Energy Technology Vision 2100

Insights from strategic technology roadmap and back casting approach

IEA Workshop on: Using long term scenarios for R&D priority setting

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Background

- METI released the "Strategic Technology Roadmap" as a navigating tool for strategic planning and implementation of R&D investment (March 2005).
  - Covering 20 areas including:
    - information and communication technology, life science, environment and manufacturing
  - Structure:
    - Scenario for Introduction
    - Technology Overview
    - Roadmap
- Energy Technology Vision 2100 developed by ANRE/METI was integrated into this STR.

Development of "Energy Technology Vision 2100"

Purpose

- To establish METI strategic energy R&D plan
  - To consider optimum R&D resource allocation.
  - To prioritize energy R&D programs and specific project of METI.
- To prepare strategy for post-Kyoto and further deep reduction of GHG
- To develop technology roadmap to be reflected in METI's energy, environmental and industrial policy

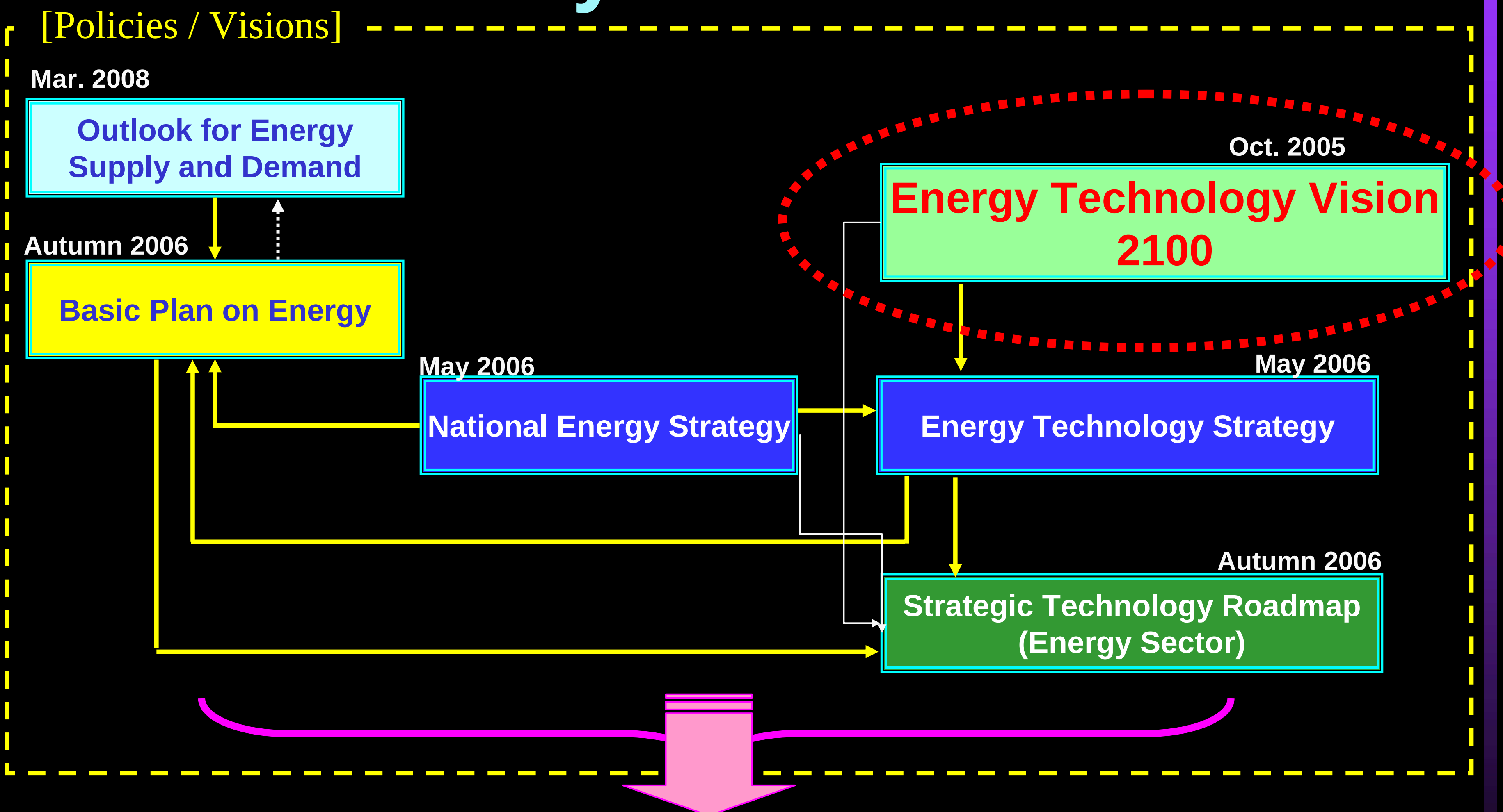
Energy Technology Vision 2100

Agency for Natural Resources and Energy

Ministry of Economy, Trade and Industry

- **An approach to LCS from Energy Policy**
- **Purpose**
  - **To establish strategic energy R&D plan by**
    - **identifying technologies and developing technology portfolio to prepare for resource and environmental constraints**
    - **considering optimum R&D resource allocation in METI**
- **Timeframe:**
  - **Vision and Technology roadmap: - 2100**

