The Application of the LEAP Software Tool to Energy Sector Analysis in the Republic of Korea

East Asia Energy Futures / Asia Energy Security Project

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Directions of the Study

- Applying LEAP software tool to the ROK
- Establishing a comprehensive and effective LEAP data set for the ROK
- Assessing the properness of the application and dataset
- Projecting future energy outlook based on business-as-usual case
- Developing reasonable and meaningful alternative scenarios
- Analyzing the results and implication of the alternative scenarios

This presentation will show

- How to apply the LEAP software tool to the ROK's energy sector.
- The structure of ROK2003: An Overview
- The obstacles and problems in the application
- Possible energy issues being analyzed based on LEAP ROK data set and ROK2003.
- Know-how might be shared with other regional working group

Organization of the Presentation

1. ROK's Energy Policy
2. LEAP Modeling in ROK
3. LEAP ROK2003
4. Demand Sector
5. Transformation Sector
6. BAU Energy Paths
7. Obstacles and Tasks
8. Alternative Scenarios

1. ROK's Energy Policy

Energy Policy and Modeling

- Various types of energy policy give a exogenous shock to (inter)national energy system.
  - Energy demand & supply
  - Energy mix
  - Energy efficiency
  - The innovation of energy –related technology

➔Energy models help to foresee the impacts and to analyze the implications of energy policy.

ROK's Energy Policy: Problems and Challenges

- Maintaining a stable energy supply for **enduring *economic growth***
- ***Encouraging competition*** in energy market
- Reducing the dependence on oil
- Diversification of energy sources
- Establishing environment- and climate-friendly energy system for ***Sustainable Development***.
- Strengthening ***the long-run potential for pollution control***
- Restructuring an energy system with low GHG emissions

Directions of ROK's Energy Policy

- Sustainable Energy System
  - To stimulate energy efficiency
  - To stabilize energy supply capacity
- Energy Technology Innovation
  - To develop energy technologies
- Competitive Energy Markets
  - To privatize energy industries
  - To improve efficiency in energy market
- Regional Cooperation
  - To diversify energy sources
  - To stabilize energy supply and prices

2. LEAP Modeling in ROK

Previous Work

- Beijing workshop, June 2000
  - Nautilus provided support in the use of the LEAP software
  - The first national dataset for LEAP was developed.
- Berkeley workshop, February 2001
  - The first rigorous application was made.(ROK2000)
  - The conceptual and analytical understanding was elaborated in the training session.
- Berkeley workshop, January 2002
  - After the 3rd training workshop ROK2000 was completed. And the dataset was applied to the LFG generation issue.

Why LEAP?

- There is a huge range of models that can be used to address energy-related issues, and they are grouped into three categories: macroeconometric models, CGE models, energy-economy models
- Energy-economy models, so called 'bottom-up' models, are technology based models found on engineering relationships..

Strengths and Weakness of Bottom-Up Arpproach

Strengths of Bottom-up Approach

- The capacity to address at a more detailed sectoral and sub-sectoral level the implications of energy policies on energy system

Weaknesses of Bottom-up Approach

- The models may fail to adequately capture opportunity or welfare costs of technological substitution.

➔ The choice of modeling platform depends on the purpose of analysis.

LEAP Modeling Platform

LEAP modeling platform

- With its flexible structures, LEAP allows the user to simulate and assess the impacts of alternative energy policies on energy system-especially technological fields, and to project the energy supply and demand situation
- As a database, LEAP provides a comprehensive system for maintaining energy information.

Best Conditions for Applying LEAP Modeling Platform

LEAP model is most useful where:

- There is insufficient historical macro-economic data for trend analysis
- There are significant technological changes in energy sector.
- There are short-run development problems
- There is a need to disaggregate energy uses.
- There is a strong policy scheme that is shaping the national energy system.

Energy Modeling in the ROK

- Macroeconometric Models
- CGE Models
  - KEED (Korea Energy Environmental Dynamic GE Model, KEEI)
- Energy-Economy Models
  - KEEI Model, EFOM-Env (Korea Energy Economics Institute)
  - MARKAL (Korea Institute of Energy Research)
  - META-Net, LEAP (Yonsei University)

3. LEAP ROK2003: An Overview

LEAP ROK Models

- ROK1998 (LEAP v.95)
  - Highly aggregated but simple and intuitive
- ROK2000 (LEAP v.2000)
  - Highly disaggregated but complex and with uncertainties in BAU paths
- ROK2003 (LEAP v.2003))
  - Less disaggregated than ROK2000 but with reasonable and rigorous BAU paths

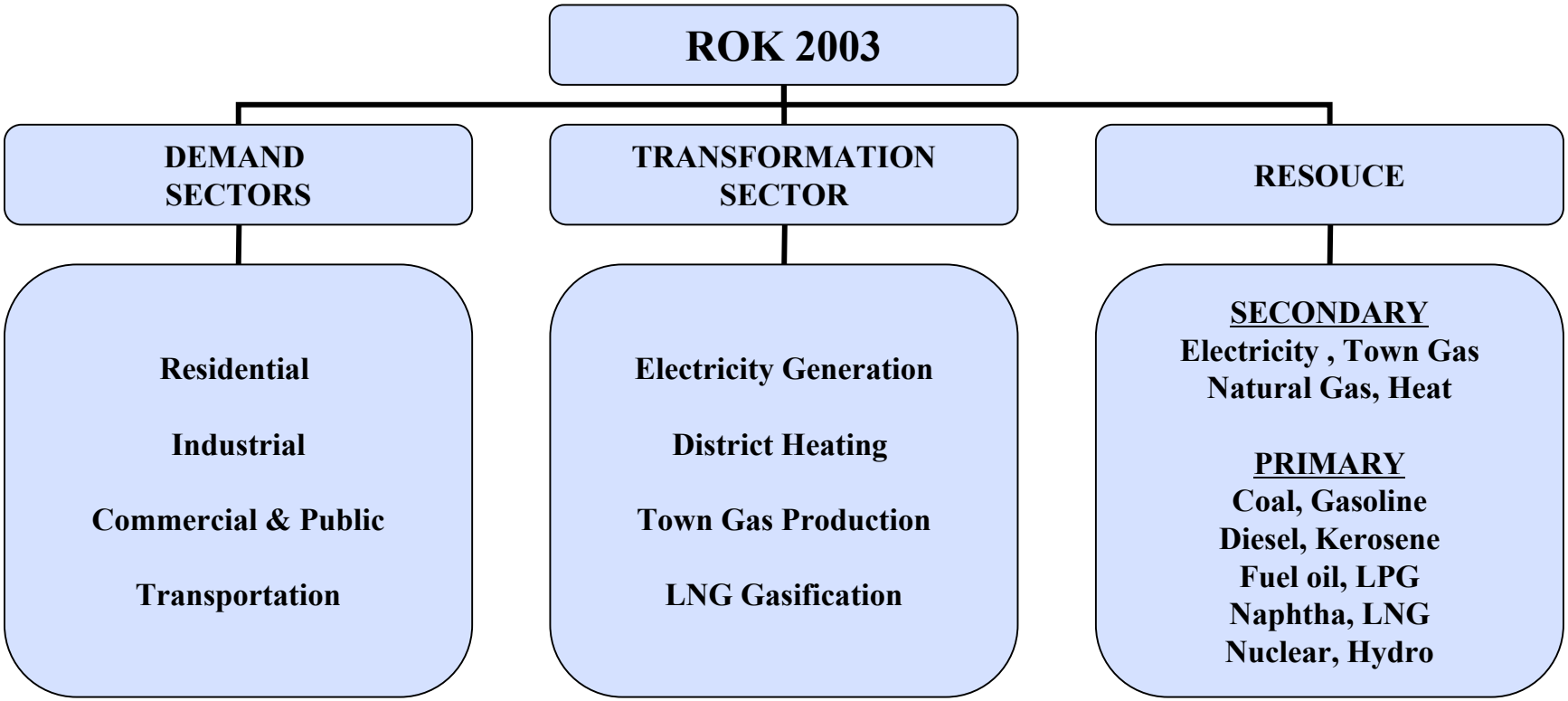
Determinants of Model Structure

- The purpose of analysis
- The modes of shock
- Methodological approach of the analysis
- Time horizon
- Geographical coverage
- Sectoral coverage
- Data restriction or availability

