METI's Energy Technology Vision 2100 and CCS Technologies

International Workshop on CO_2 Geological Storage

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Toranomon Pastoral Hotel Tokyo

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  http://www.meti.go.jp/committee/materials/g51013aj.html (J)
  http://www.iae.or.jp/2100.html (E)
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- **Concluding Remarks**

Energy Technology Vision 2100

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

Why to consider Ultra Long-term?

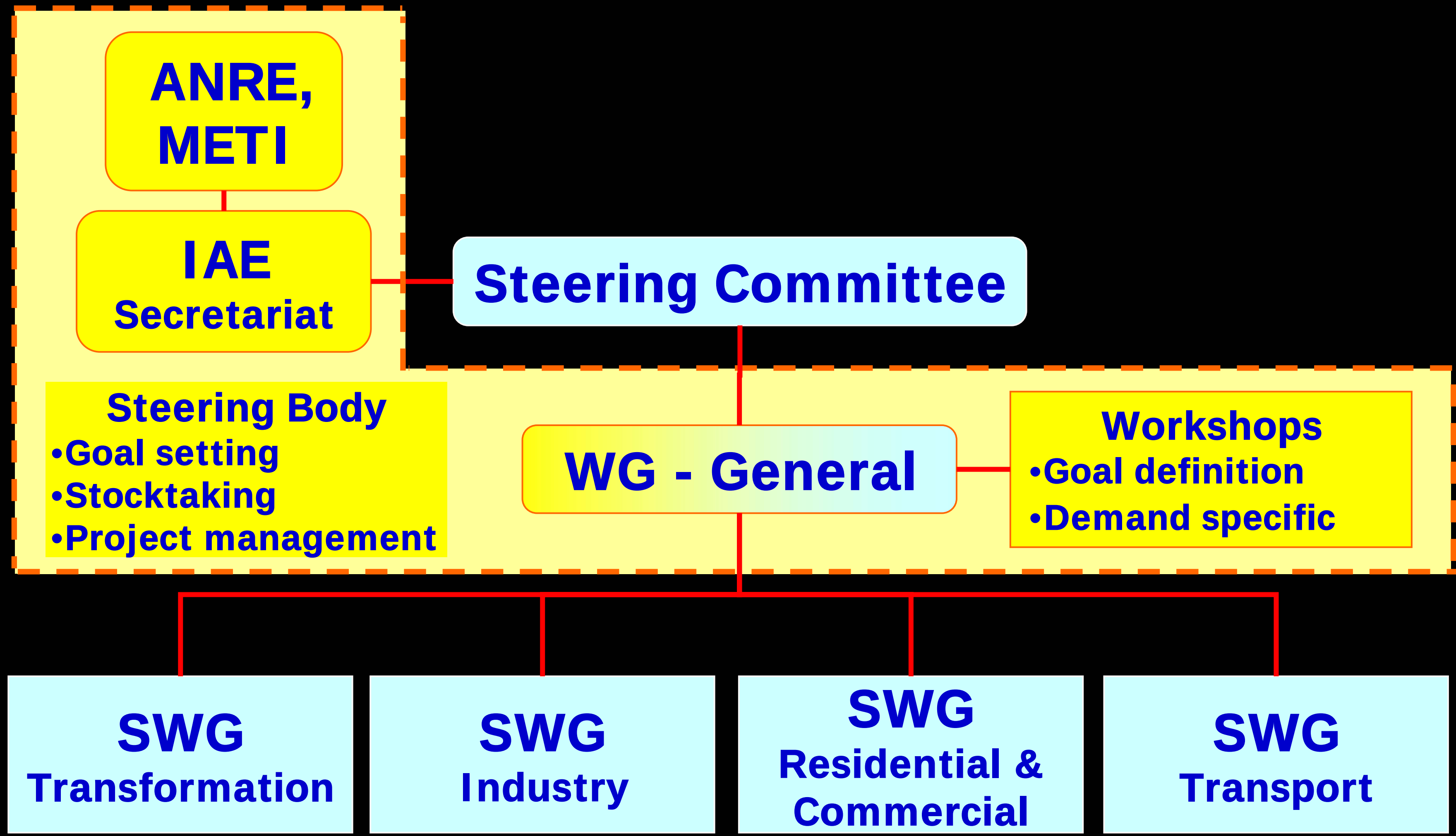
- Timeframe for future risk or constraint
  - Resource (10s ~ 100yrs?)
  - Environment (100 ~ 1000 yrs)
- Long lead time for energy sector in general
  - Research and development to commercialization
  - Market diffusion
  - Infrastructure development
  - Stock turnover time (10s yrs)

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

Work Structure

Development of Draft "Technology Vision"



Methodology - Backcasting

Exploratory (opportunity-oriented):

