Nuclear Power Economics in Korea

2014.08.

IAEA

INPRO
International Project on
Innovative Nuclear Reactors
and Fuel Cycles

KEPCO E&C
KEPCO ENGINEERING & CONSTRUCTION COMPANY, INC.

Yong-eok LEE

Contents

1. Nuclear Energy Issues in Korea

- **Nuclear energy economic issues in Korea after Fukushima**
  - Growing concerns over nuclear safety
  - Political discussion on nuclear energy policy
  - Intensified controversy over nuclear power economics
  - Emphasis on Public Acceptance (PA)
- **Is nuclear option still more competitive than fossil fuel plants?**
  - Most of the issues derived from Fukushima accident is reflected in the 6th Basic Plan for Long-term Electricity Supply and Demand (2013~2027, Feb. 2013, MOTIE Korea)

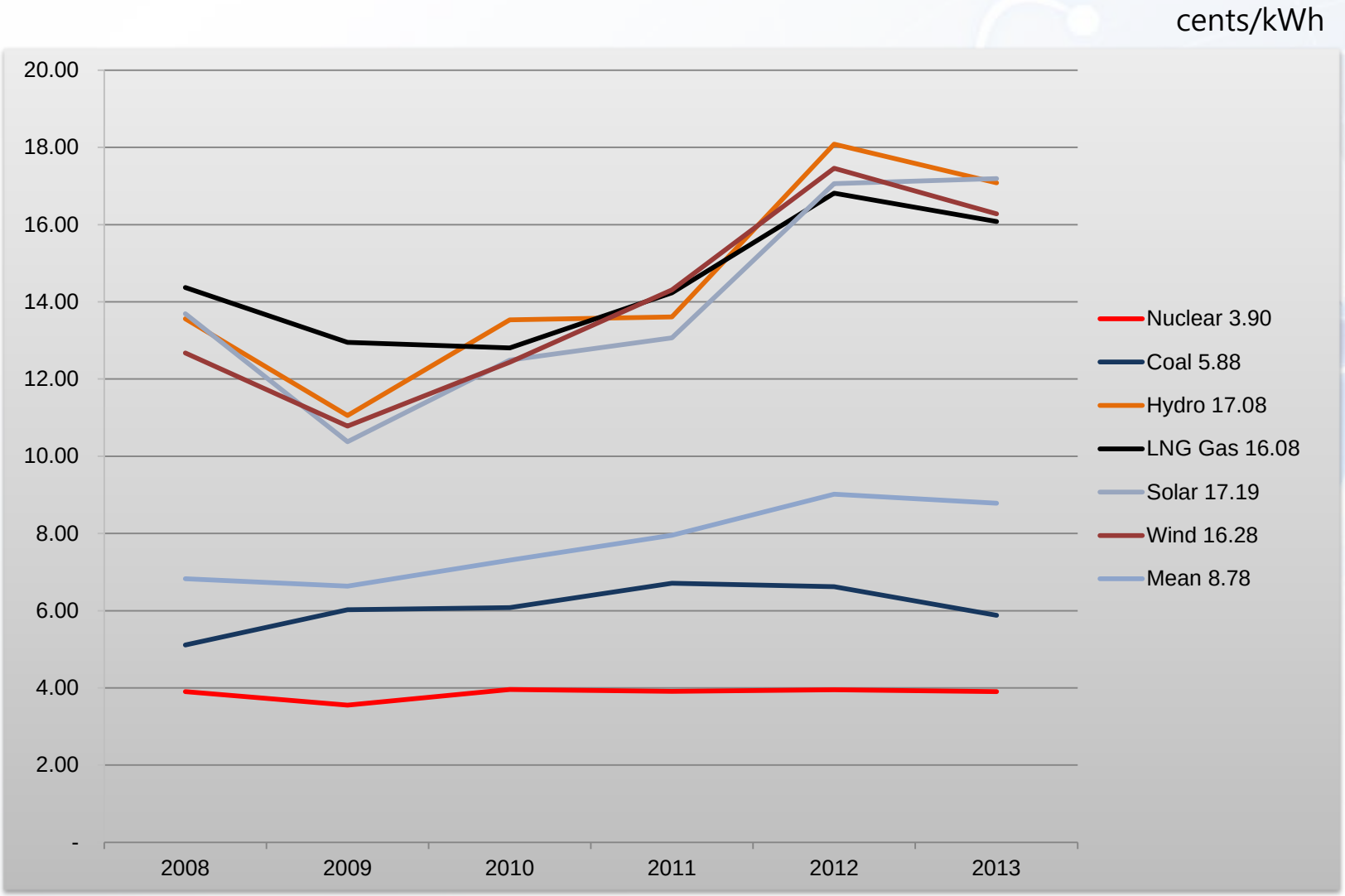
Ω The 6th Generation Mix (2013~2027)

