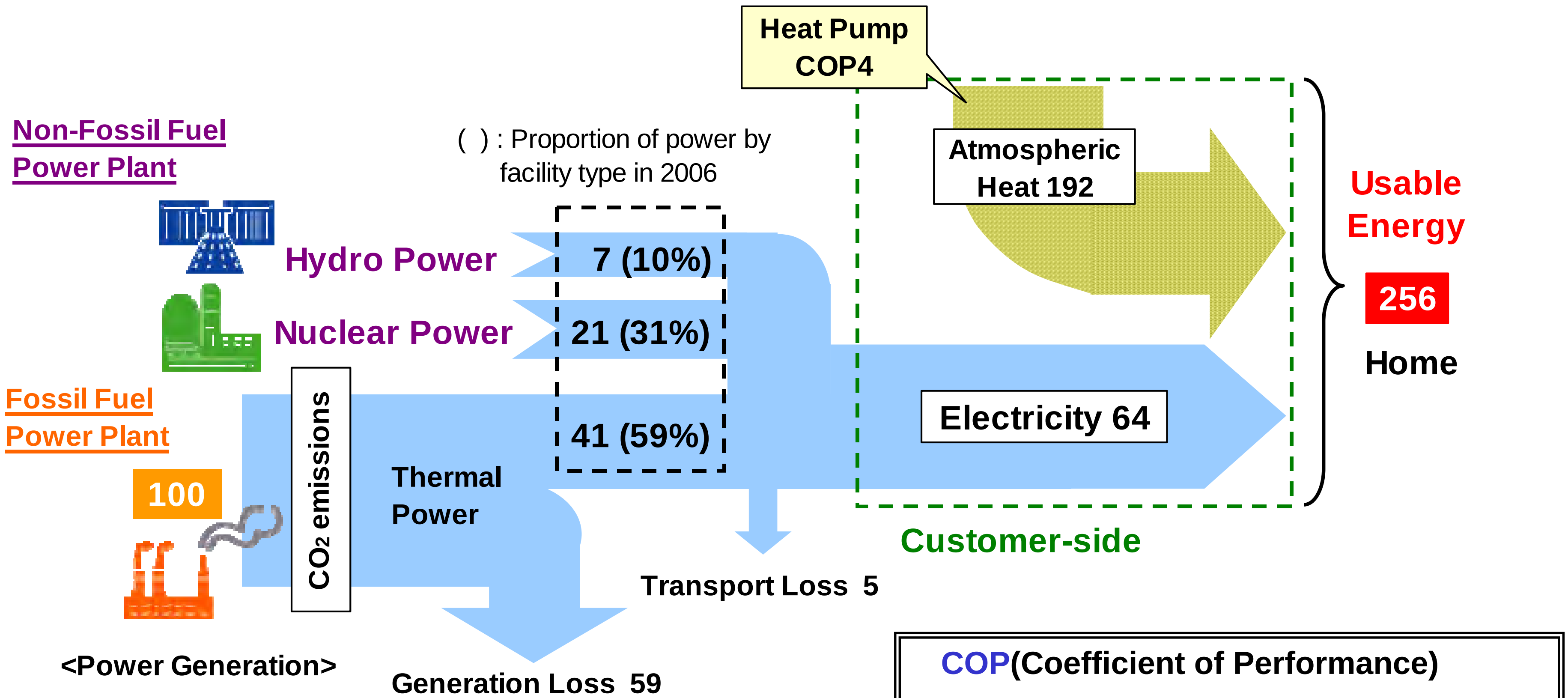
An Estimation of Energy Utilization by Heat Pump



COP(Coefficient of Performance)

$$= \frac{\text{Cooling or Heating Capacity (kW)}}{\text{Heat Pump Power Consumption (kW)}}$$

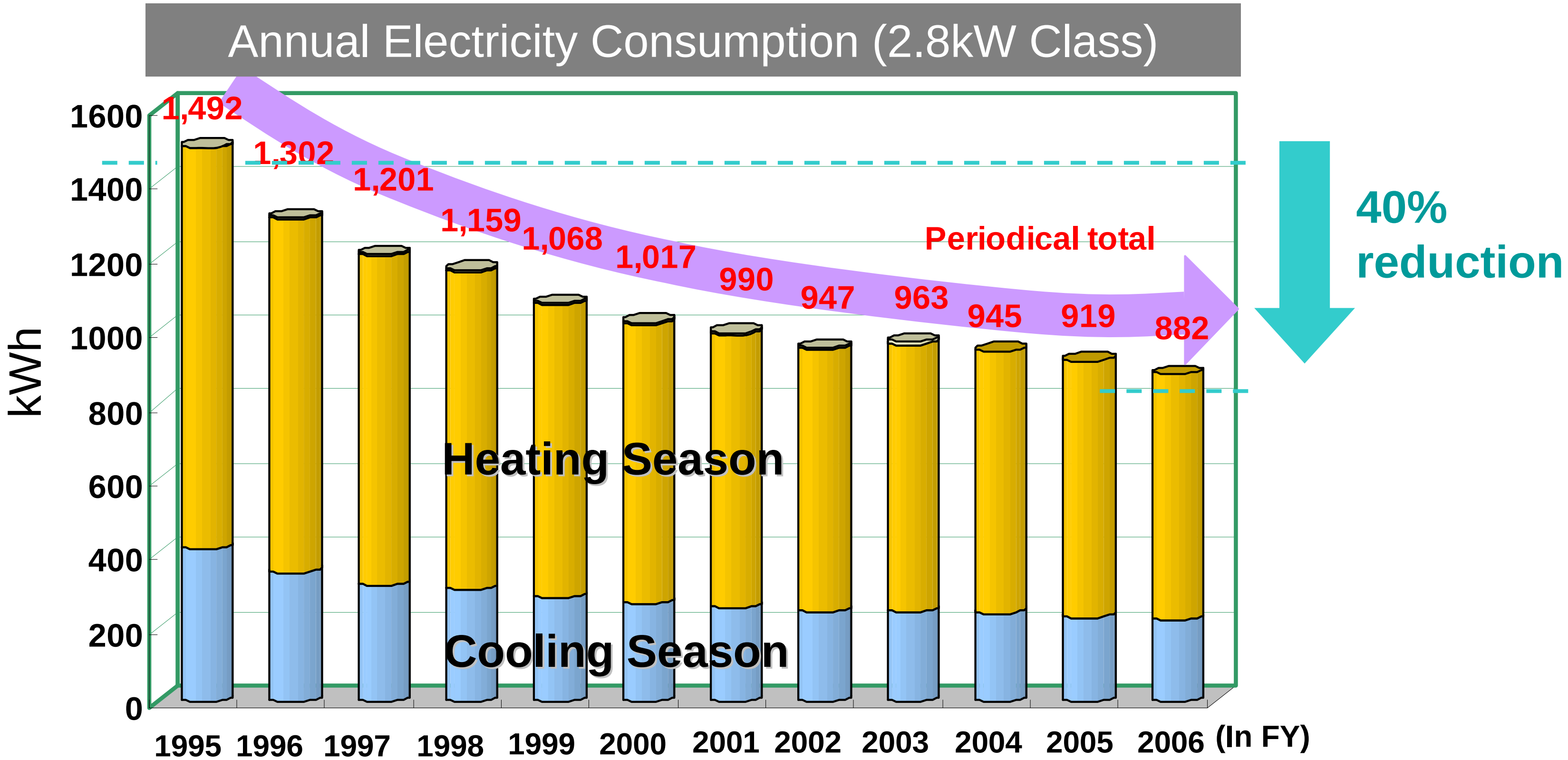
- **256 units of energy can be used with 100 units of fossil fuels.**

(Source: "Environmental Action Plan by the Japanese Electric Utility Industry," the Federation of Electric Power Companies, September 2006)

Efficient
Air Conditioner (AC)

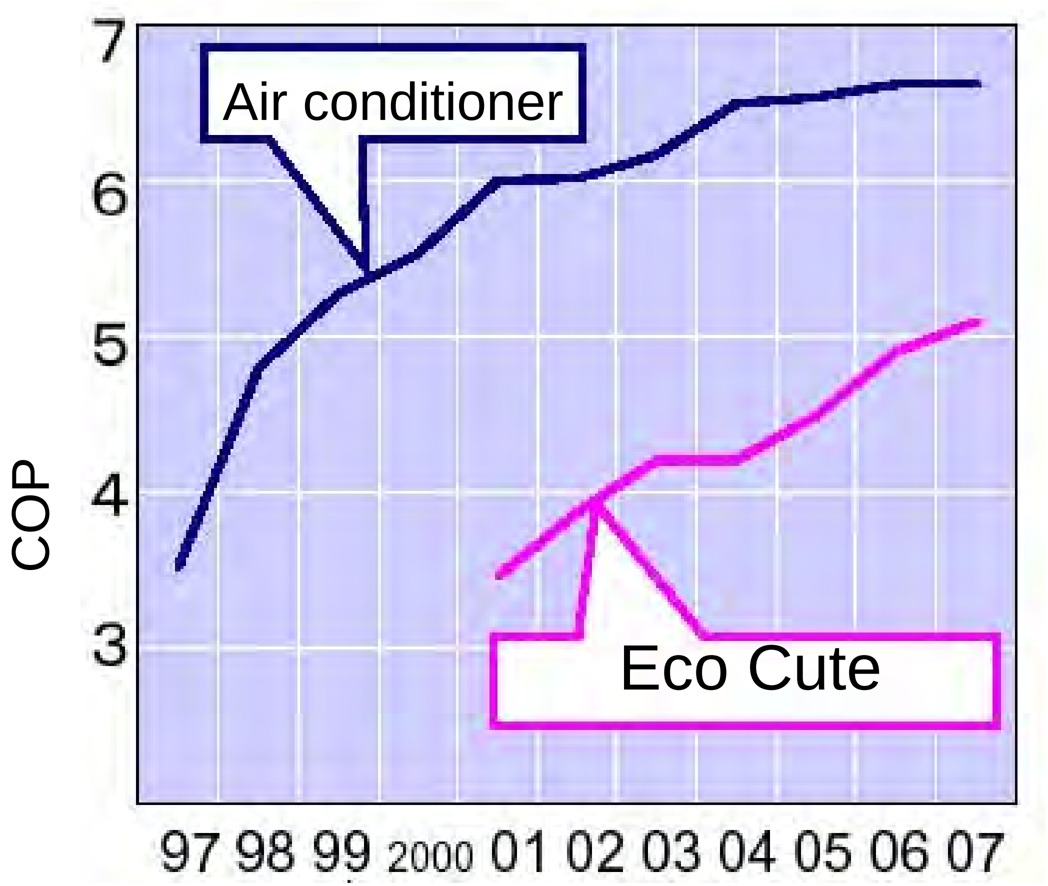
Efficiency Improvement of House AC

- The annual electricity consumption for heating and cooling decreased by about **40%** in past ten years.
- Recently, air conditioners with close to **COP 7** have made their debut.



※Cooling and heating AC, 2.8kW cooling capacity, average consumption of high class products.
※Annual electricity consumption is calculated by the standard of "Japan Refrigerator and AC Industry (JRA4046)"
Source: Association of Japan Refrigerator and Industry

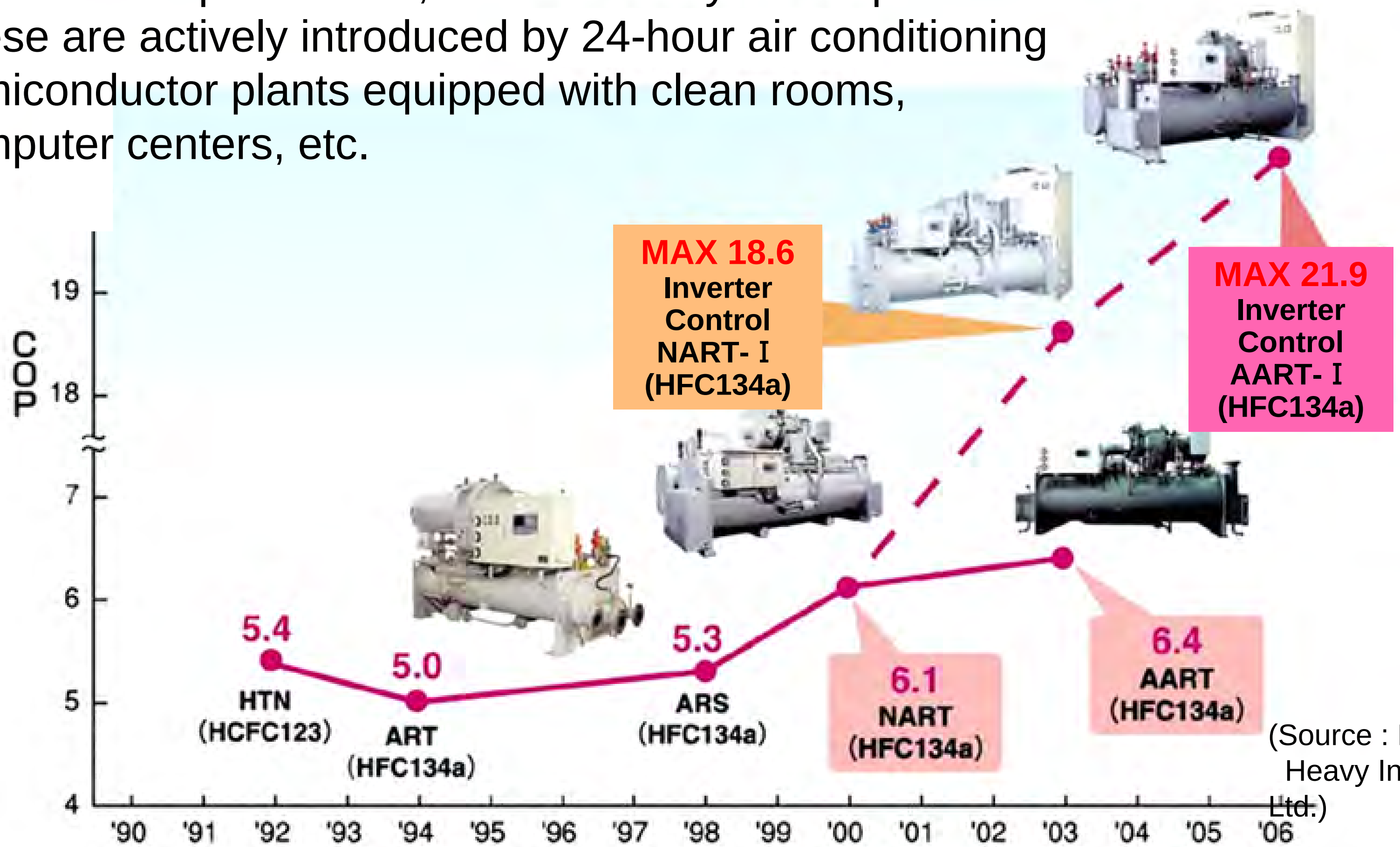
Efficiency Improvement



Efficiency of air conditioners and Eco Cute increased twice as high and 50%, respectively.

Changes in Performance of Centrifugal Chillers

- Centrifugal chillers are mainly used for air conditioning in large facilities such as buildings and factories.
- Advanced centrifugal chillers, of which the efficiency is increased to **COP=20 or higher by inverter-controlled** variable-speed operation at the time of partial load, are also newly developed.
- These are actively introduced by 24-hour air conditioning semiconductor plants equipped with clean rooms, computer centers, etc.

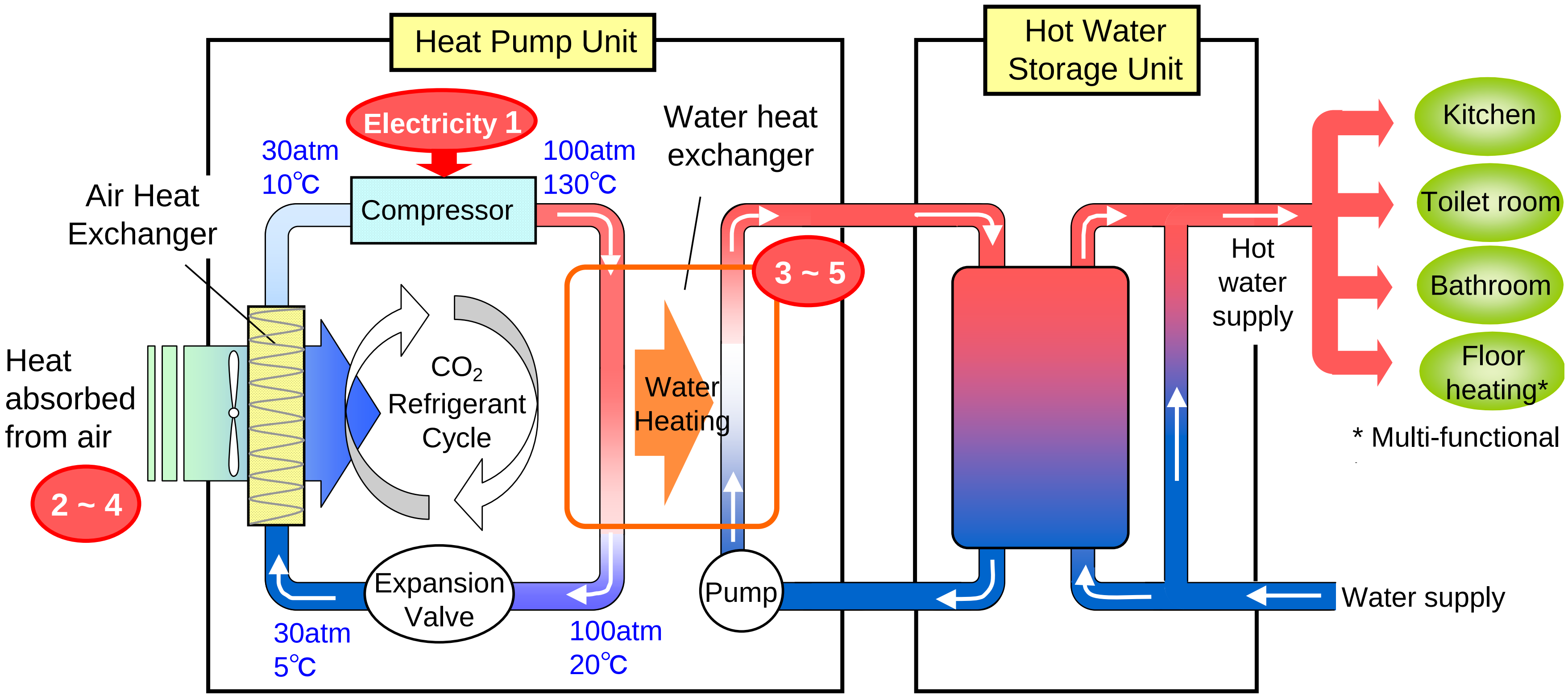


(Source : Mitsubishi Heavy Industries, Ltd.)

Heat Pump Water Heater

What is "Eco Cute" ?

The natural refrigerant (CO_2) heat pump water heater, **"Eco Cute"**, is highly efficient.



1 (Electric Energy) + **2~4** (Atomospheric Heat) = **3~5** (Available Hot Water Supply)

※"Eco Cute" is the name used by the electric power companies and water heater manufactures when they call the natural refrigerant (CO_2) heat pump water heaters.

Main Features of "Eco Cute"

High Efficiency

- "Eco Cute" pumps up air heat to hot water, so that it can **produce thermal energy 3 to 5 times** more than the energy (electricity) required for running its system.

Natural Refrigerant

- **Natural refrigerant (CO_2)** has very little impact on global warming.
- It can heat water as high as up to a **maximum of 90°C** by solely operating a heat pump due to the physical properties of CO_2 refrigerant.

Low Running Cost

- By combining **inexpensive electricity of the night-only service** with the highly efficient heat pump system, it is able to achieve superior running cost performance.

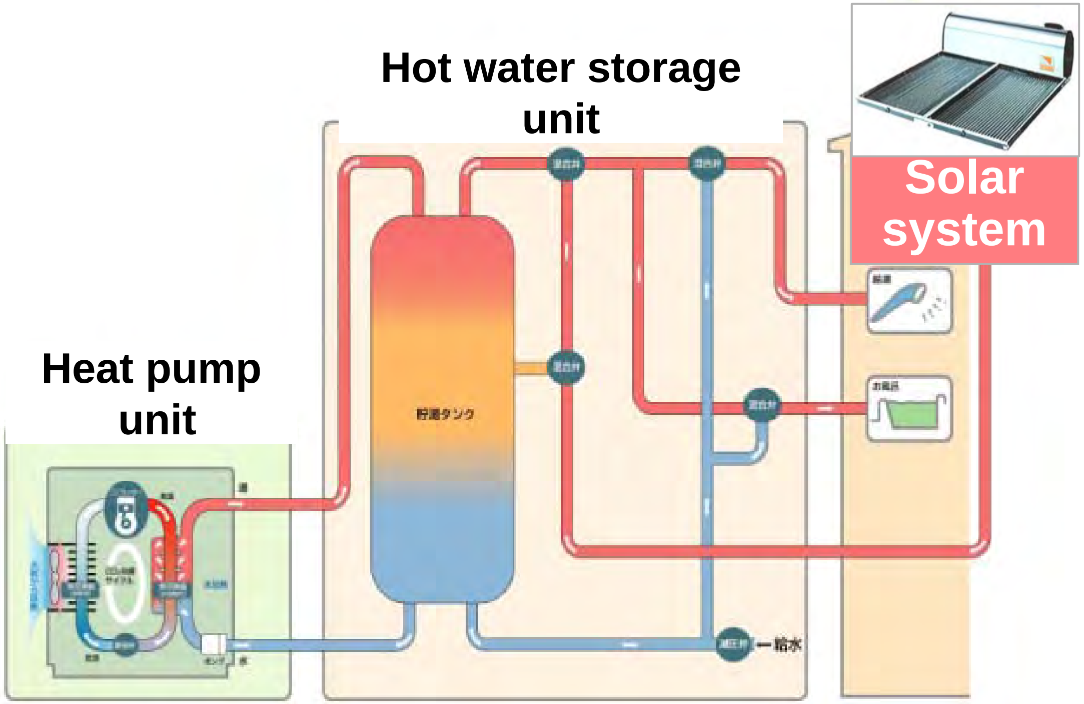
Various Types of "Eco Cute"

Solar Hybrid Type

The hot water heated by the solar water heater is mainly used for daytime, and the running short of hot water is supplied by "Eco Cute".

"Eco Cute" calculates the quantity of required hot water automatically.

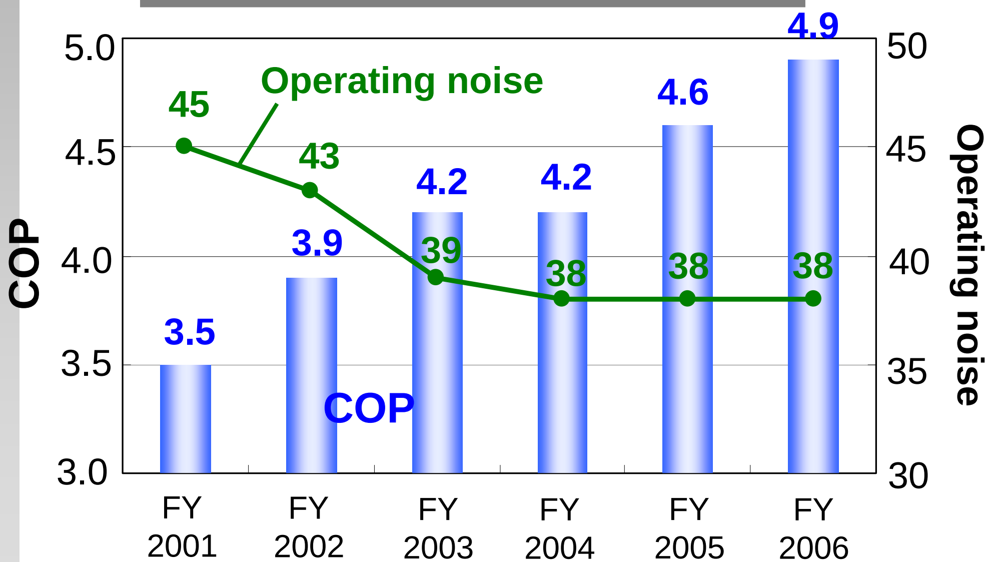
This system achieves **COP6.0** or more.



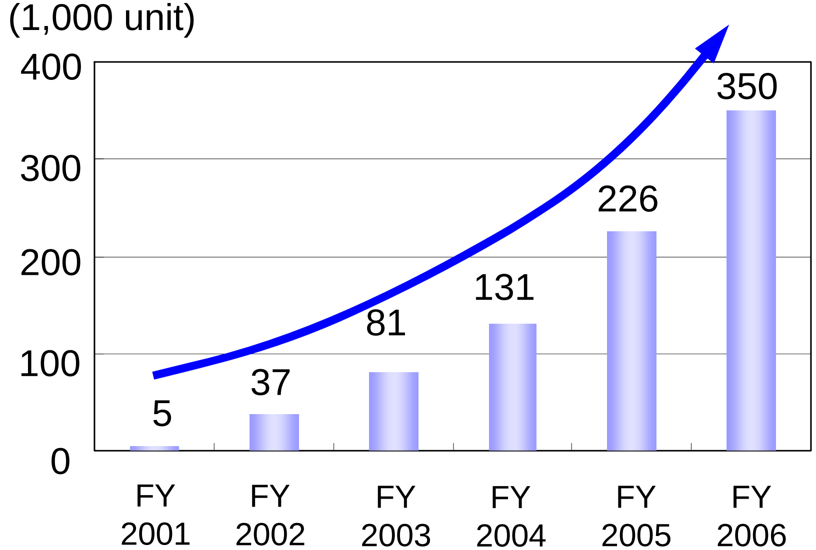
Performance Improvement and Shipments Trend of "Eco Cute" for Residential Use

- **COP** of the first model has been improved **from 3.5 * to 4.9** *, and the operating noises have decreased from 45dB to 38dB.
  (*under the rated heating condition of the JRA(Japan Refrigeration Association))
- In fiscal 2006 only, **about 350,000 units** were shipped throughout the country, and it is now reaching over **1 million** units in total.
- The Japanese government sets a plan to introduce **5.2 million units** by the time of 2010.

Performance Improvement
of "Eco Cute" (Top-runner model)

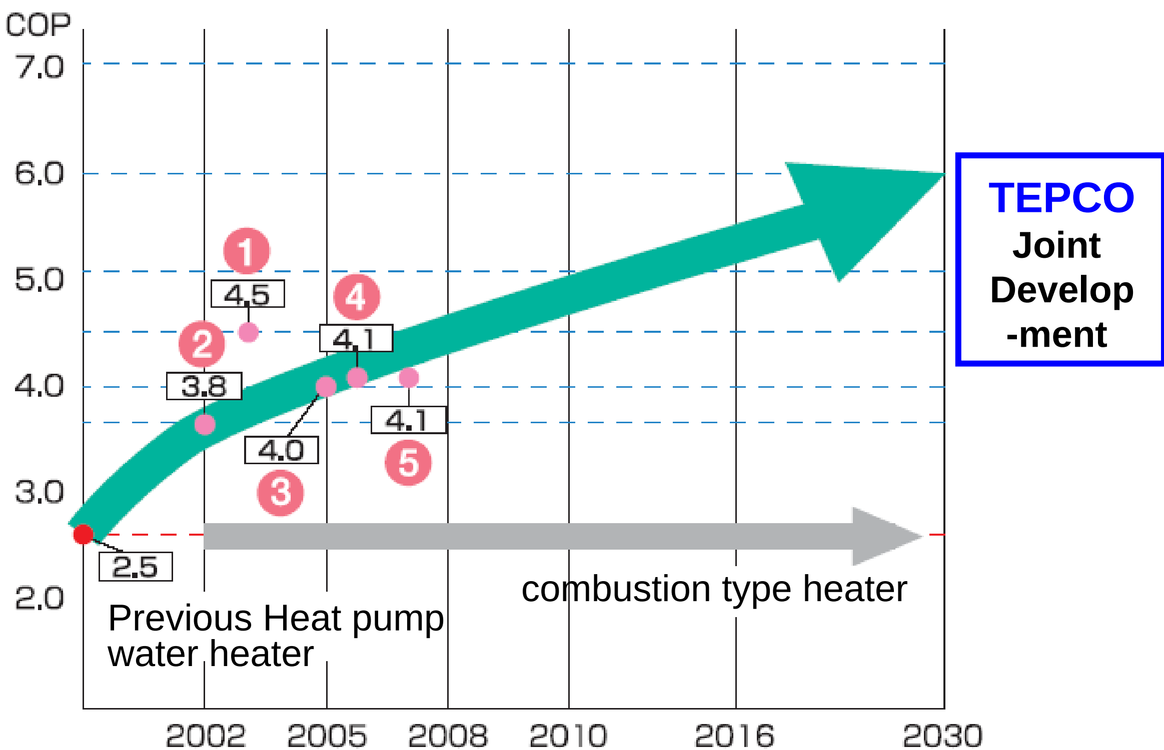


Shipment Trend
of "Eco Cute" (Residential Use)



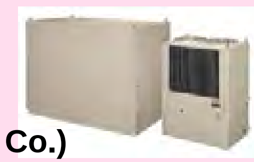
TEPCO's Development of Heat Pump Water Heater for Business Use

Various types of Heat Pump Water Heater for **business use** depending on hot water supply loads for hotels, hospitals, sports facilities, stores and restaurants have been placed on the market.



1 "Hot Power Eco BIG" (Toshiba Carrier)
(28kW) COP4. 5

2 "Eco Cute" (Nihon Itomic Co.)
(26.3 kW) COP3.8



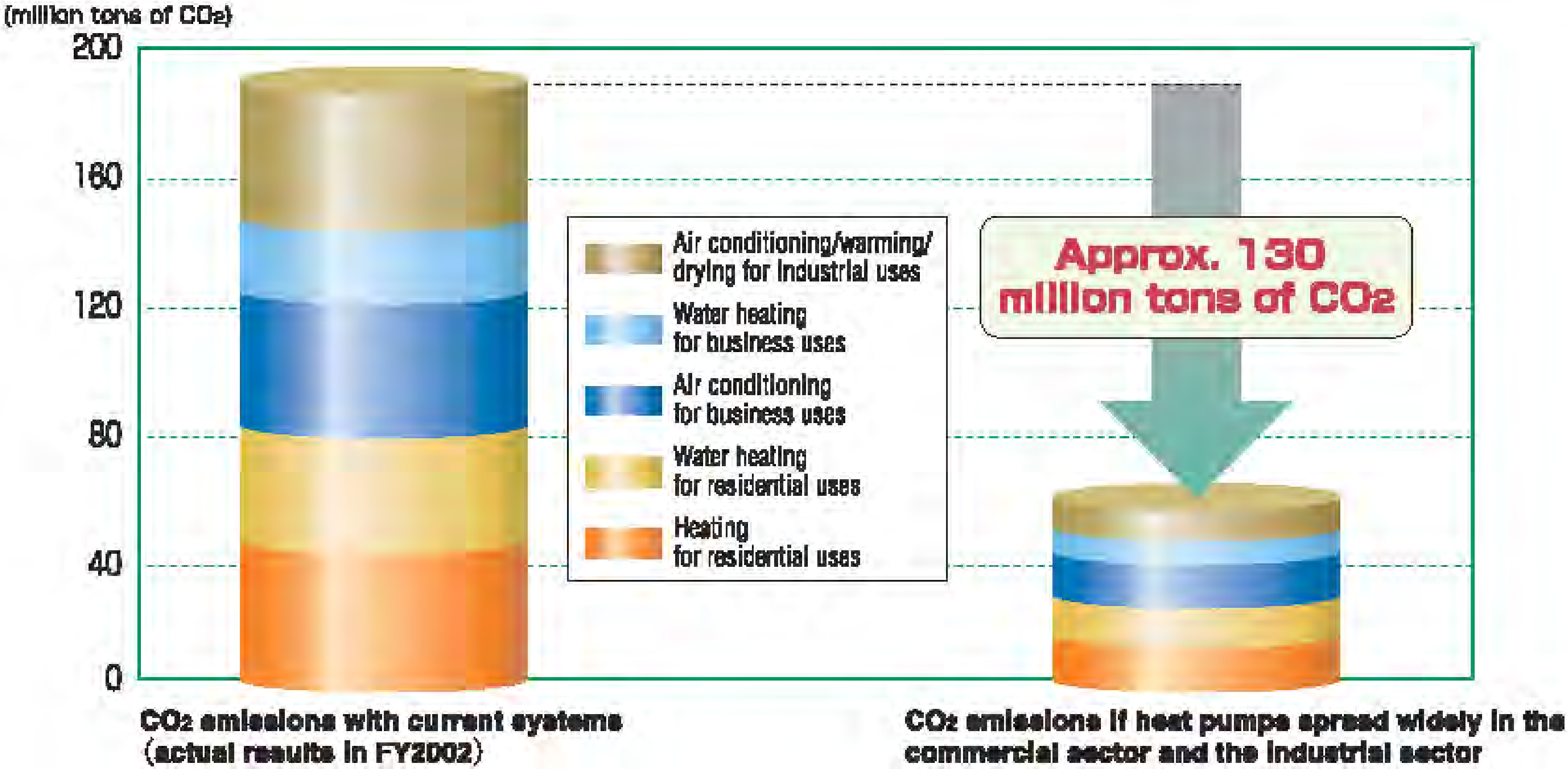
3 "Eco Cute" (Daikin Industries)
(4.5 - 13.5 kW) COP4.1

4 "Eco Cute" (Hitachi Appliances)
(15 - 30 kW) COP4.1

5 "Eco Cute" (Mitsubishi Electric Works)
(40 - 320 kW) COP4.1

Potential and Promotion

Potential of Reduction in CO_2 Emissions in Japan



About <u>130 million tons</u> of reduction in the residential + business + industrial sectors in Japan.

Source: Calculation by HPTCJ

Governmental Policy Support

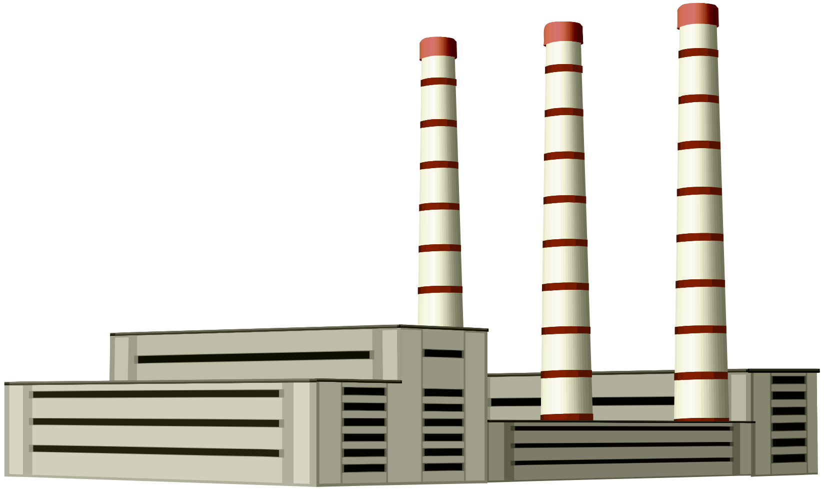
1. **Encourage dissemination of heat pumps as the government's policy**
   - "Kyoto Protocol Target Achievement Plan" (2005)
   - "New National Energy Strategy" (2006)
   - "Basic Energy Plan" (2007)

2. **Apply subsidies and tax breaks**
   - Eco Cute
   - Highly efficient heat pumps for air conditioning

Thank you for your attention!

