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Study of Energy Efficiency Solutions for a Smart Water Heating System

Najat Abdeljebbar, Lab LRI, National Higher School of Electricity and Mechanics, Morocco
Abdelwahab Haddaoui, Lab LRI, National Higher School of Electricity and Mechanics, Morocco

ABSTRACT

The preservation of natural water and electricity resources is essential for the development of smart cities. Indeed, water and electricity are highly dependent and must be analyzed together to improve the energy efficiency. This article is about the study of the integration of renewable energy and smart solutions in a water heating system. The existing system uses mainly heat pumps to cover the most of the hot water needs. The purpose of this work is to explore possible solutions to optimize the electricity and the water consumption of the installation.

KEYWORDS

Energy Efficiency, Solar Energy, Thermal Panels, Water Heating System

1. INTRODUCTION

Located in North West Africa, Morocco enjoys a privileged geographical position, a varied climate and two sea fronts facing west on the Atlantic Ocean and north on the Mediterranean Sea. However, the country's sustained economic development over the past decades has nevertheless had significant impacts on the environment, generating pressures on natural resources in addition to those resulting from urbanization, population growth and climate change. Therefore, a certain number of precautions must be taken in order to optimize the energy efficiency by minimizing the consumption of water and electricity and promoting the use of renewable energies. Indeed, energy efficiency is a priority in the national energy strategy: the ambition is to save 12% of energy consumption in 2020 and 15% in 2030. In this context, energy efficiency action plans have been implemented in all key sectors, in particular transport, industry and building (Renewable Energy, Ministry of Industry, Investment, Trade and the Digital Economy, n.d.). In this context, the use of solar thermal energy for water heating system production is one of the major challenges in the transition to energy-efficient building.

The purpose of this work is, in the first part, to study the possibility to add solar panels to the existing water heating system of a traditional Hammam, the objective is to optimize its energy efficiency and minimize the water-related energy consumption. In the second part, we focused on reducing water consumption by proposing the integration of the smart water grid.

2. DESCRIPTION OF THE EXISTING SYSTEM

The water heating system is used to supply a traditional Moroccan Hammam. This system uses 3 heat pumps to produce hot water at about 60° C with a backup made with an electrical resistance. The Hammam has three rooms with different temperatures in addition to showers. The consumption

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of this Hammam is estimated at about 30,000 l/d, with an energy requirement estimated at 4000 Mwh per year.

Our work aims to reduce the electrical energy consumption of the system by using solar energy. Indeed, this kind of energy is an unavoidable option for the minimization of dependence on fossil energy sources and for the reduction of gas emissions. Solar energy is considered as clean, available and inexhaustible and it can be converted using existing technologies in order to satisfy the human needs. In fact, photovoltaic technology converts solar energy into electrical one, while thermal solar technology recovers energy from the sun to provide heat. That heat can be used for hot water production, or air conditioning.

In the following paragraph, we will focus on improving energy efficiency and reducing the electrical energy consumption of the water heating system of the traditional Hammam, the proposed solution is the addition of thermal solar system.

3. INSERTION OF SOLAR THERMAL SYSTEM

3.1 Description of a Solar Thermal System

Solar thermal system is generally divided into 5 subsystems (Ministry of Housing and Urban Policy, n.d.):

- Collection: a set of solar collectors that transform solar radiation into thermal energy.
- Transfer: a solar hydraulic circuit that connects the collectors to each other and distributes energy throughout the entire system.
- Storage: solar storage tanks.
- A back-up system (electric): it provides the necessary energy to guarantee at all times the hot water needs, especially during periods of low sunlight.
- Regulation: A device for regulating, measuring and controlling the system.

3.2 Study of the Feasibility of Integration of the Solar Thermal System

The reduction of the energy consumption due to the use of solar energy depends on several criteria as the climate, the location of the solar collectors, the size and design of the system; it depends also of the choice of equipment and its maintenance. Therefore, it is necessary to seek the best economic adjustment of the size of solar equipment to the needs to be satisfied. In fact, the design of a solar system first involves determining the collector surface area according to the volume and profile of hot water consumption. By simplifying the problem, it is a question of determining how many collectors of a certain brand and type are required to achieve the target energy production for a given installation.

The functioning of the solar water heating system is simple. During sunny hours, the primary circuit of the solar collectors increases its temperature and transfers the collected heat to the storage tanks to coil-type heat exchangers located inside or outside the tanks. The fluid flow in the solar circuit is carried out under pressure by a pump and a control system according to the heating capacity available at any time. It must be taken into account that as the coverage rate increases, the temperature of the fluid in the collector also increases and this causes the decrease in the efficiency of the sensor. In addition, high coverage means that the temperature in the tanks will often reach the maximum temperature, causing the plant to shut down (Ministry of Housing and Urban Policy, n.d.).

The implementation and design of a solar thermal system depends on several major factors, including:

- Hot water needs: a correct estimation of hot water needs is crucial to the optimal design of the system.

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