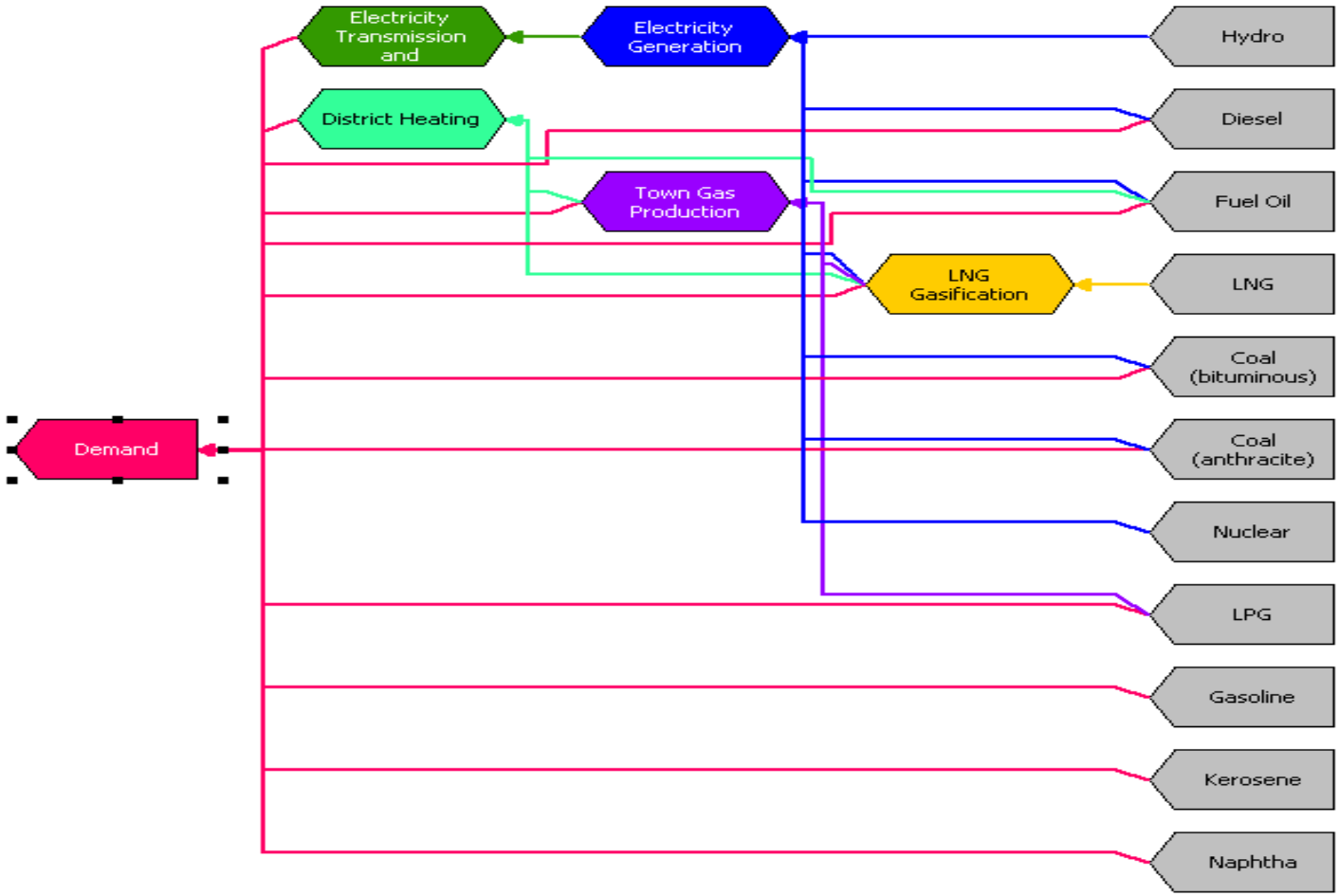
ROK Models

- The purpose is to assess the recent ROK's energy policy scheme and its regional implication
- Shock: Policies on energy demand, supply, and technological change
- Methodology: LEAP software (scenario analysis)
- Time horizon: 2000-2015 (medium-term)
- Geographical coverage: National model
- Sectoral coverage: Energy sector
- Data availability: Quite good!

The Structure of ROK2003



ROK2002 Model Diagram



Current Status of ROK2003

- Well equipped with key data, parameters, and BAU path
- Highly disaggregated in residential demand, transportation and transformation sectors
- Well structured to be applied in electricity generation and transportation analysis
- Two alternative scenarios are under developing in the climate policy context

Key Data Gaps

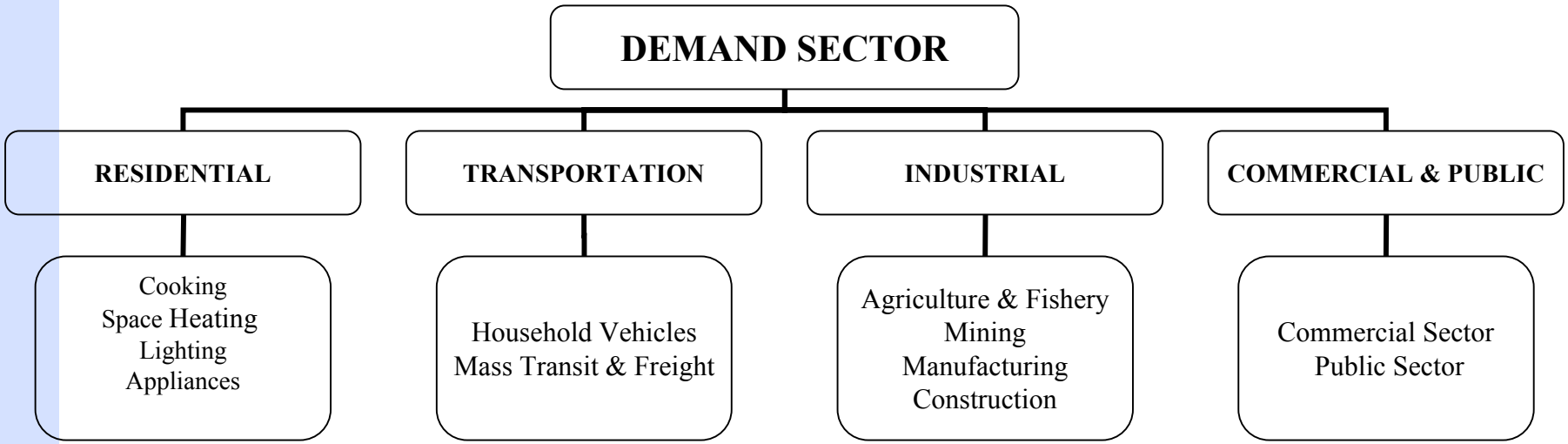
- Small Electricity Appliances
- Renewable Energy Uses
- Mass transit & freight: BAU path
- Air Transportation
- Heat Production of CHP
- Electricity Production of HOB
- Oil Refining Process
- Domestic Coal Mining

Key Data Sources

- Ministry of Commerce, Industry, and Energy
- Korea Energy Economics Institute
- Korea National Statistical Office
- Korea Development Institute
- The Bank of Korea
- Korea Electric Power Corporation
- Korea District Heating Corporation
- Korea Coal Corporation
- Korea Gas Corporation

