Analytical Studies on Nuclear Energy in JAERI

I. Nuclear Power – Current Status
II. Assessment of Nuclear Energy Systems
1. Study on Effective Plutonium Utilization
2. Study on Impacts by Nuclear Phase-out

October 28, 2002

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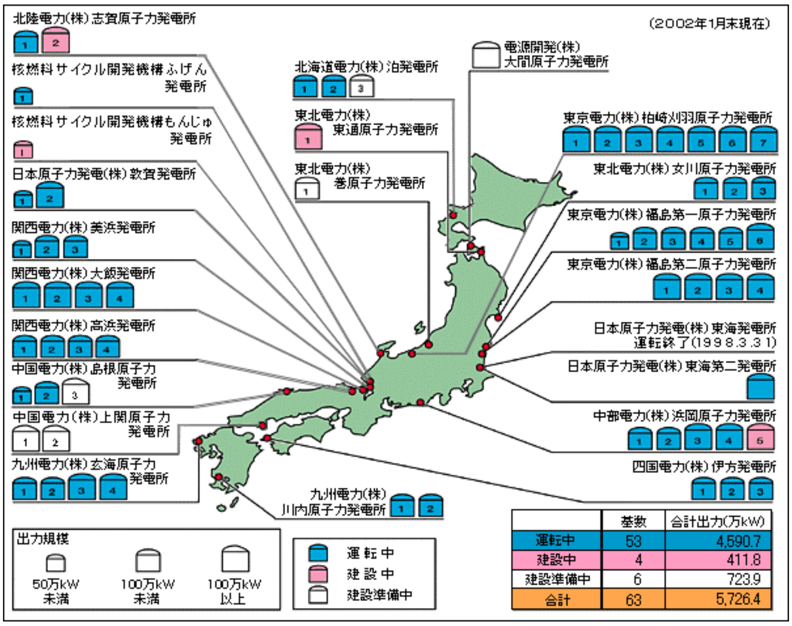
I. Nuclear Power – Current Status

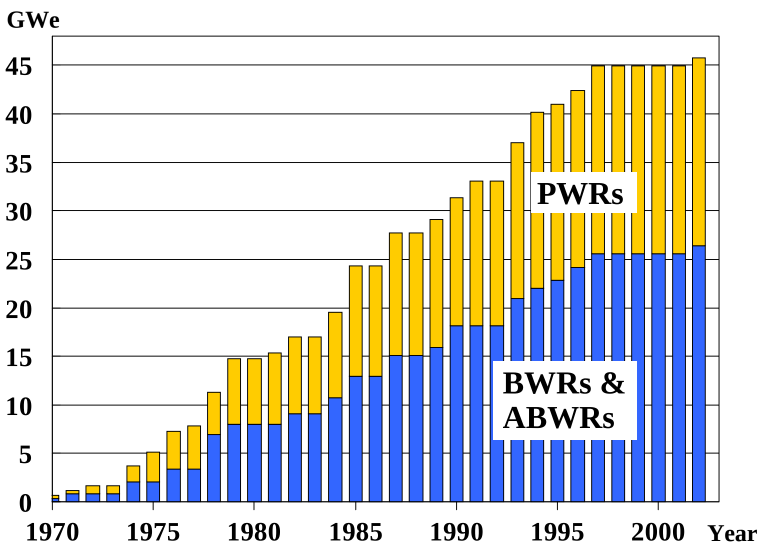
Nuclear Power Capacity in Japan

	Number of Units	Generating Capacity (MWe)
LWRs in Operation		
Pressurized Water Reactors	23	19,366
Boiling Water Reactors	27	23,664
Advanced BWRs	2	2,712
Total	52	45,742
LWRs under Construction		
Boiling Water Reactors	1	1,100
Advanced BWRs	2	2,738
Total	3	3,838
Advanced Thermal Reactor in Operation		
Fugen (Prototype)	1	165
Fast Breeder Reactor under Construction		
Monju (Prototype)	1	280

