

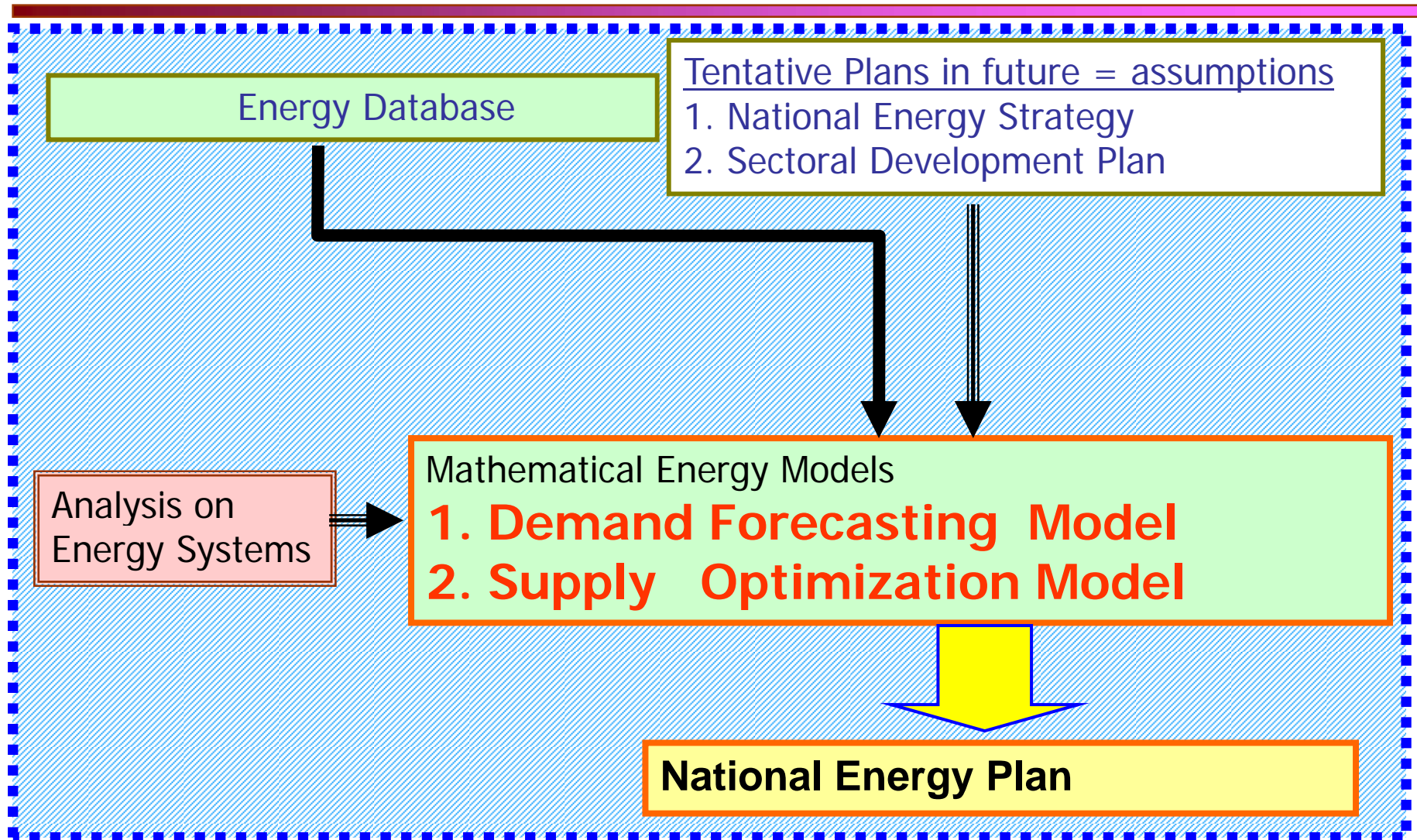
Energy Supply Optimization Model

January 27, 2009

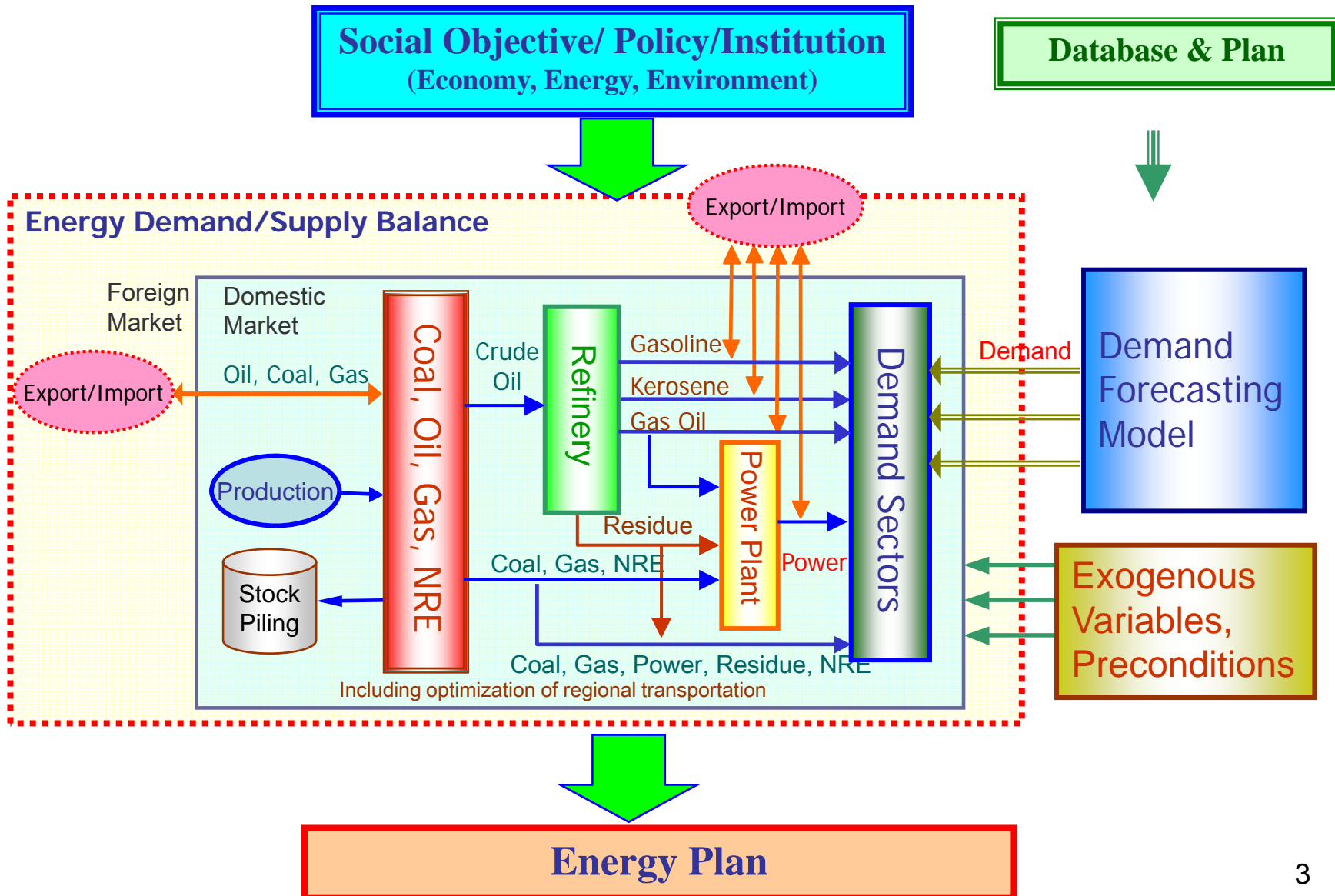
The Institute of Energy, Economics, Japan
(JICA Study Team)

Tatsuyuki ASAKURA

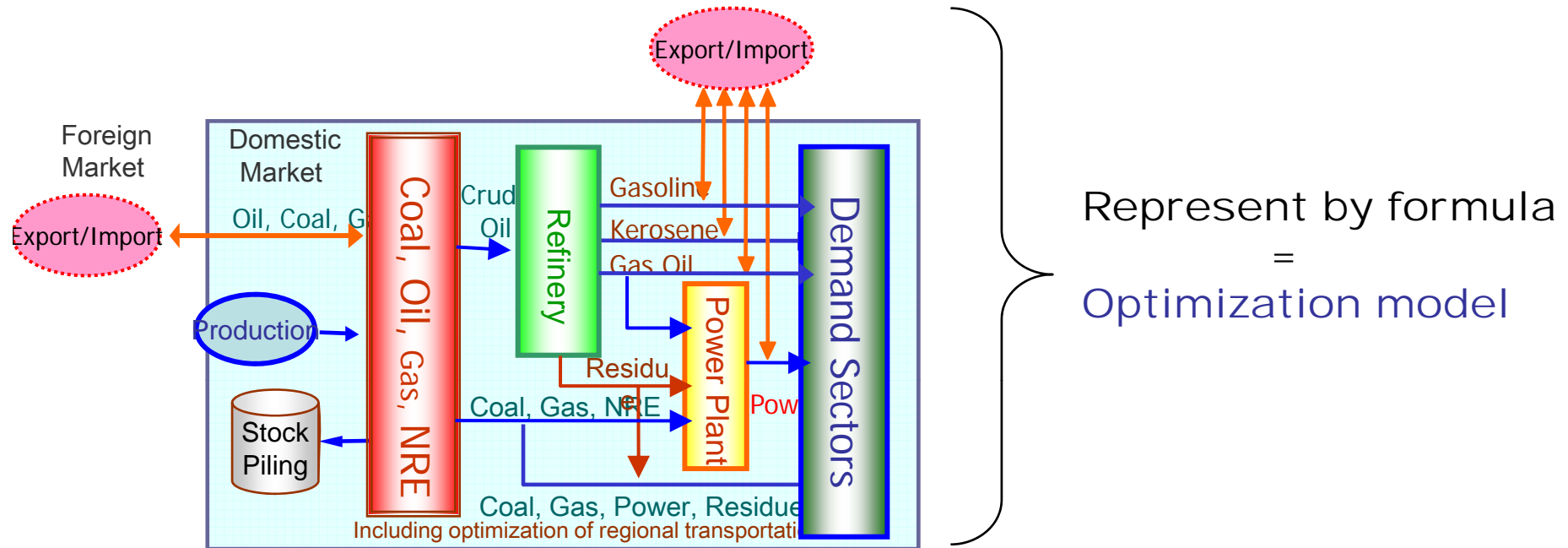
Position of Mathematical Energy model



Structure of Optimization Model



Concept of Optimization model



Condition

- 1 Energy should be balanced.
 - 2 Cost should be minimized.
- $$\text{cost} = \text{production cost} + \text{import cost} - \text{export sales} + \text{operation cost}$$



Output information

- 1 For all energy by year
 - Production
 - Import
 - Export
 - Consumption
- 2 Total CO2 emission by year

Samples of Scenarios/case study

Case Setting of Philippine project

High Growth Case:
*Catch up Thailand by 2030
 in
 terms of aggregate GDP*
Low Growth Case:
Growth rate lowers to 4%

Economic Growth Rate

Economic Growth..4.0 & 6.0%
 Crude Price.....\$160/Bbl
 EEC.....0.5%

*To examine effects of
 different policy selections*

BAU Case

Economic Growth...5.0%
 Crude Price... \$160/Bbl
 EEC.....0.0%

*Under the assumptions for the BAU
 case, per capita GDP will exceed
 \$2,000 by 2020. In international
 comparison with Thailand,
 aggregate GDP increases 60% in
 2005 to 75% in 2030.*