- **Nuclear Power Plants in case Policy-Driven Generation**
  - Postponing for new reflection amount for 2025 to 2027
    - considering public acceptance (PA) level after Fukushima
  - 11 nuclear plants of KHNP in the 5th Generation Mix that are planned to be built by 2024 are reflected in certainty
  - Extension of Approved Duration will be decided later,
    - assuming PA, strict safety check has been passed
- **Korean government decided to let NPPs provide base load power because of the unique situation in Korea:**
  - Korea needs to stably supply energy (energy security), cut greenhouse gas emissions and lower power generation cost.
  - Size of Nuclear Power: 25% in 2012 → 27% in 2027

Ω Paradigm Shift in Nuclear Policy

- **Before Fukushima**
  - Focus on efficiency and economic benefits of NPP construction and operation
  - Achieve NPP technology self-sufficiency in a short-term
    - Choice & Focus
  - Ensure Owners' management activities in general
- **After (to-be)**
  - Prioritize nuclear safety on the basis of public acceptance
    - Safety enhancement technology
    - Radiation safety management technology
    - Natural disaster response measures
  - Strengthening of monitoring, open & competition System
  - Enhancement of safety infrastructure and safety culture

2. Electricity production costs in Korea



- ***Source: KPX, EPSIS (Electrical Power Statistics Information System)***

Lesson Learn of Korean NPP

- **Replicating standard reactors and construction in series**
  - OPR1000 → APR1400 → APR1400+
- **Making the best use of existing power infrastructure when constructing new NPPs**
- **Constructing specialized supply chain (A/E, NSSS, etc.) and nuclear industry cluster led by the government & public company**
  - Stable domestic nuclear business environment such as sales
  - Cutting back on R&D cost when developing new technologies
  - Reducing project management, engineering, manufacturing, construction and O&M costs thanks to close cooperation among industrial partners
  - Lower interest thanks to easy financing
  - A predictable licensing process can avoid unexpected costs

3. Review of INPRO methodology

INPRO User Requirements for Nuclear Economics

- UR1 (CN: Cost of Nuclear energy): taking all relevant costs and credits into account, should be competitive with that of alternative energy sources
  - CN < k * CA (cost of energy from alternative source)
  - factor **k** is usually > 1 and is based on strategic considerations