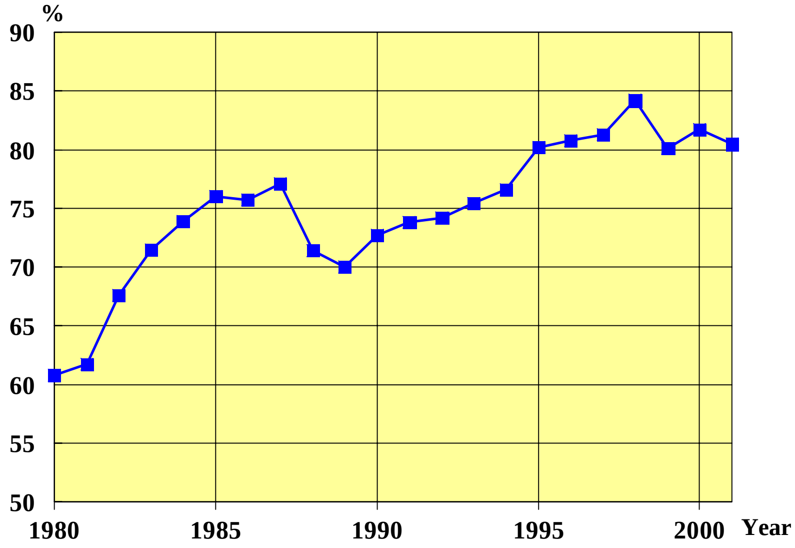
Distribution of Nuclear Power Stations



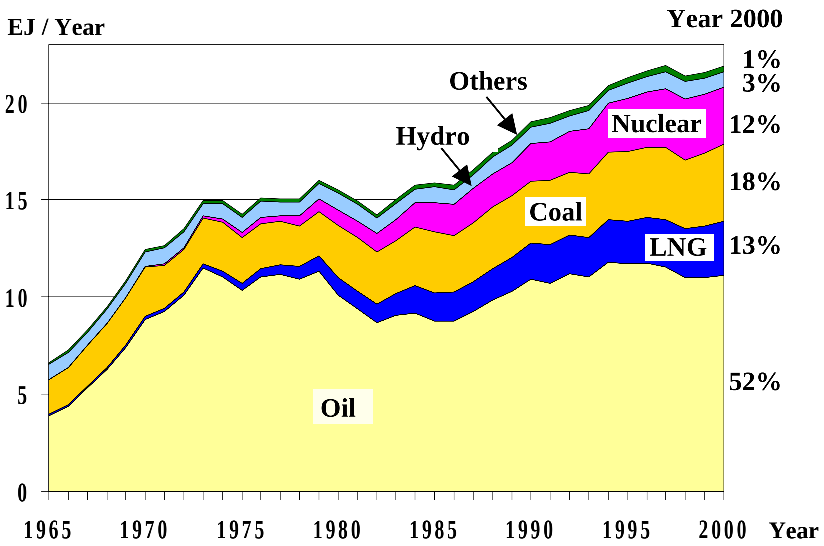
Growth of Nuclear Power Capacity



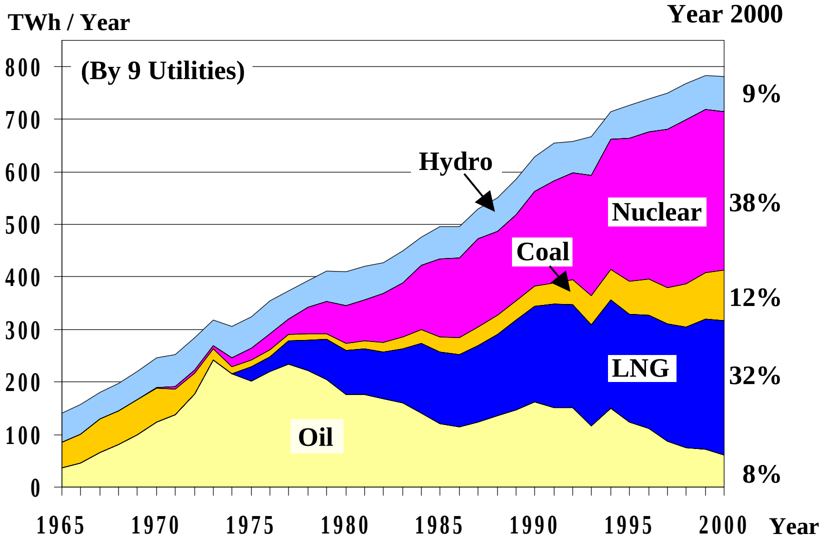
Capacity Factor of Nuclear Power Stations