Feedback Seminar on Energy-Efficiency Potential in South Africa

Efficient Operation and Maintenance of Existing Coal Power Plants

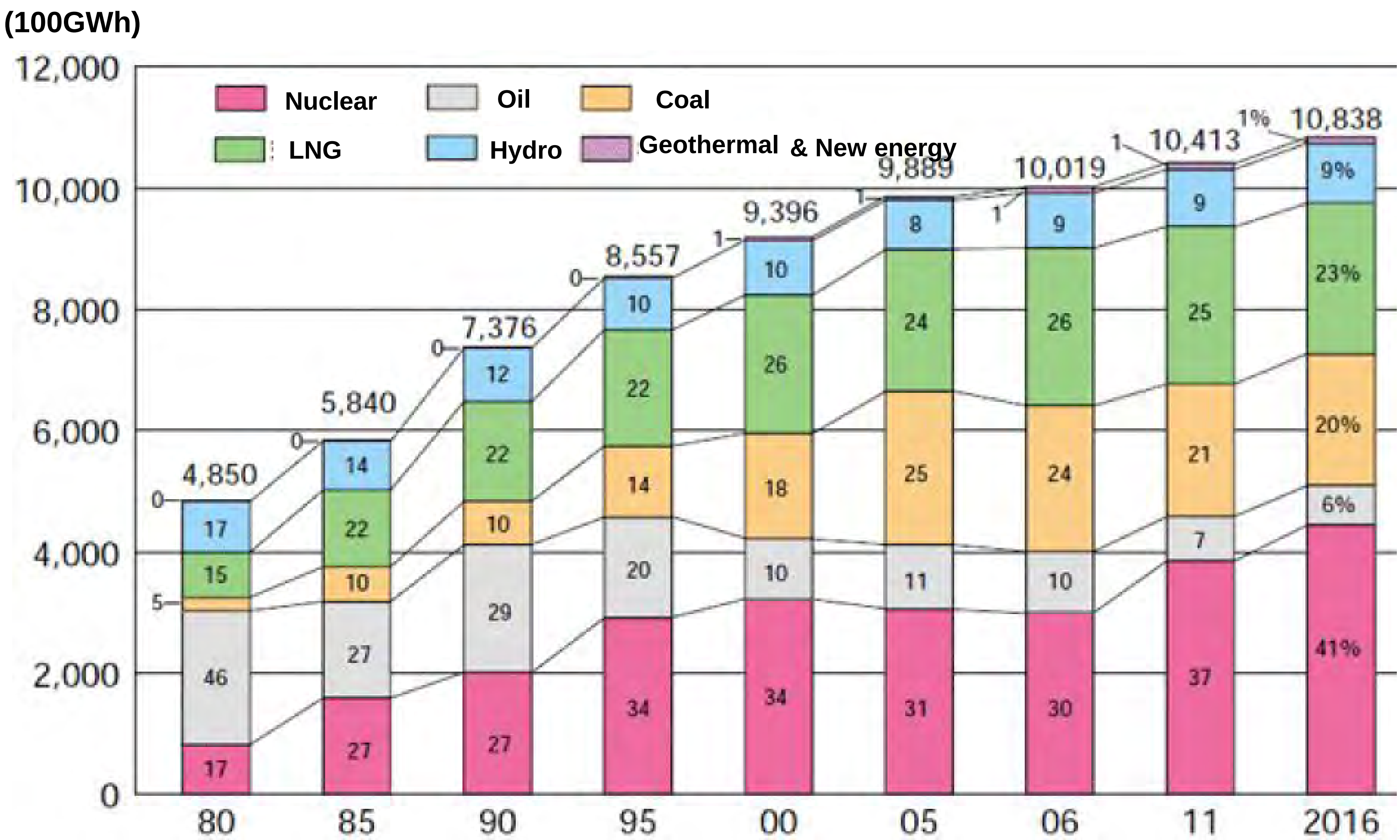


January 2009

JICA Study Team

Kiyoshi Kataoka

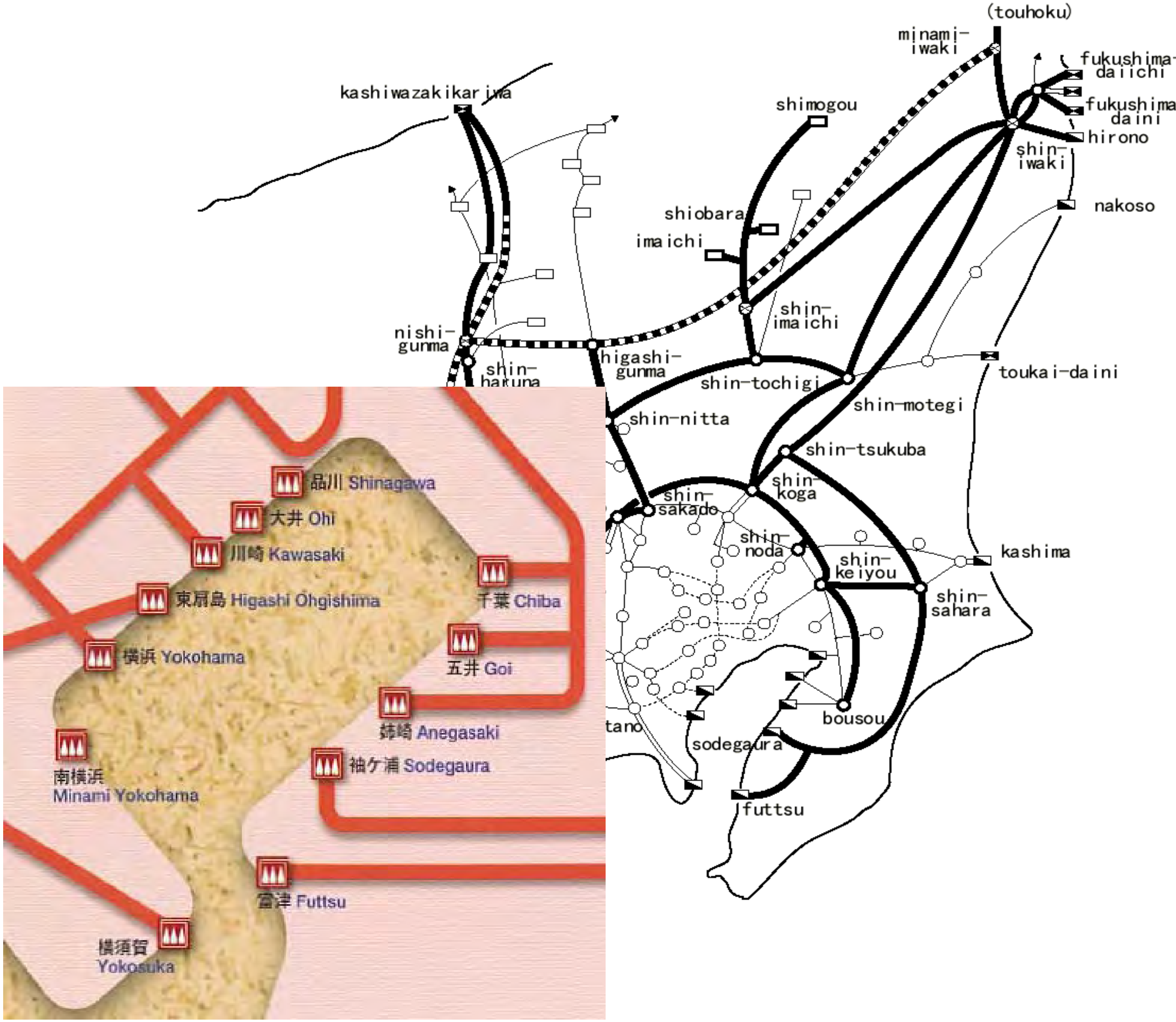
Power Generation Trend by Source



Annual Power Generation (FY)

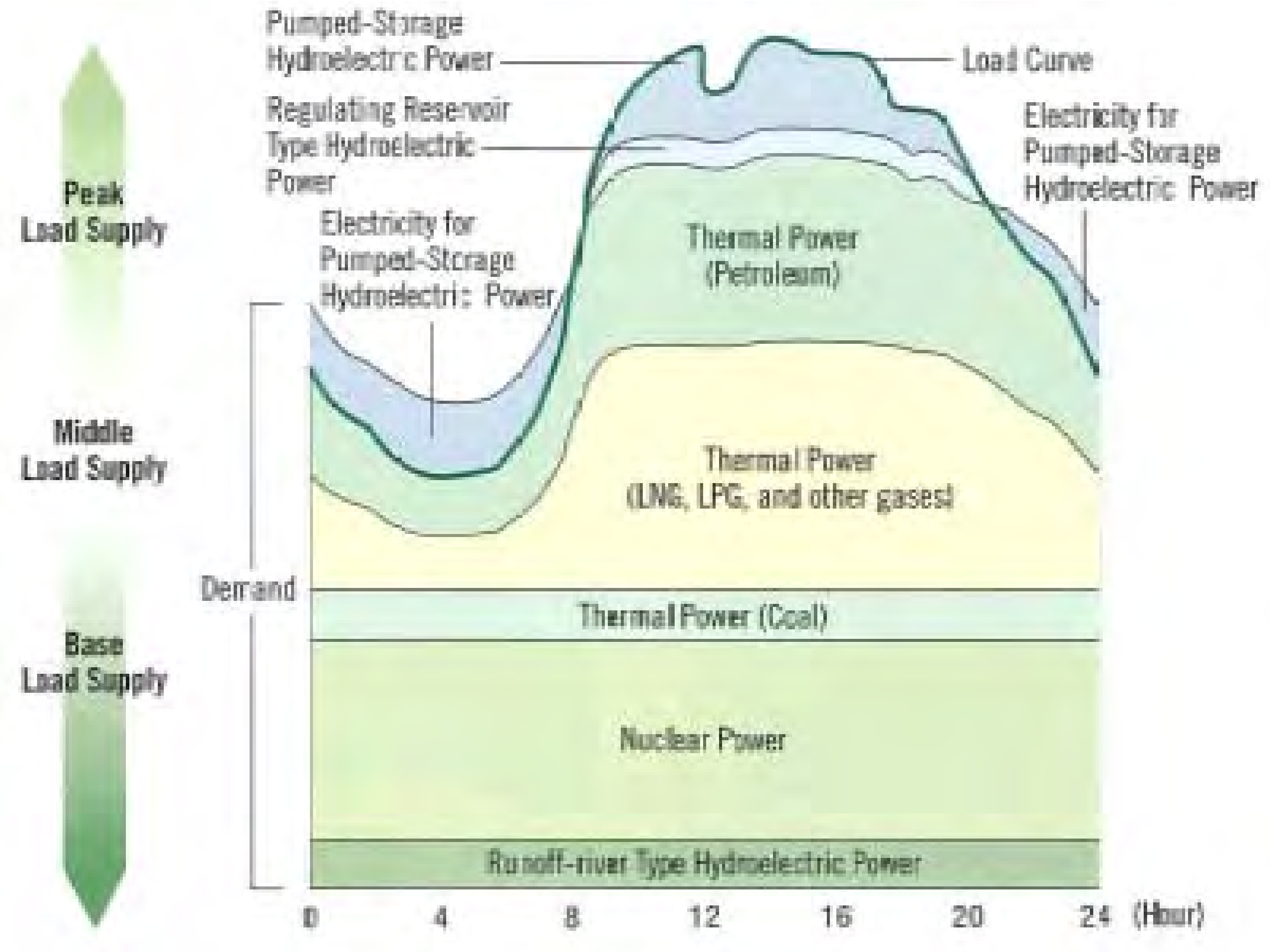
Source: Federation of Electric Power Companies of Japan

Power Plants and Network



Source: TEPCO

Generation Curve of A Day



Source: TEPCO Corporate Brochure 2007

Operation of Thermal Power Plants by Fuel Types

- Coal-fired power plants are of base-load operation.

  Coal-fired power plants can continue safe operation at approximately 50% without auxiliary fuels.

- LNG power plants represent middle-load operation.

  In case of TEPCO, most power plants operating in densely-populated areas such as Tokyo are LNG-fired.

- Heavy oil/crude oil power plants are used to adjust the load or cope with the peak.

  Many plants repeatedly start and stop operation every day.

Characteristics of Thermal Power Plants in Japan

- All fuels used at thermal power plants are imported.
  (crude oil, heavy oil, coal, LNG, etc.)
- Thermal power plants are built along coastlines.
  (seawater is used as the cooling water for condensers in most cases)
- The capacity per generator of thermal power plants has increased to 125, 175, 350, 600, and 1000 MW. The steam conditions have also been upgraded in parallel with the increase of the capacity.
- 600 and 1000 MW class boilers are categorized as supercritical pressure boilers or ultra supercritical pressure boilers.

Operation/Maintenance of a Thermal Power Plant – 1/2
(securing quality and safety of facilities under laws and regulations)

- Maintenance of the reliability and safety of thermal power generation facilities is controlled under the Electricity Enterprise Law established by the Government (it is obliged to report occurrence of facility and personal accidents).
- Power producers must strive to maintain/improve thermal power plants operated under harsh service conditions with high temperature and high pressure (welding repair and non-destructive inspections must be performed by engineers who have passed national examination).
- Only facilities that have received and passed on-the-spot inspections by specialized inspectors of the government when they are opened for periodical inspection/maintenance are allowed to operate.
- In case of a facility accident or personal accident, the plant may be suspended from operation depending on the content of the accident (the power producer must identify the cause of the accident and take a countermeasure, and receive an on-the-spot inspection by a specialized inspector of the government. The plant cannot resume operation unless it passes the inspection).

Operation/Maintenance of a Thermal Power Plant – 2/2 (securing the environment under laws and regulations)

- The Basic Environment Law defines the environmental standards and standard values for air-quality issues, water-quality issues, noise, vibrations, etc. (in many cases, standards by local governments are added to regulation values of the national government, and on-the-spot inspections by a dedicated inspector may by involved).
- Major environmental preservation measures
- Air quality control → SOX, NOX, dust, coal dust fly
- Water quality control → drainage, warm drainage, oil leakage
- Noise and vibrations → noise, vibrations
- Wastes → coal ash, desulfurized gypsum
- Environmental harmonization with surroundings → greening, scenic preservation

Standard Inspection and Maintenance Intervals under the Electric Enterprise Law

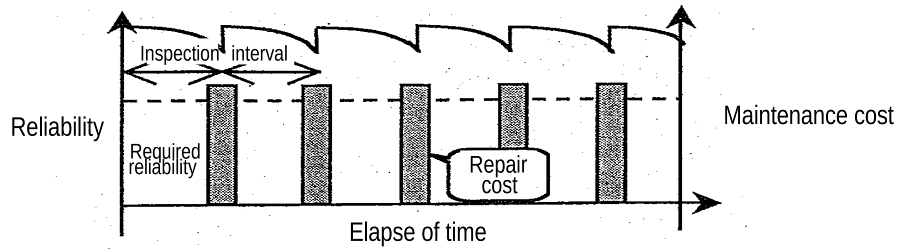
	Minor Inspection	Major Inspection
BOILER	Every 2 years	Every 4 years
STEAM TURBINE	Every 4 years	Every 8 years
GAS TURBINE	Every 2 years	

Plants that are not inspected and maintained within the period defined under the law cannot be operated.

State of inspection and maintenance of gas turbines is controlled in EOH.
Gas turbine combustors: minor inspection after 8,000 hr (EOH)
Gas turbine main units: major inspection after 25,000 hr (EOH)
[EOH = Equivalent Operation Hour]

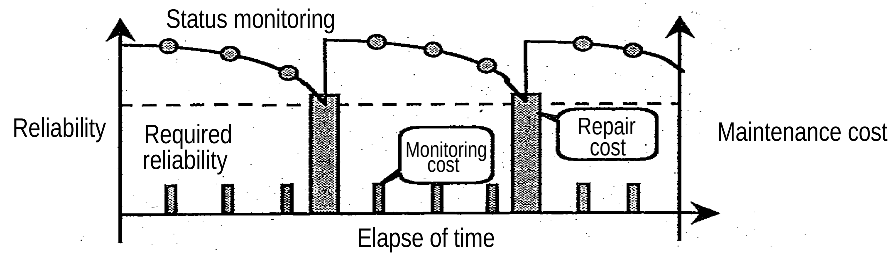
Maintenance Mechanism

TBM: Time Based Maintenance



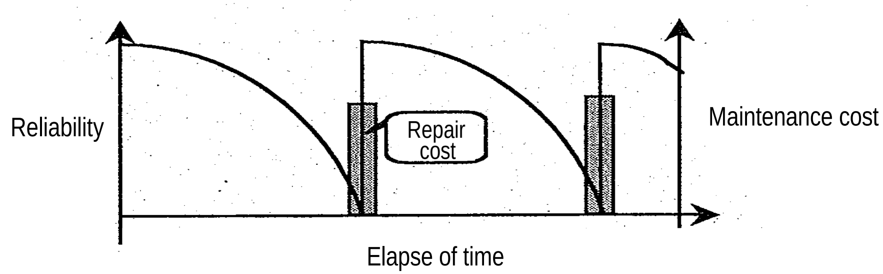
In case of TBM

CBM: Condition Based Maintenance



In case of CBM

BDM: Break Down Maintenance



In case of BDM

Concept of TBM, CBM and BDM

Examples of Specific Contents of TBM and CBM

- Contents of TBM (time based maintenance) (examples of major inspection)
  - Building a temporary scaffolding at the top inside the furnace
  - Visual inspection of the furnace interior, and measurement of thickness/outer diameter of representative regions (comparison with the previous data, inspection of corroded/thinned, discolored or bulged regions in particular)
  - Removal of sample tubes (scale thickness measurement, metallographic inspection)
  - Repair of burner tiles and repair of burnt region of the air nozzle
  - Replacement of deteriorated and damaged parts

- Contents of CBM (condition based maintenance) (examples of major inspection)
  - Diagnosis of points where abnormally high temperature is indicated with SH and RH tube metal
  - Follow-up inspection of regions where abnormal metal texture was detected in the previous inspection data
  - Inspection of the bearings of large auxiliary units that have been operated at allowable limit of vibrations
  - Lateral spread check of trouble that has occurred in similar units

Operation of Thermal Power Generation Facilities

- Formation of teams on watch for coal-fired power generation facilities
  (e.g., latest facility with 600 - 1000 MW, 1 control room for 1 unit)
  8-hour shift with 5 teams, 1 team consisting of 4 to 5 people (1 team consisting of 6 to 7 people in case of 1 control room for 2 units)
- Operation of auxiliary facilities is commissioned to an external organization
  Coal facilities (coal unloader, coal storage, coal feeder)
  Ash handling system (clinker-based wet type, ash-based dry type)
  Electrostatic precipitator, desulfurization equipment (wet type)
  *Effective utilization of ash and gypsum

Maintenance Structure for Thermal Power Generation Facilities

- Daily maintenance (performed by plant employees in principle)
  Minor repair/instrument calibration that can be performed during operation
- Scheduled outage maintenance (performed by an affiliated specialty company)
  Stop the facility for 1 to 2 weeks due to supply-demand adjustment, and perform minor repairs and condenser tube cleaning.
- Periodical inspection/maintenance (performed by affiliated company, while quality, safety and process control is performed by the plant)
  Voluntarily maintain weak facilities/regions based on legal inspection
- Preventive maintenance (to be studied based on the inspection/maintenance database)
  Replacement and major repair of age-deteriorated regions
  Example: replacement of boiler tubes, replacement of facilities with degraded performance

New Employee Training Program (in Case of Staff on Watch)

- Basic training (on routine work, for 2 months)

  Education on the mechanism of power plant and on safety, and how to read related drawings
- Training on work on watch (introductory training for 1 month in routine work)

  Safety education mainly on-site work, knowledge on patrols, etc.
- Training on work on watch (for 6 months)

  Basics of equipment operation, maintenance and disaster control, OJT
- Simulator-based training and repetitive training on OJT (all group members to be on watch will participate, and recognize their respective roles allocated)

  Facility operation and response to generated alarms

Efforts to Improve Independent Technological Capability

- Mechanism of education and training

  Establishment of various technical documents, manuals, etc.

  Education and training using the company's training facility

  Training for external specialized lecturers

- Mechanism of skill certification

  Certify employee who have specialized knowledge and contribute to the company as special staff (treatment according to the techniques/skills)

  Identification of personal technique/skills using a skill map

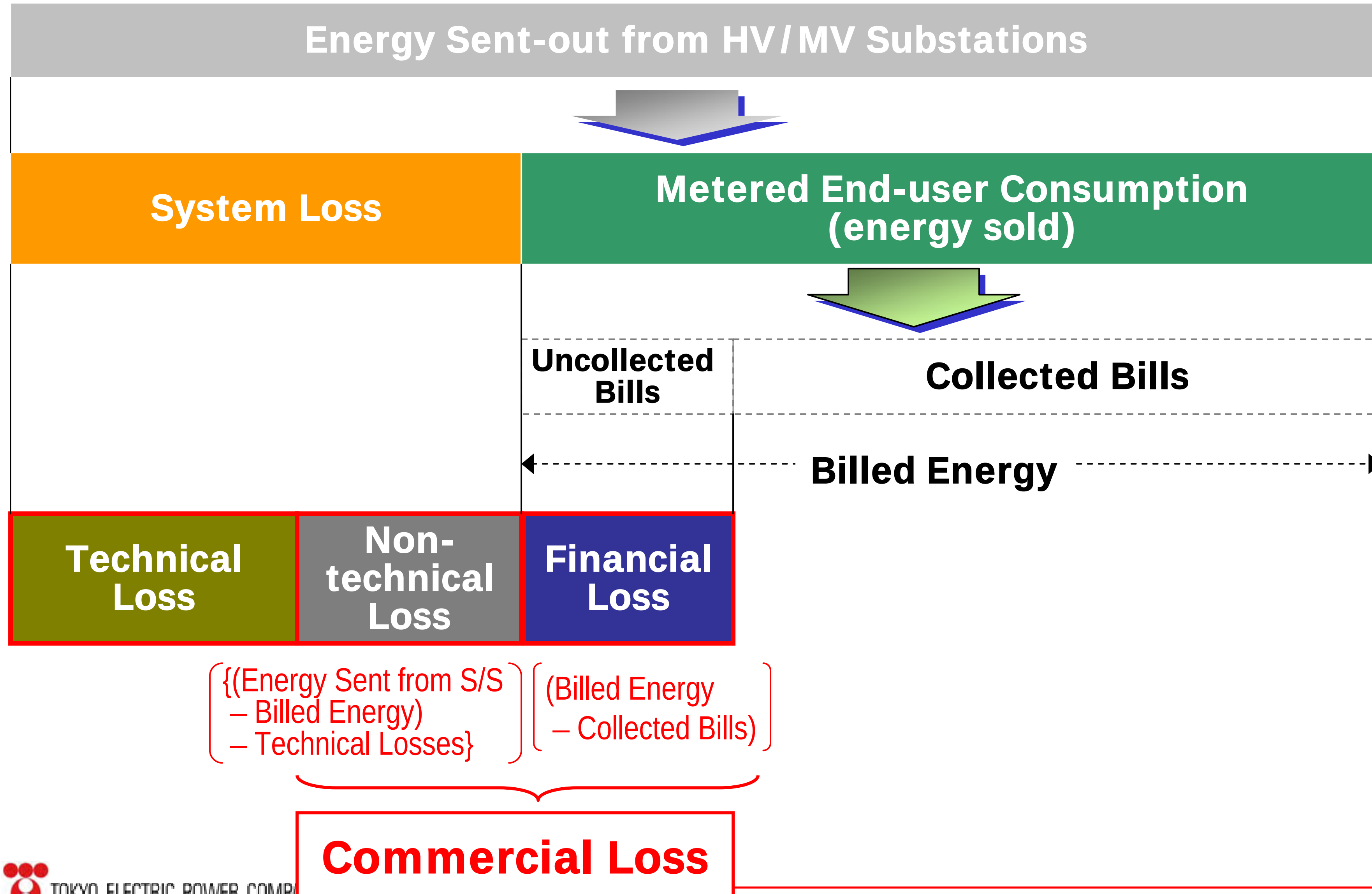
Loss Reduction & Reliability Improvement in Distribution System

January 2009

Tokyo Electric Power Company
(JICA Study Team)
Koichi HOSHI

TOKYO ELECTRIC POWER COMPANY
TEPCO

Image of Distribution Loss



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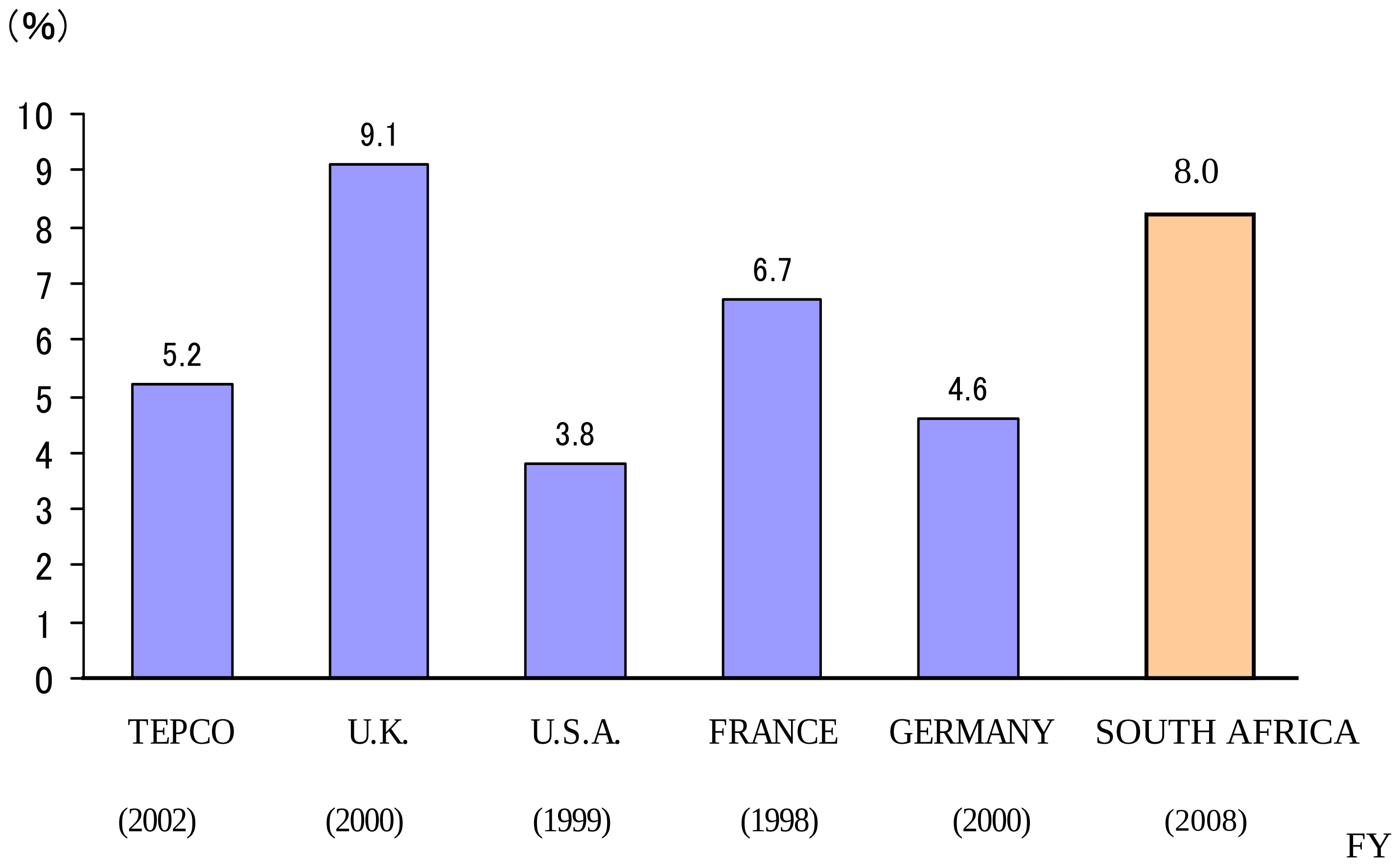
Transmission & Distribution Loss

International Comparison of Line Loss



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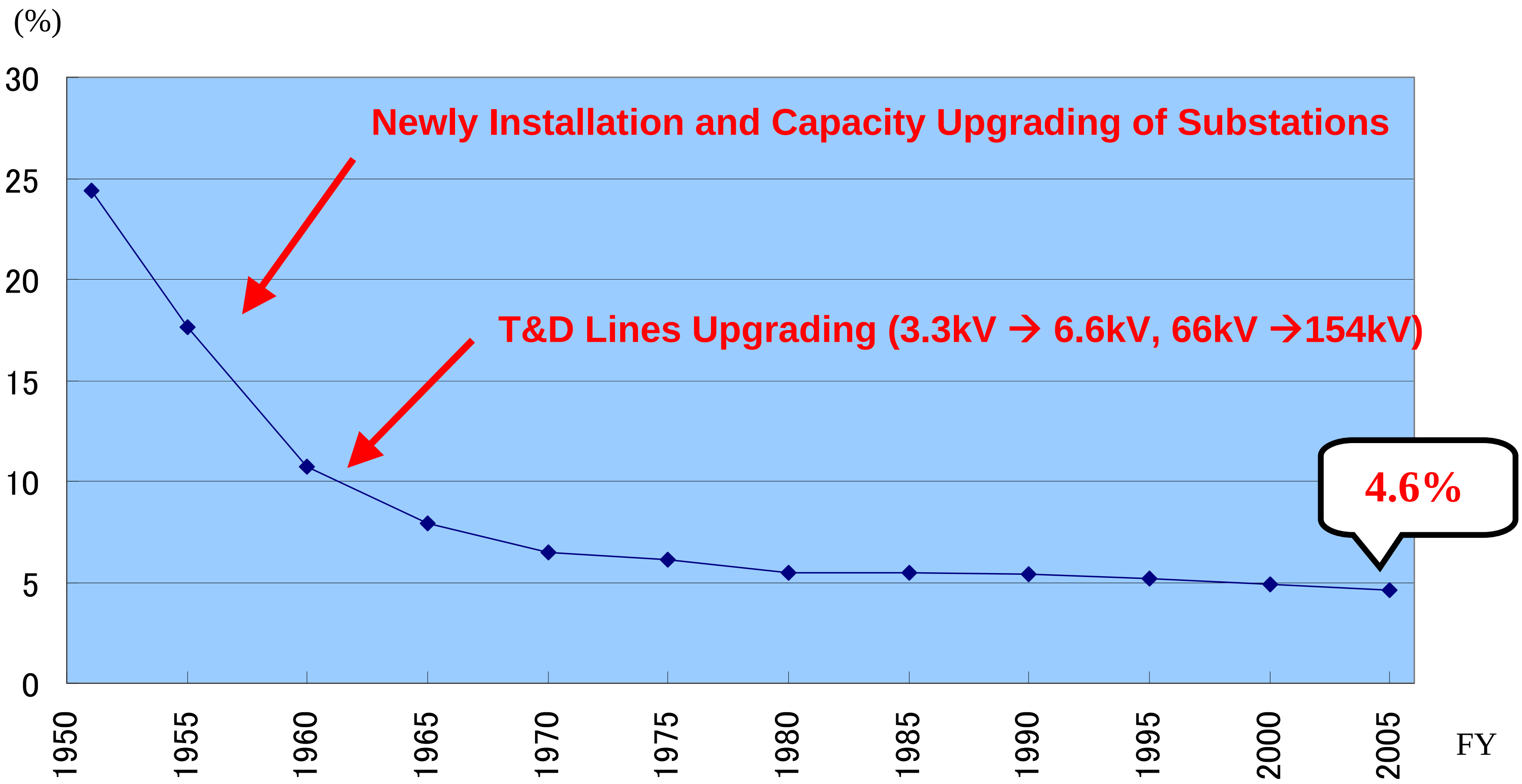
Transmission & Distribution Loss

TEPCO's historical trend of Loss



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Types of Distribution System Loss

Technical Loss

- Conductor
  - Resistance Loss
  - Corona Loss or Leakage (very few)
- Transformer
  - Core Loss
  - Copper Loss

→ **Mostly losses come from conductor. Countermeasures advisable.**

Non-technical Loss

- Non Technical Loss
  - Inaccurate Metering
  - Defective Meter
  - Tampering/Pilferage

Financial Loss

- Financial Loss
  - Uncollected Revenue

Commercial Loss (Non-technical Loss and Financial Loss)

Countermeasures for Distribution Loss

(Focusing on the Technical Loss)

- Leveling distribution system loads by network re-configuration(for MV, LV system)
- Power factor correction by capacitor placement
- Install new feeders
- Install new transformers
- Build a substation
- Re-conductoring (Replace with larger cross section conductor)

Overview of Countermeasures

1. Leveling of distribution system loads by network re-configuration

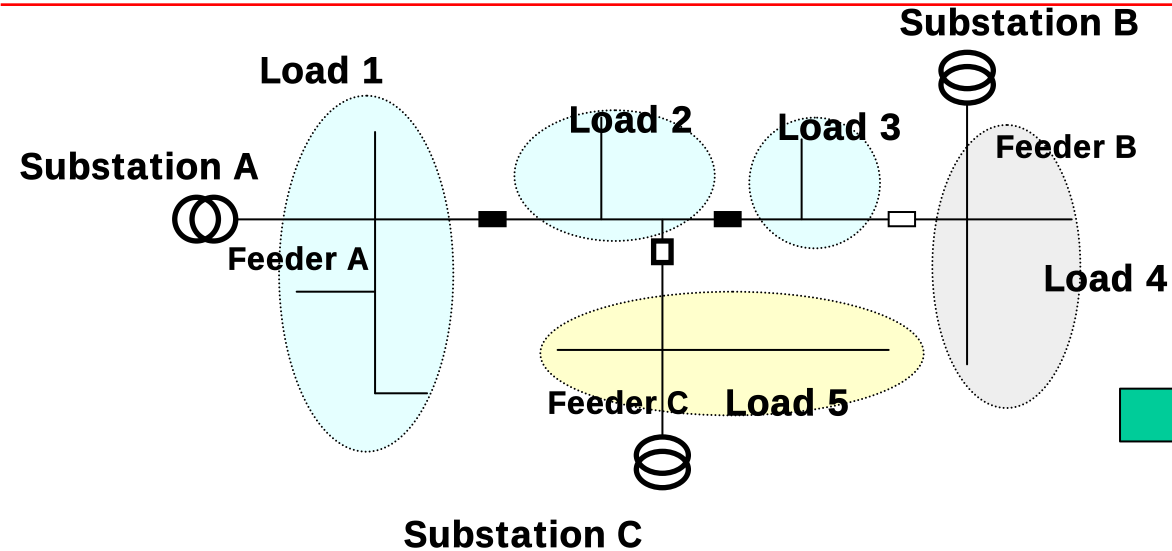
☐Basic Idea

- Some loads in the heavy loaded feeder shifted to another lightly loaded feeder
- Sectionalizing switchgear allocation for load shift (new interconnection between feeders may be required)
- Optimal switching allocation may be done by distribution system analysis software

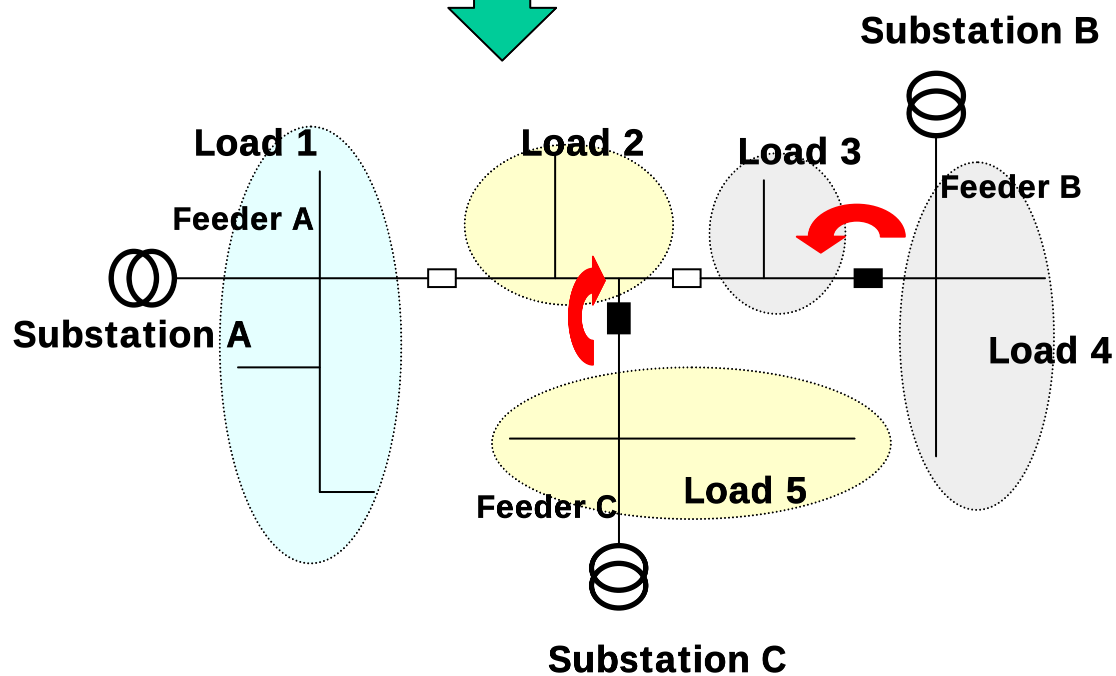
☐Comments

- First step for loss reduction with less investment

Image of Load Leveling



MV System Re-configuration



Note:
After re-configuration, loss reduction in feeder A may have much more impact on the total system loss than the loss increase in feeder B & C.

