Development of a Strategy for CO_2 Mitigation for Coal Fired Power Generation in the Korean Electricity Industry

15 May 2007

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Scope of Presentation

I Overview of Korean Power Sector

II Projected Carbon Dioxide Emissions

III Overview of KESP Project

IV Model Development for KESP

V Future Works & Remarks

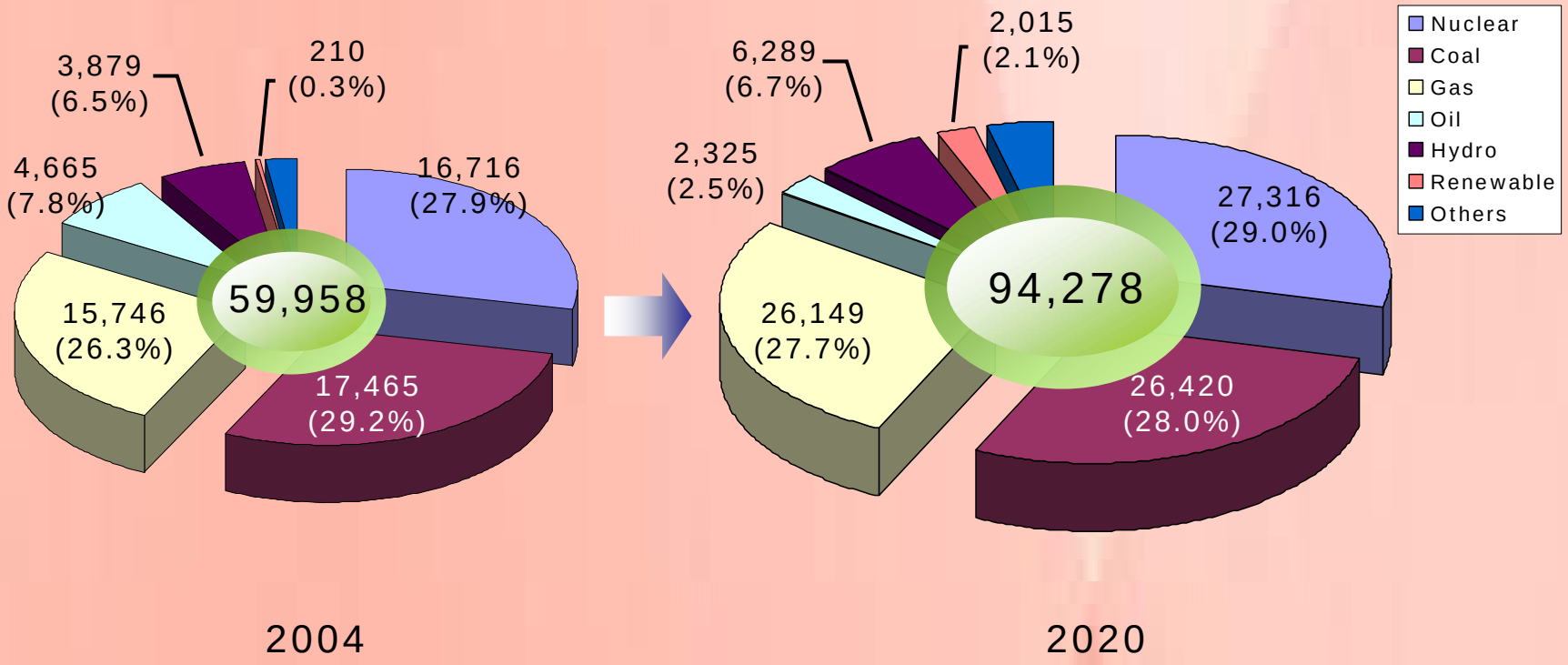
I. Overview of Korean Power Sector

Status and future energy needs in the Korean power sector

- Current capacity for all fuel sources is about 60 Gwe(2004).
- Government target for 2020 is to increase capacity to over 94.3 GWe.
- Need to build some 40 GWe of capacity (new and replacement units)
- Nuclear plants will pre-dominate but with strong growth in coal and gas fired units plus some renewable energy systems

