Hybrid Renewable Energy Systems for the Supply of Services in Rural Settlements of Mediterranean Partner Countries HYRESS project

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Abstract

Hybrid renewable energy systems is one of the most promising applications of renewable energy technologies in remote areas, where the cost of grid extension is prohibitive and the price of fossil fuels increase drastically with the remoteness of the location. It has been demonstrated that hybrid energy systems can significantly reduce the total life-cycle cost of stand-alone power supplies in many situations, while at the same time providing a more reliable supply of electricity through the combination of energy sources. Applications of hybrid systems range from small power supplies for remote households providing electricity for lighting or water pumping and water supply to village electrification for remote communities. Mixed combinations of renewable energy systems are also possible, that is applications where different renewable energy technologies are applied in one location without the systems being necessarily interconnected in one electricity grid. Although a range

of hybrid system configurations are possible what we have learned so far is that the choice must suit the community considered. Also the problem of energy storage could be addressed by the use of a hydrogen subsystem, which is an alternative to diesel generators as a backup and can help to reduce dramatically the size of the battery banks as well.

The strategic objective of the HYRESS project is to remove the knowledge barriers against the installation of Renewable Energy Systems and creation of micro and mini-grids. An efficient tool to apply and fulfill the strategic objective is the development, installation, testing and evaluation (technically and socially) of the performance of low-cost pilot hybrid renewable energy systems and mini-grids in selected remote sites far away from the grid, of Mediterranean Partner Countries. The hybrid systems will consist of photovoltaics, small wind generators, hydrogen subsystems and biodiesel generator and they will be installed in selected sites of Egypt, Tunisia and Morocco. On these sites micro-grids will be created or upgraded both in capacity and in incorporation of renewables.

Introduction

The strategic objective of the HYRESS project is to remove the knowledge barriers against the installation of Renewable Energy Systems and the creation of mini-grids based on renewables. Research challenges can be found in the field of system management but also best combination of available technologies according to the local prevailing conditions, that is build up hybrid systems to match a varying supply with very different consumption profiles. For reducing expenses it is also very important to minimize the system storage requirements. Next to this excellent system management, the technology design has to carefully adapt to the extreme framework conditions:

The technologies have to be very robust and designed for the local climatic and social conditions

- The requirements for service and maintenance must be very low

- The technologies should be cost effective and preferably locally manufactured
- Appliances must have low levels of energy consumption, and be able to cope with the power supplied from stand alone systems (e.g. fluctuating power, Direct Current or Alternating Current supply etc.)

- Several system typologies will be examined i.e. Direct Current based *versus* Alternating Current mini grid systems for optimum and continuous power and energy supply.
- The storage systems have to perform well under the high temperature conditions of the MPC. Under these conditions the research that has already taken place for the operation of hydrogen subsystems is minimal and so this project will provide valuable new data.

HYRESS project work plane

Besides the project coordination and management activities, HYRESS is organized in the following work packages:

WP 1: Detailed research on geographic and socio-economic framework conditions for Mediterranean Partner Countries (MPC)

WP 1 regards detailed research on geographic and socio-economic framework conditions for Egypt, Morocco and Tunisia. The objective of this WP is to obtain a complete picture of the socio-economic and environmental framework conditions relevant for enhanced hybrid Renewable Energy installations in MPC.

WP 2: Design, construction and testing of pilot hybrid mini-grid system installations

WP 2 regards the hybrid systems technology development and application for the two cases in Egypt and Tunisia.

WP 3: Design, construction and testing of pilot RE-Hydrogen system

WP 3 regards the hybrid systems technology development and application for the Morocco case (Hybrid system with hydrogen subsystem).

WP 4 : Technical and social monitoring and assessment

This work package encompasses a holistic and integrated monitoring strategy to be implemented throughout the entire project lifetime. The issues to be covered include:

- Technical and economic monitoring of installations and demand side measures: Plant outputs, changes in demand patterns, local economic benefits, job creation, etc.
- Social issues, local population involvement, attitudes
- Environmental impact, covering: local perception of impact, visual pollution, saved emissions and general environmental impact

WP 5: Research Results and Research Recommendations – Lessons learnt – Dissemination activities

WP 5 is devoted to recording and systematise the research results and conclude the research recommendations and lessons learnt. Activities include, the extraction of the key conclusions and lessons learnt from the technical and socio-economic evaluations, and the formulation of required optimisation of installations, develop a follow-up plan of actions (further projects and research requirements), present executive summary for policy makers, for industry and research, propose (and possibly find new) means for project sustainability and repeatability after the project end, organisation of closing workshops to present and disseminate the project results and launch further activities.

