CO_2 Capture and Storage in the Greek Electricity Generation Sector

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ABSTRACT

The purpose of the work presented in this paper is to examine and evaluate the perspectives of application of CO_2 Capture and Storage (CCS) technologies in the Greek electricity generation sector, which is dominated by the utilisation of the domestic lignite resources.

Lignite plays an important role in Greece's energy sector as it currently satisfies over 60% of the country's needs in electric power. The annual production of lignite is around 65 million tons and almost the entire production is consumed for electricity generation in the Greek coal-fired power plants, which are about 4500 MW and use conventional technology. It is estimated that in 2010, approximately 37.5 % of the existing lignite-fired power plants, which produce 49.2 % of electricity in Greece, will reach 30 years of their operational life. Therefore, taking into consideration the forecasts for increase in the electricity demand over the coming years, the old and low-efficiency units should be either renovated or replaced by new units.

The new EU regulations on power plant emissions, coupled with the Kyoto Protocol requirements raise obstacles for the firing of lignite. Taking also into account the identified requirements for new units and renovation of old units, the use of CCS technologies in lignite-fired power plants can help to eliminate these obstacles and solve emission problems. The current discussion will build upon the state of the art in CCS technological concepts for power plants and will be focused on the evaluation of the most promising identified technologies for clean utilisation of coal, namely the pre-combustion, post-combustion and oxyfuel technological options, which are applicable for lignite applications.

Results from thermodynamic simulations conducted within the framework of various EU-funded projects, both for green-field and retrofit applications of typical Greek power plants will be used to demonstrate the potential for emissions reduction and evaluate the associated power output and efficiency penalties. The power plant simulations have been performed with the thermodynamic cycle calculation software ENBIPRO (**EN**ergie**-BI**llanz**-PRO**gram), a tool for heat and mass balance solving of complex thermodynamic circuits, calculation of efficiency and exergetic and exergoeconomic analysis of power plants, as well as the commercial thermodynamic cycle calculation software GATECYCLE.

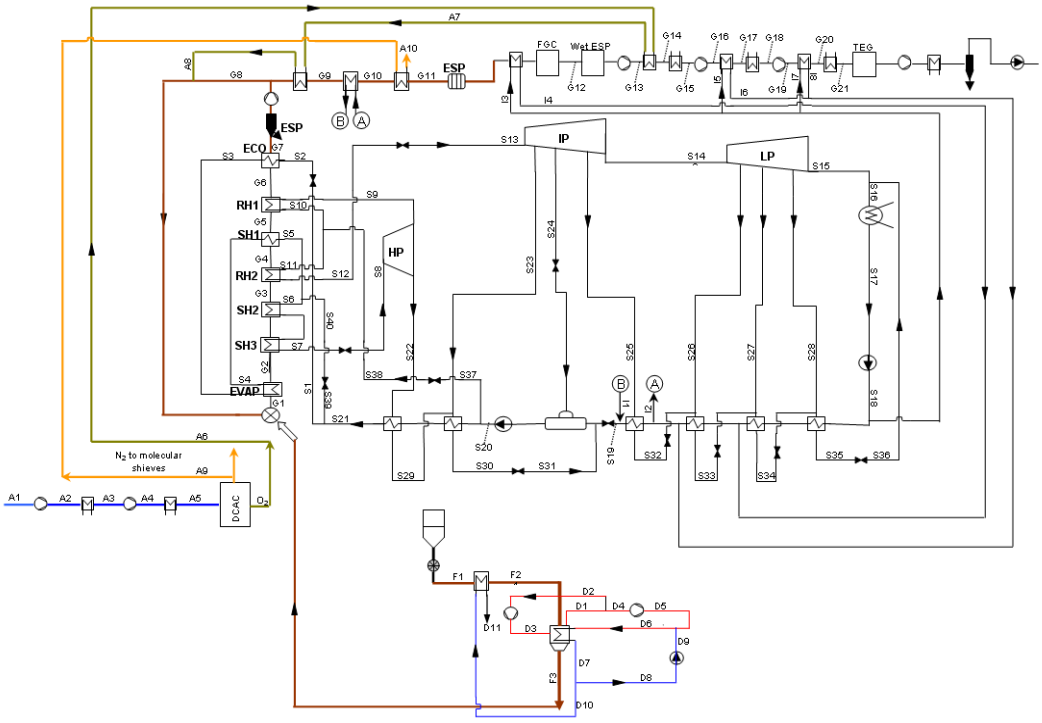
The reference power plant used for the assessment of both the efficiency of a retrofit oxyfuel and post-combustion amine scrubbing application as well as the efficiency of a Greenfield

oxyfuel power plant is a 360 MWel lignite-fired power plant with reheat and 7 water preheaters with steam extraction from the ST. Since the raw lignite has high moisture content, a fuel pre-drying system has been integrated in both the reference power plant and the CO_2 capture power plants, based on utilisation of the heat content of the moisture removed in the form of steam from the raw lignite, for the drying (WTA drying system). The main energy requirements for the O_2/CO_2 recycle combustion are:

- Air compression for the air separation unit
- Compression of the final product for transportation and sequestration
- Cooling water pumps consumption for flue gas cooling and air inter-cooling at the ASU

On the other hand, the energy requirements for amine scrubbing are:

- Heat consumption for regeneration of the reach solution: this low-grade heat is provided from the power plant in the form of low-pressure steam extraction at about 5 bars.
- Electricity consumption: the most energy-consuming process is the flue gas blower, which is used for the flue gas pressure elevation in order to overcome the system pressure drop. This category also includes the energy required for the pumping of the amine solution and the pumping of the absorber wash water.
- Compression of the final product for transportation and sequestration.



The application of CO_2 capture technologies in a power plant is highly costly in terms of efficiency and net power output reduction. In the oxyfuel case, due to the high amounts of heat produced during the CO_2 compression, the flue gas condensation, the compression of air for the ASU as well as due to the high heat content of the flue gas exiting the boiler at increased temperatures, the efficiency and the power penalties can be significantly reduced when this heat is integrated in the water/ steam cycle of the power plant. However, despite the increase in gross power output for the oxyfuel PP and despite the integration of heat that would otherwise be wasted, the huge demand for auxiliary power results in a significant penalty in the power plant performance (ca. 8.5 percentage points).

The thermodynamic data, coupled with the investment costs provide an insight on the economics associated to CO_2 sequestration options and the viability of the power plants within the framework of the application of a CO_2 economic penalty, in an electricity generation system based on low-quality coal. The cost of electricity generation from plants integrating CO_2 capture technologies is assessed in the current study and compared to the electricity generation costs arising from the current electricity generation system.

Finally, the discussion also tackles the available CO_2 storage options and scenarios in the Greek territory, based on recent surveys for the assessment of CO_2 storage sites in Greece conducted within the framework of EU projects. The candidate geological sites are mostly situated in Northern Greece and the total storage capacity amount to ca. 2170 Mt CO_2.

Keywords: CO_2 capture& storage, lignite power plants

Proposed Topic: CO_2 capture & CO_2 storage