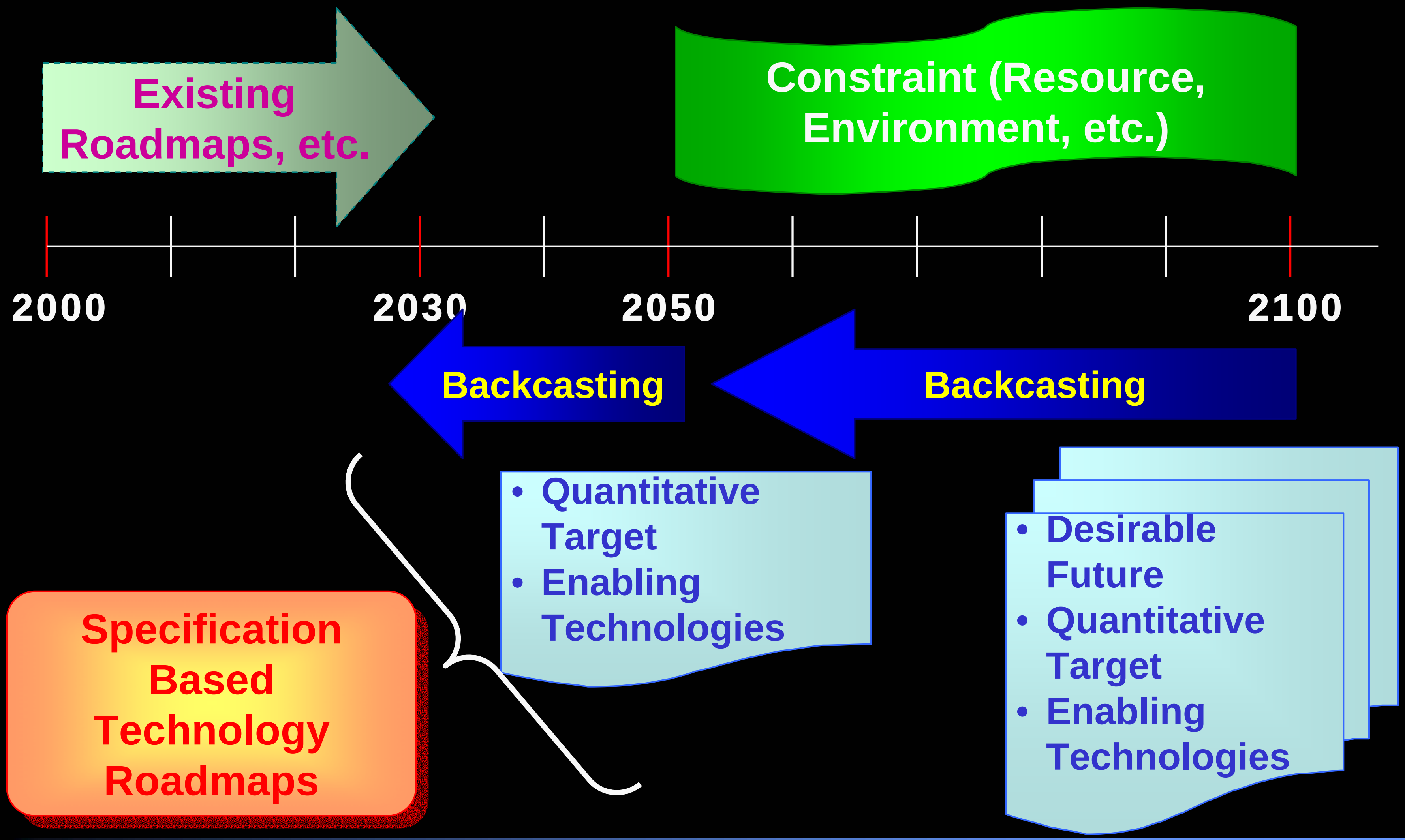
- ***what futures are likely to happen?*** ⇒ ***Forecasting***
  - starts from today's assured basis of knowledge and is oriented towards the future

Normative (goal-oriented):

- ***how desirable futures might be attained?*** ⇒ ***Backcasting***
  - first assesses future goals, needs, desires, missions, etc. and works backward to the present

Clement K. Wang &Paul D. Guild

Framework of Backcasting



Basic Recognition on the Energy Sector

- Constraints on energy connect directly to the level of human utility (quantity of economic activity, quality of life).
- Consideration of future energy structure should take into account both resource and environmental constraints.
- The key to achieve a truly sustainable future is technology.
- However, there is great uncertainty because various kinds of options are selected in the actual society.

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

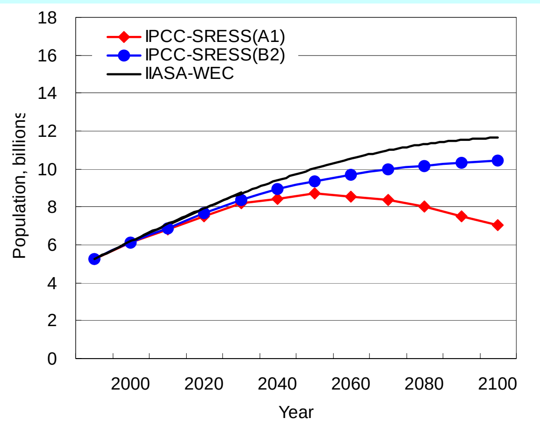
- The effect of modal shift or changing of lifestyle were not expected.
- Although the assumption of the future resource and environmental constraints includes high uncertainties, rigorous constraints were assumed as "preparations".
- To set excessive conditions about energy structure to identify the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

Desirable Futures

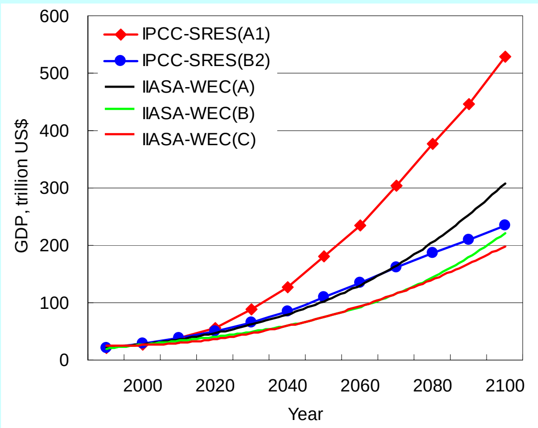
- Society where the economy grows and the **quality of life improves**
- Society where necessary **energy** can be quantitatively and stably secured
- Society where the global **environment** is maintained
- Society where **technological innovation** and utilization of advanced technology are promoted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

Assumptions towards 2100

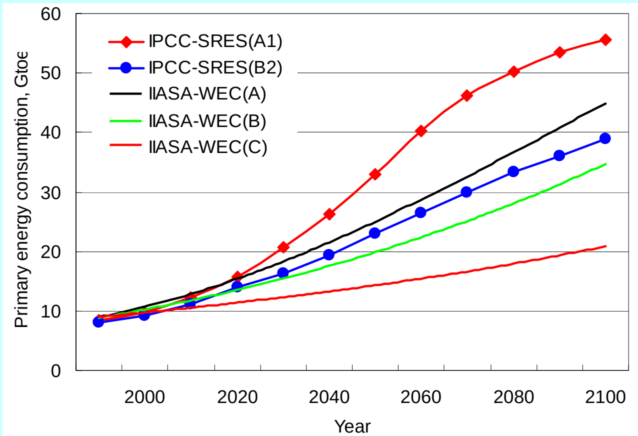
- **Population and economy**
  - To increase continuously
- **Energy consumption**
  - To increase following the increase in population and GDP