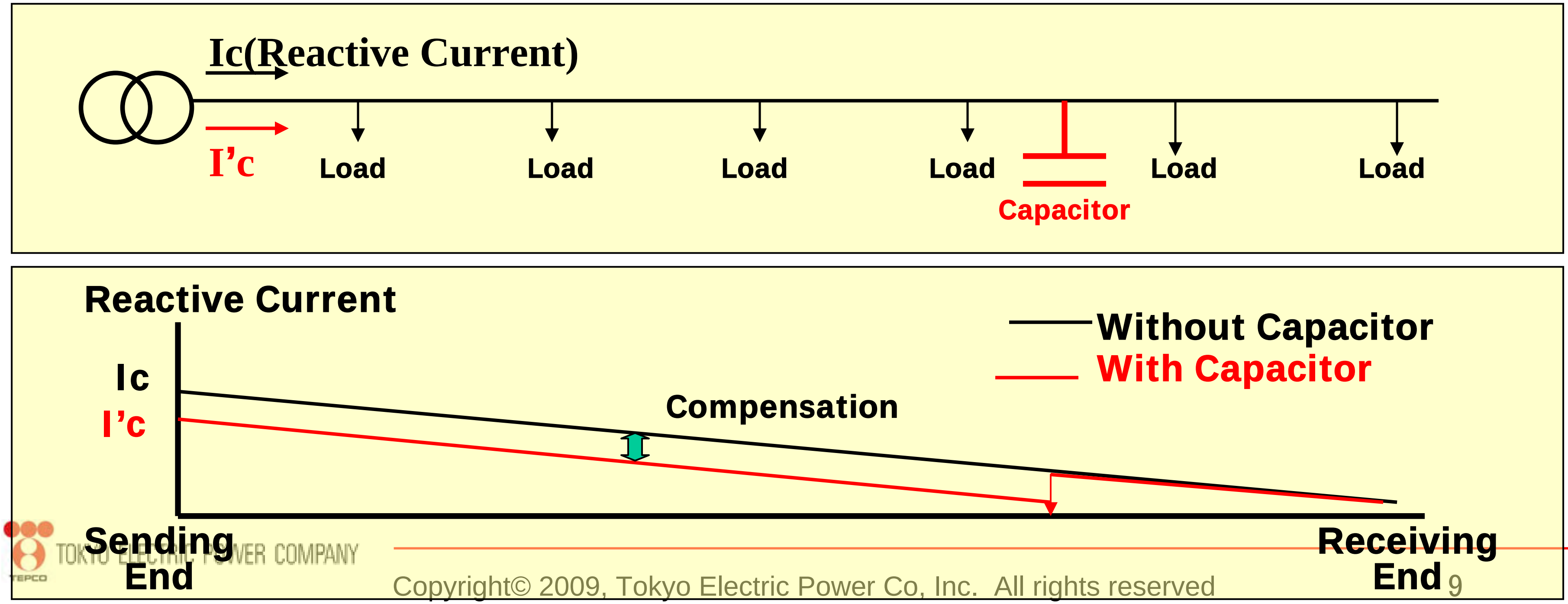
Overview of Countermeasures

2. Power factor correction by capacitor placement

□Basic Idea

- Improvement of power factor reduces power flow in a feeder. Thus, system loss reduction achieved
- Power factor improved by compensating the reactive power

□**Image of Reactive Current Compensation**



Overview of Countermeasures

3. Install new feeders/transformers/substations

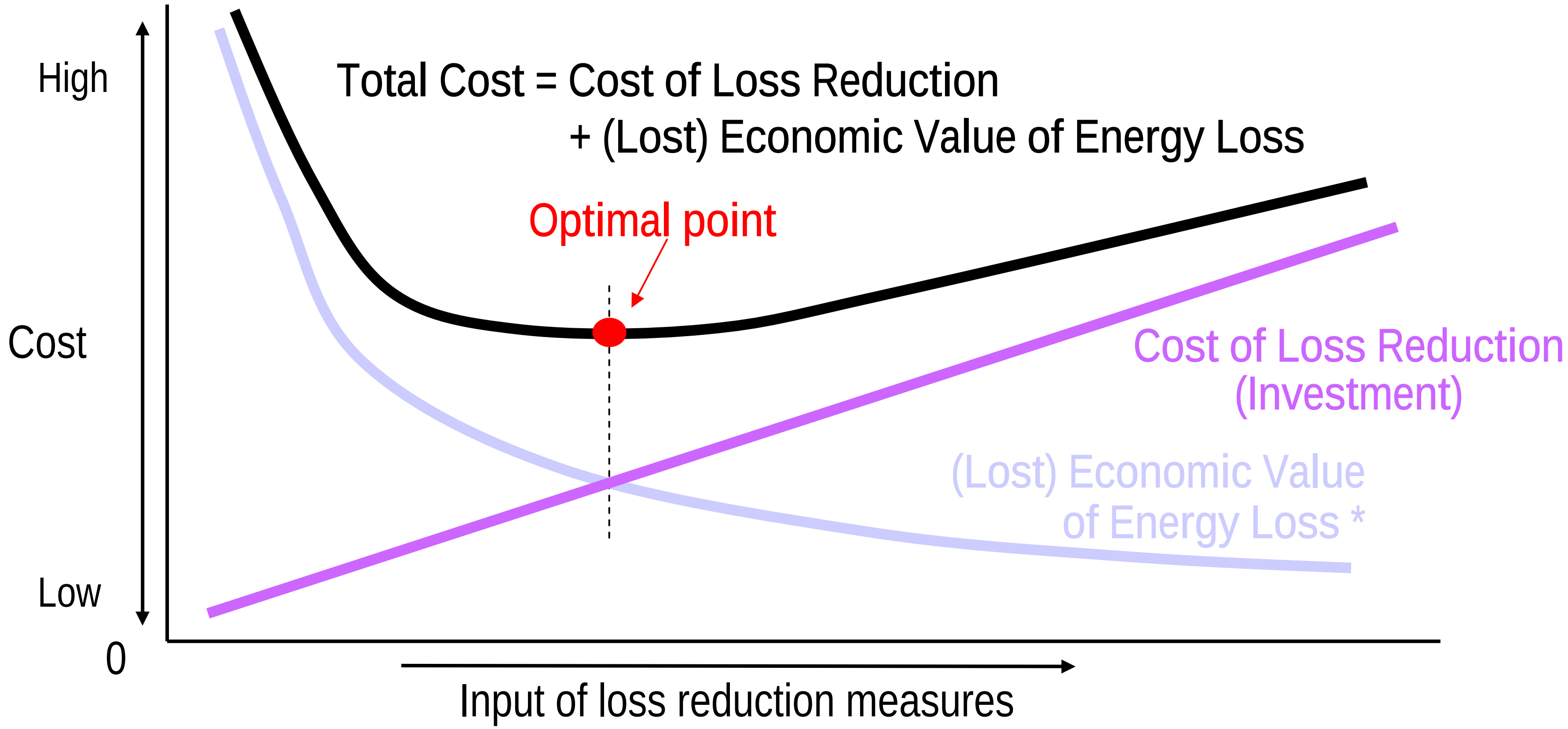
☐Basic Idea

- Heavy loaded area to be supplied by new feeder so that existing feeder supplies less loads (for new feeder install, sometimes new HV/MV transformer needed)
- New substation to be built in the center of high load density area so that existing feeder supplies less loads

☐Comments

- Building new facilities(feeders, transformers, substations) requires a certain level of investment. Impact of loss reduction and investment must be carefully considered.

Evaluation of Loss Reduction Measures



- **When "Cost of Loss Reduction" > "Economic Value of Reduced Energy Loss", the loss reduction measure is considered feasible**

→**Determine the most effective measures and their respective input**

TEPCO Loss Reduction Experiences

- Loss Reduction & Reliability Improvement in Jamaica
  - Client: Marubeni, Jamaica Public Service (JPS)
  - Period: Aug 2007 – July 2008
- Power Distribution System Loss Reduction(Phase II)
  - Client: Electricite du Laos/World Bank
  - Period: Mar 2007 – Dec 2008 (Phase II)
  - Period: Mar 2004 – Mar 2005 (Phase I)
- Feasibility Study on Loss Reduction of Distribution Network
  - Client: National Electric Power Co. Jordan/JICA
  - Period: Sep 1999 – Oct 2000

Reliability Indices

SAIDI : System Average Interruption Duration Index (Annual Average Interruption Duration per Customer)

$$\text{SAIDI} = \frac{\Sigma\ (\text{Interruption Duration} \times \text{Number of Interrupted Customers})}{\text{Total Number of Customers}}$$

TEPCO = 3 minutes

SAIFI : System Average Interruption Frequency Index (Annual Average Interruption Frequency per Customer)

$$\text{SAIFI} = \frac{\Sigma\ (\text{Total Number of Interrupted Customers})}{\text{Total Number of Customers}}$$

TEPCO = 0. 04 times

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Distribution Network in TEPCO

Typical Multi-Divided and Multi-Connected System(Standard Configuration)

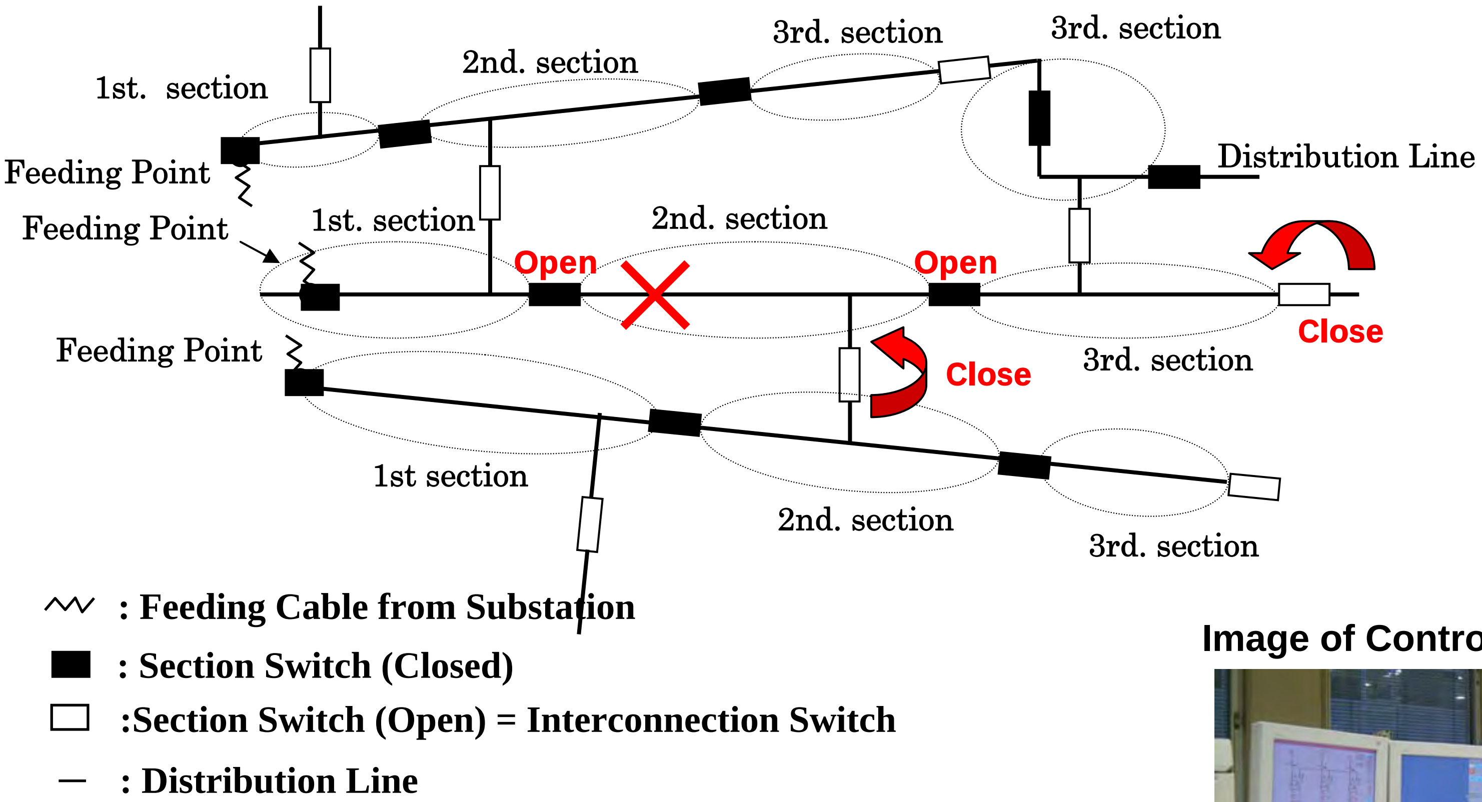

Image of Control Center with DAS

- ❑ Flexible network to demand growth
- ❑ Restored automatically (Distribution Automation System(DAS))
- ❑Section switch remote operation capability

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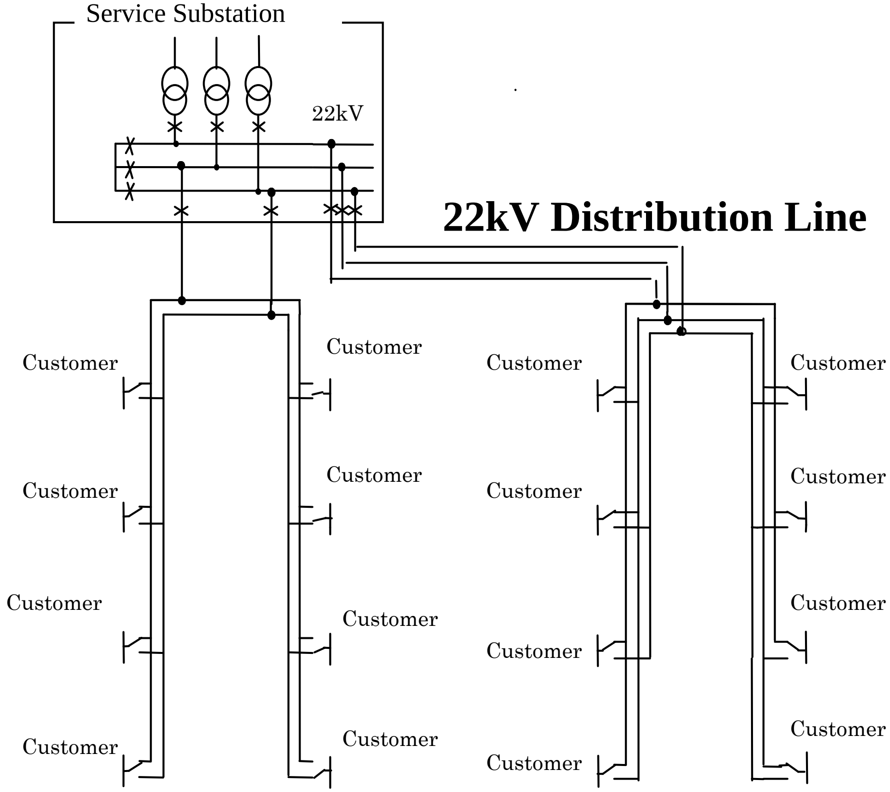
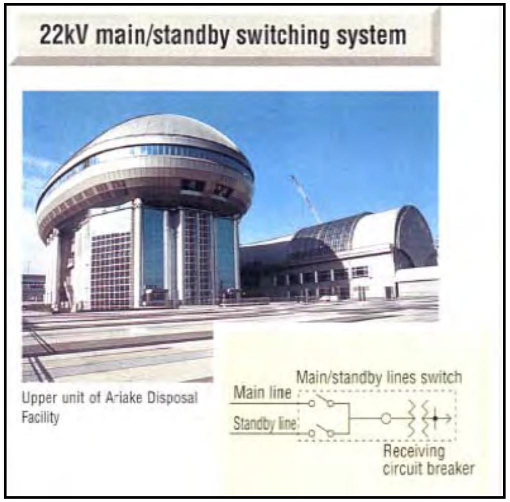
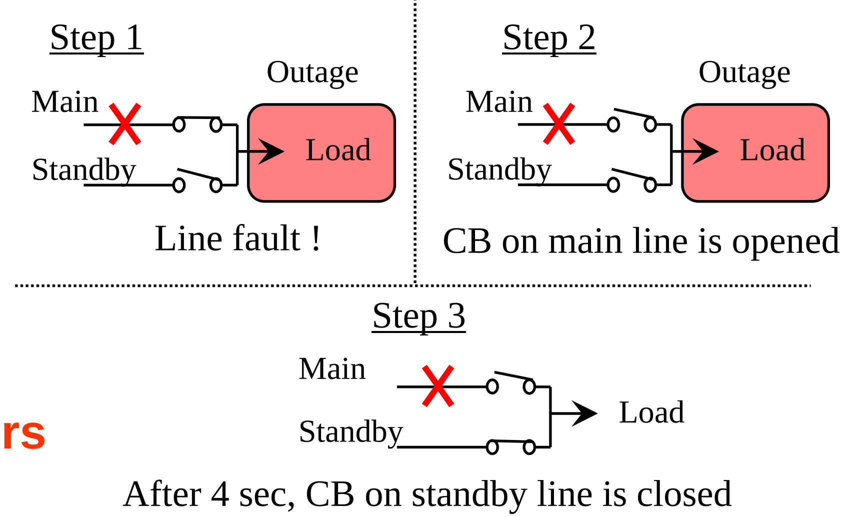
Distribution Network in Urban Area

22kV Main/Stand-by Switching System for Urban Area





Steps to Restore



- □Applied in urban area with large customers
- □2 line service drops
- □Automatic switching when one line contingency

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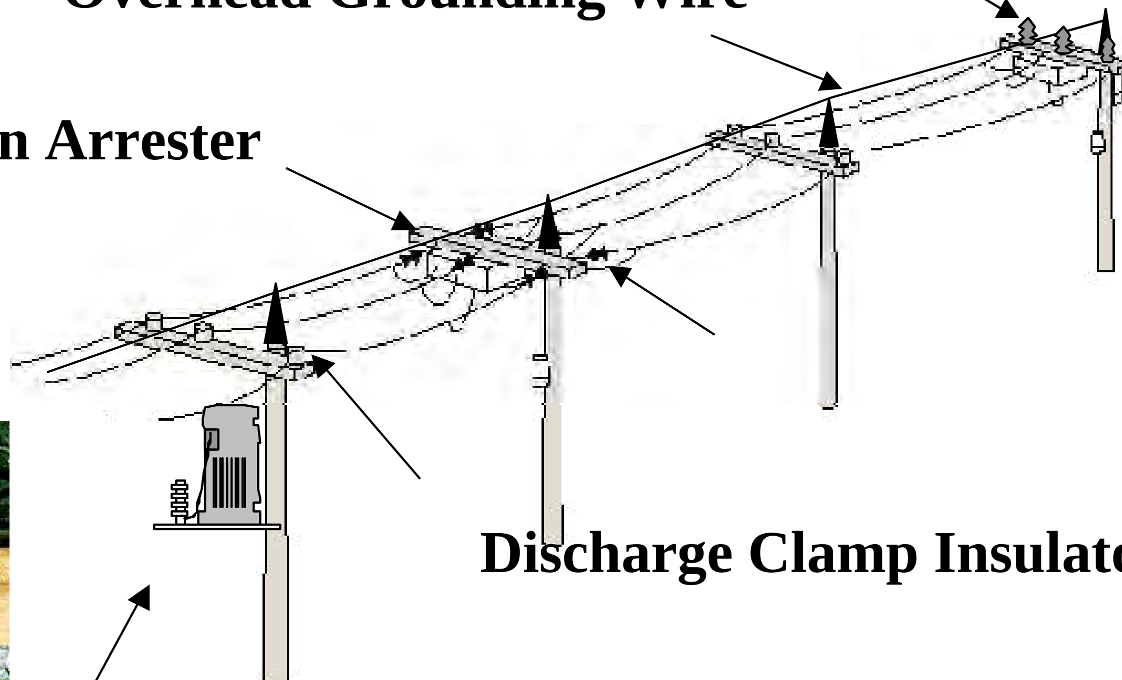
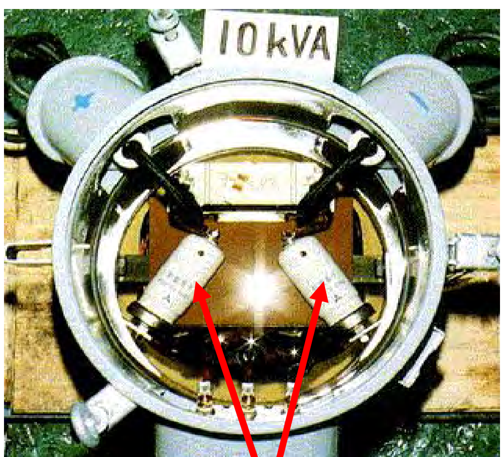
Equipment for Reliability Improvement

Items of Lightning Protection on Overhead Network



Inside of
Pole mounted Transformer



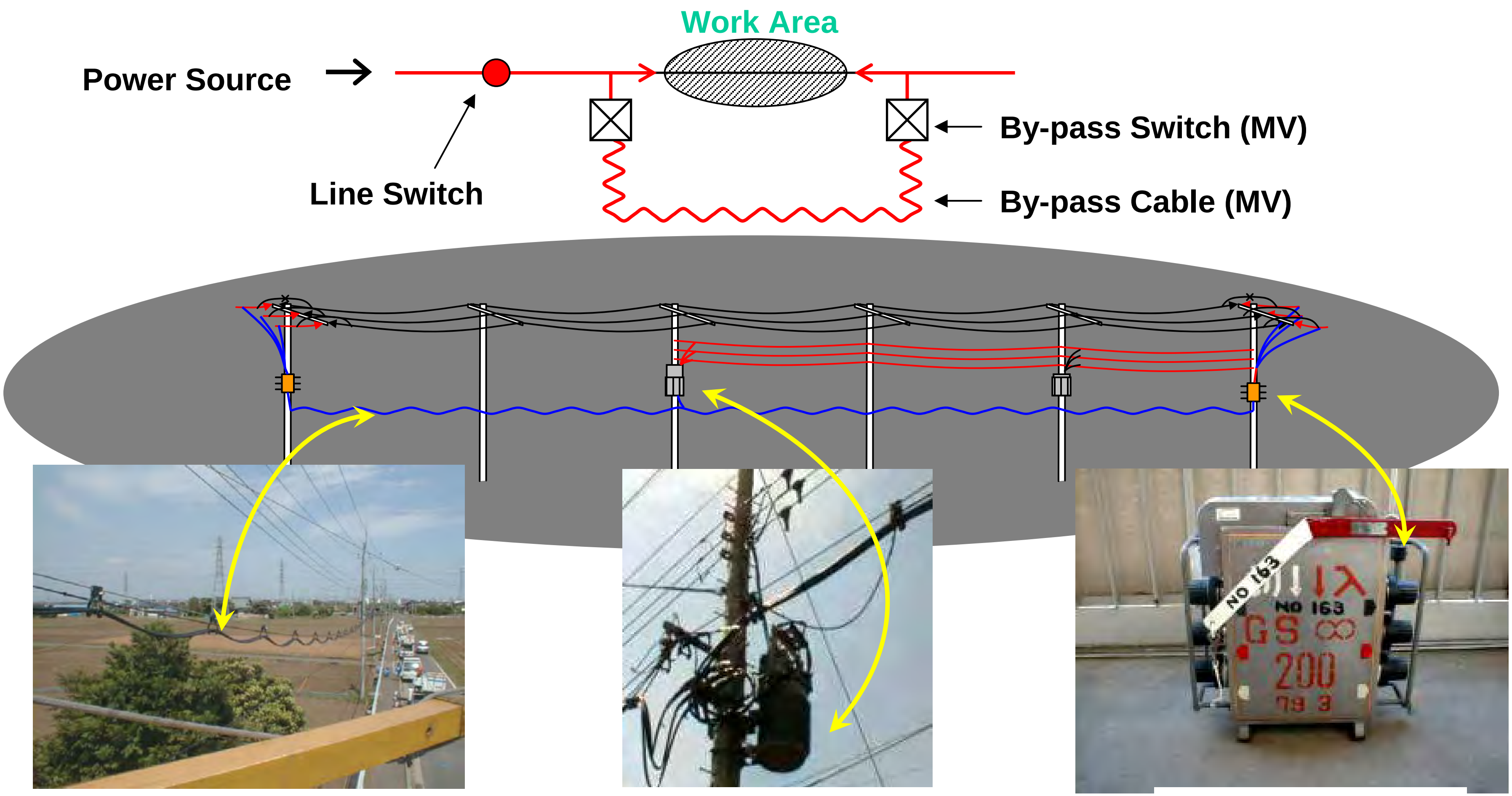
Non-interruption Work Method

- **MV Non-interruption Methods**
  - Temporary switch method
  - MV by-pass method
  - Temporary interconnection method
- **LV Non-interruption Methods**
  - Temporary switch method
  - Temporary transformer method
- **Generating Vehicle (Generator) Method**

Various Methods for reduction of outage time

Introduction of Live Line Distribution Work

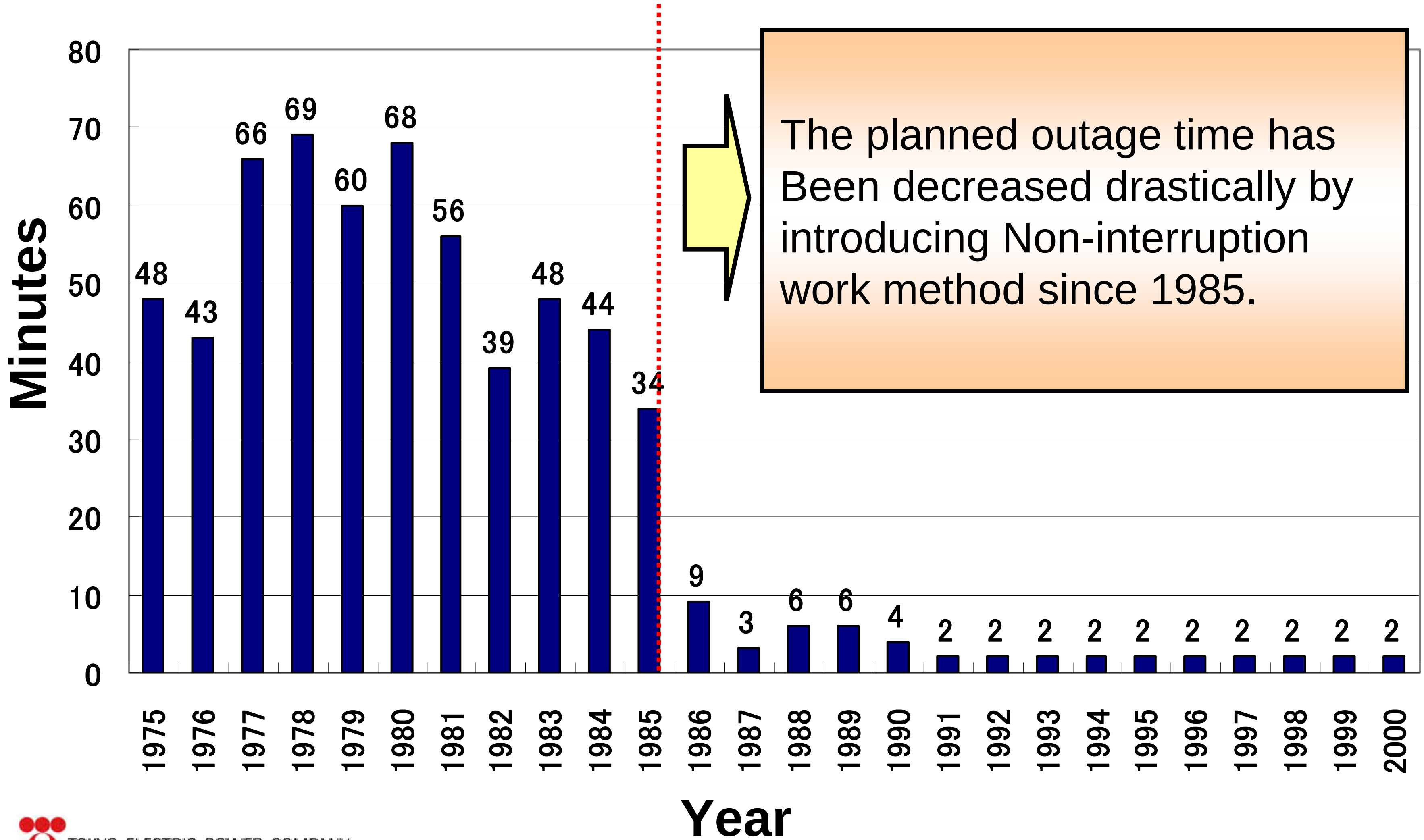
- By using “By-Pass Cables” & “By-Pass Switches”, “Planned Outage” is avoided. (Work Area is by-passed.)
- Low voltage (LV) supply is continued by connecting to a neighboring LV system or temporary transformers.



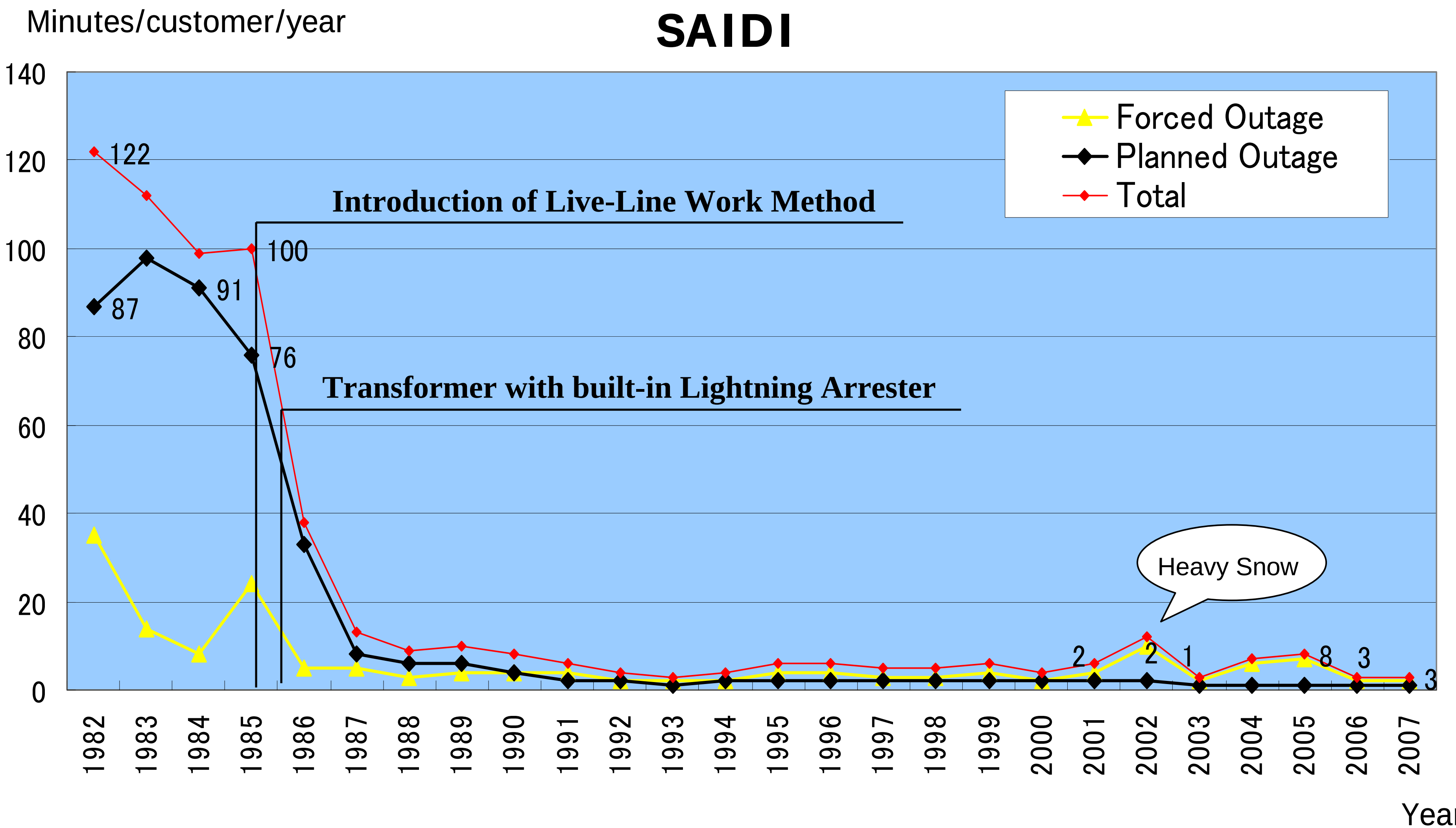
By-Pass Cable **Temporary Transformer** **By-Pass Switch**

Effect of Non-interruption Work Method

Reduction of “Planned Outage” Duration



TEPCO's Power Supply Reliability



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Feedback Seminar on
Energy – Efficiency Potential on South Africa

Energy Demand Forecasting Model

Jan 27, 2009

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

Tomoyuki INOUE

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1. Concepts of Energy Master Plan

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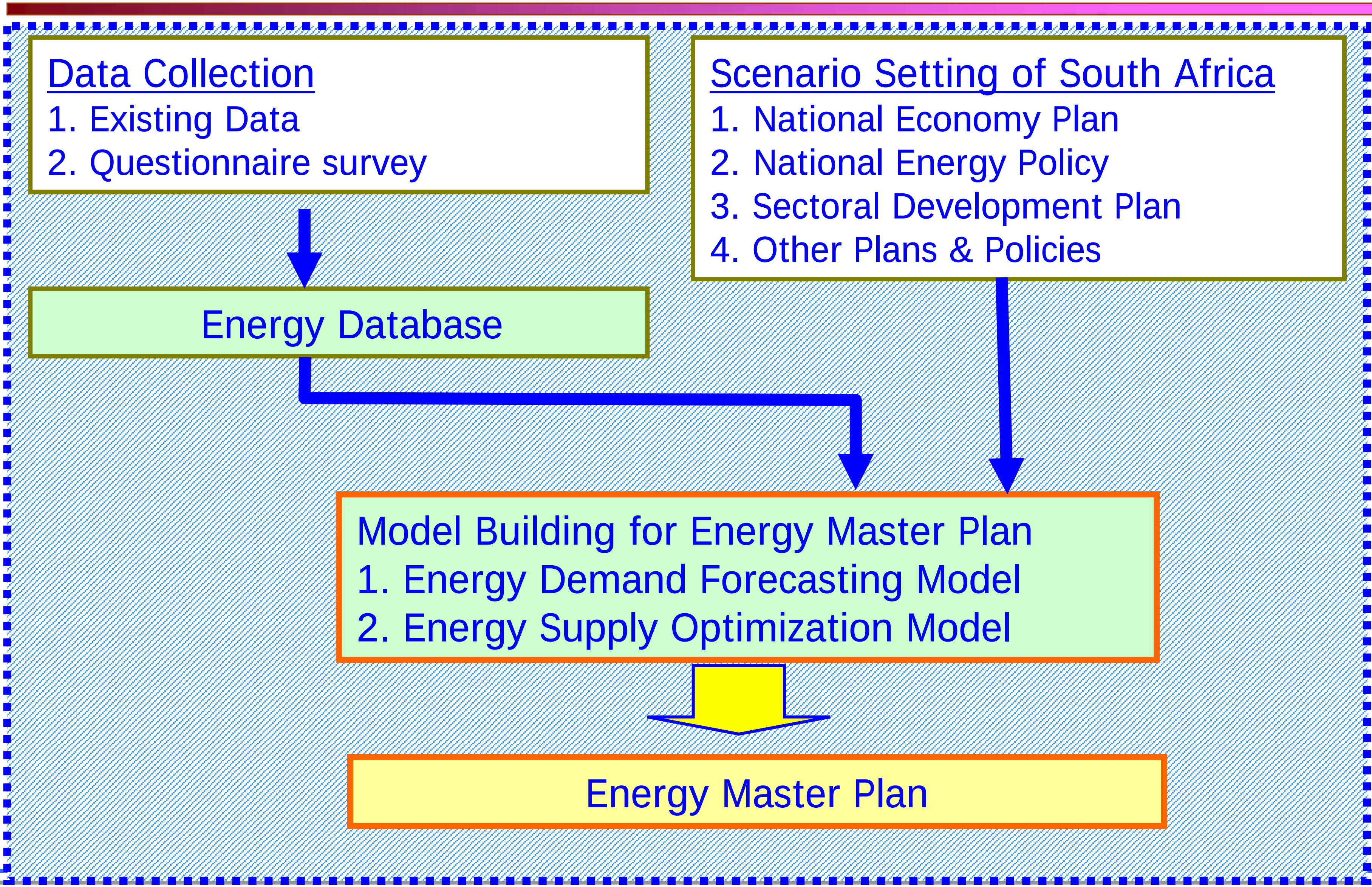
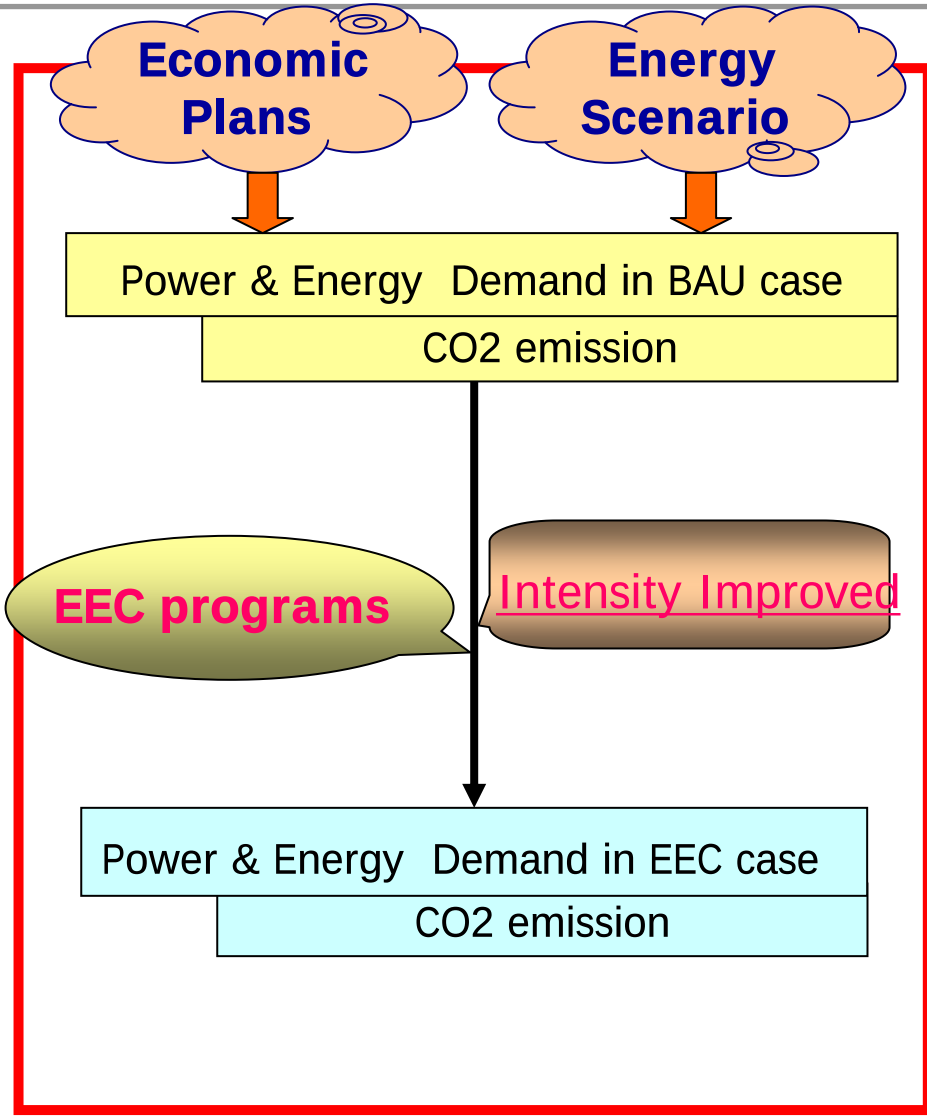
1. Concepts of Energy Master Plan



2. Trial Energy Demand Forecasts for SA

2.1 Framework of Energy Demand Forecasting Model



Software:

Simple-E (Econometric Model building engine)

MS-Excel add-in software

Actual Data : 1990-2007 (18 years)

Forecast years: 2008-2030(23 years)