4. Demand Sector

The Structure of Demand Sector



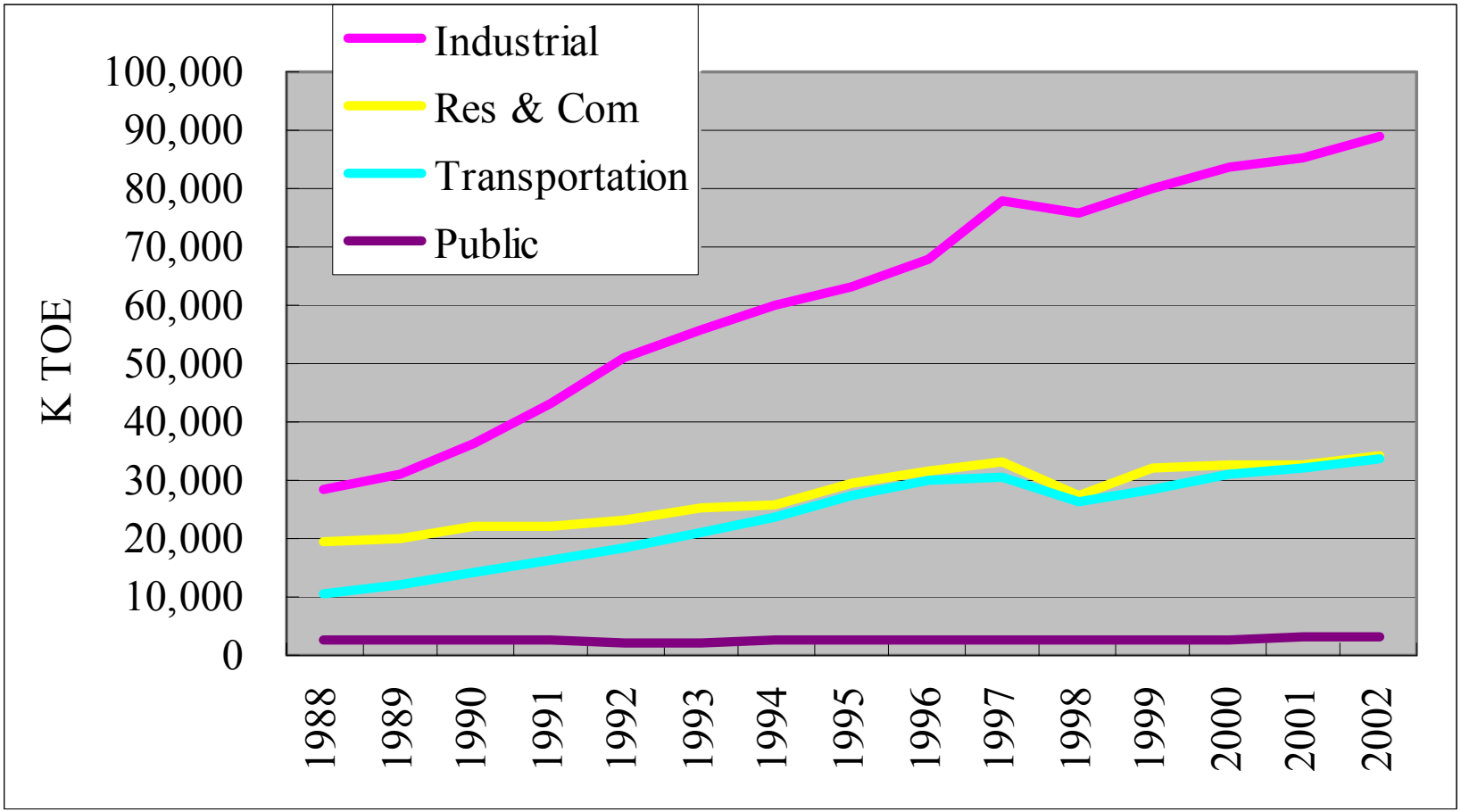
Energy Balance: TFE

UNIT: 000 TOE	coal	Pet	LNG	Town Gas	Heat	Elect	Total
FINAL	**19,847**	**92,660**	**256**	**12,561**	**1,119**	**20,600**	**149,173**
INDUSTRIAL	19,129	47,209	207	3,308	.	11,374	83,135
TRANSP	-	30,824	.	-	.	175	30,999
RESIDENT	718	13,487	49	9,024	1,097	7,891	32,414
PUBLIC	-	1,141	-	229	22	1,160	2,626

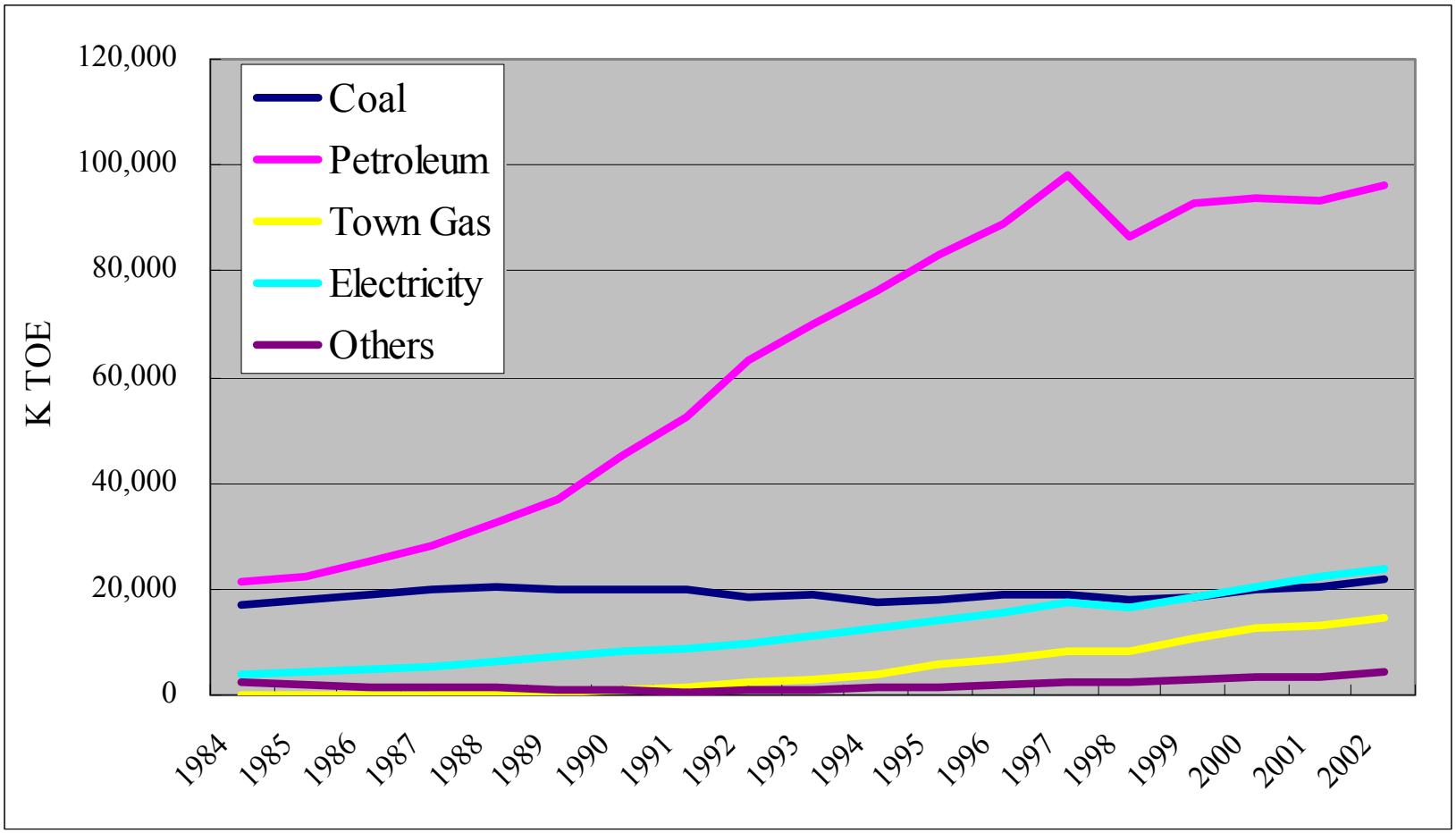
Final Energy Demand in 2000

(M TOE)	Coal	Petroleum	Town Gas	Electricity	Heat	Renewable	Total	
Industrial	19.1	48.2	3.3	11.4	0	1.9	83.9	56.0%
Residential & Commercial	0.7	13.5	9.0	7.9	1.1	0.2	32.4	21.6%
Public & Others	0	1.1	0.2	1.2	0	0	2.6	1.7%
Transportation	0	30.8	0	0.2	0	0	31.0	20.6%
Total	19.8 13.2%	93.6 62.4%	12.6 8.4%	20.6 13.7%	1.1 0.7%	2.1 1.4%	150 100%	

Evolution from 1984 to 2002 of TFE by Sector



Evolution from 1984 to 2002 of TFE by Fuel



End-Uses of Residential Sector

END USES	FUEL TYPE	DEVICE
HEATING	COAL, GAS, HEAT, OIL, ELECTRICITY	Boilers District Heating
LIGHTING	ELECTRICITY	Incandescent bulbs Fluorescent bulbs Other bulbs
COOKING	LPG Town Gas	Town Gas Stove LPG Stove
APPLIANCES	ELECTRICITY	Refrigerator, Rice cooker, Air conditioner, TV, PC, Electric stove, Kimchi Refrigerator, Washing machine, Vacuum cleaner

Residential Sector

	Cooking
Town gas	51.3
LPG	46.3
Oil	0.9
Electricity	0.4
Coal	0.2

	Heating
Oil	48.6
Town gas	37
District	6.4
LPG	3.4
Electricity	1.6
Coal	1.5

Industrial Sector

- The share of GDP of industrial sector is 44.5%. It is expected to decrease to 40.6% in 2020
- The construction activity will increase to 3.5% in 2020 to meet the increasing demand for floor space driven by economic growth.

