HYRESS PROJECT. STUDY CASE OF KSAR GHILÈNE, TUNISIA

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ABSTRACT: The strategic objective of HYRESS project is to remove the knowledge barriers against the installation of RE Systems. The ultimate objective of the project is to develop, combine, install, test and assess the performance of low-cost pilot hybrid RE systems in remote areas of the Mediterranean. The main system design criteria have been modularity, robustness, simplicity in use and the requirement of a very low maintenance. Research challenges can be found in the field of system management but also in the best combination of available technologies according to the local prevailing conditions. Within HYRESS project, three pilot hybrid systems will be developed, installed, tested and evaluated (technically and socially) in selected sites of Egypt, Morocco and Tunisia. ITER will be responsible for the micro-grid design at Tunisia. The place chosen is the site of Ksar Ghilène, a village located in southern Tunisia, in the governorate of Kébili at Bouflija depression.

Keywords: Hybrid, micro-grids, design, villages, system, monitoring, storage

1 INTRODUCTION

Hybrid systems must be configured and sized after taking into account the local conditions of the installation place. The systems should fulfill criteria such as modularity, robustness, and simplicity in the use while providing very low maintenance. Additional considerations for the technology's selection and implementation are also considering regarding the possibility of systems' standardization and replication.

Furthermore, all local installations must serve as models of good practice, accelerate local skill development, and promoting and encouraging international partnerships amongst all the relevant players, such as research, financial, and regulatory institutions, industry and service companies, in particular SMEs, local representatives and other social players.

The overall goal for this work is the proposition of appropriate concepts and typologies for hybrid systems according to technical requirements, local needs and local social conditions, proposing appropriate typologies of hybrid systems.

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This paper describes an action plan in order to design and develop a hybrid RE system for electricity generation of electricity in such rural areas. Electrification of isolated rural areas is a key component of poverty eradication and sustainable development. Tunisia's environmental policy aims at maintaining the ecological balance, develop natural human resources, and control all forms of pollution. It also seeks to reconcile development needs with environmental imperatives in order to protect natural resources (air, water, soil, and biodiversity), reduce existing risks to such resources, and improve the living conditions of the population. The Tunisian case is a model of success for developing countries, always searching a balance between the imperatives of sustainable economic development and the demands for coherent social promotion.

2 KSAR GHILÈNE OVERVIEW

The village of Ksar Ghilène is located in the governorate of Kébili, in the south-western Tunisia, and its geographical coordinates are 33 North, 9.4 East.

Figure 1: View of the village of Ksar Ghilène

This rural community is distributed in several houses, and shares some public buildings, such as a primary school, a health center, a mosque and public showers.

The population is about 50 families, over 300 people, and although the main activity used to be agriculture and cattle rising, the tourism is nowadays the main source of income. There are 5 hotels with total capacity of 600 beds, and employing 110 people.

This location can be described as a "renewable village". There are several solar home systems, fitted with stand alone photovoltaic system, solar thermal equipment. Also, the community has a wind turbine and a PV RO desalination plant.

Next figure shows the actual village distribution. It occupies a total area of about 2x2 km^2.

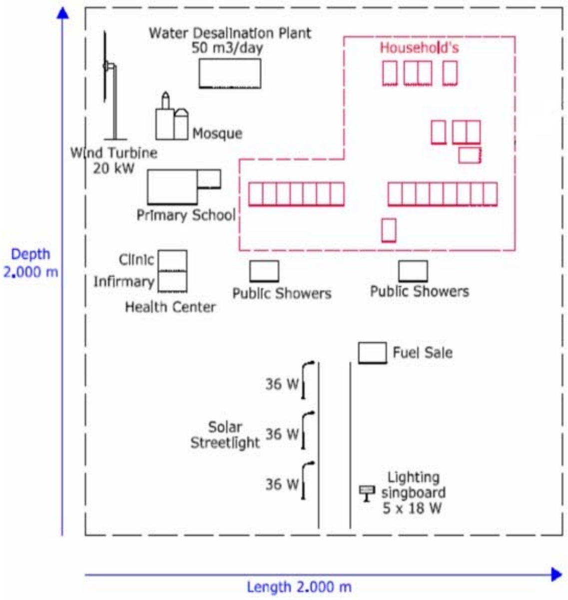

Figure 2: Scheme of the village of Ksar Ghilène

This village is a tourist destination that offers culture and traditions to visitors. Although, this area has several renewable energy resources, its continuously increasing energy demand made it necessary to increase the installed power of the existing RE system. The selection of the appropriate design of the hybrid RE system according to the particularities of Ksar Ghilène falls within the aim of this project.

