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SEE/P7-02: Economic, CO2 Emission and Energy Assessments of Fusion Reactors

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Global warming due to rapid greenhouse gas (GHG) emission is a serious environmental problem, and fusion reactors are expected as one of safe and abundant electric power generation systems to reduce GHG emission amounts. To search for economic, environment-friendly and energy-efficient fusion reactors, system studies have been done using PEC (Physics-Engineering- Cost) code taking care of life-cycle cost of electricity (COE), CO2 gas emission rate equivalently including other GHG emission, and energy payback ratio (EPR), for magnetic fusion reactors (tokamak (TR), spherical tokamak (ST) and helical (HR)) and inertial fusion reactors (IR). At first, reactor system modeling is described and typical design parameters are derived. The magnetic fusion reactor designs strongly depend on achievable plasma beta value and permissible magnetic field strength, and inertial fusion designs depend on the driver energy and driver repetition rate.
Using the PEC code, COE, CO2 emission rate and EPR can be analyzed. The former two indecies were previously evaluated by the authors, and the latter parameter EPR is defined here as a ratio of electric output energy to input energy investments required for construction, operation, fuel, replacement and decommissioning. Especially, as for TR design to reduce COE and to raise EPR, high plasma-current- drive efficiency is required for low-beta (normalized beta <4) reactor designs.
In these extensive assessment studies, we clarify typical scaling formulas for COE, GHG emissions and EPR of various magnetic and inertial fusion reactors with respect to key design parameters; such as electric power (1~3GW), plant availability (0.65~0.85), normalized beta (3~5) or averaged beta (3~5%), maximum magnetic field strength (10~16 T), thermal efficiency (0.37~0.59), operation year (20~40Year) and isentrope parameter (2~4). These formulas might be important for making a strategy of fusion research development.
As future assessments, the accident risk probability and related accident settlement expenditures should be included in COE, in addition to CO2 environmental tax and nuclear fuel tax, for the comparisons with other electric power generation systems such as oil-fired, nuclear fission and solar power systems.

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