1. Power Plant Efficiency

a. supercritical steam power plant

The enhancement of power plant generation efficiency is a target of the saving energy and decreasing of the CO_2 emission. The conventional **supercritical steam power plant** (steam pressure 246 kg/cm^2g, temperature 538 or 566 !) has **37 ~ 38 %** of the generation efficiency (does not include in plant use electric power). In 1990's the efficiency of **ultra supercritical steam power plant** was reached to 41.7 % (steam pressure 316 kg/cm^2g, temperature 566 !), however, the maximum efficiency is estimated 42 ~43 %.

b. LNG combined cycle power plant

The LNG combined cycle power plant generates the power with two types of turbines. The first turbine is operated with the high temperature combustion gas, and the second turbine is operated with the steam generated by the output gas of the first turbine. The efficiency of the LNG combined plant is **46 %** at the combustion temperature is 1100 ! class, and become **48 ~ 50 %** for the 1300 ! class.

c. Coal gasification

" IGCC

The gasified coal can be used for the combined cycle power plant like the LNG. The Integrated gasification combined cycle (IGCC) power plant is under the development, and the estimated efficiency is 48 ~ 50 % for the 1500 ! combustion gas class.

" MCFC

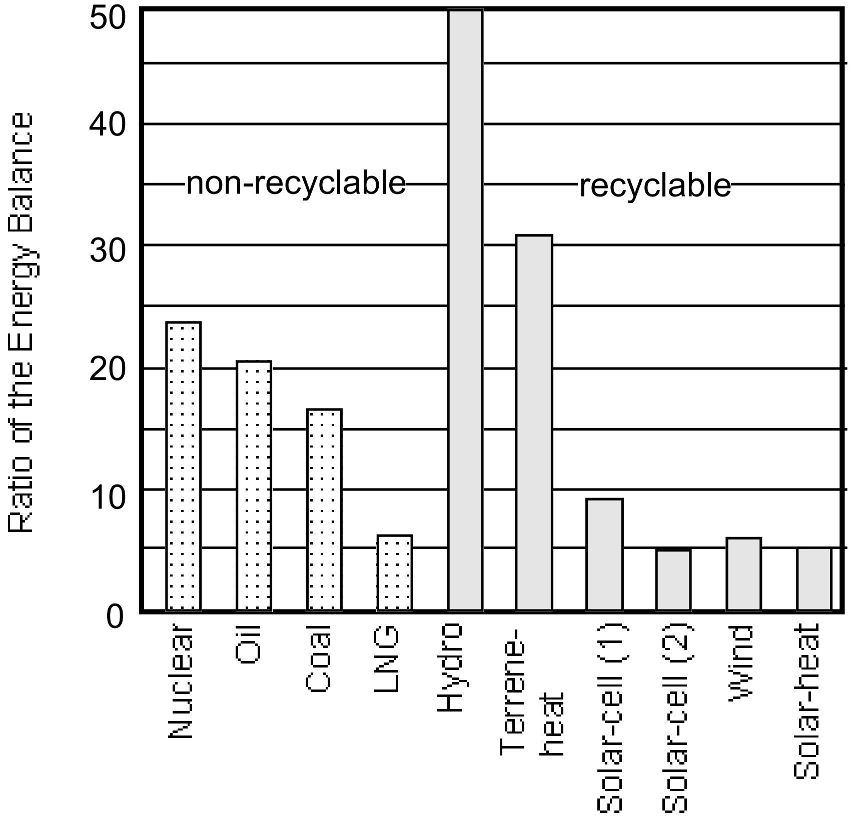
The gasified coal can be used also for the fuel cell. The molten carbonate fuel cell (MCFC) is estimated having the efficiency of 60 %, combining steam turbine using exhaust heat (650 !) of the cell.

NOTE: Japan consumes 30 Mton of the coal for the electric power generation. When the efficiency enhanced from 42 % to 43 %, 700 kton of call can be saved. The saved coal can operate a 700 MW power plant in a half year.