At the moment, the village electricity demand is been solved by the use of SHS, which supply the basic requirements of the rural households (3 fluorescent tubes, a radio and a B&W TV set) during several hours per day. Water needs are covered by an autonomous RO desalination unit, supplied by a 10.5 kWp PV Plant. Other RE equipment: Solar streetlights, independent stand alone PV for the school, the health centre, the mosque and the public showers. There is also a pilot stand alone wind energy system with a power of 25 kWp.

3 SYSTEM DESIGN

3.1 Demand analysis

Nowadays the RE systems installed in the village, which were implemented in order to satisfy individual requirements, have been in operation for many years and, therefore the population is familiar with them. However, this new approach is expected to introduce some changes in the use of such resources.

With all these considerations in mind, we have decided to design a micro-grid only for the household. But the stand alone solar systems will be kept in place and also, the health centre, the primary school and the mosque will continue being supplied with the power of the wind turbine. Consequently, an AC grid will be installed in order to cover the all electricity needs for the inhabitants of the village, while the SHS will cover their DC needs (for example DC refrigerators).

A typical village house (with an average of 5 persons per house) is formed by one or two rooms, the kitchen and the living room. The dimensions of the houses may vary between 10x7m^2 and 9x7.5m^2. The main loads that are taken into consideration are some lighting, B&W or Color TV, and some radios. We will consider that all the inhabitants have the same behavior so, consume for the 50 families will be approximately 30kWh/day.

3.2 Available solar and wind potential

We have used different sources in order to estimate the annual irradiation hours for Ksar Ghilène:

- A renewable energy resource web site sponsored by NASA's Earth Science Enterprise program (http://eosweb.larc.nasa.gov/sse/RETScreen)
- A global meteorological database software, known as Meteonorm, from the company METEOTEST (http://www.meteotest.ch)
- And the climatic maps, provided by ANME

According to the climatic maps the annual irradiation hours are between 3000 – 3200 and the annual average global solar radiation is between 5.00 – 5.25kWh/m^2 day. This data match up approximately with the ones from RETScreen and METEONORM. In both cases, throughout the year, the irradiation is higher than 1800kWh/m^2.

Wind energy potential has been studied using the data from a measurement station located at the site. This station has two anemometers, one at a height of 10m and the other at 35m. The Weibull distribution of these data shows that at a height of 10m, the wind with speed between 3 – 7m/s represents the 52.33% of the local conditions.

3.3 Hybrid RE system

The micro-grid will be designed under the philosophy of AC coupling. It provides maximum flexibility in expanding the system and reduces installation efforts and cost. The modularity and extendibility of the system could be guaranteed only installing further battery inverters or other generators on the AC side, giving the ability to react promptly and flexibly to increasing consumption.

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 our case this control unit is integrated into the key component (bi-directional battery inverter) which simplifies system operation and decreases the investment costs.

This distribution also helps reducing the costs for the entire system, especially the ones related to the cabling on the DC side and the subsequent distribution on the AC side.

Different components from SMA Technologie AG (www.sma.de/en) will be used, in order to create the micro-grid.

In the following figure, a scheme representing the AC bus micro-grid is shown.

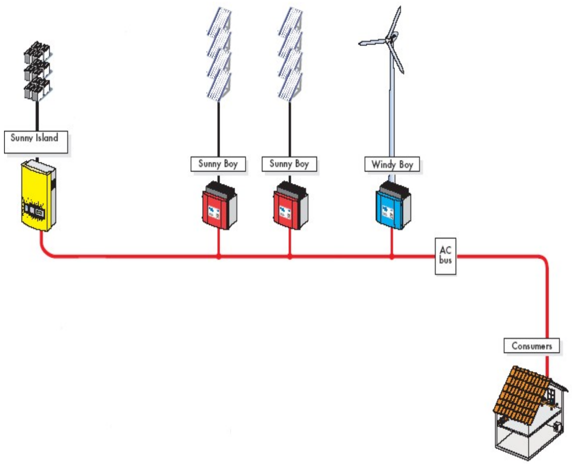

Figure 3: Hybrid system layout in Tunisia

The technical specifications for the Tunisian installation are summarized in the following table:

Table I: Technical specifications

Description
PV plant, 72 µamorphous thin film photovoltaic modules, total power 7.62 kW
2xSunny Boy SB3300 grid inverter with communication piggy back and communication cable RS485
5kW Wind Turbine
2xWindy Boy WB2500 with communication piggy back and communication cables RS485
2xSunny Island battery inverter SI5048 with communication piggy back and communication cable RS485, includes also battery temperature sensor
24xPVS solar batteries 3000 Ah/C – 100h 2V
Battery fuse SMA SI-Batfuse.03 for tow Sunny Island

Different types of fuses and protections will be used in order to protect the diverse electronic components of the system. Together with these protections, the different electrical circuits have been designed for guaranteeing the operation safety.

The system also includes a monitoring system, which will be described in detail below.

