The Impact of Climate Policy on ROK's Energy Sector: Application of the LEAP Model to Energy Sector Analysis

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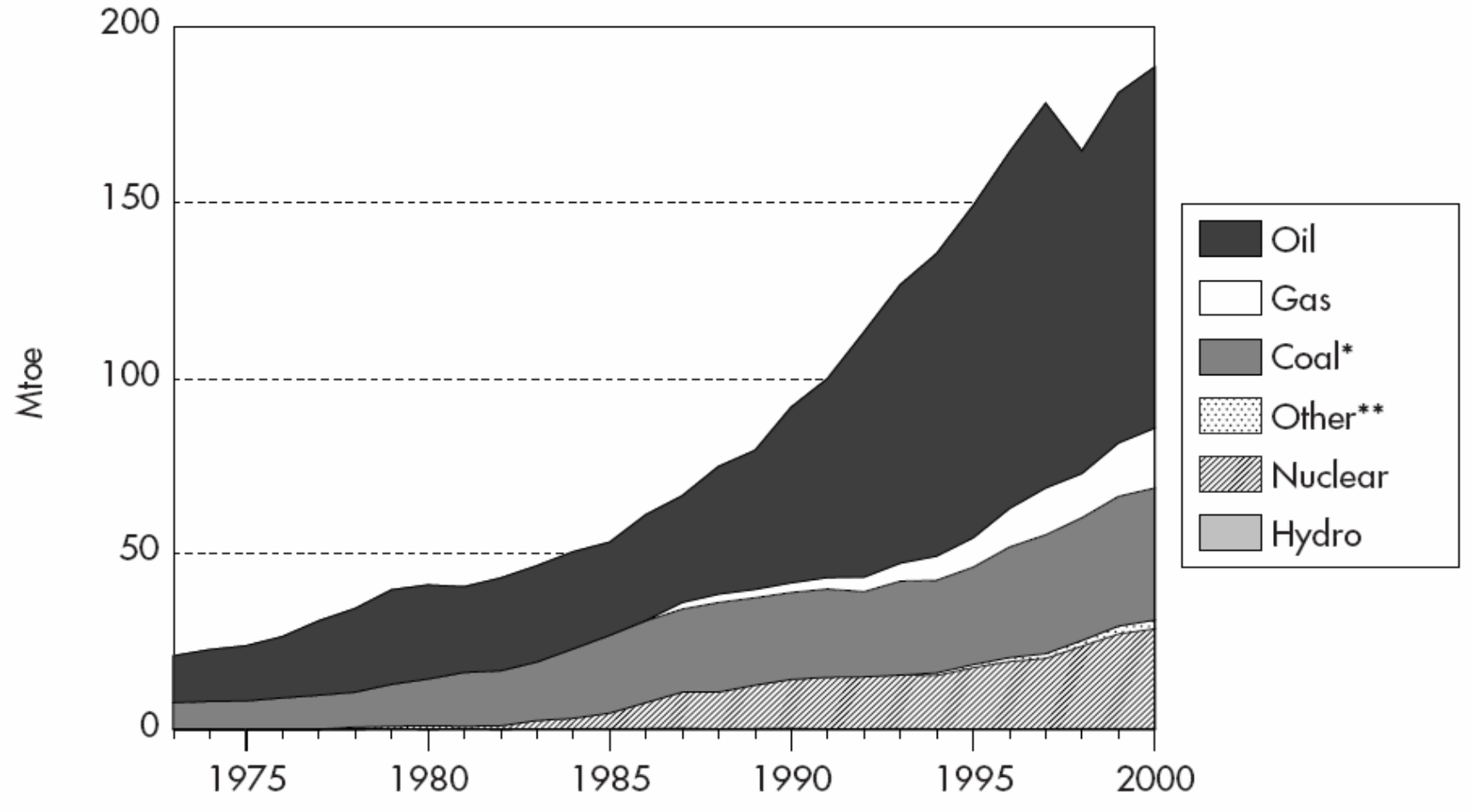
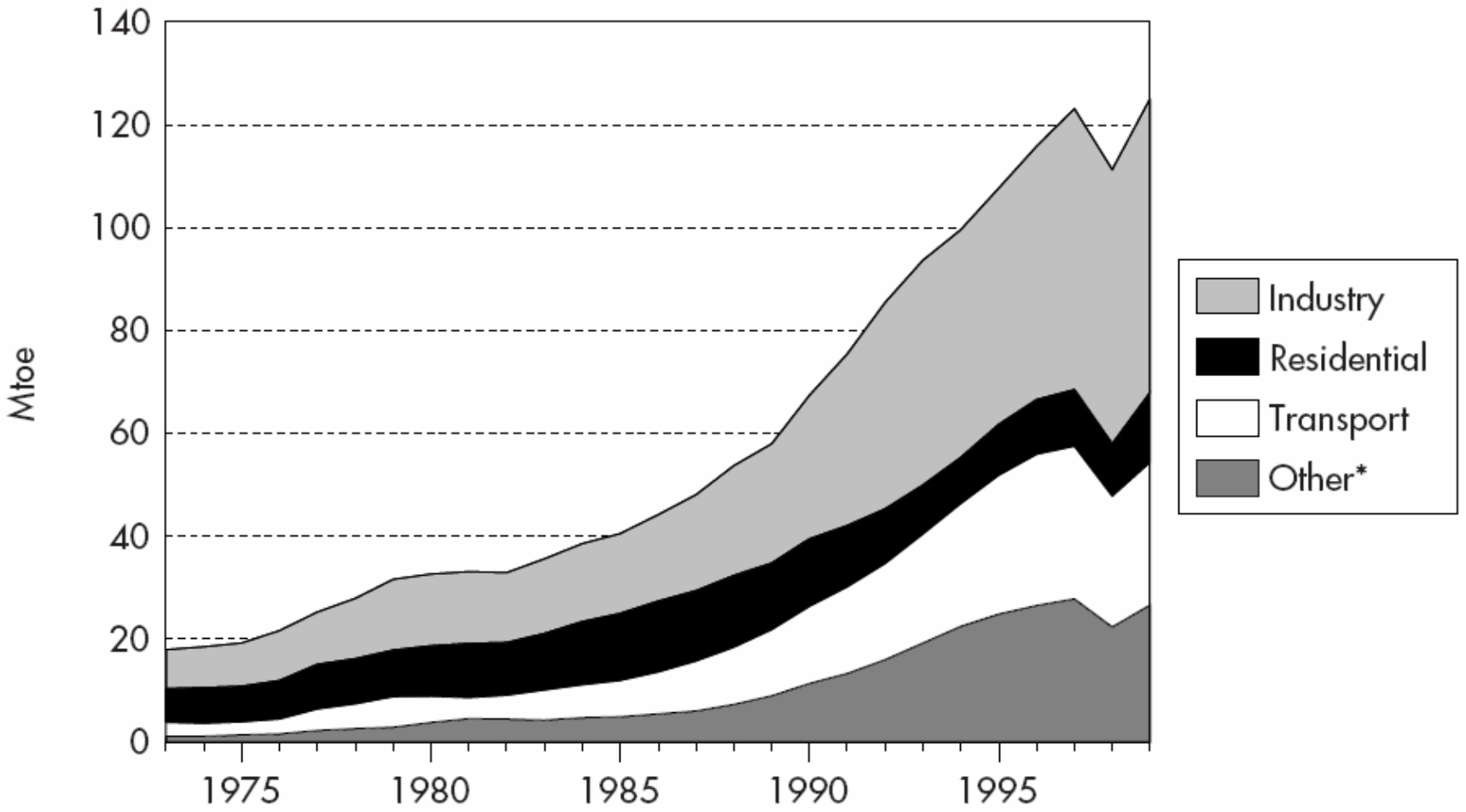
1. OVERVIEW OF ROK'S ENERGY SECTOR