2. Life Cycle Assessment for the Power Plant

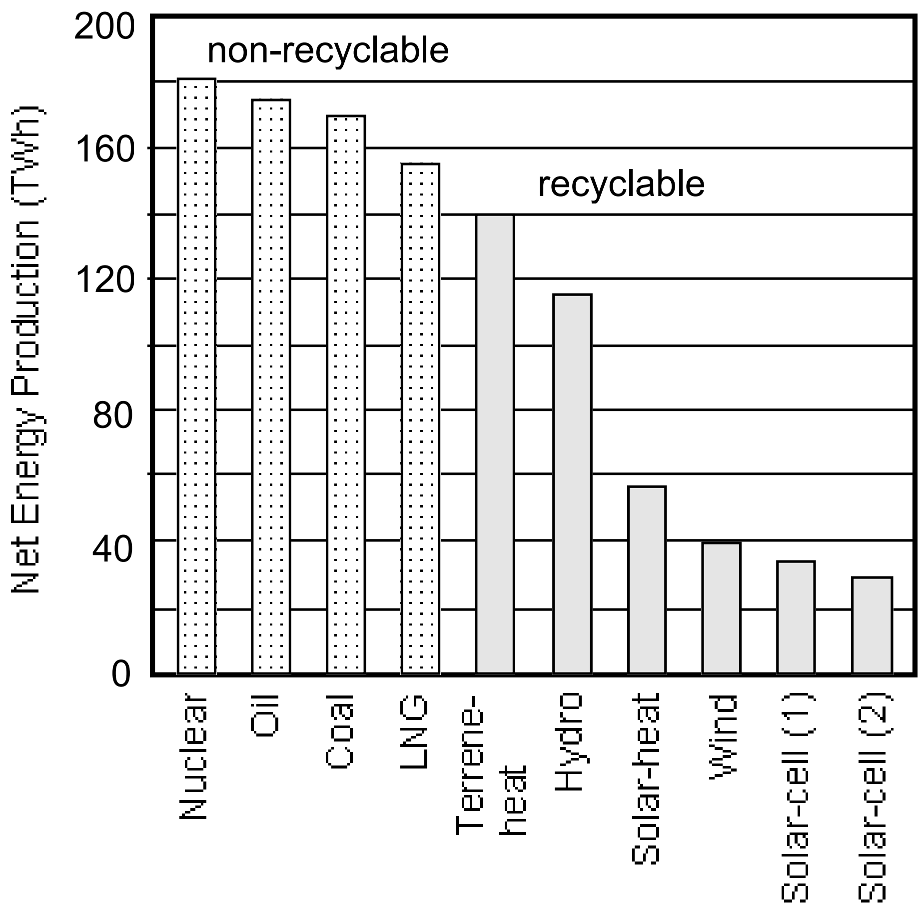
One of the assessment methods for **power generation systems** is the **energy balance analysis**. This method compares the **output energy** and direct/ indirect **input energy** for the power generation systems. In the calculation process of the input energy, we consider required energy and resources such as for, system construction, fuel mining, transportation, waste management, and equipments of electricity transmission.

The figure shows the ratio of output energy and input energy for each power generation systems, and the table describes electric output and plant utilization rate for each system. The ratio of LNG power plant is relatively low because of the required energy for liquidation process, and even if in the case of pipe line use, much energy is required for the pressurization of the gas. (Solar-cell (1) is the system for home, and Solar-cell (2) is the system for electric power industry). On the nuclear power plant case, we suppose once through and gaseous diffusion enrichment.



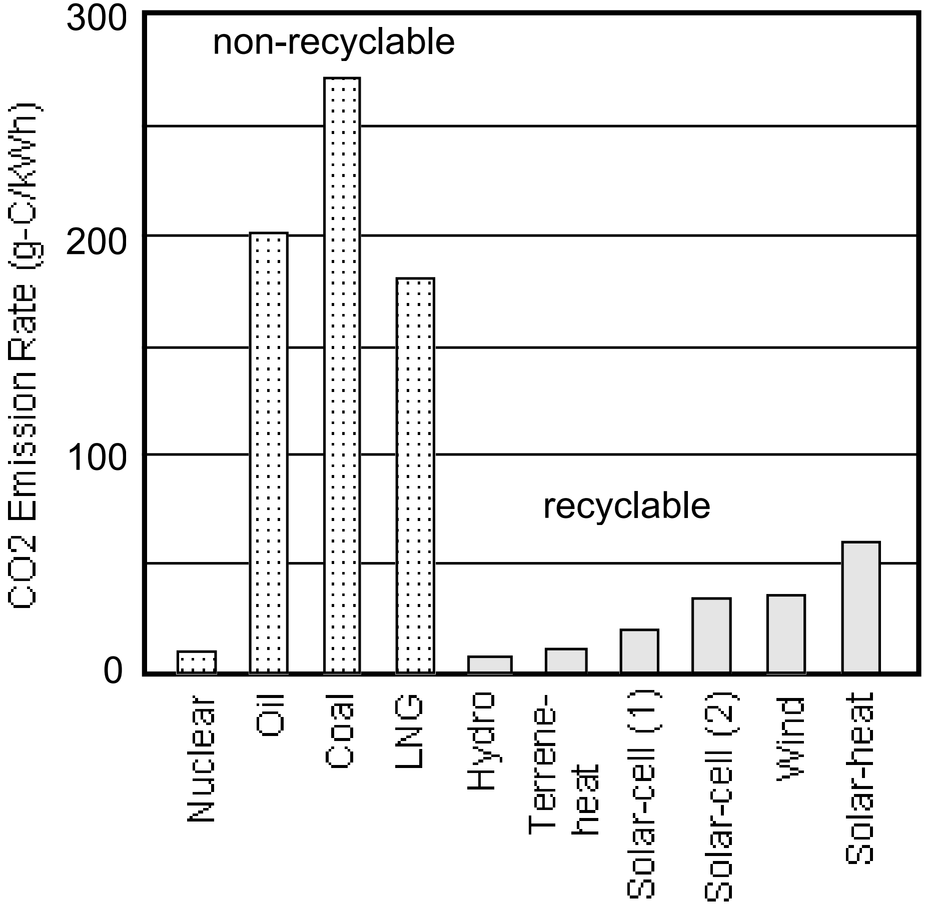
Plant	Generation Output (MW)	Plant Utilization Rate (%)
Nuclear Power	1000	75
Oil Power	1000	75
Coal Power	1000	75
LNG Power	1000	75
Hydro Power	10	45
Terrain-heat Power	55	60
Solar-cell (1)	0.003	15
Solar-cell (2)	1	15
Wind Power	0.1	20
Solar-heat Power	5	30