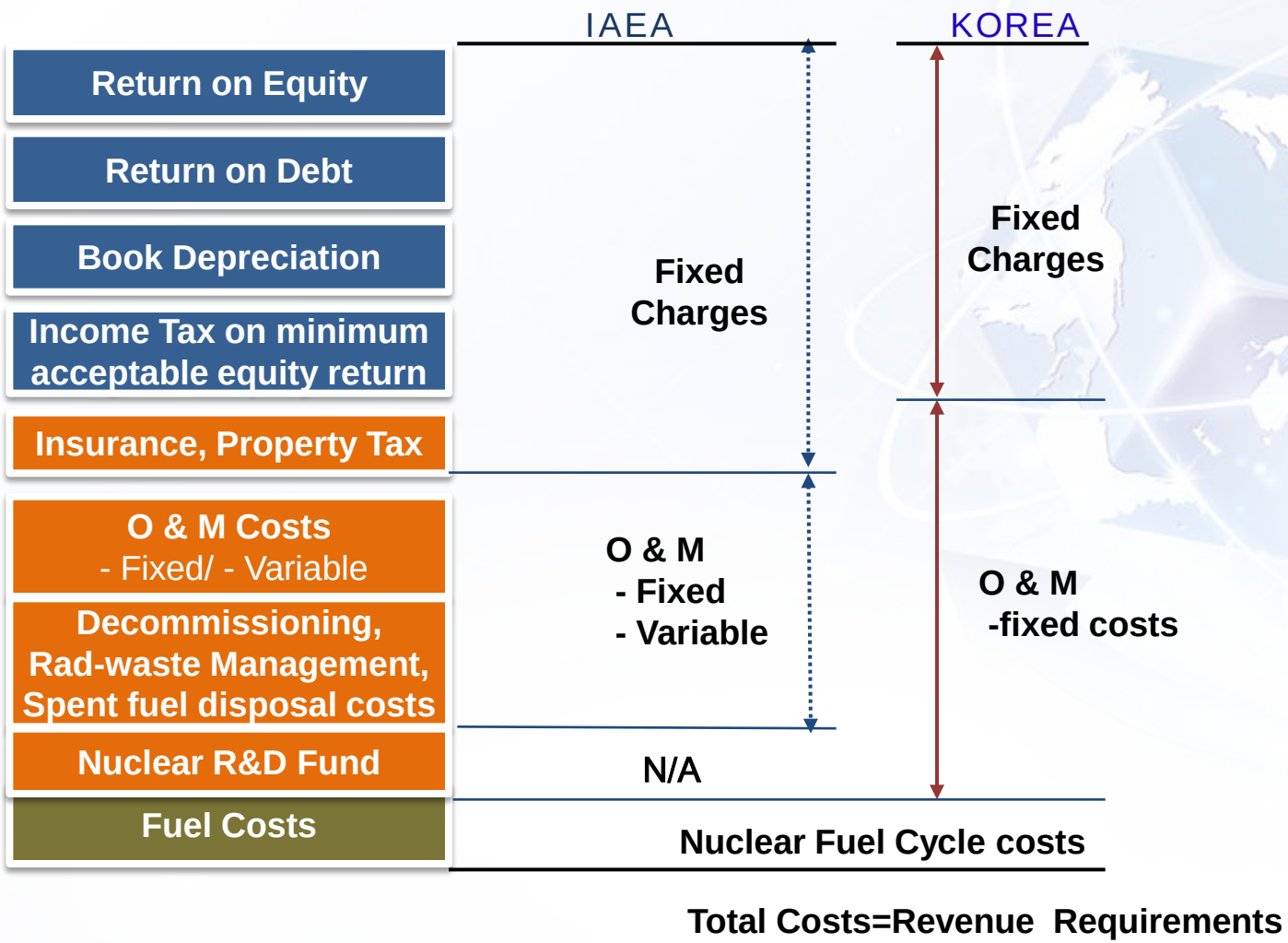
IPPO (Independent Power Producer Ownership) concept

- Goal of the firm is to maximize profits.
- Apply the Discounted Cash Flow method: IRR/ROI/NPV

RUO (Regulated Utilities Ownership) concept

- Goal is to minimize revenue requirements so as to provide low-cost: Choosing the Alternatives
- Apply the Levelized Revenue Requirements (LRR) method

Levelized Unit Energy Costs (LUEC)



4. Major Issues influencing LUEC in Korea

Major Issues	Action	Cost Impact
• Safety Enhancement	Reflect 11 design improvements + minor change	U$ 100M/plant
• Quality Concern	Risk premium to QA and Licensing Schedule	Add 12Months to Engineering and Procurement Schedule
• Decommissioning and Rad-waste Management	Budget increase in Decommissioning, Low and Intermediate level radioactive waste and Spent Fuel Disposal	Budget increase 7.5% of amount
• Conservative Plant Life Time	Apply 40 years of life time to NPP like coal power plants rather than the design life of 60 years.	Increase in fixed charge
• External costs for severe accident response	Conduct severe accident probability assessment based on scenarios and hypothesis	Impossible to generalize the possibility of severe NPP accidents

