



# Energy Technologies Systems Analysis Program Annex IX Technical Conference

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## MARKAL Applications in Taiwan

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# Outline

- **Energy Overview of Taiwan**
- **Taiwan MARKAL**
- **Application of Taiwan MARKAL**
- **Scenario Analysis for Energy Outlook**
- **CO<sub>2</sub> Mitigation Scenario**



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A light blue world map is centered on the slide, serving as a background for the title. The map shows the outlines of continents in a soft blue color. Overlaid on the map is the title "Energy Overview of Taiwan" in a large, bold, red sans-serif font. The text is centered horizontally and spans across the middle of the map. The map is slightly faded to ensure the red text is the primary focus.

# Energy Overview of Taiwan

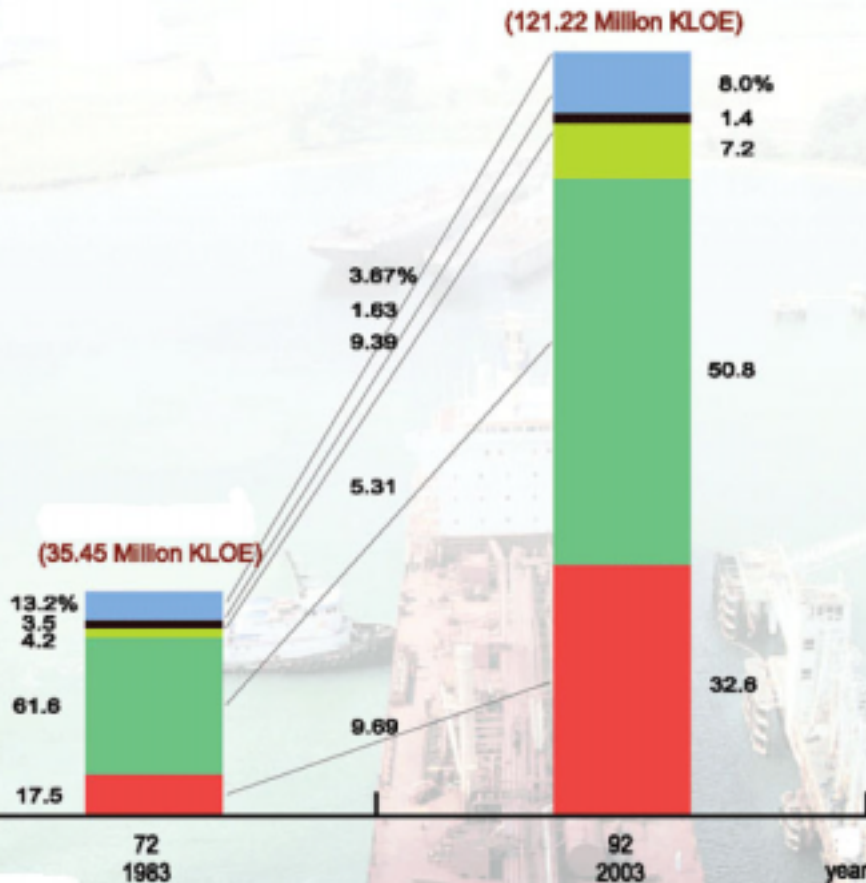


# Structure of Energy Supply

COAL Oil Natural Gas & LNG Hydro Power Nuclear Power

## Energy Supply in 2003

Unit:10<sup>3</sup> K



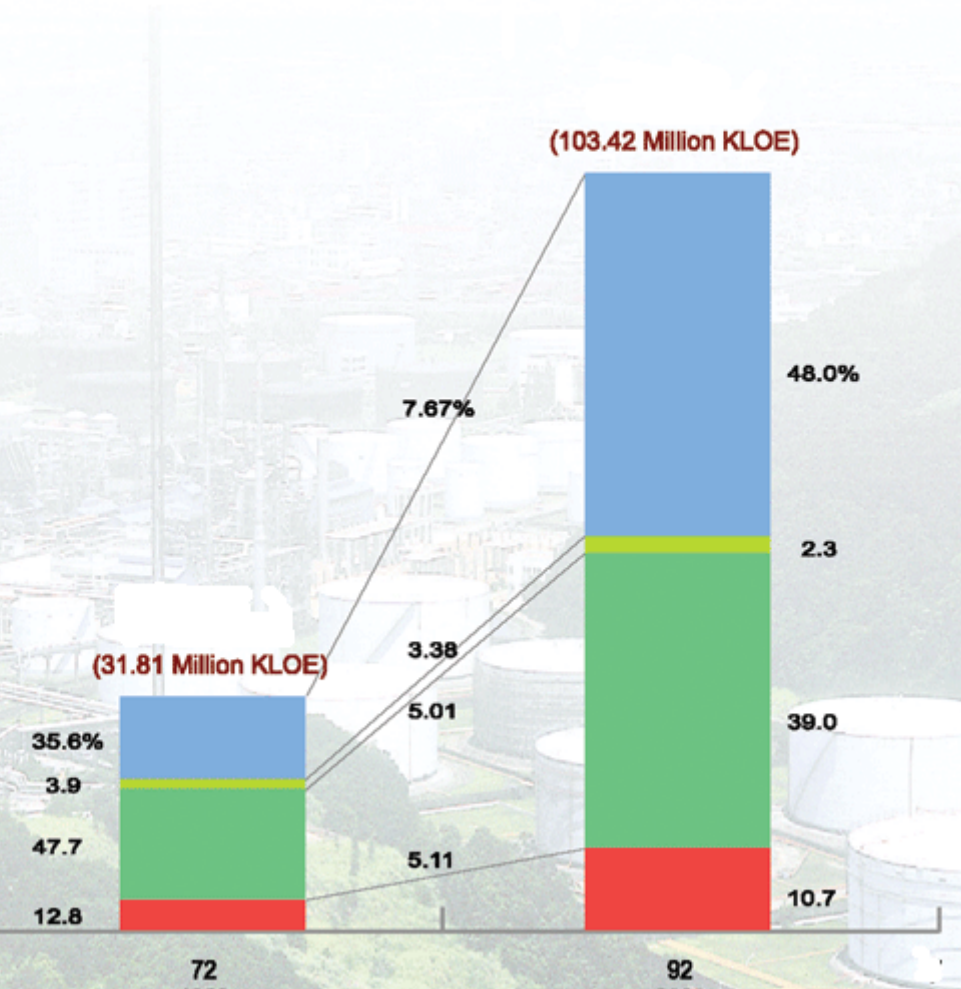
Item	2003		1983		Average annual growth rate
	Quantity	%	Quantity	%	
Coal	39,469.3	32.5	6,202.2	17.5	9.0
Oil	61,525.5	50.8	21,842.6	61.6	5.1
LNG	8,030.8	6.6	-	-	-
Natural Gas	821.7	0.7	1,470.8	4.2	-2.1
Hydro Power	1,712.7	1.5	1,239.0	3.5	1.0
Nuclear Power	9,660.2	7.9	4,695.7	13.2	3.0

