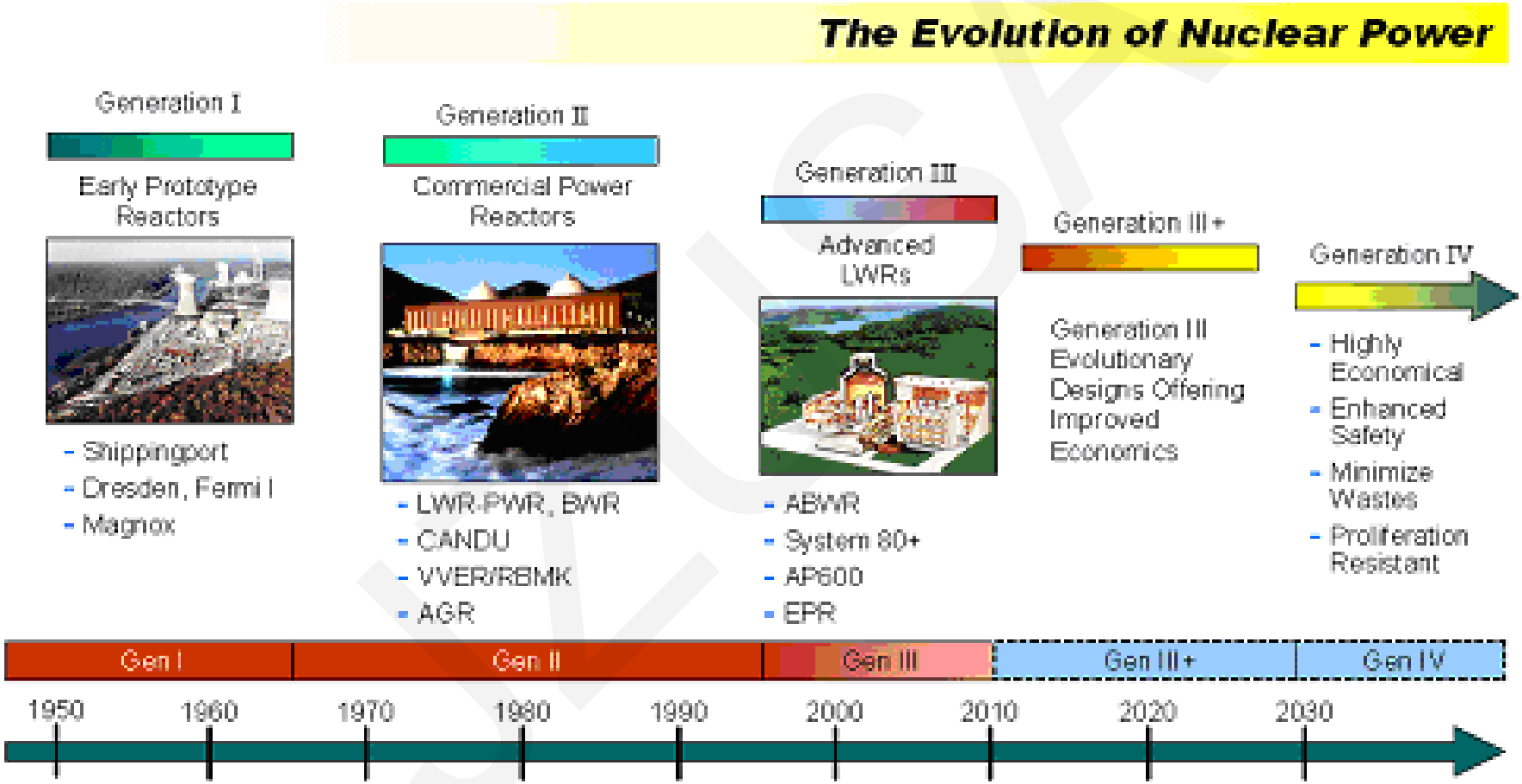
Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)