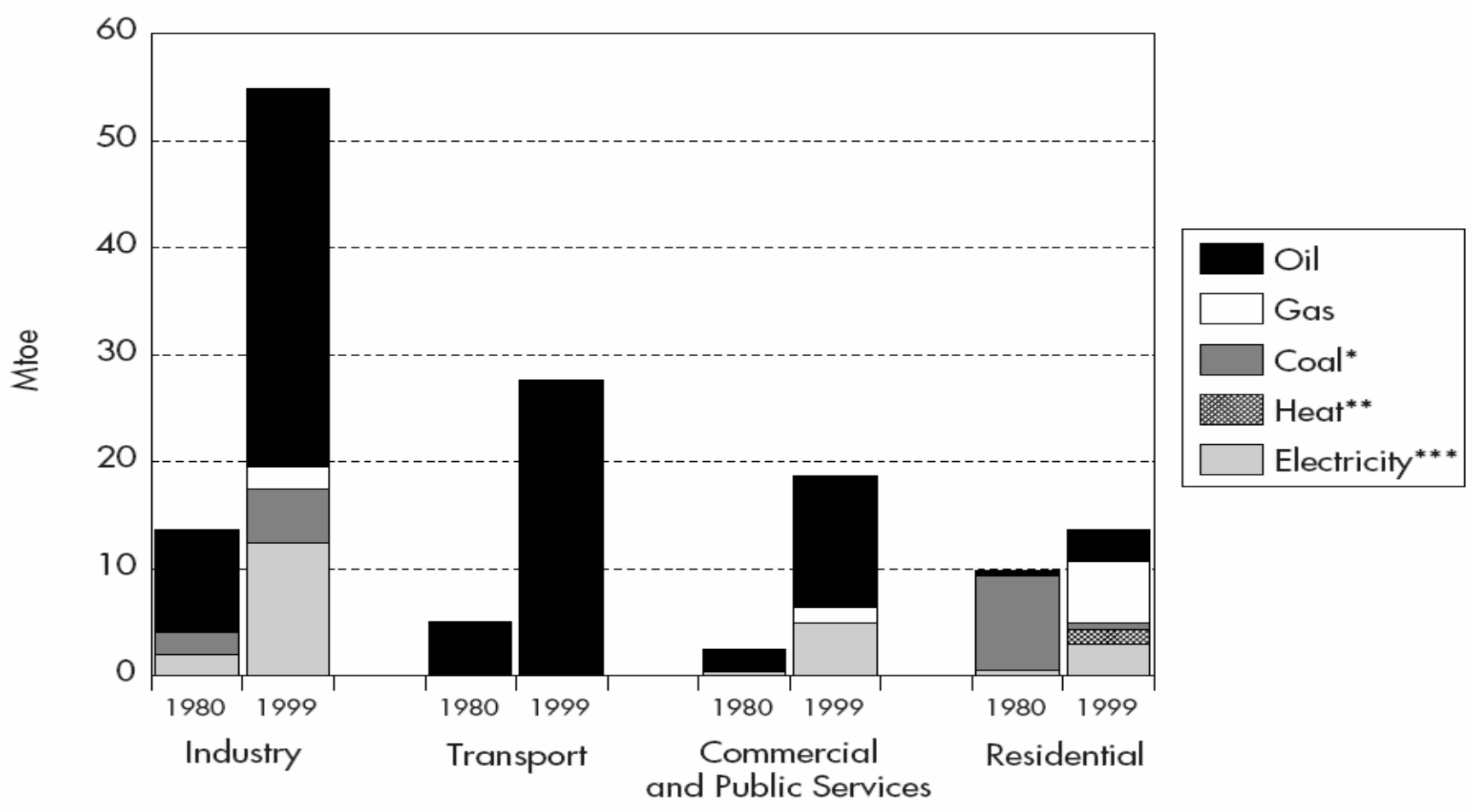
Total Primary Energy Supply



Total Final Consumption by Sector



Total Final Consumption by Sector and by Source, 1980 and 1999



- Over the past decade (1989-1999), consumption growth was led by the commercial and public services sector (19% per year), industry (14%) and transport (12%).
- The residential sector's final consumption stagnated (rising only 0.5% per annum) as a result of a shift from coal to gas and electricity, and more efficient energy use.
- Industry is the largest final consumer of energy.

- The power generation sector accounted for 23% of TFE in 1999 (13% in 1980), the transport sector accounted for 17% (13% in 1980), the commercial and public services sectors accounted for 11% (8% in 1980) and the residential sector represented 8% (26% in 1980).
- Final consumption of oil stabilized during the two oil crises of the 1970s, but rose sharply until the Asian economic crisis. Between 1987 and 1997, final oil consumption increased more than threefold.

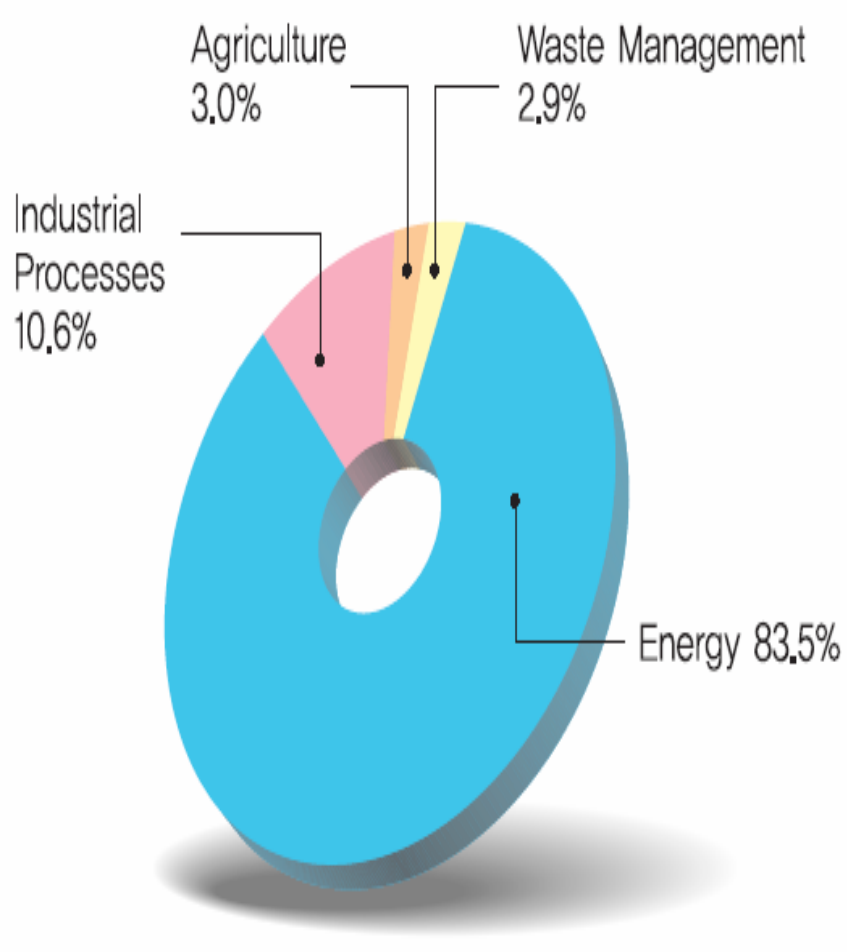
- Oil maintains the largest share in final consumption, with 53% in 1982 rising to 61% in 2001.
- Power generation grew continuously, multiplying more than nine times between 1971 and 1999, with just a slight decrease during the Asian economic crisis, the share of electricity in TFE almost doubled to 17%.
- Natural gas consumption began in 1987 and has increased since then, thanks to the development of city gas, to reach 8.7% of TFE in 2001.
- Coal consumption increased until 1988, and then began to decrease steadily. Coal represented 13% of TFE in 2001.