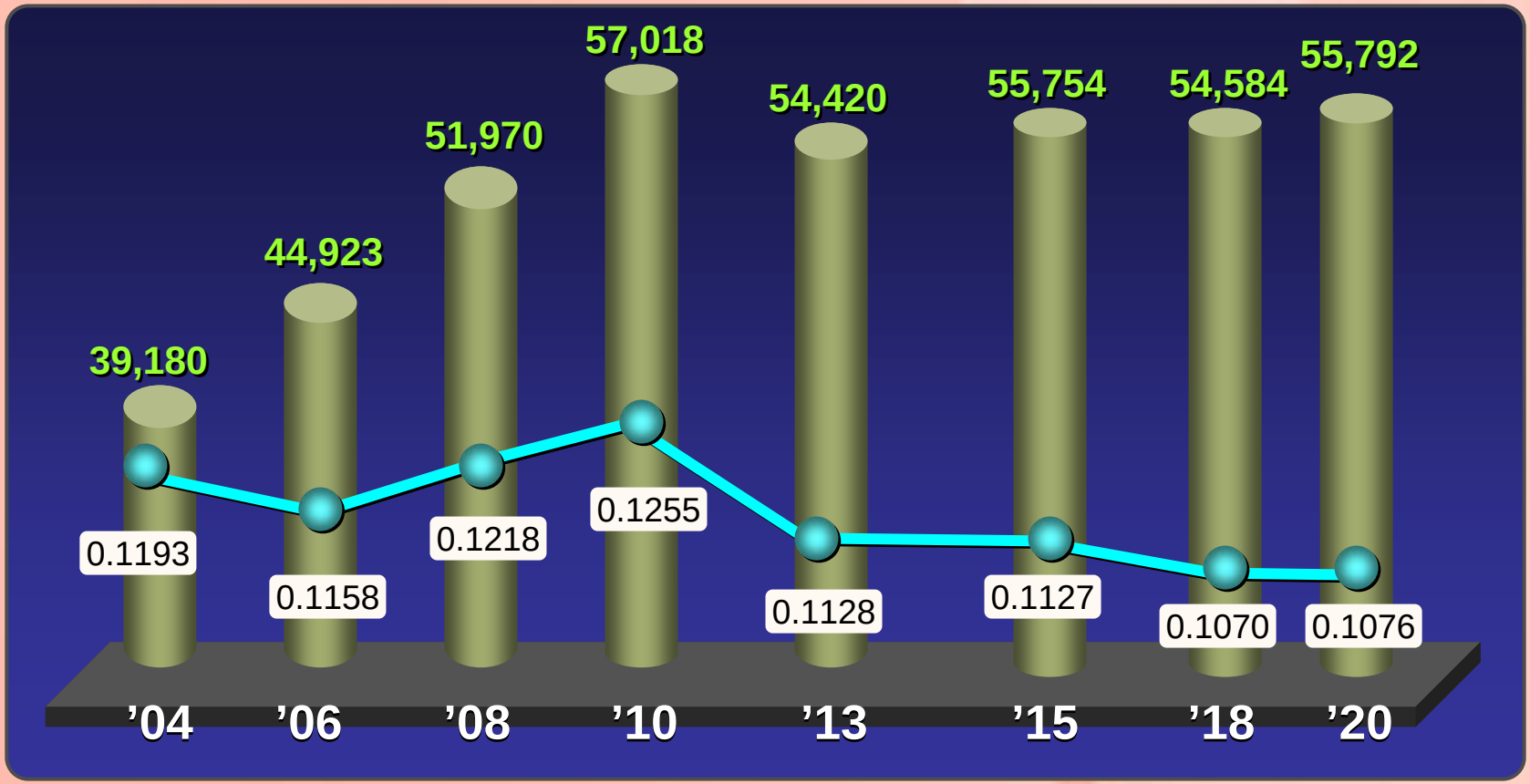
I. Overview of Korean Power Sector

Trend of Installed Capacity by Source (MWe)



II. Projected Carbon Dioxide Emissions

Forecast of Carbon Emissions (Unit: Kton-C, kg-C/kWh)