Forecast of world population



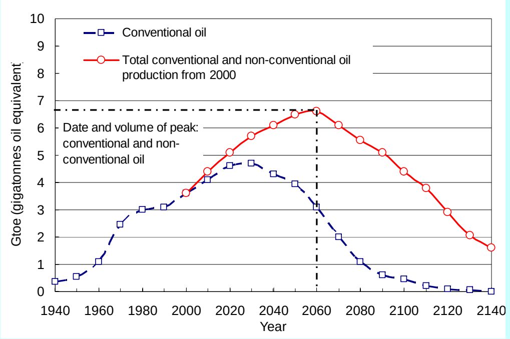
Forecast of world GDP



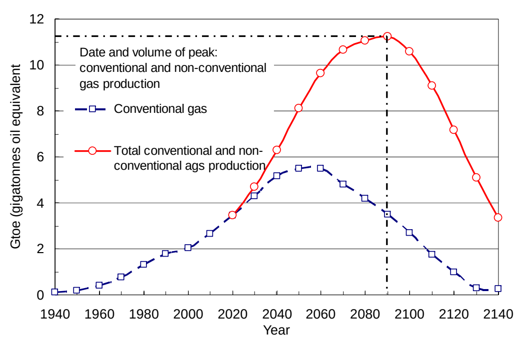
Forecast of energy consumption

Resource Constraints

- **Although assumption of the future resource constraints includes high degree of uncertainties, the following rigorous constraints were assumed as "preparations".**
  - **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

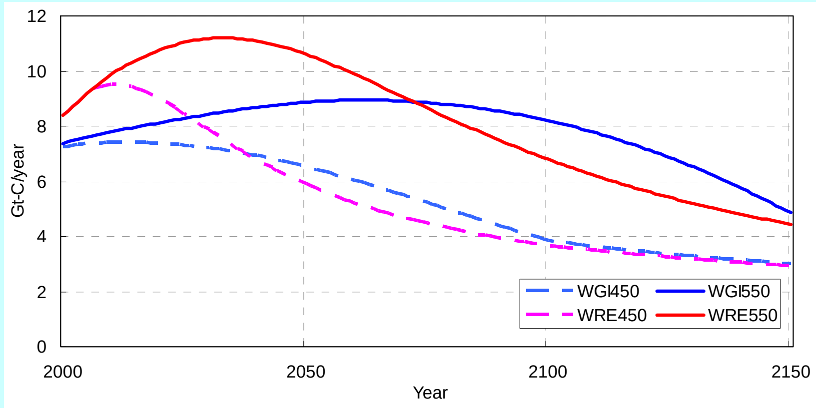


The Complementarity of Conventional and Non-Conventional Gas Production: giving a Higher and Later Peak to Global Gas Supplies