Overview of Energy Related Policy & Measures

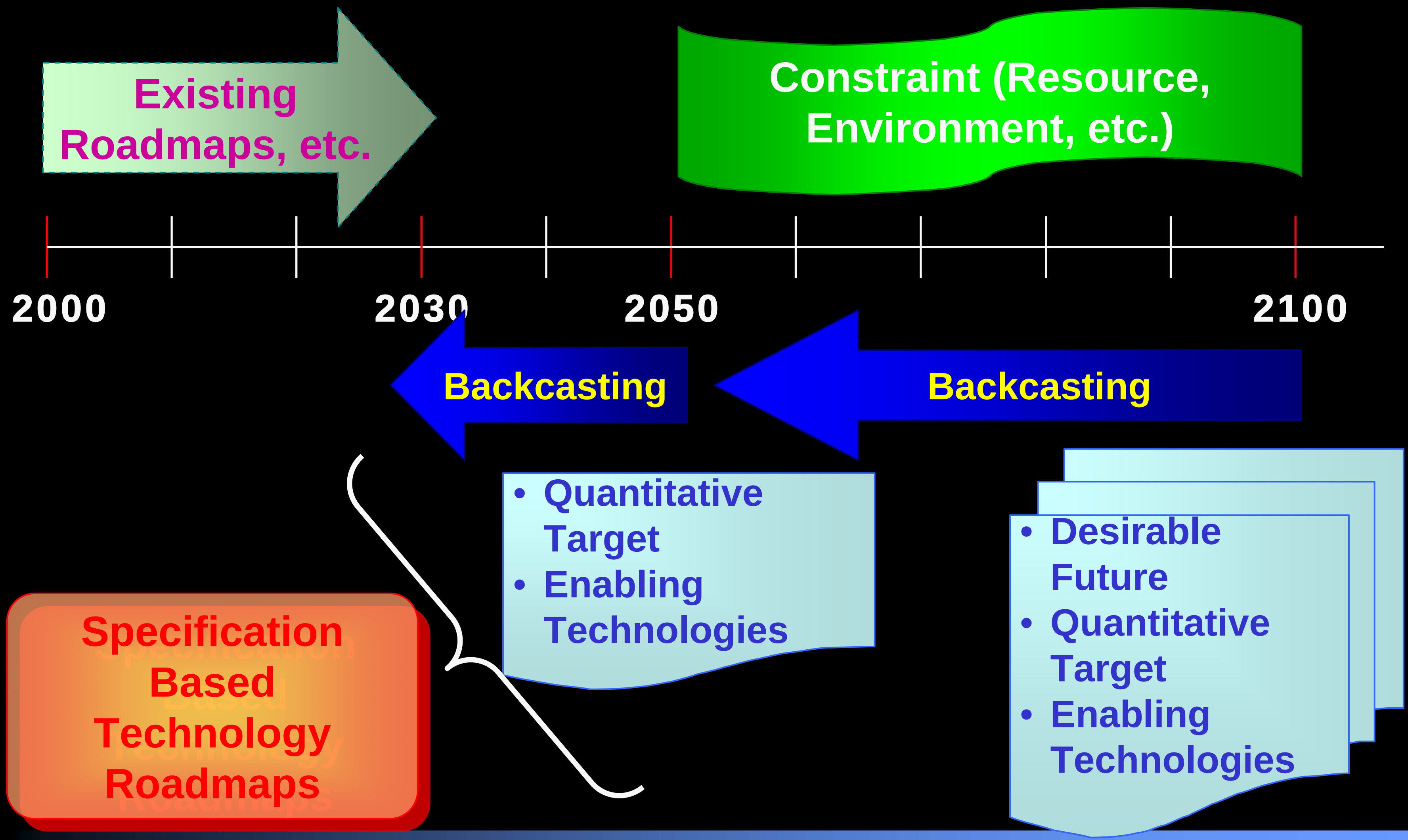


[Policy Planning, Resource Allocation / Policy Implementation / Policy Evaluation]