III. Overview of KESP Project

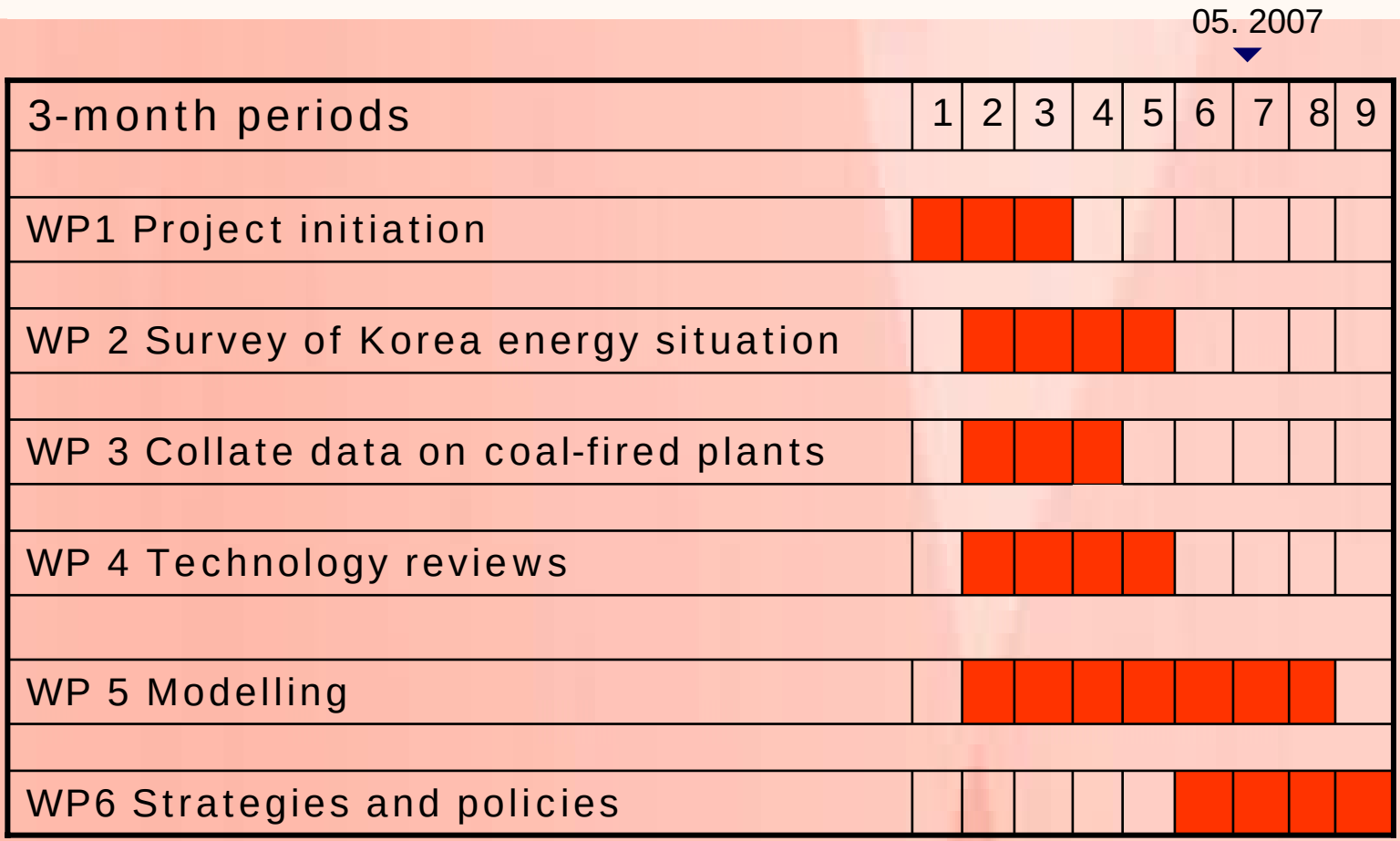
Project aims and objectives

- To establish a strong modelling capability within KEPRI in order to best support Korean electricity industry in the ongoing development of energy and environmental policies for the power utility sector.

- To develop a short-medium-long term policy for comprehensive greenhouse gas (GHG) mitigation in the power generation sector of Korea, with emphasis on CO_2 mitigation options from coal fired power plant.

III. Overview of KESP Project

Project schedule



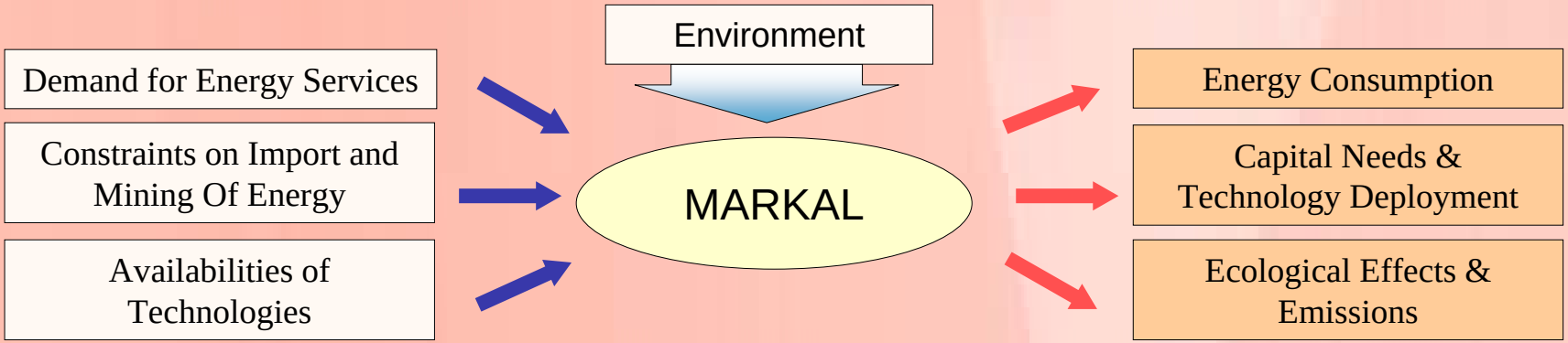
III. Overview of KESP Project

Benefits of KESP (Korea Electricity Strategy & Policy) Project

- The primary benefit will be the determination of the potential effect and contribution of several carbon mitigation options in the Korean power sector.
- It will also provide input to the development of a strategy for coal utilisation that will be needed to ensure the future secure electricity supply for Korea, while minimising emissions of conventional pollutants and GHGs.
- The output will aid future technology selection, development and deployment in Korea by the KEPCO subsidiaries, as well as enhancing the scope for further international cooperation.