Example of estimates for oil and natural gas production

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

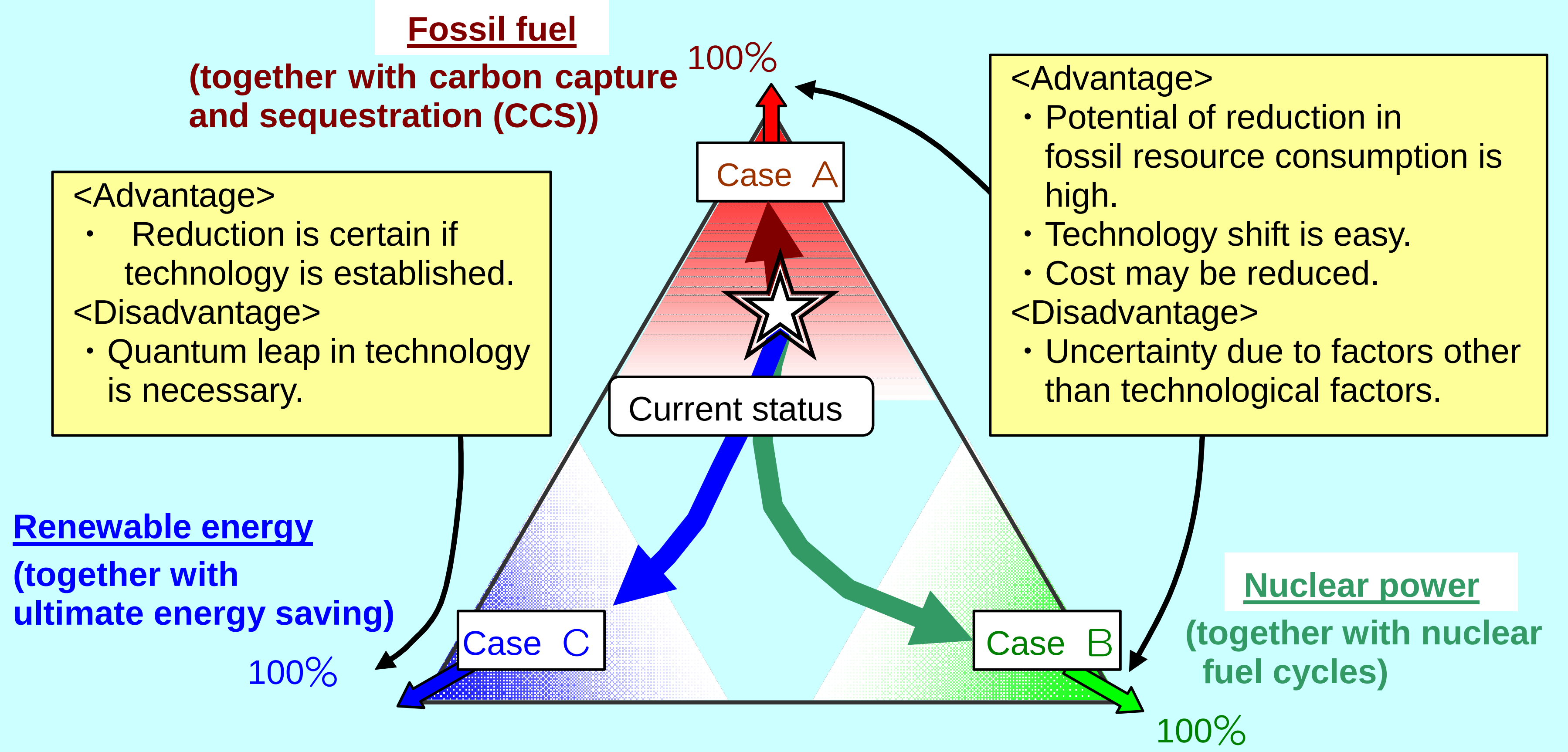
To Overcome Constraints ---

- **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

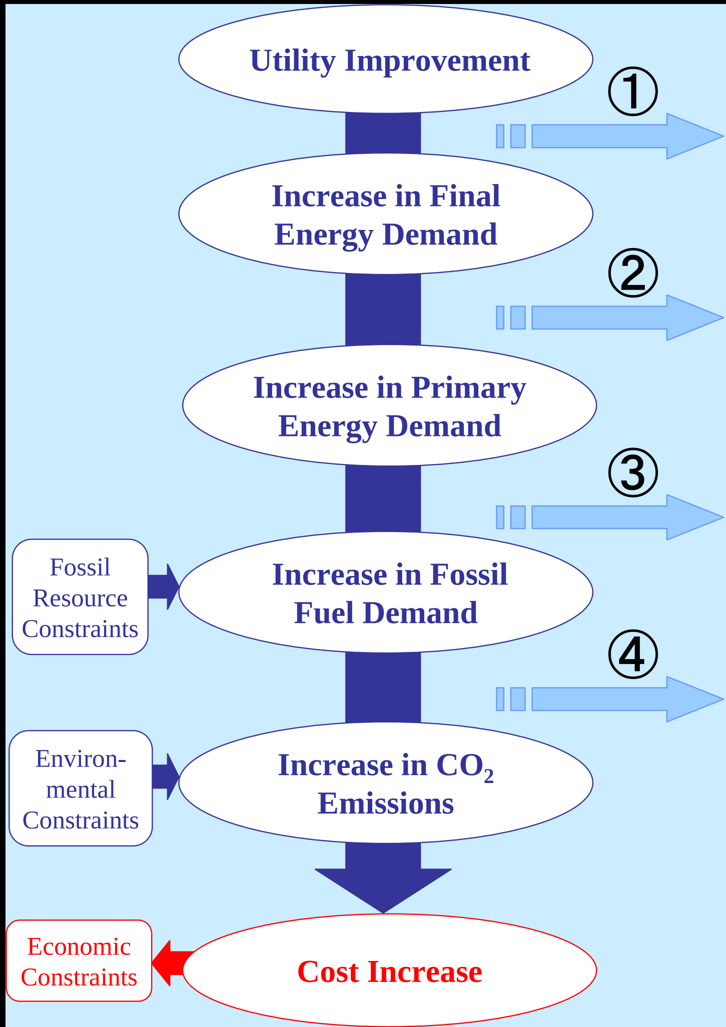
Industry	:	t-C/production volume	=	t-C/MJ	×	MJ/production volume
Commercial	:	t-C/floor space	=	t-C/MJ	×	MJ/floor space
Residential	:	t-C/household	=	t-C/MJ	×	MJ/household
Transport	:	t-C/distance	=	t-C/MJ	×	MJ/distance
(*Transformation sector*: t-C/MJ)				Conversion efficiency		Single unit and equipment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

Three Extreme Cases and Possible Pathway to Achieve the Goal



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

Basic Approach to Achieve the Desirable Future



① Cut off the chain between "utility" and "energy demand"

energy saving, efficiency improvement, self-sustaining, and material saving

② Cut off the chain between "final energy demand" and "primary energy demand"

improvement of energy conversion efficiency

③ Cut off the chain between "primary energy demand" and "fossil fuel demand"

Fuel switching to non-fossil

④ Cut off the chain between "fossil fuel demand and CO_2 emissions"

CO_2 capture and sequestration

Sketch of Technology Spec. 2100

Extreme Case-A (Fossil + CCS)

Effective use of fossil resources together with carbon capture and sequestration

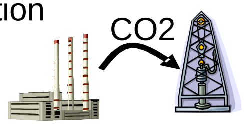
- ***Case A assumes a situation where we cannot heavily rely on energy saving.***
- ***The growing ratios of electricity and hydrogen in composition are considered.***

**Value is compared to that in 2000*

[Target in the Transformation Sector]

(1)Production of Electric Power and Hydrogen
Eight times* the current total amount of power generation

Fossil Fuel



CO2

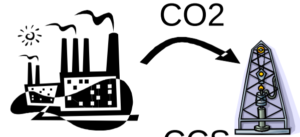
CO2 Capture and Sequestration (CCS)

Supplying by coal thermal power with CCS

Electric power and/or Hydrogen

[Target in the Industrial Sector]

(1) Over 80% of fossil fuel consumption to be put to CCS process



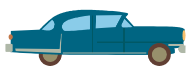
CO2

CCS

(2) Over 65% of sector's energy to be supplied with electric power and/or hydrogen from the conversion sector

[Target in the Transport and Res/Com Sectors]