# Generation III pressurized water reactors and China's nuclear power

Yong WANG, Ji-en MA, You-tong FANG

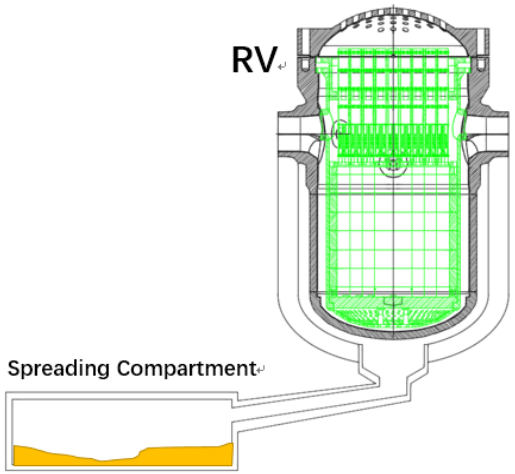
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http://dx.doi.org/10.1631/jzus.A1600035

# The Evolution of Nuclear Power



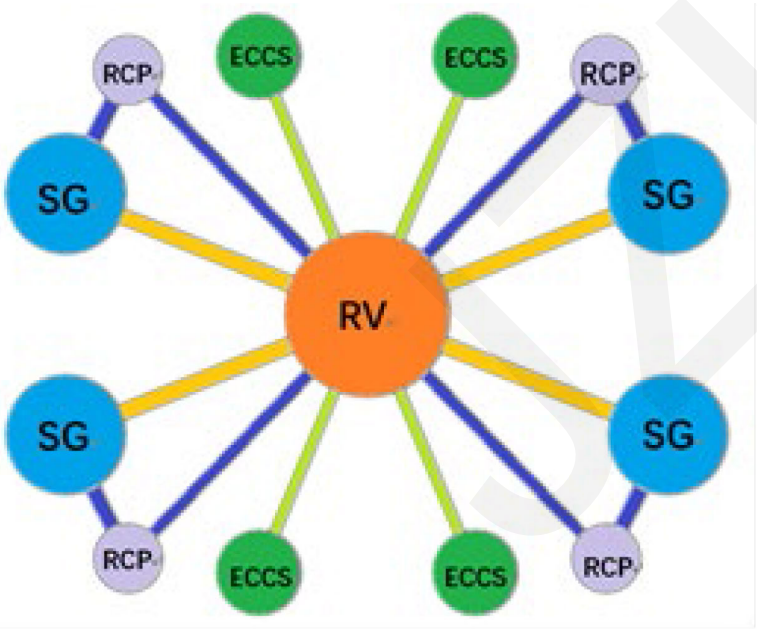
# EPR Design Features

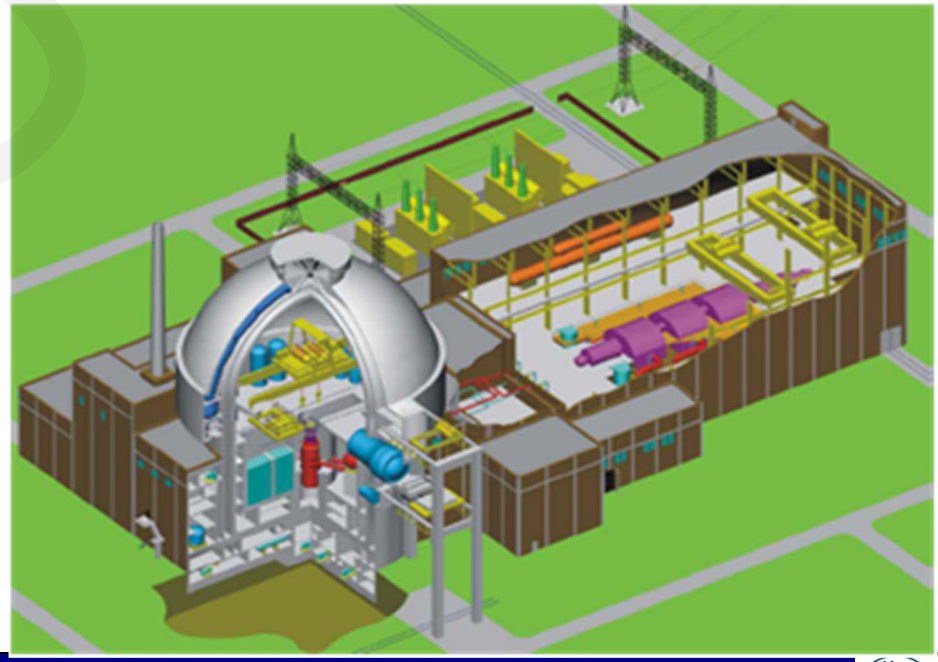
- 4-Train Safety Systems
- Double Containment to protect against commercial aircraft crash
- Core Catcher for severe accident mitigation
- Can run on a full MOX Core
- Higher Plant Efficiency (37%)
- Digital I&C (Siemens TELEPERM-XS)
- 10-15% less uranium consumption
- 15 days outages
- Above 90% life time capacity factor
- Robust design with small technology leap