Description of the hybrid system to be installed in Egypt

The system design was performed to cover part of the electricity and water needs of the local community with the boundary conditions of the total system budget. The proposed design offers modularity, reliability and using of the shelf components. Beside the electricity production the system in Egypt provides also fresh water through a brackish water desalination unit and pumped well water through water pumping system.

The Abokida hamlet site is located at the El-Gaish Road (military road). Located about 90km south east of Alexandria city. The Abokida hamlet consists of 13 houses for 13 families and a mosque. The population in the hamlet is about 60 inhabitants. The location is a newly reclaimed land under development. The people live mainly on grassing and farming. The site suffers from lack both water and electricity. The site is a developing area and it is expected in the near future that the number of inhabitants will triple immediately after the installation of the system.

The proposed Hybrid system will consist of PV modules connected in series to achieve the appropriate inlet voltage of the string inverter and then in parallel to achieve the required peak power. Each group of PV modules that are connected in series is connected to the micro grid via a string inverter. The multi string configuration offers better energy yield and more system reliability. The wind turbine produces three phase AC power. The rectifier that converts the three phase AC power to DC and then the wind turbine inverter converts the DC power to the appropriate one or three phase power of the micro grid. The storage batteries will be sized to cover a short period of autonomy (maximum one day). This is because of the nature of the current hybrid system configuration that allows the direct load coverage without passing all the energy through the batteries.

As far as the loads concerns, the houses electrification will be covered via the micro grid. Awareness rising seminars should be carried out to establish a good energy management at consumption level in order to avoid over consumption or unexpected blackouts. The water pumping system will operates as far as there is available energy and the water tank is empty. Finally, the desalination plant will operates when there is feed water in the feed water tank and the fresh water tank is not full. A lay out of the system is shown in Fig. 1.

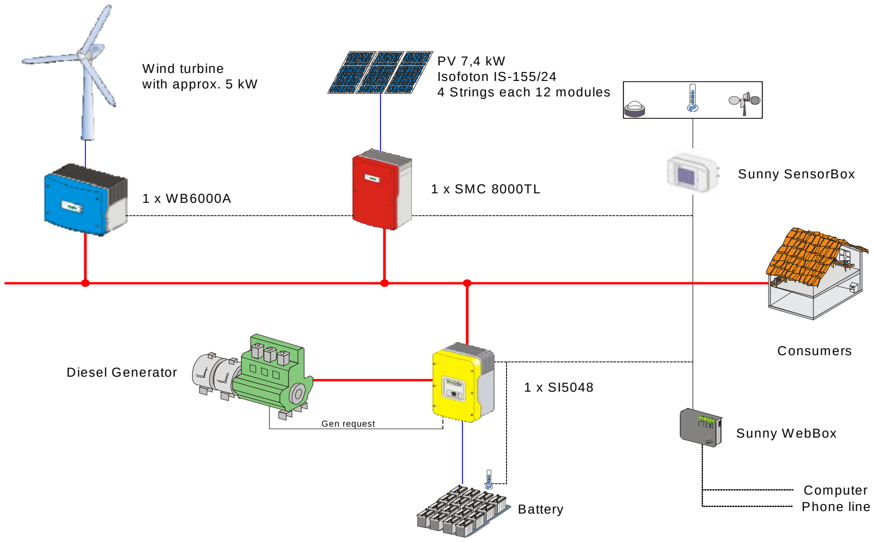

Figure 1:Hybrid system layout in Egyypt

Description of the hybrid system to be installed in Tunisia

Ksar Guilène can be described as a “renewable village”. There are several solar home systems, stand alone photovoltaic system, solar thermal equipment and a wind turbine. There are 50 families, about 300 people, and most of them work in the tourist area. About 47 houses, each of which has 100 W, solar home system in DC current. This PV system supports the house electrification and other little consumers. While, the mosque, the primary school and the health centre are covered by a stand alone wind energy system.

The AC bus mini grid is shown. Nowadays it is well known that more flexible systems, with consequently modular structure systems, are achieved via coupling all consumers and generators on the AC side. The structure of such supply systems requires, in addition to the power conditioning equipment, a control and supervision unit which is responsible for implementing a specific operation control strategy and for securing the grid and system components. In small and medium power systems (3 - 30 kW) this control unit is often integrated into the key component (bi-directional battery inverter) which simplifies system operation and decreases the investment costs. This distribution also helps to reduce the cost of the entire system, especially the costs for the cabling on the DC side and the subsequent distribution on the AC side, see Fig. 3.