Primary Energy Consumption in Japan

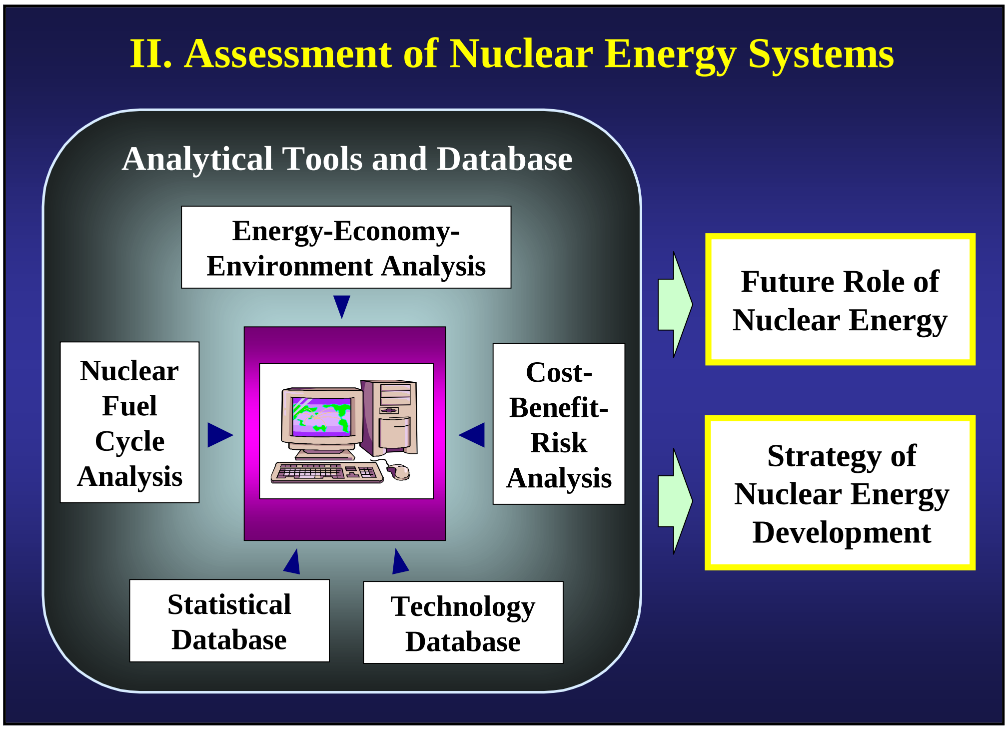


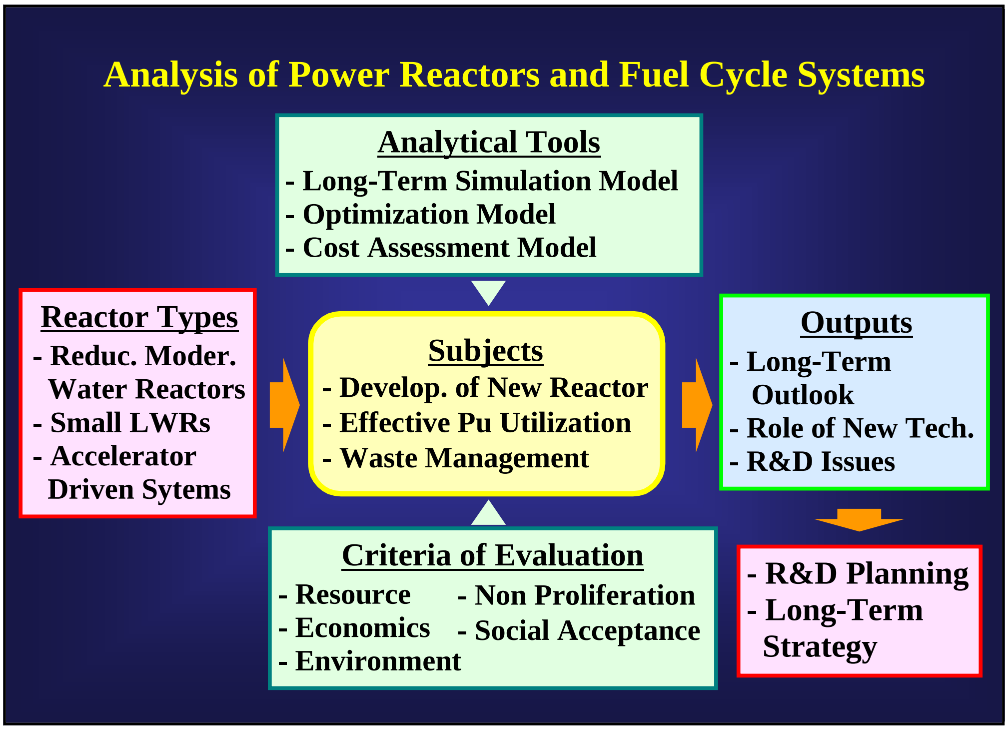
Electric Power Generation in Japan



Technical Subjects for Future Development

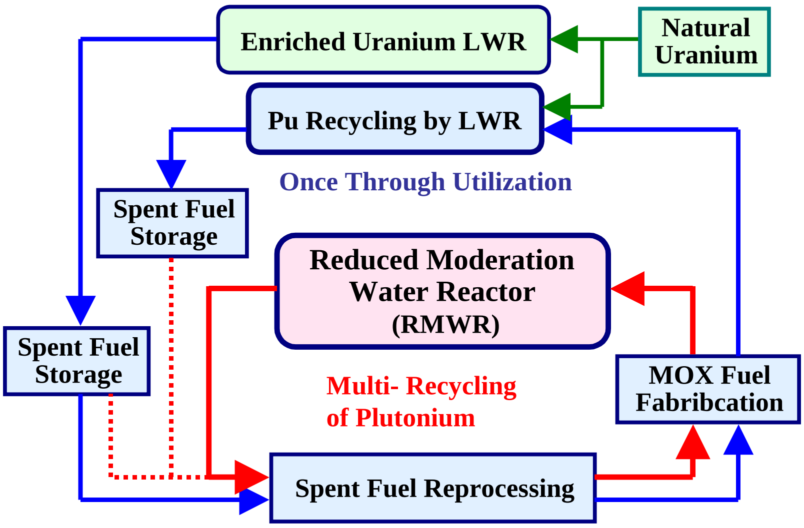
Subjects	Time Range	Technical Options
Improvement of Safety	Short	Passive Safety, Higher Reliability of Equipments / Systems
Reduction of Generation Costs	Short	Simplification of Systems, Higher Fuel Burn-up
Effective Use of Plutonium	Short - Long	From Burning to Breeding, Backup Strategy for FBR Development
Disposal of High Level Wastes	Mid - Long	Transmutation or Recycle of Minor Actinides
Expansion of Application	Long	Hydrogen Production, District Heating, Industry Process Heat
Assure Fuel Resources	Long	Development of Breeders, Uranium from Seawater, Thorium


II. Assessment of Nuclear Energy Systems
