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Environmental and economic advantages associated with the use of RDF in cement kilns

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ABSTRACT

In this study, the development of refuse-derived fuel (RDF) materials from non-recycling wastes, and the determination of its potential use as an alternative fuel in cement production and energy conservation are presented; we also examine the prospects of greenhouse gas emission reduction and calculation of CO_2 feasibility upon replacing petroleum coke with RDF. At first, RDF (solid recovered fuel-SRF) produced from MSW is given and its effects on cement production process are examined. The effect of RDF on clinker production was determined. For this purpose, the RDF was mixed with the main fuel (petroleum coke) in different ratios and followed by the characterization of produced clinker. The emission values measured in industrial scale rotary cement kiln remained below the limit values of directives that are acceptable in cement industry. The results of these experiments provided the basis for an industrial process which is now operative in İstanbul. This study will be a preliminary preparation for emission trade which will become more important for Turkey after the signing of the Kyoto Protocol by this country.

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1. Introduction

Global warming is one of the most critical environmental problems that humankind is facing. The increase of the greenhouse gases lead to the global warming. One of the major greenhouse gases from human activities is carbon dioxide (CO_2). Its concentration in the atmosphere is rapidly increasing upon combustion of fossil fuel-oil, coal and gas (Nithikul, 2007).

Currently the production of 1 ton of cement commonly results in the release of 0.65–0.95 tonnes of CO_2 depending on the efficiency of the process, the fuels used and the specific type of cement product. Higher fossil fuel prices are increasingly forcing cement plants to consider the use of alternative fuels for clinker production. It is well known that RDF saves large amounts of money, based on various experiences mostly in European countries, where well-developed waste collection and disposal systems combine with high disposal costs (Lechtenberg and Partner, 2008).

Considering the scale of the worldwide cement production, even a slight decrease in the average global emissions per ton can lead to CO_2 reduction. Every 10% decrease in the cement CO_2 intensity by 2050 could save around 0.4 Gt CO_2 and substantially contribute to slowing climate change. Typically, around 55% of the CO_2 emissions in the production of cement clinker originates from the conversion of limestone ($CaCO_3$) into lime (CaO). Around 40% of the emissions stems from combustion processes necessary to initiate the reaction at 1450 °C (WWF – Lafarge Conservation Partnership, 2007).

The main problem regarding the use of RDF by cement kilns is the chlorine content. When the chlorine content is high, it weakens the concrete in terms of 2, 7, and 28 days' compressive strength. The chlorine compounds and alkali-silica reactions create salts. These salts generate microcracks and the compressive strength decreases (European Committee for Standardization [ECS], 2002). Also, chlorine creates the oxidation of iron in concrete. However, the cement industry estimates that up to 20% of the heat from RDF could supply the load of a cement kiln, and the cement kiln could also burn other wastes, such as tires, at the same time (Gendebien et al., 2003).

Today there is an increasing focus on environmental issues such as global warming and it is a well-known fact that carbon emissions into the atmosphere need to be reduced in order to combat climate change. Industry therefore faces a challenge in terms of its energy requirements. As the material present in RDF cannot be recycled, it is currently sent to landfill which is an environmentally unsound option, as landfills produce large volumes of methane – a greenhouse gas. The unique nature of a cement kiln, with flame temperatures burning in excess of 2000 °C means that materials such as these can be completely destroyed without producing waste ash or harmful emissions. Furthermore, as energy is recovered in the burning process, it makes excellent use of an otherwise waste material (Lagan Cement, 2008)

The Kyoto marks an important turning point in efforts to promote the use of renewable energy as a key strategy for reducing GHG emissions worldwide (Sözen et al., 2009). Kyoto Protocol, which was adopted in 1997 and is now considered as the most

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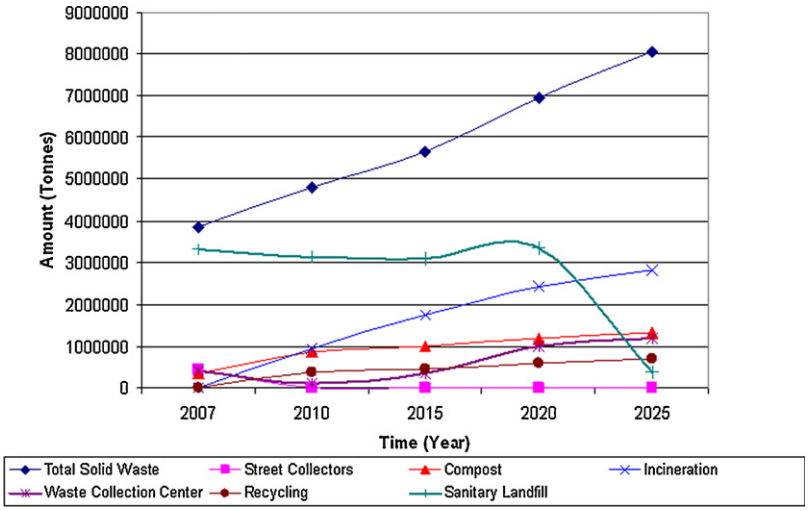

Fig. 1. Solid waste strategy plan in Istanbul.

significant international effort ever made to minimize the effects of global warming and climate changes, is of great importance for determining the obligations to reduce greenhouse gas emissions and the applicable mechanisms. After a long process, Turkey has become a party to Kyoto Protocol in 2009 and thus undertaken the obligations stipulated for the parties thereto (Coşkun and Gençay, 2011).