Reference Case

Economic Growth...5.0%
 Crude Price.....\$160/Bbl
 EEC.....0.5%

Other Cases

EEC (1.0%)
 Super EEC (1.5%)
 Motorization
 Nuclear Development
 Gas Market Development
 with LNG Import
 Increased Renewables
 such as Geothermal &
 Biofuel
 etc

Price Changes

Economic Growth...5.0%
 Crude Price.....\$120 or \$200/Bbl
 EEC.....0.5%

*To identify maximum impact
 of energy price changes from
 \$120/Bbl to \$200/Bbl and
 Super+high \$240/Bbl in 2030*

Analyze(1)—Total Primary Energy & CO2

At 2030 unit=ktoe

	Total Primary Energy	ratio
S-EEC	59,803	0.82
LowGrowth	62,183	0.85
EEC	66,011	0.91
S-HighPrice	70,305	0.97
HighPrice	71,515	0.98
E85	72,762	1.00
E20	72,770	1.00
ref	72,774	1.00
LowPrice	74,178	1.02
Vehicle-plus	74,578	1.02
BAU	84,450	1.16
HighGrowth	84,474	1.16

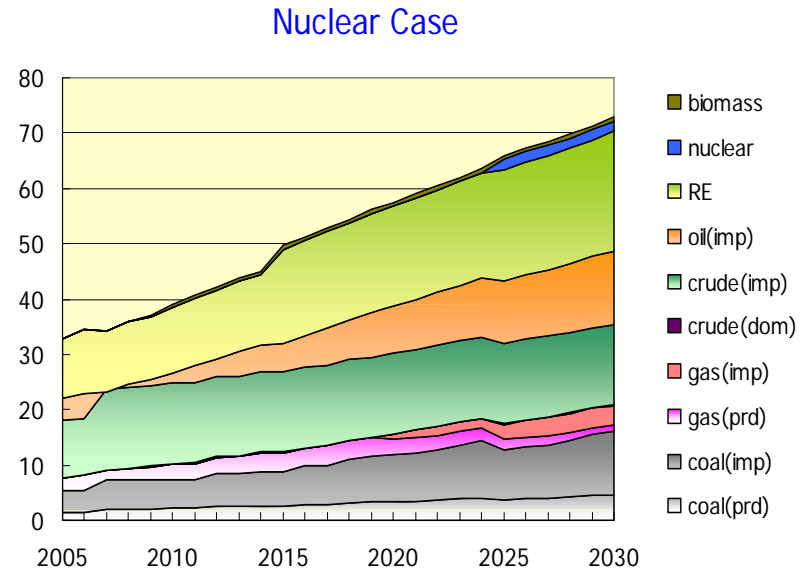
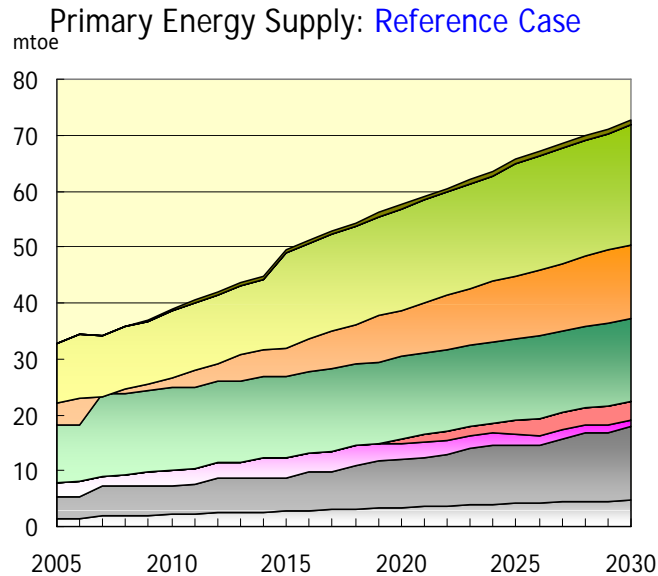
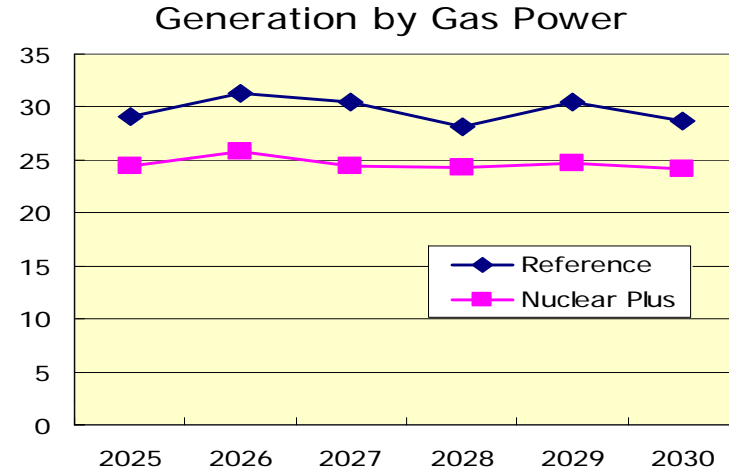
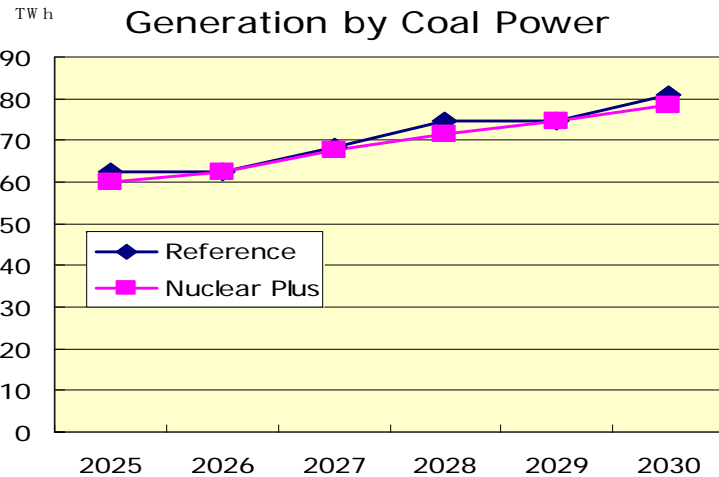
case	CO2 emission (Mton)	ratio
S-EEC	113.09	0.72
Low growth	119.88	0.77
EEC	134.40	0.86
E85	137.68	0.88
S-HighPrice	149.32	0.96
E20	149.42	0.96
High Price	152.96	0.98
reference	156.21	1.00
Low Price	160.74	1.03
Motorization	161.39	1.03
High growth	194.40	1.24
BAU	195.13	1.25

