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## Exploiting solar energy potential through thermal energy storage in Slovenia and Turkey

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## ABSTRACT

Thermal energy storage (TES) is regarded as among the most feasible environmentally friendly solutions for saving energy. R&D activities for heating and cooling of buildings lead to the development of various technology types.

This paper attempts to give an overview of the energy situation, solar energy potential, TES concepts and technologies used in solar applications around the world with the emphasis on two Mediterranean countries, Turkey and Slovenia. Energy savings and CO<sub>2</sub> emission reduction potential when TES is used in various solar applications of buildings are also discussed.

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## 1. Introduction

The foremost global challenges facing the energy market today are growing environmental concerns, especially climate change, economic development and energy security. Developing and deploying more efficient and less environmentally damaging energy technology is critical to achieve objectives of energy security, environmental protection and economic and social development. It is not fully clear what would be the world population and energy demand at the end of the present century, but it is also obvious that searching for new energy sources is required because of diminishing gas and oil supplies. The increasing interdependence of energy markets requires new approaches to energy technologies and policies.

Solar energy is the most important renewable energy source that waits to be exploited to meet the global challenges of the energy market. Besides biomass and hydropower, solar thermal is the second largest renewable energy source following wind power in meeting global energy demand. According to Solar Heat Worldwide Report [1], by the end of 2010, installed capacity was 195.8 GWth corresponding to 279.7 million m<sup>2</sup> of collector area in operation in 55 countries representing more than 90% of the solar market in the world. The calculated number of different types of solar thermal systems in operation exceeded 53 million by the end of 2010. Hereof, an estimated 85% were used for domestic hot water preparation in single family houses and 10% were attached to larger domestic hot water consumers such as multifamily houses, hotels, hospitals, schools, homes for elderly people, etc. The remaining 5% of the worldwide installed capacity supplied heat for both domestic hot water and space heating (solar combisystems) and for other applications, such as solar supported district heating, industrial processes and solar air conditioning applications.

Solar energy with its intermittent characteristics needs to be stored for efficient utilization. Thermal energy storage technologies are used to close the gap between supply and demand of such intermittent resources. Duration of the storage can be short and diurnal, respectively (day/night) or long and seasonal, respectively (summer/winter). For seasonal storage (summer/winter), underground thermal energy storage (UTES) is one of the mostly used in solar plants. For short term applications thermal energy storage in water or rocks, phase change materials (PCM) and thermo-chemical reactions are preferred. Recently there are hybrid systems that combine short and long term storage technologies in the same system.

Global energy security concerns and environmental policy issues are assuming more important roles as driving forces in energy technology progress and encouraging greater international collaboration. Turkey and Slovenia are cooperating on the three years joint project with the title: Thermal Energy Storage for Efficient Utilization of Solar energy. This article gives the overall situation in energy, solar energy, TES concepts and applications as well as energy savings potential in the mentioned countries.

## 2. Current energy situation

### 2.1. Slovenia

Energy use in Slovenia has been increasing in the past decades and is based on solid fuels, nuclear energy and renewable energy sources. Slovenia, as a member of the European Union, had to adopt all European guidelines and directives on energy especially for the promotion of renewable energy sources.

Energy use is followed statistically by the Office of Energetics governed by the Ministry of Economy [2]. Use of primary energy was 273.7 PJ in 1997 and the sources were: oil products (104.3 PJ), nuclear energy (67.7 PJ), coal (58.7 PJ), natural gas, hydro energy and renewable sources. Consumption of primary energy was 308.2 PJ in 2011. In the last fifteen years energy consumption increased for 34.5 PJ, which represents 12.6% increase. Data can be seen in Fig. 1. Consumption of final energy was 206.6 PJ in 2011. Oil products represented the largest share (103.4 PJ), followed by electricity (46.0 PJ), natural gas (29.0 PJ), renewable sources (15.7 PJ) and others.

Final energy consumption is divided into three major groups: traffic, industry and households. In traffic oil products (75.7 PJ), in industry natural gas (22.7 PJ) and electricity (20.8 PJ), in households electricity (24.3 PJ), oil products (21.0 PJ) and renewable sources of energy (13.4 PJ) prevail (Fig. 2). Largest share of renewable sources is being used for households, oil products for traffic, electricity has large share within industry as well as in households.

### 2.2. Turkey

Turkey is one of the rapid developing countries in the world. In 2010, Turkey was the 16th largest economy in the world and the 6th largest economy in Europe [3]. Recently Turkey had a

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