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The status of energy conservation in Taiwan's cement industry

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HIGHLIGHTS

- This study summarizes the energy savings implemented in Taiwan's cement industry from the on-line Energy Declaration System.
- The energy audit group audited seven Taiwanese cement plants in 2011 and revealed energy saving potential was 1708.5 KLOE.
- This work aims to examine what Taiwan has done and also describes the current status in cement industry.
- In addition, some potential energy conservation opportunities or measures are revealed in this paper.

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ABSTRACT

The cement industry represents one of the most energy intensive sectors in Taiwan. Energy audits are the direct tools which are employed to help reduce energy consumption. The objectives of energy audits are to establish energy audit systems, provide on-site energy audit service and reduce production cost. This study summarized the energy savings implemented in Taiwan's cement industry; the data were obtained from the on-line Energy Declaration System in 2010. The total implemented energy savings amounted to 68,512 kilo liter of crude oil equivalent (KLOE). The energy audit group audited seven Taiwanese cement plants in 2011 and revealed an energy saving potential of 2571.6 MWh of electricity and 1002.8 KLOE of thermal energy. The total potential energy saving was 1708.5 KL of crude oil equivalent (KLOE), equivalent to a 4560 t reduction in CO_2 emissions, representing the annual CO_2 absorption capacity of a 122 ha forest plantation.

1. Introduction

The total annual cement production in Taiwan, by 18 kilns of 12 plants, was approximately 20 million tons in 2010–2011. In general, there are three principal steps in cement production: raw material processing, clinker burning processing and finish grinding processing. The raw material and clinker burning processing can be classified as wet process and the dry processing, respectively. The clinker is produced from the raw material process in sequence operations: preheating the raw materials; precalcination, burning inside the kiln and clinker cooling (UNIDO, 1994; Sattari and Avami, 2007). Producing clinker is the most energy-intensive step, and the dry process is more energy-efficient. Cement production processes are costly operations as well as highly intensive in terms of energy (Kabir et al., 2010). Energy accounts for 40–60% of the total production cost (Dumas, 1990; Worell et al., 2000). The cement industry is one of the largest users of fossil energy in Taiwan's manufacturing sector. The concentration of greenhouse gases (GHG) from manufacturing factory activities and vehicle emissions has increased significantly over the years. Energy intensity (from the environmental aspect) and the economic perspective are closely intertwined; this integral relationship must be thoroughly considered in order to increase efficiency and decrease costs (Avami and Sattari, 2007). Consequently, energy research institutes and governmental energy departments from various nations are all committed to developing methods for accurately assessing energy efficiency; the results can be used as references for policy-making. Additionally, the energy utilization status can be compared among different countries to achieve the common aim of reducing greenhouse gas emissions. Numerous analytical studies have been undertaken on energy conservation in regard to different industries. Energy use, savings and energy efficiency of machines used in industrial sectors have been studied by many researchers. Plant operational energy audits

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and optimization evaluations are regularly carried out to reduce specific energy consumption and optimize output (Lowes and Bezant, 1990). Increasing energy efficiency is the most direct method for reducing GHG emissions. Little or no investment is needed to achieve a 10–30% reduction in GHG emissions (Ghaddar and Mezher, 1999). Energy auditing has been demonstrated to be an effective energy management program (Engin and Ari, 2004; Lafarge Canada Inc., 2002) and it has been applied to calculate and evaluate the possibility of reducing the energy demand of each operational unit in the manufacturing process. Demand can be reduced through low cost energy conservation measures (Engin and Ari, 2004).

Taiwanese industry is primarily small and medium scale, and energy management technology lately has been increasingly adopted. To alleviate the adverse environmental impact (e.g., global climate change, global warming and atmospheric emission pollutants), the United Nations passed the Framework Convention on Climate Change (FCCC) in 1992 to limit greenhouse gas emissions. Recently, the government has also actively promoted the concept of saving energy and implemented energy saving measures. According to the "Energy Management Law"[1] of Taiwan, energy users should observe the regulations promulgated by the central authority; these include conducting an energy audit, as well as setting an energy conservation target and action plan. However, industry usually focuses on production and still has a strong need for assistance in regard to adopting and carrying out energy saving measures. Increased energy utilization efficiency is necessary for industry to obtain the desired results of energy audits. This work aims to examine what Taiwan has done in terms of its energy conservation policy, and also describes the current status in the cement industry. In addition, some potential energy conservation opportunities or measures are presented in this paper.