# AES2006 Design Features

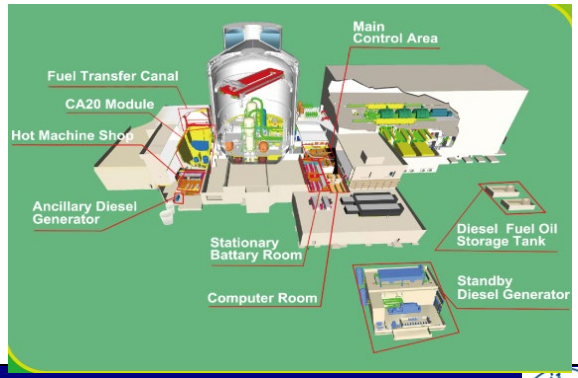
- VVER1000 stretched to 1200 MW
- 60 years service life
- Higher thermal efficiency (35.7%)
- 4-loop design /horizontal SGs



# AP1000 and CAP1400 Design Features

- Passive Safety Systems – use forces of nature (gravity, convection, natural circulation to improve safety and simplify systems)
- Passive systems for core cooling, containment isolation, residual heat removal and containment cooling
- No outside electricity needed for 72 hrs
- Number of pumps and safety class valves reduced by about 50%
- In-vessel retention of core melt
- Passive Containment Cooling system
- Proven PWR components



# Discussion (1/2)

| Item | EPR(AREVA) | AES2006(ROSATOM) | CAP1400(SNERDI) |
|---|---|---|---|
| Design life (years) | 60 | 60 | 60 |
| Availability（%） | >92% | >90% | >93% |
| Construction duration (From FCD to connecting to grid）(months) | <54 | <54 | <56（to be less for fleet construction） |
| Gross electrical output (MWe) | 1770 | 1197 | 1500 |
| Average discharge burnup of fuel (MWD/tU) | >50000 | >60000 | >53000 |
| Fuel cycle length (months) | 24 | 12, capable of 18-24-month refuel cycle | 18, capable of 24-month refuel cycle |
| MOX fuel loading capability | Available | Available | Available |
| Engineering safety features | Active | Active + passive | Passive |
| Operation action time (hour) | <0.5 | <6 | <72 |

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# Discussion (2/2)

| Item | EPR(AREVA) | AES2006(ROSATOM) | CAP1400(SNERDI) |
|---|---|---|---|
| Severe accident mitigation | Dedicated severe accident depressurization valves, core catcher, containment spray system, passive hydrogen recombiner | Pilot-operated relief valves, passive heat removal system via steam generator, passive heat removal system from containment, core catcher, passive hydrogen recombiner | Passive depressurization squib valve, passive containment cooling system, in-vessel retention, passive hydrogen recombiner |
| Containment | Double-envelope: external, reinforced concrete; internal, pre-stressed concrete | Double-envelope: external, ordinary concrete; internal, pre-stressed reinforced concrete | Double-envelope: external, reinforced concrete; internal, steel |
| Capability of withstanding large commercial aircraft crashes | Available | Available | Available |
| Core damage frequency (CDF) (1/ry) | $<1.24\times10^{-6}$ | $<5.94\times10^{-7}$ | $<4\times10^{-7}$ |
| Large release frequency (LRF） (1/ry) | $<9.6\times10^{-8}$ | $<3.7\times10^{-9}$ | $<5.07\times10^{-8}$ |

# Conclusions

- Standardised design to expedite licensing, reduce capital cost and reduce construction time
- Simpler and more rugged design, making them easier to operate and less vulnerable to operational faults
- Higher availability and longer operating life - typically 60 years
- Further reduced possibility of core melt accidents
- 72-hour grace period, so that following shutdown the plant requires no active intervention for 72 hours
- Resistance to serious damage that would allow radiological release from an aircraft impact
- Higher burn-up to reduce fuel use and the amount of waste
- Greater use of burnable absorbers ("poisons") to extend fuel life.

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