Energy Policy scenarios of CCS implementation in Greece

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Abstract: The energy balance of Greece is strongly dependent on imported oil. The rather late introduction of natural gas has increased the diversity of the energy mix while the share of renewable sources in primary energy supply still needs to increase according to the existing potential. Yet, Greece as the most of the EU developed countries encounters a serious task: the need to increase its electricity production that it almost increases 5% per year but at the same time to reduce the CO_2 emissions according with the National and International (20-20-20) regulations and allocation plans. Therefore reducing CO_2 emissions has become a major priority for national government. Even more, from 2013 and onwards there will be the full implementation of the wholesale market in the European Trading Scheme (ETS) which is currently in the last stages of a transition phase.

In Greece electricity is generated mainly from lignite thus making the electricity sector the main one of the GHG emissions with levels that are above 40% of the total in the country and more than the average of the corresponding ones of the rest of the EU countries. The possible implementation of the Carbon Capture and Storage (CCS) technology would be able to become very decisive due mainly to the large use of the lignite as the major fuel on the energy mixture of the country. CCS technology has the potential of increasing the flexibility on the achievement greenhouse gas emissions reduction by allowing the continuing use of fossil fuels, which still guarantees feasibility in the energy sector. This work presents a roadmap with the modeling of the main technologies associated to the CCS and its implementation into the Greek energy system considering existing National and International Strategic energy plans under different scenarios. The implementation of CCS technologies would have a large influence on the national electrical power production, having the responsibility for large shares of the emissions reduction that can potentially achieved in this sector. For this purpose, the TIMES (The Integrated MARKAL/EFOM System) has been chosen as the principal tool for building a technical-economic model of the Greek energy system and its possible evaluation over time (2040).
There is some limited work related with the implementation of CCS technology in Greece and the lignite sector, thus the objective of this work. This work will present briefly an overview of the reference energy system in Greece followed by the proposed used energy equilibrium model. Next, the current situation and characteristics of the lignite power plants are described while at the end energy scenarios are discussed related with the implementation of CCS in the energy mixture of the country and the required policies.

At the end of 2009, EU imported 54% of its primary energy with 30% of its oil coming from Russia and 61% of its natural gas from various countries (42% from Russia, 24% from Norway, 18% from Algeria and 16% from other countries) with predictions of 73% for 2020. EU also produces 4,721 Mt of CO_2 (10.22 tons/capita in 2006) with a total from 1900-2004 of 273,221 Mt of CO_2 while it has compromised to reduce it 20% in 2020 compared to 1990. These details related with the EU-27 energy dependency serves as a base of comparison between the current Greek energy dependency and sources mixture.

In Greece the total installed capacity at the end of 2009 was 14,584MW (12,884MW in the "interconnected system" and 1,700MW in the "non-interconnected system" or "Autonomous Islands"). This production was by the Lignite with 4,953 MW on 22 Present Power Plants, Natural Gas of 3,349MW, Oil of 2,109MW, and RES of 4,339MW (Hydro: 3,170 – Wind: 1087MW - Solar: 42MW – Biomass: 40MW, Geothermal: 0 - CSP: 0). Between 1995 and 2009 total nominal installed capacity in the interconnected system of the electricity generation system rose from 9,198MW to 12,884MW. However, because of high increase of electricity demand, Greece is currently lacking sufficient power capacity. Investment in power generation, particularly during the past seven years, which coincide with the first steps of market liberalisation, has not been sufficient to allow for a normal reserve margin. The main energy form used up to now to generate power in the interconnected system is indigenous lignite which is extracted (mainly from Public Power Corporation, PPC) from surface mines located in the northwest part of Greece (Ptolemaida/Kozani) and secondarily in Peloponnese (Megalopolis). Lignite plants cover mainly the baseload.

The Reference Energy System (RES) descibing the current energy situation in Greece is the backbone of the TIMES modeling approach. From the RES, the optimization model chooses the least-cost energy system, representing energy technologies and energy flows for a given time horizon and given end use energy demands. Necessary enterprise to begin the progress of CCS technology in any country is to set up the environmental and regulatory assessment of this new technology at national level. For the entire design of national energy systems it is necessary to consider specific factors including regional resource endowments, conversion technologies, information, time, prices and investment finance, operating costs or age of infrastructures. Therefore the TIMES model has been used to perform scenarios of the Greek energy system and its evolution until 2040.

There are three main scenarios (A, B, C) implementing CCS technologies and policy measures to the new power plans licensed to be constructed and are:

(1) **Scenario A**: The lignite/hard coal power plants that are already licensed to be built, are assumed to have CCS.

(2) **Scenario B**: CCS will be available for the power plants in the first scenario plus all the power plants from 2015 onwards that are approved and that use Lignite/hard coal/Mazut fuel. The power plants without license and without a defined year for starting will be considered not havinge CCS.

(3) **Scenario C**: CCS will be available to all power plants that are licensed, including the NG power plants. The power plants that are not licensed yet are assumed not having the CCS technology installed.

Each of these main scenarios has 3 sub-scenarios with different taxations and permit prices for CO_2 emissions. In this work mainly scenarios B and C related with the proposed energy policy are shown along with their results.