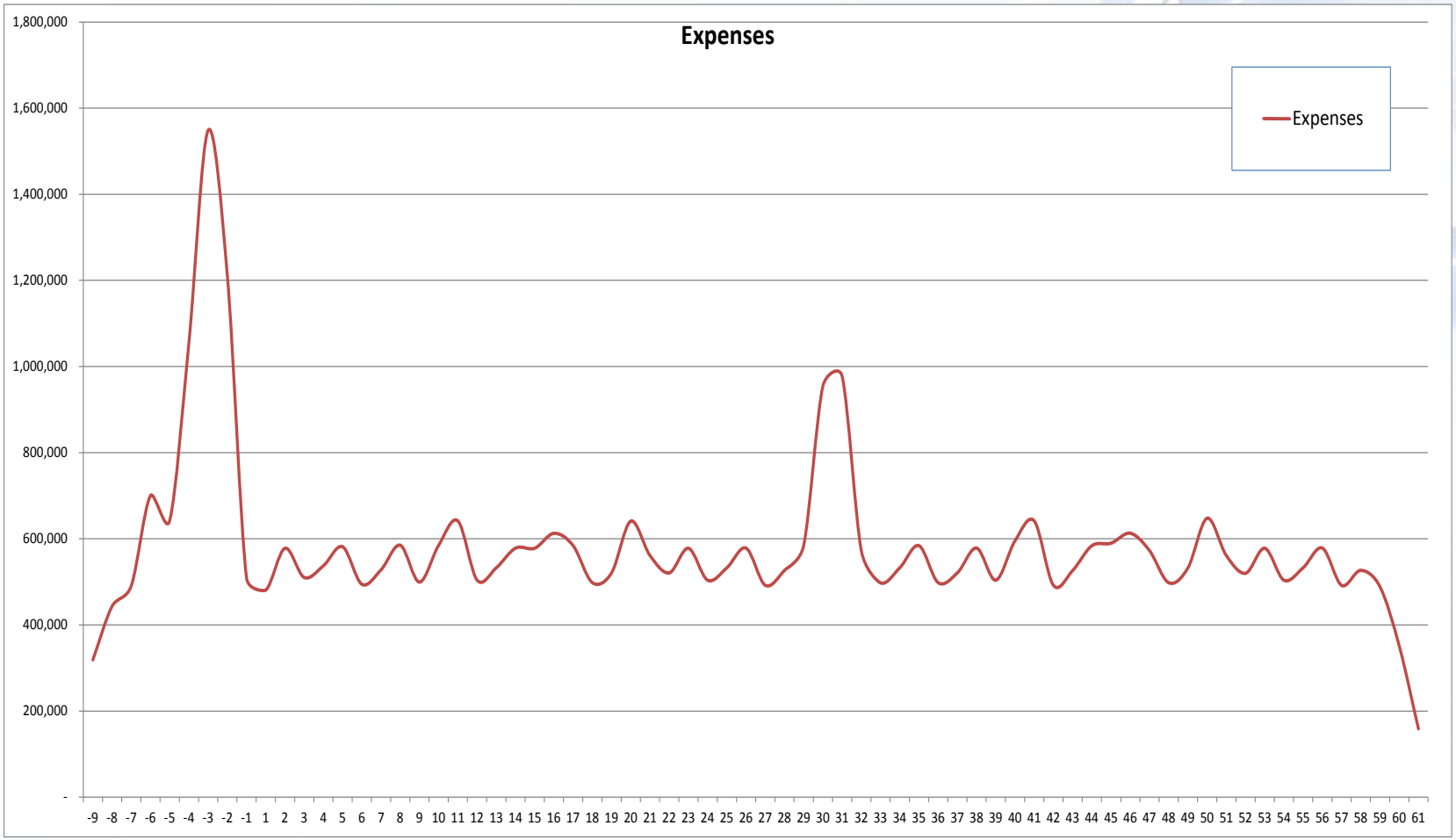
5. Assessment of Major Issues

Basic assumptions for assessment

- Technical Parameters:
  - Reference: Korean APR1400 (Gross: 1455MWe, PWR)
  - Two units are built on the same site simultaneously
  - Site specific costs are included such as land, infrastructures
  - Design life time: 60 years
  - Total project duration (base): 120 Months
  - Load factor (base load): 90 %
- Economic Parameters
  - Cost basis: December 2013 constant value
  - Discount Rate: 6%
  - Overnight Costs (base): 2,100 U$/kWe excluding EDC & IDC