Dependence of : 87.25% → 97.65%



# Structure of Energy Demand

- Coal & Coal products
- Petroleum Products
- Natural Gas & LNG
- Electricity



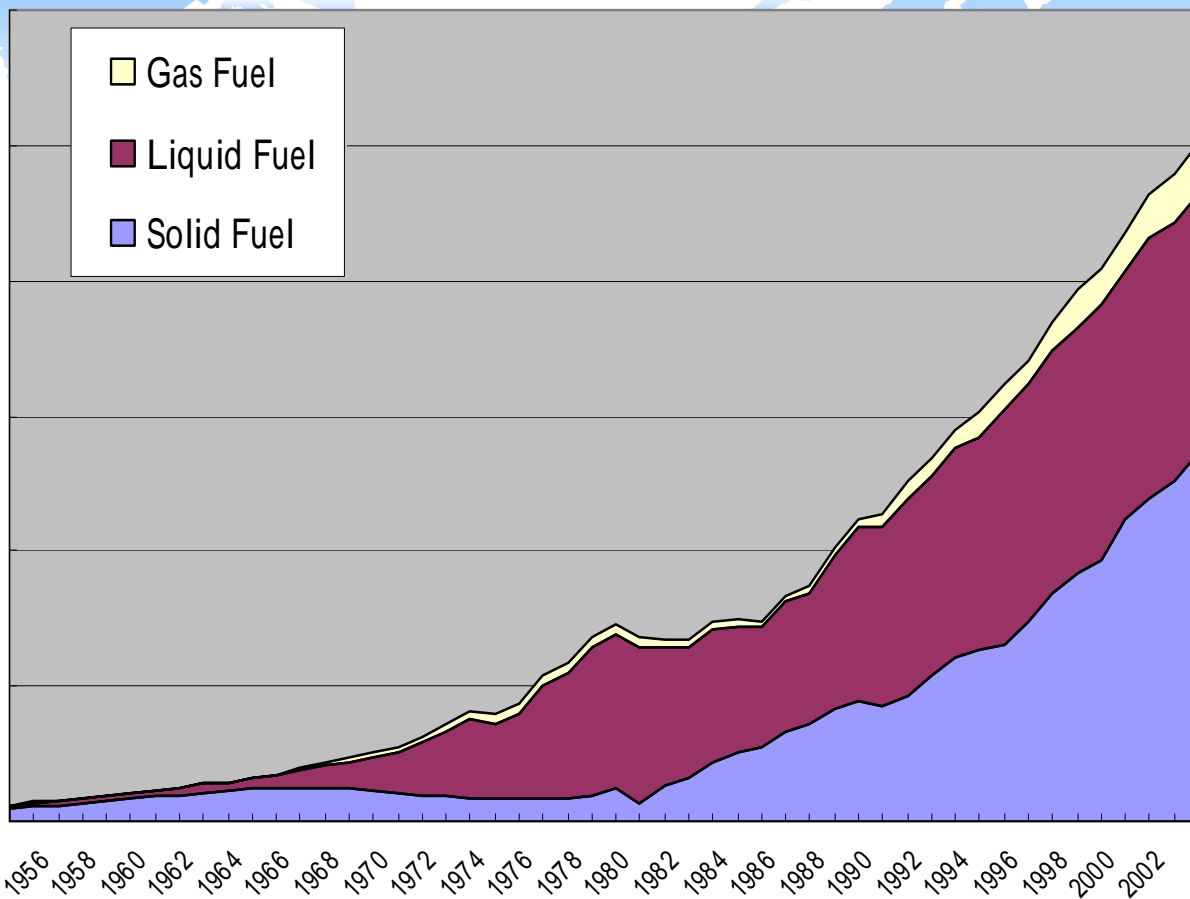
## Energy Demand in 2003

Unit: 10<sup>3</sup> L

Item	2003		1983	
	Quantity	%	Quantity	%
Coal & Coal Pro.	11,071.0	10.7	4,086.0	12.8
Petroleum Pro.	40,296.2	39.0	15,161.3	47.7
LNG	1,340.0	1.30	-	-
Natural Gas	1,089.6	1.00	1,250.6	3.93
Electricity	49,623.3	48.0	11,308.3	35.6



# CO<sub>2</sub> Emission in Taiwan: 1954 ~ 2003



Unit: Million me

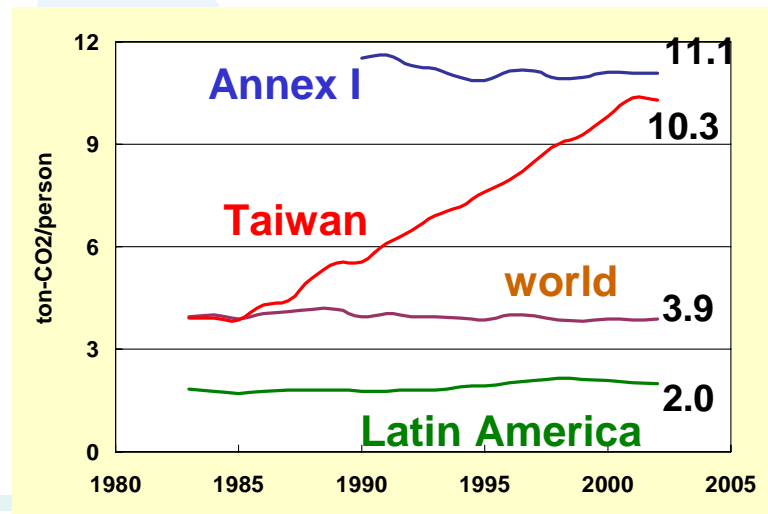
	Solid Fuel	Liquid fuel	Gas fuel
1955	5.6	1.4	0.1
1965	12.0	4.8	0.6
1975	8.2	31.8	3.3
1985	25.6	46.3	2.9
1990	42.7	66.4	4.4
1995	65.2	87.4	9.2
2000	111.6	91.8	14.5
2003	136.1	96.1	18.7



# Challenges to Taiwan's Sustainable Development

- ❑ Energy demand grows rapidly. Total energy consumption will double in 2025.
- ❑ The link between energy use and CO<sub>2</sub> emissions remains strong because of the predominance of fossil fuels in energy supply (up to 95% in 2025)
- ❑ CO<sub>2</sub> emission grows by 121% between 1990 and 2003.

## Trends of Per capita CO<sub>2</sub> Emissions





# Taiwan MARKAL





# Context of Technology Database

## □ 3 technology forms

✓ **Conversion technology: All electricity generation technology, including**

- Nuclear Power
- Thermal Power
- Cogeneration
- Hydro Power

✓ **Process technology:**

- Coke
- Oil Refinery
- LNG Gasification



# Context of Technology Database

## □ 3 technology forms (Contd.)

✓ Demand technology: including 3 demand sectors

➤ Industry

➤ Residential & Commercial

➤ Transportation



# Context of Technology Database

## Demand Technology

### Industry

Iron & Steel  
Cement  
Steam  
Motor  
Process Heat  
Non-energy  
Feedstock

### Residential & Commercial

- Cooking
- Water heating
- Refrigerator
- Air conditioning
- Lighting
- Elec. Appliance
- elec. in misc. service
- fuels in misc. service