(1)100% of energy demand is supplied with electric power and/or hydrogen



Transport

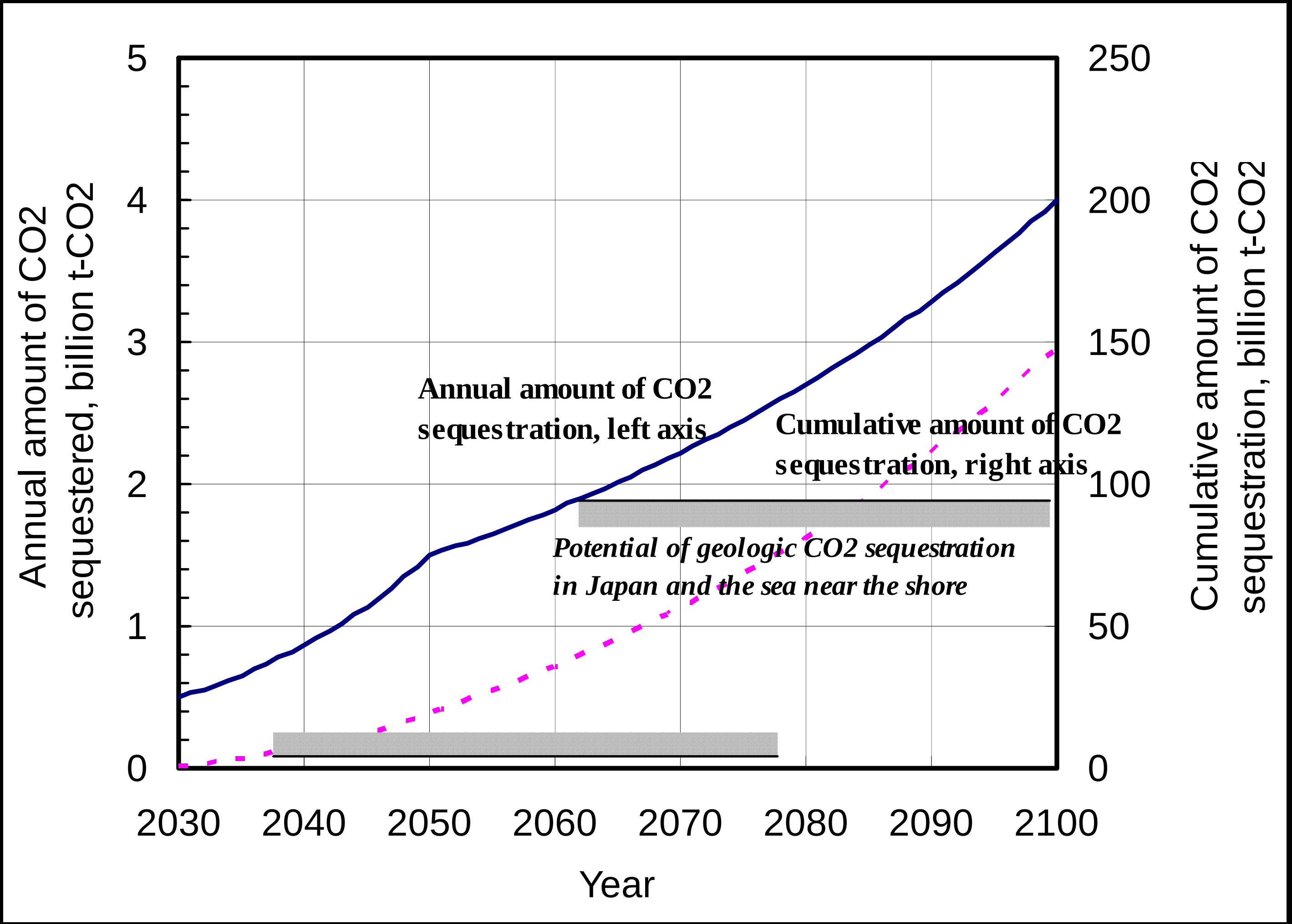
Res/Com (Residential)

Res/Com (Commercial)

The total amount of CO_2 sequestration in conversion and industrial sectors is approximately 4.0 billion t-CO_2/year.

Additional energy required for the CCS process is not included.

CCS Activities under Case-A and Geological Sequestration Potential



Sketch of Technology Spec. 2100

Extreme Case-B (Nuclear)

Effective use of nuclear power (with fuel cycle establishment)

- Case B assumes a situation where we cannot heavily rely on energy saving.
- The growing ratios of electricity and hydrogen in composition are considered.

**Value is compared to that in 2000*

[Target in the Transformation Sector]

(1) Production of Electric Power and Hydrogen

Eight times* the current total amount of power generation

Nuclear Power

Supplying by nuclear power

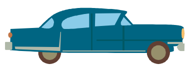
Electric power and/or Hydrogen

[Target in the Industrial Sector]

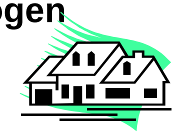
(1)All demand is supplied with electric power and/or hydrogen with the exception of feedstocks and reductants

[Target in the Transport and Res/Com Sectors]

(1)100% of energy demand is supplied with electric power and/or hydrogen



Transport



Res/Com (Residentila)

Res/Com (Commercial)

Sketch of Technology Spec. 2100

Extreme Case-C (Renewable + Ultimate Energy Saving)

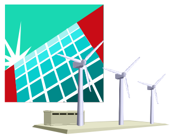
Maximum use of renewable energy sources combined with ultimate energy saving

** Value is comparedto that in 2000*
*** Per unit utility*

[Target in the Transformation Sector]

(1) Production of Electric Power and Hydrogen

Twice* as much as the amount of the current total power generation




Renewable Energies

Supplying by renewable energies

Electric Power, Hydrogen and/or Biomass

[Target in the Industrial Sector]

Energy demand to be reduced by 70%**

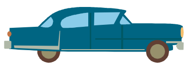
(1) 50% of the production energy intensity is reduced.

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

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

[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%

Res/Com (Residential)

Res/Com (Commercial)