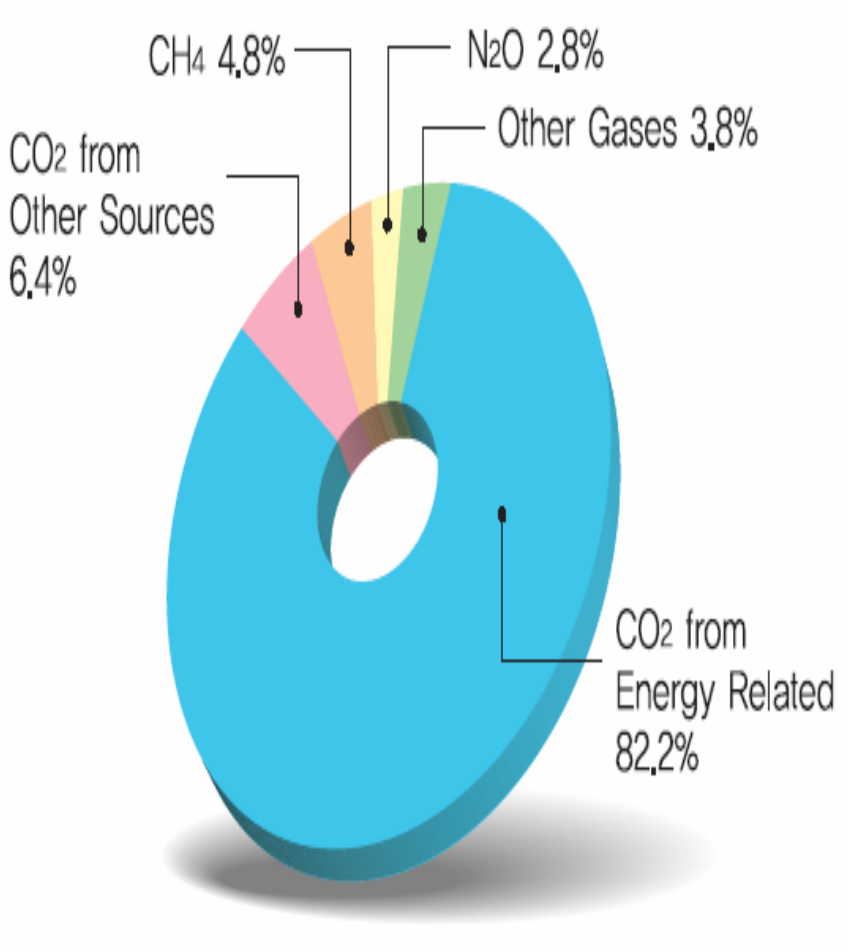
2. CLIMATE POLICY MEASURES

GREENHOUSE GAS INVENTORY

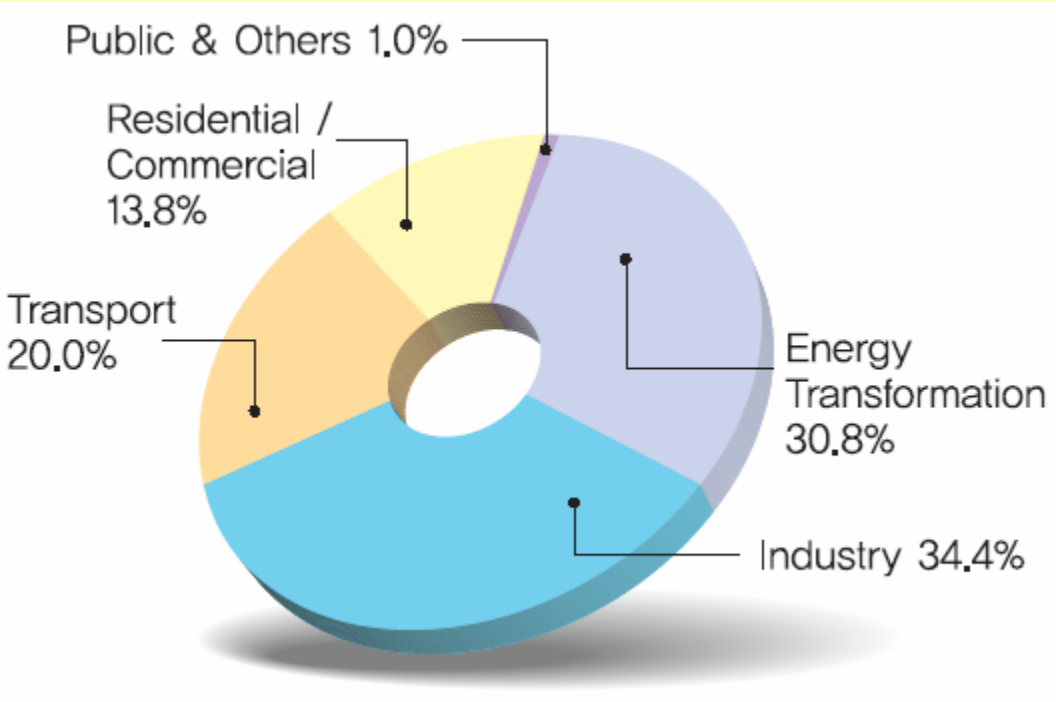
- In 2001, total GHG emission recorded 148.0 MtC, 2.6% increase from 144.3 MtC in 2000, caused by the increase in energy consumption.
- Energy accounted for 83.5%, industrial processes 10.6%, waste 2.9%, and agriculture 3.0% of GHS emission.
- Energy related carbon dioxide accounted for 82.2% of total GHS emissions, whereas carbon dioxide from other sources accounted for 6.4%.

GHG Emissions by Source and Gas (2001)





GHG Emissions from Fuel Combustion (2001)



Trend of GHG Emissions

- The trend of total GHG emissions between 1990~2001 shows an average annual increase of 5.2% from 84.7 MtC in 1990 to 148.0 MtC in 2001 with per capita emission rising 4.3% per year since 1990 recording 3.13 tC in 2001.
- On the other hand, GHG intensity, an indicator of greenhouse gas emissions per unit GDP, began to fall from 1996. The greenhouse gas intensity fell from 0.322 tC per million won in 1990 to 0.300 tC per million won in 2001.

GHG Emissions by Source

	1990	1995	1998	1999	2000	2001	1990–2001 Average Annual Growth Rate (%)
Total Emissions	84,738 (100.0)	123,445 (100.0)	123,974 (100.0)	135,542 (100.0)	144,259 (100.0)	148,038 (100.0)	5.2
Energy	67,567 (79.7)	101,490 (82.2)	102,335 (82.5)	111,528 (82.3)	119,601 (82.9)	123,540 (83.5)	5.6
Industrial Processes	5,428 (6.4)	12,747 (10.3)	12,393 (10.0)	14,933 (11.0)	15,886 (11.0)	15,755 (10.6)	10.2
Agriculture	4,798 (5.7)	4,917 (4.0)	4,821 (3.9)	4,656 (3.4)	4,519 (3.1)	4,405 (3.0)	−0.8
Land-Use Change & Forestry (Sinks)	(−)6,476	(−)5,793	(−)9,949	(−)10,422	(−)10,156	(−)9,448	3.5
Waste	6,945 (8.2)	4,291 (3.5)	4,425 (3.6)	4,425 (3.3)	4,254 (2.9)	4,337 (2.9)	−4.2
Net Emissions	78,262	117,651	114,025	125,120	134,102	138,590	5.3

- Greenhouse gas emissions increased 5.6% per year from 67.6 MtC in 1990 to 123.5 MtC in 2001 from fuel combustion and fugitive emissions in the energy sector. The 10.2% yearly growth rate in industrial processes since 1990 showed close to a three-fold increase from 5.4 MtC in 1990 to 15.8 MtC in 2001.
- Emissions from agriculture fell 0.8% per year since 1990 to 4.4 MtC in 2001 largely due to the reduction in rice cultivation and fertilizer use and the declining number of livestock since the late 1990s.
- Emissions from waste also fell by an annual 4.2% since the early 1990s. Despite the continual rise in removals by sinks in land use change and forestry sector between 1990 and 1999, the figures since then have been maintained at around 10 MtC.