	Share(%)
Agri&Fish	5.04
Mining	0.18
Manufact.	92.16
Construct	2.62

Commercial & Public Sector

.	.	2000	2010	2020	2030
Energy Use	K TOE	13,558	20,900	27,399	31,804
Floor Space	M m^2	473	725	928	1,075
Energy Intensity	K TOE/M m^2	28.66	28.82	29.53	29.58

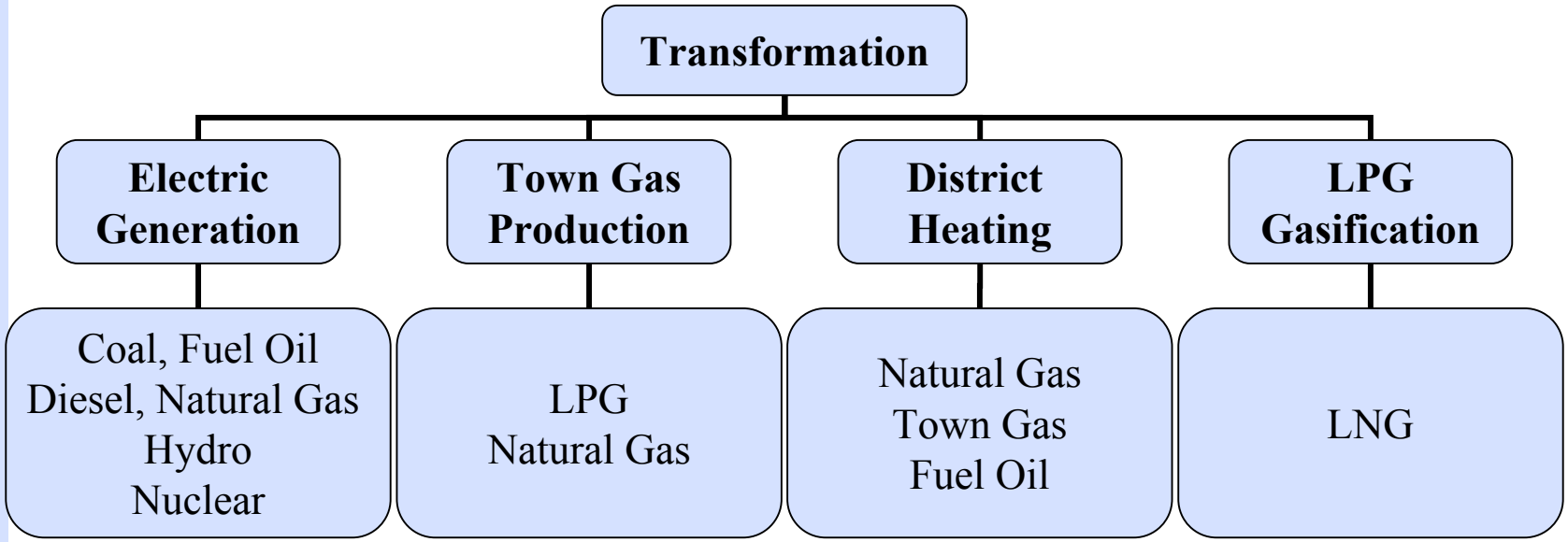
Transportation Sector

Household	Vehicle Population	Fuel Use (Ktoe)
Cars	7,671,000	9,042
SUV	522,000	972
Bus	1,284,000	2,542
Truck	2,254,000	5,268
Sum	11,731,000	17,824

MassTran & Freight	Vehicle Population	Fuel Use (Ktoe)
Taxi	232,243	1,927
Bus	69,170	2,138
Truck	235,791	2,815
Marine	1,827	6,191
Rail	7,297	492
Sum	546,328	13,616

5. Transformation Sector

Transformation Sector



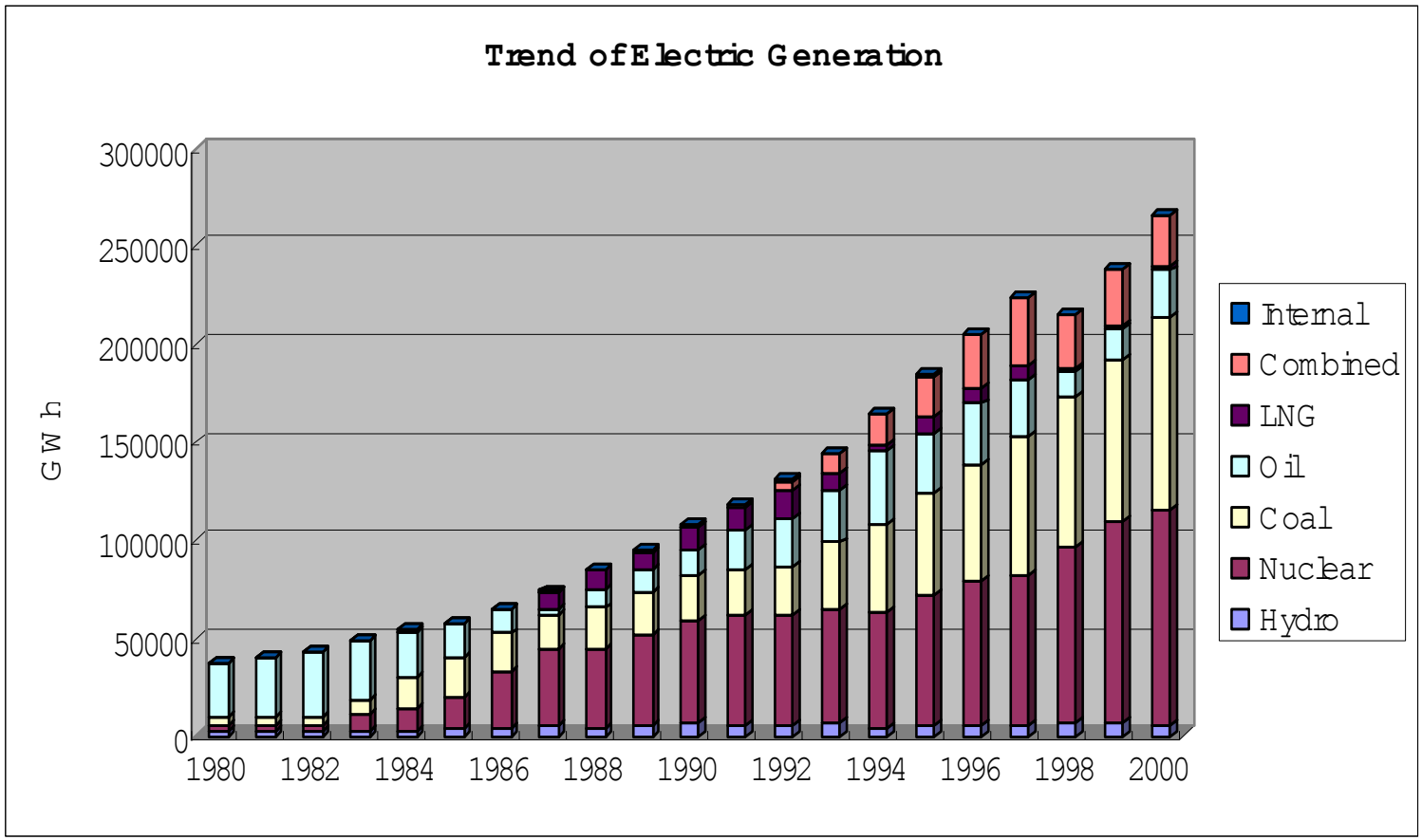
Energy Balance: Transformation

UNIT: 000 TOE	coal	Pet	LNG	Town Gas	Heat	Elect	Hydro	Nuclear	Total
PRIMARY	**42,911**	**100,280**	**18,924**	.	.	.	**1,402**	**27,241**	**192,888**
Electricity	23,064	6,042	5,403	108	-809	-22,910	1,402	27,241	39,541
Heat	-	331	436	120	-355	.	.	.	532
Town Gas	-	312	12,387	-12,520	.	.	.	.	179