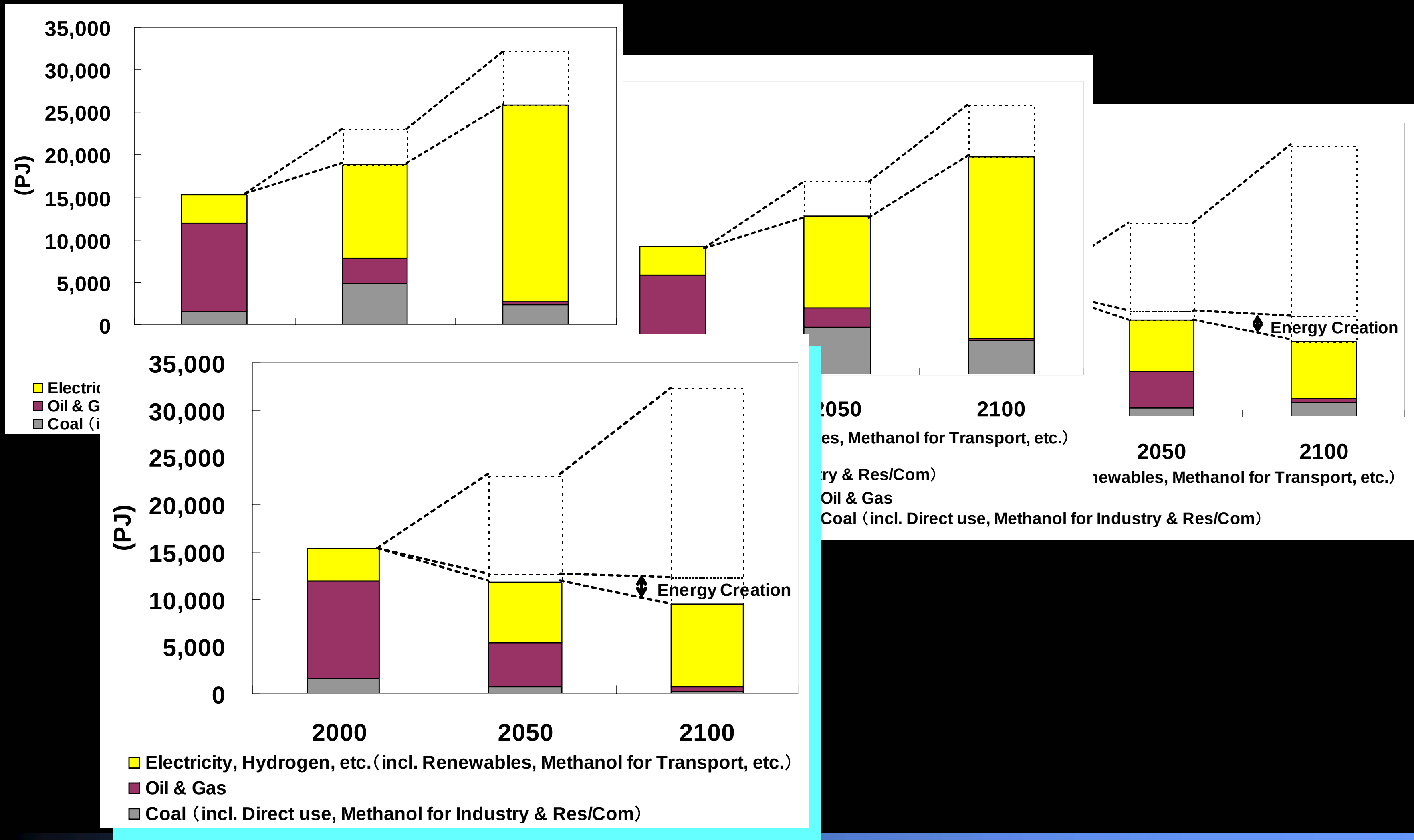
Significance of CCS in Case A
(Fossil + CCS)

- … while it can reduce CO_2 emission generated from use of non-conventional fossil resources significantly, it is merely a **transitional solution** … However, this has an immediate effect, and can be regarded as an emergency measure.
- Potential of CO_2 sequestration is supposed to be high worldwide. On the other hand, there **may be a limitation for geological sequestration potential** in Japan. However, if **ocean sequestration** is realized, the potential in Japan becomes larger.

Sector Specific Considerations on CCS

- Transport
  - If we try to make CO_2 emissions zero in the transport sector, we have to supply energy to vehicles in the form of electricity or hydrogen which are supplied by nuclear power, renewables, or fossil fuels with CO_2 capture and sequestration.
- Industry
  - The process and scale in this sector enables CO_2 capture and sequestration if required when using fossil resources.

Scenario Analysis on Extreme Cases and Mix Case



Possible Solution with the Combination of Three Cases (1/2)

- ... **capacity for geological sequestration** is considered to have limitations. We have to consider ocean sequestration to satisfy the required capacity ...
- Case A (fossil + CCS) cannot be a long-term solution due to the limitation of fossil resources. Therefore, the combination of case C (renewable + energy-saving) and case B (nuclear) is desirable ... on a long-term basis, by **avoiding rapid climate change by CCS as required on a mid-term basis**.

Possible Solution with the Combination of Three Cases (2/2)

- ... combination of these cases can vary according to situations in the future. It is important to prepare technologies through R&D for social and economic changes at various occasions in the future.
- As a result, we can acquire an optimal and robust energy system structure...
- Also, if we prepare for the three extreme cases ..., their synergy effect enables the reduction of fossil resources consumption and CO_2 emissions...

Ongoing and Future Tasks

- To coordinate with domestic activities on short- & mid-term energy strategy
  - Development of roadmaps based on forecasting approach
  - Prioritization on energy R&D (incl. CCS) in Council for Science and Technology Policy
  - Development of National Energy Policy
  - Revision of energy related action plans
- To coordinate with international activities

Related International Activities

- International Energy Agency
  - Energy Outlook 2006
  - Energy Technology Perspective
  - Response to Gleneagles Action Plan
    - Suggesting cooperation of IEA and CSLF
- Asia-Pacific Partnership for Clean Development and Climate
    - Work Plan includes collaboration on CCS