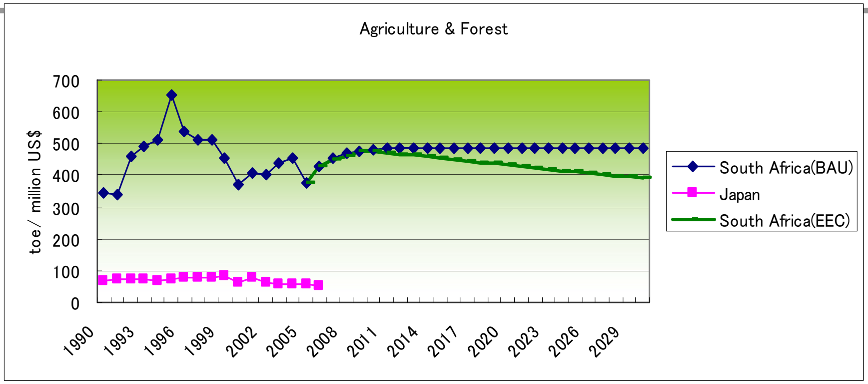
Forecasted items

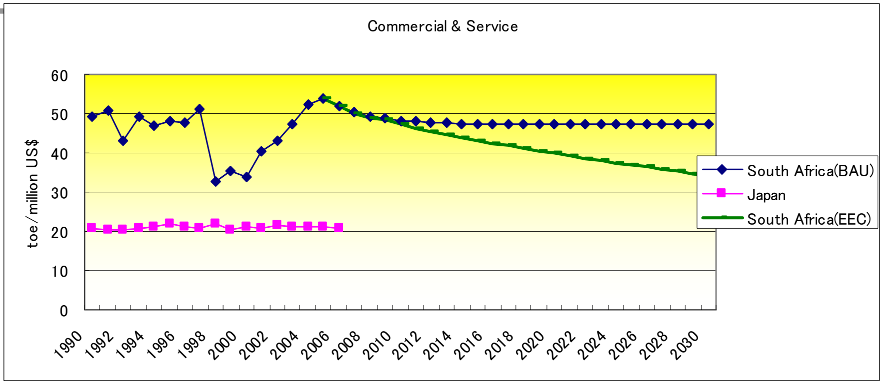
- **Final Energy Demand**
- **Power demand by Sector**
- **Fuel supply to Power sector**
- **Power generation & Power capacity**
- **Primary Energy Supply**
- **Energy consumption per GDP**
- **Energy consumption per population**
- **Power consumption per GDP**
- **Power consumption per Household**
- **CO2 emission by sector**

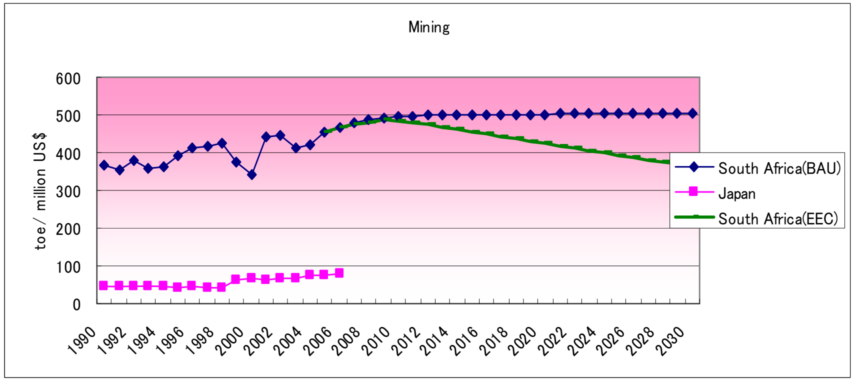
2.2 Scenario and Case Setting

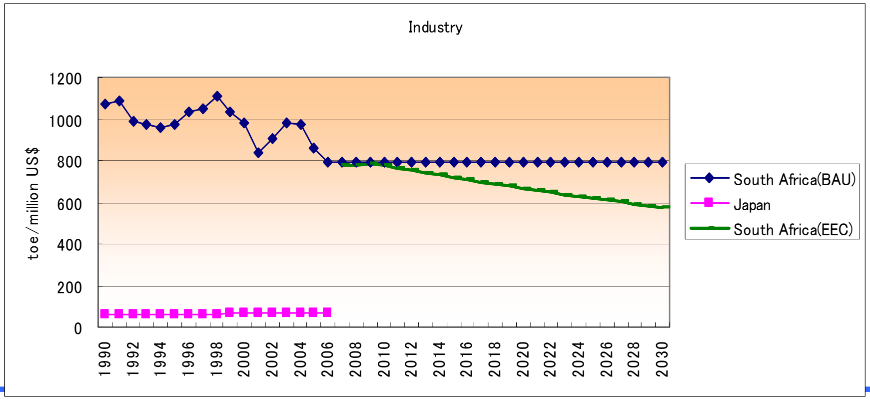
	BAU case	EEC case
Economic Policy & Plans	○GDP growth rate GDP: 2008-2010:3.0%,　2011-2020:4.0%,　2021-2030:5.0% ○Stability of macro economy (exchange rate, inflation and money supply) Exchange rate:　7.5R/$ - 10.0R/$　from 2008 to 2030 ○Investments Road, Water supply, Energy supply, Housing, Public facilities ○Sectoral Industry policy Enhancing Labor intensive industry (Business outsourcing, Tourism, Bio fuels)	
Energy Policy & Plans	○CTL : +10,000ktoe in 2010 ○GTL: +4% per year from 2009 to 2025	
Power Policy & plans	○Open cycle gas turbine: 750MW in 2009、300MW in 2010 ○Nuclear power : Additional +1GW per year from 2020 to 2030 (total= +11GW) ○NG power generation : 800 MW in 2011, 800 MW in 2015, 800MW in 2020, 800 MW 2026 ○Renewable Energy: 1.0% in 2010 to 4.0% in 2025 ○Reserve margin : 5% in 2009 to 16% in 2017 ○IPP shares : 5% 2009 to 30% in 2023	
Energy Efficiency Policy	○Efficiency of coal power station: 34% ○Distribution loss : 8.5% from 2009 to 2030 ○Sectoral Energy Efficiency Strategy （Refer to　Next Page）	○38% ○8.5% in 2009 to 5.0% in 2016 ○Mining:15%, Transport:9%, Commerce:15% Residential:10%　Total:12%

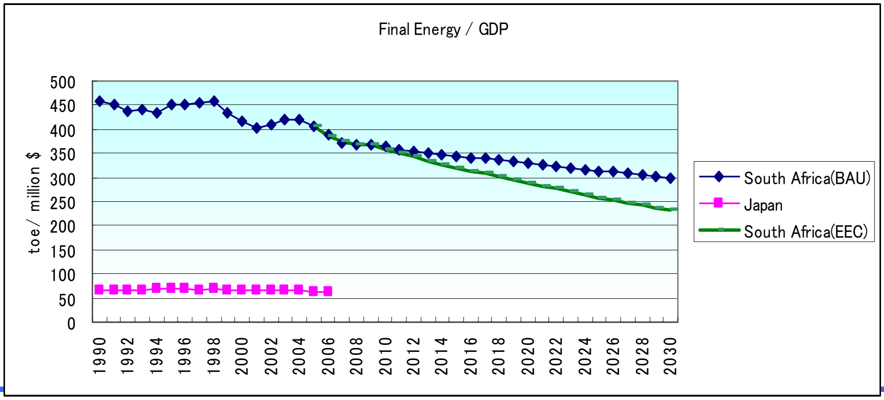
2.3 Intensities in BAU and EEC











2.4 Final Energy Demand

IEE JAPAN

BAU case unit: million toe

	2005	2010	2015	2020	2025	25/10
Agriculture	1.6	1.8	1.9	1.9	1.9	0.1
Mining	4.5	4.7	4.8	4.8	4.8	0.1
Manufacturing	22.5	24.1	28.8	34.3	42.9	3.9
Commercial	4.0	4.5	5.6	7.1	9.4	5.1
Transportation	15.7	17.9	21.3	25.8	32.9	4.1
Residential	16.7	17.6	19.3	21.3	23.6	2.0
Total	65.0	70.7	81.7	95.1	115.4	3.3

EEC case unit: million toe

	2005	2010	2015	2020	2025	25/10
Agriculture	1.6	1.8	1.8	1.7	1.6	-0.9
Mining	4.5	4.6	4.4	4.1	3.7	-1.4
Manufacturing	22.5	23.8	26.3	29.0	33.7	2.4
Commercial	4.0	4.4	5.1	6.0	7.4	3.5
Transportation	15.7	17.7	20.2	23.4	28.4	3.2
Residential	16.7	17.4	18.1	19.0	20.0	0.9
Total	65.0	69.8	75.9	83.2	94.9	2.1

12.5% down in 2020

17.8% down in 2025

2.5 Power Demand

BAU case unit: TWh

	2005	2010	2015	2020	2025	25/10
Agriculture	5.5	6.5	6.9	7.3	7.6	1.1
Mining	28.3	29.8	30.3	30.3	30.1	0.1
Manufacturing	81.5	98.8	126.3	160.1	213.2	5.3
Commercial	27.1	30.8	38.6	48.8	64.9	5.1
Transportation	5.4	6.2	7.4	8.9	11.3	4.1
Residential	37.0	43.8	53.6	65.6	79.3	4.0
Total	184.8	215.9	263.0	321.0	406.4	4.3

EEC case unit: TWh

	2005	2010	2015	2020	2025	25/10
Agriculture	5.5	6.4	6.5	6.5	6.5	0.0
Mining	28.3	29.3	27.6	25.6	23.7	-1.4
Manufacturing	81.5	97.3	115.3	135.6	167.4	3.7
Commercial	27.1	30.3	35.2	41.4	50.9	3.5
Transportation	5.4	6.1	7.0	8.1	9.8	3.2
Residential	37.0	43.4	50.5	58.7	67.5	3.0
Total	184.8	212.9	242.1	275.9	325.8	2.9

14.0% down in 2020

19.8% down in 2025

2.6 Power capacity

BAU case

unit: MW

	2005	2010	2015	2020	2025	25/10(%)
Coal (Eskom)	39,378	40,484	44,134	46,510	50,015	1.4
Coal (Auto)	2,044	2,096	7,897	16,040	22,734	17.2
Natural gas	1	12	1,756	2,634	2,634	43.6
Hydro	1,321	2,342	2,342	2,342	2,342	0.0
Nuclear	1,840	1,842	1,842	2,780	7,472	9.8
Other	0	1106	1106	1106	1106	0.0
Total	44,584	47,882	59,078	71,413	86,303	4.0

EEC case

unit: MW

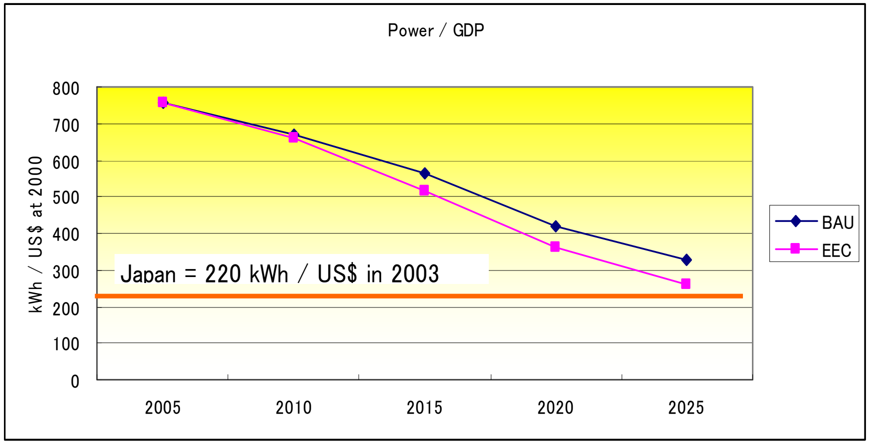
	2005	2010	2015	2020	2025	25/10
Coal (Eskom)	39,378	39,838	39,254	38,269	37,528	-0.4
Coal (Auto)	2,044	2,063	7,024	13,161	17,007	15.1
Natural gas	1	12	1,756	2,634	2,634	43.6
Hydro	1,321	2,342	2,342	2,342	2,342	0.0
Nuclear	1,840	1,842	1,842	2,780	7,472	9.8
Other	0	1,106	1,106	1,106	1,106	0.0
Total	44,584	47,203	53,324	60,293	68,089	2.5

Load Factor	70.0%	72.5%	72.5%	72.5%	72.5%	72.5%
Reserve Margin	6.0%	5.0%	12.0%	16.0%	16.0%	16.0%

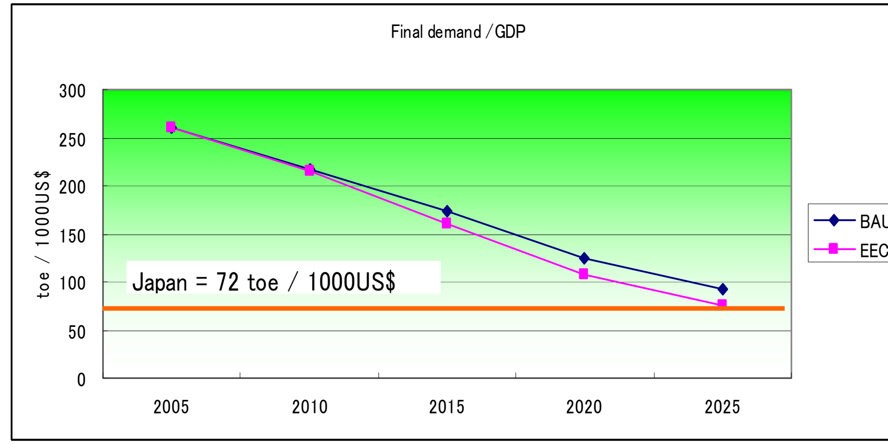
15.6% down in 2020

21.1% down in 2025

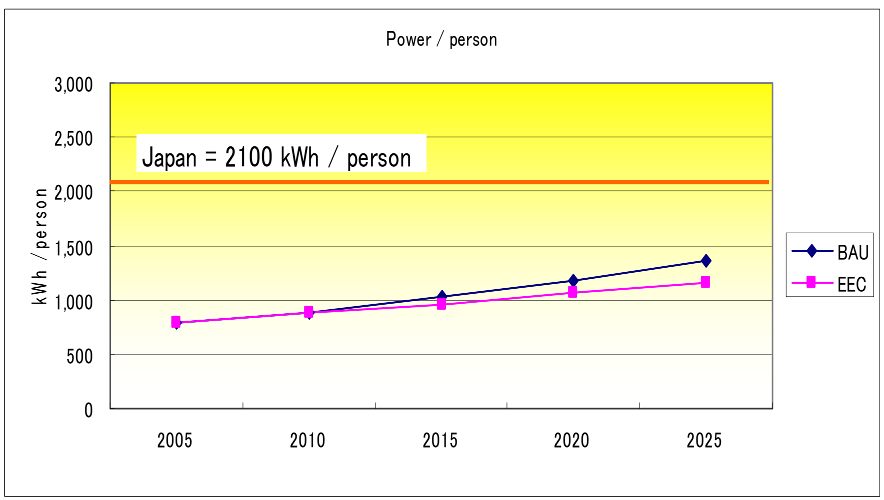
2.7 Power & Energy Demand Comparison



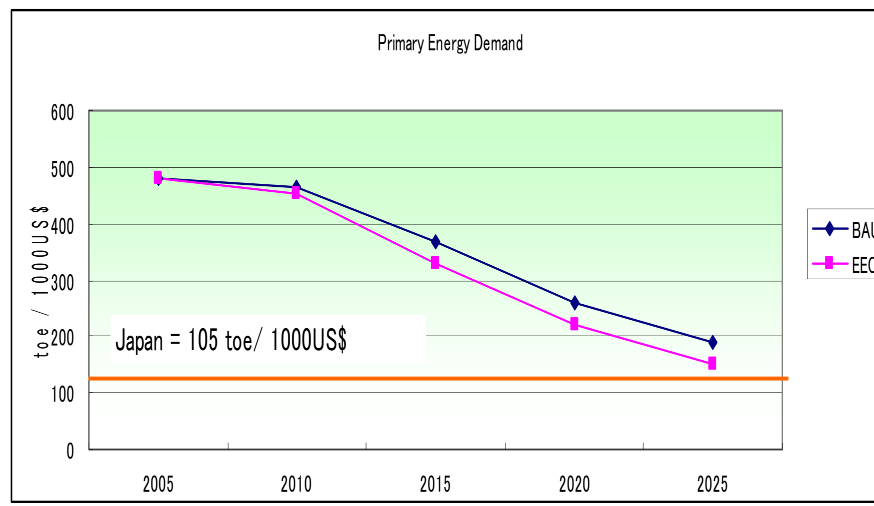
Power demand / GDP



Final Energy Demand / GDP



Residential Power Demand / population



Primary Energy Demand / GDP

3. Considerations

3.1 The consistency between Economic strategy and Energy plan is important for making Strategic Energy Plan. In order to keep the consistency, Energy Demand Forecasting Model and Energy optimization model are required.

3.2 And also, for the consistency among several energy plans such as, power development plans, coal development plans and so on, the above models are used. The Models are used to evaluate the energy projects programmed differentially in view point of country wide energy balance.

3.3 For maintaining the models, several kinds of experts such as Energy policy maker and Model builder are required in energy responsible departments and/or agencies. Then capacity building for the experts are required.

Thank you !!

Energy Supply Optimization Model

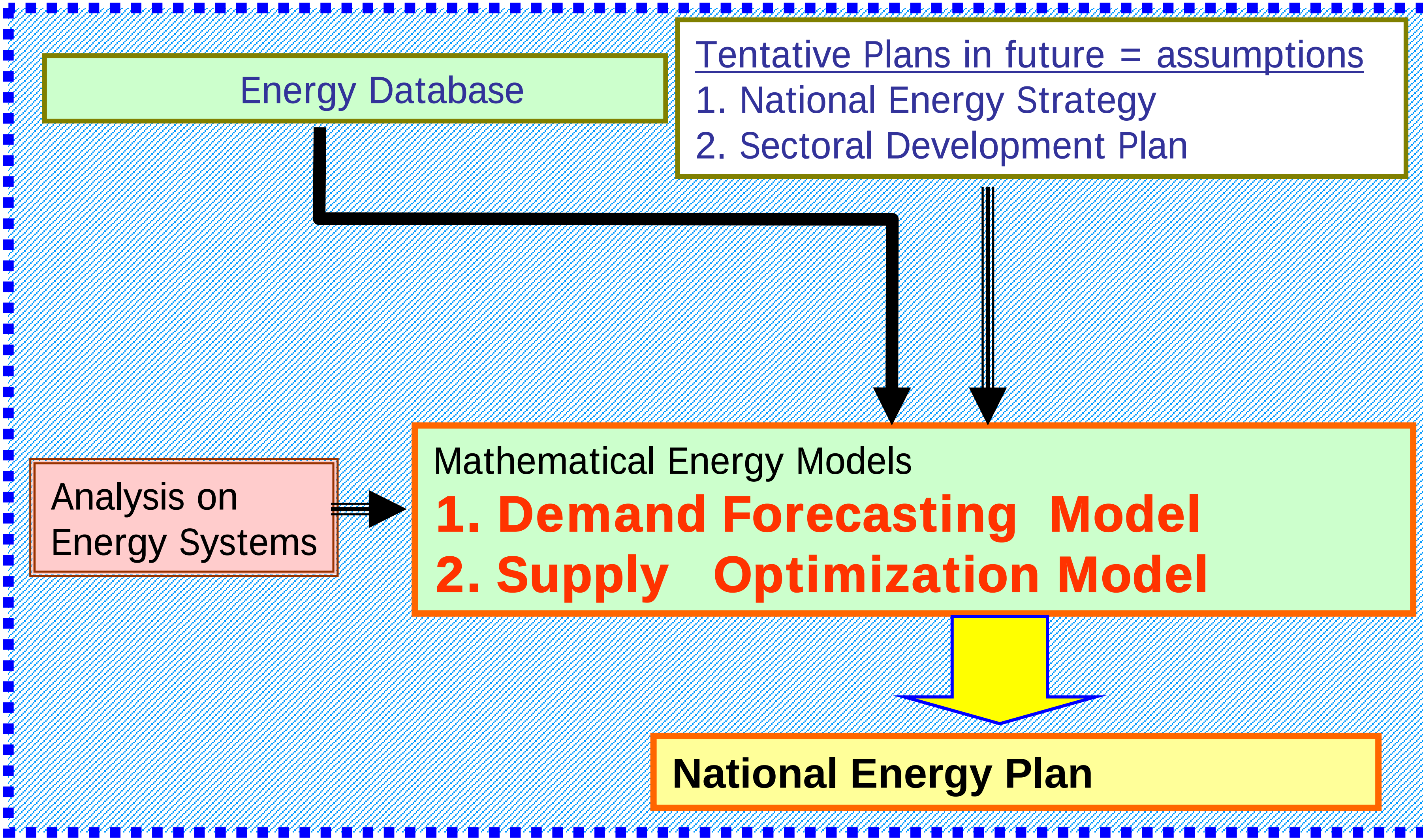
January 27,2009

The Institute of Energy, Economics, Japan

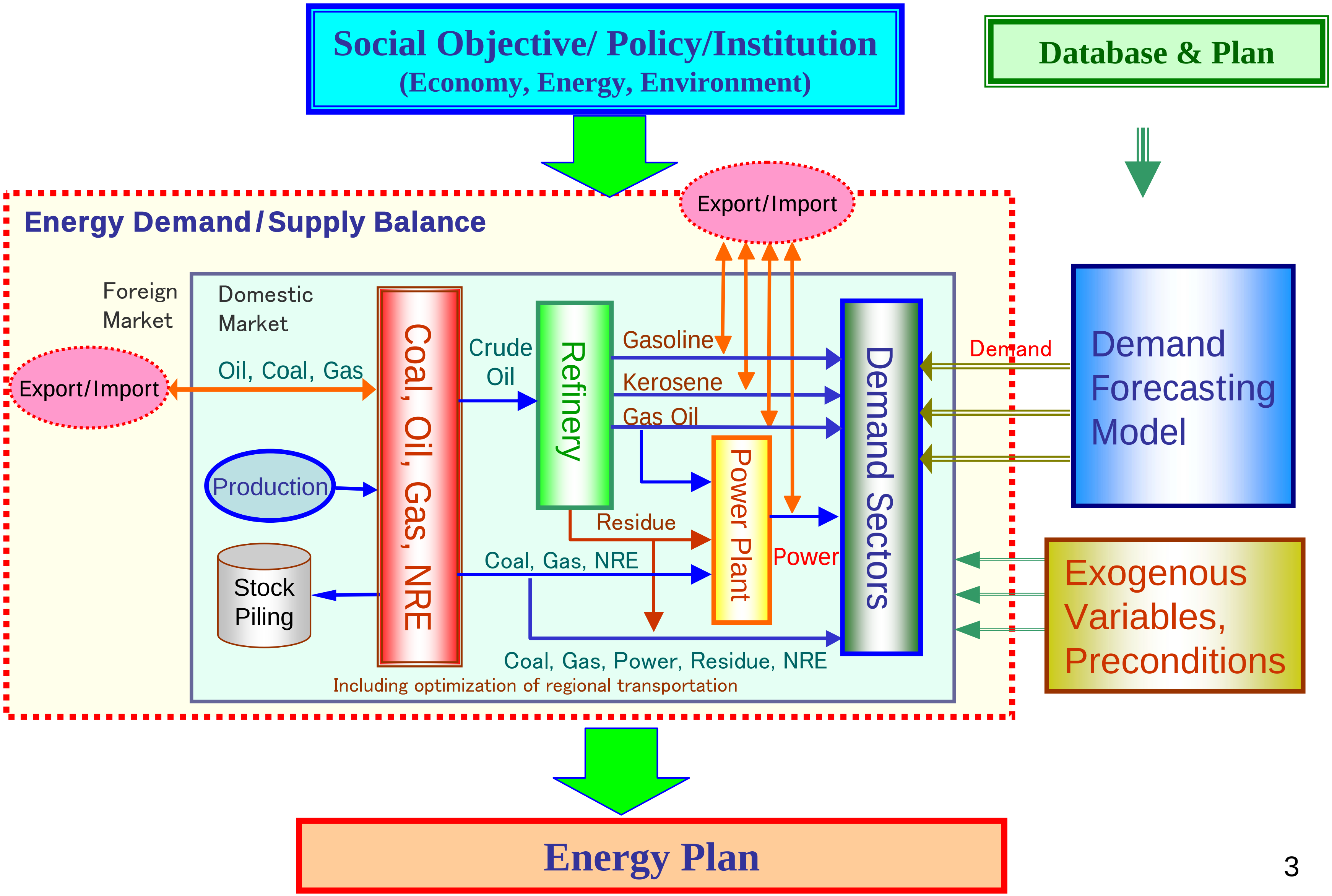
(JICA Study Team)

Tatsuyuki ASAKURA

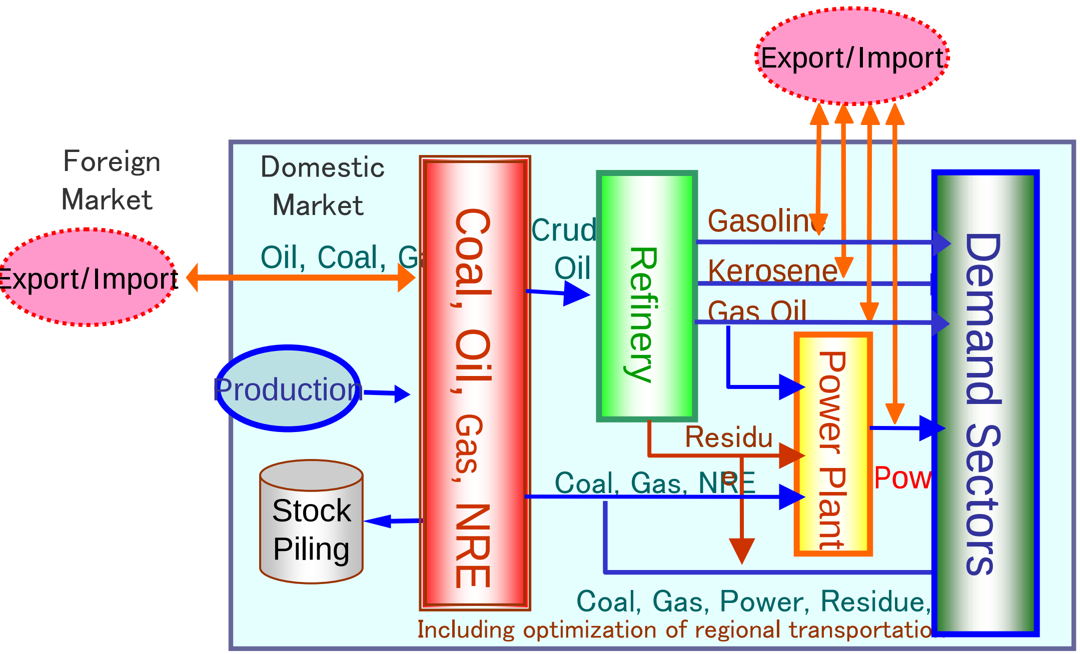
Position of Mathematical Energy model



Structure of Optimization Model



Concept of Optimization model



Represent by formula
=
Optimization model

Condition

1 Energy should be balanced.
2 Cost should be minimized.
cost = production cost
+ import cost
– export sales
+ operation cost

Output information

1 For all energy by year
Production
Import
Export
Consumption

2 Total CO_2 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%

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

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.

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

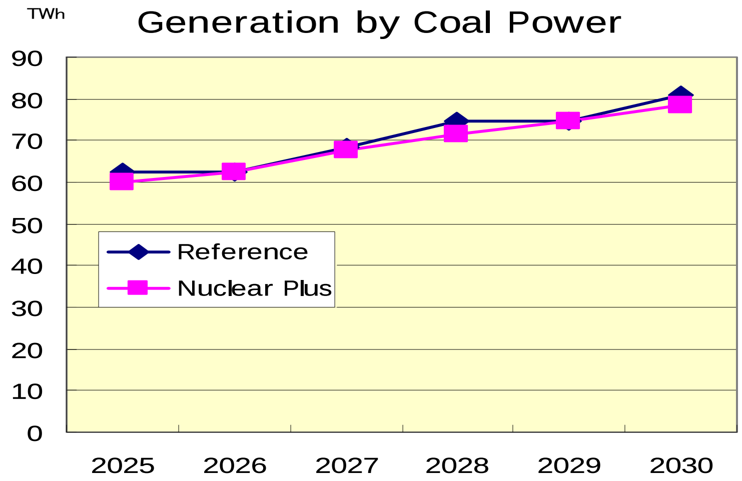
case	CO2 emission (Mton)	ratio
S-EEC	113.09	0.72
Low growth	119.88	0.77
EEC	134.40	0.86
E85	137.68	0.88
S-HighPrice	149.32	0.96
E20	149.42	0.96
High Price	152.96	0.98
reference	**156.21**	**1.00**
Low Price	160.74	1.03
Motorization	161.39	1.03
High growth	194.40	1.24
BAU	195.13	1.25

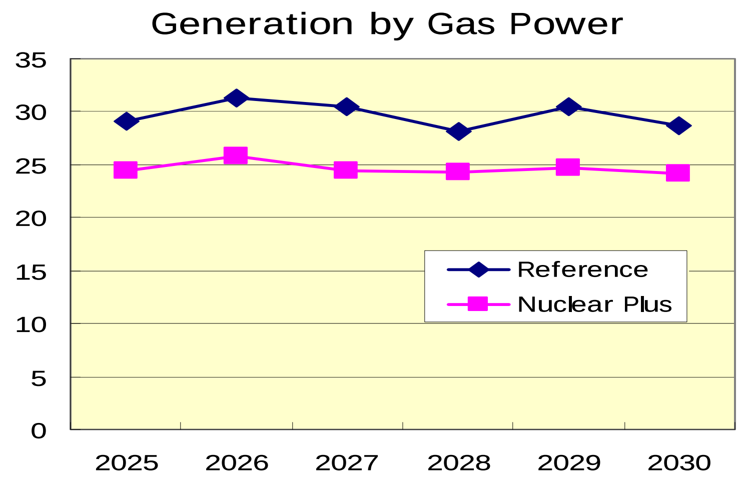
In order to decrease the total primary energy (TPE) and CO2 emission, It is best to promote the energy efficiency and conservation (EEC).

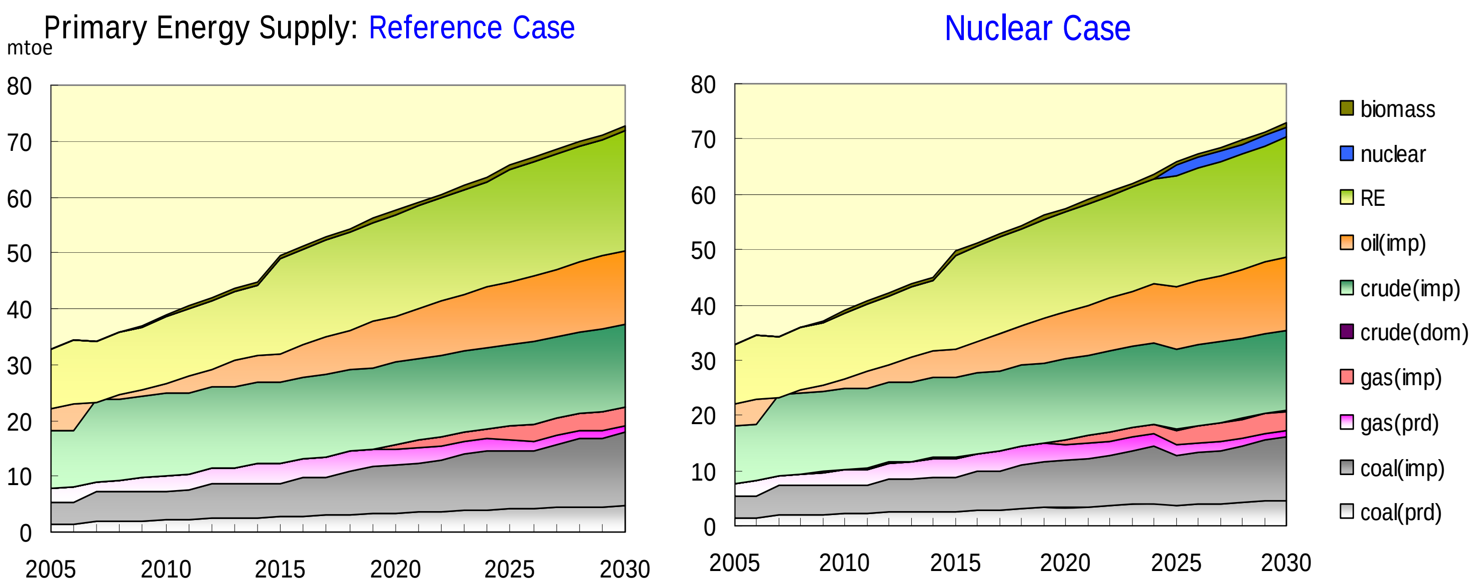
Economic growth gives the second effect to the TPA & CO2 emission.