ROK'S CLIMATE POLICY

- Recognizing that the conservation of energy and reduction of greenhouse gases are consistent with long-term development of the economy, Korea adopted various policies and measures for energy conservation and reduction of GHG emissions.
- Inter-Ministerial Committee on UNFCCC was established in 1998 to formulate, implement and promote the Comprehensive Action Plans for UNFCCC.

The Second Comprehensive Action Plan for Climate Change Policy

- During the First Comprehensive Action Plan period (1999~2001) , Korea accomplished 27 tasks, including the introduction of voluntary agreement (VA), renewable energy development , increased sewage treatment levels, as well as 111 detailed measures
- In the Second Comprehensive Action Plan (2002-2004) formulated in 2001, the agreement on the implementation plan for the Kyoto Protocol and the changes in ROK's economic and industrial circumstances were reflected

- Second Action Plan contains various detailed projects for the reduction of GHG emission in three relevant areas:

- Promotion of Technology to Reduce GHG and Development of Environment-Friendly Energy
- Strengthening Policies and Measures for GHG Reduction
- Inducement of Public Participation and Cooperation

Summary of the Action Plan

Energy	Demand	Integrally Managed Energy Conservation Policy	3-Year Plan for Energy Audit
			Expansion of Voluntary Agreement (VA)
			Energy Service Companies (ESCO)
		Improvements in Energy Efficiency	High Efficient Equipment Certification Program
			Energy Efficiency Standards & Labeling Program
	Supply	Expansion of Renewable & Clean Energy Use	Formation of Market Demand for Renewable Energy and Improvement in Its Economics
			Expansion of Integrated Energy Supply Project
			Stable Supply of Natural Gases
			Stable Supply Level of Nuclear Energy
			Promotion of Landfill Gas (LFG) Projects
	Building	Improvement of Energy Efficiency in Buildings	Mandatory Standards for Building Insulation & Energy-Efficient Designs
			Energy Efficiency Labeling Program for Buildings
			Green Building Certification Program
	Transportation Fuel	Promotion of Clean Fuel & Compact Cars	Promotion of CNG Buses and Compact Cars
			Development of Diesel Cars

Transportation	Efficient Management of National Transportation System & Traffic Demand	Promotion of Efficient Transport Mode Sharing
		Reduction of Traffic Congestion Areas
		Expansion of Public Transportation Service
		Traffic Demand Management
		Regulation on Idle Running Vehicles & Restriction on Car Use
	Establishment of Comprehensive Logistics Information Network & Standardization of Logistics Equipments	Establishment of Comprehensive Logistics Information Network
		Promotion of Logistics Standardization
Agriculture and Livestock	Improvements in Patterns of Farming and Animal Husbandry	Reduction of Methane from Irrigated Rice Paddies and Nitrous Oxide from Uplands
		Improvement in Enteric Management of Ruminant Livestock
		Improvement in Livestock Manure Treatment Facilities
Land-Use Change and Forestry	Forest Management	Promotion of Forest Tending Projects
		Control of Forest Pest Insects and Diseases
		Enforcement of Forest Fire Management System
	Forest Maintenance	Control of Deforestation and Replantation of Harvested Areas
	Afforestation	Promotion of Urban Greening
Waste	Minimization & Recycling of Waste	Waste Minimization
		Waste Recycling
	Establishment of Foundation for Waste Treatment	Municipal Waste Landfill Facilities
		Waste Incineration Facilities
		Sewage & Wastewater Treatment Facilities

Energy Sector

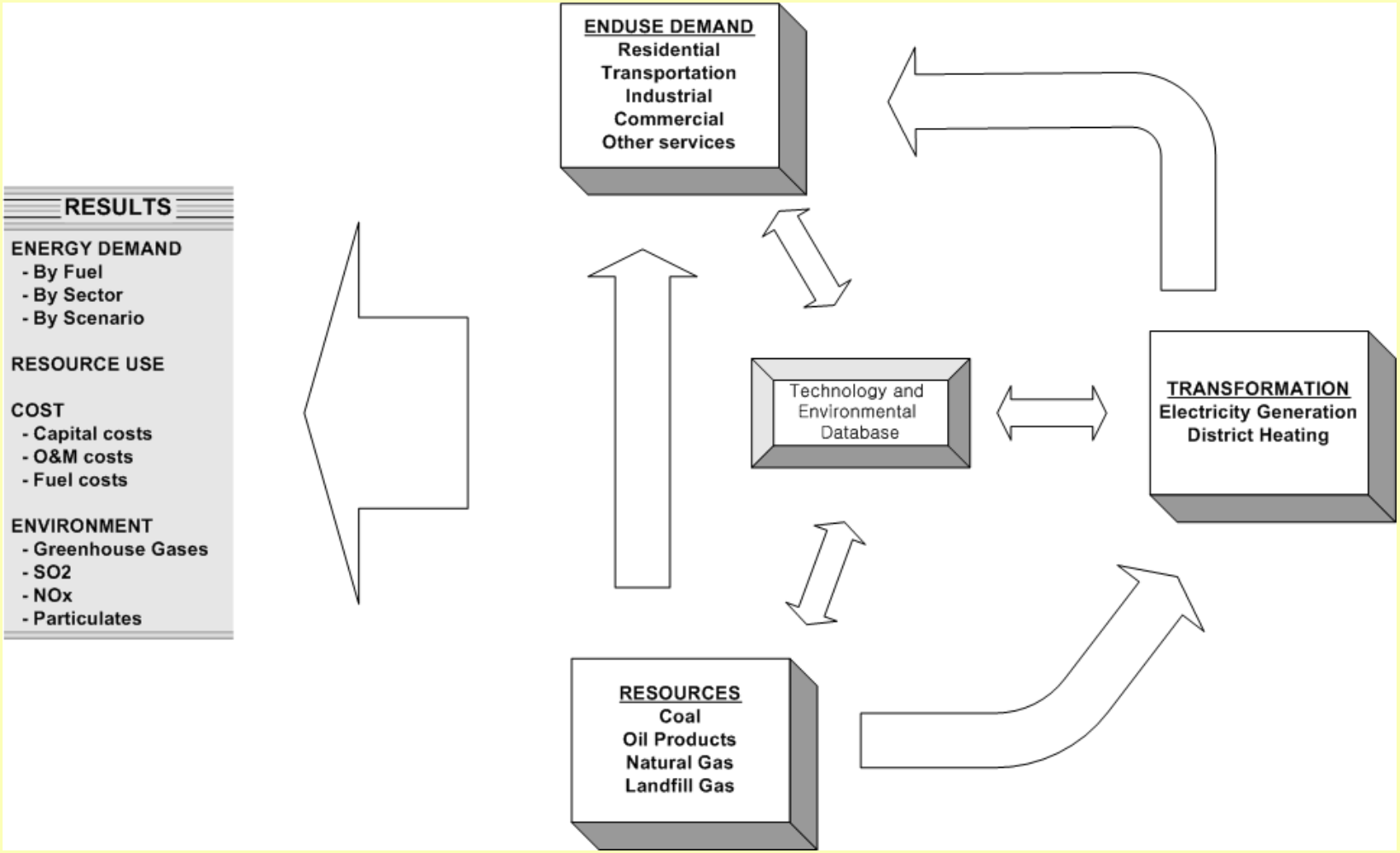
- In 2000, 83% of total greenhouse gas emissions came from the energy sector (e.g. fuel consumption and fugitive emissions).
- Hence, recognizing that the reduction of greenhouse gas emissions in the energy sector is of the utmost importance for devising countermeasures for the UNFCCC, profound and diverse policies and measures are being developed and promoted.
- In the energy sector, for instance, policies are being devised for energy supply & demand, buildings and transportation fuel.