Following shows the **net electric power generation** (produced power minus input power required for the plant construction and operation), supposing all power plant capacity is **1000 MW** and utilization length is **30 years**. The result reflects the **utilization rate**, for example, the power plants which utilization rates are high have larger net energy production values as the nuclear, oil, coal, and LNG power plant.



3. CO_2 emission rate

The CO_2 emission rate (CH_4 is included as the **converted value in CO_2**) for each power generation system can be estimated from the input energy used in the **energy balance analysis**. The CO_2 is emitted not only form the operation process of the fossil fuel combustion power plant, but also from the plant construction process (such as the CO_2 produced in the cement production) and fuel mining process (CH_4).



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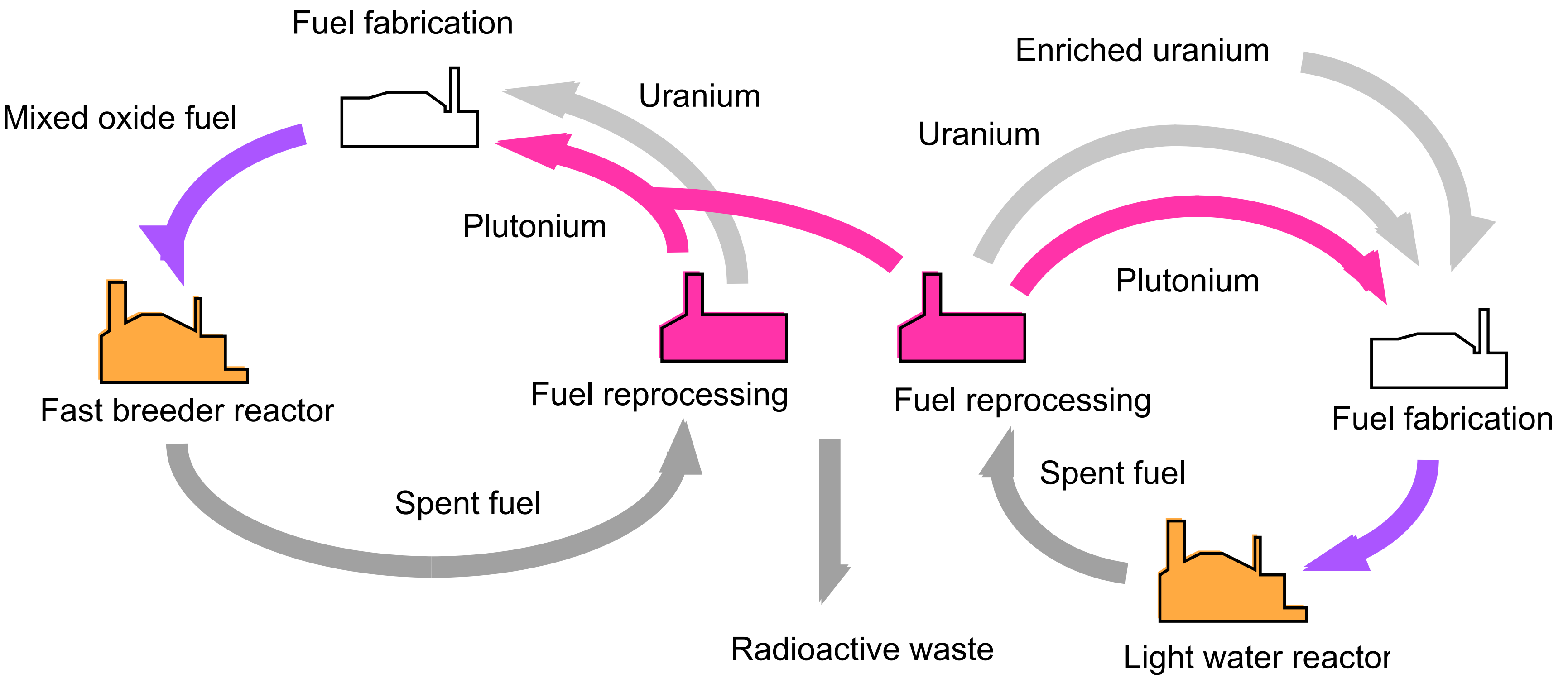
4. Nuclear fuel cycle and energy security