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

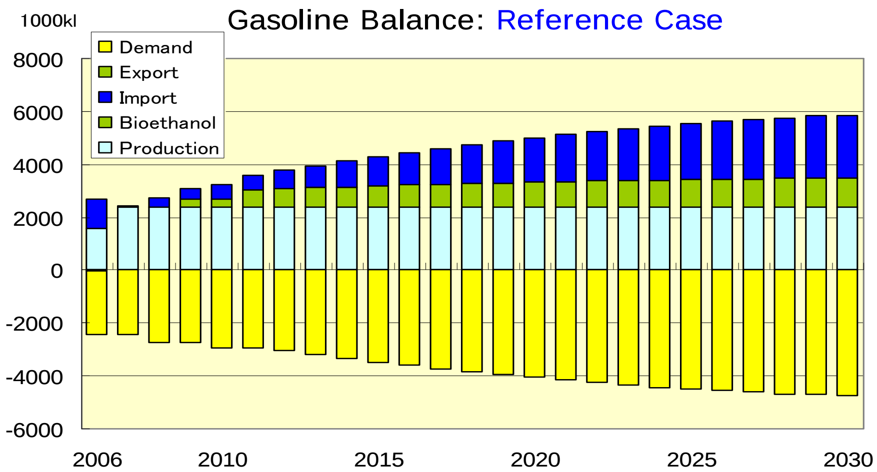
Analyze(2) Ref and Nuclear

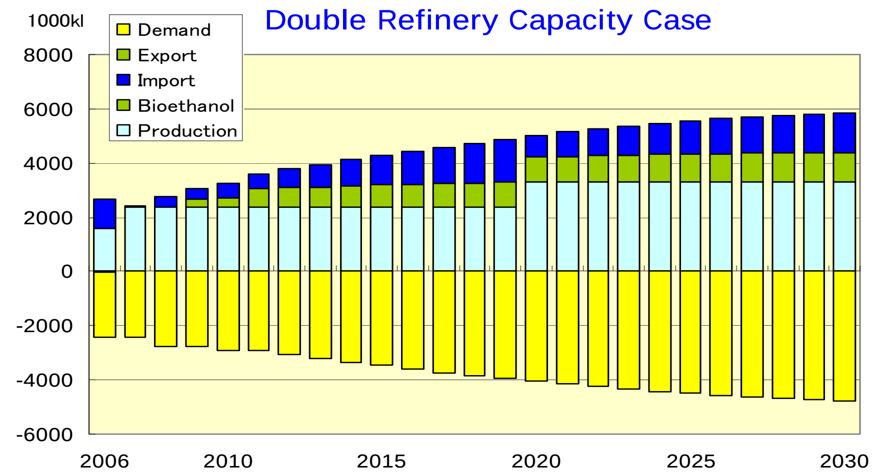


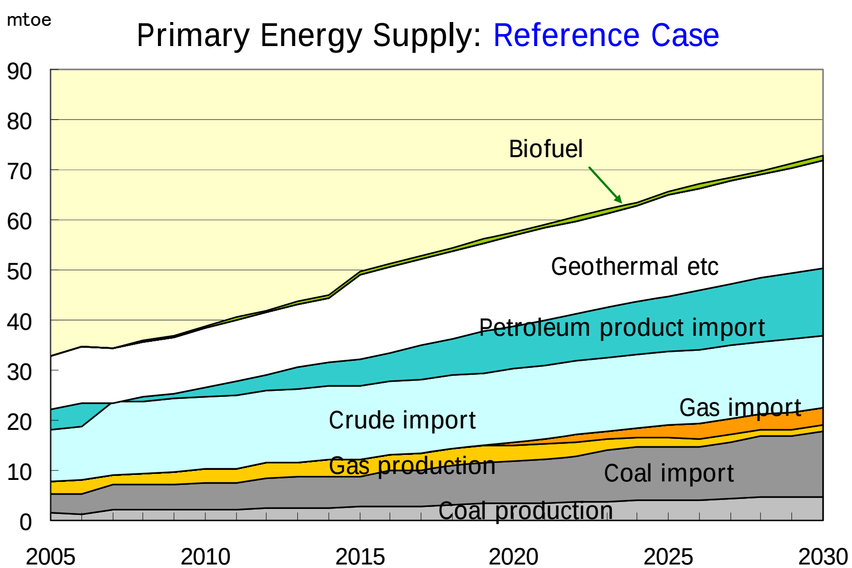


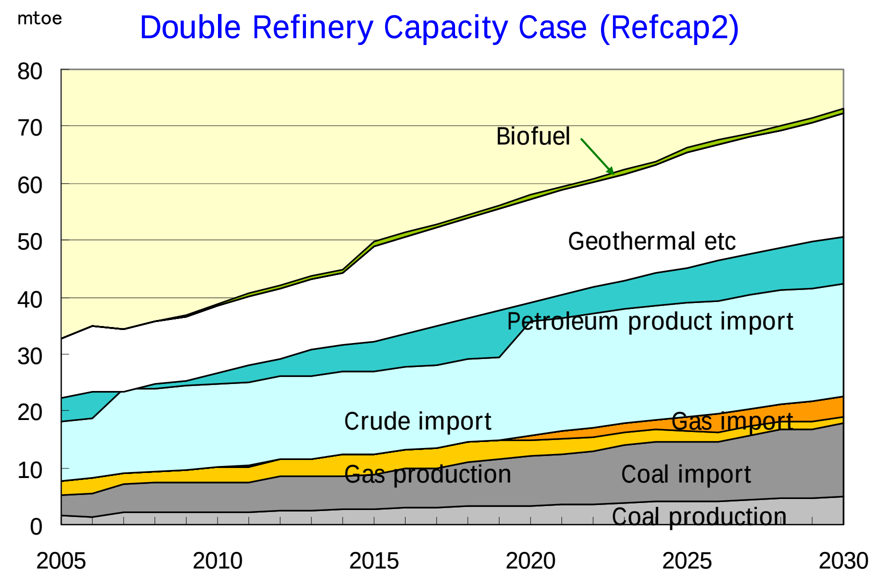


Analyze(3) -Ref and Refinery Cap enlarge



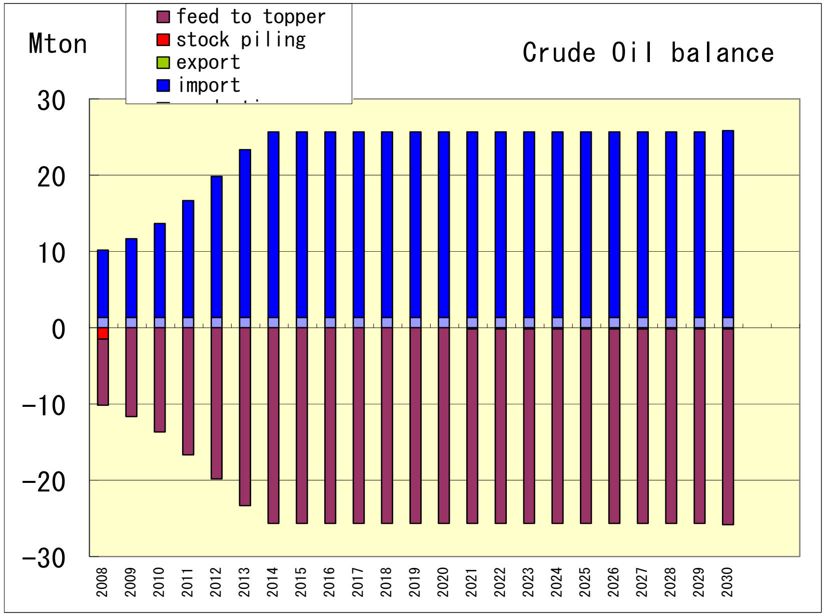


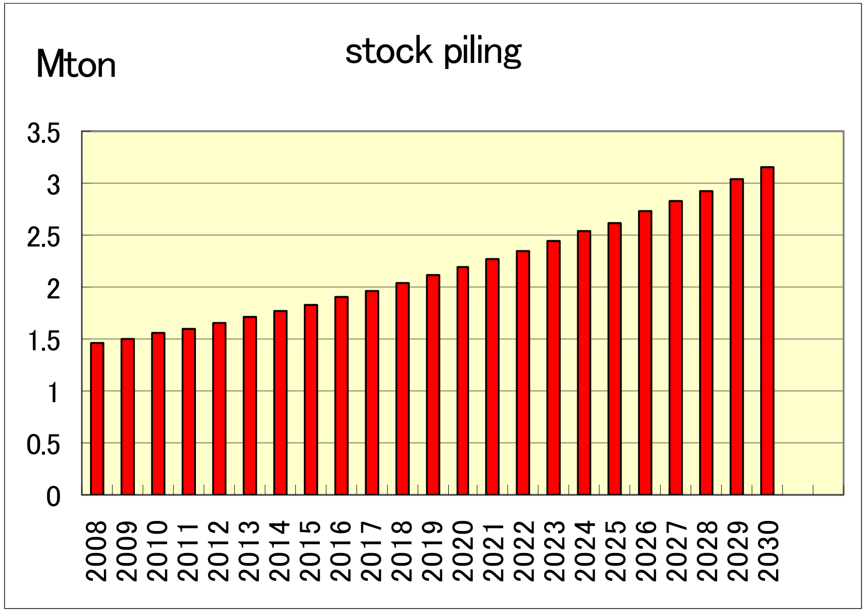


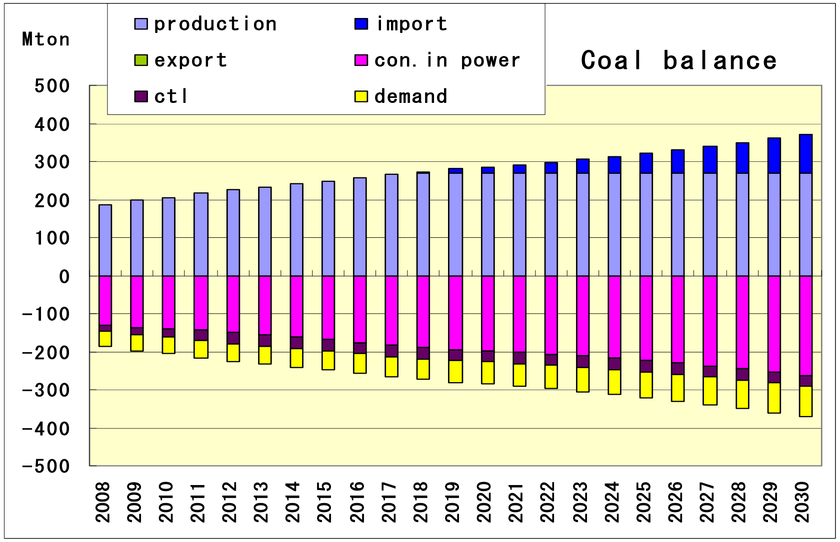


Trial Optimization model for SA

The result of BAU (1)





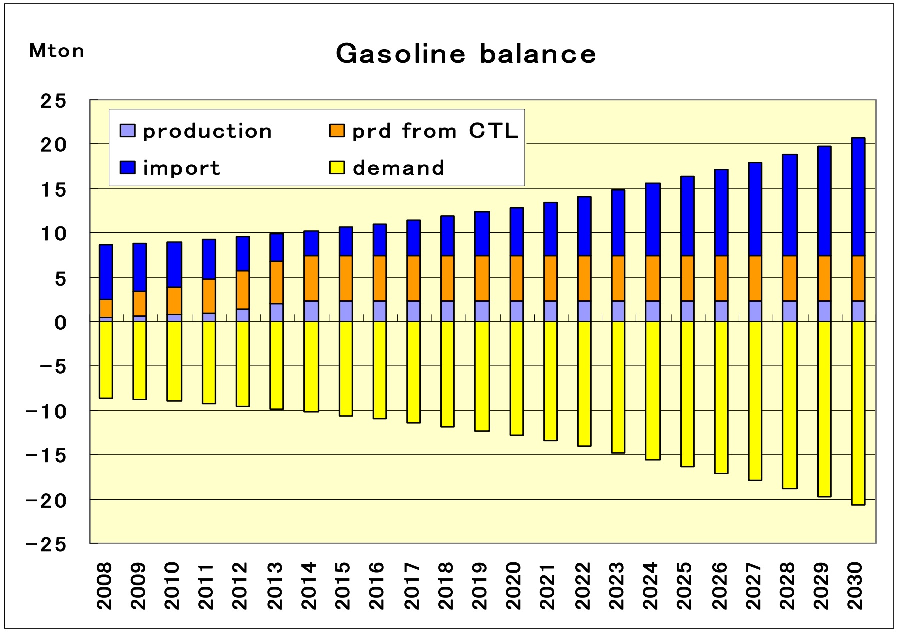


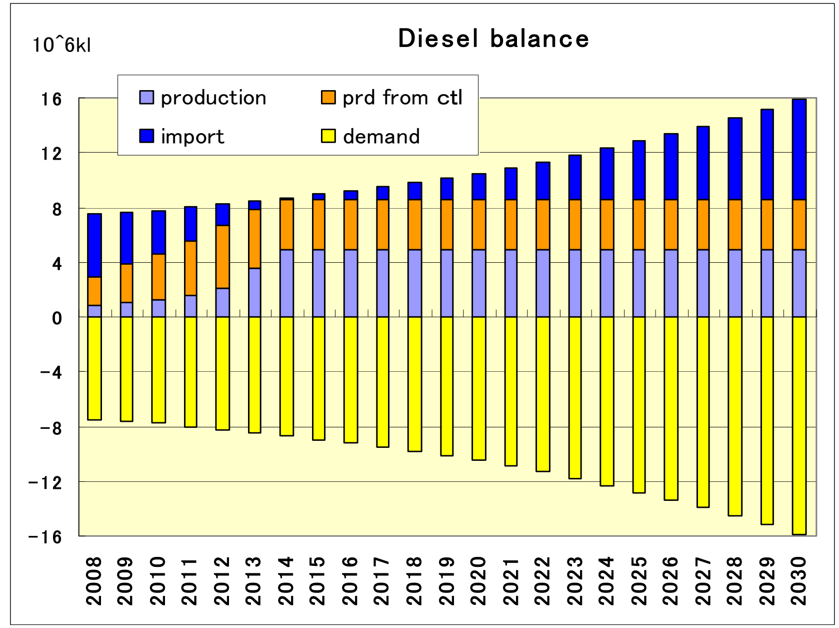
Criterion for oil stockpiling

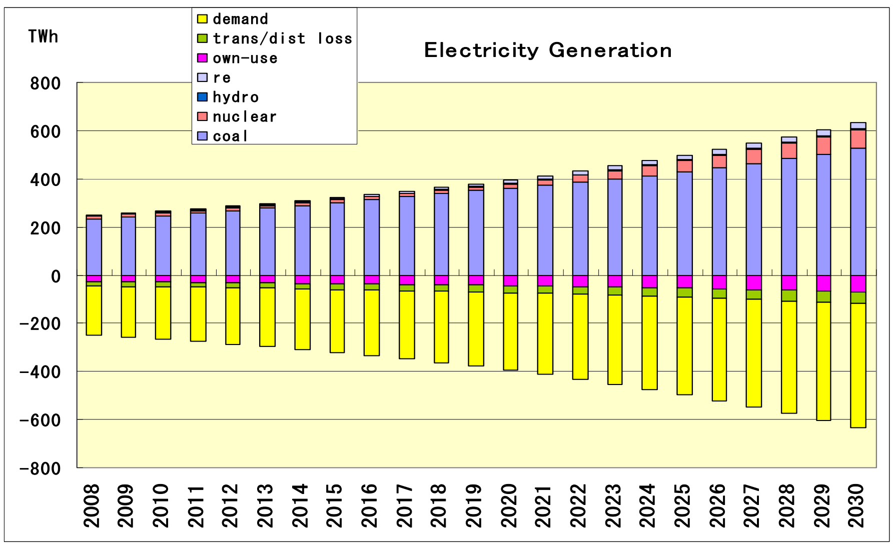
28 days of consumption
of total petroleum production

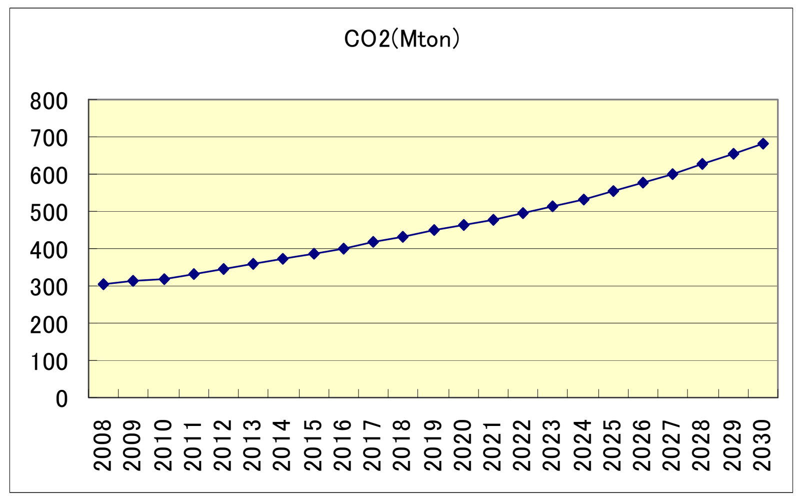
It starts at 2008.

The result of BAU (2)

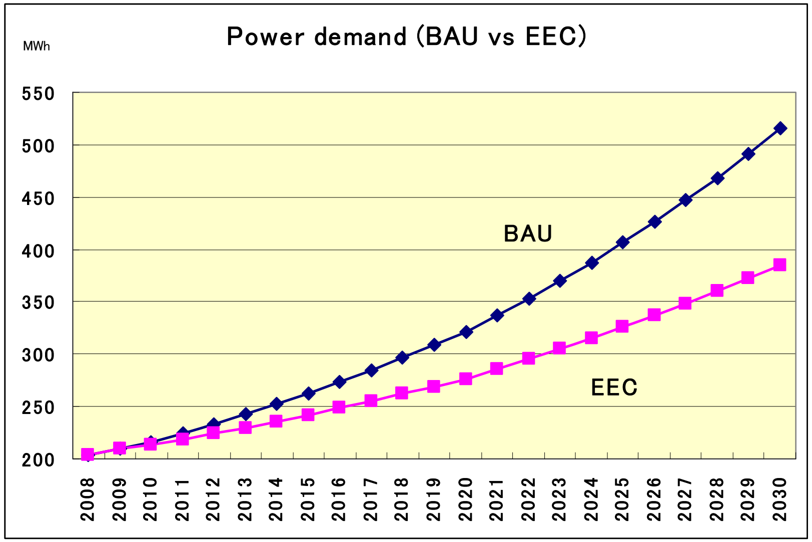


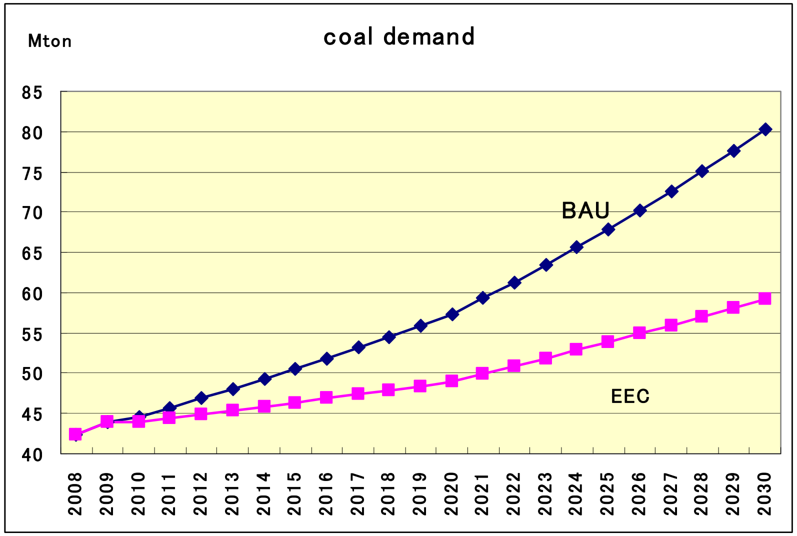


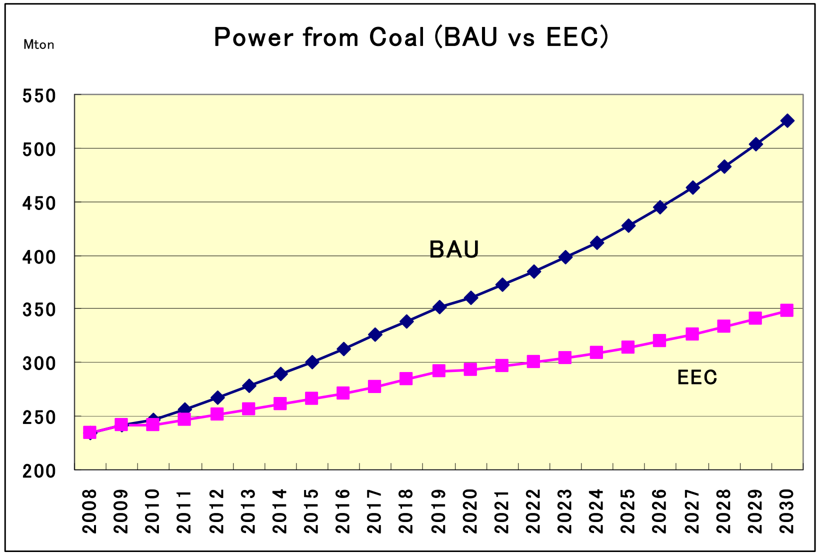


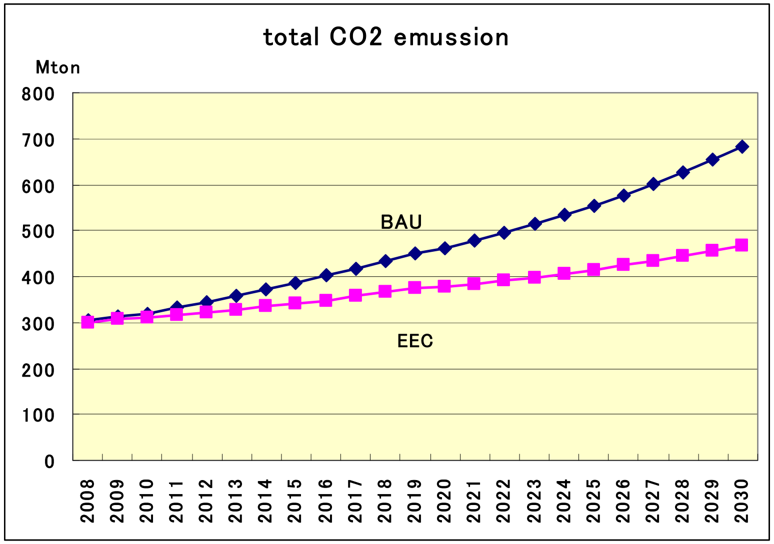


The comparison of BAU and EEC case(1)

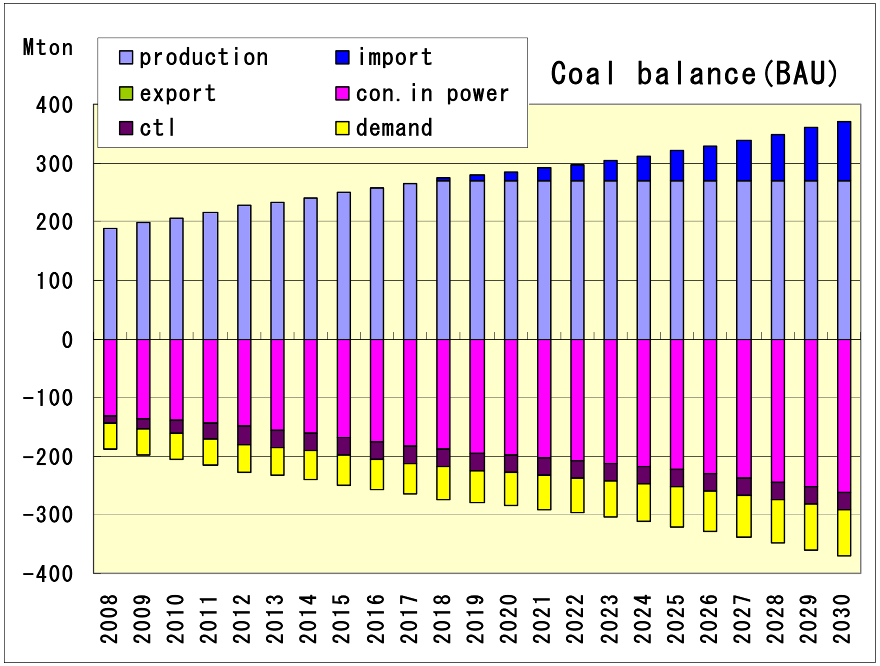


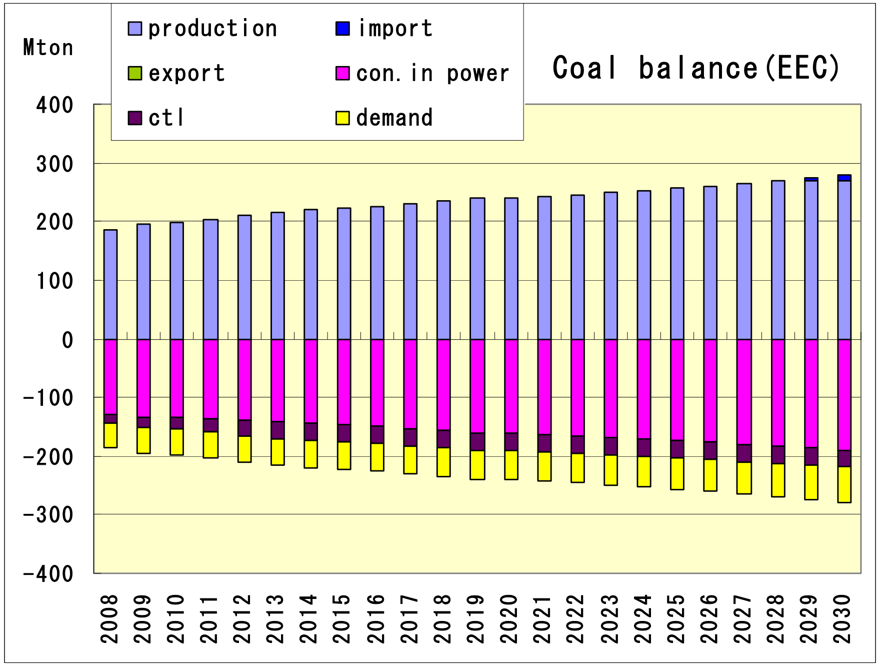






The result of BAU and EEC case(2)





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 !

Energy Efficiency Feedback Session - 27 January 09

	Name	Organisation	Attended
1	Dr Tony Paterson	Aluminium Federation of SA	
2	Mr Keith Arnold	AngloGold Ashanti	
3	Mr Peter Nott	ArcelorMittal	
4	Mr Dennis Brits	ArcelorMittal	
5	Mr Francois van der Bank	ArcelorMittal SA	
6	Mr Koji Baba	Bank of Tokyo-Mitsubishi UFJ, Ltd.	
7	Ms Ntsiki Mbono	BHP Billiton	
8	Mr Barry Bredenkamp	Central Energy Fund	
9	Mr Raoul Goosen	Central Energy Fund	
10	Mr Tebogo Snyer	Central Energy Fund	
11	Ms Gillian Chan-Sam	Central Energy Fund (CEF) Pty Ltd	
12	Mr Thabo Mahlatsi	City of Johannesburg	
13	Mr Frans Dekker	City of TSHWANE	
14	Mr Kagiso Keatimilwe	CSIR	
15	Mr Mongo Mehlwana	CSIR	
16	Mr Moses Chundu	DBSA	
17	Mr Yaw Afrane-Okese	DBSA - REMT	
18	Mr Lambona Aphane	Department of Minerals and Energy	
19	Mr Maphuti Legodi	Department of Minerals and Energy	
20	Ms Nelisiwe Magubane	Department of Minerals and Energy	
21	Dr Edwin Ritchken	Department of Public Enterprises	
22	Mr Maesela John Kekana	Department of Trade and Industry	
23	Ms Chanel van Zyl	Department of Trade and Industry	
24	Mrs Marba Visagie	Department of Trade and Industry	
25	Mr Chris Forlee	Department Public Enterprises	
26	Mr Johan van Zyl	Department Public Enterprises	
27	Dr Elsa du toit	DME	
28	Mr Dumisane Buthelezi	DTI	
29	Mr Maesela Kekana	DTI	
30	Mr Tsheko Modise	DTI	
31	Mr Yohei Miyauchi	Embassy of Japan	
32	Mr Yusuke Nakanishi	Embassy of Japan	

33	Mr Craig van Zyl	Eris Property Group	
34	Mr Piet Buys	Eskom	
35	Mr Raj Pandaram	Eskom	
36	Mr Nigel Vlok	Eskom	
37	Mr Dhevan Pillay	Eskom	
38	Mr Lawrence Padachi	Eskom	
39	Ms Rochelle Chetty	Eskom	
40	Mr Mark Chettlar	Eskom Holdings Limited	
41	Mr Corrie Visagie	Eskom Holdings Limited	
42	Mr Zaheer Khan	Eskom Holdings Ltd	
43	Mr Monkwe Mpye	Eskom Holdings Ltd	
44	Mr Raj Pandaram	Eskom Holdings Ltd	
45	Mr Nigel Volk	Eskom Holdings Ltd	
46	Mr Mike Hughes	Exxaro	
47	Mrs Madeleine Ronquest	FirstRand Ltd.	
48	Mr Idi Okada	Hitachi	
49	Mr Tatsuyuki Asakura	IEEJ	
50	Mr Tomoyuki Inoue	IEEJ	
51	Mr Takeo Suzuki	IEEJ	
52	Mr Ono	JICA SA	
53	Mr Sakurai	JICA SA	
54	Ms Kea Tlhaphane	Johnson Matthey	
55	Mr Phillip de Bruyn	Marubeni Corp	
56	Mr Rob Ashdown	Merchantec Coprorate Finance	
57	Mr Tatsuya Hori	Mitsui & Co. Europe plc.	
58	Mrs Christine Dunbar	National Business Initiative	
59	Mrs Valerie Geen	National Business Initiative	
60	Mr Nhlanhla Sibisi	National Business Initiative	
61	Ms Candice Wakefield	National Business Initiative	
62	Mr Thembani Bukula	NERSA	
63	Mr J Coetzer	NERSA	
64	Ms Elsie Coetzee	NMISA	
65	Mr Mhlonipheni Shezi	Pretoria Portland Cement	
66	Ms Amanda Luxande	REEEP	

67	Mr Boikanyo Mokgatle	SAAPA	
68	Mr Nelson Mbatha	Shell	
69	Ms Karin M Ireton	Standard Bank	
70	Mr M Yshima	Sumitomo Corp	
71	Mr Hope Mashele	TFMC	
72	Mr Marc James Thomson	Toyota Tsusho Africa (Pty) Ltd	
73	Dr Willem den Heijer	University of North West	
74	Mr Charl Marais	University of North West	
75	Mr Peet du Plooy	WWF	

＋ 東電側団員４名、佐川氏（BTMU）

Appendix Ⅱ

Workshop on
Energy Demand Forecast and Supply Optimization Model

28th, January 2009, at DTI meeting room, Pretria

Appendix II:

Workshop on
Energy Demand Forecast and Supply Optimization Model
28th, January 2009, at DTI meeting room, Pretria

1. 報告資料

1) Energy Demand Forecasting Model

Mr. T. Inoue, IEEJ

2) Energy Supply Optimization Model

Mr. T. Asakura, IEEJ

2. 出席者

以下の表の通り

	名前	所属
1	Tshilidzi Ramuedzisi	DME Planning, Director
2	Mmabakwena Dithupe	DME Planning
3	Nombuelo Mahlangu	DME Planning
4	Elias Modiba	DME Planning
5	Sarau Lepawanc	DME Planning
6	Jeff Subramoncy	DME Planning
7	Rabelani Tshikalange	DME EE
8	Gabriel Jamo	Dti ecomic infr.
9	Thobo Gopane	Dti
10	Paula MakcabnHere	Dti
11	Ehvis Ramafamba	Dti
12	Velalphi Msimarg	DST-Energy
13	Roumen Anguela	Univ. of Pretoria

Energy Demand Forecasting Model

Workshop, Jan 2009

CONTENTS

1. Methodology for Energy Demand Forecasting Model
2. Energy Demand Forecasting Model Building
3. Simulation Results & Evaluation

The Institute of Energy Economics, Japan

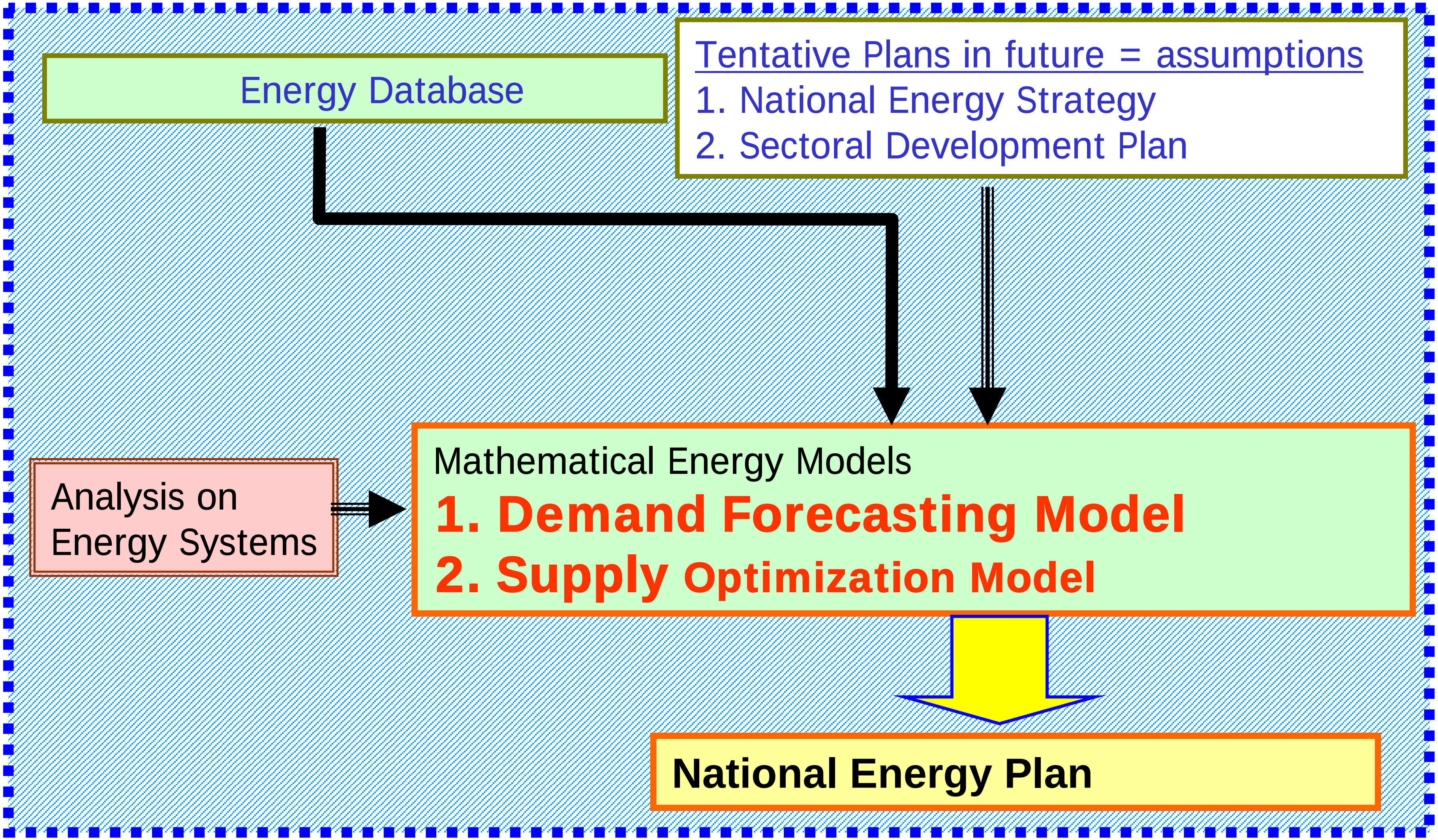
Energy Supply Optimization Modeling

The Institute of Energy, Economics, Japan

Tatsuyuki ASAKURA

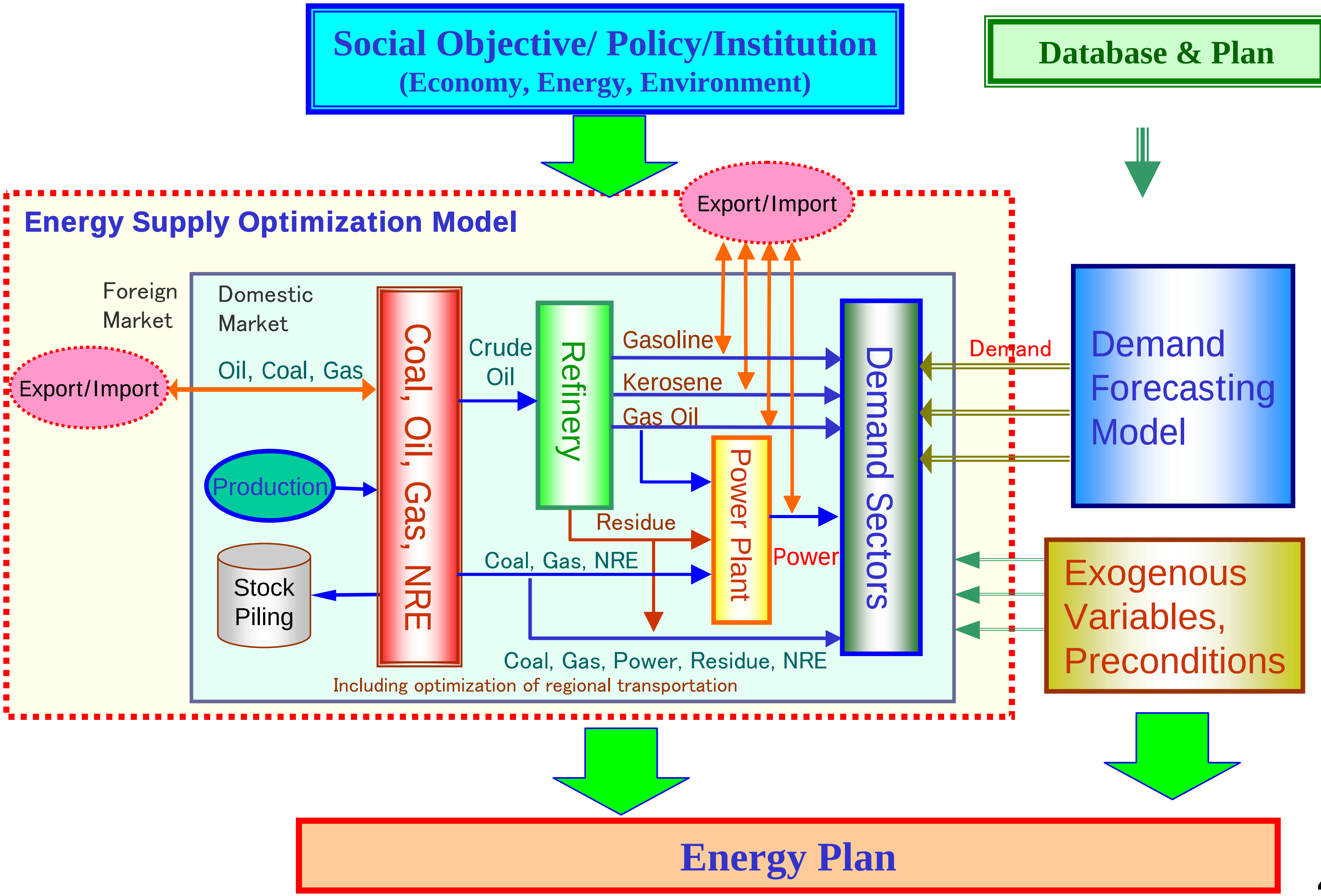
28/Jan, 2009

Position of Mathematical Energy model

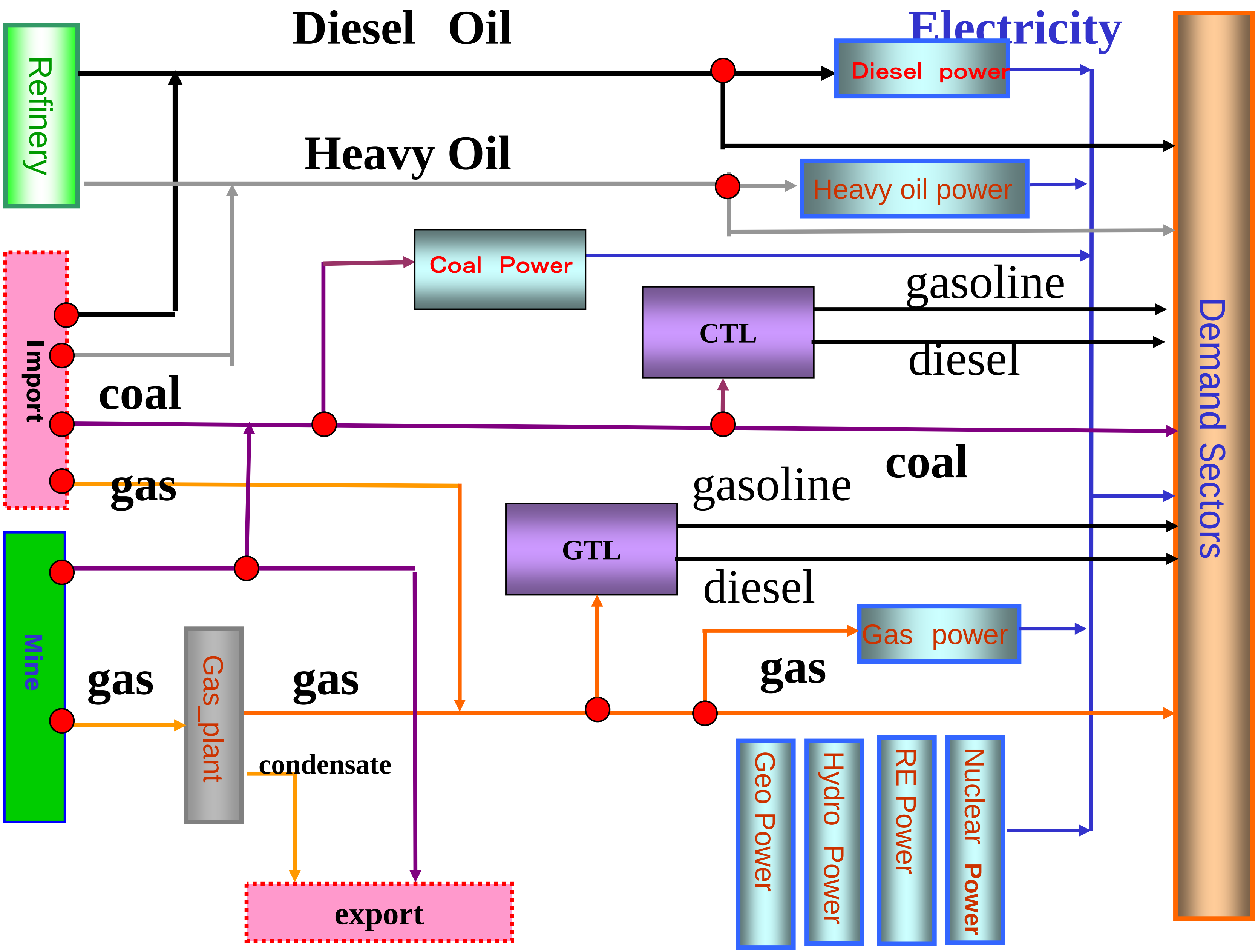


What is the LP optimization model ?