Scenario Study on the Vision

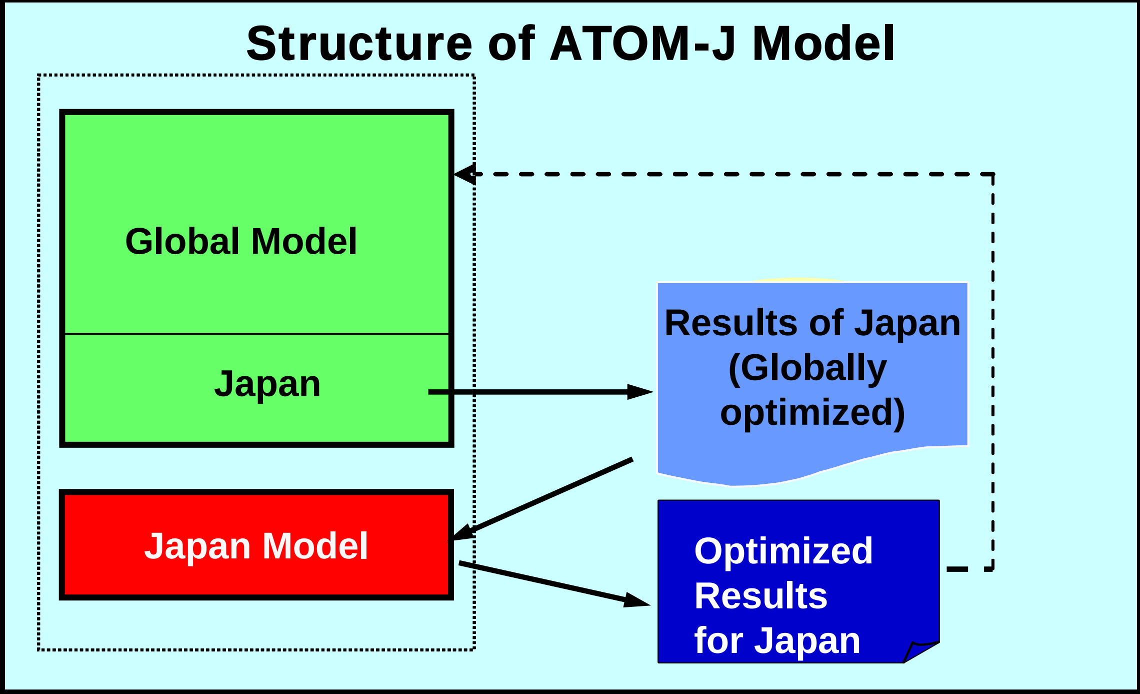
Energy Scenario of Japan

based on Energy Technology Vision 2100

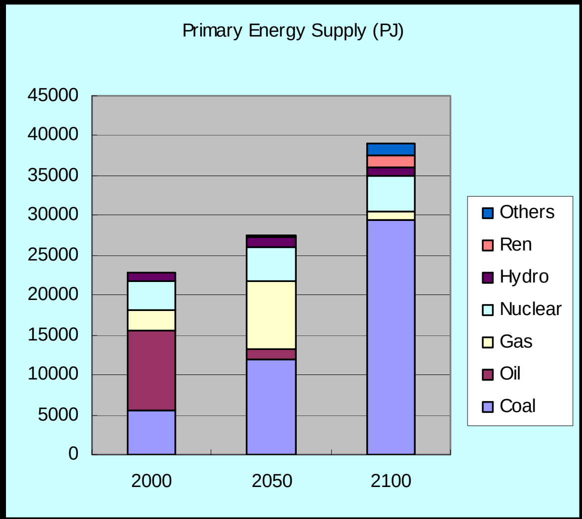
- Case Study by an Energy Model "ATOM-J" developed by Akai.

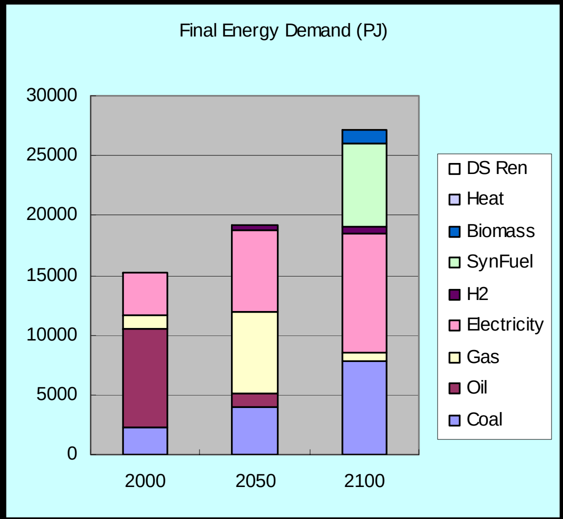
ATOM-J Model

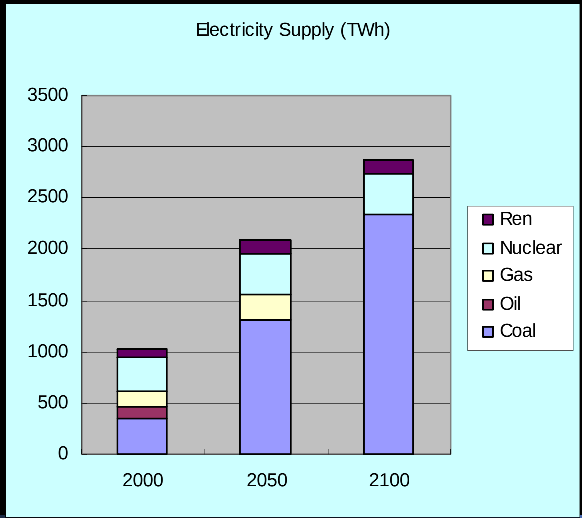
- Optimized LP
- Term：1990-2100
- 18 world regions
- Demand Sectors
  - Industry
  - Household
  - Service
  - Transport