Analytical Tools and Database
Energy-Economy-Environment Analysis
Nuclear Fuel Cycle Analysis
Cost-Benefit-Risk Analysis
Statistical Database
Technology Database
Future Role of Nuclear Energy
Strategy of Nuclear Energy Development


Analysis of Power Reactors and Fuel Cycle Systems
Analytical Tools
- Long-Term Simulation Model
- Optimization Model
- Cost Assessment Model
Reactor Types
- Reduc. Moder. Water Reactors
- Small LWRs
- Accelerator Driven Sytems
Subjects
- Develop. of New Reactor
- Effective Pu Utilization
- Waste Management
Outputs
- Long-Term Outlook
- Role of New Tech.
- R&D Issues
Criteria of Evaluation
- Resource
- Economics
- Environment
- Non Proliferation
- Social Acceptance
- R&D Planning
- Long-Term Strategy

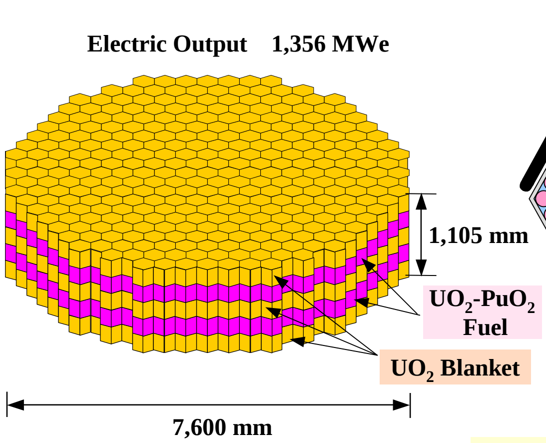
1. Study on Effective Plutonium Utilization