### Transportation

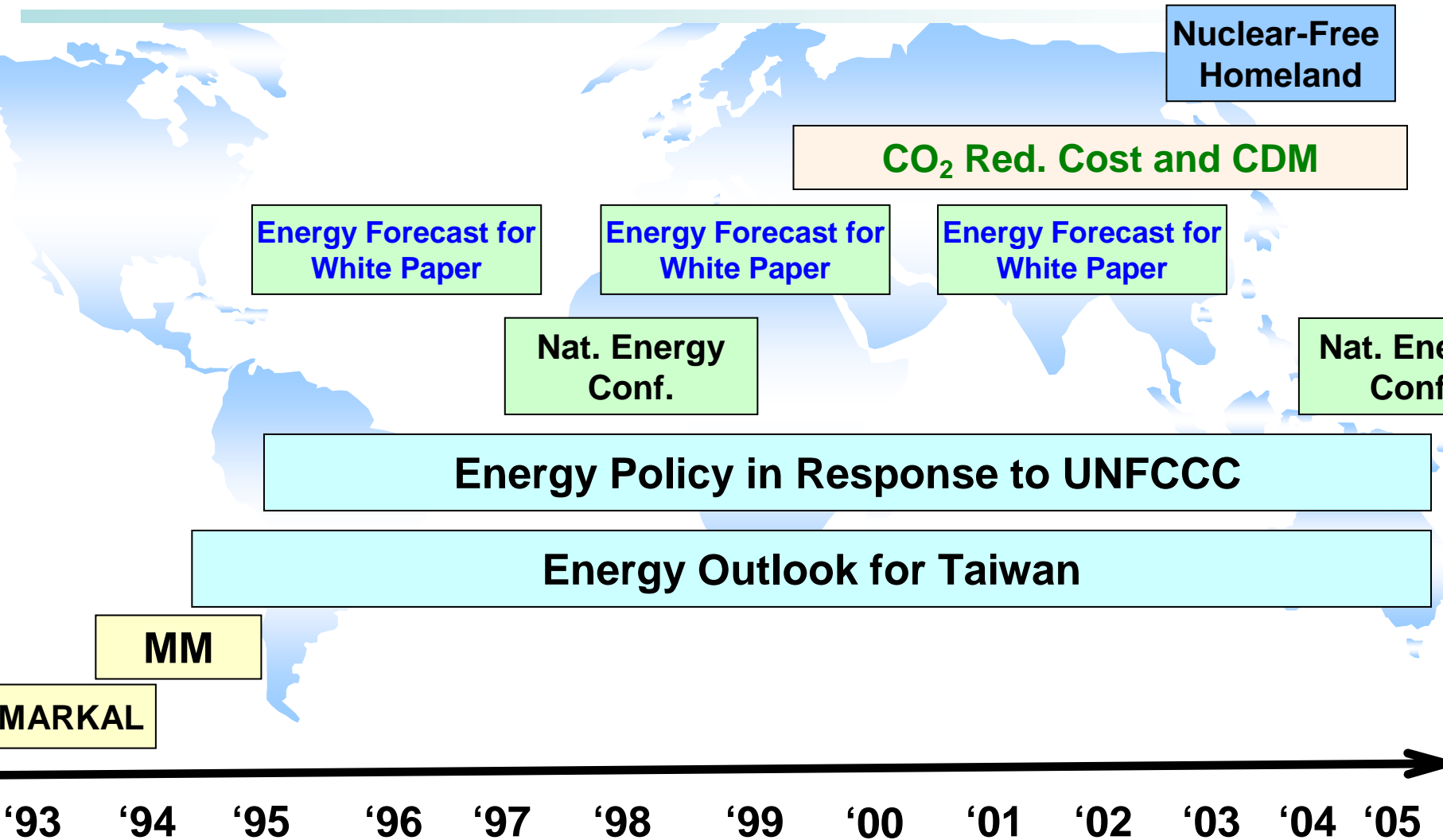
- Cars
- Buses
- Railways
- Domestic aviation
- Passenger ship
- Motorcycles
- Light trucks
- Heavy trucks
- Freight railways
- Freight ship

A light blue world map is centered in the background, showing the outlines of continents. A horizontal light blue bar is positioned above the map, and another is below it.

# Application of Taiwan MARKA



# Development and Application of Taiwan MARKAL



'93 '94 '95 '96 '97 '98 '99 '00 '01 '02 '03 '04 '05



# Development and Application of Taiwan MARKAL

- ❑ Forecast energy supply and demand balances
- ❑ Develop future energy development scenarios for evaluating the benefits and costs of CO<sub>2</sub> mitigation strategies and making international comparison
- ❑ Generate information on emission scenarios for the National Energy Conference
- ❑ Analyze the impacts of energy conservation, renewable energy strategy, and “Nuclear-Free Homeland” policy on the future energy structure of Taiwan



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A light blue world map background, centered on the Pacific Ocean, with the title text overlaid in the center.