3. THE MODEL: LEAP ROK2003

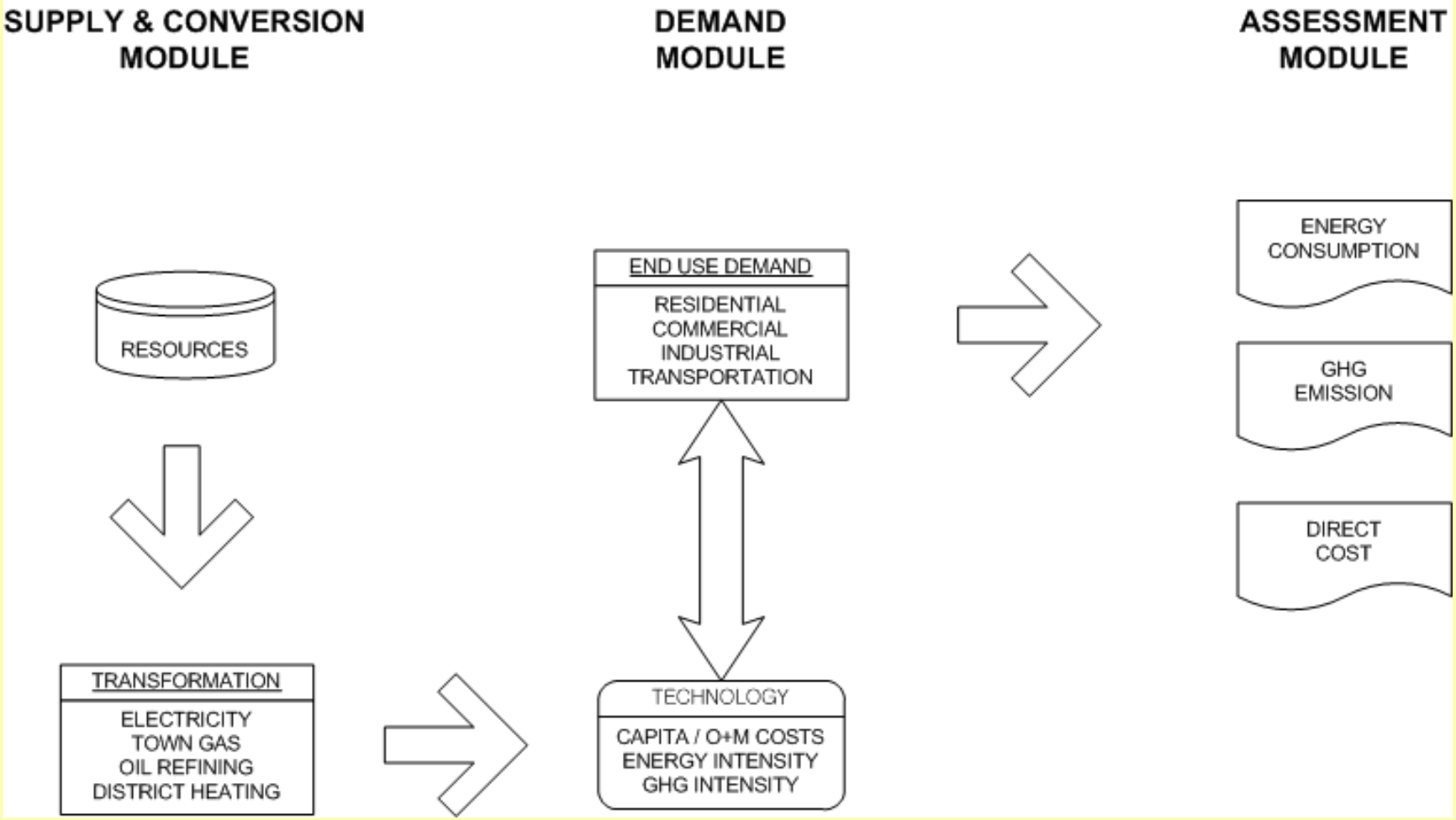
LEAP MODELING PLATFORM

- **LEAP: L**ong range **E**nergy **A**lternatives **P**lanning System
- **Key Characteristics:** accounting framework, user-friendly, scenario-based, integrated energy-environment model-building tool.
- **Scope:** energy demand, energy supply, resources, environmental loadings, cost-benefit analysis, non-energy sector emissions. Most aspects optional.
- **Flexible Approach to Modeling:** basic relationships are all based on non-controversial physical accounting. Also allows for spreadsheet-like "expressions", for the creation of econometric and simulation models.
- **Time:** medium to long-term, annual time-step, unlimited number of years.
- **Data requirements:** flexible, low initial data requirements. Includes *TED* database, with technical characteristics, costs and emission factors of ~ 1000 energy technologies.
- **Geographic Applicability:** local, national, regional.