Plutonium Recycling in Water Cooled Reactors



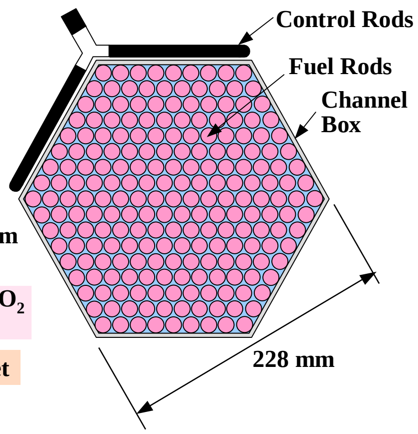
Example of RMWR Designs

Entire Reactor Core



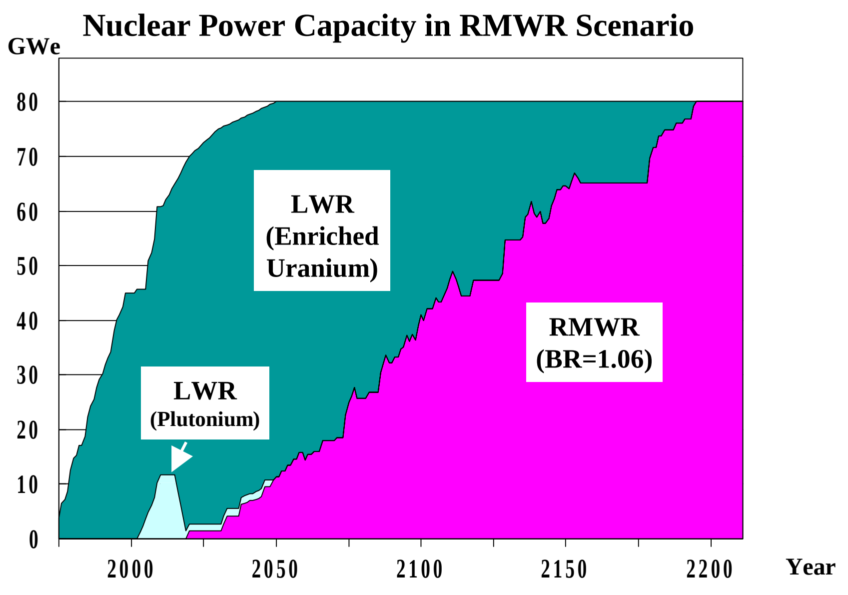
Number of Fuel Assemblies	900
Number of Control Rods	283