Scope of Work

- **Timeframe**
  - Vision: - 2100
  - Technology roadmap: -2100
    - Benchmarking years: 2030 and 2050
- **Approach**
  - To introduce backcasting methodology
  - To compile experts' view
  - To confirm long-term goal using both top-down and bottom-up scenario analysis

Framework of Backcasting



Premises

- Resource and environmental constraints do not degrade utility but enrich the human race (improve utility)
- To develop the technology portfolio for the future in order to realize it through development and use of the technologies.
- **Not to set preference to specific technology such as hydrogen, distributed system, biomass, etc.**

Assumptions

Developing a Challenging Technology Portfolio

- The effect of modal shift or changing of lifestyle were not expected.
- Although the assumption of the future resource and environmental constraints includes high uncertainties, rigorous constraints were assumed as "preparations".
- To set excessive conditions about energy structure to identify the most severe technological specifications.
  - As a result, if all of them are achieved, the constraints are excessively achieved.

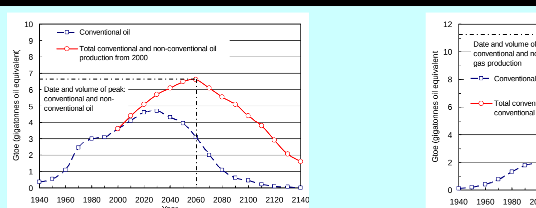
Definition of Desirable Futures

- **Society where the economy grows and the quality of life improves**
- **Society where necessary energy can be quantitatively and stably secured**
- **Society where the global environment is maintained**
- **Society where technological innovation and utilization of advanced technology are promoted through international cooperation**
- **Society with flexible choices depend on national and regional characteristics**

Assumptions towards 2100

Resource Constraints

- Although assumption of the future resource constraints includes high de... uncertainties, the following constraints were assumed a...
  - Oil production peak at 2050
  - Gas production peak at 2100



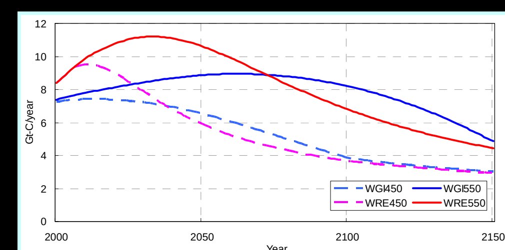
The Complementarity of Conventional and Non-Conventional Oil Production: giving a Higher and Later Peak to Global Oil Supplies

The Complem... Conventional ... Peak to Global...

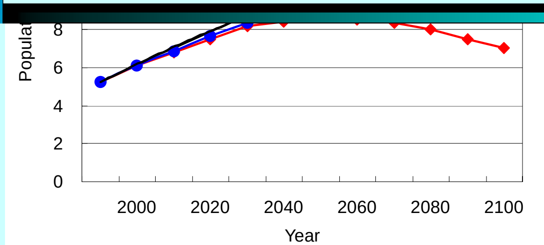
Example of estimates for oil and natural gas

Environmental Constraints

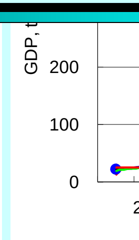
- CO_2 emission **intensity** (CO_2 / GDP) should be improved to stabilize atmospheric CO_2 concentration
  - 1/3 in 2050
  - Less than 1/10 in 2100 (further improvement after 2100)