In order to decrease the total primary energy (TPE) and CO2 emission, It is best to promote the energy efficiency and conservation (EEC).

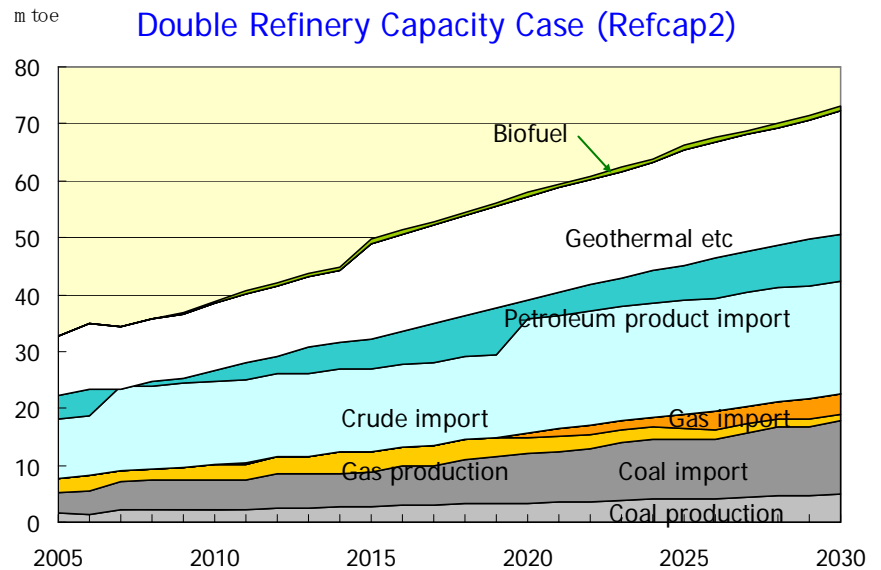
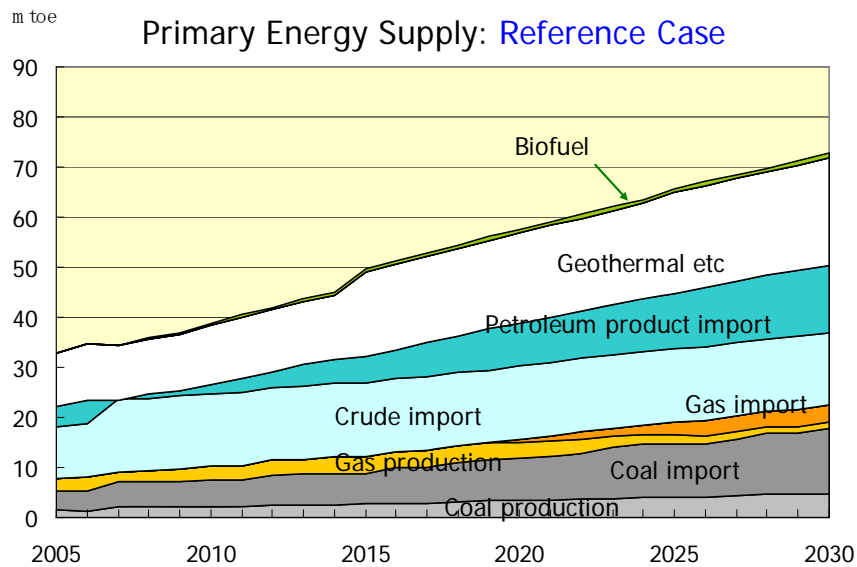
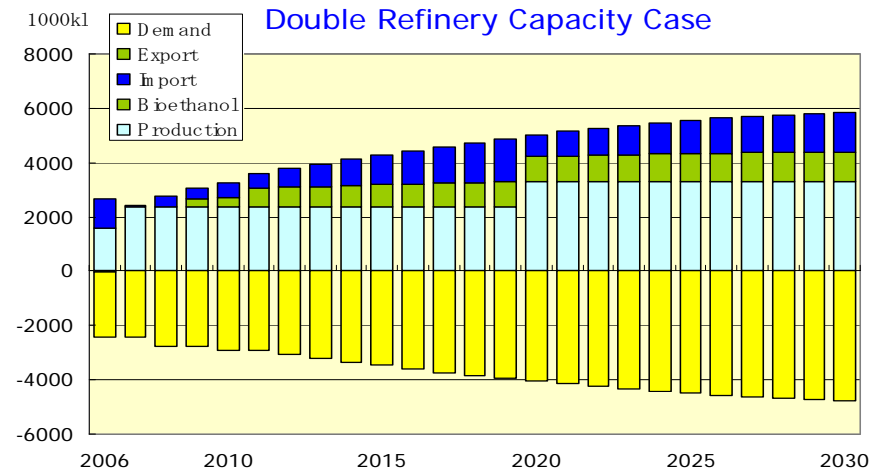
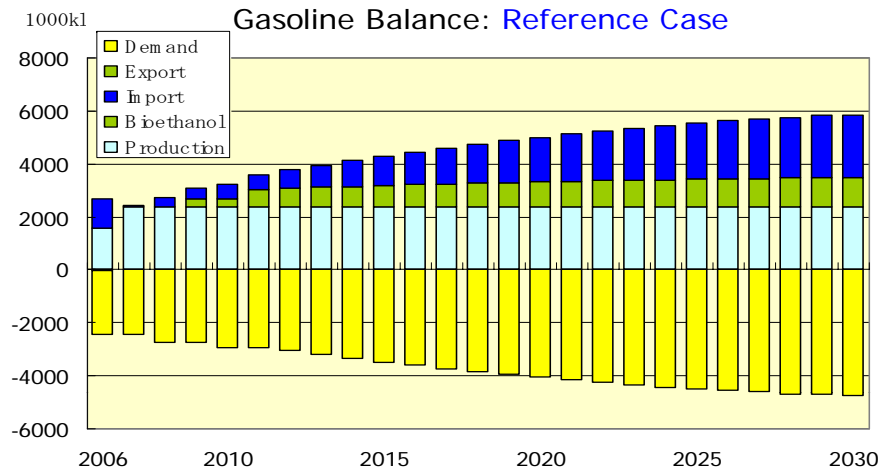
Economic growth gives the second effect to the TPA & CO2 emission.

