermittent nature. With this respect, RES technologies such as photovoltaic solar panels as well as wind power generators are coupled with water electrolysis for the production of hydrogen. The produced hydrogen is stored in form of pressurized gas and consumed on-demand in order to produce thermal and electrical energy in case of shortage of Renewable Energy. More specifically, RES technologies are used to harvest primary energy to be directly applied to cover the building's contingent loads. In case of excess Renewable Energy availability, the excess energy is converted to hydrogen to be used as energy storage medium. In case of Renewable Energy shortage, the stored hydrogen is applied as green fuel in order to cover the building's electrical and thermal energy demand, through combined heat and power generation by means of Fuel Cells as well as by direct combustion for additional heat production when needed.



EMCS Energy Management and Control System
BMS Building Management System
SPS Safety and Protection System

Within this framework, since the system would have limited efficiency if State-of-the-Art technologies would be utilised, a further parallel objective concerned the improvement of single technologies' performance in order to contribute to the improvement of the whole system's efficiency. Furthermore, with an outlook to future potential applicability, each component was specifically designed for building environments (domestic or commercial), thus targeting the highest level of Safety. Ease of installation and maintenance, and ease of operation thanks to a higher level of automation were also a target. Last but not least, reduction of investment costs on single key components was pursued. Finally, the synergistic operation of the various system components was tackled together with the development of optimised operational strategies.

In order to achieve the abovementioned project objectives, the work programme had been broken down into the following detailed objectives:

1. To design the **RES-H2 hybrid energy system** and develop a simulation tool able to predict its performance, thus aiding in the system's design (WP2);
2. To improve performance of **water electrolyser technology**, and render it compatible with domestic environments by working particularly on Safety and on reducing overall system's dimensions and cost (WP3);
3. To reduce the weight and the cost of pressurized hydrogen storage technologies by:
    a. Targeting the development of **lightweight composite pressure vessels** for hydrogen gas storage (WP4);
    b. Targeting the development of a low cost and high production capacity **manufacturing process based on Ring Winding** (WP4);
4. To develop **domestic heating technologies based on hydrogen combustion** rather than on conventional combustion of natural gas (WP5);
5. To develop **low temperature Solid Oxide Fuel Cell technology** (WP6);
6. To develop **FC-based micro-cogeneration systems** (WP6);
7. To develop an effective **Energy Management and Control System** building on **optimised operational strategies** (WP7);
8. To implement the **small-scale RES-H2 hybrid energy system prototype in a real building** (WP8);
9. To scale up the system and develop an **integrated full-scale RES-H2 hybrid energy system demonstrator** to cover the energy needs of a small building (WP9);

10. To guarantee Safety in the building through installation of a **Safety and Protection System** and the development of appropriate safety procedures (WP10);
11. To **assess the risks** related to hydrogen production, storage, distribution and consumption in a building environment (WP10);
12. To define a strategy and measures to be undertaken towards **Standardization** (WP10);
13. To **assess applicability, acceptability, as well as the economic viability** of the proposed RES-H2 hybrid energy system in the building sector (WP11).

Performed work and achieved results

This hybrid energy system has been installed in a real building environment in order to demonstrate its application in commercial or residential buildings types from the perspective of technical feasibility as well as from the point of view of safety. The concept has been demonstrated through two installation steps; the first step foresaw a reduced scale prototype installation focusing on satisfying the electrical energy demand of a target indicative 150 m^2 surface area dedicated to office use; the second step foresaw a full-scale installation focussing on satisfying both the electrical as well as the thermal energy demand of a target indicative surface area of about 600 m^2.

A consistent part of the work has been dedicated to achieve a safe design of the overall hybrid energy system. This included upgrading the demonstration building's facilities to host the full-scale installation, which includes, between others, the hydrogen generation, storage and consumption technologies, as well as the hydrogen distribution grid in full safety. To guarantee Safety, a Safety and Protection System, integrating flame detectors, heat detectors, smoke detectors, and hydrogen gas detectors, has been installed. Last but not least, the coordinated and synergistic operation of the various hybrid energy system components among themselves and with the RES is enabled by an Energy Management and Control System, which, building on optimised operational strategies, manages collaboration of the RES with the public electrical supply grid, minimising the use of the grid.

Expected final results and their potential impact and use

The development of the H2SusBuild RES-H2 hybrid energy system allowed demonstrating to what extent hydrogen gas storage can be applied to balance the intermittent nature of RES technologies, thus ensuring continuous operation of energy systems based on RES applied to cover the thermal as well as electrical energy needs of buildings.

To this end, the project aimed first of all to demonstrate technical feasibility of achieving installation and coordinated / synergistic operation of such a system within a real building environment. Moreover, the project allowed assessing appropriateness of Safety measures put in place in order to ensure a safe environment for inhabitants despite the use of hydrogen, thus contributing to provide guidelines for the use of hydrogen technologies in buildings. Economic feasibility was also assessed thanks to a study aimed at understanding the future potential economic viability of applying such a system in buildings. Last but not least, the use of appositely developed simulation tools will allow understanding in which cases it will be possible to apply the proposed RES-H2 hybrid energy system according to local climate, building types, and site specificities.

Contact information

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