# Scenario Analysis for Energy Outlook in Taiwan

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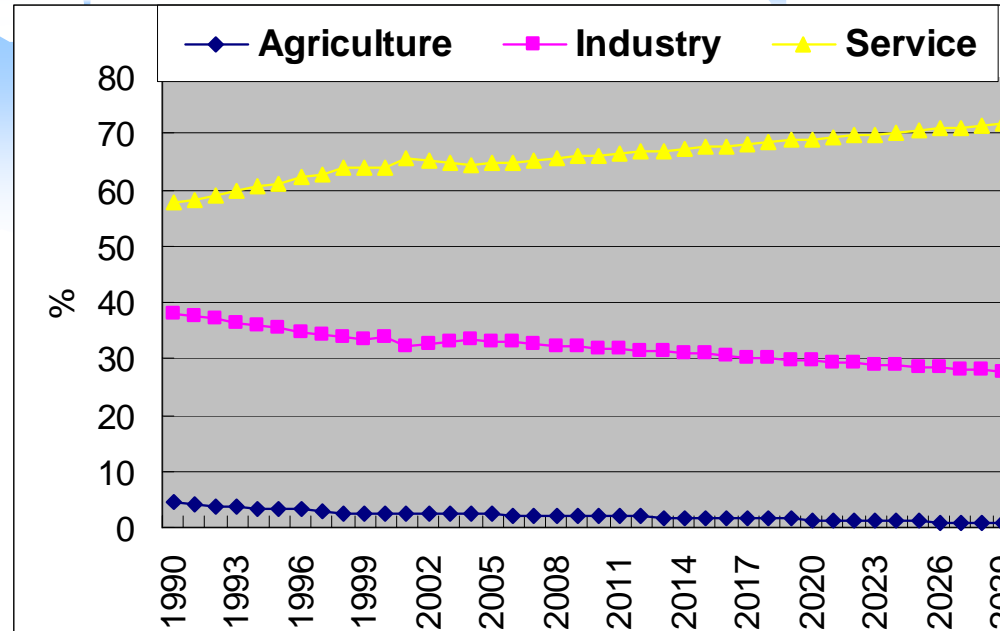


# Scenarios Analysis for Energy Outlook: Key Assumptions

## GDP & Population

Period	GDP (10 <sup>9</sup> NTD)	GDP growth rate (%)	Population growth rate (%)
-1995	7,237	7.12	0.92
-2000	9,559	5.72	0.90
-2005	10,864	2.59	0.53
-2010	13,534	4.49	0.49
-2015	16,680	4.27	0.40
-2020	20,289	4.00	0.30
-2025	24,656	3.98	0.16
-2030	29,935	3.96	-0.02