The Structure of LEAP



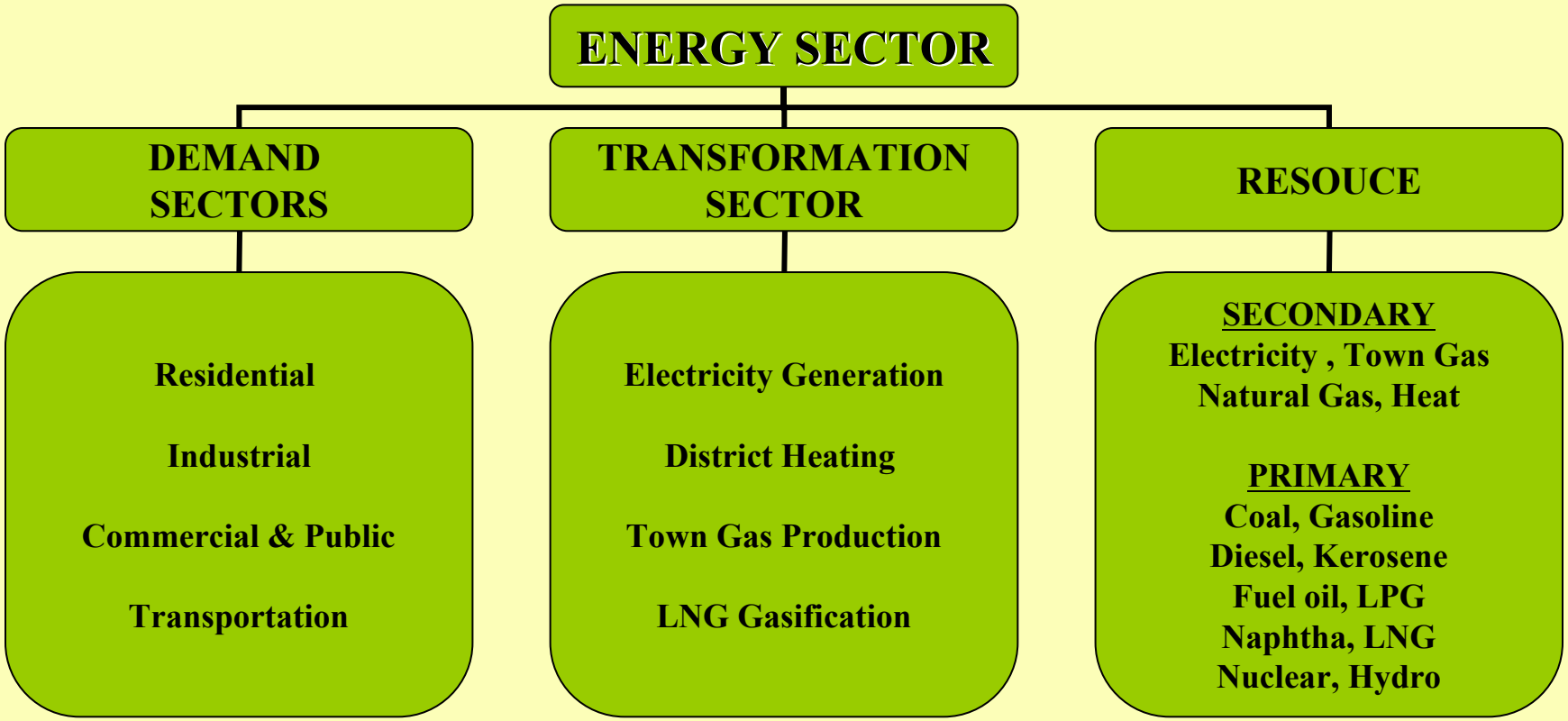
Modular Components of LEAP



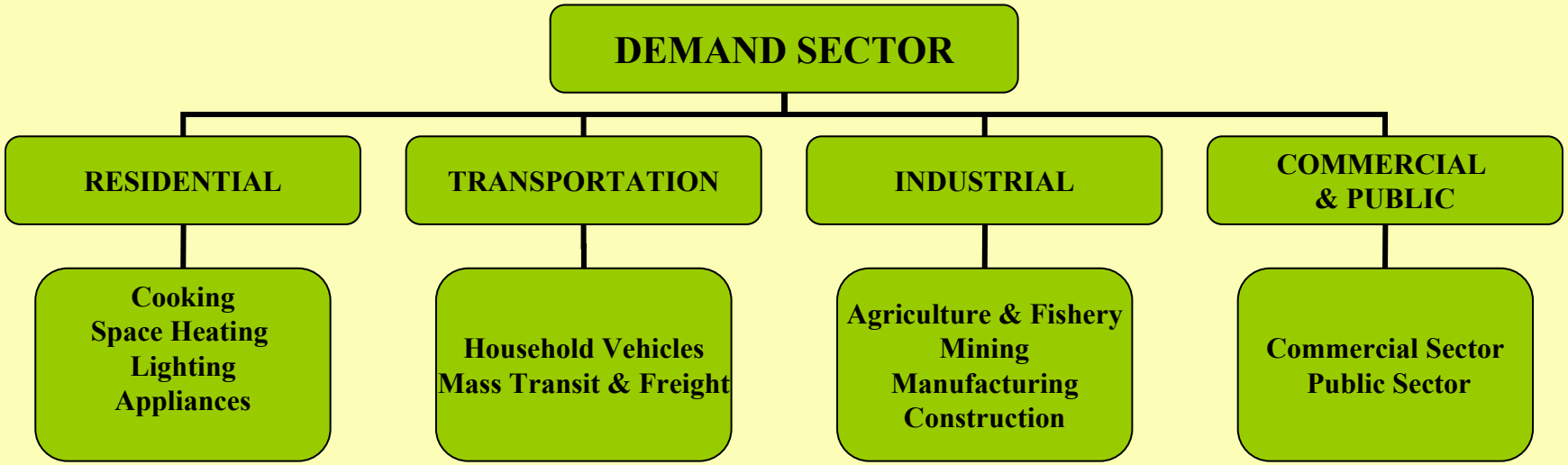
LEAP ROK2003

- Model Name: LEAP ROK2003
- Base year: 2002
- Time horizon: 2000-2015 (medium-term)
- Geographical coverage: National model
- Sectoral coverage: Energy sector
  - Final energy use
  - Transformation
  - Primary energy supply
- TED: Energy and Environmental Impacts

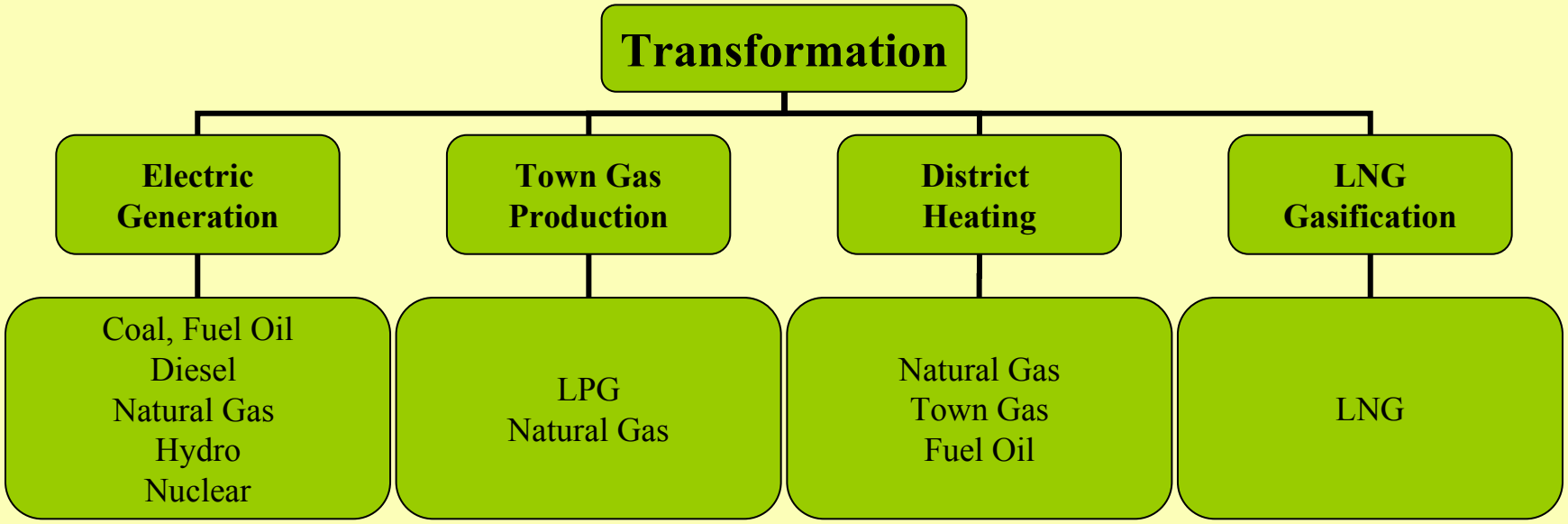
The Model Structure of ROK2003



Demand Sector



Transformation Sector



POLICY SCENARIOS

- BAU Scenario
- Four Alternative Scenarios
  - SCENARIO ONE: Natural Gas - Stable Supply of Natural Gases
  - SCENARIO TWO: Nuclear - Stable Supply of Nuclear Energy
  - SCENARIO THREE: Transportation - Promotion of CNG Buses and Sub-Compact Cars
  - SCENARIO FOUR: Green Building - Improvement of Energy Efficiency in Buildings
- Integrated Alternative Scenario

Scenario One: Natural Gas

- Policy measures
  - Stable supply of natural gases
  - Expansion of the supply infrastructure such as nationwide pipelines and the construction of LNG terminals
- Expected Effects
  - Long-term import source which was limited to Asia such as Indonesia has been extended to the Middle East such as the State of Qatar and Oman to strengthen the stable supply of natural gas by 2010.
  - Natural gas supply rate is expected to increase gradually from 58.7% in 2000 to 67.2% in 2005 and 73.0% in 2010.

Scenario Two: Nuclear

- Policy measures
  - Stable supply level of nuclear energy
  - By 2008 radioactive waste treatment facilities will be constructed to transport and dispose the waste currently stored within the nuclear energy generation site.
  - Technological development will also be implemented to increase the output from nuclear power generation.
- Expected Effects
  - The share of nuclear power will be maintained in the long-term at 44.5% level of the total power generated in 2015.