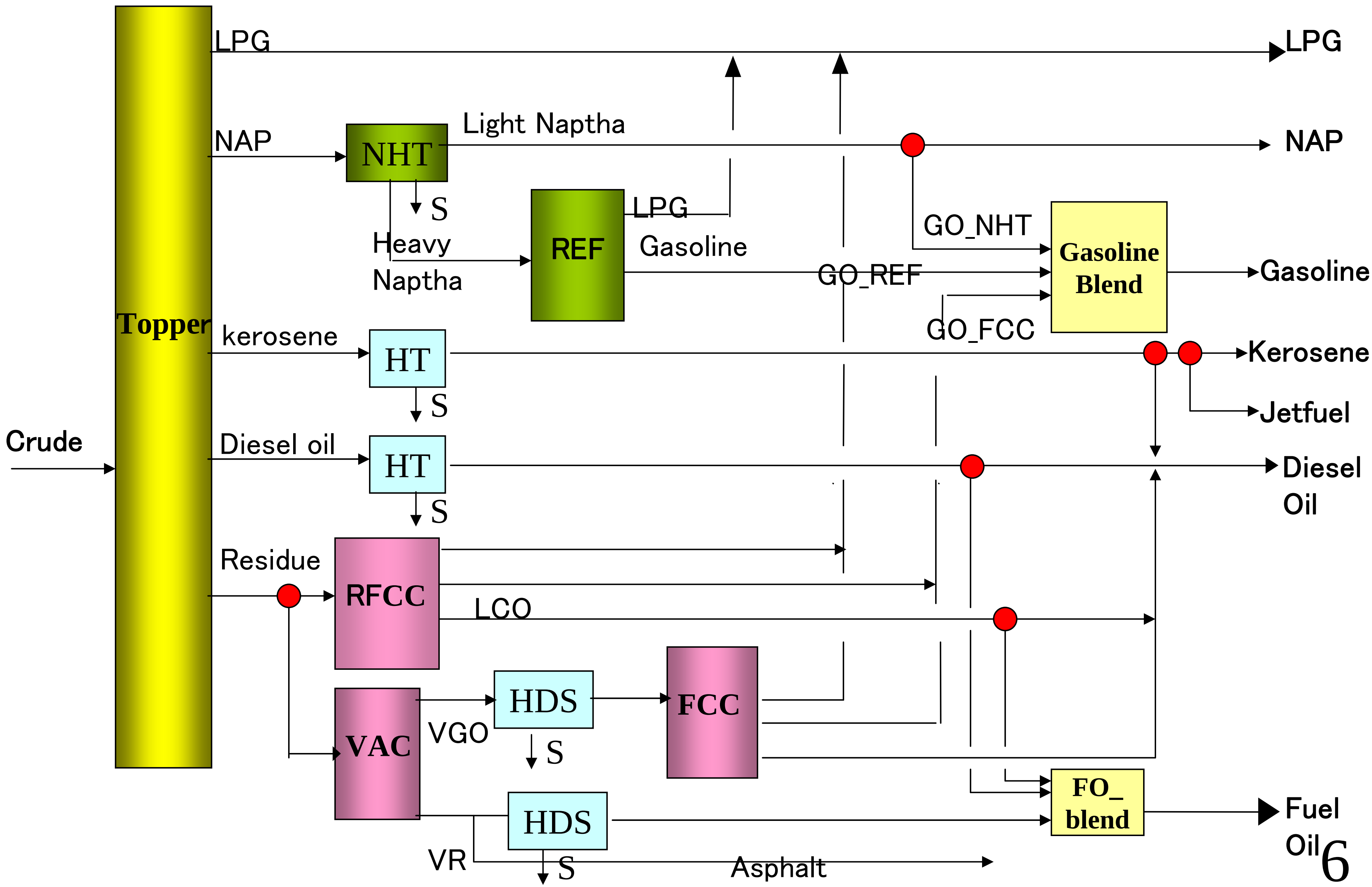
Structure of Optimization Model



Typical Flow Diagram of Coal･Gas･Electricity



Typical Flow Diagram for Refinery model



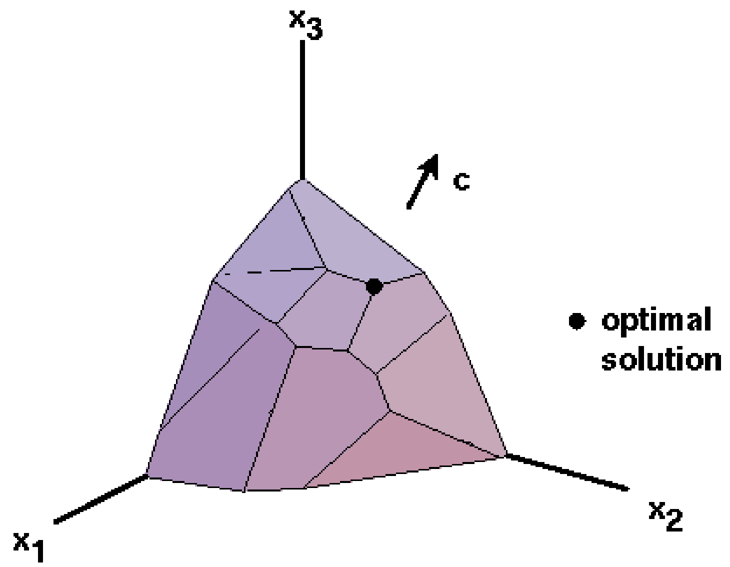
What is LP model?

Definition：

①LP model is composed of many constraints and one objective function and many variables.

②Constrain and objective function are represented in linear formula.

③LP model is to get variables values with max or min objective function under satisfying all constraints.



Set of variables satisfying constraints is convex polyhedron.

Optimal solution always exists on vertex of convex polyhedron.

LP finds this vertex.

Model Summary : Basic Constraints

1　production＝Yield＊Raw material feed

ex)　gasoline production＝0.3＊Crude oil feed

2　fuel consumption＝860*Generating power ／（heat value*thermal efficiency）　(power plant)

3　production + import - export = Demand :balance

4　Generating power≦Capacity＊load factor＊（1－self_use）　（power plant）

5　Min of Imp/Exp≦ Imp/Exp ≦Max of Imp/Exp

Brown letter : variables (model will decide)

Blue letters : input data

Model Summary : Objective function

Total cost＝Σ（y）（year cost）／（1＋r）^（y－2008）:NPV

year cost＝production cost + import cost + transfer cost
+ operation /maintenance cost - export sales
- domestic sales(demand)

r：deflator by year

y：year

General form of LP model

Constrains

$$a_{1,1} * X_1 + a_{1,2} * X_2 + \cdots + a_{1,n} * X_n \leq b_1$$
$$a_{2,1} * X_1 + a_{2,2} * X_2 + \cdots + a_{2,n} * X_n \leq b_2$$
$$\vdots$$
$$a_{m,1} * X_1 + a_{m,2} * X_2 + \cdots + a_{m,n} * X_n \leq b_m$$

Objective function

$$Z = c_1 * X_1 + c_2 * X_2 + \cdots + c_n * X_n \rightarrow Max \quad or \quad Min$$

Variables : $X_j \geq 0$ for $j = 1, 2, \cdots, n$

parameter : $a_{i,j}, b_i$ for $i = 1, 2, \cdots, m$ $j = 1, 2, \cdots, n$

Right hand side : b_j

Operator : $\leq, =$

operator in constrains : any kinds of $\leq, \geq, =$ are allowed .

Features of LP model

1 **Optimal solution is mathematically guaranteed .**
(It is difficult to solve optimization model except LP in the real business field)

2 **There are some useful LP software.**
Even if you do not know how to solve LP, you can solve it.
All you have to know is how to use solver.

3 **There are many cases which LP can be applied in business field including energy field .**

Defect of LP model

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１ **All constraints and objective function should be linear.**

If it is non linear, it must be approximated to linear.

２ **Optimal solutions are apt to be extreme.**

ex）It is full load today, stop the next day in the case plant load,
This pattern often happens.（Not realistic）

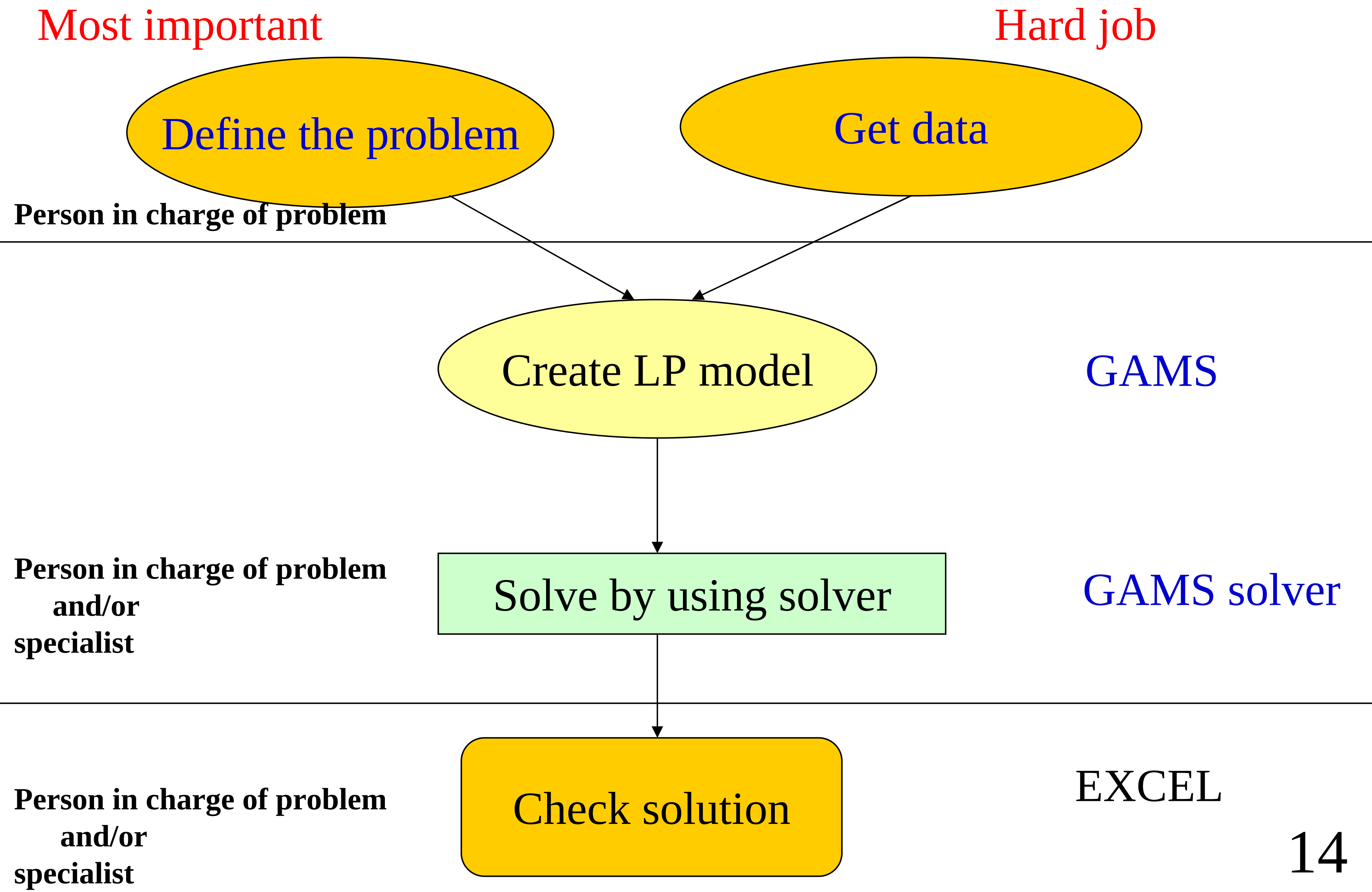
measure）After getting the solution, new constraints should be added or modified in trial and error in order that solutions comes to near realistic.

３ **True cause of infeasibility may be difficult to be founded**

（ infeasibility means that constraints can not be satisfied
In many cases miss data and miss constraints)

How to build up the optimization model and sample of Technical Transfer

Procedure to solve the LP model



Role of persons to build the model

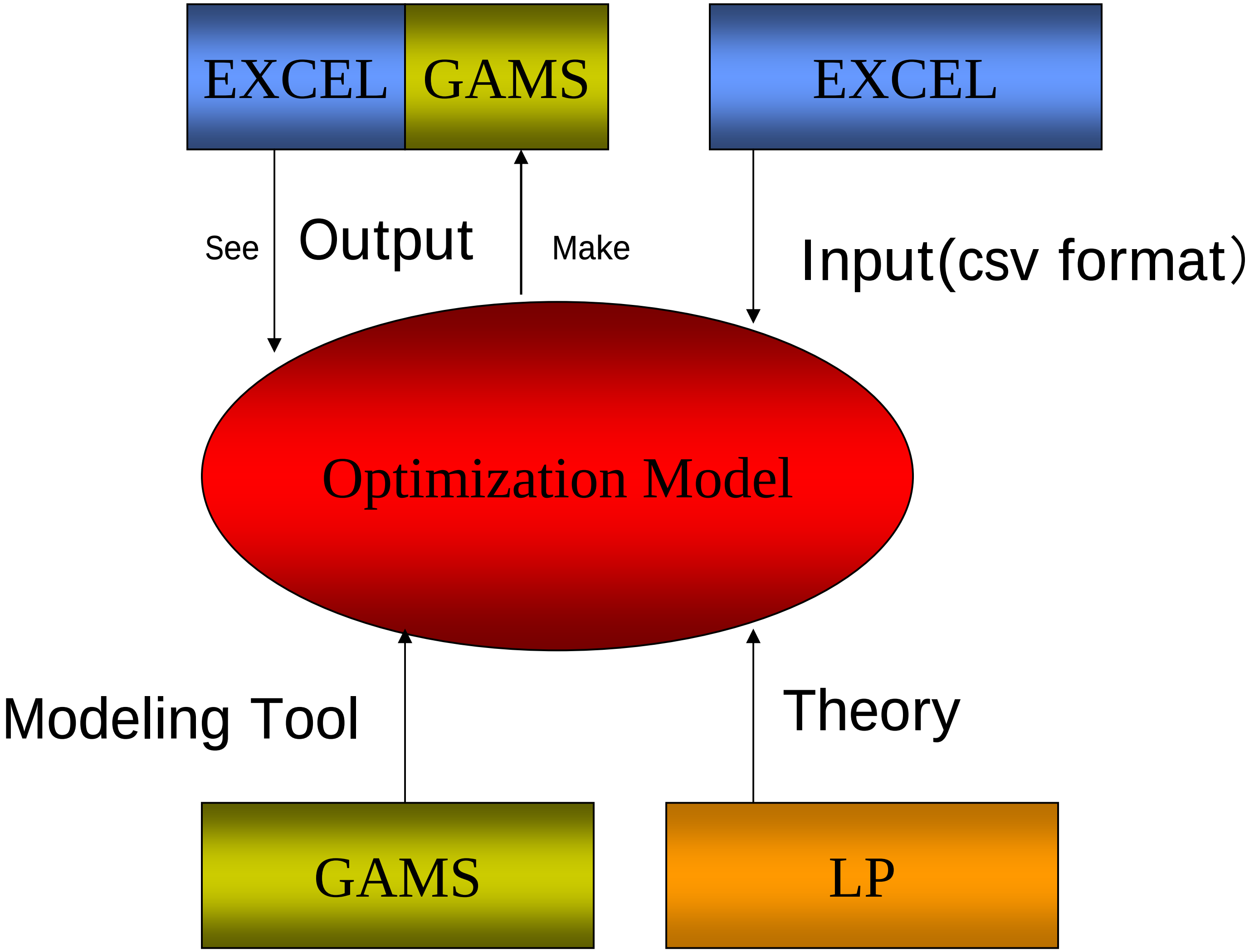
The role of persons who want to solve the problem

1 Define the purpose to build the optimization model
2 Define the energy flow
3 Define the constraints
4 Collect data
5 Analyze the results

The role of the modeler

1 Cooperate to define the energy flow and constraints with the above person
2 Actualize the LP model using GAMS
3 Cooperate to analyze the results

System tool



EXCEL
GAMS
EXCEL
See
Output
Make
Input(csv format)
Optimization Model
Modeling Tool
Theory
GAMS
LP

System tool : GAMS

GAMS: The Generalized Algebraic Modeling System

product name of GAMS Co.ltd
home page address = www.gams.com

GAMS is a modeling system for mathematical programming and optimization

1. **Computer language**
2. **MARKAL uses GAMS. (LP base)**
3. **Many oil refining companies in USA, Europe and Japan use GAMS as a tool of optimal production planning system.**

The barrier of building the model

There are some barriers in building up the optimization model.

The hardest problem is to collect data.

Reason) 1 Every data is requested in order to build up the model.
There are many confidential data.

ex) Oil refinery plant technical specification.
This plant is belonging to the private company.
This data is usually confidential outside the company.

Reason) 2 The optimization model is used for the future energy policy.
So many data of the future is not easy to get.

Example of technical transfer

1 The concept of optimization model by LP (lecture)

- What is optimization model ？
- What is LP model ？
- Feature of LP model
- Application area of LP model

2 How to make LP model (lecture)

- how to draw energy flow
- how to make constraint
- how to make object function

3 How to use tool(=GAMS)

- GAMS grammar (lecture)
- Simple LP examples by GAMS (exercise)

4 Making the energy model & test (cooperation)

5 Doing the various case studies (cooperation)

6 Analyzing the various case studies (cooperation)

Example of the optimization model

Scale of Philippines LP model

Ex) Philippines supply optimization model

Target year = 2006 ~ 2030 (25 years)

No of constraints = 7,700
No of variables = 10,700

execution time < 1 second

Software : GAMS
(Generalized Algebraic Modeling Software)

Input and Output

IEE JAPAN TEPCO

Input	Production Demand Import/Export Technology Cost/Price Economy/Security Environment EXCEL

Output	Balance Check of Result Check of Input EXCEL

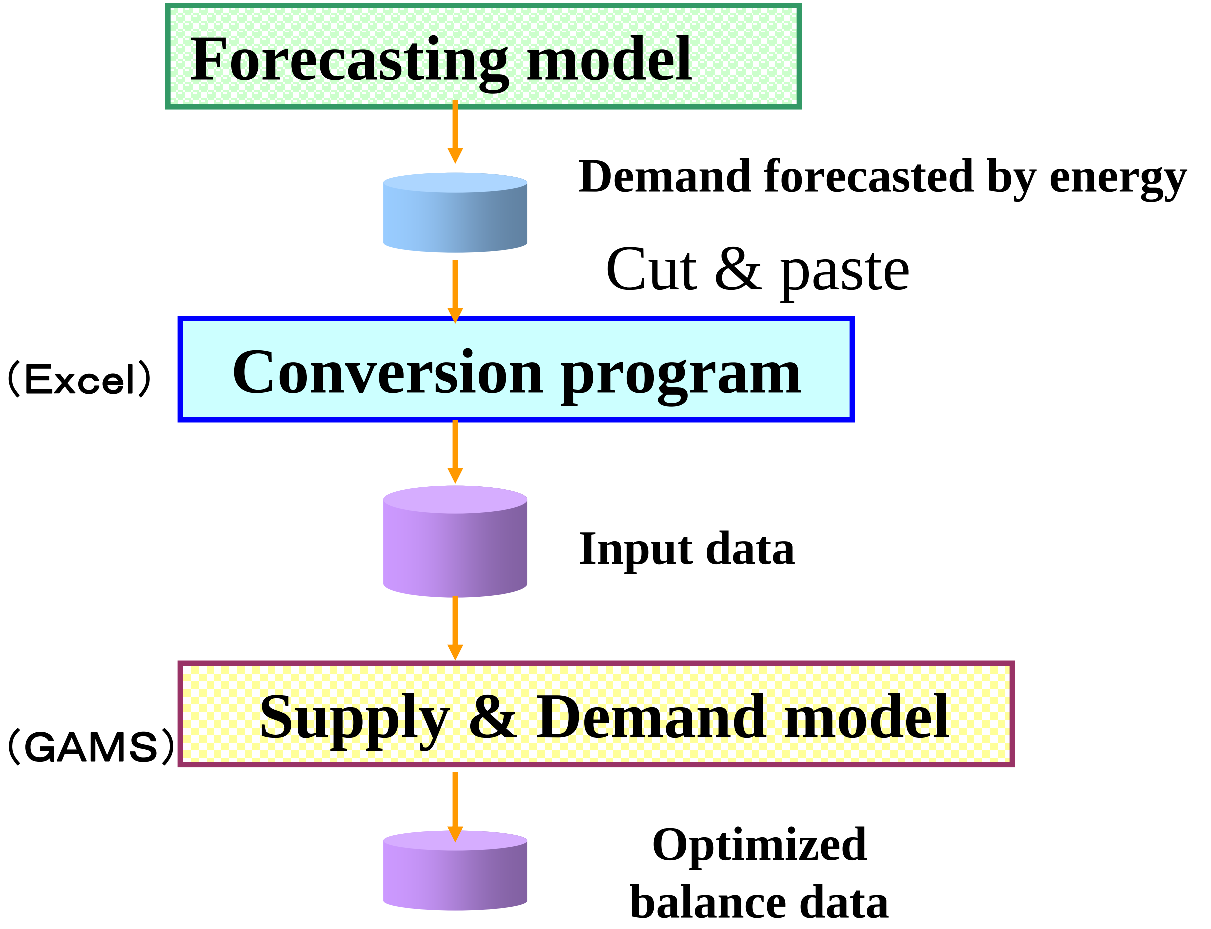
Input items(1)

Production	Max/Min production / year Capacity of each Plant (power, refinery etc) Base Generation of power (Nuclear, Hydro)
Demand	All energy (ktoe/y) (Coal, Gas, Petroleum products, RE)
Import/Export	Max/Min of Import for each energy Max/Min of Export for each energy
Economy Security	Deflator Exchange rate Stock day for oil stockpiling Initial oil stock
Environment	CO_2 emission CO_2 emission max (if necessary)

Input items(2)

Technology	Yield for every plant (ex refinery) plant Heat Value for each energy Specific gravity of energy Power Plant Availability Thermal Efficiency for each power plant Self Use ratio in power plant and refinery Distribution loss ratio in power
Cost / Price	Production cost Import cost / Export price Operation/Maintenance cost Domestic sales price
Structure	All energy flow Policy (ex Domestic production/Import>= xx)

Demand data from Forecasting model



Example of the demand data

* demand	KTOE	KTOE	KTOE	KTOE	KTOE	KTOE	KTOE	KTOE	KTOE	KTOE
x	Coal	gas	LPG	gasoline	jet_fuel	kerosene	Diesel	Fuel_oil	el	RE
2006	17500.08	1868	57	8405	1754	625	7260	49	16370	9967
2007	19044.68	1881.883	56.5165	8844.235	1821.205823	80.3413	7505.31	50.72719	17050.34	9786.662
2008	19090.66	1889.766	56.89907	9000.569	1853.657677	80.78488	7613.271	51.06321	17466.41	9735.12
2009	19764.2	1960.106	59.52955	9183.418	1891.203711	82.82778	7774.752	52.33039	18003.14	9977.579
2010	20070.5	1992.65	61.30352	9384.277	1933.19616	82.69026	7906.46	52.18012	18564.64	10057
2011	20571.85	2047.89	63.94825	9696.743	1998.350124	82.9946	8120.892	52.29764	19304.15	10151.7
2012	21090.68	2104.171	66.83086	10031.54	2068.216789	83.14394	8347.085	52.30693	20078.83	10262.73
2013	21625.75	2161.525	69.93088	10387.89	2142.610008	83.20899	8585.738	52.25698	20888.95	10385.77
2014	22176.24	2219.979	73.23562	10765.26	2221.406186	83.22645	8837.178	52.17276	21734.97	10517.79
2015	22741.68	2279.557	76.73798	11163.34	2304.532612	83.21559	9101.58	52.06702	22617.52	10656.67
2016	23322.04	2340.307	80.43592	11581.89	2391.958529	83.13653	9378.344	51.90996	23537.17	10800.92
2017	23916.96	2402.216	84.32848	12021.05	2483.688237	83.04609	9668.383	51.74208	24495.1	10949.48
2018	24526.48	2465.298	88.41797	12480.97	2579.755719	82.94663	9971.881	51.56453	25492.38	11101.6
2019	25150.55	2529.564	92.70847	12961.94	2680.220413	82.83904	10289.03	51.37802	26530.01	11256.76
2020	25789.44	2595.029	97.20547	13464.35	2785.163889	82.72282	10620.13	51.1814	27609.45	11414.58
2021	26675.85	2691.06	102.905	14121.95	2922.520743	82.57957	11053.87	50.93362	28939.56	11563.35
2022	27592.85	2790.087	108.9273	14813.92	3067.050693	82.43518	11510.25	50.67783	30335.82	11714.03
2023	28541.42	2892.187	115.2885	15541.72	3219.063212	82.29095	11990.29	50.41444	31801.39	11866.47
2024	29522.58	2997.442	122.0059	16306.95	3378.891228	82.14813	12495.07	50.14383	33339.58	12020.57
2025	30537.43	3105.931	129.0983	17111.33	3546.890982	82.00796	13025.73	49.86638	34953.86	12176.26
2026	31587.06	3217.738	136.5854	17956.67	3723.442105	81.87171	13583.51	49.58243	36647.92	12333.49
2027	32672.65	3332.945	144.4881	18844.9	3908.947874	81.74063	14169.7	49.29232	38425.59	12492.22
2028	33795.41	3451.638	152.8286	19778.08	4103.83564	81.61602	14785.68	48.99638	40290.91	12652.41
2029	34956.58	3573.903	161.6303	20758.37	4308.557399	81.49918	15432.91	48.69493	42248.13	12814.05
2030	36157.47	3699.826	170.918	21788.06	4523.590493	81.39148	16112.91	48.38828	44301.69	12977.1

Save File

1. This is the 1 sheet of input_data.xls.
2. This data comes from the forecasting model result.
3. This sheet data is converted to 1 file with extention "csv" by click the "Save File" .

Output item

Balance	Energy Balance Refinery Balance Electricity Balance
Check of output	Production Supply Consumption Import Export
Check of Input	Cost Bound Demand

Balance table

year	term	crude	coal	gas	LPG	gasoline	kerosene	jet_fuel	diesel	fuel_oil	el
		ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe	ktoe
2008	productior	1278	84369.42	1619.57	56.9	2620.22	0	1106.09	2955.02	5829.31	21448.29
2008	import	7386.74	0	271.55	0	6380.35	80.78	747.57	4658.25	0	0
2008	export	0	0	0	0	0	0	0	0	5778.25	0
2008	surplus	0	0	0	0	0	0	0	0	0	0
2008	stock pilin	0	0	0	0	0	0	0	0	0	0
2008	supply	8664.74	84369.42	1891.12	56.9	9000.57	80.78	1853.66	7613.27	51.06	21448.29
2008	transform	8664.74	59169.44	0	0	0	0	0	0	0	0
2008	own–use	0	0	0	0	0	0	0	0	0	2359.31
2008	loss(waste	0	0	0	0	0	0	0	0	0	1622.56
2008	final consu	0	19090.66	1889.77	56.9	9000.57	80.78	1853.66	7613.27	51.06	17466.41
2009	productior	1278	89177.23	1619.57	59.53	3516.34	0	1481.61	3965.64	7923.99	22107.38
2009	bio	0	0	0	0	0	0	0	0	0	0
2009	import	10350.09	0	342.25	0	5667.08	82.83	409.59	3809.11	0	0
2009	export	0	0	0	0	0	0	0	0	7871.66	0
2009	surplus	0	0	0	0	0	0	0	0	0	0
2009	stock pilin	0	0	0	0	0	0	0	0	0	0
2009	supply	11628.09	89177.23	1961.82	59.53	9183.42	82.83	1891.2	7774.75	52.33	22107.38
2009	transform	11628.09	61107.94	0	0	0	0	0	0	0	0
2009	own–use	0	0	0	0	0	0	0	0	0	2431.81
2009	loss(waste	0	0	0	0	0	0	0	0	0	1672.42
2009	final consu	0	19764.2	1960.11	59.53	9183.42	82.83	1891.2	7774.75	52.33	18003.14

How to utilize Scenarios/case study

Samples of the other country

Case Setting

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%

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

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.

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

The result of case studies

1 Case studies only demand changes.

1) Reference (EEC, GR, price) = (0.5%, 5%,160$)
2) BAU (EEC, GR, price) = (0.0%, 5%,160$)
3) EEC (EEC, GR, price) = (1.0%, 5%,160$)
4) Super+EEC (EEC, GR, price) = (1.5%, 5%,160$)
5) E20 ref + (bio+ethanol =20%)
6) E85 ref + (bio+ethanol =85%)
7) High Growth (EEC, GR, price) = (0.5%, 6%,160$)
8) Low Growth (EEC, GR, price) = (0.5%, 4%,160$)
9) High Price (EEC, GR, price) = (0.5%, 5%,200$)
10) Super High Price (EEC, GR, price) = (0.5%, 5%,240$)
11) Low Price (EEC, GR, price) = (0.5%, 5%,140$)
12) Vehicle+plus(motorization) ref + (motor owner 10—20% up)

Analyze(1)—Total Primary Energy & CO2

At 2030

	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).

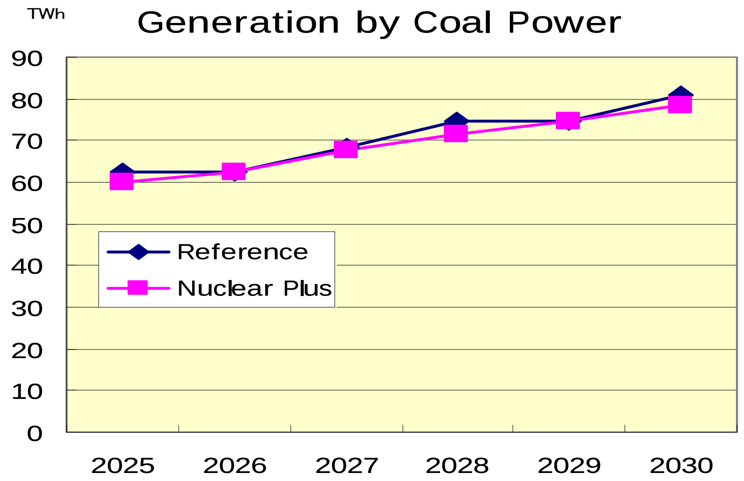
Economic growth gives the second effect to the TPA & CO2 emission.

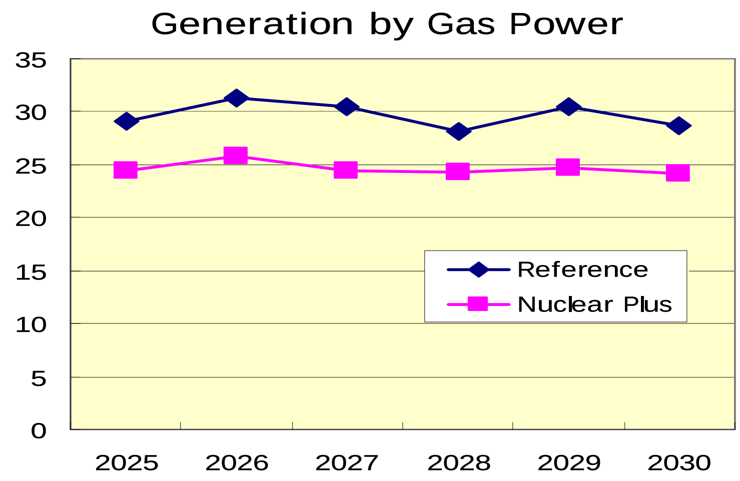
The price gives a little effect to TPE & CO2 emission.