IV. Model Development for KESP Project

MARKAL energy system modeling



MARKAL

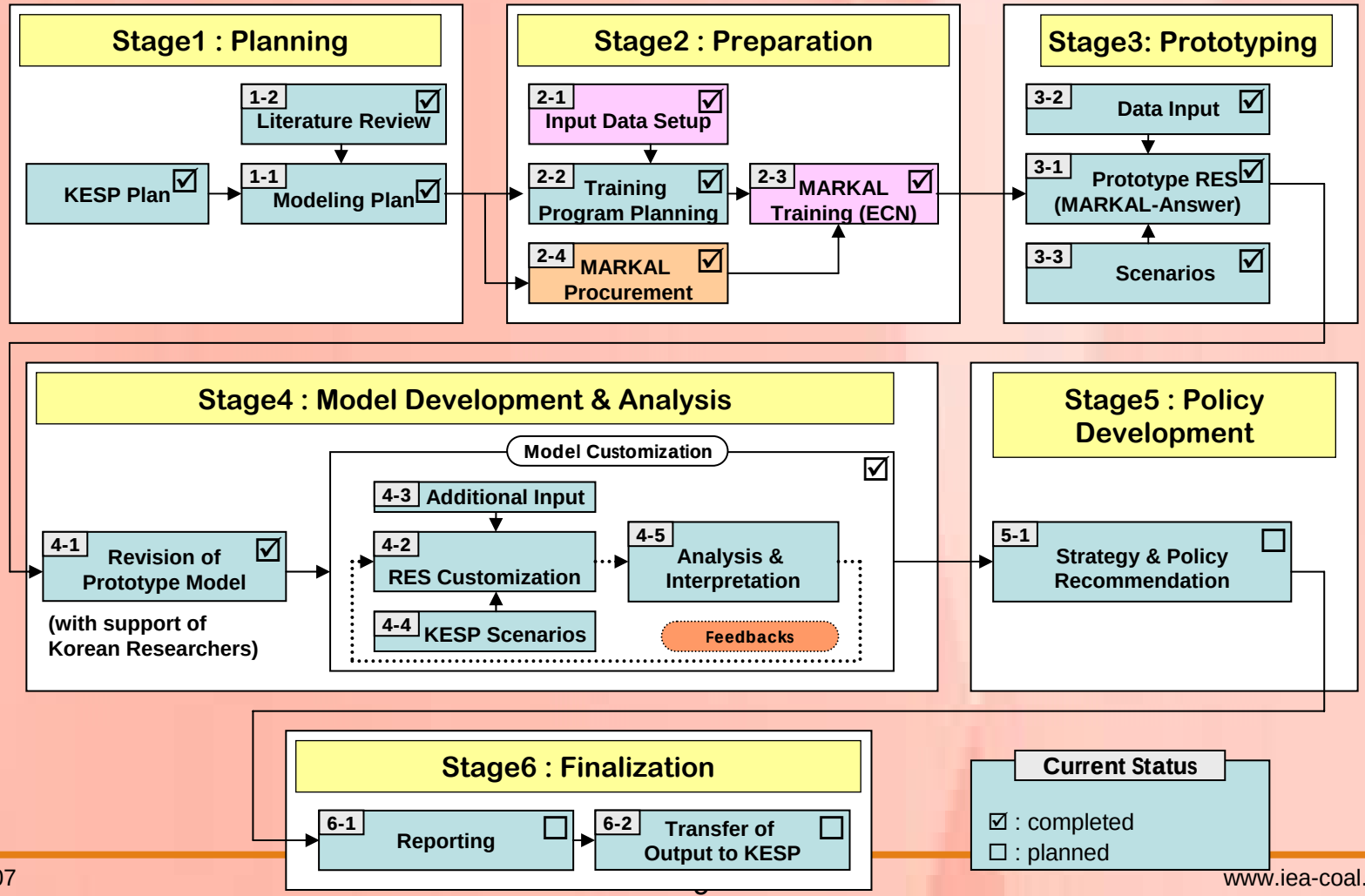
- "Bottom-up" energy-technology-environmental systems model
- Least-cost solutions for energy system planning
- A framework for exploring and evaluating alternative futures, and the role of various technology and policy options

MARKAL Features

- Provides a coherent and transparent framework -> Data assumptions are open and each results may be traced to its technological roots
- Flexible -> facilitates "What-if?" questions
- Long history(>20yrs) of widespread use(>50 countries)
- Evolves to MARKAL-MACRO, TIMES

IV. Model Development for KESP Project

Modelling approach



IV. Model Development for KESP Project

KESP MARKAL outline

Outline

- Model Package : MARKAL standard
- Scope : Korea's Electricity and Related Heat
- Modeling Period : 2004 – 2044
  (every 5 years for 40 years)
- Reference Year : 2004
- Unit of Currency : USD of 2004
- Discount Rate : 7%

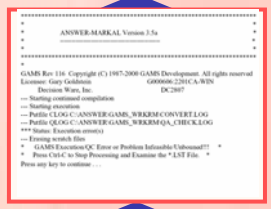
- User Interface

ANSWER Ver.6

- Model Generator

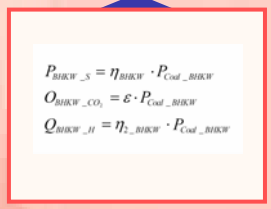
MARKAL Std.

