



Solar water heating systems feasibility for domestic requests in Tunisia: Thermal potential and economic analysis

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ABSTRACT

The main goal of the present work is to study the energetic and the economic potential of the deployment of Domestic Solar Water Heating systems (DSWHs) instead of using electric/gas/town gas water heaters. A case study related to Tunisian scenario was performed according to a typical Tunisian household composed of 4–5 persons. In this scenario we evaluated the performance and the life cycle perspective of the two most popular DSWHs over the recent years (i.e. DSWH with flat-plate solar collector, FPC, and DSWH with evacuated-tube solar collector, ETC). The dynamic behavior of DSWHs according to Tunisian data weather was achieved by means of TRNSYS simulation. The Results showed that the FPC and ETC provide about 8158 and 12002 kW h/year of thermal energy. The economic potential of DSWHs in saving electricity and reducing carbon dioxide emissions was also investigated. Results showed that the annual savings in electrical energy relatively to the FPC and ETC are about 1316 and 1459 kW h/year, with a pay-back period of around 6 and 10 years, respectively. Based on gas/town gas water heaters, the FPC and ETC save about 306 m³ and 410 m³ of gas/town gas with a payback period about 6 and 7.5 years, respectively. We found that the life cycle savings by installing the solar system instead of buying electricity to satisfy hot water needs are about \$3949 (FPC) and \$4400 (ETC). We establish also that the use of the DSWHs instead of installing gas/town gas water heaters save about \$1518 (FPC) and \$2035 (ETC). From an environmental point of view the annual CO₂ emission per house is reduced by 27800 kgCO₂.

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1. Introduction

Tunisia is the northernmost African country on the Mediterranean coast and the smallest (163,600 km²) among those situated along the Atlas mountain line. It is bordered on the west by Algeria and on the south by Libya and the Mediterranean Sea to the north-east and north with a 1300-km of coastline (Fig. 1). Tunisia lies between latitudes 30° and 38°N, and longitudes 7° and 12°E. Despite its small size, Tunisia offers a remarkably diverse natural landscape. The country is divided into three distinct physical regions, the Tell Atlas Mountains and the Dorsale Ridge separated by the fertile valley of the Medjeza River in the north. Tunisia has a temperate Mediterranean climate characterized by warm dry summers and wet winters influenced by sea breezes [1]. Despite limited hydrocarbon resources, Tunisia has enjoyed a promising energy situation characterized by a largely surplus energy balance until the middle of the Eighties. The energy sector played during this period a key role in financing the economic growth of the country (about 13% of the national GDP and 16% of the national exports [2]). Currently, the energy sector accounts for approximately 5%

of the GDP of the country and less than 7% of the total national exports. Since the end of the Eighties, the favorable situation started to deteriorate due to the joint effect of two major factors which are: (i) The stagnation of the national hydrocarbon resources and (ii) The sharp increase of energy demand, notably electricity, as induced by economic and social growth [3]. Thus, the energy balance moved from a surplus situation of approximately 3 Mt in the beginning of the Eighties to a slightly deficit situation. In 2003, Tunisia's imports of oil reached 128.3 million tones, around 46% of oil consumption, following growing energy demand and supply imbalances [4]. In order to address this deficit, the Tunisian authorities have engaged an energy policy compatible with sustainable development. The concerns related to improving the energy balance have also led the authorities to set in October 2000 a national energy commission whose mission is the drawing up of a national program which aims to rationalizing energy consumption and promoting renewable energies [5,6].

As a result, Tunisian policy makers have begun acknowledging the need to resort to cleaner sources of energy, particularly solar energy. In fact, the country is blessed with a huge amount of solar energy which ranges from 1800 kW h/m² per year in the North to 2500 kW h/m² per year in the South spread over 3000 h. This favorable circumstance allows Tunisia to be a pioneer in the exploitation of solar energy in the production of domestic hot

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