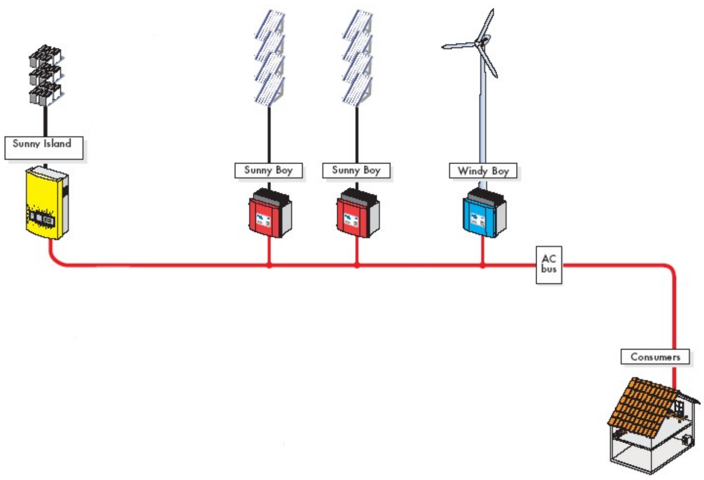

Figure 2:The mini grid in Tunisia

Description of the hybrid system to be installed in Morocco

Energy storage plays an important role in the development and operation of a RE system. The integrated wind and solar energy system, based on long-term seasonal storage as hydrogen, is considered a promising alternative to overcome the intermittence of the RE sources. In comparison to commonly used battery storage, H_2 is well suited for long term (weeks) storage applications, because of its high mass energy density.

A typical autonomous RE-hydrogen system must include both short-term and long-term energy storage. A battery bank is used for short-term energy storage due to its high charging-discharging efficiency, and also to take care of the effects caused by instantaneous load and electrolyser transients and wind energy peaks. Batteries alone are not appropriate for long-term storage because of their low energy density and self-discharge.

The combination of a battery bank with long-term energy storage in the form of H_2 can significantly improve the performance of a stand-alone RE systems. In such a RE system, the electrolyser generates H_2 during times when excess solar and wind energy is available and then the fuel cell utilizes this H_2 to produce electricity when there is insufficient solar and wind energy. The intent of this part of project is to demonstrate that H_2 is reliable energy storage medium for RE and that it is safe. Figure 3: Concept of hydrogen based hybrid system shows the concept of hydrogen based hybrid system.

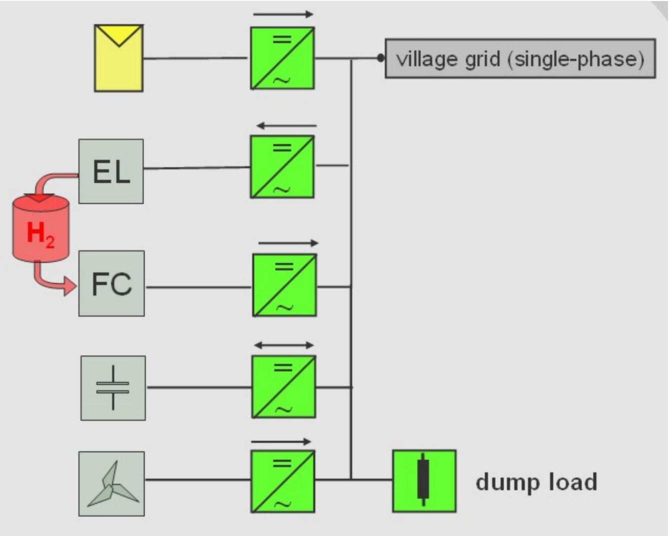

Figure 3: Concept of hydrogen based hybrid system

Conclusions

Hybrid renewable energy systems, (*i.e.* systems that combine more than one renewable energy technology such as photovoltaics and wind turbine), is one of the most promising applications of renewable energy technologies in remote areas, where the cost of grid extension is prohibitive and the price of fossil fuels increase drastically with the remoteness of the location. It has been demonstrated that hybrid energy systems can significantly reduce the total life-cycle cost of stand-alone power supplies in many situations, while at the same time providing a more reliable supply of electricity through the combination of energy sources. Applications of hybrid systems range from small power supplies for remote households providing electricity for lighting or water pumping and water supply to village electrification for remote communities.

Ultimate objective of HYRESS is to develop, combine, install, test and assess the performance of low-cost pilot hybrid RE systems in remote areas of the Mediterranean, which are not yet grid-connected. The hybrid systems will be consisted of photovoltaics, small wind generators, hydrogen subsystems and biodiesel generator and they will be installed in selected areas of the MPC countries to set-up and provide electricity.

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