Global carbon dioxide emission scenario



Forecast of world population



Forecast of world GDP

Forecast of energy consumption

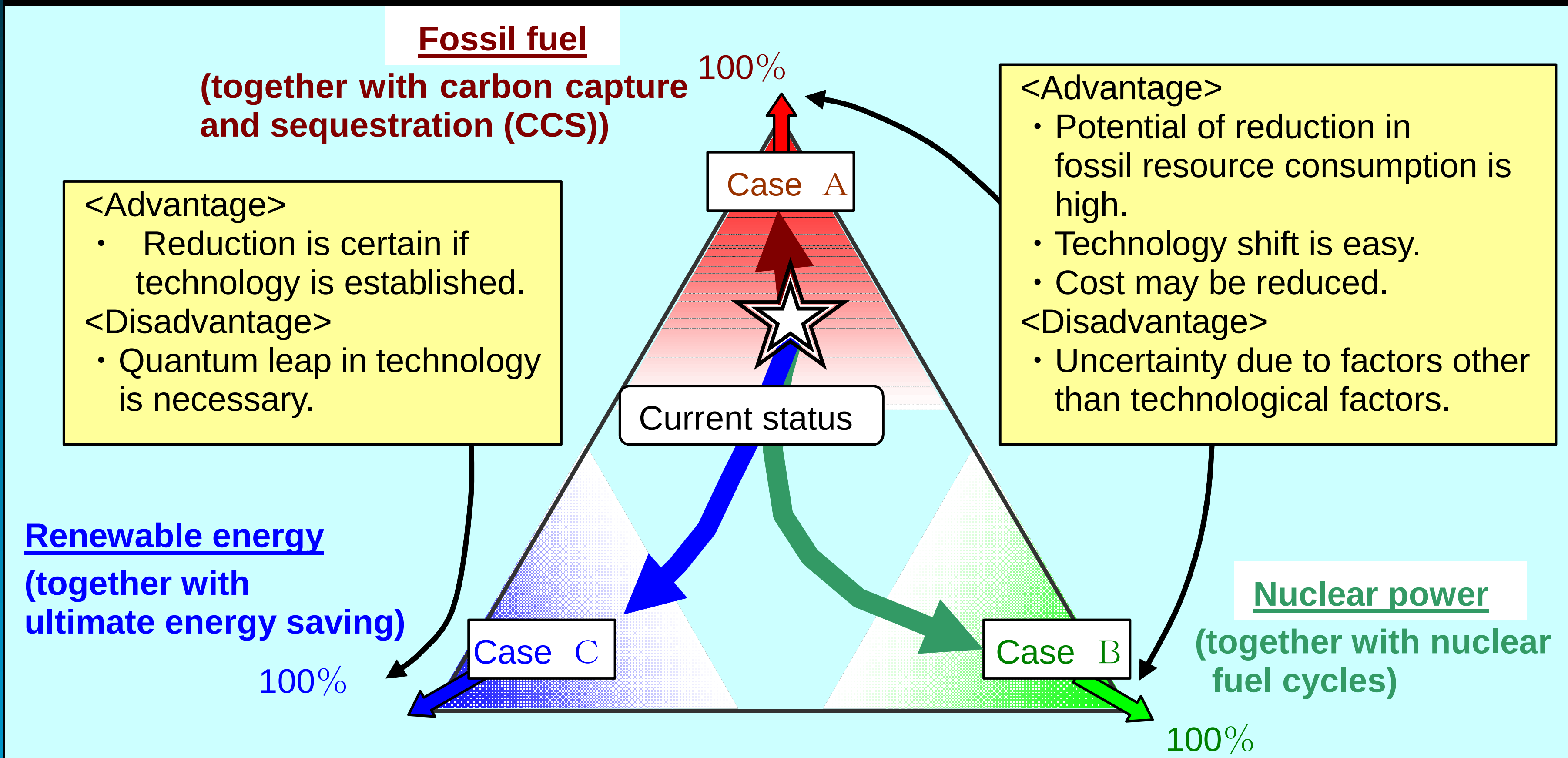
To Overcome Constraints ---

- **Sector specific** consideration
  - Residential/Commercial
  - Transport
  - Industry
  - Transformation (Elec. & H_2 production)
- Definition of goal in terms of sector or sub-sector specific CO_2 emission **intensity**.
- Identification of necessary technologies and their targets

Demand sectors and their typical CO_2 emission intensity

Industry	:	t-C/production volume	=	t-C/MJ	×	MJ/production volume
Commercial	:	t-C/floor space	=	t-C/MJ	×	MJ/floor space
Residential	:	t-C/household	=	t-C/MJ	×	MJ/household
Transport	:	t-C/distance	=	t-C/MJ	×	MJ/distance
(*Transformation sector*: t-C/MJ)				Conversion efficiency		Single unit and equipment efficiency

Three Extreme Cases and Possible Pathway to Achieve the Goal



- **Cases A & C assume least dependency on energy saving**

Sketch of Technology Spec. 2100

Extreme Case-A (Fossil + CCS)

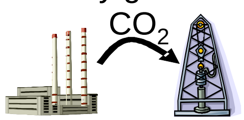
- Case A assumes a situation where we cannot heavily rely on energy saving.
- The increase of the share of electricity and hydrogen is considered.

** Values are relative to those in 2000, otherwise stated*

[Target in the Transformation Sector]

(1) Production of Electricity and Hydrogen
About eight times* the current total amount of electricity generated

Fossil Fuel



CO_2 Capture and Sequestration (CCS)

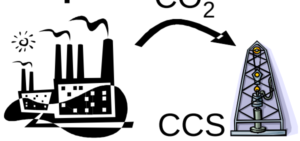
Supplying with coal fired power plants with CCS

Total amount of CO_2 captured and sequestered in transformation and industry sector becomes approximately 4.0 billion t-CO_2/year.
*** Additional energy required for the CCS process is not included.*

Electricity or Hydrogen

[Target in the Industry Sector]

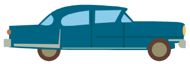
(1) CCS it applied to over 80% of CO_2 emissions from fossil fuel consumption



(2) Over 65% of the energy demand is supplied by electricity or hydrogen from the transformation sector

[Target in the Transport and Res/Com Sectors]

(1)100% of the energy demand is supplied by electricity or hydrogen



Transport

Res/Com (Residential)

Res/Com (Commercial)

Sketch of Technology Spec. 2100

Extreme Case-B (Nuclear)

- Case B assumes a situation where we cannot heavily rely on energy saving.
- The increase of the share of electricity and hydrogen is considered.