The price gives a little effect to TPE & CO2 emission.

Analyze(2) Ref and Nuclear

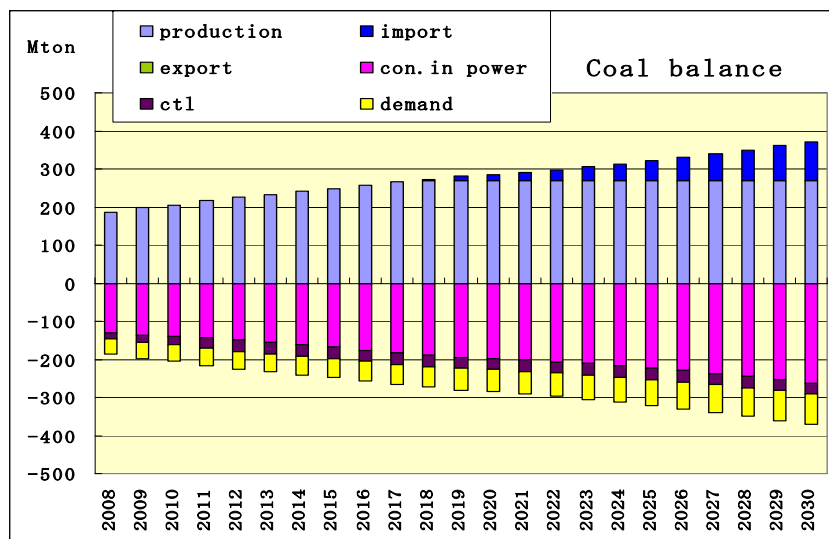
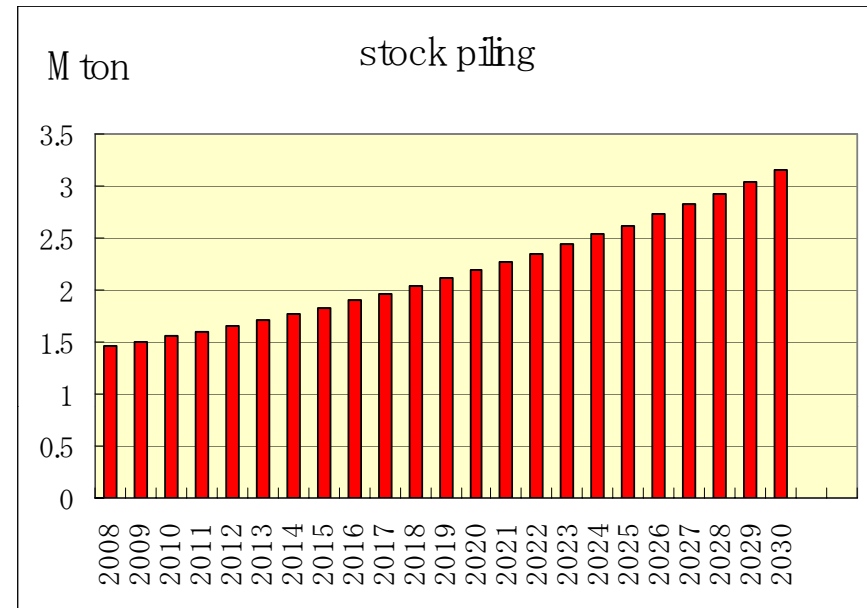
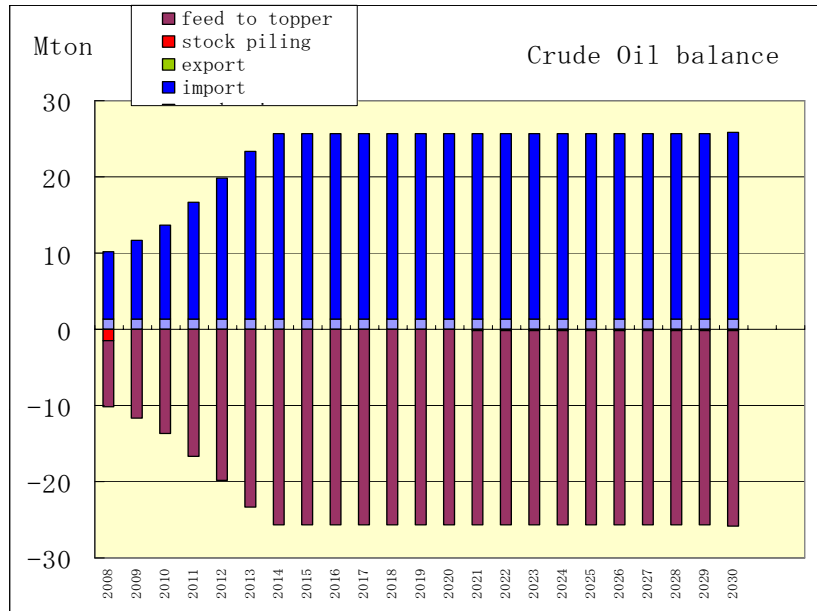