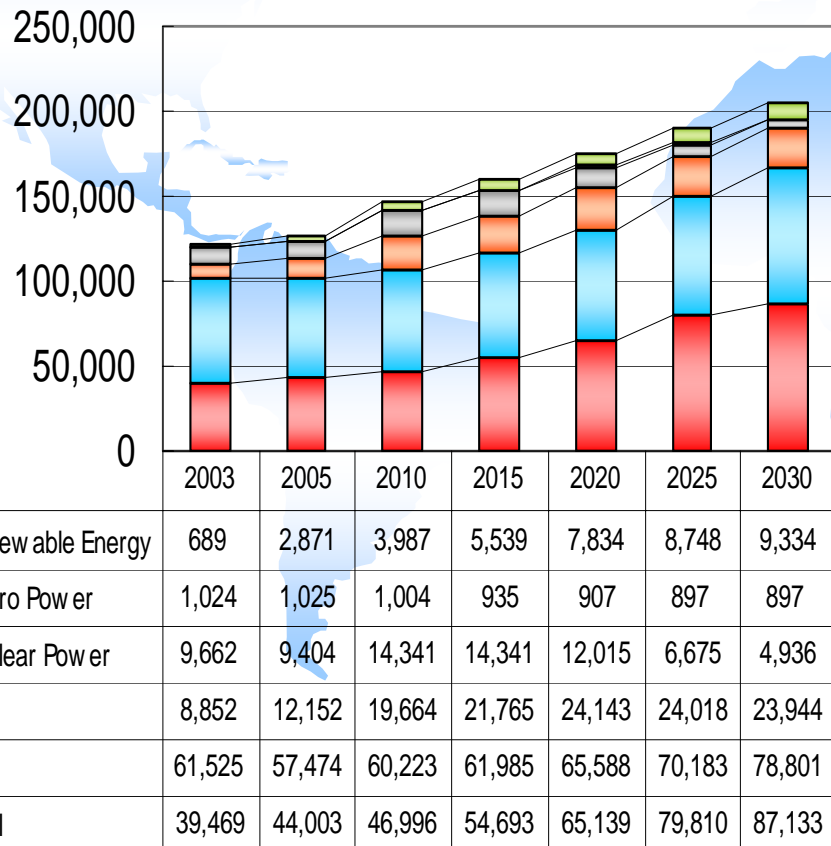
## Structure of GDP



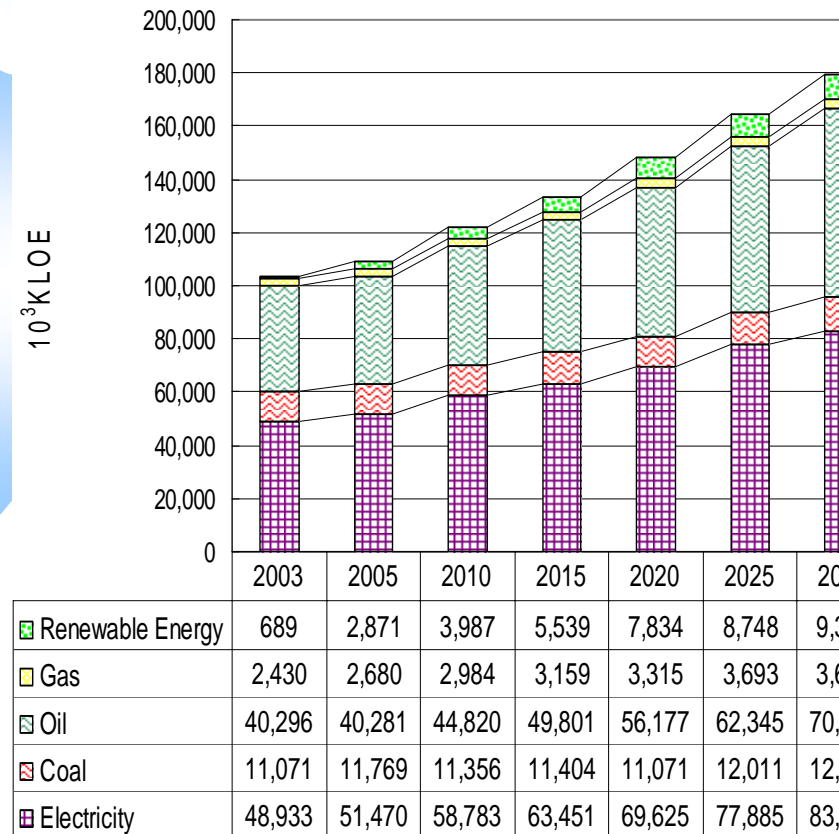


# Scenarios Analysis for Energy Outlook: Forecast Result

## Energy Supply

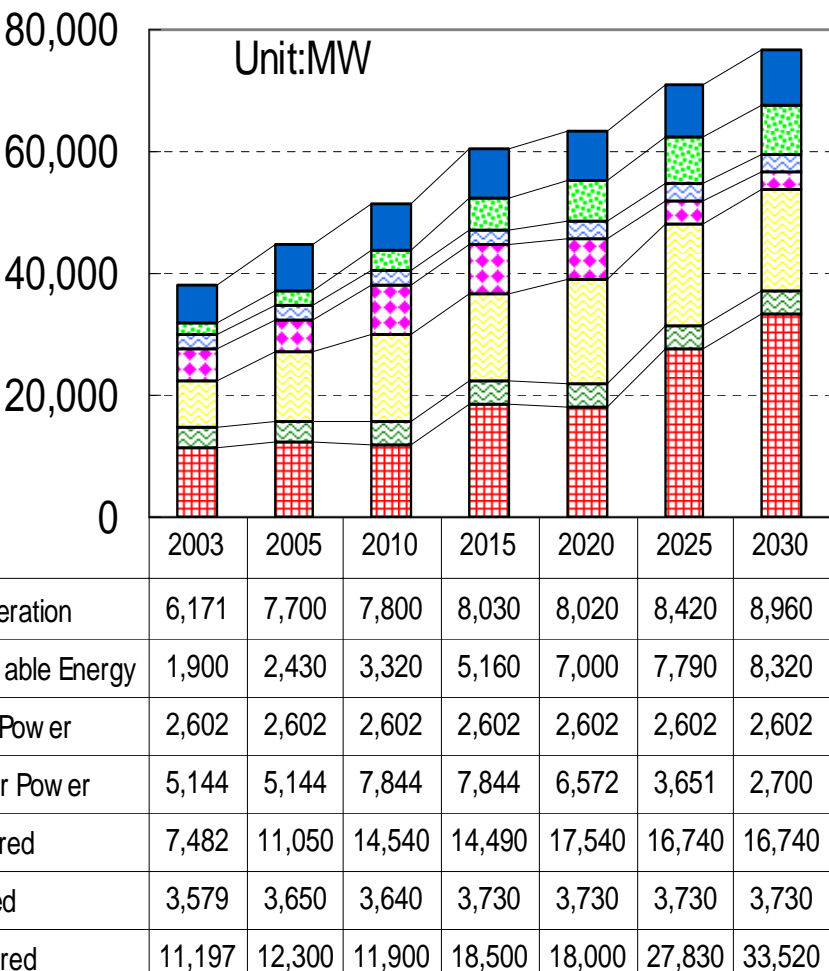


## Energy Demand

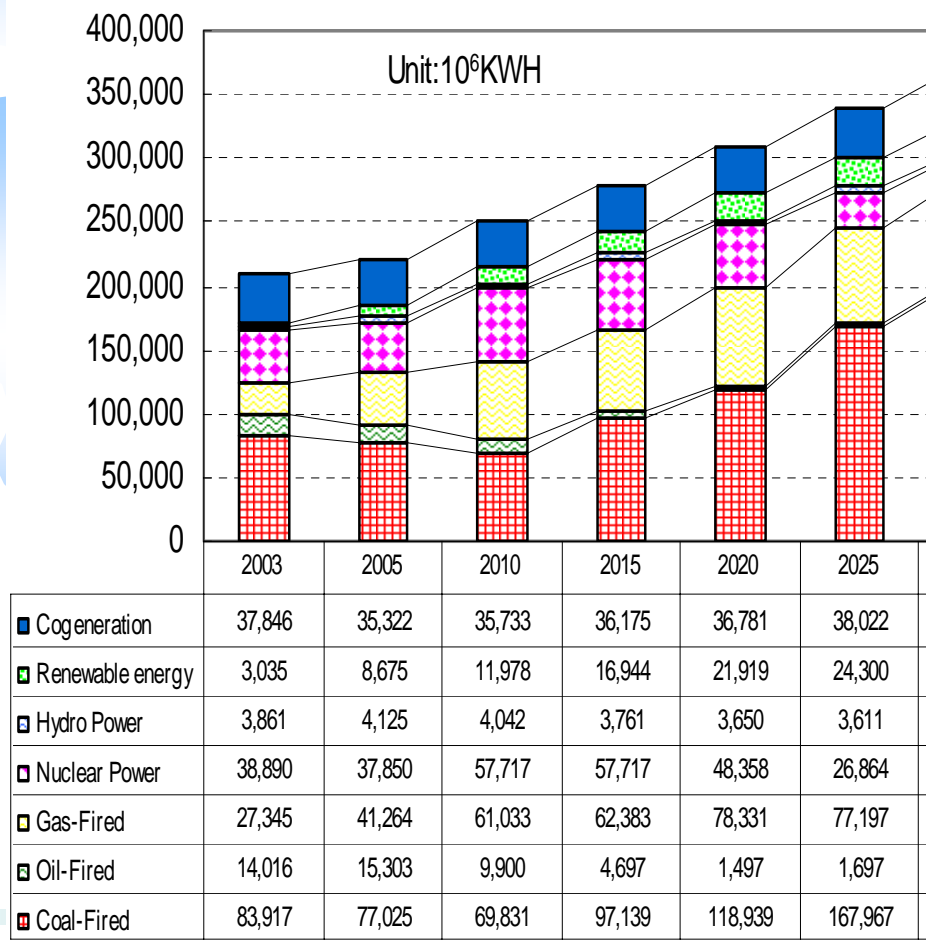


# Scenarios Analysis for Energy Outlook: Forecast Result

## Electricity Capacity



## Electricity Generation





# CO<sub>2</sub> Mitigation Scenario

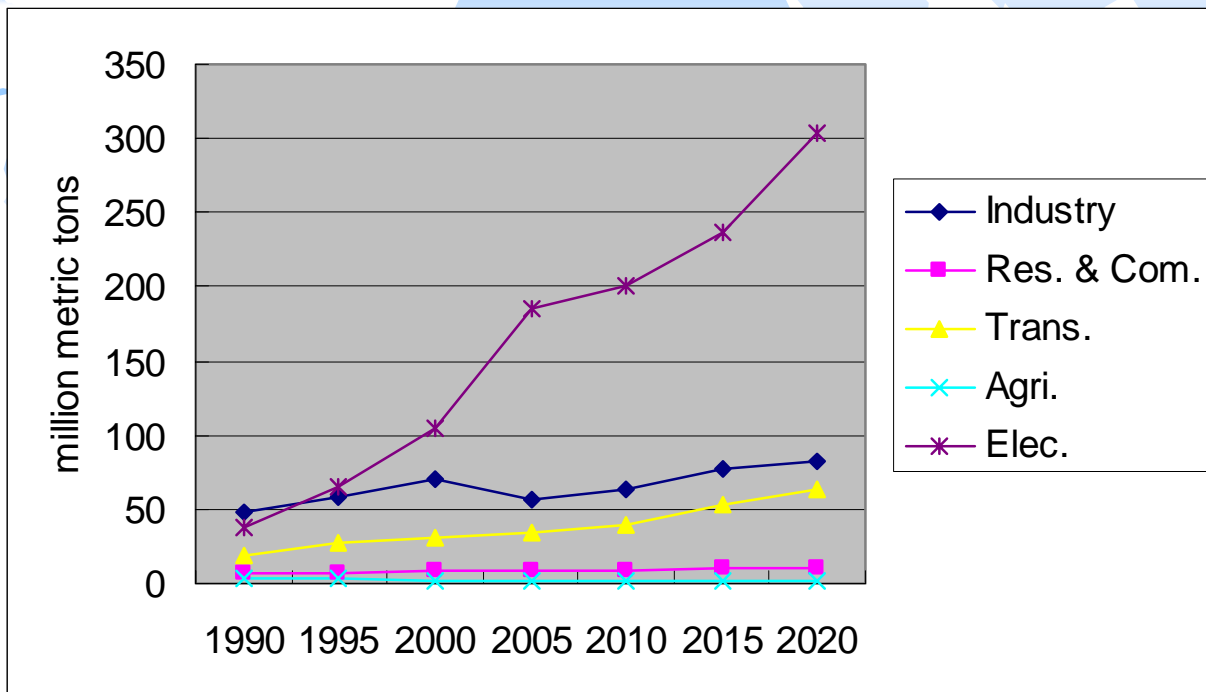
# CO<sub>2</sub> Mitigation Scenario Analysis: Emission Trend

	CO <sub>2</sub> Emission	CO <sub>2</sub> Per capita	Energy Intensity	GHG Intensity
Unit	Million metric tons	Metric tons of CO <sub>2</sub> /population	KLOE/10 <sup>6</sup> NTD , 1996 price	Metric tons of CO <sub>2</sub> /10 <sup>6</sup> NTD , 1996 price
1990	113	5.6	10.1	22.1