** Values are relative to those in 2000, otherwise stated*

[Target in the Transformation Sector]

(1) Production of Electricity and Hydrogen

About eight times* the current total amount of electricity generated

Nuclear Power

Supplying by nuclear power

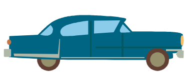
Electricity or Hydrogen

[Target in the Industry Sector]

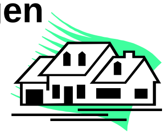
(1) All the energy demand is supplied with electricity or hydrogen with the exception of feedstocks and reductants

[Target in the Transport and Res/Com Sectors]

(1)100% of the energy demand is supplied by electricity or hydrogen



Transport



Res/Com (Residentila)

Res/Com (Commercial)

Sketch of Technology Spec. 2100

Extreme Case-C (Renewable + Ultimate Energy Saving)

** Values are relative to those in 2000, otherwise stated*
*** Per unit utility*

[Target in the Transformation Sector]

(1) Production of Electricity and Hydrogen

About twice* of the current total electricity generated

Renewable Energies

Electricity, Hydrogen or Biomass

[Target in the Industry Sector]

Energy demand to be reduced by 70%**

(1) 50% of the production energy intensity is reduced.

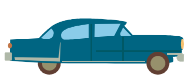
(2) Making the rate of material energy regeneration to 80%

(3) Improvement of functions such as strength by factor 4

Supplying by renewable energies

[Target in the Transport Sector]

(1) 70% of the energy demand is reduced through energy saving and fuel switching.**



Transport

For automobile, 80% is reduced

[Target in the Res/Com Sector]

(1) Energy demand to be reduced by 80% through energy saving and energy creation.

Res/Com (Residential)

Res/Com (Commercial)