2. Current status in the cement industry

According to the statistical information of the Mineral Commodity Summaries 2012 (U.S. Geological Survey, Mineral Commodity Summaries, 2012), total global cement production was estimated at 3400 million tons in 2011. China was the largest producer, accounting for 58.8% of the global cement production, followed by India (6.2%), the USA (2.0%), Turkey (1.9%) and Brazil (1.8%), as shown in Table 1. Energy consumption in the cement industry will continue to increase in conjunction with market growth. Taiwan's industries are primarily small and medium scale and the country has extremely limited coal and petroleum resources. Taiwan depends on imports for approximately 99.3% of its primary energy; rapid economic development has rapidly increased the demand for energy and, in particular, electricity. The cement industry represents one of the most energy intensive sectors in Taiwan. In 2010, Taiwan's cement industry consumed 1.8 million KLOE for its total annual production. Meanwhile, the entire industrial sector consumed 64.7 million KLOE, signifying an increase of 9.0% a yearly. In comparison with 2009, energy use in 2010 increased by 2.1% (predominantly in electricity and coal), as shown in Table 2. The average energy use in the industrial sector increased by 2.9%, while average cement industry energy use decreased by 4.8% during the 2006–2010 periods. After the negative influence of the global financial crisis in 2008, the production of cement decreased and induced the energy consumption to decrease significantly.

Energy intensity (E/GOV) is a measure of the energy efficiency of a nation's economy. E/GOV in this study is calculated as units of energy (E) per unit of gross output value (GOV) in the cement industry. Fig. 1 shows the energy intensity of the cement industry in recent years. It can be seen that the energy intensity of Taiwanese cement industry was $1.79 \times E^{-2}$ (E/GOV) LOE per NT dollar[2] in 2010, having decreased by 2.4% compared to 2009. The reason for the improved energy efficiency from 2006 to 2010 was the positive influence of Taiwan's energy conservation policy. Due to the fluctuating cement price from year to year, using energy intensity to gauge energy conservation efficacy might be misleading. Therefore, the annual production of cement and unit production energy consumption was also listed in Table 2. The government of Taiwan has taken substantial preparatory measures and established an energy audit group to help energy users enhance energy efficiency, reduce CO_2 emissions, and promote energy savings by all industrial sectors. During 2006–2010, cement production has decreased and energy consumption thus has also decreased. Fig. 2 shows the recent energy intensity for the cement. Evidently, the energy improvement potential of cement is over 10% at least compared with the cement industry of China.

3. Energy auditing methodology

Energy audits are the most comprehensive approach to improve an existing system's energy efficiency (Avami and Sattari, 2007). There are three objectives of energy audits in Taiwan: (1) assisting energy users to establish energy audit systems; (2) assisting energy users to implement energy management and set energy saving goals; and (3) providing on-site energy audits and guidance, technology and information services related to energy saving. The energy audit process involves the following stages:

(a) Before conducting an on-site audit, the energy audit group studies the historical consumption trends and technological information of the plant.
(b) During this on-site audit, the auditors discuss the main energy consuming equipment with representatives of the energy user or equipment operators.
(c) The auditors compare the operating manual and equipment specifications of the energy consuming equipment to the operation and maintenance records provided by the energy user and check for abnormalities.
(d) All relevant major energy consuming equipment or manufacturing processes' data used for the analysis are obtained either from the plant control panel or by on-site measurement using the relevant instruments (such as IR thermal analyzer, ultrasonic flow meter, illumination meter, and so on).
(e) After the on-site audit, any potential for saving opportunities is identified and the economic calculations are done to produce an on-site energy audit report.
(f) Finally, a database is established which contains possible saving opportunities, the economic calculations and energy consumption data for use by the government in developing its energy policy, as well as for use by other energy users as a reference.

4. Energy conservation technology and potential for the cement industry

According to the report issued by the Bureau of Energy, Ministry of Economic Affairs, Taiwan, the energy cost represents over 35% of total production costs in the production of cement.

[1] Energy Management Law is promulgated by Taiwan's President in August 8, 1980 (modified in July 8, 2009) to serve the purpose of upgrading energy management aimed at rational and efficient utilization of energy.

[2] The NT dollar (New Taiwan dollar), or simply Taiwan dollar, is the official currency of the Taiwan Area of the Republic of China (ROC) since 1949.