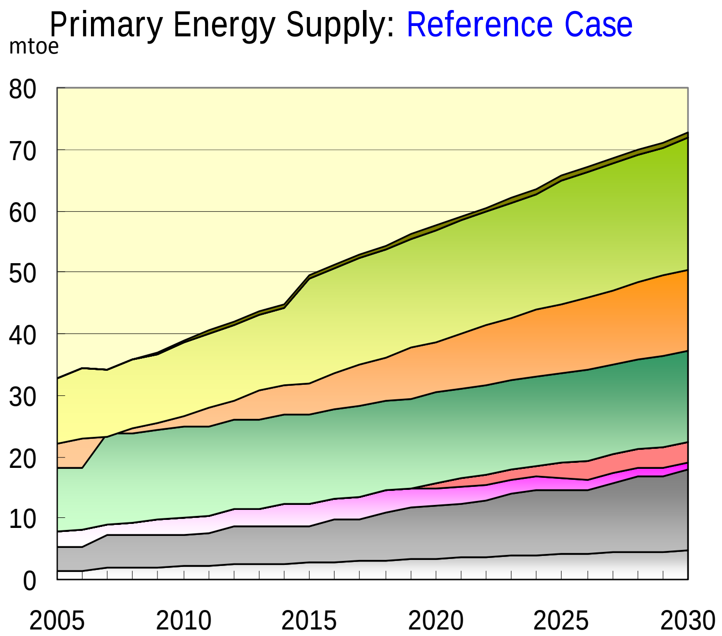
２ Case studies only supply changes. (demand=Reference)

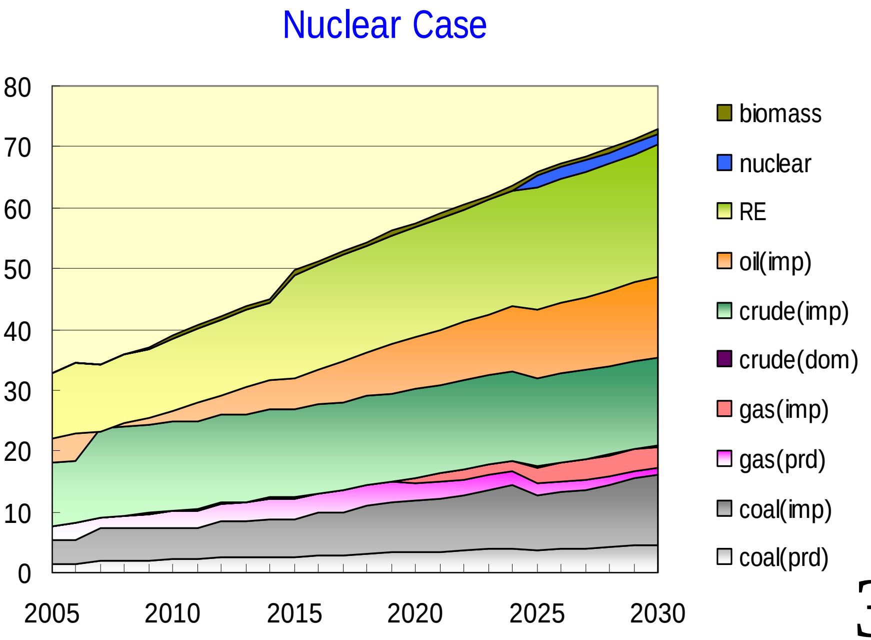
1) Reference (EEC, GR, price) = (0.5%, 5%,160$）
2)nuclear begins to start.
3)Refinery capacity twice
4)Renewable energy twice

Comparison between Ref and Nuclear

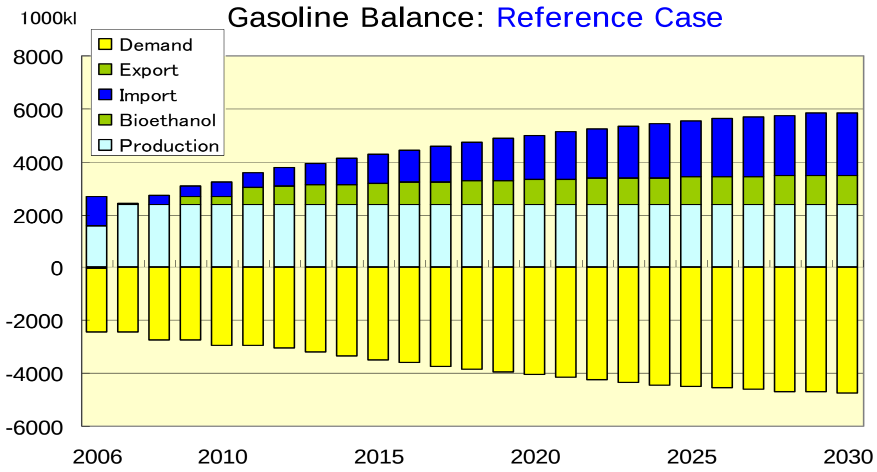


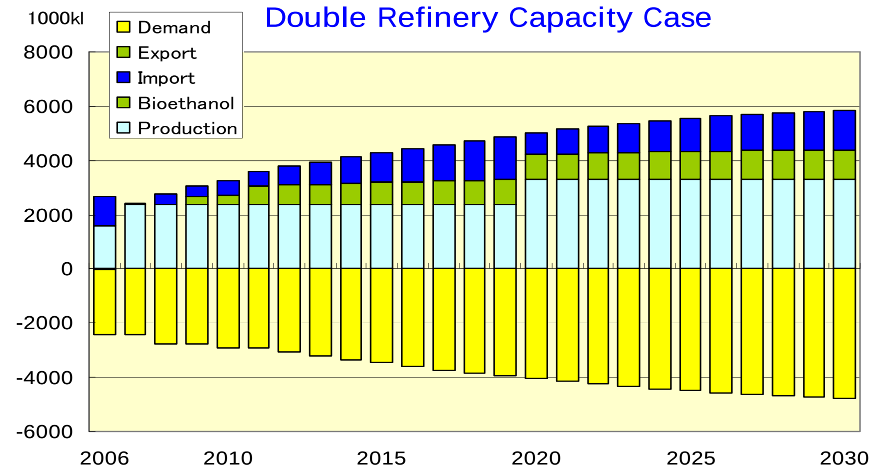


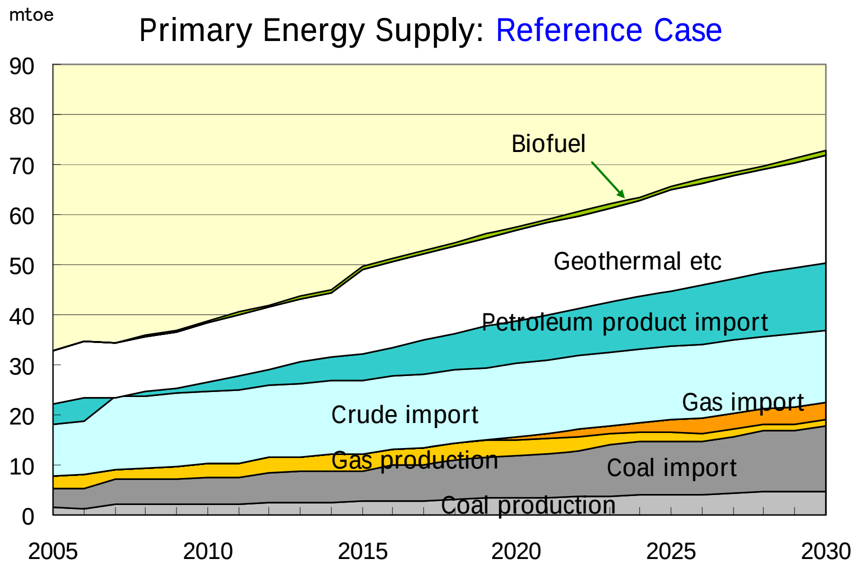


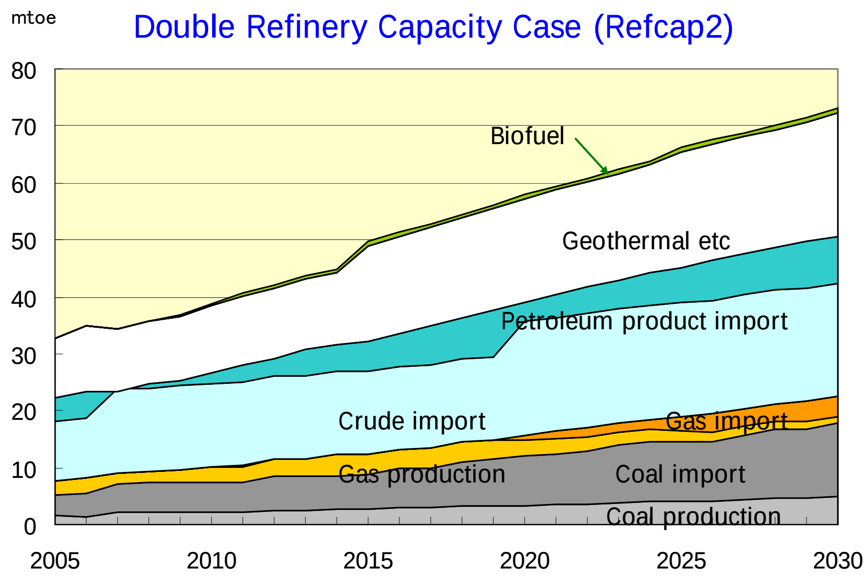


Comparison between Ref and Refinery Capacity enlarge



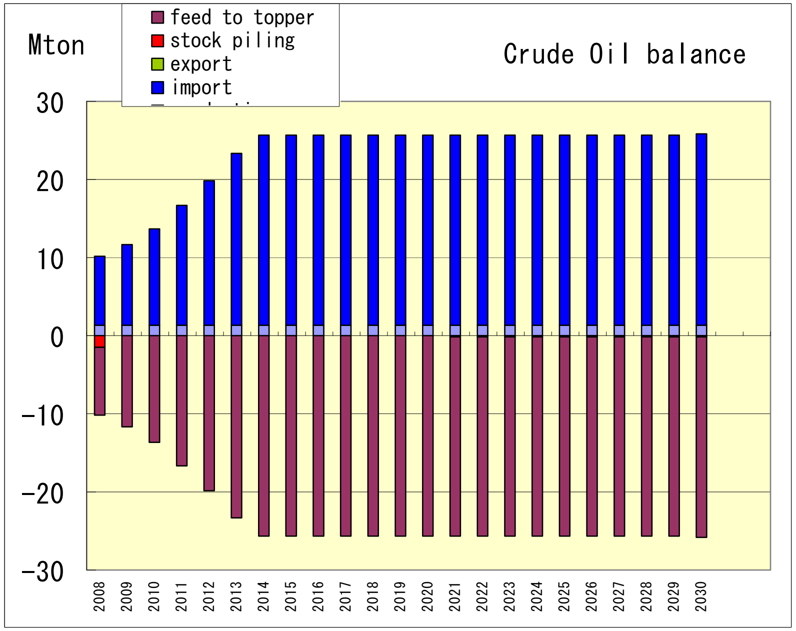


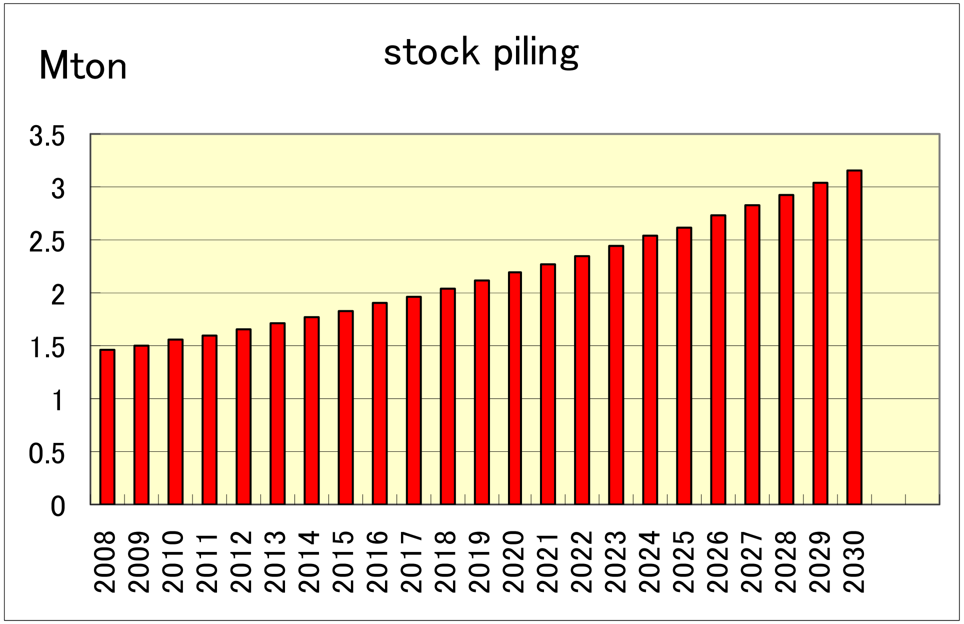


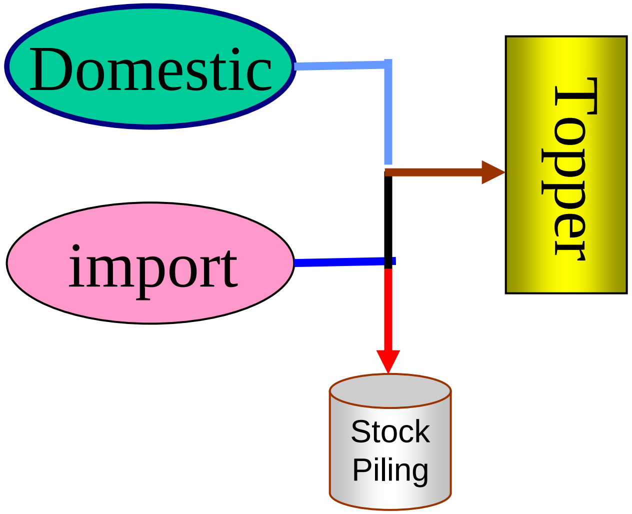


Trial Optimization model for SA

The result of crude oil balance



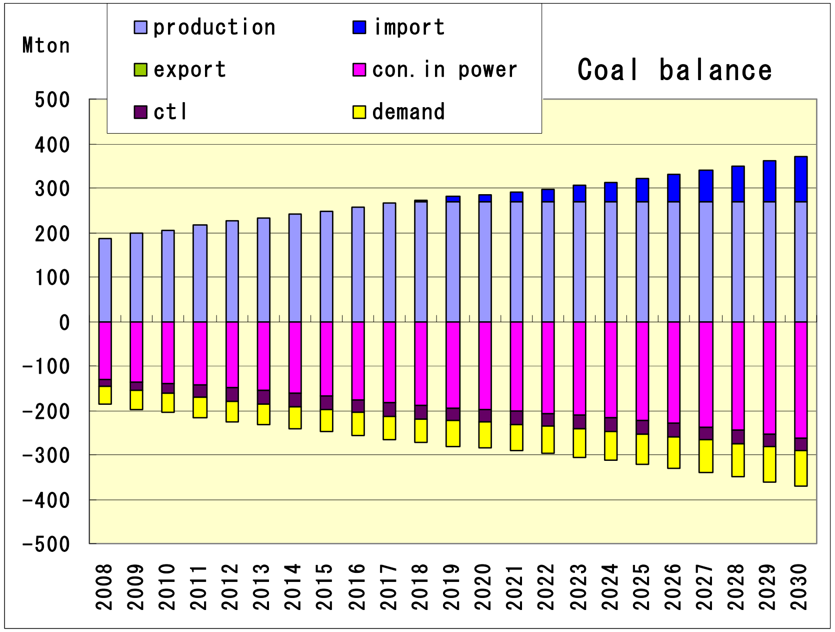


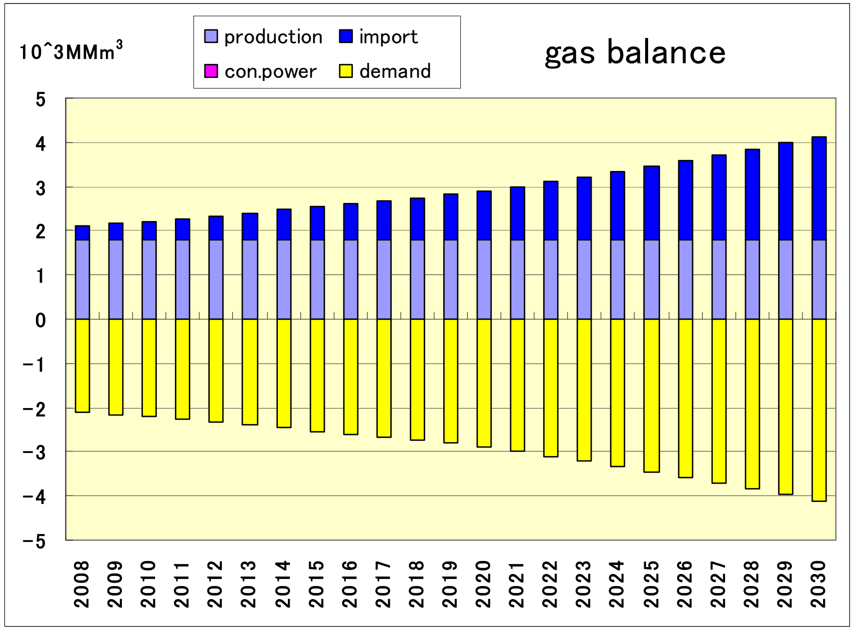


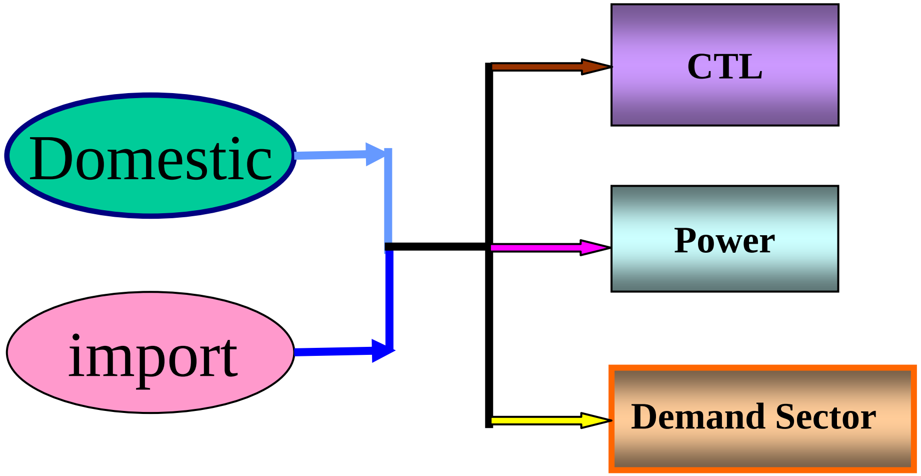
Criterion for oil stockpiling

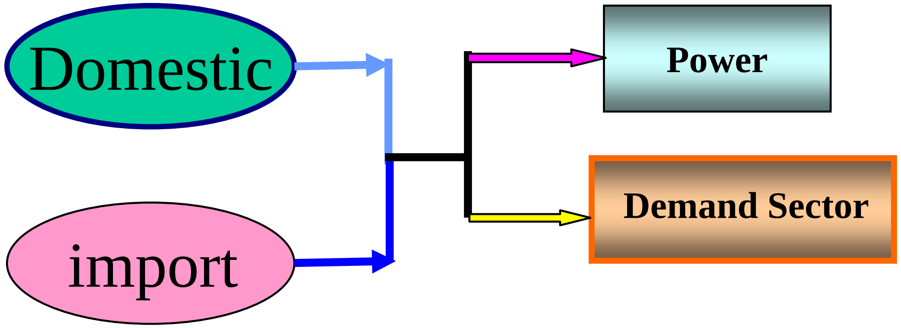
28 days of consumption
of total petroleum production

The result of coal balance

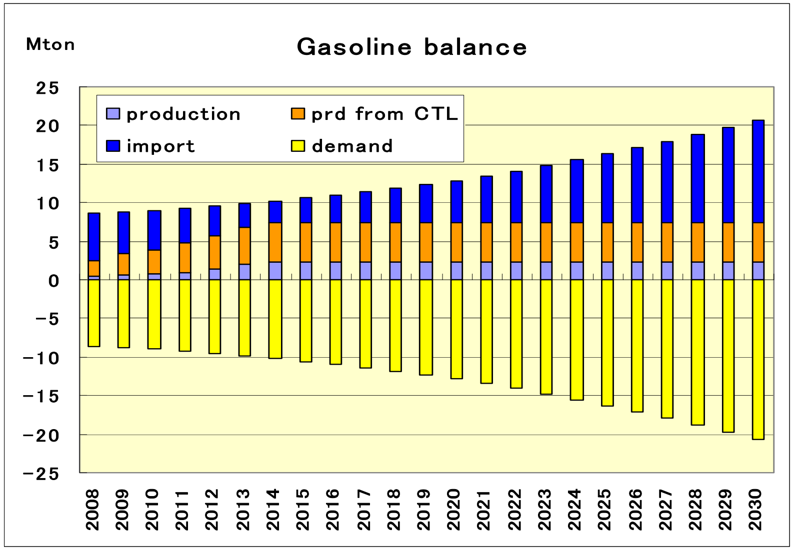


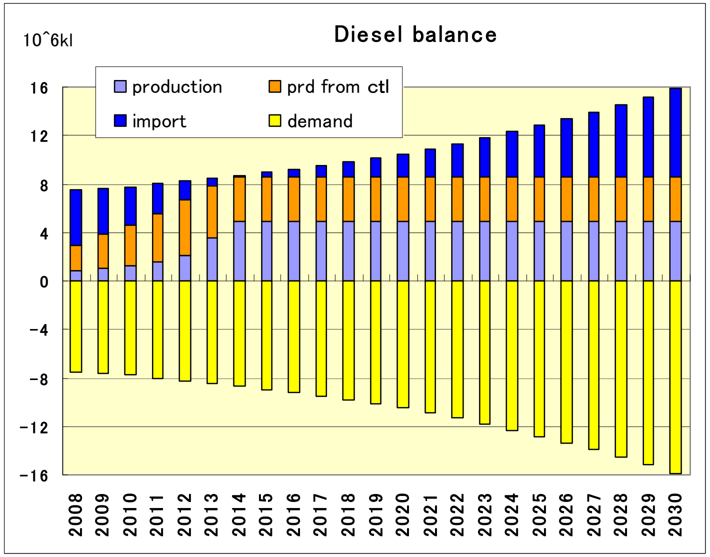


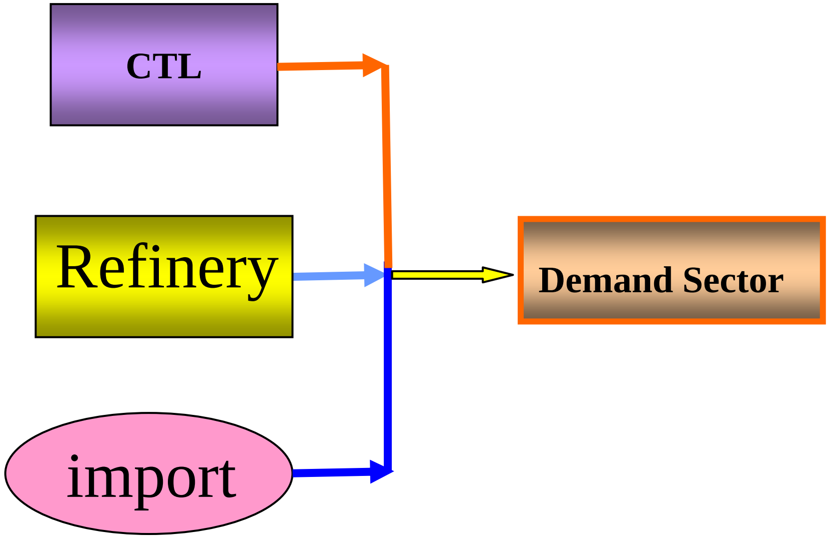




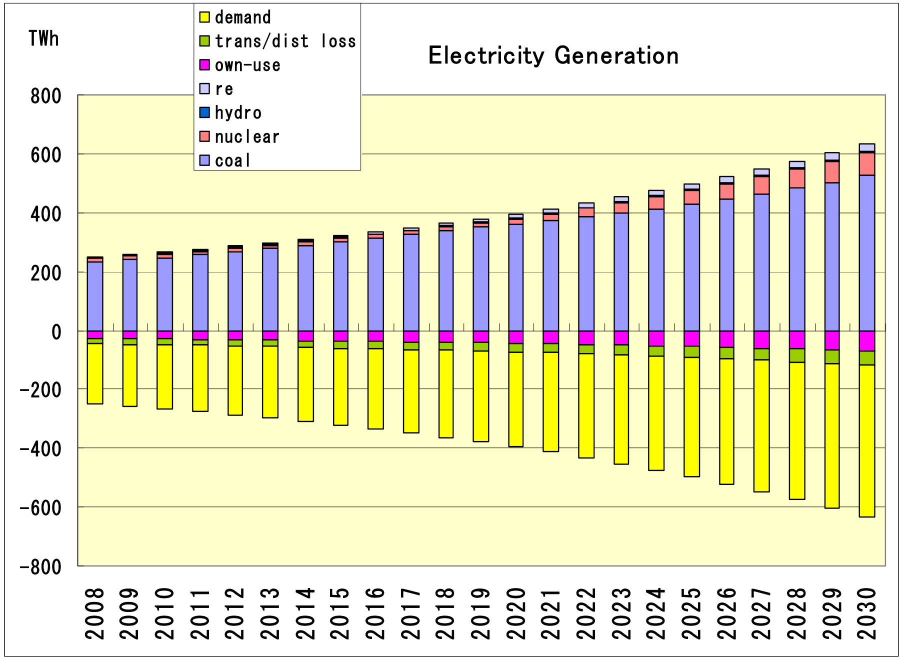
The result of Gasoline / Diesel oil balance

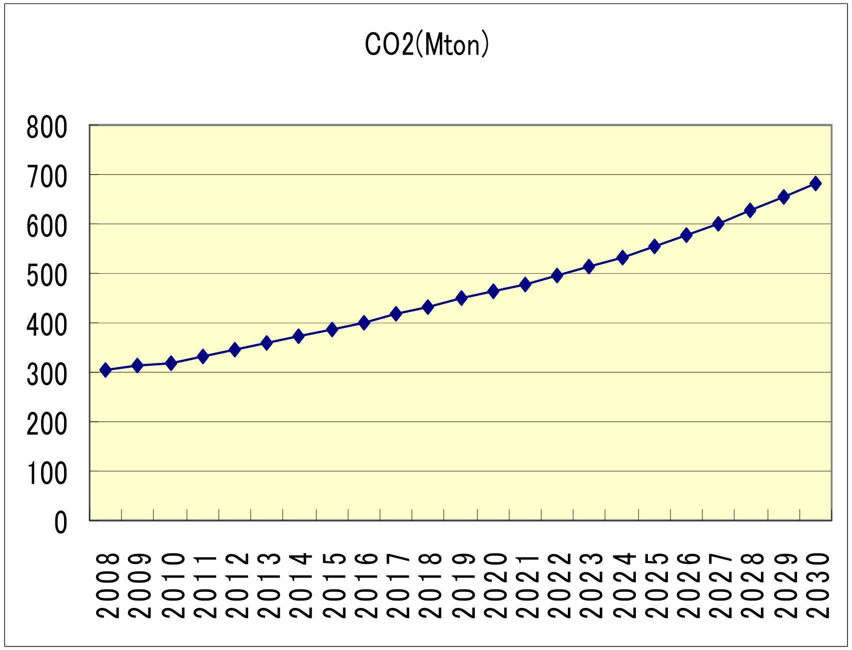


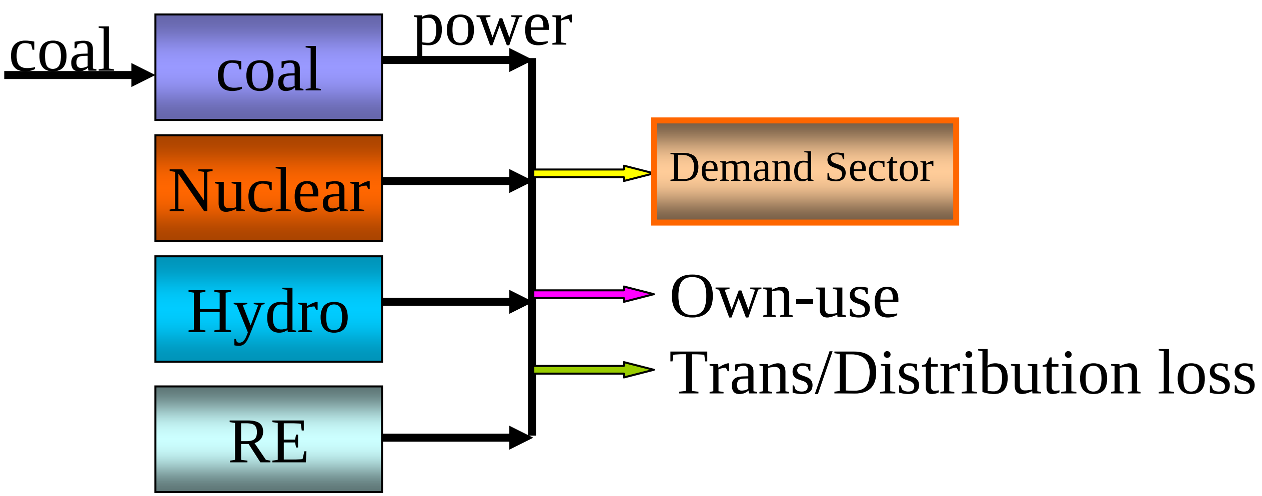




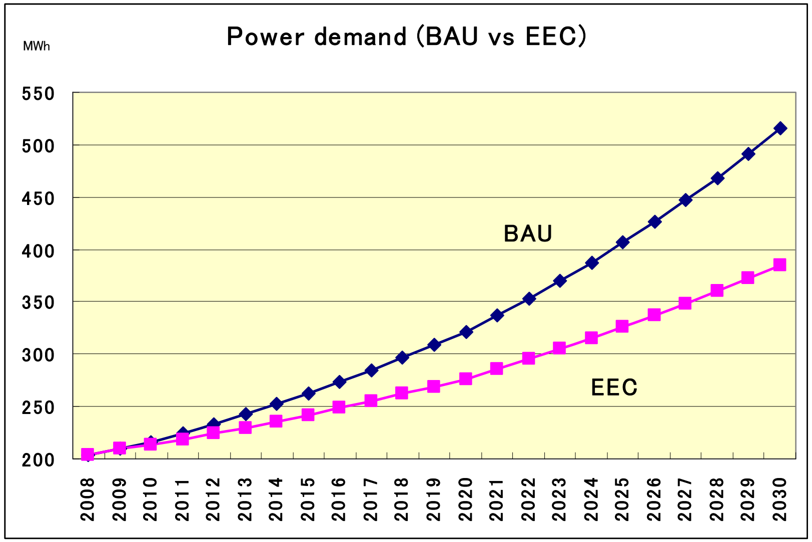
The result of Power balance and CO2 emission

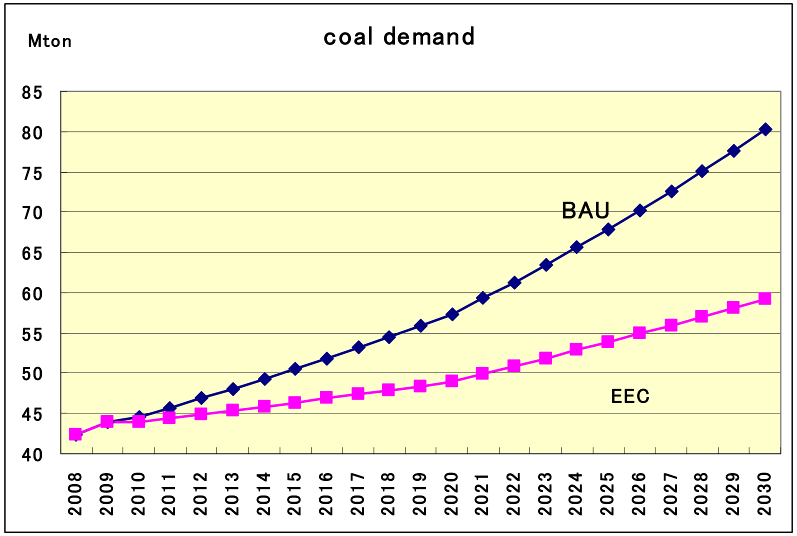


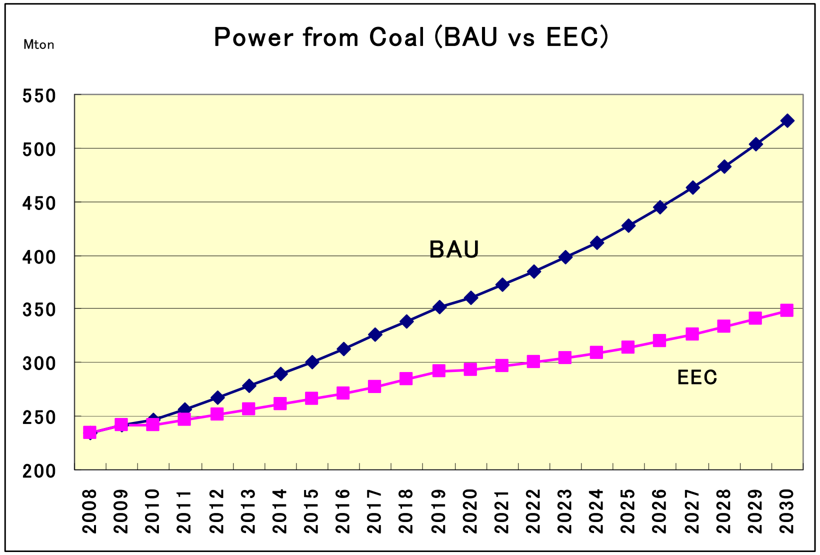




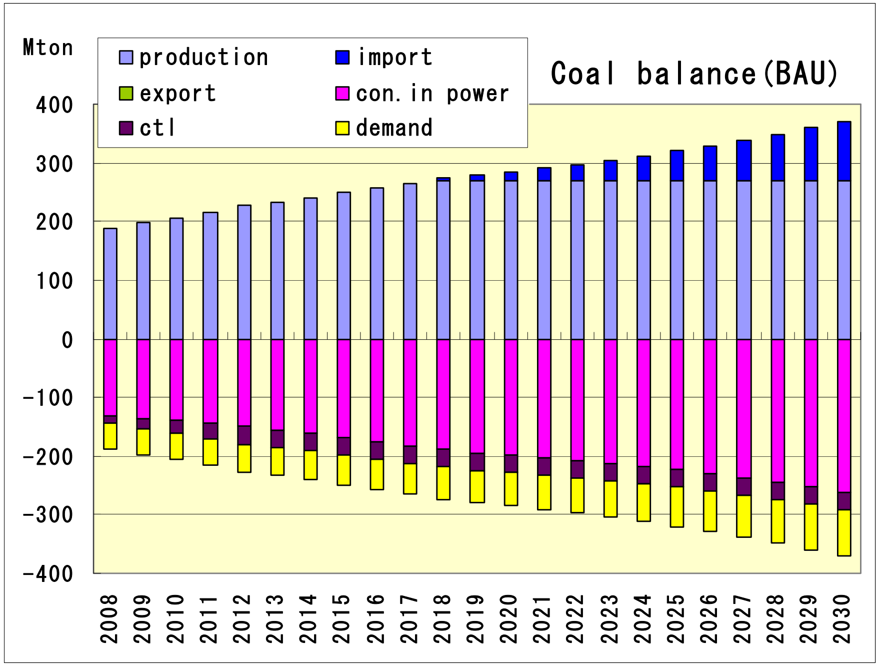
The result of BAU and EEC case

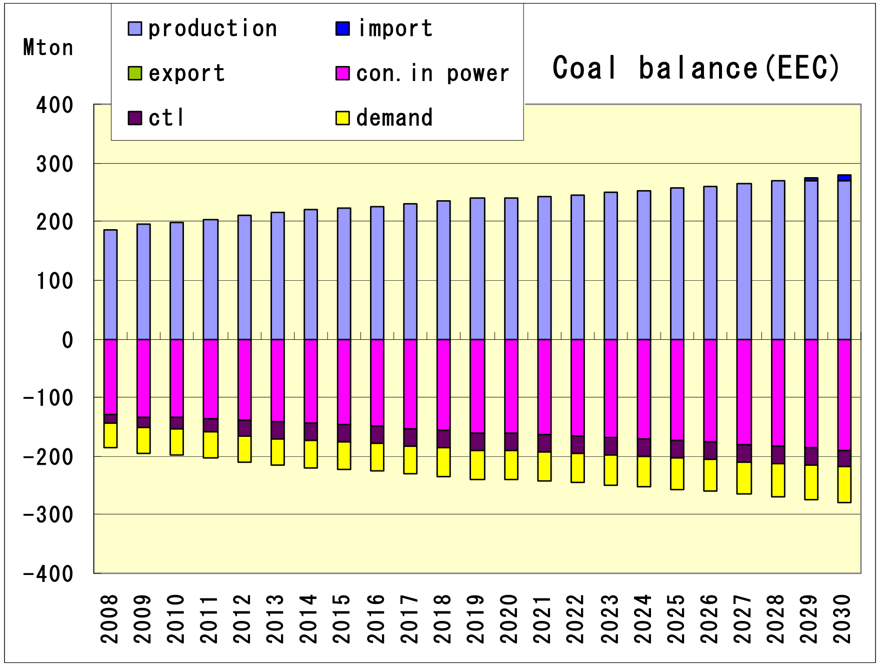


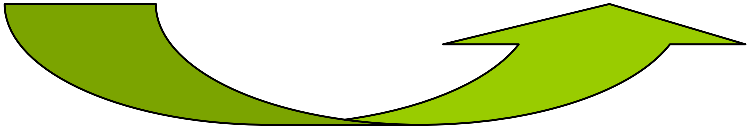




The result of BAU and EEC case







Conclusion words

The Optimization model has the following true worth.

1 If the situation surrounding energy changes, what happens?
2 If policy for energy is set, what comes?

Using the optimization model, you can get various information for answering above questions.

I recommend that you will have the Demand Forecasting model and Supply Optimization model of national wide, however in order to realize this idea, you are needed to have experts of modeling because you have always to maintain models.

Thank you very much !

1. Methodology for Energy Demand Forecasting Model

1.1 Concepts of the Energy Demand Forecasting

- Link to the social economic development plan
- Consider energy policies.
- Incorporate energy price effects
- Link to Power Development Plan
- Estimation for CO_2 emission
- Demand data creation for Optimization model

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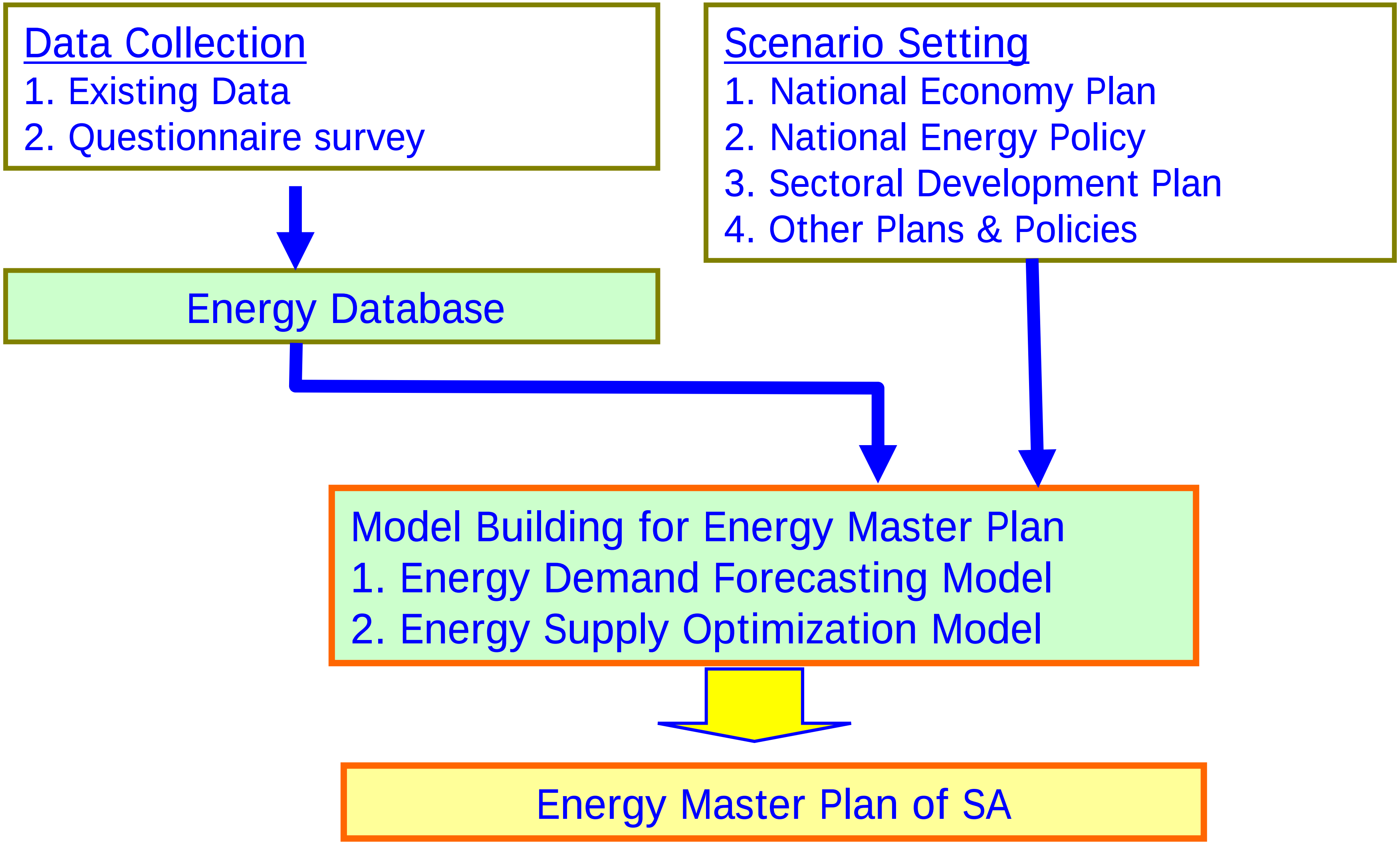

Data Collection
1. Existing Data
2. Questionnaire survey
Scenario Setting
1. National Economy Plan
2. National Energy Policy
3. Sectoral Development Plan
4. Other Plans & Policies
Energy Database
Model Building for Energy Master Plan
1. Energy Demand Forecasting Model
2. Energy Supply Optimization Model
Energy Master Plan of SA

1.3 Procedures for Energy Demand Forecasting

- **Scenario setting**

  Social & Economic Plans are selected

  Energy Plans and Power supply plans are referred.

- **Model building**

  The model is based on Econometric theory

  The model engine is Simple E (MS-EXCEL Add-in software)

  Forecasting equations are estimated by Regression analysis

- **Simulation**

  Check the forecasting values and the growth rates.

