Biomass Retrofitting A Natural Gas-Fired Plant To A Hybrid Combined Cycle (HCC)

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Abstract. This work investigates retrofit of a natural gas fired plant for co-firing with biomass. The retrofit is by integration of a solid biomass combustor with the bottoming cycle of a combined cycle gas turbine (CCGT) plant, to form a Hybrid Combined Cycle (HCC). The motivation is the need to find efficient options for substitution of natural gas by biomass to meet the imminent need to reduce CO_2 emissions as well as improve security of supply in the utility power sector, which in some regions is heavily dependent on power generation from rather new CCGT plants. The work is based on process simulations using an existing 600 MW_{fuel} combined heat and power CCGT plant (commissioned 2006) as reference.

It is shown that the HCC retrofit only yields a minor decrease in plant efficiency; electric efficiency (η_e) of 43.3%, compared to 44.4% for natural gas-only in the reference plant (full load and full substitution of supplementary firing corresponding to 39% of natural gas). A HCC with higher biomass-firing capacity and an additional high-pressure condensing turbine can increase the substitution of natural gas to 59% yielding η_e = 40.8% and total efficiency (electricity and heat) of 87.1%, i.e. a larger decrease in efficiency than for 39% substitution. A HCC plant gives in all configurations higher electric efficiency than a corresponding combination of single-fuel stand-alone plants, CCGT for natural gas and steam CHP plants for biomass, with the same share of biomass in the fuel mix.

A simulation representing one year's operation of hybrid and reference options, including part load cases, show that overall efficiencies can be kept at roughly the same levels as in full load.

It is recognized that layout of existing plant, projected level of natural gas substitution and local conditions in fuel supply and energy demand are necessary to consider when assessing the most suitable option for CO_2 abatement by biomass in a gas power plant.

Keywords. Biomass, Energy Efficiency, Modeling, CCGT, District Heating.