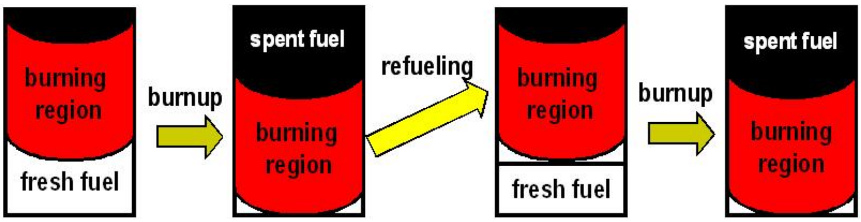
CANDLE Reactors

Innovative Nuclear Reactors, which do not require either enriched uranium or plutonium



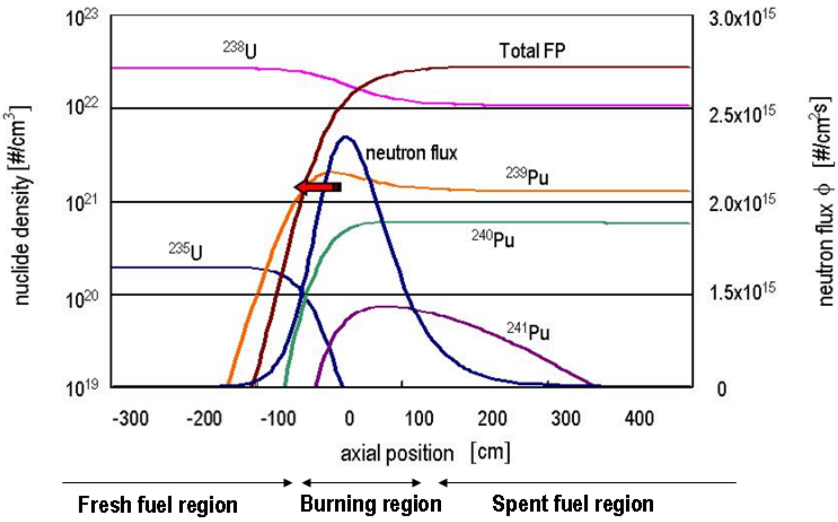
CANDLE burning

What is CANDLE burning?

In conventional reactors, control rods inserted at the startup of operation are gradually extracted along burning of fuel in order to maintain reactor critical. On the other hand CANDLE reactors do not need this kind of control rods. As shown in the above figure, the burning region moves, at a speed proportionate to the power output, along the direction of the core axis without changing the spatial distribution of the nuclide densities, neutron flux and power density.

Why is CANDLE burning possible?

The distributions along core axis of neutron flux and number density of each nuclide are shown in the right figure. Here the core height is taken infinite for explaining the CANDLE burning in the most general case. Near the boundary between fresh fuel and burning regions U-238 absorbs a neutron leaking from the burning region and becomes Pu-239, and then this region changes to the burning region. Near the boundary between burning and spent fuel regions the density of Pu-239 saturates and fission products (FP) accumulate, and then this region changes to the spent fuel region. Therefore, the burning region shifts to the fresh fuel region.

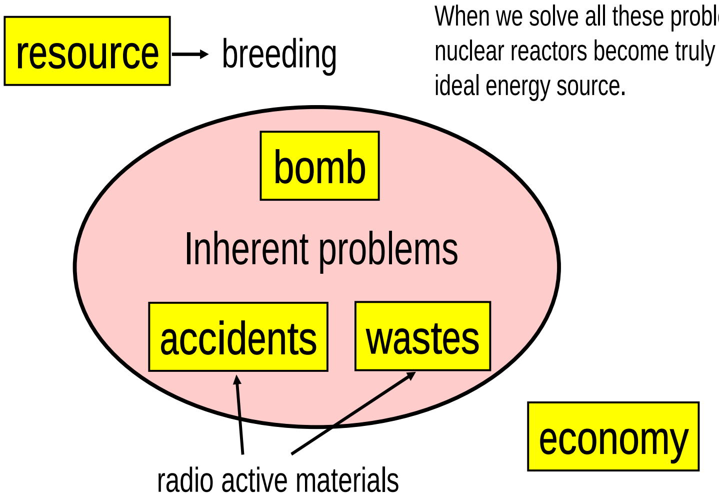


Nuclide densities and neutron flux along core axis

How CANDLE satisfies the requirements for nuclear energy?

Requirements for Nuclear Energy

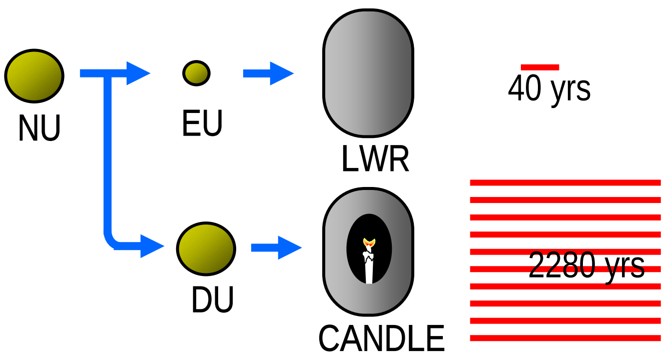
When we solve all these problems,
nuclear reactors become truly
ideal energy source.



Resource

Burn-up of the spent fuel is about 40%

CANDLE after LWR



Nuclear Bombs

Excellent features on physical protection and nonproliferation

CANDLE reactor can be operated
without enrichment plant
or reprocessing plant
for ever, once it starts,
if only natural or depleted uranium is available.

Safety

1. Burnup reactivity control mechanism is not required:
   Reactor control becomes simpler and easier.
   Reactivity-induced accidents are avoided.
2. Reactor characteristics do not change with burnup:
   Power peaking and reactivity coefficients do not change with burnup.
   Orifice control along burnup is not required
   Estimation of core condition is very reliable.
3. Possibility of re-criticality accidents at CDA is considerably reduced :
   Since the control rods are not inserted in the core under full operation, and coolant amount in the core is small.
4. Infinite neutron multiplication factor of fresh fuel is less than unity:
   Risk for criticality accident is small.
   Transportation and storage of fresh fuels become simple and safe.

Waste

Amount of spent fuel per produced energy:

Amount for CANDLE reactor ≒ 0.1 × Amount for LWR

≒ 0.25 × Amount for FBR

Amount of MA per produced energy is considerably reduced.

Amount of wastes associating to fuel cycle is drastically reduced.

Economy

Merits:

Simple reactor: low O&M cost

Simple fuel cycle: low fuel cycle cost

Average power density?

Positive item:
Power flattening

Negative item:
Low cooling performance

Reference:

H. Sekimoto, Light a CANDLE, COE-INES (2005)