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Evaluation of the long-term environmental performance of Greek lignite-fired power stations

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ABSTRACT

At national, regional and global level, there is no doubt that the electric generation from fossil fuel-fired power plants is one of the greatest causes of air pollution and climate change. However, fossil fuels contribute more than 70% in the planet electricity generation during the last 30 years. In Greece, lignite is the only proved significant indigenous fossil fuel source, currently representing about 50% of the national electricity generation (a situation which is not expected to change dramatically in the near future). As a result, owed to the use of local lignite reserves (poor quality lignite), the Greek Lignite Thermal Power Stations (LTPSs) are responsible for the production of significant airborne emissions and particle releases (e.g. CO_2, SO_2, NO_X, PM). At the same time, Greece, on top of the Kyoto Protocol, has accepted specific obligations and incorporated into its national legislation several air quality Directives concerning the reduction of various harmful gases and particle releases attributed to fossil fuel combustion. Thus, wide scrutiny of concentration time series of all these airborne emissions constitutes an important indicator of the current technology used, considering at the same time that any violation noted should be the object of serious national concern. Under this argument, the current work presents and evaluates the long-term environmental performance of the Greek lignite-based electricity generation system as far as CO_2, NO_X, SO_2 and PM are concerned up to the year 2011. According to the results obtained, one may rank the operating LTPSs according to their environmental performance giving to the Greek society the necessary tools to determine their utilisation factor on top of the techno-economic criteria used up to now.

Contents

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1. Introduction

The role of energy in the social and economic progress of mankind is of unquestionable value, but beyond that, it is also an essential part of our daily life. Population and income growth are the two most powerful driving forces behind the demand for energy. Since 1900, our planet population has more than quadrupled and real income has grown by a factor of 25. World primary energy consumption grew by 45% over the past 20 years and is expected to keep growing by 40% over the next 20 years [1]. Electricity generation is the fastest and largest growing source of world energy demand, greater than the primary energy used in both the transportation and the residential–commercial sector. For the time being, fossil fuels (coal, oil and natural gas) continue to dominate in the world's electricity generation sector (Fig. 1) but their consumption presents large variations from country to country, depending on the available domestic resources and national energy policies.

Unfortunately, this strong long-term dependence on fossil fuel combustion for energy production has caused several environmental problems, such as greenhouse gas (GHG) accumulation, acidification, air pollution, water pollution, damage to land surface and increase of ground-level ozone, which have a huge impact on present and future generations' health [2,3]. Among fossil fuels, coal (hard coal and lignite, i.e. principal fuel sources used for electricity generation) is considered to be the largest contributor to the human-made increase of CO_2 in the atmosphere. Furthermore, combustion of coal is responsible for significant air pollutant releases, such as sulphur oxides (mainly sulphur dioxide), various oxides of nitrogen and fine particles, with the abatement of these emissions comprising a common environmental issue of the international agenda [4].

Annual world production of lignite decreased by 5.5% in 2009, to about 915 million tons. Following its 1989 peak, lignite production declined steadily until 1999, largely owed to supply and demand problems in central and Eastern Europe. Since then, production has been fairly stable, close to the production levels of 2009. It should be noted that hard coal and lignite currently represent approximately 80% of EU's fossil fuel reserves, while approximately 30% of electricity generation in the EU-27 is coal-based (11% from lignite and 19% from hard coal). In several countries across Europe (e.g. Greece, Serbia) lignite accounts for a significant percentage of total power generation (i.e. more than 50%) (see Fig. 2) [5], with many of these nations featuring amongst the top lignite producing countries in the world. Finally, it should be noted that Europe – where lignite represents an energy resource of key importance – is responsible for around 50% of the respective world production [6].

In Greece, lignite is the only proved significant indigenous fossil fuel source, representing more than 50% of the national (interconnected) electricity generation (Figs. 1 and 2), making the country the second lignite producer in the EU and the fifth in the world, based on the mining of more than 60 Mt on an annual basis. However, although electricity production from natural gas and renewable forms of energy has increased during the recent years, dominant role of lignite is not expected to change dramatically in the near future. At the same time, Greece – as an EU Member State –, on top of the Kyoto Protocol, has accepted specific obligations and incorporated into its national legislation several air quality Directives concerning the reduction of various harmful gases [7] and particle releases attributed to fossil fuel combustion. This legislative framework, apart from setting threshold values for measuring and assessing ambient air quality, it also defines, among others, the number and location of sampling points as well as the measuring and reference methodologies for each flue gas. In this context, the Greek Public Power Corporation (PPC) (i.e. the exclusive supplier and practically the sole producer of energy deriving from lignite combustion) contributes to the monitoring of ambient air quality in the vicinity of the thermal power plants under its operation, with numerous measuring stations performing systematical air quality measurements.

To this end, the national levels of harmful gases emitted and particles released from the thermal power plants as a by-product of lignite combustion, constitute an important indicator of the current technology used, as well as of the compliance of the State with its commitments under the corresponding environmental legislation. Thus, as it may be easily concluded, wide scrutiny of concentration time series of all these harmful gases and particle releases is of great importance, considering at the same time that any violation noted should be the object of serious national concern. Under this argument, considering the leading role that lignite has been playing in the national electricity sector [8] until today – and will continue to do so in the foreseeable future – the current work presents and evaluates the long-term environmental

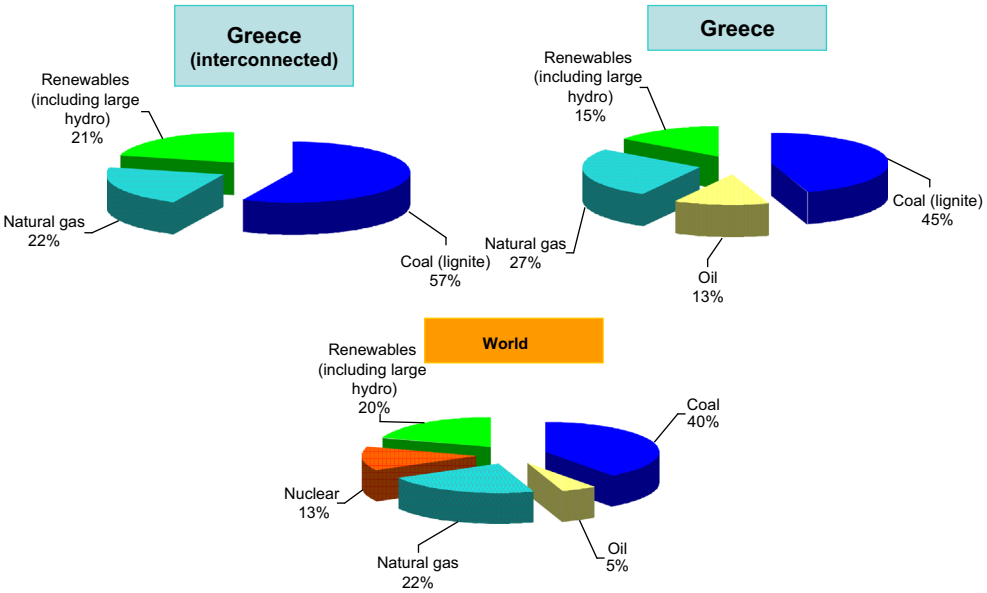

Fig. 1. Sources of electricity generation as for January 2011.