3.4 Data acquisition system

Remote data monitoring, and control of the system will be done by using the datalogger Sunny WebBox together with the Sunny SensorBox, with module temperature included and integrated irradiation meter, from SMA. This will allow the measurement of the irradiance, module temperature, wind speed and ambient air temperature.

Data will be collected by local people in the village. After that, the information will be sent to WIP – Renewable Energies [1] (the partner in charge of the social and technical analysis of the system). Once the reports are prepared, WIP will send them to all HYRESS partners for its dissemination.

3.5 Control Cabinet

The accumulation system and the electronic components of the installation must be placed in an indoor and protected area. It is important to take into account that ambient temperature could be above 50ºC. Besides, integration concepts are relevant in the cabinet design.

With this purpose, a control cabinet has been designed, with dimensions 2.2m by 6.7m and optimized in order to fit all the components at the lowest possible costs.

Inside the cabinet, the batteries will be placed on the floor in one row configuration, making room for the inverters, monitoring and protecting system. In a lateral, near to the top, there is a ventilation grid of 0.7 x 0.9 m in order to favor natural air flow. Also, there is a floating floor in order to facilitate the cabling connections and maintenance.

3.6 Cabling

AC output will be distributed in groups of households. The cable will be embedded with electrical signs. Moreover, a register box will distribute the different lines.

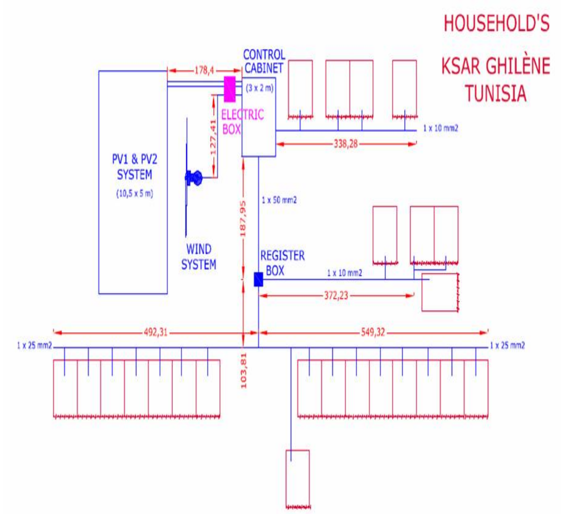

Figure 4: Hybrid system layout in Tunisia

In the previous figure sizes are shown, and they are calculated depending on the distances between different equipments and considering voltage losses below 3%.

4 SOCIAL AND ECONOMICAL ASPECTS

The main philosophy for this installation is facilitate a logical evolution of the actual energy production profile of the village. We are aiming to transform the individual sets of energy production to a centralized one, and therefore securing power supply to the consumers.

This is an important change, not only from a technical point of view but also in social and economical aspects of the community.

From a social point of view, there are important issues which need to be addressed. The philosophy of this new system is modularity, expandability, redundancy of the supply, as well as a simplifying their interconnection.

With the actual structure of the community, all the consumers generate what they are able to consume, in fact, what the SHS generates.

In the new distribution, all the consumers must take into consideration the whole community. The fact of having a micro-grid for the entire household, could lead to unexpected issues related to the management of the available power.

The SHS will remain operational in order to supply the DC needs (refrigerators). The new AC micro-grid will supply the other needs, like lighting, TV or radio, among others.

Since inhabitants of Ksar Ghilène are already used renewable energies, we believe that this new approach will be accepted.

5 CONCLUSIONS

Much of the southern region of Tunisia is semi-arid and desert. These regions are experiencing extremely serious difficulties due to environmental degradation. In this way, a long term strategy together with an action plan have been established, in order to improve and create installations based on renewable energy resources in rural areas.

The “renewable village” of Ksar Ghiléne has been studied with the aim of introducing a hybrid RE system for energy generation. This area has several renewable energy resources, which makes it suitable for this kind of installations. Furthermore, the village is developing significantly, making necessary to increase the capacity of its power facilities. The election of the better design according to the particularities of Ksar Guilène is the aim of this report.

For this purpose, we will use AC coupled renewable energy PV and Wind. The battery inverter will be placed in a string way in order to manage the micro-grid.

The devised system offers excellent possibilities for stand-alone grids, due to their high flexibility. This will drastically simplify the design of PV-systems.

We use the string-technology that will considerably improve and facilitate the design and performance of our system.

The existent experience with thousands of grid-connected PV systems, with outputs ranging from one to several hundred kilowatts, has shown that the costs for grid connecting and monitoring of PV-systems adds up to almost 50% of the cost for the entire installation.

With an AC coupling and an appropriate system management, we can develop a technological solution for energy supply in remote areas, which are far away from the main grids, like in Ksar Guilène.

The Tunisian case is a model of success for developing countries, always searching a balance between the imperatives of sustained economic development and the demands for coherent social promotion.

[1] Acknowledgements

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