- Solver



CPLEX (LP+Barrier)

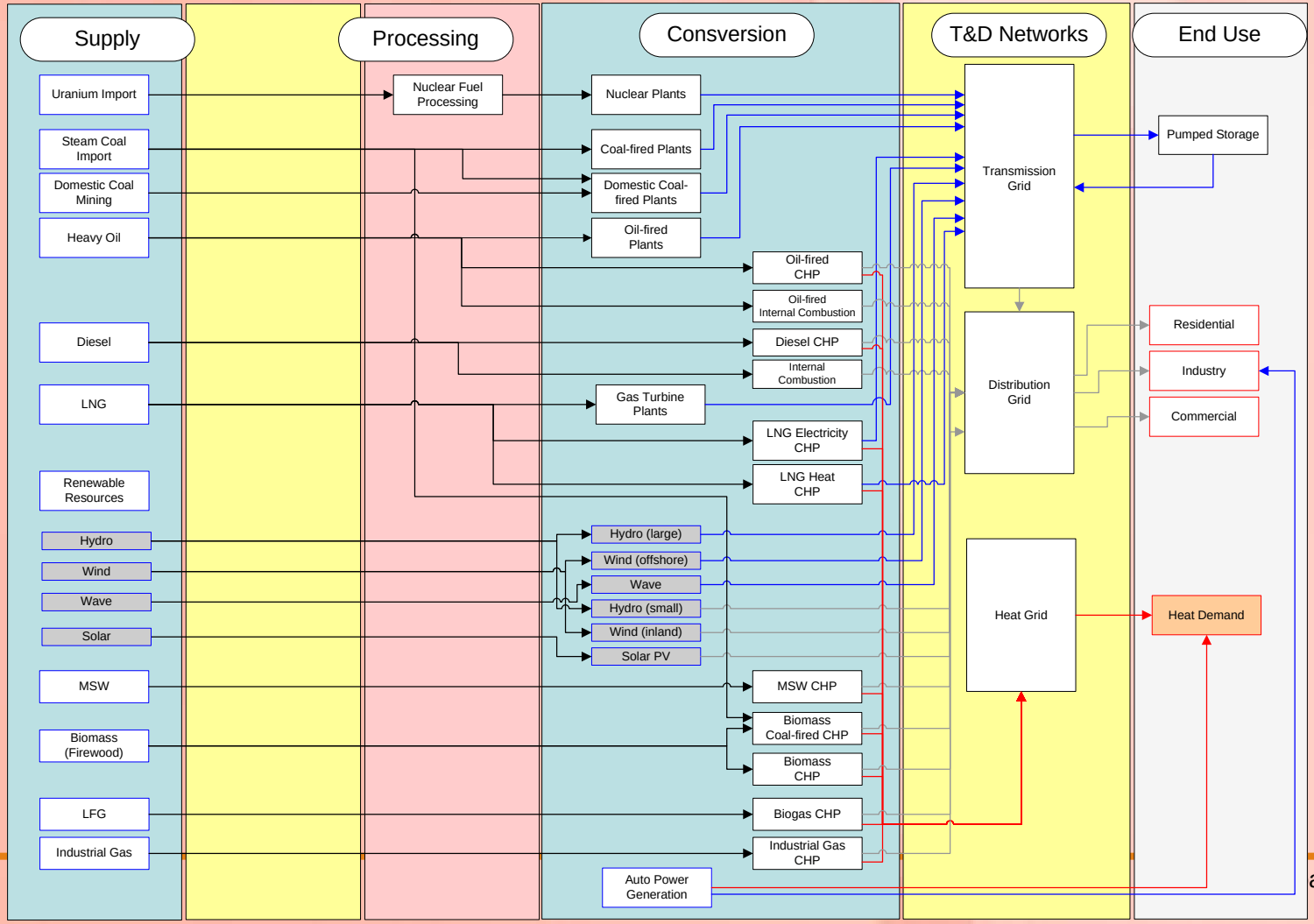
- Modeling Language



GAMS

IV. Model Development for KESP Project

RES (Reference Energy System) Structure



IV. Model Development for KESP Project

Input data processing

Korea

- National Electricity Supply Plan(2006-2020)
- Energy Statistics of Korea(2005)
- Electricity Statistics of Korea(2005), …

Worldwide

- IEA
  - ETP 2006, Energy Technology Analysis
  - Energy Balance of OECD 2003-2004, Electricity Information 2006 …
  - WEO 2006 …
- UK
  - The Energy Challenge (DTI, 2006)

MARKAL Case Studies

- ETSAP Research Papers
- Journal Papers

* ETSAP is an energy system modeling program of IEA

KESP MARKAL

Input Data

- General Data
  - **Electricity & Heat Demands**
  - **Time Fractions**
  - **Baseload**
  - **Energy Resource Price Projection …**
- Technology Data
  - **Annual Availability**
  - **Energy Conversion Efficiency**
  - **Emission Coefficient/Activity**
  - **Fixed & Variable O&M Costs**
  - **Life Time**
  - **Total Cost of Investment**
  - **Annual Growth Rate**
  - **Start Year**
  - **Residual Installed Capacity**
  - **Bound on Capacity/Activity**
  - **Electricity to Heat Ratio**
  - **Transmission Efficiency**
  - **…**