Analyze(3) - Ref and Refinery Cap enlarge



Trial Optimization model for SA

The result of BAU (1)

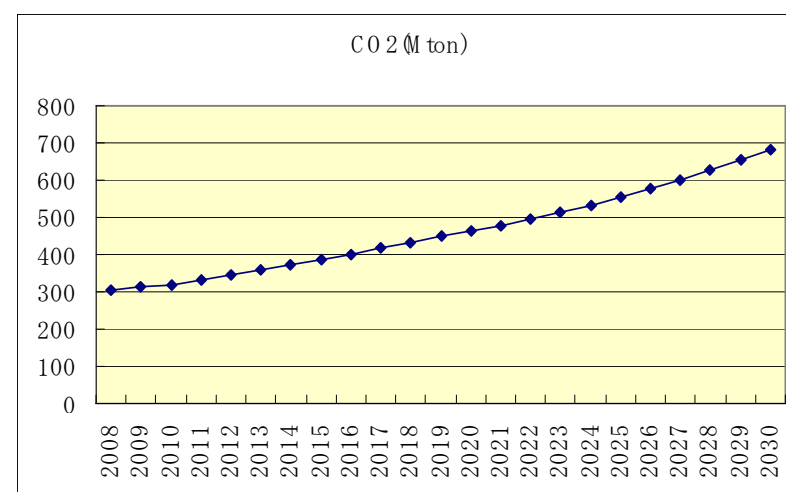
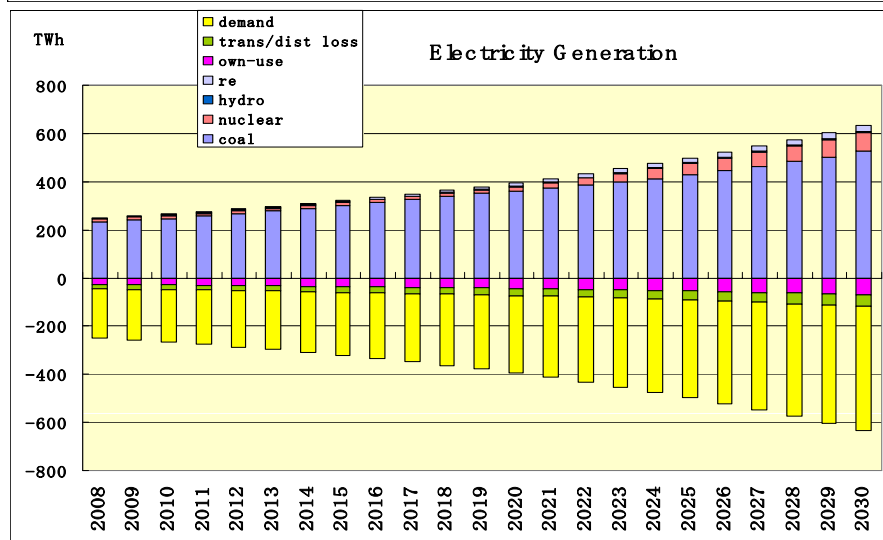
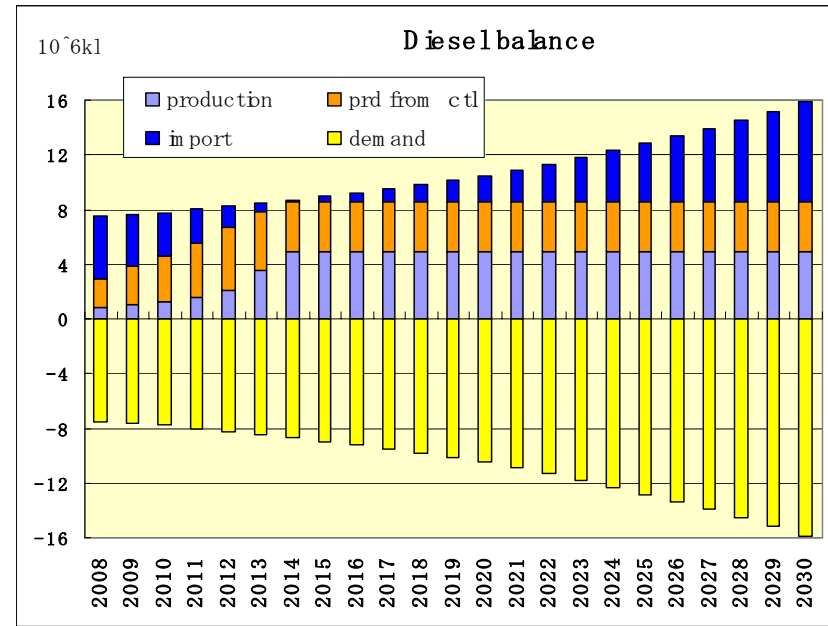
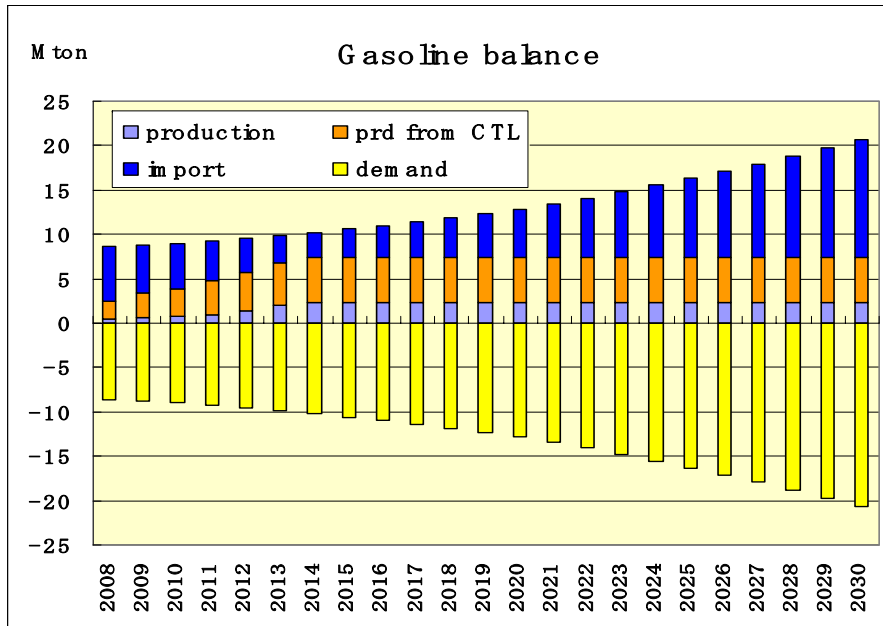


