



Status and prospect of solar heat for industrial processes in China

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ABSTRACT

In the past decades, solar heat for industrial processes (SHIP) have been rapidly developed and applied, and also getting more and more attention all over the world. China is the largest energy consumer with industry accounting for almost 70% of its total energy consumption. Low- and medium-temperature heat takes up 45% of process heat, covering 50–70% of industrial energy consumption, which provides a favorable condition for solar application in industrial processes. China has built developed some demonstration projects to make industrial processes well integrated with solar heating systems. This paper briefly summarizes the status of China's energy consumption, integration of SHIP, as well as available matching solar technologies. Ten typical industrial sectors are selected to specifically describe their potential of SHIP. Moreover, 26 SHIP cases covering the selected 10 sectors are presented by field researches, with capacity of energy saving and emission reduction previously investigated according to their own proportion of SHIP. The potential of SHIP in the 10 sectors are further predicted by optimistically and conservatively making their proportion in SHIP 5.5% and 2% respectively during the period of 2016–2020. The results show that at least 39.40 million tons of coal equivalent and 98.22 million tons of CO₂ emission is expected to be reduced in 2020 in China's all industrial sectors although solar can meet different proportions of heat demand in different industrial sectors.

1. Introduction

1.1. Energy consumption in China

Global primary energy consumption increased by just 1.0% in 2015, similar to the below-average growth recorded in 2014 (+1.1%) and well below its 10-year average of 1.9%. Oil remains the world's leading fuel, accounting for 32.9% of global energy consumption, followed by coal and natural gas, which take up 29.2% and 23.8%, respectively. The fuel mix shifted away from coal towards lower-carbon fuels. China is the largest energy consumer in the world, experiencing a growth of 1.5% in 2015, and now accounts for 23% of global energy consumption. Although coal still remains the dominant fuel, accounting for 64% of China's total energy consumption, this is the lowest share on record [1].

The world's proved oil reserves, natural gas reserves and coal reserves fell in 2015– 1.7×10^{12} barrels, 1.87×10^{15} m³ and 8.91×10^{11} t, respectively, and are sufficient to meet 50.7 years, 52.8 years and 114 years of global production demand, respectively [1]. Industry consumes large amounts of energy every year. The proportion of industrial energy consumption is not the same in different regions. As shown in Fig. 1, the proportion of industrial energy consumption in the total value is over

50% in regions like Asia, Latin America, Middle East and OECD Asia Oceania, with African industry taking up the minimum proportion of 18% [2]. Process heat takes up 50–70% of the total industrial energy consumption, with low- and medium-temperature heat accounting for 45% of the portion [3].

Industry is the economic backbone in China and it contributes 35.9% of gross domestic product (GDP) [4]. Industry accounts for about 70% of the total energy consumption and the proportion has been rapidly increasing in recent years, as shown in Fig. 2 [5].

China's energy consumption structure of industry is shown in Fig. 3 by fuel types [5]. The industrial energy demands are mainly met by fossil fuels, especially coal which exhausts huge quantities of CO₂ in combustion. Industrial sectors can mainly be divided into manufacturing, power and mining, and the corresponding energy consumption distribution is exhibited in Fig. 4. Manufacturing occupies the dominant portion, i.e. 82.1%, with power and mining accounting for the remaining 9.7% and 8.2%, respectively [6].

Due to huge amount of energy consumed in industrial processes and serious environmental problems caused by fossil fuels combustion, enterprises are not encouraged to utilize fossil fuels in industrial processes anymore. Now enterprises seek for industrial systems based on

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Nomenclature and acronyms		CSTIF	Chinese Solar Thermal Industry Federation
SHIP	solar heat for industrial processes	ETC	evacuated tube collector
OECD	Organization for Economic Co-operation and development	FPC	flat plate collector
GDP	gross domestic product	CPC	compound parabolic collectors
OPEC	Organization of petroleum exporting countries	PTC	parabolic trough collector
IEA	International Energy Agency	HTF	heat transport fluid
SHC	Solar heating and Cooling Programme	LFR	linear Fresnel reflector
RD&D	research, development, demonstration	EPC	Energy Performance Contracting
HTF	heat transfer fluid	BOT	Build-Operate-Transfer