IV. Model Development for KESP Project

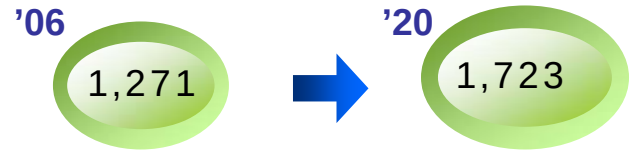
Base Scenario Development

Base Scenario

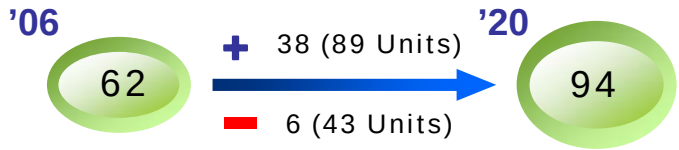
- Business As Usual (BAU) Scenario
- Based on **National Electricity Supply Plan of Korea (NESP)** (2006)
  - Planning Periods : 2006-2020
  - Projection of Electricity Demand by Sectors
  - Construction & Closedown Plan of Power Plant
  - Policies for Demand Management
- Little Consideration on the Carbon Reduction Options
- No Consideration on CCT & CCS Technologies

Key Features of NESP

- Electricity Demand (PJ)

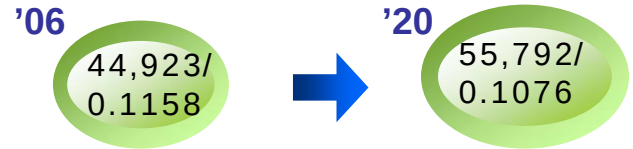


- Construction & Closedown (GWe)



- Total Investment of 32 billion USD

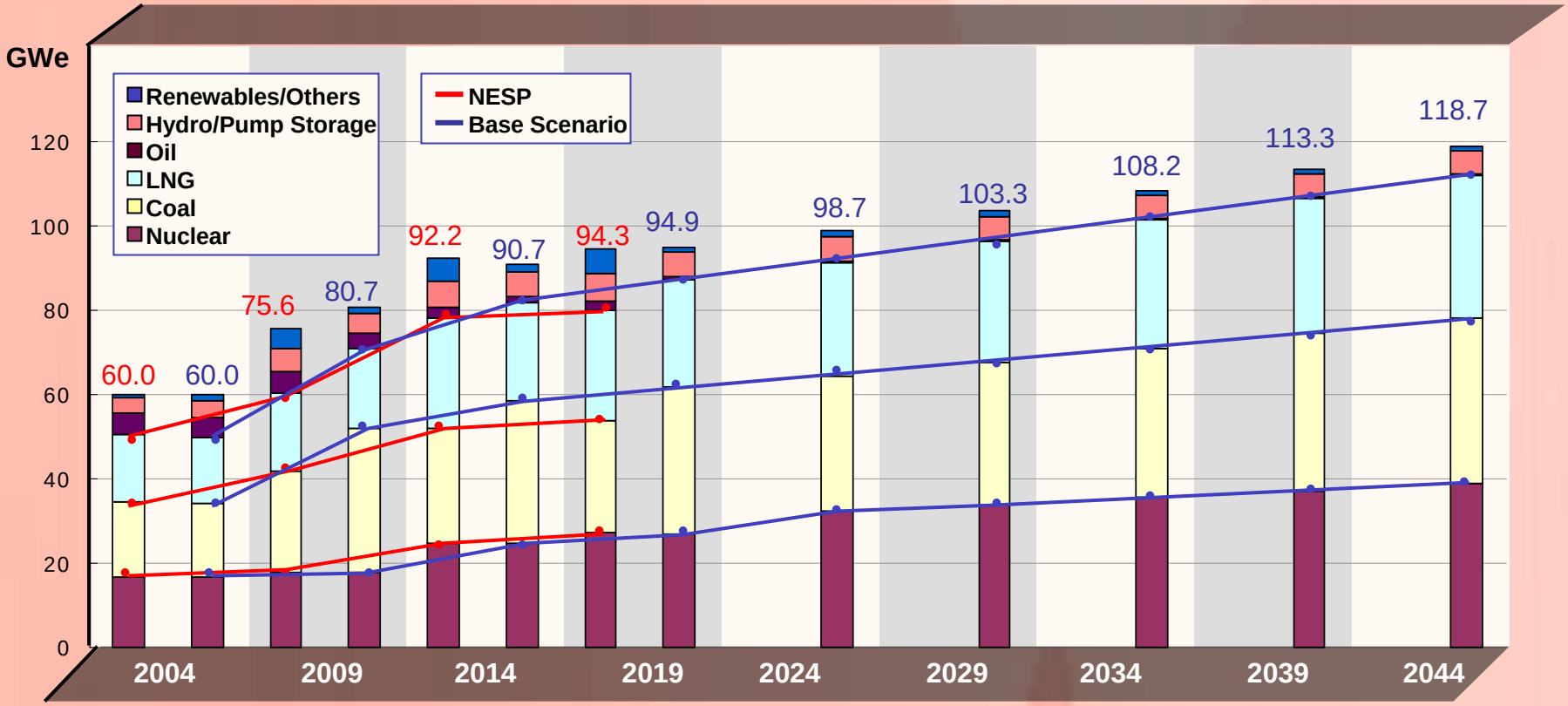
- Emission (ton-C, Kg-C/kWh)