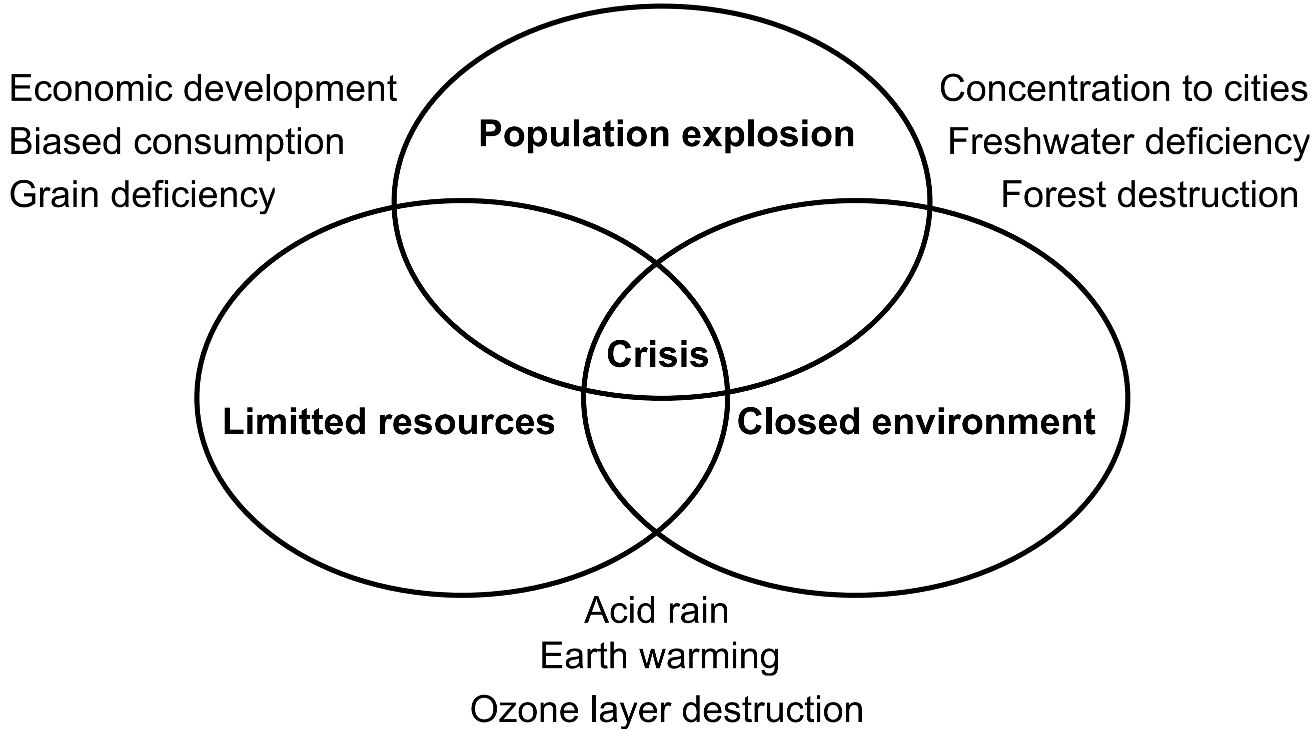
To prevent nuclear weapon proliferation (Nuclear non-proliferation treaty:NPT), plutonium must be closed in the nuclear fuel cycle which is intended to consume the nuclear fuel efficiently. The nuclear fuel cycle is advantageous for the energy security, however, it requires complex processes.

- once through
- delayed reprocessing



Nuclear fuel cycle plan in Japan

5. Trilemma


Economic development
Biased consumption
Grain deficiency
Population explosion
Concentration to cities
Freshwater deficiency
Forest destruction
Crisis
Limitted resources
Closed environment
Acid rain
Earth warming
Ozone layer destruction