Criterion for oil stockpiling

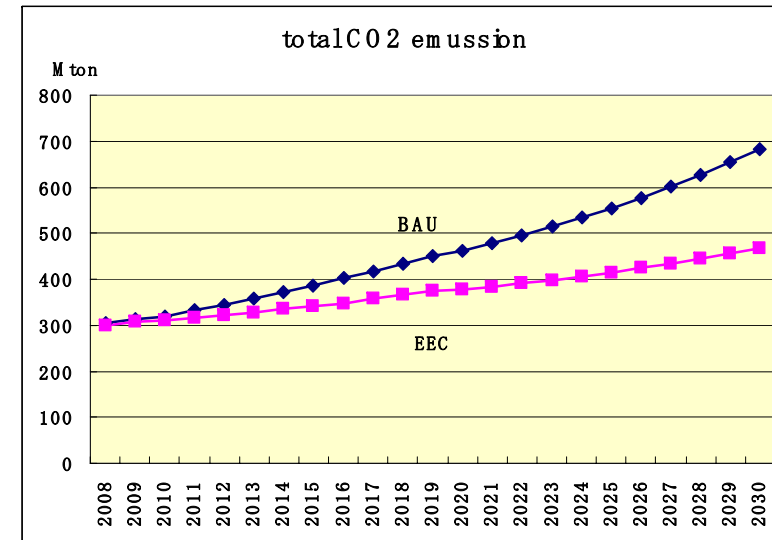
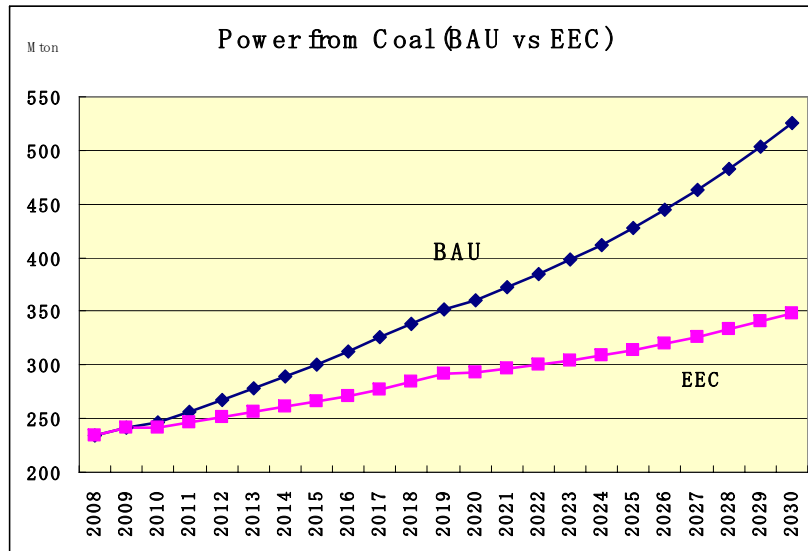
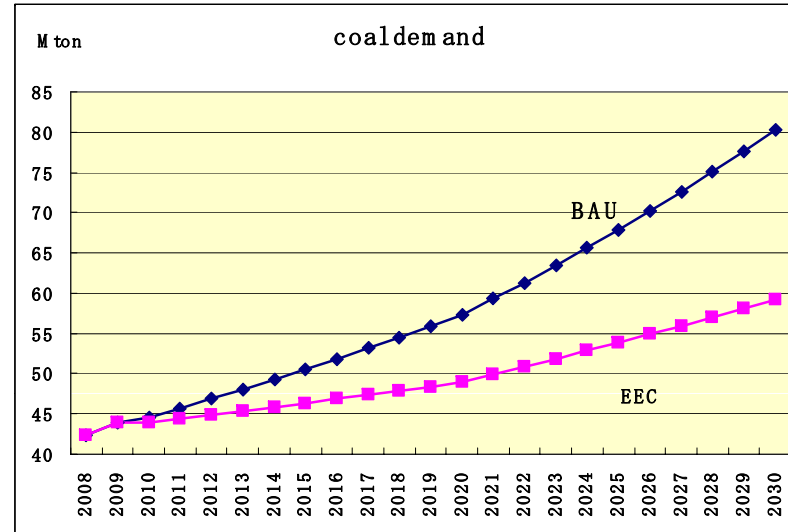
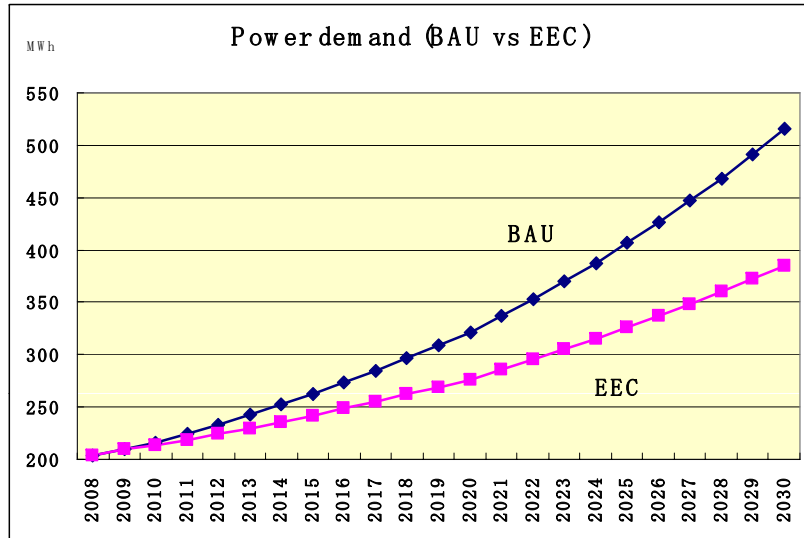
28 days of consumption
of total petroleum production