IV. Model Development for KESP Project

Model run results : Base scenario

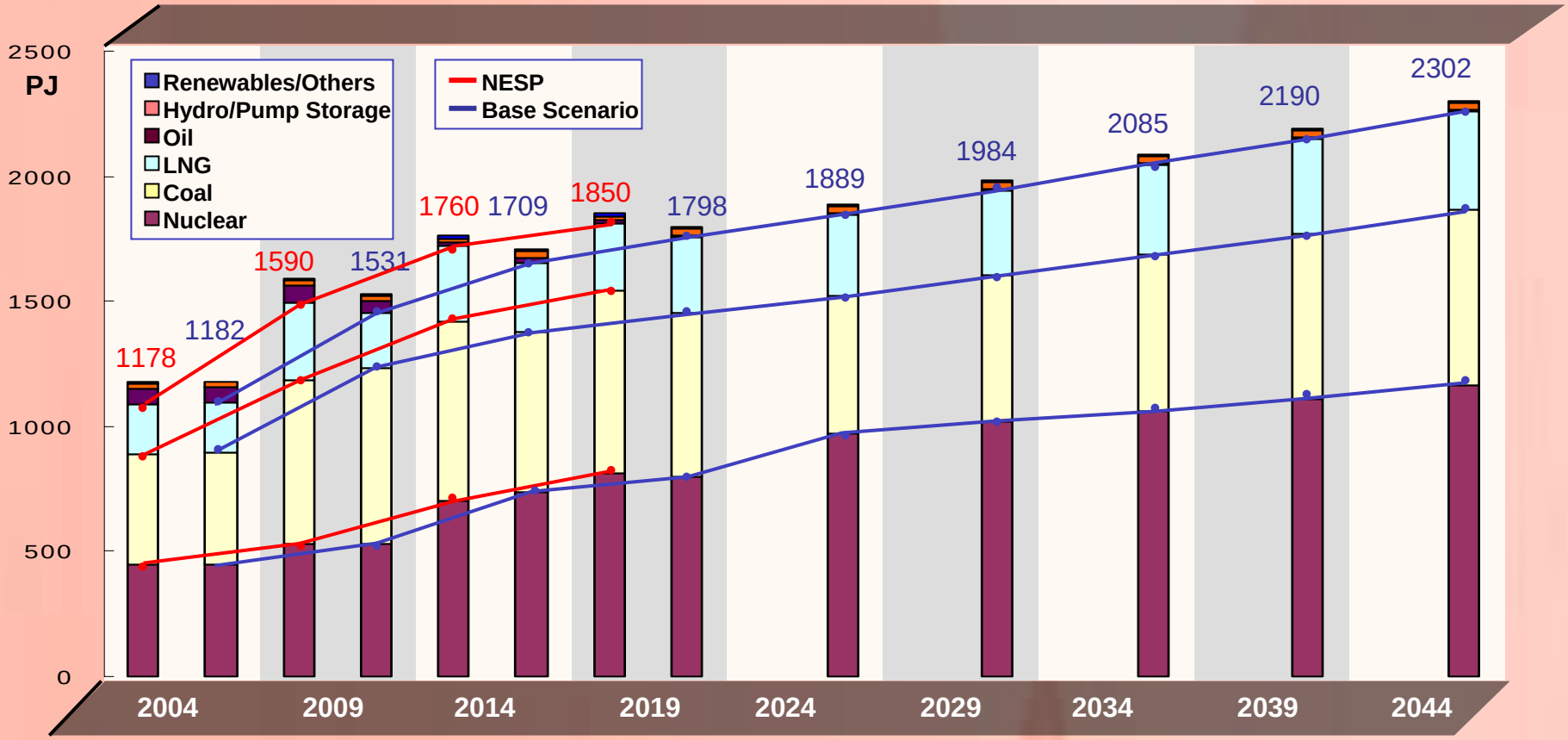
- Capacity Growth : NESP vs. Base Scenario