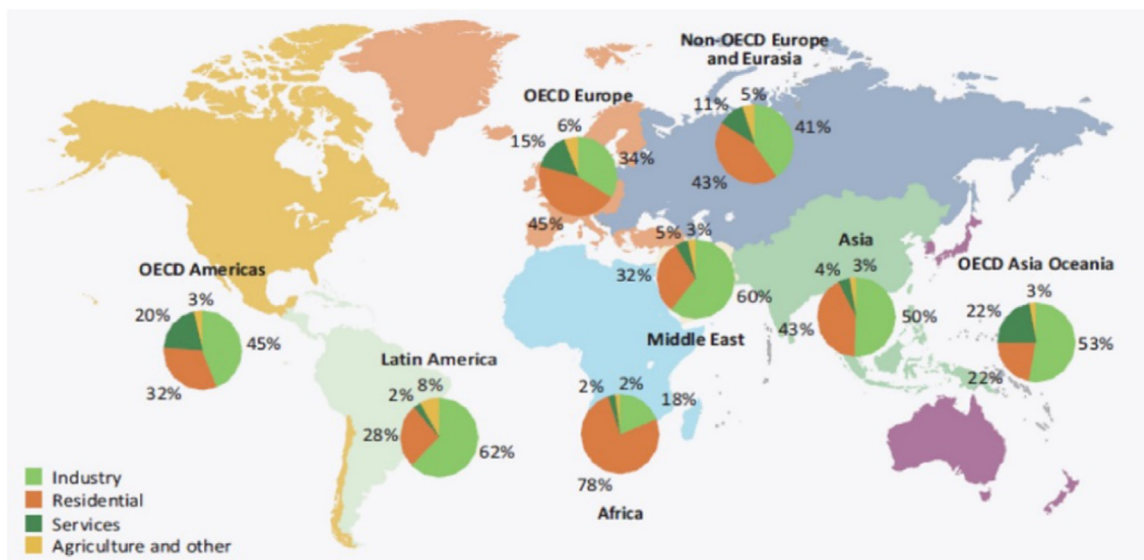


Fig. 1. Share of the total final energy consumption by region [2].

renewable energy to improve market competitiveness, and to reduce fuel costs and environmental pollution accompanying. Therefore, traditional energy supplies should be shifted to renewable energy sources and new technologies urgently need to be developed and applied in industries. Among all forms of renewable energy, solar energy attracts the most attention as the most promising option to be applied in industrial processes. Solar energy is abundant, free and clean, and does not make any noise or any kind of pollution to the environment. Therefore, it becomes extremely significant to apply renewable energy especially solar energy to industrial processes. Up to now, many attempts have been made to extract solar energy by means of solar collectors, sun trackers and giant mirrors in order to utilize it for industrial

purposes in China.

1.2. Solar thermal industry in China

By the end of 2014, an installed capacity of 410.2 GW_{th} corresponding to a total of 586.1 million square meters of collectors had been in operation worldwide, with China accounting for the largest proportion of 70.6% (i.e. 289.5 GW_{th}), as shown in Fig. 5. In the year 2014, the area of newly installed solar collectors reached 6670 m² and

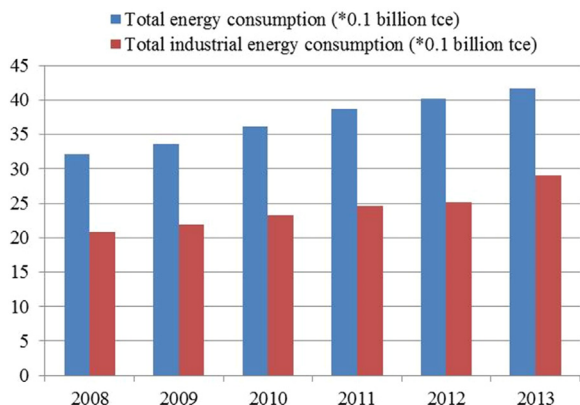


Fig. 2. Industrial consumption of the year 2008–2013 in China [5]. Note: ‘tce’ in this figure means ‘ton of standard coal equivalent’.

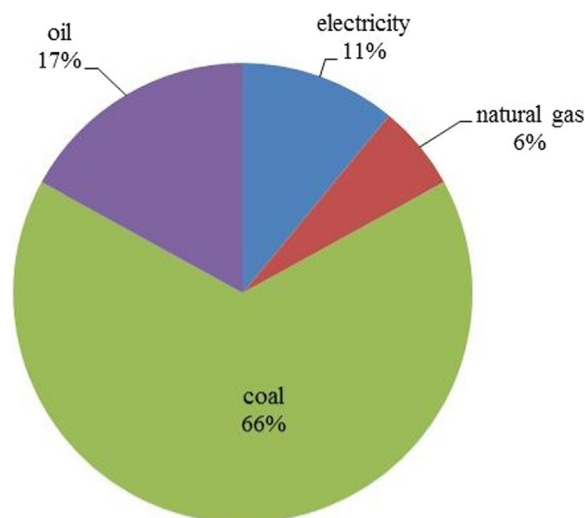


Fig. 3. China's energy consumption structure by fuel types in 2014 [5].

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