DEVELOPMENT OF MARGINAL ABATEMENT CURVES FOR CLEAN FOSSIL FUEL TECHNOLOGIES

Abstract

New fossil fuel electricity generation technologies, such as integrated gasification combined cycle (IGCC), and advances in existing technologies including natural gas combined cycle (NGCC) and fuel cells, offer the potential for delivering electricity at both significantly higher efficiencies and lower emission levels than conventional coal- and natural gas-based technologies. Furthermore, when combined with carbon capture and storage (CCS), CO_2 emissions from IGCC and NGCC can be reduced by 90 percent, making these fossil fuel technologies competitive with nuclear and renewables from an emissions reduction standpoint. The present paper describes a study of the costs and emission reduction benefits of IGCC, advanced NGCC, fuel cells, and CCS technologies being developed by the U.S. Department of Energy's National Energy Technology Laboratory (NETL). Marginal abatement curves (MACs), providing estimates of CO_2 emission reductions as a function of marginal costs (in dollars per metric ton of CO_2) for each of these technologies, and for a portfolio comprising all four technologies, are presented. The MACs were estimated using the Energy Information Administration's National Energy Modeling System (NEMS). NEMS is a comprehensive economic model of the energy sector, which can be used to simulate electricity generation capacity additions to 2030 by technology type; NEMS also projects CO_2 emission levels. For this paper, NEMS runs were made with different CO_2 tax values specified for each run. Two sets of runs were made for each of the four technologies and for the entire technology portfolio—a "with R&D" set representing the expected impact of NETL's (i.e., federal) R&D on the technology's costs and heat rates, and a set of "baseline" runs representing expected costs and heat rates in the absence of NETL's R&D programs ("without R&D"). For each combination of technology type and CO_2 tax value, the difference between the CO_2 emissions for the "with R&D" run and the baseline run represents the emission reductions contribution of NETL's R&D program for the technology type. The marginal costs associated with these emission reduction benefits will be the specified CO_2 tax, as the model will continue to incur costs to reduce emissions up to the tax level (once marginal costs equal CO_2 taxes the model will choose to pay the tax rather than reduce emissions further). By plotting the CO_2 taxes against the emission reductions, marginal abatement curves for each technology, and for the technology portfolio, were derived. In addition to MACs showing total cumulative emission reductions to 2030, MACs for two ten-year periods (2010-20 and 2020-30) are presented in order to illustrate how emission reduction costs decline over time due to NETL's continuing R&D efforts, as well as technological learning resulting from commercial experience with the technologies. The model's projections of capacity additions by technology type are also presented and discussed. The results illustrate that the fossil fuel technologies considered offer significant potential for reducing greenhouse gas emissions at costs competitive with other low-emitting electricity generation technologies.