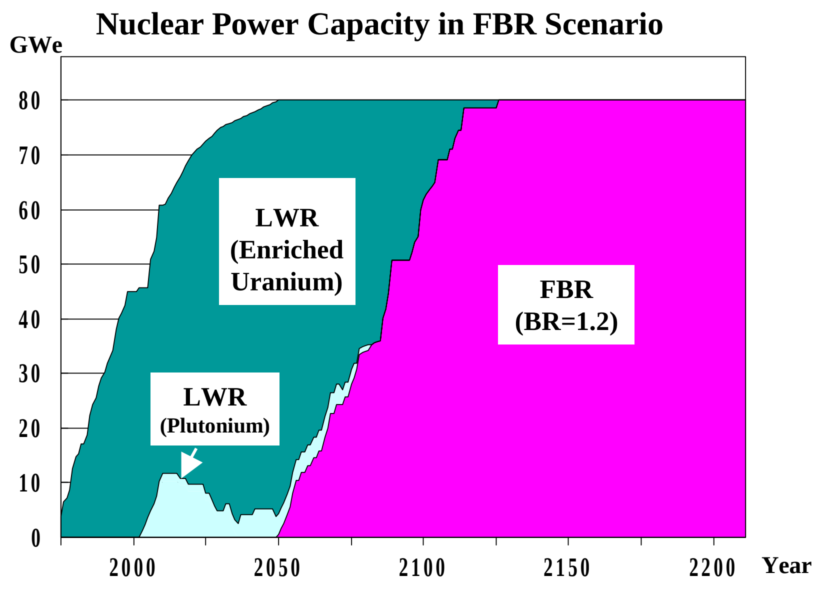
Fuel Assembly

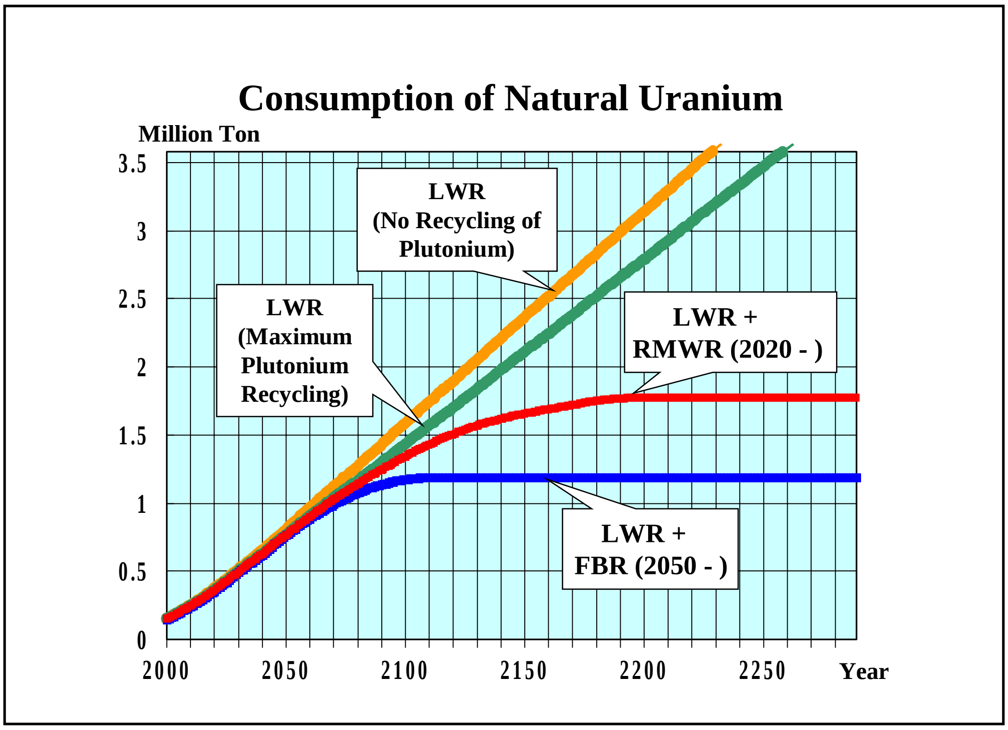


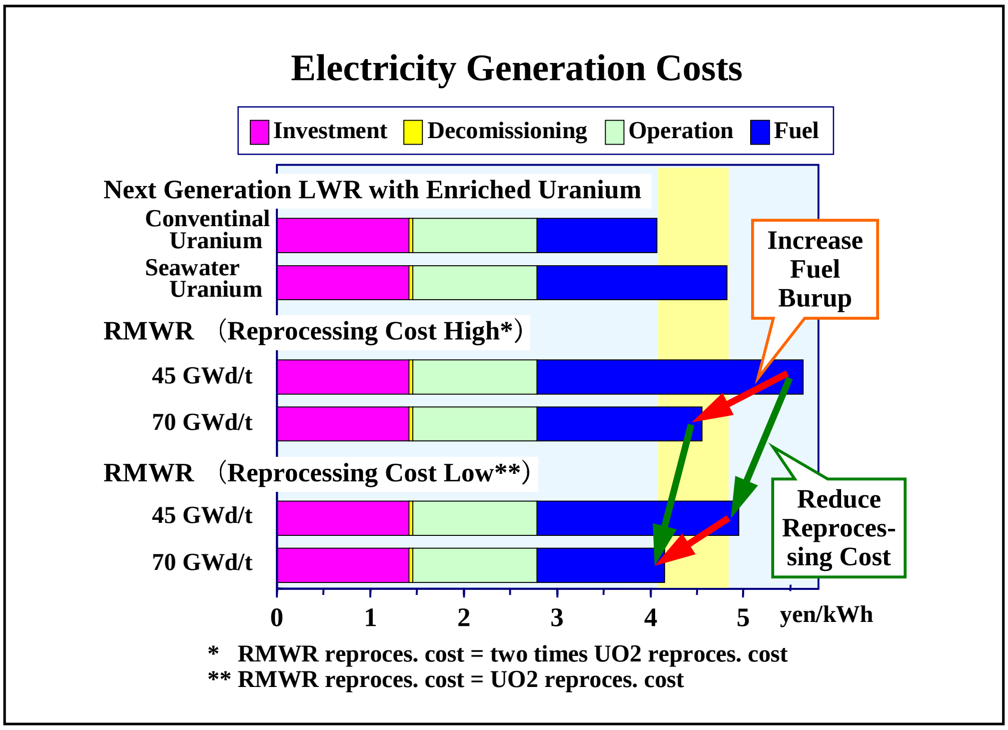
Number of Fuel Rods	217
Outer Diameter of Fuel Rod	13.7mm
Pitch of Fuel Rod	1.3mm