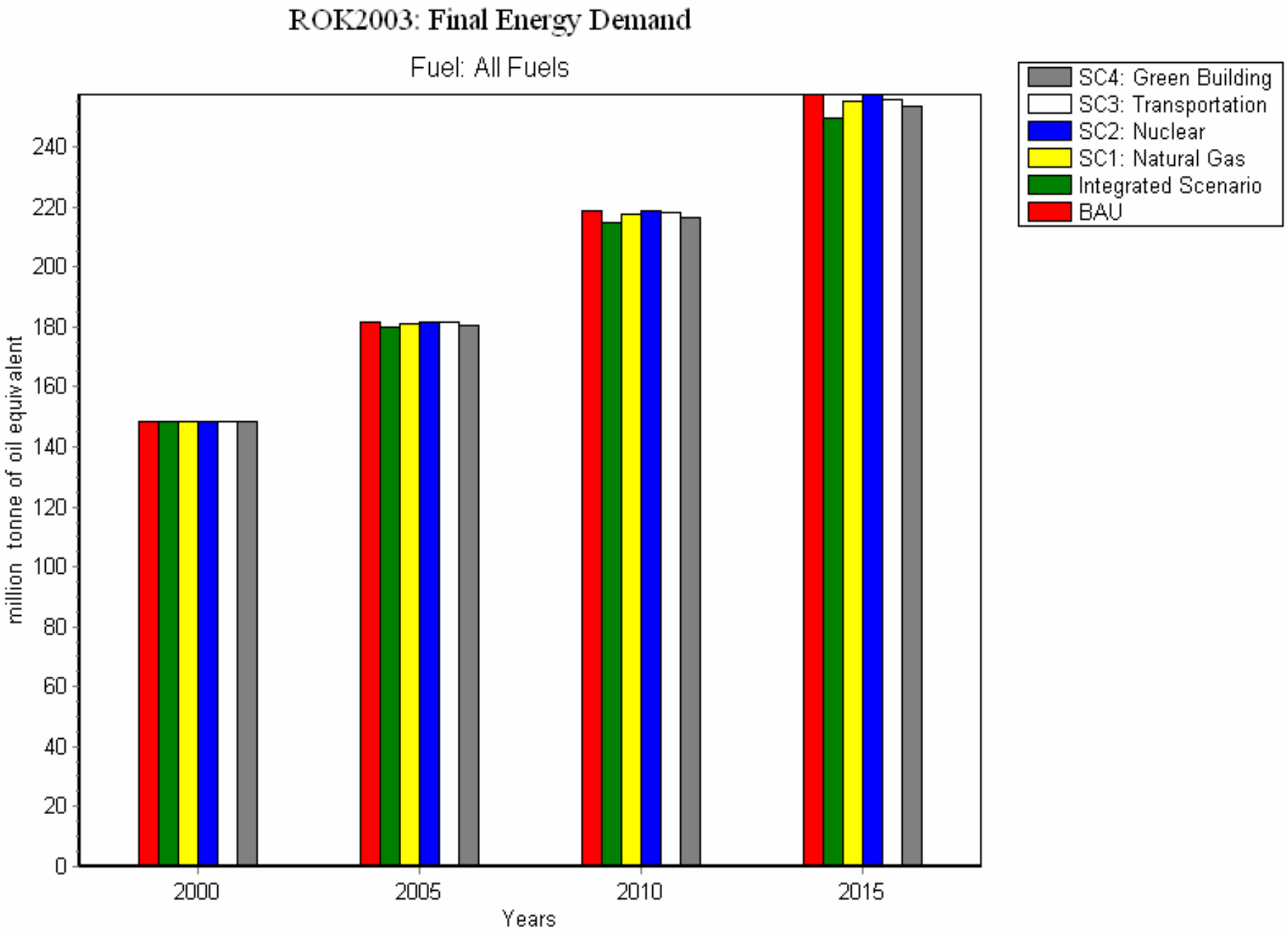
Scenario Three: Transportation

- Policy measures
  - To promote the substitution of natural gas buses, financial support for the purchase of buses and tax benefits will be provided.
  - The purchase or utilization of sub-compact cars will lead to such benefits as reduced or waived vehicle tax.
- Expected Effects
  - By 2007, approximately 20,000 natural gas buses will be in service nationwide.
  - The share of sub-compact cars in private cars will be 15% by the end of 2020.

Scenario Four: Green Building

- Policy measures
  - ROK has revised the regulations on Equipment Standards for Buildings.
  - Improvements in the Standards for Building Energy Efficiency and insulation are being promoted to upgrade current prescriptive standard to a performance based standard.
  - In 2001, integrated implementation guidelines for the Green Building Certification Program was provided.
- Expected Effects
  - The energy intensity of buildings in commercial and public sector will be 15% lower than BAU case in 2020.

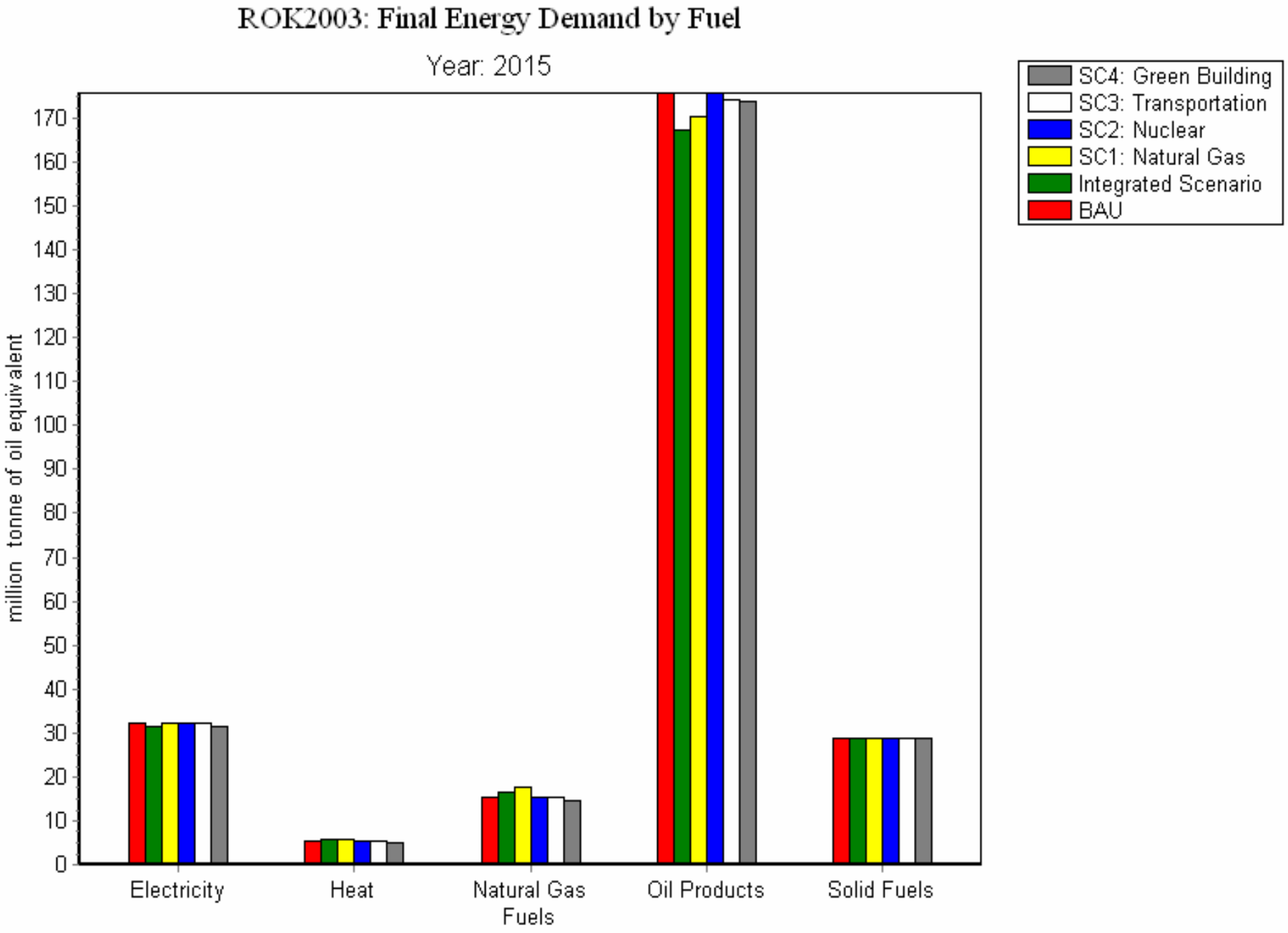
4. RESULTS FROM MODELING AND SIMULATION


ROK2003: Final Energy Demand
Fuel: All Fuels
SC4: Green Building
SC3: Transportation
SC2: Nuclear
SC1: Natural Gas
Integrated Scenario
BAU
million tonne of oil equivalent
0
20
40
60
80
100
120
140
160
180
200
220
240
2000
2005
2010
2015
Years