5. Assessment of Major Issues

Cash Flow projection including Back fitting for 60 Years



5. Assessment of Major Issues

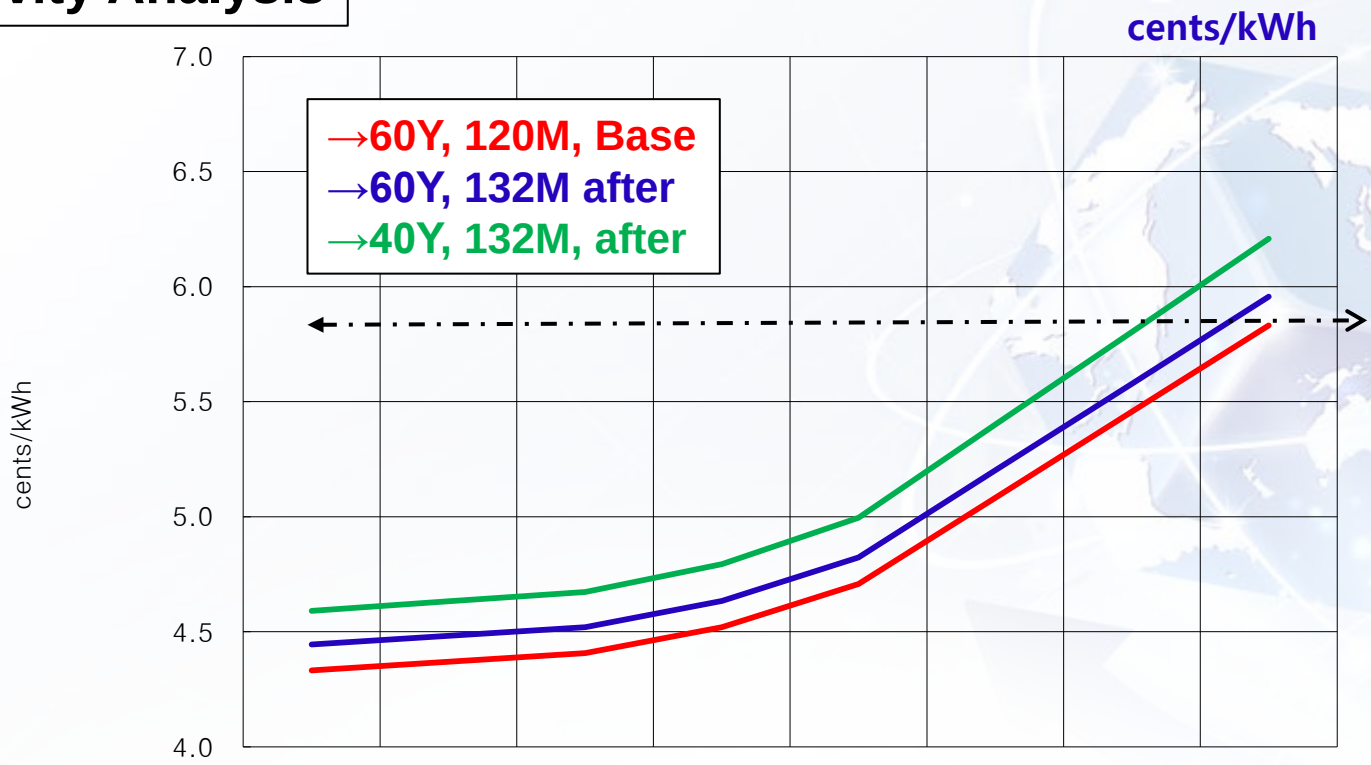
Assessment Results

cents/kWh

ISSUES	Cost Impact	Assessment			Remarks
		Diff.	Before Fukushima	After Fukushima	
Rad-waste/Decommissioning	+ 7.5% of amount	0.10	1.39	1.49	
Fixed Charge	Sub-total of Fixed Charge	0.20	2.10	2.30	
- Safety Enhancement	+ 100M USD of capital costs	0.04	0.00	0.04	
- Quality Concern	+ 12 Months of expansion	0.02	2.10	2.12	+ IDC
- Conservative Plant Life Time	- 20 years of plant life time	0.14	2.10	2.24	+ Fixed Charge
LUEC	cents/kWh	0.30	4.33	4.63	+7% increase

5. Assessment of Major Issues

Sensitivity Analysis



+ Capital costs	Base	+ 0.1 B$	+ 0.2 B$	+ 0.5 B$	+ 1.0 B$	+ 2.0 B$	+ 3.0 B$	+ 4.0 B$	at +1.0 B$
60Y, 120M, Base	4.33	4.37	4.41	4.52	4.71	5.08	5.46	5.83	+ 19.9%
60Y, 132M after	4.44	4.48	4.52	4.63	4.82	5.20	5.58	5.96	+ 18.0%
40Y, 132M, after	4.59	4.63	4.67	4.79	5.00	5.40	5.80	6.21	+ 15.0%
Coal Plant (actual 2013)	5.88	5.88	5.88	5.88	5.88	5.88	5.88	5.88	-

6. Conclusion

- **Nuclear option still more competitive than fossil options**
  - Include all external costs related to NPP which can be generally estimated without considering accident scenarios
  - Coal power plants do not include the external cost
- **It is believed that nuclear power does contribute to national economy and energy security in Korea**
  - Impossible to generalize the probability of severe NPP accident:
    - such as accident scenario analysis, atmosphere dispersion modelling, assessment of exposure dose, etc.
  - However, additional cost is required for PA unlike the past.
- **In conclusion,**
  - we must research on "**Nuclear Safety Economics**" to gain competitiveness over fossil fuel plants in terms of both economic benefits and safety.