Simulation of Nuclear Fuel Cycle Systems



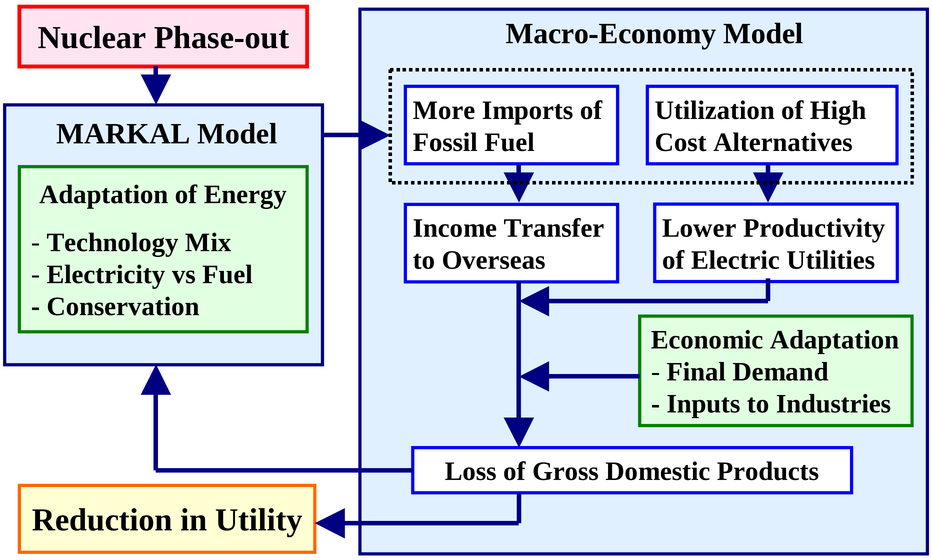



Consumption of Natural Uranium
Million Ton
3.5
3
2.5
2
1.5
1
0.5
0
2000
2050
2100
2150
2200
2250
Year
LWR (No Recycling of Plutonium)
LWR (Maximum Plutonium Recycling)
LWR + RMWR (2020 -)
LWR + FBR (2050 -)

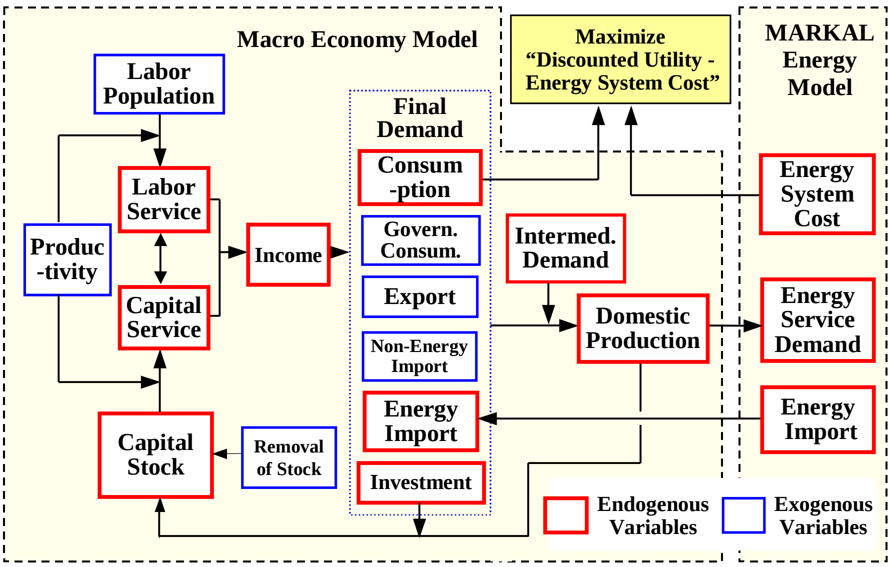

Electricity Generation Costs
Investment
Decomissioning
Operation
Fuel
Next Generation LWR with Enriched Uranium
Conventional Uranium
Seawater Uranium
RMWR （Reprocessing Cost High*）
45 GWd/t
70 GWd/t
RMWR （Reprocessing Cost Low**）
45 GWd/t
70 GWd/t
Increase Fuel Burup
Reduce Reproces-sing Cost
0
1
2
3
4
5
yen/kWh
* RMWR reproces. cost = two times UO2 reproces. cost
** RMWR reproces. cost = UO2 reproces. cost