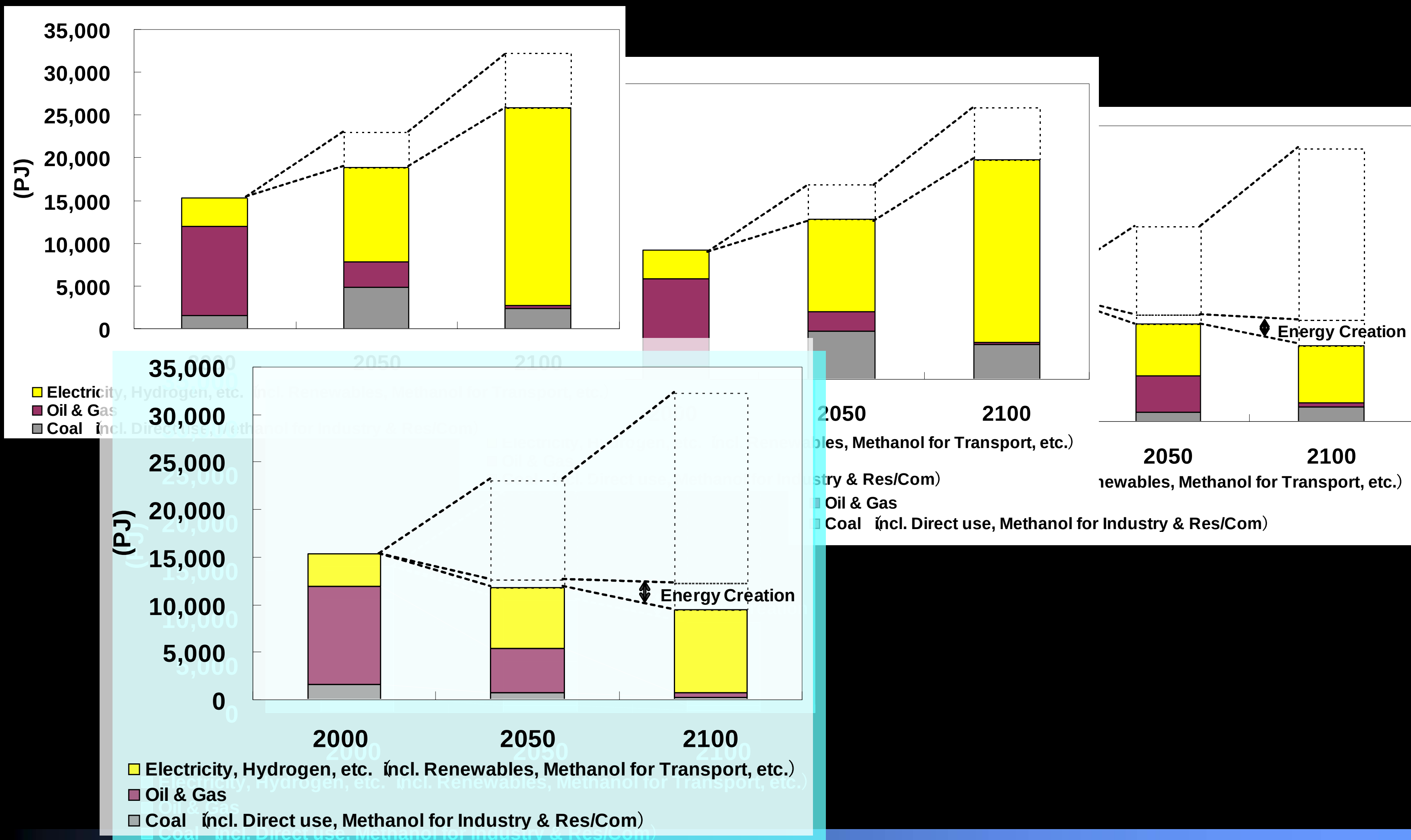
Development of Technology Roadmaps

- Target sectors:
  - Residential and Commercial
  - Transportation
  - Industry
  - Transformation (Energy supply)
- Summary roadmap
  - Target specifications and milestones
  - Typical technologies
- Detailed roadmaps
  - Technology breakdown for sub-sectors

Important Cross-Boundary Technologies

- Once a cross-boundary technology is established, it can work effectively in a wide range of applications. Here, the following technologies are identified:
  - Energy-saving technologies
  - Energy storage technologies
  - Power electronics technologies
  - Gasification technologies
  - Energy management technologies

