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SURVEY ON FUTURE ENERGY SYSTEM STRUCTURE UNDER CO₂ CONSTRAINTS AND GENERATION COST

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Overview

Future structure of energy system in the 3E (Environment, Energy, and Economy) problems has been discussed from the viewpoint of sustainable development with protecting from global warming 1-2), by using the energy module of GRAPE model 3).

Methods

The long-term energy supply simulation is performed that optimizes the energy system cost until 2100 for the world in SRES- B2 scenario 4), where energy demand under the CO₂ emission constraint etc. is assumed, by using the energy module of GRAPE model. It has been taken up for the trial calculation in "Intergovernmental Panel on Climate Change, the third report" 5).

Results

Various energy structures affected by CO₂ constraint and nuclear generation cost were parametrically surveyed as follows:

- The nuclear generation cost is assumed for both first breeder reactor (FBR) and light water reactor (LWR) to be expensive at 60mills/kWh for FBR estimated cost under the Business as Usual condition, nuclear energy is not introduced. In the condition, primary energy 30Gtoe, assumed to be necessary in the world for 2100, can be supplied enough by fossil energy such as coal, and rests are oil, natural gas, and so on.
- Nuclear power generation and renewable energy, such as biomass and Photovoltaic are greatly introduced, and IGCC with carbon capture and sequestration also followed, transposed from fossil energy from 2050, in the CO₂ constraint case where energy conservation of 10Gtoe is assumed in the world for 2100. The CO₂ constraint has improved the necessity of nuclear and renewable energy.
- Nuclear power generation is further introduced from 2020 while biomass is still used well, by the effort in a nuclear power industrial field when the nuclear generation cost is cheap at 40mills/kWh for a current LWR level. First 50 years electricity by nuclear was generated mainly by LWR and replaced by FBR gradually. Finally, nuclear power, especially FBR supplies 30% of total primary energy and reduces 3GtC of CO₂ emissions in 2100. It is understood that the effect of the cost reduction is also important. Total renewable energy places 30 % of electricity generation in 2100.
- The long-term optimization model in which the discounted total energy cost for each 10 years until 2150 is minimized has simulated for above three cases. Here, minimization of 30 years total energy cost for each interval of 10 years is performed to simulate realistic situation. LWR and FBR are in a rival relation as a power generation energy source. When the FBR power generating cost is higher than LWR one, the FBR introduction will delay, which causes the rise of the power generating cost and the carbon reduction marginal cost in the future. Moreover, FBR would not come to be introduced until 2050 to supplement the lack of LWR, in spite of the uranium resource exhaustion for about 2070 years. Coal and natural gas was mainly used in the former half of 21st century and Biomass and IGCC with carbon capture and sequestration are greatly introduced in the latter half.
- Long-term optimization of 100 years is considered as planned economy and nuclear energy is introduced well, while succession optimization of 30years, realistic policy determination because usual long-term plan forecasts 30years, and nuclear energy would not be introduced much due to the use of fossile energy with low cost.

Conclusions

Taking the effort for energy-saving as major premise, carbon-sequestration for fossil fuel, renewable energy and nuclear energy should be altogether developed under the CO₂ constraint. Especially, fast breeder reactor will be attached importance to, due to its carbon free and resource limitless features, as the 22nd century is approaching.

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