Data on Generation Facilities

	Efficiency (%)	Capital Cost (K KRW/kW)	O&M Cost (KRW/kW)	Output Share (%)
Coal	39.25	920	32,628	38.7
Oil	37.45	800	21,612	7.4
LNG	35.68	-	-	0.6
Internal	37.2	1,154	69,840	0.1
Combined	44.15	505	16,536	9.5
Hydro	N.A.	617	12,024	1.2
Nuclear	N.A.	1,346	41,544	42.4

Electric Generation by Fuel



Non-Electricity Transformation

- District heating
- Town gas production
- LNG gasification process

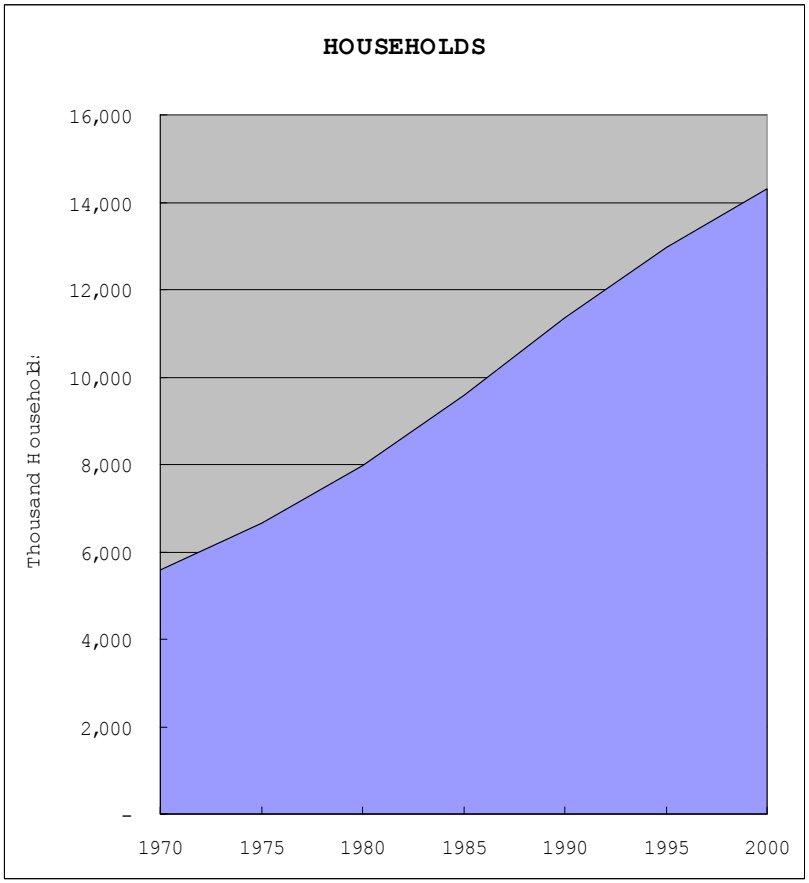
6. BAU Energy Path

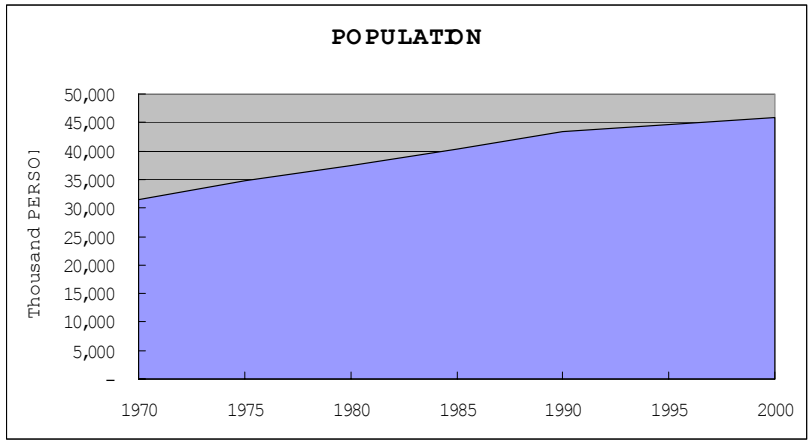
Assumptions of BAU Path

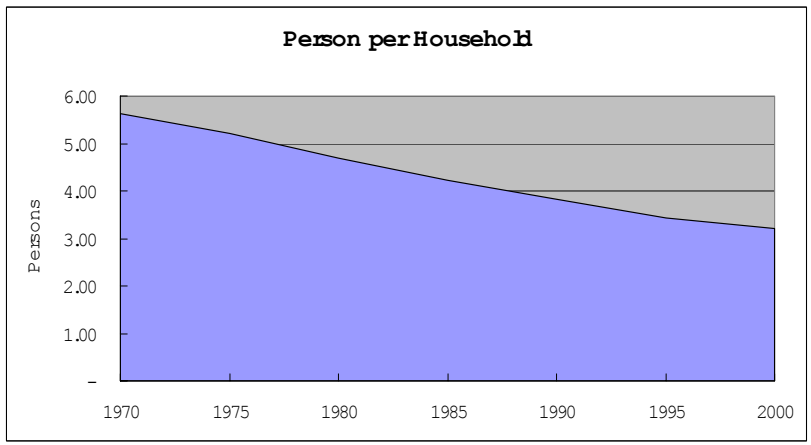
- GDP: 4.9% annual growth rate for the years 2000-15
- Population: 0.6% annual growth rate
- Households: 1.5% annual growth rate
- Residential
  - Expansion of town gas use and district heating
  - Disappearance of LPG and coal uses
- Industrial
  - Decrease of the share of industrial GDP
  - Decrease of manufacturing and increase of construction
- Commercial & Public
  - Increase of floorspace in commercial and public sector

- Electricity Generation Capacity
  - Stable maintenance of nuclear
  - Expansion of CHP
  - Reduction of coal and oil generation
- Increase of LNG gasification facilities
- Expansion of district heating area
- Enlargement of town gas-using households