IV. Model Development for KESP Project

Model run results : Base scenario

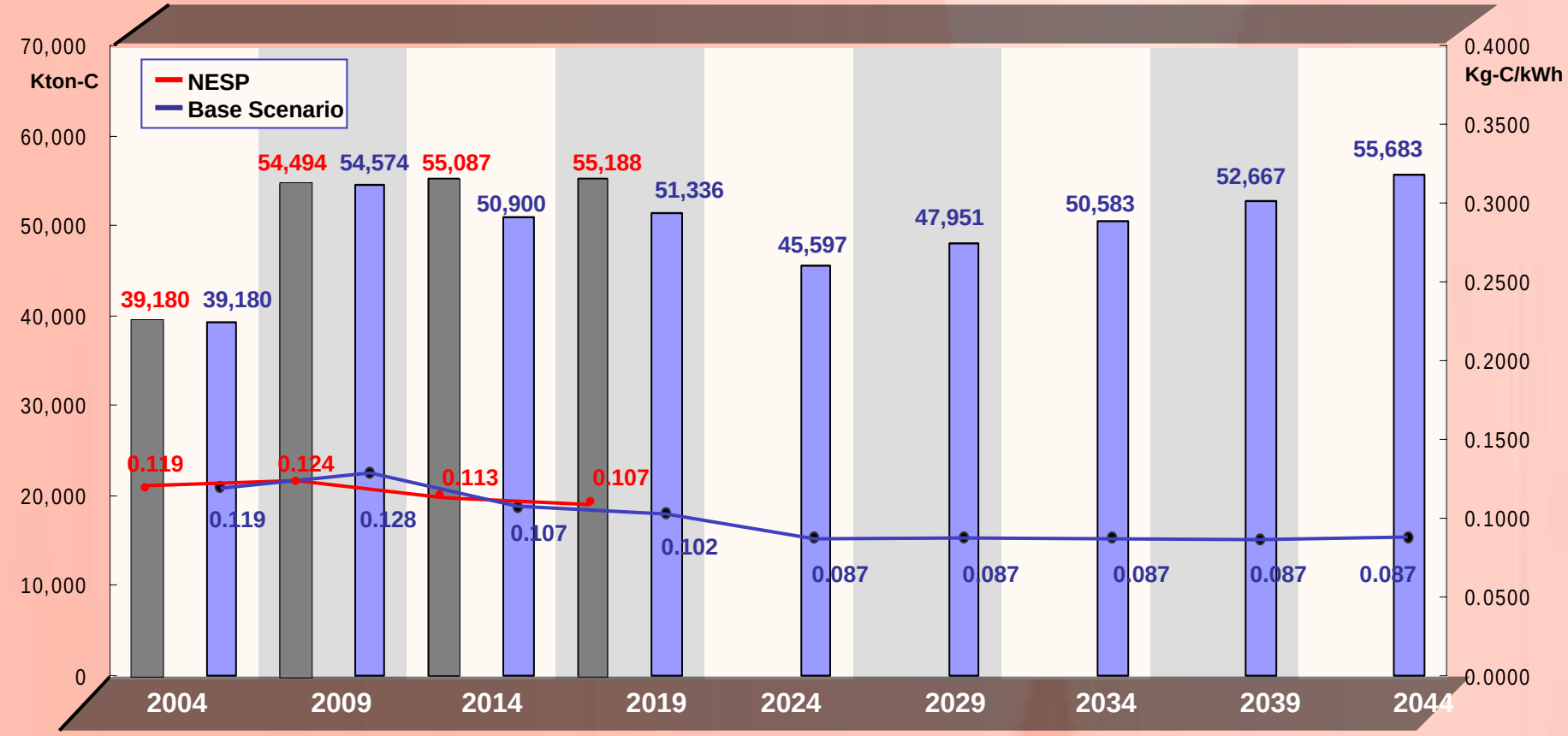
- Power Generation : NESP vs. Base Scenario



IV. Model Development for KESP Project

Model run results : Base scenario

- Emission : NESP vs. Base Scenario



V. Future Works & Remarks

Future works : Scenario development & Run

		Technology					Tax
		New Tech. (Not CCS)	Fossil (upper B.)	CCS Tech.	Nuclear (upper B.)	Renewable (Lower B.)	
BASE Scenarios		Out	Out	Out	Out	Out	-
Tech Scenarios	New Tech. w/o CCS	In	40%(2044)	Out	40%(2044)	5%(2044)	-
	New Tech. with CCS	In	50%(2044)	In	↓	↓	-
	High Nuclear	↓	40%(2044)	↓	50%(2044)	↓	-
	High Renewable	↓	↓	↓	40%(2044)	15%(2044)	-
Tax Scenarios	BASE-TAX	↓	↓	↓	↓	5%(2044)	$20 /TCO2
	Low Carbon Tax	↓	↓	↓	↓	↓	$10 /TCO2
Tech Plus and Tax Scenarios		↓	60%(2044)	↓	30%(2044)	5%(2044)	$30 /TCO2
Emission Constraint							

V. Future Works & Remarks

Future works : Scenario development & Run

Future Technologies

- No CO2 Capture
  - Coal, Steam Cycle (I) (II)
  - Coal, USC Steam Cycle
  - Coal, IGCC (I) (II)
  - Gas, CC (I) (II)
  - Coal, IGCC & SOFC
  - Gas, IGCC & SOFC
- With CO2 Capture
  - Coal, Steam Cycle, CA
  - Coal, Steam Cycle, Membrane + CA
  - Coal, USC Steam Cycle, Membrane + CA
  - Coal, IGCC Selexol (I) (II)
  - Gas, CC, CA
  - Gas, CC, Selexol/OxF
  - Coal, CFB, Chemical looping
  - Gas, CC, Chemical looping

- Tech Scenario
- Tax Scenario

- Tech + Tax Scenario
- Emission Constraint Scenario

KESP
MARKAL

August 2007

Strategy & Policy Recommendations

Thank You !
Grazie !

Q & A