2. Study on Impacts by Nuclear Phase-out

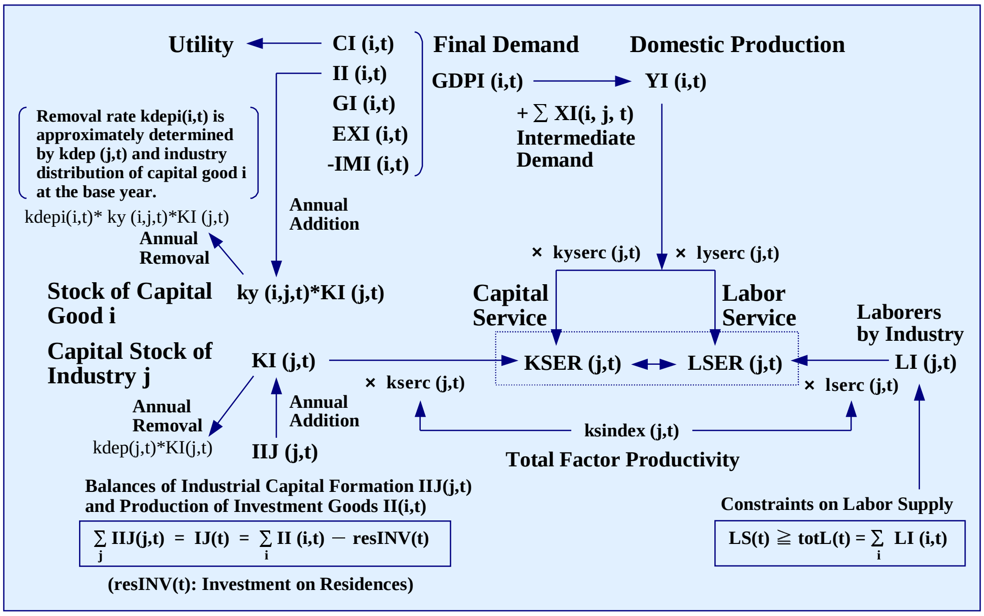
Development of an Energy–Economy Model



Basic Structure of the Energy-Economy Model



Structure of the Macroeconomic Model



Linkage of MARKAL and Economy Model

Energy Service Demand in MARKAL

$ED(t) = (ED_0(t)/Y_0(t))*Y(t)$ Y(t) is GDP or Industry Production

ED_0 and Y_0 are for the reference case

Imports in Eonomy Model

IM('Mining') = Import Coef. * Production of Material Industry
+ R(t) * Energy Imports (from MARKAL)

IM('Oil Prod.') = (1-R(t)) * Energy Imports (from MARKAL)

R(t) is currently fixed to 0.78.

Objective Function

Obj = U – EC

U : Final Consumption
EC: Energy System Cost

Note: The increase of U by one unit is not conceptually identical with the decrease of EC by one unit. Therefore, the linked model should be used within the range of GDP increases that satisfies the condition 'unit increase of U > unit decrease of EC'.

Procedures of Analysis

1. **Establishment of Energy Scenario**
   - Basic Assumptions – GDP, Energy Service Demand, Fuel Prices
   - Optimum Energy Scenario by MARKAL
2. **Establishment of Reference Energy-Economy Scenario**
   - Determine Economic Parameters to Meet Assumed Economic Growth (Total Factor Productivity, Flexibility of K-L Substitution, etc.)
3. **Investigate the Impacts by Nuclear Phase-out**
   - Optimize the Energy-Economy Systems without Nuclear Energy
   - Analyze Sensitivity with Respect to Potential Flexibility of Economy (Goods/Services Mix of Final Consumption, Intermediate Inputs, and Investment)
   - Analyze Sensitivity to Other Assumptions (e.g. CO_2 Emission Caps)

Results of Analysis

To be presented at the next ETSAP Workshop.