Verification by Scenario Analysis using GRAPE Model



Scenario Study on the Vision

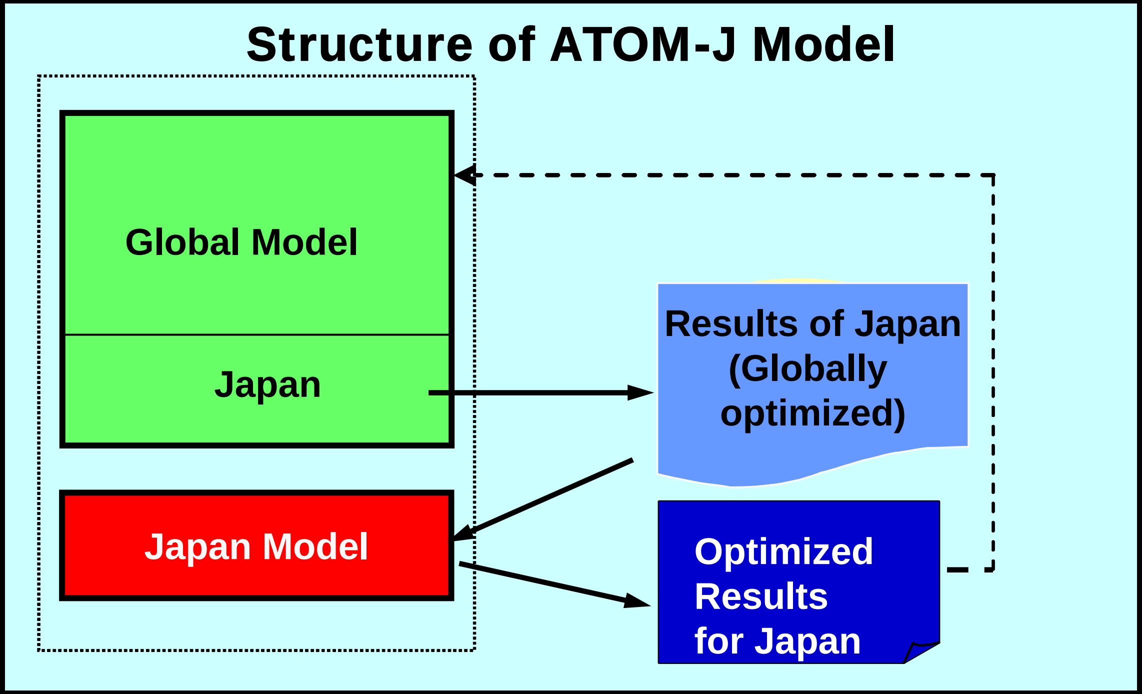
Energy Scenario of Japan

based on Energy Technology Vision 2100

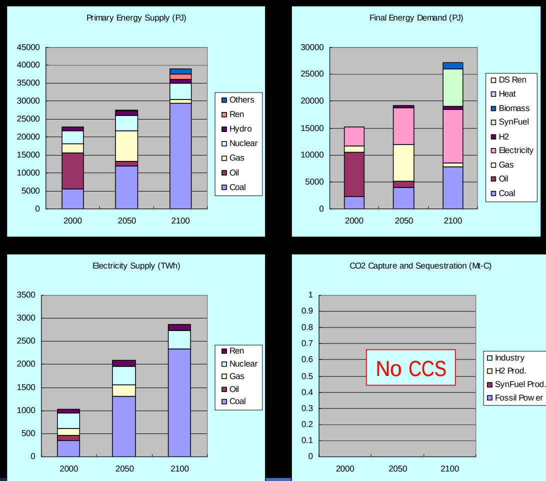
- Case Study by an Energy Model "ATOM-J" developed by Akai.

ATOM-J Model

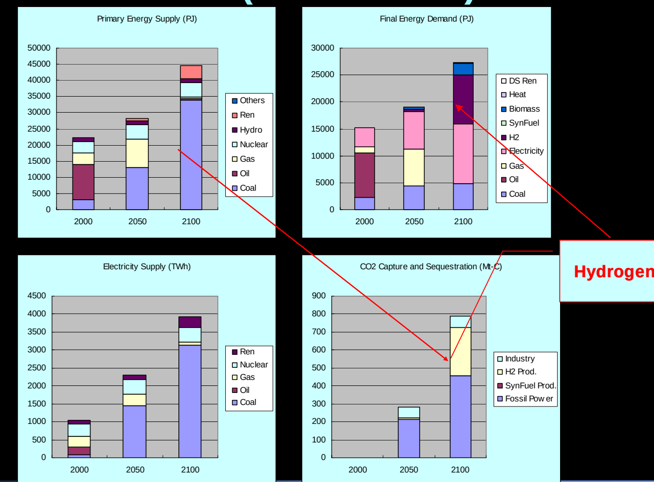
- Optimized LP
- Term：1990-2100
- 18 world regions
- Demand Sectors
  - Industry
  - Household
  - Service
  - Transport



Energy Scenario of Japan
BAU defined in the ETV 2100

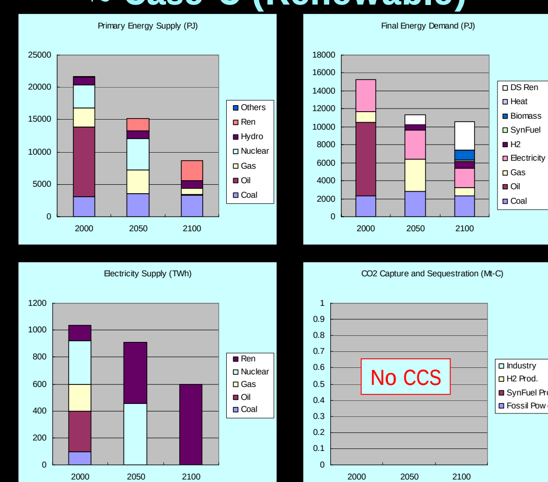


Energy Scenario of Japan
≈ Case-A (Fossil + CCS)