Final Energy Demand by Scenario (Mtoe)

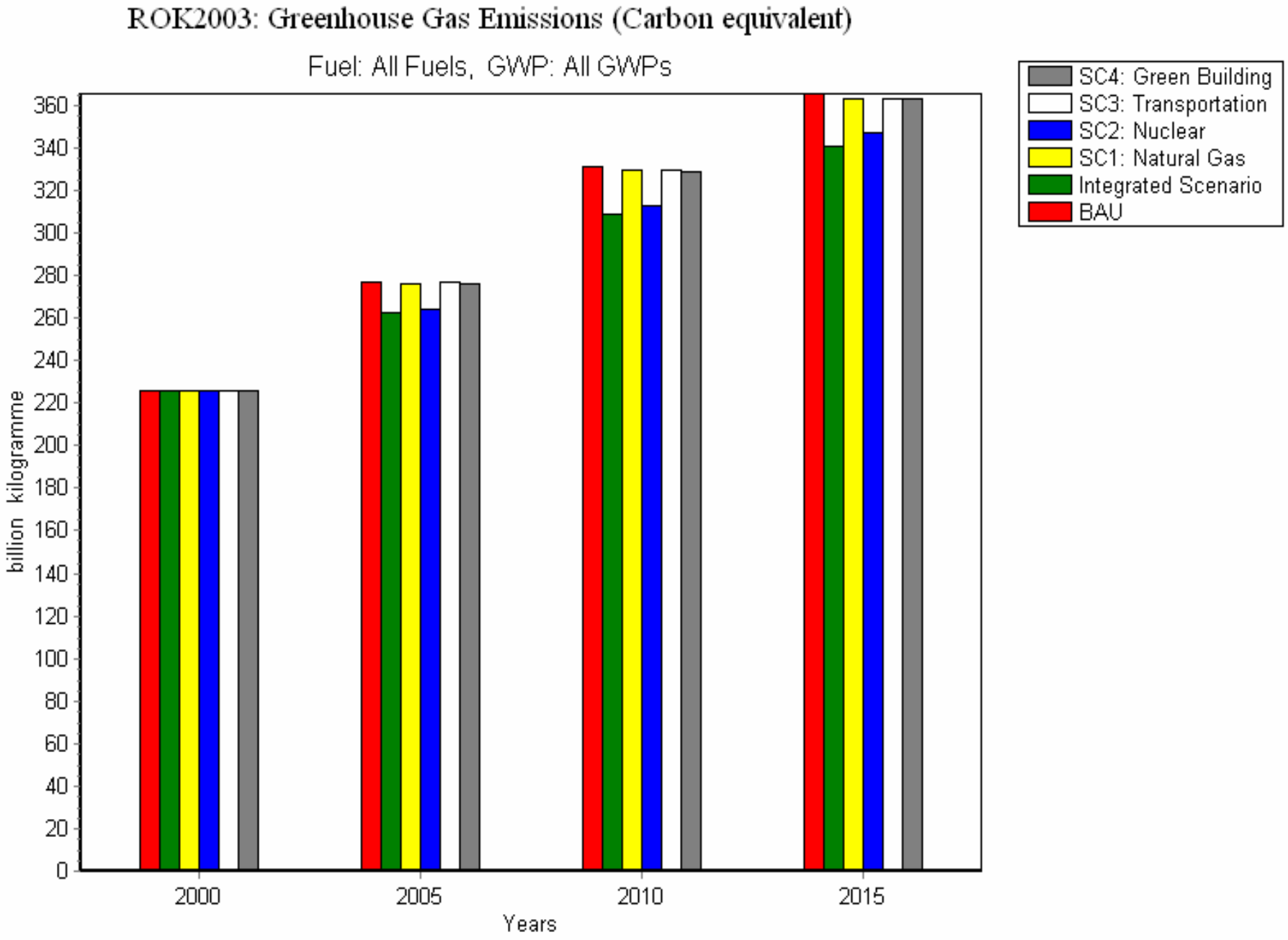
	2000	2005	2010	2015
BAU	148.3	181.8	219.0	257.5
SC1: Natural Gas	148.3	181.1	217.5	255.1
SC2: Nuclear	148.3	181.8	219.0	257.5
SC3: Transportation	148.3	181.6	218.4	256.0
SC4: Green Building	148.3	180.7	216.6	253.6
Integrated Scenario	148.3	179.9	214.6	249.9

- Final energy demand in the BAU scenario in 2015 is 73% greater than in the base year.
- Each scenario achieves energy saving relative to BAU except the Nuclear (SC2) scenario.
- Energy saving of Green Building (SC4) scenario is most significant, achieving energy savings of more than 3,900 Ktoe in 2020.


ROK2003: Final Energy Demand by Fuel
Year: 2015
million tonne of oil equivalent
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
Electricity
Heat
Natural Gas
Fuels
Oil Products
Solid Fuels
SC4: Green Building
SC3: Transportation
SC2: Nuclear
SC1: Natural Gas
Integrated Scenario
BAU

Final Energy Demand by Fuel in 2015 (Mtoe)

	Electricity	Heat	Natural Gas	Oil Products	Coal
BAU	32.2	5.4	15.3	175.7	28.9
SC1: Natural Gas	32.3	5.9	17.7	170.5	28.7
SC2: Nuclear	32.2	5.4	15.3	175.7	28.9
SC3: Transportation	32.2	5.4	15.3	174.1	28.9
SC4: Green Building	31.4	5.1	14.4	173.8	28.9
Integrated Scenario	31.5	5.6	16.6	167.5	28.7


ROK2003: Greenhouse Gas Emissions (Carbon equivalent)
Fuel: All Fuels, GWP: All GWPs
billion kilogramme
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
2000
2005
2010
2015
Years
SC4: Green Building
SC3: Transportation
SC2: Nuclear
SC1: Natural Gas
Integrated Scenario
BAU

GHG Emissions (MtC)

	2000	2005	2010	2015
BAU	226.2	277.0	330.8	365.5
SC1: Natural Gas	226.2	276.3	329.3	363.0
SC2: Nuclear	226.2	264.3	313.2	347.3
SC3: Transportation	226.2	276.7	329.9	363.4
SC4: Green Building	226.2	276.1	328.7	363.0
Integrated Scenario	226.2	262.6	309.2	340.5

- GHG emission in the BAU scenario in 2015 is more than 61% greater than in the base year.
- Each alternative scenario has lower emission than the BAU scenario.
- GHG reduction is most effective in the Nuclear scenario (SC2), and GHG can be reduced without further reduction in energy use.

SUMMARY

- Various policies and measures were introduced in 2003 by the Second Comprehensive Action Plan for energy conservation and reduction of greenhouse gas emissions as advocated by the UNFCCC.
- This Study applied the LEAP model to assess the impacts of the Second Comprehensive Action Plan as a climate change policy on ROK's energy sector and GHG emissions.
- Result shows that the Action Plan could reduce GHG emissions by 7% and energy use by 3% in 2015.

- Final energy demand in the BAU scenario in 2015 is more than 73% greater than in the base year. Each of the four alternative scenarios achieves energy savings relative to BAU, and the energy saving of Green Building Program is the most significant.
- GHG emission in the BAU scenario in 2015 is more than 61% greater than in the base year. Each of the four alternative scenarios has lower emissions than the BAU scenario, and especially the stable supply of nuclear energy has a significant advantage in reducing GHG emission.