Renewable and Sustainable Energy Reviews 16 (2012) 3002–3013

Contents lists available at SciVerse ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Solar water heating potential in South Africa in dynamic energy market conditions

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ARTICLE INFO

Article history:
Received 21 July 2011
Accepted 29 January 2012
Available online 22 March 2012

Keywords:
Solar water heating
Solar thermal
Potential
Scenario

ABSTRACT

This paper is an attempt to determine the potential for solar water heating (SWH) in South Africa and the prospects for its implementation between 2010 and 2030. It outlines the energy market conditions, the energy requirements related to residential and commercial water heating in the country and the solar water heating market dynamics and challenges. It was estimated that 98% of the potential is in the residential sector and the rest in the commercial sector. The total thermal demand for 20 years for water heating was estimated to 2.2 EJ. A 'Moderate SWH implementation' will provide 0.83 EJ of clean energy until 2030 and estimated cost savings of 231 billion rand. For an 'Accelerated SWH implementation' these figures are 1.3 EJ and 369 billion rand. The estimated accumulated reduction of CO_2 emissions due to SWH can be as high as 297 Mt. The increased affordability of residential hot water due to SWH is an important social factor and solar water heating has a strong social effect.

Contents

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doi:10.1016/j.rser.2012.01.065

1. Introduction

In the last decade South Africa experiences steady economic growth. Large scale housing and electrification programs of the South African Government are underway and they exert pressure on the energy market in the country. The electricity demand in the country grew by 50% between 1990 and 2007 [1]. In the last 10 years 7.5 billion rand were spent to electrify 2.136 million homes (in this paper we use the following exchange rate: 1 US Dollar = 6.9 South African rand) [2]. The electricity consumption in the country is experiencing an accelerated growth as is shown in Fig. 1, while generating capacity is about constant around 40 GW. The reserve margin of the national electricity grid is reaching 9% in 2008 after a steady decline from 25% in 2002 [1]. The International Energy Agency's (IEA) energy balance for South Africa shows a total primary energy supply (TPES) of 127,637 ktoe in 2007 out of which 15,298 ktoe (12%) in the residential sector.

The capital expenditure in the electricity generation sector between 2004 and 2008 is 37.5 billion rand. The growing energy demand and strain on the national electricity grid is pressing the South African Government to heavily invest in new generating capacities to meet the growing demand. The approved generation projects amount to 204 billion rand and in addition there are planned transmission projects for 15.5 billion rand and distribution projects for 25 billion rand. The South Africa's electricity public utility ESKOM has an approved construction program for the next two decades for additional 16 GW generating capacity, most of which is from coal-fired plants [1]. This is 40% increase with respect to present day capacity.

With ever more growing energy demand and the current power deficit in South Africa, the need for utilization of the rich renewable energy resources of the country becomes more obvious and demanding than ever before. With more than 320 sunny days a year in most of South Africa and the current under-use of solar power, a new approach is needed to accelerate the implementation of technologies for solar use [3]. Domestic and commercial water heating requires significant energy resources.

It is clear that in these conditions it is mandatory to look for a new approach to deal with the looming energy crisis in the country. By submitting its pledge following the Copenhagen Accord to take mitigation action for 34% reduction below the 'business as usual' emissions growth trajectory by 2020, South Africa recognized the need for limiting the use of fossil fuels such as coal and petroleum products. In its policies the Government is aiming at the establishment and the development of a modern renewable energy industry. It must offer in the long run a sustainable, non-subsidized alternative to fossil fuels. In the South African White Paper on Renewable Energy [4], a medium-term (10 years) target is set to reach 10,000 GWh (0.8 Mtoe) renewable energy contribution to final energy consumption by 2013. Renewable energy is to be utilized for power generation and non-electric technologies such as solar water heating (SWH) and bio-fuels. This target is approximately 4% (1667 MW) of the projected electricity demand for 2013 (41,539 MW) [4].

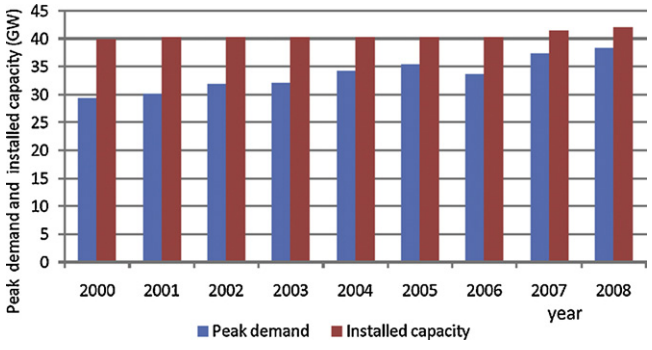

Fig. 1. Peak demand and installed capacity between 2000 and 2008 [1].

So far, the potential for solar energy use as an alternative to fossil fuels remains largely underutilized. Currently around 1% of South African homes have solar water heaters, despite the favorable geographical and climate conditions [4]. This is presenting a challenging task to further explore the potential and the technology options for accelerated introduction of solar water heating – one of the most suitable renewable energy options for the South African conditions.

Similar studies are done in neighbouring countries with similar favorable climatic conditions and similar housing structure – Zimbabwe [5] and Namibia [6]. It was found that the potential for solar water heating is mostly identified in the residential sector. In the case of Namibia only 2.4% of the houses have installed solar water heaters. In Zimbabwe the installed systems are estimated to be below 10,000, including commercial installations in hotels. Furthermore, after analysis of the potential for SWH in that country it was found that 99% of the total thermal demand is in the domestic sector and hotels and hospitals have insignificant contribution. 98% of the annual sales in China and 90% of the sales in the European Union are for the residential sector [7].

This paper is an attempt to investigate the potential for use of solar energy and solar water heating in South Africa in terms of saved energy and emissions. The residential sector, the hospitality industry and the health care institutions are identified as having the highest potential for SWH. The analysis is based on the use of three scenarios to estimate the economic, environmental and social benefits from a large scale implementation of solar water heating in South Africa.

2. South Africa's country profile

2.1. Climatic and solar irradiation conditions

South Africa occupies the most southern end of the African continent between 22° and 35°S and longitudinally from 17° to 33°E. Its surface area is 1,219,090 km^2. The climate varies from semi-arid in the north-west to sub-tropical along the East coast. The average annual rainfall is 464 mm – half of the world's average. The warm 'Agulhas' and cold 'Benguela' currents along the East and West coasts respectively have a moderating influence over the climate. The high elevation inland (average 1200 m above the sea level) keeps the average summer temperatures below 30 °C. In winter, for the same reason, night-time temperatures can drop to the freezing point.

The country's sub-tropical climate is combined with intense solar radiation throughout the year. The African insolation map with different regions differentiated by the value of the annually averaged global solar irradiance is shown in Fig. 2 [8].

In most of the inland regions of the country the irradiation is between 230 and 270 W/m^2 and along the Southern and Eastern coast lines around 180 W/m^2. These insolation levels are