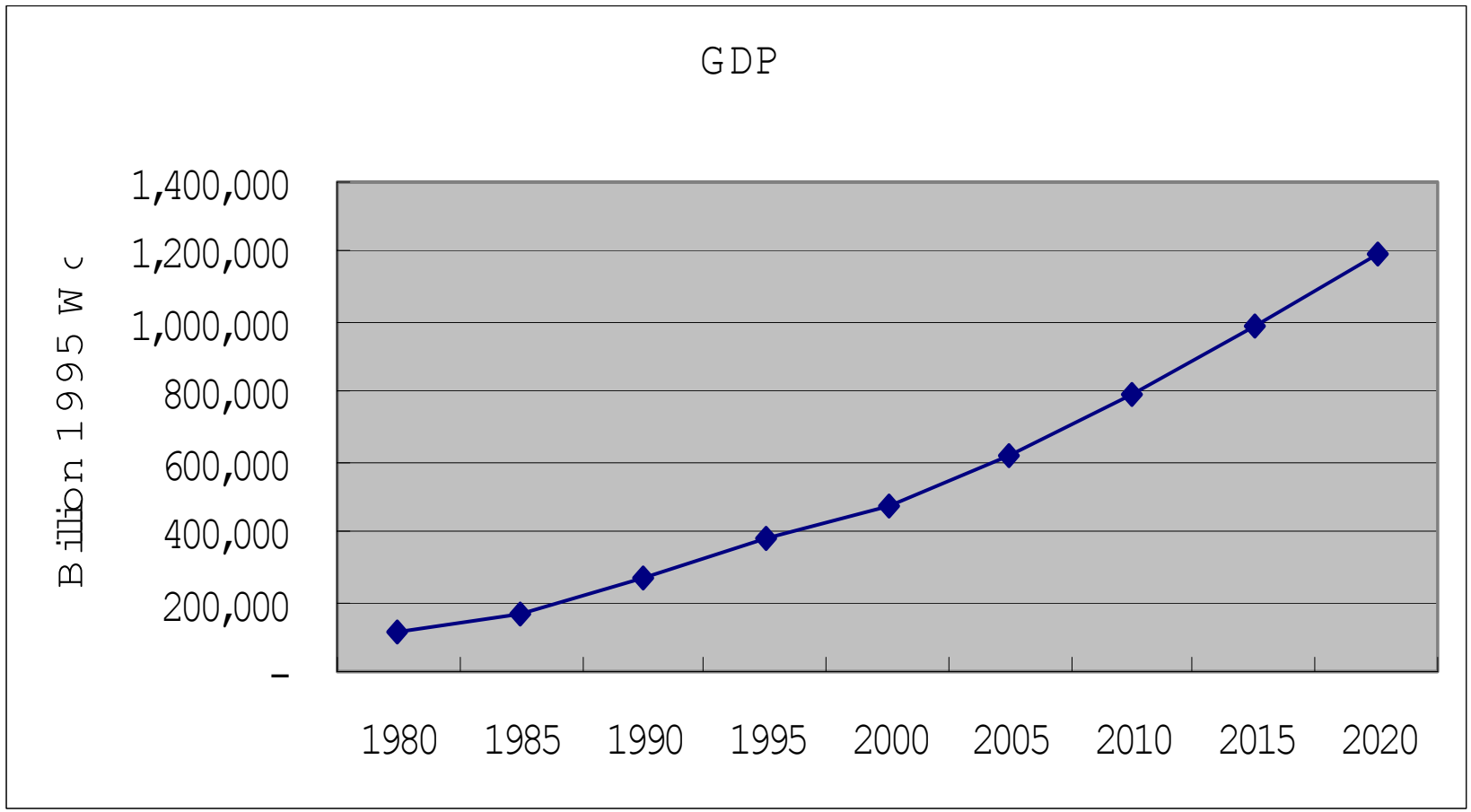
Major Demographic Data Outlook



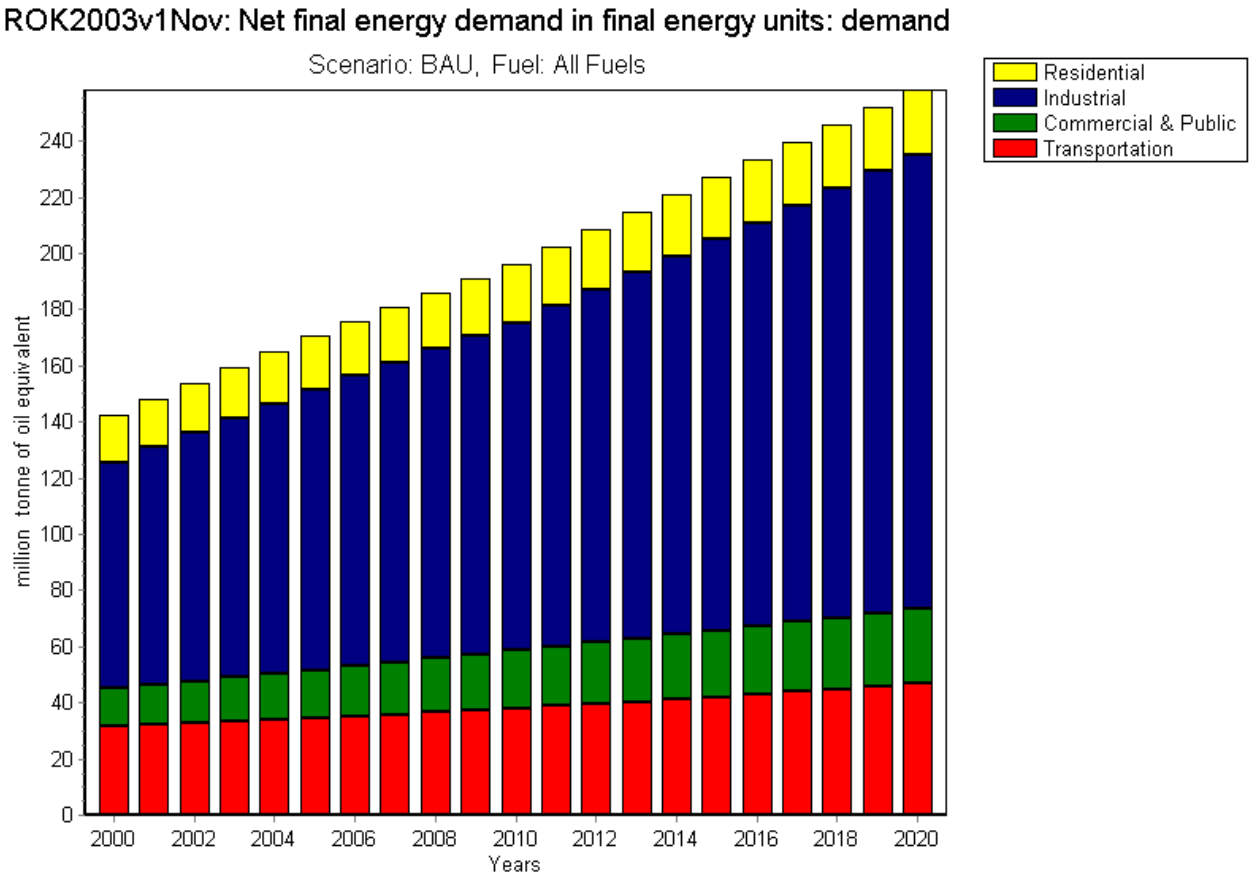




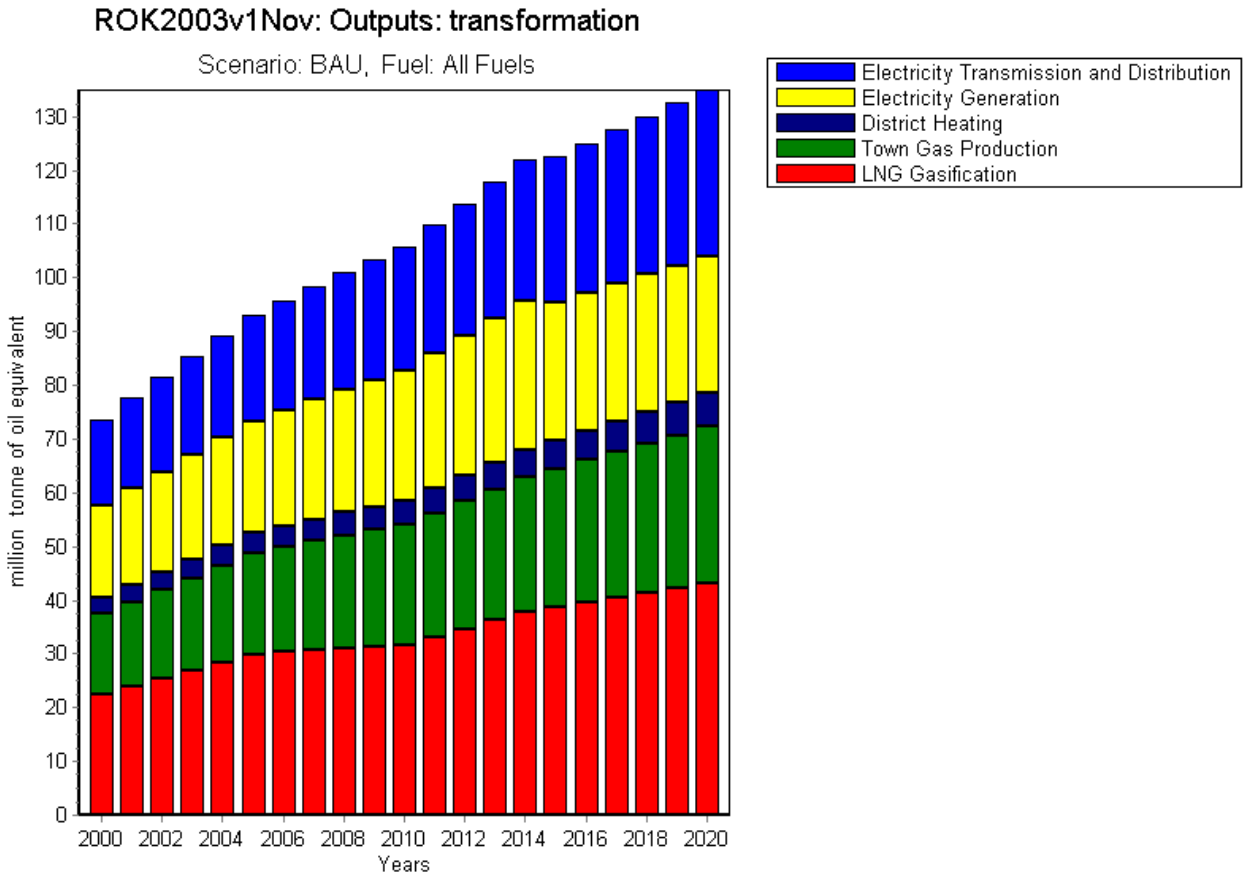
GDP Outlook


GDP
Billion 1995 Won
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
-
1980
1985
1990
1995
2000
2005
2010
2015
2020