  Check the targets and goal levels.

- **Data are linkage to Optimization model**

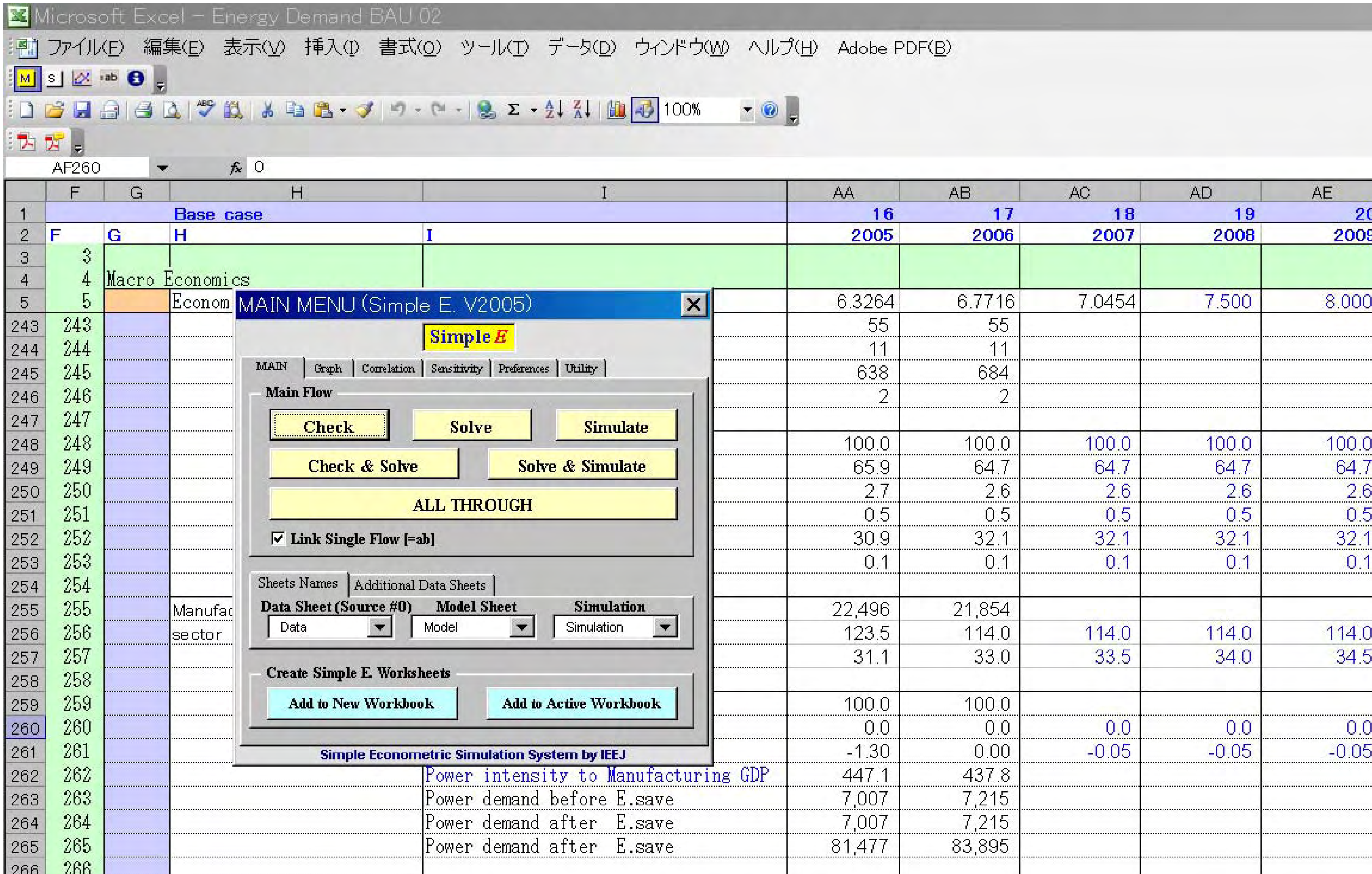
1.4 Model Structure in Simple-E

● Model structure in EXCEL sheets

1	SA-Intensity sheet	Energy intensity estimation	
2	Data sheet	Actual data input	Controlled by Simple-E
3	Model sheet	Model structure description	Controlled by Simple-E
4	Simulation sheet	Simulation result output	Controlled by Simple-E
5	Share sheet	Share & contribution calculation	
6	Growth sheet	Growth rate calculation	
7	Summary sheet	Forecast data summary	
8	CO2 sheet	CO2 emission calculation	

Energy Demand Forecasting Model is built in MS-EXCEL.

● Main menu of Simple-E in MS-EXCEL



1.5 Data Flow of the Energy Demand Forecasting Model

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Macro economic block

(1) Social economic indices
- Employees
- Population
- GDE
- Foreign exchange

(2) Production activities
- GDP by sector
- Labor productivity

(3) Energy prices
- Crude oil price
- Electricity tariffs
- Fuel prices

(4) Energy consumption
- Energy conservation
- Energy conversion
- Heat value

(5) Power generation plan
- Hydro
- Coal, Oil and Gas fired
- Nuclear
- Renewable energy

→

Energy demand block

(1) Energy demand
- Agriculture
- Mining
- Manufacturing
- Commercial
- Transportation
- Residential

(2) Power demand
- Agriculture
- Mining
- Manufacturing
- Commercial
- Transportation
- Residential

(3) Power generation
- Hydro
- Coal fired
- Oil and Gas fired
- Nuclear
- Renewable

(4) Energy consumption for generation
- Coal
- Gas
- Oil
- Others

(5) Primary & Final Energy Demand

Survey of economic activities → Forecast of GDE → Forecast of GDP

Economic Resources

- Investment and equipment
- Labor force & Wages
- Labor productivity
- Operation load for factories
- Export and Import
- FDI and Saving

Gross Domestic Demand

- Private consumption
- Government consumption
- Gross Capital Fixed Formation
- Exports
- Imports
- Total

Gross Domestic Products

- Agriculture & Fishery
- Mining
- Manufacturing
- Commercial
- Transport
- Service & Others
- Total

1.7 Main Economic indicators in the Model

● Exchange rate	
● Population & Households	
● Labor force number (Agri, Mini, Manu, Serv, Unemply)	
● Main Economic Indicators	
	Nominal GDP Real GDP at 2000 GDP deflator at 2000
● Gross Domestic Products by Sector	
	Agriculture / Mining Manufacturing / Commercial Transport / Service & Others
● Gross Domestic Expenditure（Nominal, Real)	
	Final consumption Gross fixed capital formation Exports of goods and services Import of goods and services GDE

1.8 Energy Demand Forecasting Items

● Energy Demand Sectors			
	Agriculture Manufacturing Commercial & Service	Mining Transportation Residential Use	
● Final consumption Energies			
	Coal Jet-fuel Fuel oil	LPG Kerosene City gas	Gasoline Diesel Natural gas
● Power generation			
	Coal (Eskom) Fuel oil Nuclear	Coal (Auto) Renewable	Natural gas Hydro
● Effected Items to Energy Intensity			
	Energy conservation (Technical Improvement) Energy price (Elasticity to Energy demand) Power prices and tariffs (Elasticity to Power Demand) Power ratio (Power share in the sectroal demand) Share function (Energy source share in the sector)		

2. Energy Demand Forecasting Model Building

2.1 Procedures for creating Data sheet

- Data identification description in Free area.
- Data names (Variable names) in Variable name area
- Time (1990 – 2030) in Time area
- Actual data input in Data area
- Political data input in Exogenous variable in Data area

F	G	H	I	J	TIME	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
3																
4	Macro Economics															
5		Economic data	Exchange rate	Rands/US$	ECEXC	6.94	8.61	10.54	7.56	6.46	6.3264	6.7716	7.0454	7.500	8.000	8.500
6																
7		Population	Country number	Million persons	POPNUM	44.0	44.8	45.2	45.8	46.3	46.9	47.4	47.9			
8			Growth rate	G%	POPNGR	2.5	1.8	1.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
9			Urban number	Million persons	POPUBN	24.7	25.5	26.0	26.5	27.1	27.6	28.2	28.7			
10			Urban population share	S%	POPUGR	56.2	56.9	57.4	58.0	58.5	58.9	59.4	59.9	60.3	60.7	61.1
11																
12		Household	Country Number('80=Pop/6.15, '04=Pop/5.	1000 HH	HHNUM	11,282	11,490	11,790	12,041	12,194	12,526	12,972	13,261			
13			Growth rate	G%	HHNGR	2.5	1.8	2.6	2.1	1.3	2.7	3.6	2.2			
14			Urban Number('80=Pop/6.15, '04=Pop/5.6	1000 HH	HHUBN	6,338	6,538	6,771	6,980	7,133	7,378	7,705	7,943			
15			Growth rate	G%	HHUGR	3.8	3.2	3.6	3.1	2.2	3.4	4.4	3.1			
16																
17		Labor number	Labor Male	1000 persons	LABAGR	18,216	18,597	18,822	19,099	19,327	19,554	19,762	19,972			
18		(Including Foreigners)	Labor Female	1000 persons	LABOGA	7,541	7,718	7,830	7,964	8,059	8,154	8,241	8,327			
19			Total	1000 persons	LABTOT	25,757	26,315	26,652	27,063	27,387	27,708	28,003	28,299			
20			Labor force share to Pop	%	LABSHP	58.5	58.7	58.9	59.1	59.1	59.1	59.1	59.1	59.7	60.3	60.9
21																
22		Labor shares	Labor Male	S%	LASAGR	70.7	70.7	70.6	70.6	70.6	70.6	70.6	70.6	70.6	70.6	70.6
23			Labor Female	S%	LASOGA	29.3	29.3	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4
24			Total	S%	LASTOT	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
25																

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Energy demand in the sector	MANTOL	**=**	**MANELR*RGPMAN**
Intensity to Manufacturing GDP	MANELR	**=**	**MANELR**
Power ratio	MANPOR	=	**MANPOR**
Power Efficiency rate	MAPWCO	**=**	**L1.MAPWCO*(1-APWTEC)*(1+MAPWELA*GRPRELI)**
Improvement by EC policy	MAPWTEC	**=**	**MAPWTEC**
Elasticity to Power price	MAPWELA	**=**	**MAPWELA**
P-intensity to Manufacturing GDP	MAPWITN	**=**	**MAPWDEW*1000/RGPMAN**
Power demand before E.save	MAPWDEB	**=**	**MANTOL*MANPOR/100**
Power demand after E.save	MAPWDEA	**=**	**MAPWDEB*MAPWCO/100**
Power demand after E.save	MAPWDEW	**=**	**MAPWDEA*10000/860**
Energy Efficiency rate	MAENCO	**=**	**L1.MAENCO*(1-MAENTEC)*(1+MAENELA*GRPRCRD)**
Improvement by EC policy	MAENTEC	**=**	**MAENTEC**
Elasticity to Crude oil price	MAENELA	**=**	**MAENELA**
E-Intensity to Manufacturing GDP	MAENITN	**=**	**MAENDEA*1000/RGPMAN**
Energy demand before E.save	MAENDEB	**=**	**MANTOL*(1-MANPOR/100)**
Energy demand after E.save	MAENDEA	**=**	**MAENDEB*MAENCO/100**

Continue

Total of fossil energy demand	MAFOTOT	=	**MAENDEA**
Coal	MAFOCOL	=	**MAFOTOT*MASHCOL/100**
Coal (Non-Energy Use)	MAFOCOU	=	**MAFOTOT*MASHCOU/100**
Coal (Other sector)	MAFOCOT	=	**MAFOTOT*MASHCOT/100**
City gas	MAFOGAS	=	**MAFOTOT*MASHGAS/100**
LPG	MAFOLPG	=	**MAFOTOT*MASHLPG/100**
Kerosene	MAFOKER	=	**MAFOTOT*MASHKER/100**
Diesel	MAFODIE	=	**MAFOTOT*MASHDIE/100**
Fuel oil	MAFOFUL	=	**MAFOTOT*MASHFUL/100**
Shares of fossil energy demand	MASHTOT	=	**MASHTOT**
Coal	MASHCOL	=	**MASHCOL**
Coal (Non-Energy Use)	MASHCOU	=	**MASHCOU**
Coal (Other sector)	MASHCOT	=	**MASHCOT**
City gas	MASHGAS	=	**MASHGAS**
LPG	MASHLPG	=	**MASHLPG**
Kerosene	MASHKER	=	**MASHKER**
Diesel	MASHDIE	=	**MASHDIE**
Fuel oil	MASHFUL	=	**MASHFUL**

IEE JAPAN

- Data identification description in Free area.
- Time (1990 – 2030) in Time area
- Format description

F	G	H	I	J	TIME	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
3																		
4																		
5		Economic data	Exchange rate	Rands/US$	ECEXC	7.56	6.46	6.3264	6.7716	7.0454	7.500	8.000	8.500	9.000	9.500	10.000	10.000	10.000
6																		
7		Population	Country number	Million persons	POPNTN	45.8	46.3	46.9	47.4	47.9	48.5	49.0	49.6	50.2	50.7	51.3	51.8	52.4
8			Growth rate	G%	POPNGR	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1
9			Urban number	Million persons	POPURN	26.5	27.1	27.6	28.2	28.7	29.2	29.8	30.3	30.8	31.4	31.9	32.5	33.1
10			Urban population share	S%	POPUGR	58.0	58.5	58.9	59.4	59.9	60.3	60.7	61.1	61.5	61.9	62.3	62.7	63.1
11																		
12		Household	County Number('90=Pop/6.15, '04=Pop/5.35)	1000 HH	HHNTN	12,041	12,194	12,526	12,972	13,261	13,417	13,574	13,733	13,885	14,037	14,192	14,348	14,506
13			Growth rate	G%	HHNGR	2.1	1.3	2.7	3.6	2.2	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1
14			Urban Number('90=Pop/6.15, '04=Pop/5.35)	1000 HH	HHURN	6,980	7,133	7,378	7,705	7,943	8,090	8,239	8,391	8,539	8,689	8,841	8,996	9,153
15			Growth rate	G%	HHUGR	3.1	2.2	3.4	4.4	3.1	1.8	1.8	1.8	1.8	1.8	1.8	1.7	1.7
16																		
17		Labor number	Labor Male	1000 persons	LABMGR	19,099	19,327	19,554	19,762	19,972	20,408	20,855	21,310	21,760	22,219	22,689	23,167	23,657
18		(Including Foreigners)	Labor Female	1000 persons	LABFGA	7,964	8,059	8,154	8,241	8,327	8,509	8,695	8,885	9,073	9,264	9,460	9,659	9,863
19			Total	1000 persons	LABTOT	27,063	27,387	27,708	28,003	28,299	28,917	29,549	30,195	30,833	31,484	32,149	32,827	33,520
20			Labor force share to Pop	%	LABSHP	59	59	59	59	59	60	60	61	61	62	63	63	64
21																		
22		Labor shares	Labor Male	S%	LASMGR	70.6	70.6	70.6	70.6	70.6	70.6	70.6	70.6	70.6	70.6	70.6	70.6	70.6
23			Labor Female	S%	LASFGA	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4	29.4
24			Total	S%	LASTOT	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
25																		
26		GDP	nGDP at current price	Billion Rands	NGDP	1,251	1,374	1,541	1,741	1,994	2,218	2,467	2,745	3,054	3,399	3,782	4,209	4,684
27			Growth rate	G%	GRNGDP	7.4	9.8	12.1	13.0	14.5	11.2	11.2	11.2	11.3	11.3	11.3	11.3	11.3
28																		
29			nGDP at US $ base	Billion US$	UGDP	166	213	244	257	283	296	308	323	339	358	378	421	468
30			Growth rate	G%	GRUGDP	49.8	28.5	14.5	5.5	10.1	4.5	4.3	4.7	5.1	5.4	5.7	11.3	11.3
31																		
32			nGDP per capita on US$ base	US$ per capita	UGDCAP	3,614	4,591	5,195	5,425	5,908	6,102	6,290	6,509	6,757	7,056	7,378	8,121	8,939
33			Growth rate	G%	GRUGDC	48.0	27.0	13.2	4.4	8.9	3.3	3.1	3.5	4.0	4.3	4.6	10.1	10.1
34																		
35			rGDP at 2000 price	Billion Rands	RGDP	1,009	1,046	1,115	1,175	1,236	1,273	1,311	1,350	1,404	1,460	1,519	1,580	1,643
36			Growth rate	G%	GRGDP	2.8	3.7	6.6	5.4	5.1	3.0	3.0	3.0	4.0	4.0	4.0	4.0	4.0
37																		
38			rGDP at 2005 price	Billion US$	RGDP05	220	229	244	257	270	278	288	295	307	319	332	345	359
39			Growth rate	G%	GRGDP05	2.8	3.7	6.6	5.4	5.1	3.0	3.0	3.0	4.0	4.0	4.0	4.0	4.0
40																		

●SA- Intensity Sheet

Estimation of future sectoral energy intensities.

●Share Sheet

Calculation of future economic and energy component shares in a classification table.

●Growth rate Sheet

Calculation of annual growth rates and average growth rates for variables.

●Summary sheet

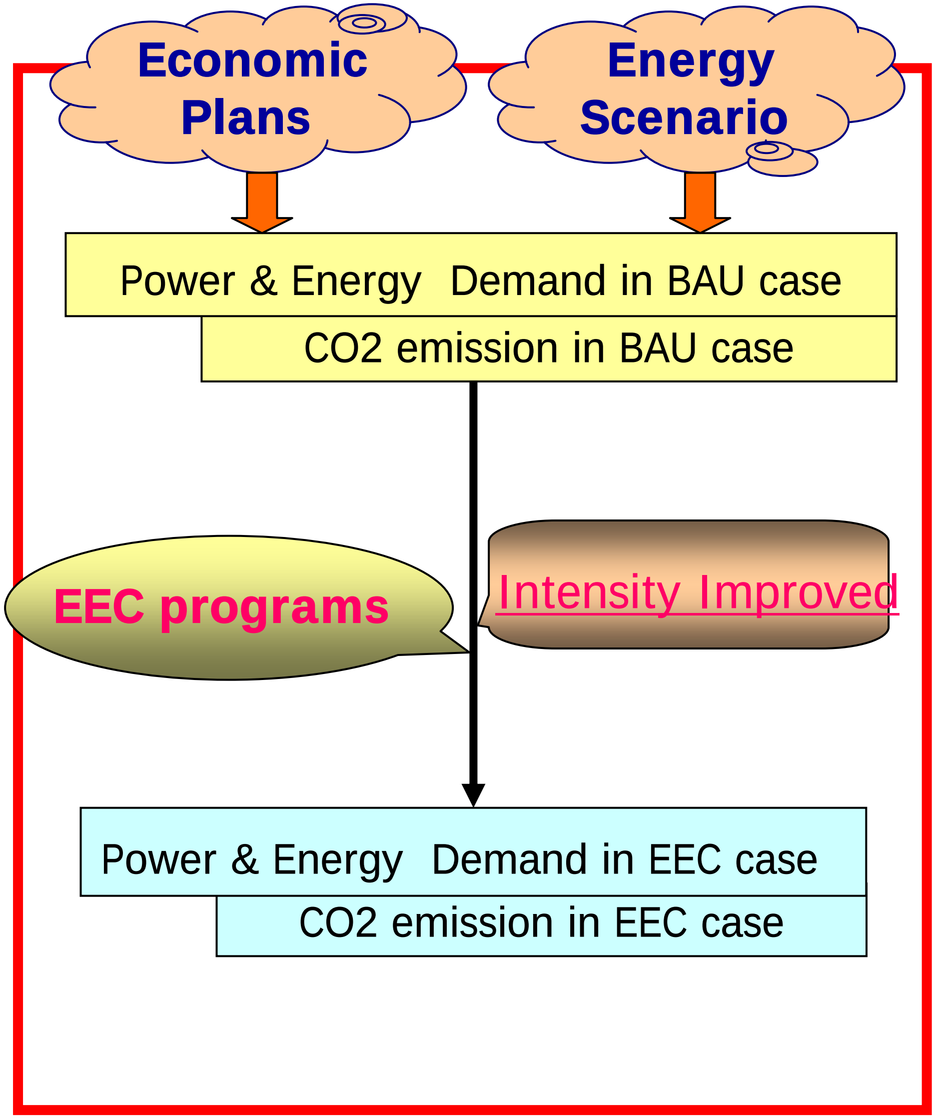
Summary table for future final energy demand, power demand and primary energy supply.

●CO2 sheet

Calculation of CO2 emission by sector.

3. Simulation Results

3.1 Framework of Energy Demand Forecasting Model



Software:

Simple-E (Econometric Model building engine)

MS-Excel add-in software

Actual Data : 1990-2007 (18 years)

Forecast years: 2008-2030(23 years)

Forecasted items

- **Final Energy Demand**
- **Power demand**
- **Fuel supply to Power sector**
- **Power generation & Power capacity**
- **Primary Energy Supply by Energy**
- **Energy consumption per GDP**
- **Energy consumption per population**
- **Power consumption per GDP**
- **Power consumption per Household**
- **CO2 emission by sector**

3.2 Scenario and Case Setting

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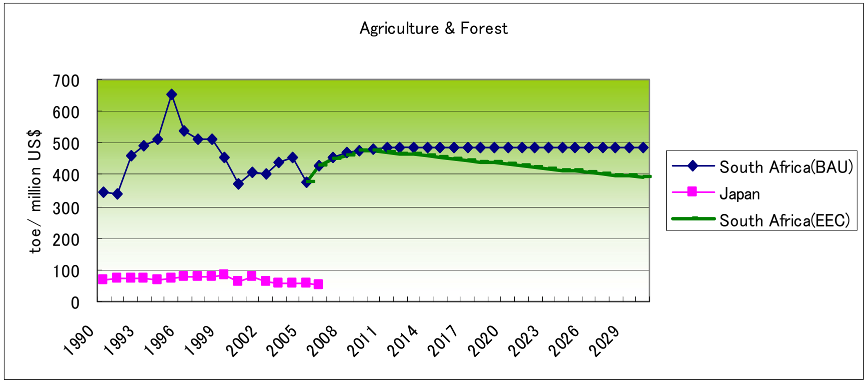
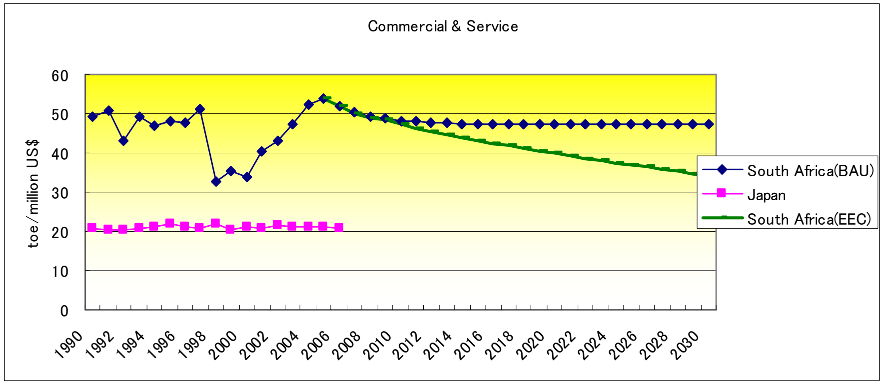
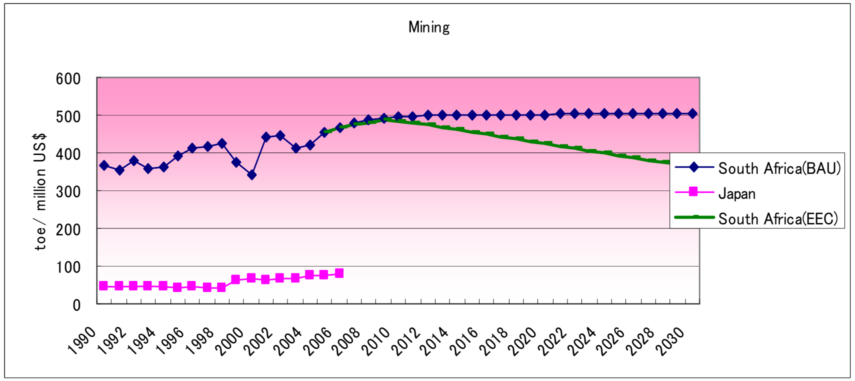
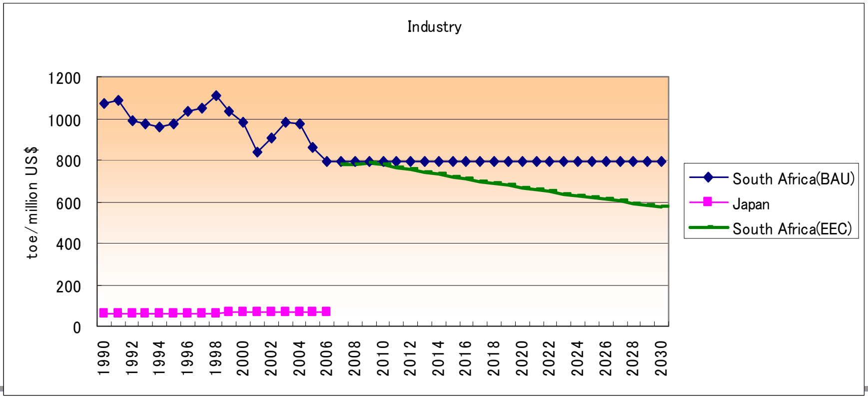
	BAU case	EEC case
Economic Policy & Plans	○GDP growth rate GDP: 2008-2010:3.0％, 2011-2020:4.0％, 2021-2030:5.0％ ○Stability of macro economy (exchange rate, inflation and money supply) Exchange rate: 7.5R/$ - 10.0R/$ ○Investment Road, Water supply, Energy supply, Housing, Public facilities ○Sectoral Industry policy Enhancing Labor intensive industry (Business outsourcing, Tourism, Bio fuels)	
Energy Policy & Plans	○CTL : ＋10,000ktoe in 2010 ○GTL: ＋4％ per year from 2009 to 2025	
Power Policy & plans	○Open cycle gas turbine: 750MW in 2009、300MW in 2010 ○Nuclear power : Additional ＋1GW per year from 2020 to 2030 (total= ＋11GW) ○NG power generation : 800 MW in 2011, 800 MW in 2015, 800MW in 2020, 800 MW 2026 ○Renewable Energy: 1.0% in 2010 to 4.0％ of total power supply in 2025 ○Reserve margin : 5% in 2009 to 16% in 2017 ○IPP shares : 5％ 2009 to 30％ of total power supply in 2023	
Energy Efficiency Policy	○Efficiency of coal power station: 34％ ○Distribution loss : 8.5％ from 2009 to 2030 ○Sectoral Energy Efficiency Strategy （Refer to Next Page）	○38％ ○8.5％ in 2009 to 5.0％ in 2016 ○Mining:15％, Transport:9％, Commerce:15％ Residential：10％ Total:12％

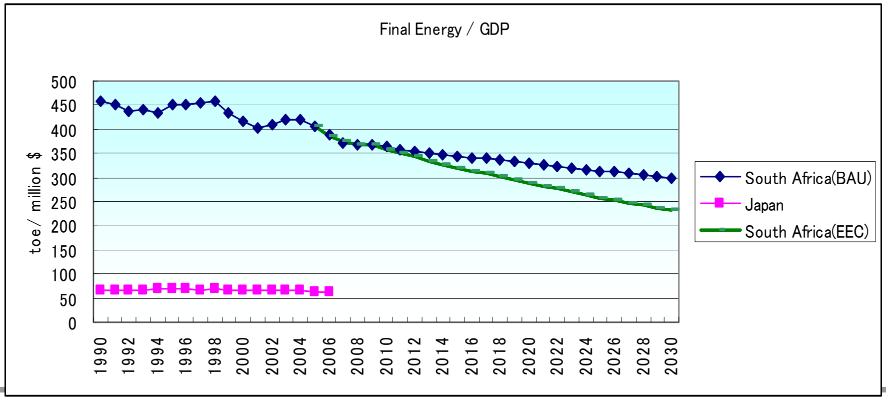
3.3 Intensities in BAU and EEC











3.4 Final Energy Demand

IEE JAPAN

BAU case unit: million toe

	2005	2010	2015	2020	2025	25/10
Agriculture	1.6	1.8	1.9	1.9	1.9	0.1
Mining	4.5	4.7	4.8	4.8	4.8	0.1
Manufacturing	22.5	24.1	28.8	34.3	42.9	3.9
Commercial	4.0	4.5	5.6	7.1	9.4	5.1
Transportation	15.7	17.9	21.3	25.8	32.9	4.1
Residential	16.7	17.6	19.3	21.3	23.6	2.0
Total	65.0	70.7	81.7	95.1	115.4	3.3

EEC case unit: million toe

	2005	2010	2015	2020	2025	25/10
Agriculture	1.6	1.8	1.8	1.7	1.6	-0.9
Mining	4.5	4.6	4.4	4.1	3.7	-1.4
Manufacturing	22.5	23.8	26.3	29.0	33.7	2.4
Commercial	4.0	4.4	5.1	6.0	7.4	3.5
Transportation	15.7	17.7	20.2	23.4	28.4	3.2
Residential	16.7	17.4	18.1	19.0	20.0	0.9
Total	65.0	69.8	75.9	83.2	94.9	2.1

12.5% improved in 2020

17.8% improved in 2025

3.5 Power Demand

IEE JAPAN

BAU case unit: TWh

	2005	2010	2015	2020	2025	25/10
Agriculture	5.5	6.5	6.9	7.3	7.6	1.1
Mining	28.3	29.8	30.3	30.3	30.1	0.1
Manufacturing	81.5	98.8	126.3	160.1	213.2	5.3
Commercial	27.1	30.8	38.6	48.8	64.9	5.1
Transportation	5.4	6.2	7.4	8.9	11.3	4.1
Residential	37.0	43.8	53.6	65.6	79.3	4.0
Total	184.8	215.9	263.0	321.0	406.4	4.3

EEC case unit: TWh

	2005	2010	2015	2020	2025	25/10
Agriculture	5.5	6.4	6.5	6.5	6.5	0.0
Mining	28.3	29.3	27.6	25.6	23.7	-1.4
Manufacturing	81.5	97.3	115.3	135.6	167.4	3.7
Commercial	27.1	30.3	35.2	41.4	50.9	3.5
Transportation	5.4	6.1	7.0	8.1	9.8	3.2
Residential	37.0	43.4	50.5	58.7	67.5	3.0
Total	184.8	212.9	242.1	275.9	325.8	2.9

14.0% improved in 2020

19.8% improved in 2025

3.6 Power capacity

BAU case

unit: MW

	2005	2010	2015	2020	2025	25/10(%)
Coal (Eskom)	39,378	40,484	44,134	46,510	50,015	1.4
Coal (Auto)	2,044	2,096	7,897	16,040	22,734	17.2
Natural gas	1	12	1,756	2,634	2,634	43.6
Hydro	1,321	2,342	2,342	2,342	2,342	0.0
Nuclear	1,840	1,842	1,842	2,780	7,472	9.8
Other	0	1106	1106	1106	1106	0.0
Total	44,584	47,882	59,078	71,413	86,303	4.0

EEC case

unit: MW

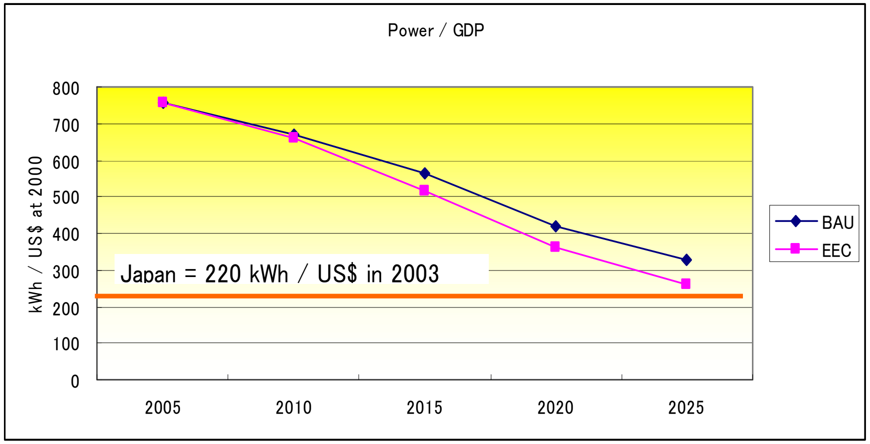
	2005	2010	2015	2020	2025	25/10
Coal (Eskom)	39,378	39,838	39,254	38,269	37,528	-0.4
Coal (Auto)	2,044	2,063	7,024	13,161	17,007	15.1
Natural gas	1	12	1,756	2,634	2,634	43.6
Hydro	1,321	2,342	2,342	2,342	2,342	0.0
Nuclear	1,840	1,842	1,842	2,780	7,472	9.8
Other	0	1,106	1,106	1,106	1,106	0.0
Total	44,584	47,203	53,324	60,293	68,089	2.5

Load Factor	70.0%	72.5%	72.5%	72.5%	72.5%	72.5%
Reserve Margin	6.0%	5.0%	12.0%	16.0%	16.0%	16.0%

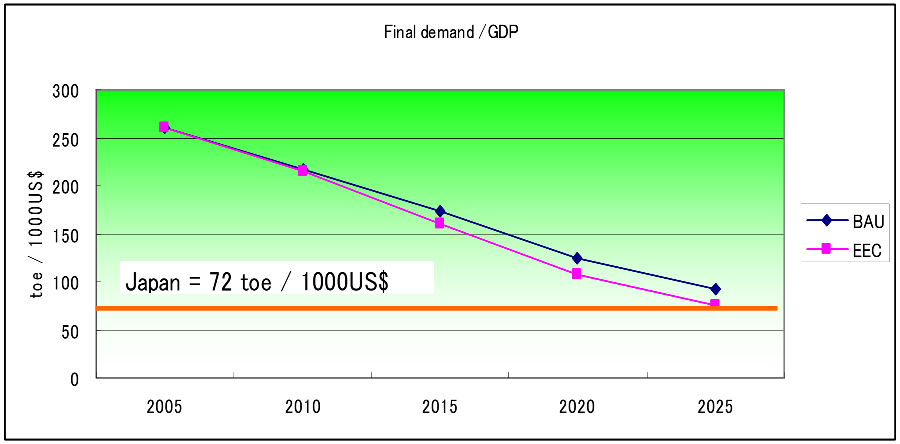
15.6% improved in 2020

21.1% improved in 2025

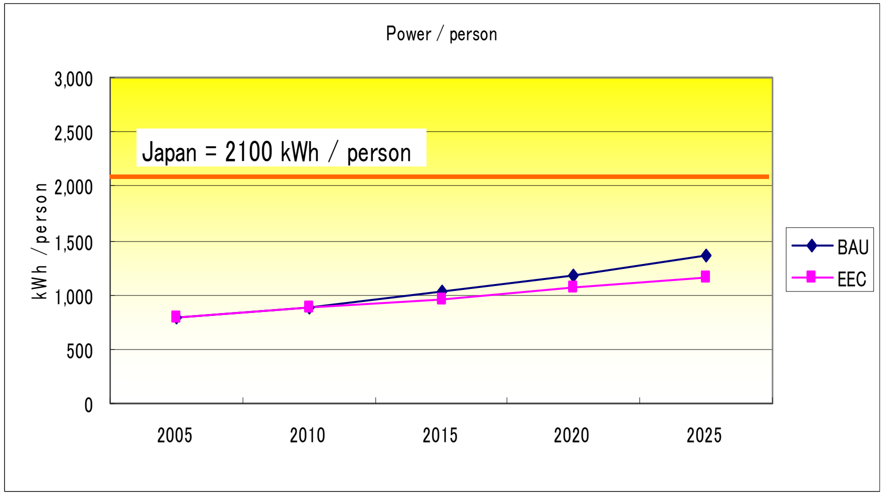
3.7 Power & Energy Demand Comparison



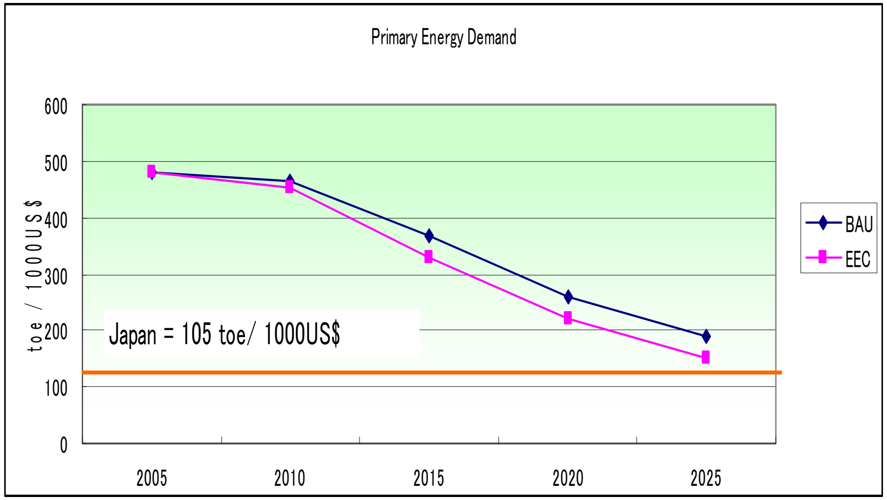
Power demand / GDP



Final Energy Demand / GDP



Residential Power Demand / population



Primary Energy Demand / GDP

3.8 Considerations

- The **consistency** between Economic strategy and Energy plan is important for making Strategic Energy Plan. In order to keep the consistency, Energy Demand Forecasting Model and Energy optimization model are useful.
- And also, for keeping consistency among several energy plans such as, power development plans, coal development plans and so on, the above models are significant. The Models are used to evaluate the **energy projects planned differentially.**
- For maintaining the models, several kinds of experts such as Energy policy maker and Model builder are required in energy responsible departments and/or agencies. Then **capacity building** for the experts are required.

IEE JAPAN

Thank you