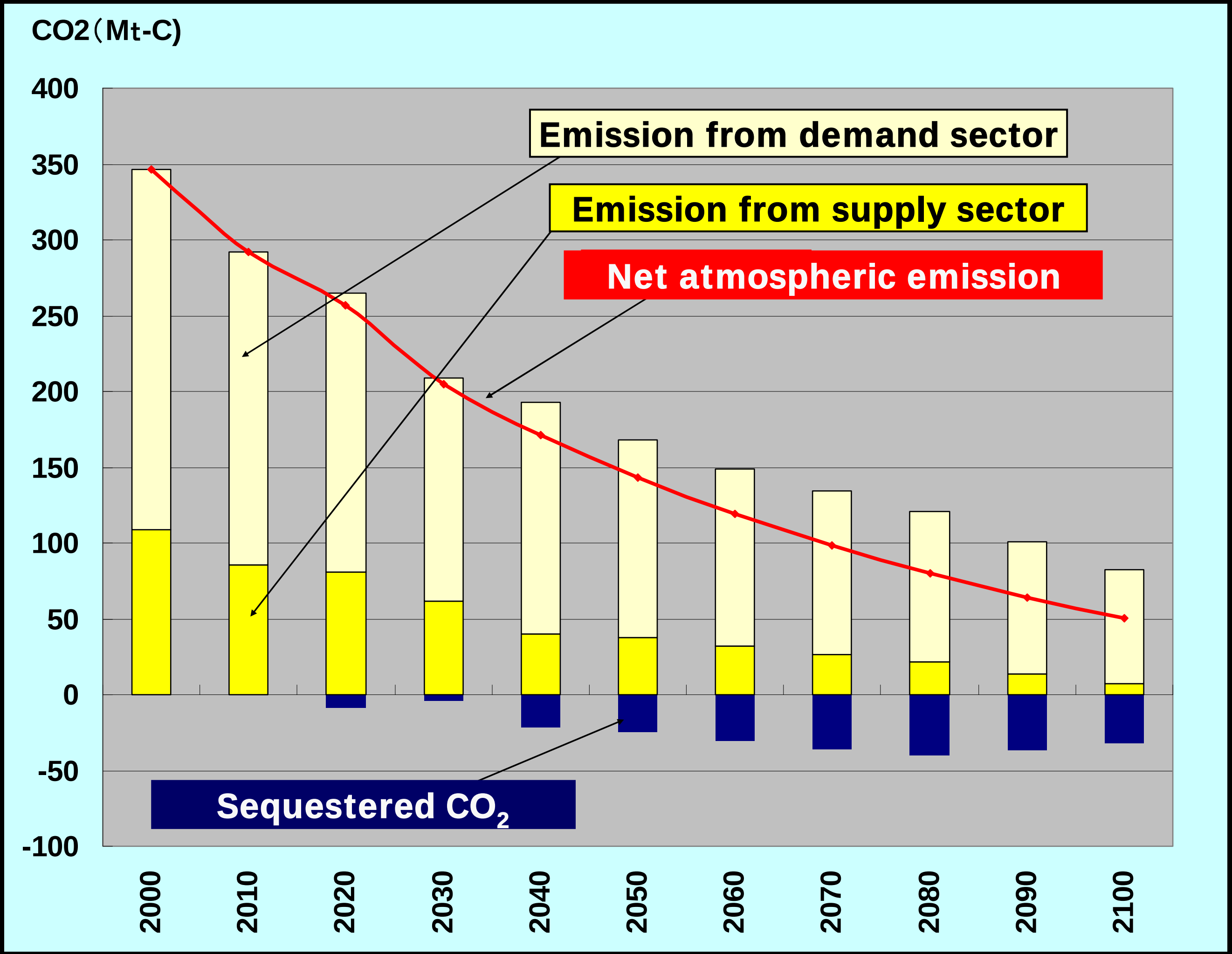
Energy Scenario of Japan
≈ Case-B (Nuclear)

Energy Scenario of Japan
≈ Case-C (Renewable)



CO_2 Emission in Japan

≈ Mix (w. CCS, Cumulative CCS potential: 10Gt-CO_2)



Implications on Specific Technology Areas

- **Hydrogen**
  - Important as an energy storage medium, especially when energy supply dominated by renewable resources.
- **Biomass**
  - Contribution to transformation sector (power generation and hydrogen production) is relatively small.
  - Mainly used in industrial sector as a carbon free resource containing carbon.
- **CO_2 Capture and Sequestration (CCS)**
  - Important as a short or mid-term option (fossil power plants, industries, hydrogen production) by increasing the flexibility of energy supply and demand structure with moderate cost.

Possible ETV 2100 Scenario

- Combination of 3 Cases -

- One of the reasonable solutions for sustainable society is a combination of the case A (in short or middle term, reduce atmospheric CO_2 by CCS), C (in long-term, utilize renewables to the maximum beside ultimate energy-saving) and B (stable operation of nuclear power plants).
- However, appropriate combination of each case may change according to the future situation, so it is important to judge R&D priority based on the future social and economical situation or status of technology progress.

Next Steps

- **Periodic update of the "Vision"**
- **Development of tecnology roadmaps for 2030 reflecting "*New National Energy Strategy* (May, 2006)" as a part of STR2007**
  - **Reinforcement by addition of short- and mid-term view through forecasting**
  - **Technology area includes:**
    - **Energy efficiency**
    - **Renewables**
    - **Nuclear**
    - **Fossil Fuels**
    - **Transportation, etc.**

Expectations towards ETP2008

- Implication from the work on ETV2100 -

- **Importance of sector specific (or technology specific, if possible) approach**
  - **Linkage with "indicators" under development and addition of indicators on important areas**
- **Large potential of energy saving or CO_2 reduction through transfer of BATs**
  - **Significant potential lies in power generation sector**
- **Breakdown of scenarios to nation or region specific trends would be useful for policy making**

Thank you!

English version of ETV 2100 is available at:

http://www.iae.or.jp/2100.html