Turkey is the only country that appears in the Annex I list of the United Nations Rio Summit and yet an official target for CO_2 emission reductions has still not been established. Thus, as part of its accession negotiations with the EU, Turkey is likely to face significant pressures to introduce its national plan on climate change along with specific emission targets and the associated abatement policies. Against this background, Turkish environmental policy is at a crossroad. As part of its bid for full membership in the EU, Turkey is under significant pressure to comply with the Kyoto Protocol, and to constrain its CO_2 emissions and other gaseous pollutants. Yet, as a newly emerging, developing market economy, Turkey has not yet achieved stability in its energy utilization and gaseous emissions either as a ratio to its GDP or in per capita terms. Actually, signing the Kyoto Protocol does not put an additional burden on Turkey until 2012. Turkey was not a party to the convention adopted in 1992 when the Kyoto Protocol was negotiated, and it is not currently included in the agreement's Annex B (http://unfccc.int/kyoto_protocol/amendment_to_annex_b/items/4082.php), which includes 39 countries that are obliged to reduce their greenhouse emissions to 1990 levels between 2008 and 2012 (Erdogdu, 2010).

As Turkey does not have legally binding targets for emission reduction at Kyoto due to its very little share of 0.4% in the global GHG emissions, it operates in a global Voluntary Carbon Market (VCM) of which the market value reached $397 mil. at the end of 2008. The countries and sectors that are outside of the scope of Kyoto Protocol are trading carbon in this specific market. The credits in this market are often generically referred to as Verified (or Voluntary, depending on the source) Emissions Reductions (VERs), or simply as carbon offsets. Voluntary offset market demand is not driven by a cap, especially in the retail market, but by Buyer motivations. These programs are actually screened as contributing to a country's regulatory requirements or Kyoto commitments (Mermod and Dömbekci, 2011).

In this context, the aim of this study is to evaluate the feasibility of producing RDF materials for use as an alternative fuel in cement kilns. This feasibility study involves examining the prospects of CO_2 in greenhouse gas emissions and energy demand by replacing petroleum coke with RDF. The successful result of this experimental pilot scale work is believed to be a pioneer study for Turkey in terms of applying Kyoto Protocol rules and satisfying environmental and economical benefits. Also it is the first time that process of alternative fuel usage and combustion technology is developed in Turkey; this should reduce fossil fuel import from abroad. Recycling processes should provide protection of natural resources.

2. Experimental studies

2.1. RDF manufacturing

Solid waste issue may be evaluated as a management problem which requires developing collection, transportation and disposal practices for wastes; raising awareness among local authorities and public. Furthermore, urbanization in Turkey has two important characteristics with respect to solid waste management issues. The first one is fast and chaotic urbanization. This leads to more acceptable urban solid waste production; the second is the accumulation of garbage in rural areas that has become a major problem in populated cities. Solid waste management strategies and targets in Istanbul have been determined until 2025 with the title of "Integrated Waste Management Strategic Plan compatible with EU Environment Regulations for Istanbul". Solid waste strategy plan in Istanbul is given in Fig. 1 (Kara et al., 2009).

RDF is a kind of alternative solid fuel, which is derived from recyclable materials municipal or industrial solid wastes, such as plastics or from materials that are hard to recycle after decomposing. Refuse-derived fuel typically consists of pelletized or fluffy MSW that remains after the removal of noncombustible materials such as ferrous materials, glass, grit, and other noncombustible materials. The remaining material is then called RDF and used in clinker production as a secondary fuel. However, the environmental concerns of incineration also apply to RDF combustion facilities. The limit values for some pollutants are the same for cement and combustion plants. There are significant differences with respect to some pollutants. (Gendebien et al., 2003).

Air emission limit values for dust, NO_x and SO_2 emissions are less stringent for cement kilns than for incinerators. This process should be carried out according to the relevant Directives where emission control requirements are indicated (Kara et al., 2009). An alternative to the aforementioned scenario is the development of systems that utilize RDF in cement kilns. These plants have remarkable energy requirements, in the order of 720–1120 kcal/kg of produced clinker. Given the high temperatures utilized, these plants would