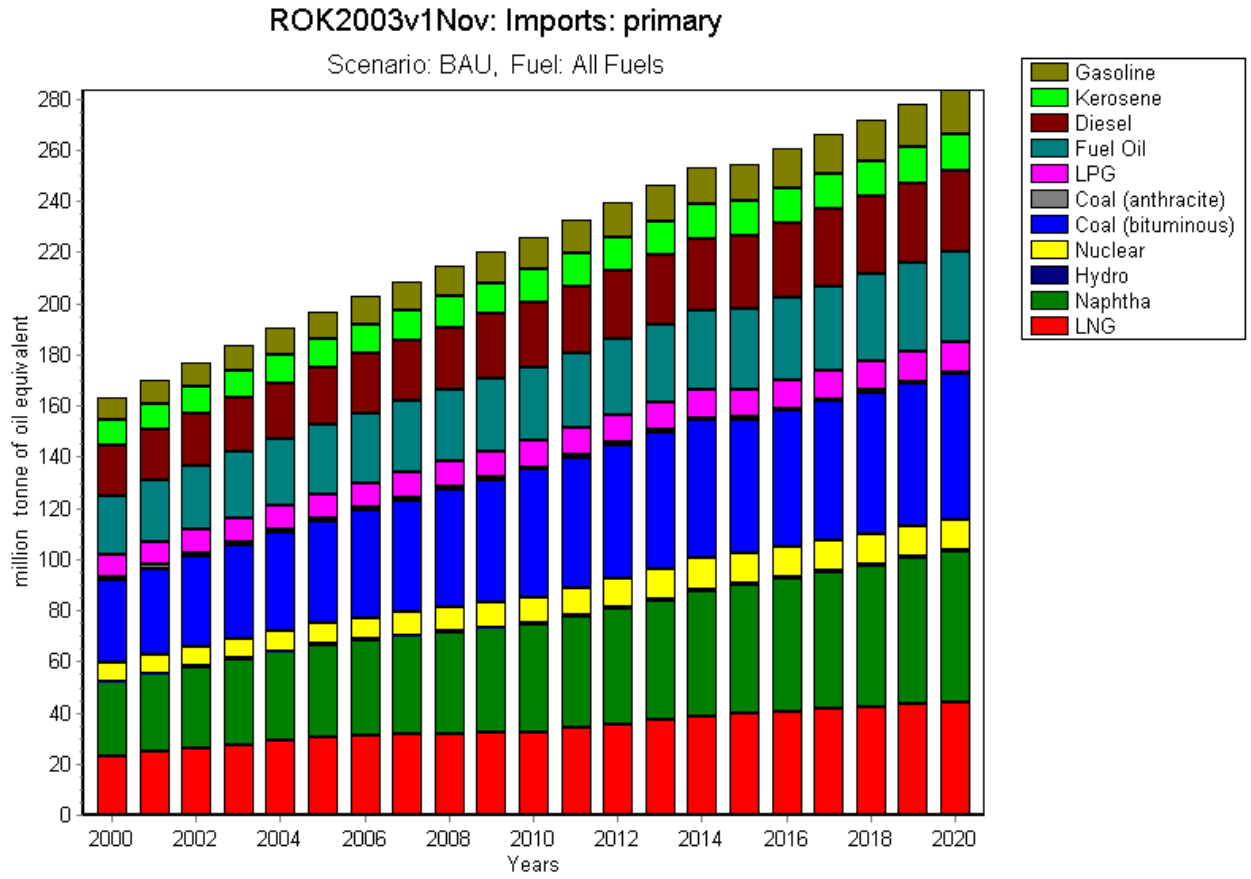
Final Energy Demand: BAU



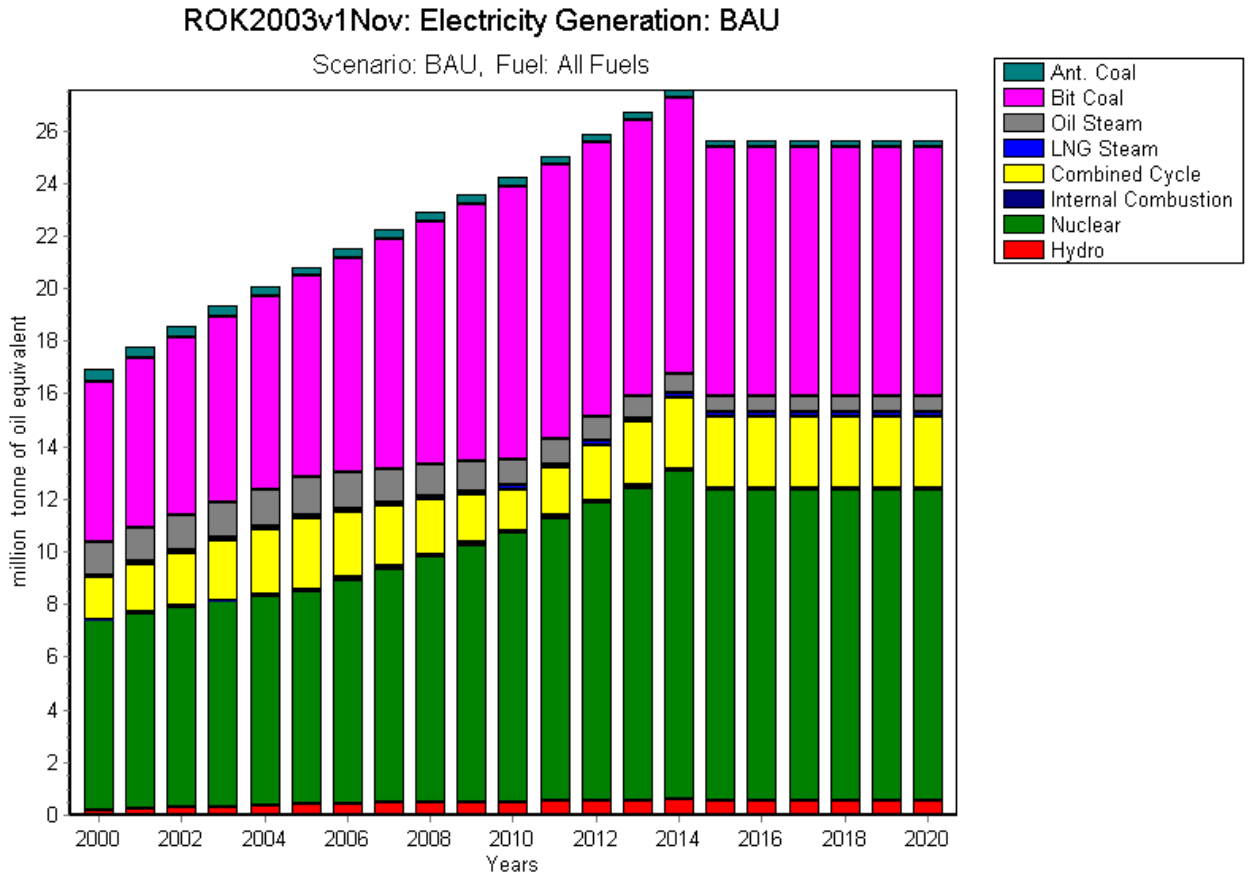
Energy Supply of Transformation Sector



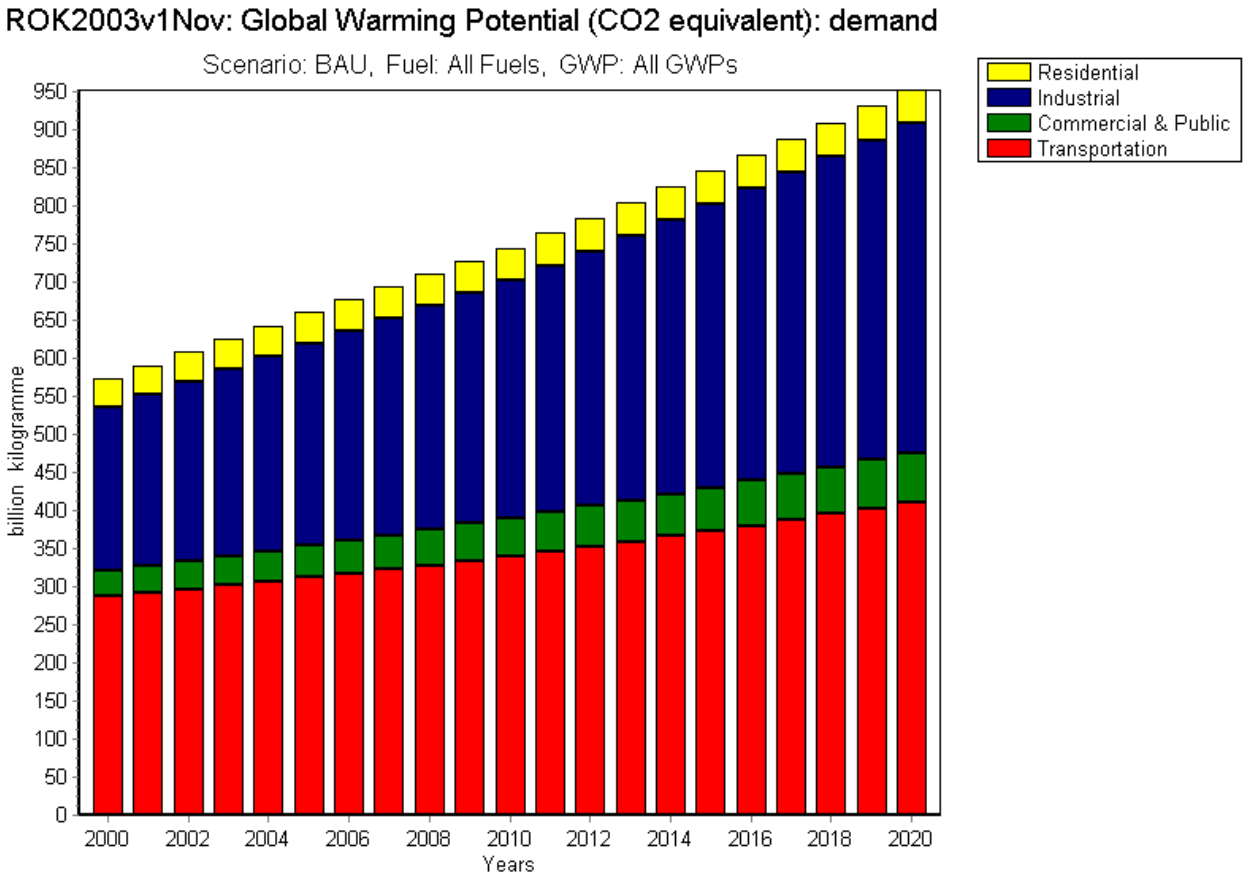
Imports of Primary Energy: BAU



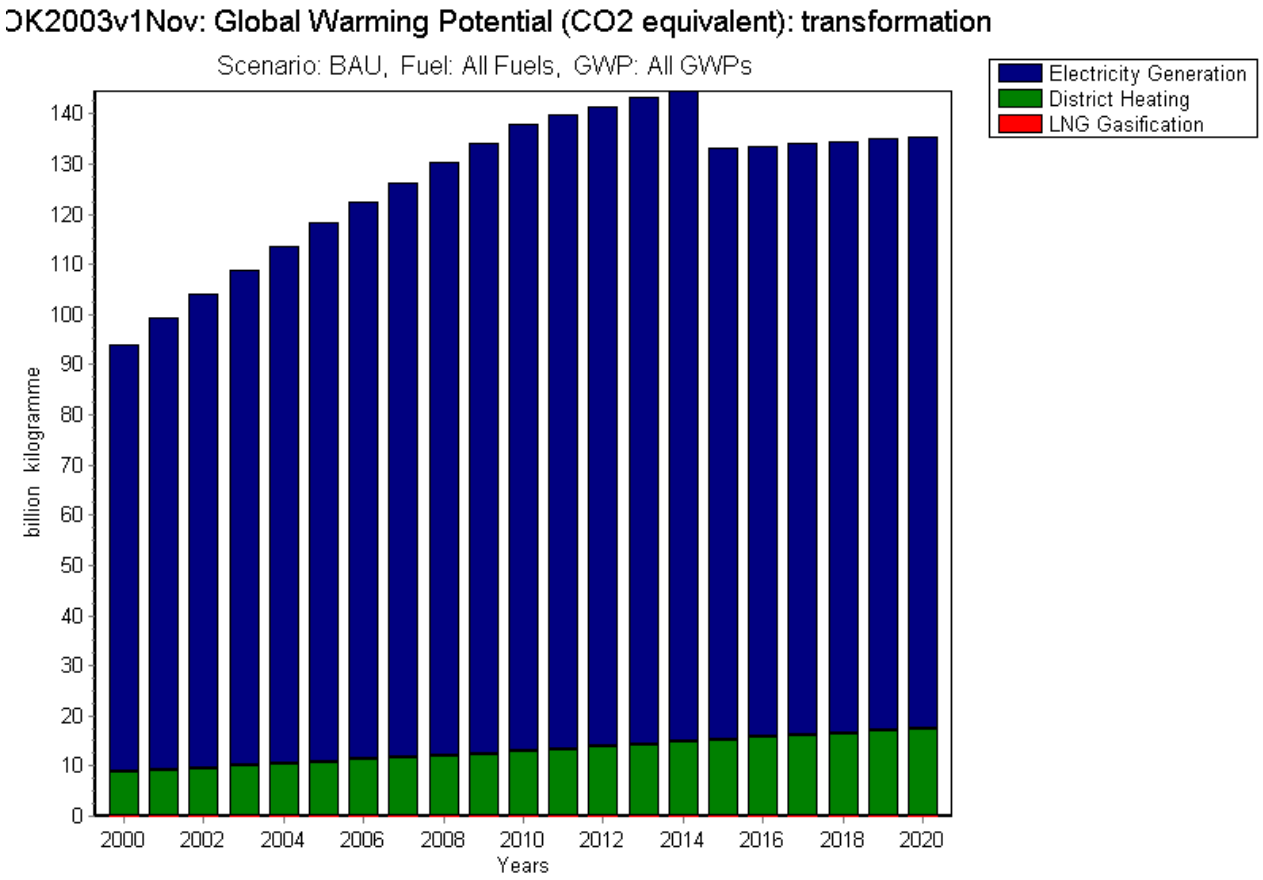
Electricity Generation: BAU



Global Warming Potential: Demand : BAU



Global Warming Potential: Transformation : BAU



Examining the Results: TFE & TPES

(Mtoe)	2000	2015
Res	16.7	22.0
Ind	80.7	139.2
Com	13.6	23.7
Trp	31.4	42.0
Sum	142.3	226.9

(Mtoe)	2000	2015
Coal	33.5	53.1
Oil	99.2	149.5
LNG	23.1	39.6
Hydro	0.2	0.5
Nuc	7.2	11.8
Sum	163.2	254.5

- Projected TFE in 2015: 226.9 Mtoe
  - MOCIE's outlook: 231.7 Mtoe
  - ➔ Accounts for 97%

- Projected TPES in 2015: 254.7 Mtoe
  - MOCIE's outlook: 288.4 Mtoe
  - ➔ Accounts for 88.3%

➔ ***BAU paths describe ROK's energy system quite well.***

7. Obstacles & Tasks

- Cost data availability
- Technology-specific emission factors rather than Tier I
- Maintaining consistency between assumptions employed in BAU scenario
- Updating the dataset and upgrading the model structure
- Applying the model to other policy alternatives
- Integrating with a top-down model.

8. Alternative Scenarios

- Introduction and expansion of Natural Gas Vehicle (NGV)
- Introduction and expansion of LFG generation
- Expansion of compact household vehicles
- Introduction of ‘fuel cell’
- Changes in energy/environmental technology
- Structural change in electricity sector
- Various regional cooperations

Future Work

- Developing future energy scenarios
- Collecting and supplementing missing data
- Trying plausible structural modifications
- Updating the dataset (2000→2001)
- Disaggregating major (sub)sectors