It starts at 2008.

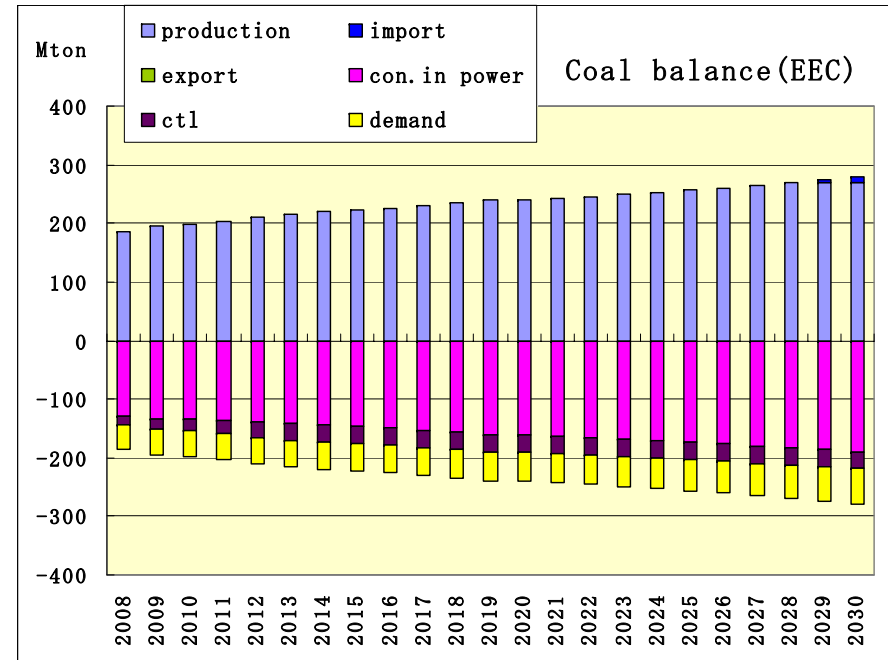
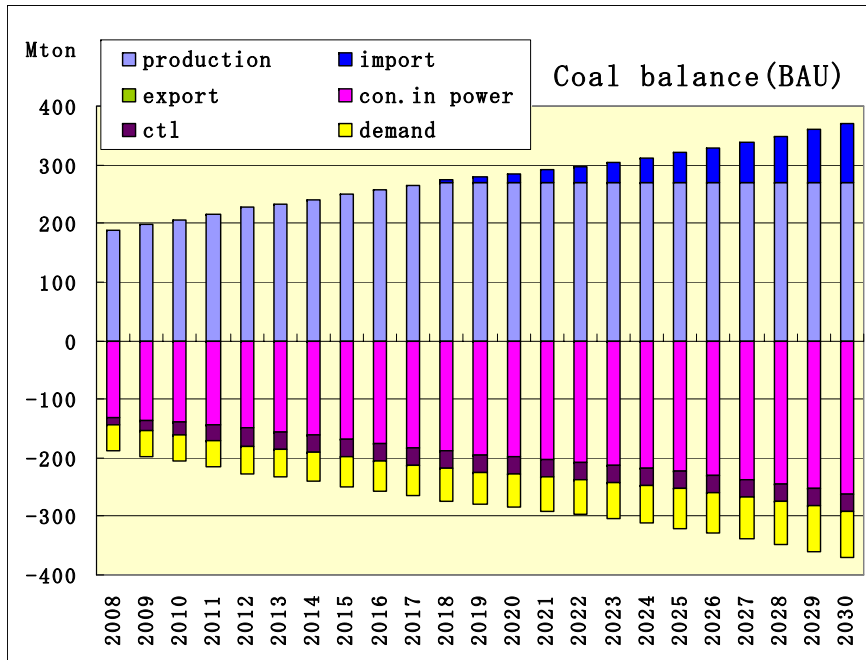
The result of BAU (2)



The comparison of BAU and EEC case(1)



The result of BAU and EEC case(2)



Summary of Optimization model



- 1 Best energy supply can be estimated from the optimization model using the energy scenarios and the energy plan under the keeping consistency with demand.**
- 2 Using the models, various energy scenarios/case study can be simulated.**
 - Economic situation changes,**
 - Energy price changes,**
 - Energy efficiency increases,**
 - Environment regulation changes, etc.**
- 3 The models can help to formulate the national energy plan, where well-examined, consensus-obtained data shall be applied.**

Thank you very much !