1995	162	7.6	9.5	22.4
2000	218	9.8	9.5	22.8
2005	286	12.5	8.1	26.1
2010	315	13.5	8.2	23.1
2015	379	15.8	8.0	22.6
2020	461	19.0	7.8	22.8

# CO<sub>2</sub> Mitigation Scenario Analysis: Emission Trend

## CO<sub>2</sub> Emission by Sector

- Industry and Commercial affected by business cycle
- Emission of Transportation continues to grow





# CO<sub>2</sub> Mitigation Scenario Analysis:

Scenario	Target	Reduction rate	Marginal/Average reduction cost
Kyoto Protocol Scenario	Mitigation target in National Energy Conference : 10 tons/CO <sub>2</sub> per capita in2020	35%	US\$ <sub>1991</sub> 207/Tons CO <sub>2</sub> (Marginal Reduction Cost)
	13 tons/CO <sub>2</sub> per capita in2020	20%	US\$ <sub>1991</sub> 101/Tons CO <sub>2</sub> (Marginal Reduction Cost)
GHG Intensity Scenario	Germany pattern : 9.4-13.1 tons/CO <sub>2</sub> per capita in2020	19%~41.7 %	US\$ <sub>1991</sub> 101/Tons CO <sub>2</sub> (Reduction rate:19%)(Marginal Reduction Cost)
	Argentina pattern : 12.7tons/CO <sub>2</sub> per capita in2020	14%	US\$ <sub>1991</sub> 23.2/TonsCO <sub>2</sub> (Marginal Reduction Cost)
	USA pattern : 11.4tons/CO <sub>2</sub> per capita in2010	18%	US\$ <sub>1991</sub> 41/TonsCO <sub>2</sub> (Marginal Reduction Cost, in 2010)
Contraction & Convergence Scenario	13tons/CO <sub>2</sub> per capita in2020	20%	US\$ <sub>1991</sub> 101/TonsCO <sub>2</sub> (Marginal Reduction Cost)
Triptych approach Scenario	Mitigation target by sector in 2015 Industry : 126million tons CO <sub>2</sub> Electric : 60million tonsCO <sub>2</sub> Residential & Commercial : 102million tons CO <sub>2</sub>	24%	-



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# Thank You