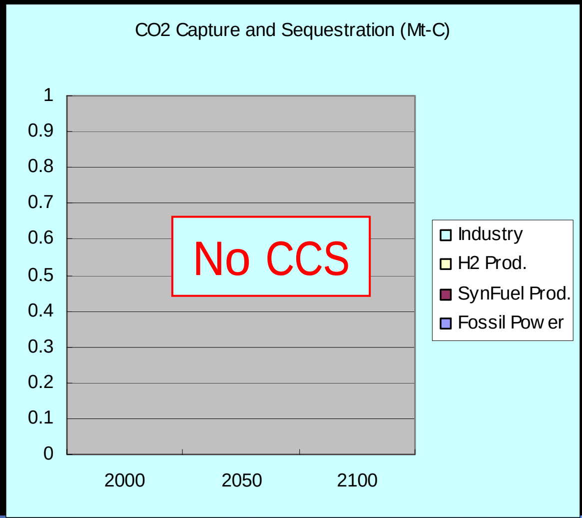


Energy Scenario of Japan
BAU defined in the ETV 2100

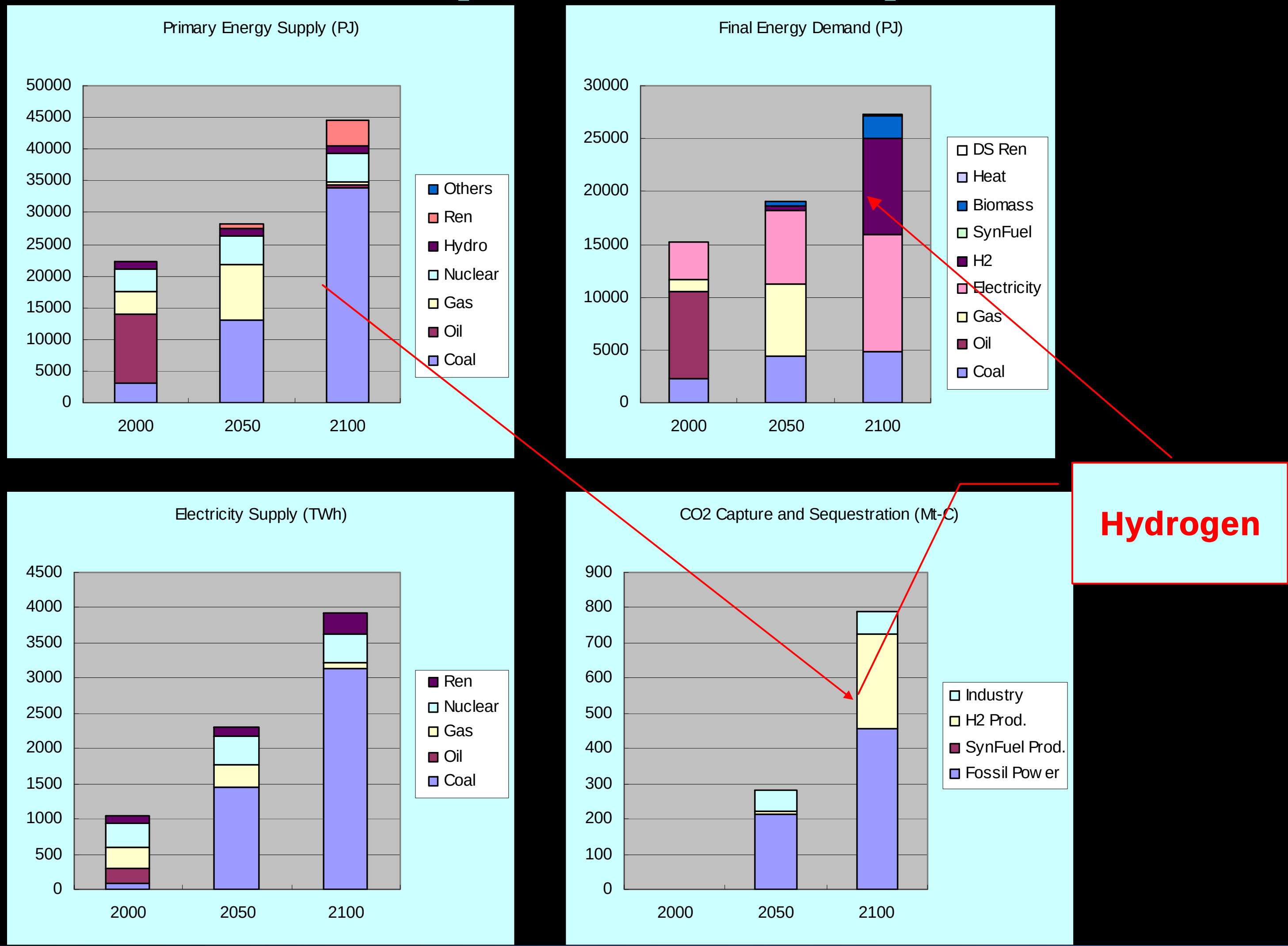






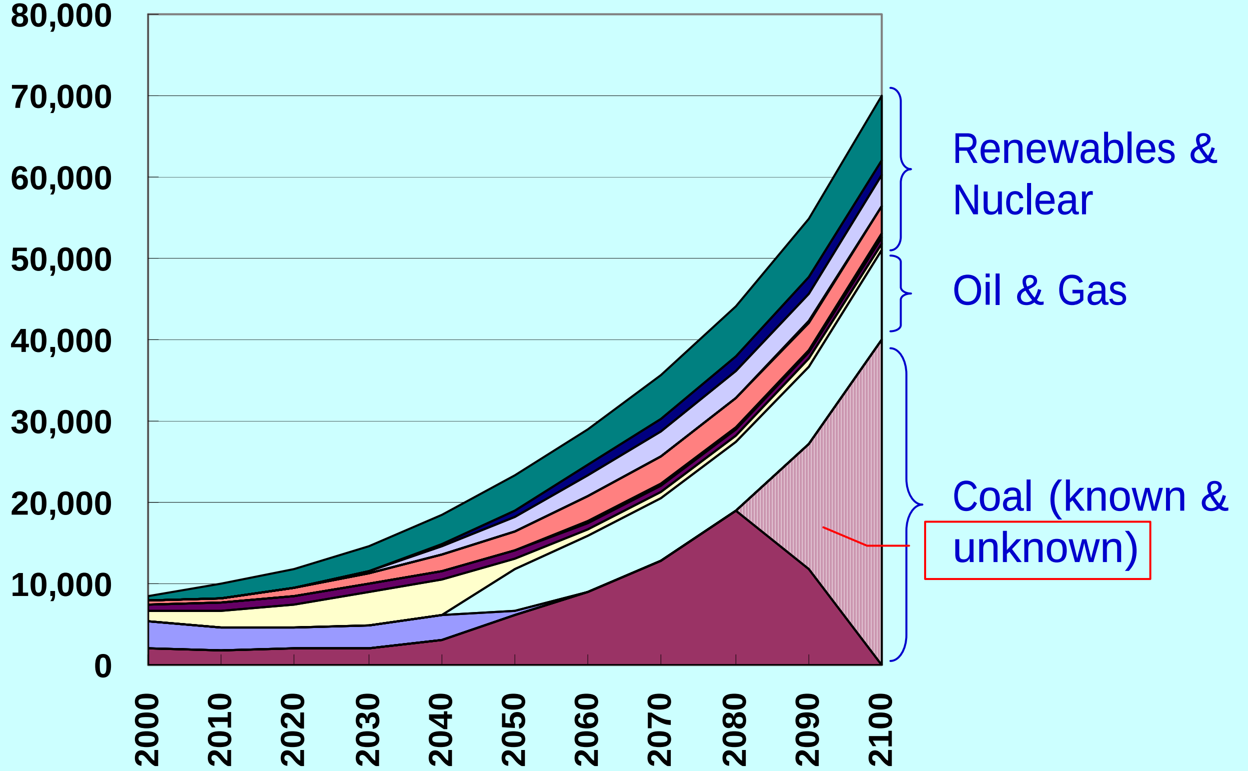


Energy Scenario of Japan
≈ Case-A (Fossil + CCS)

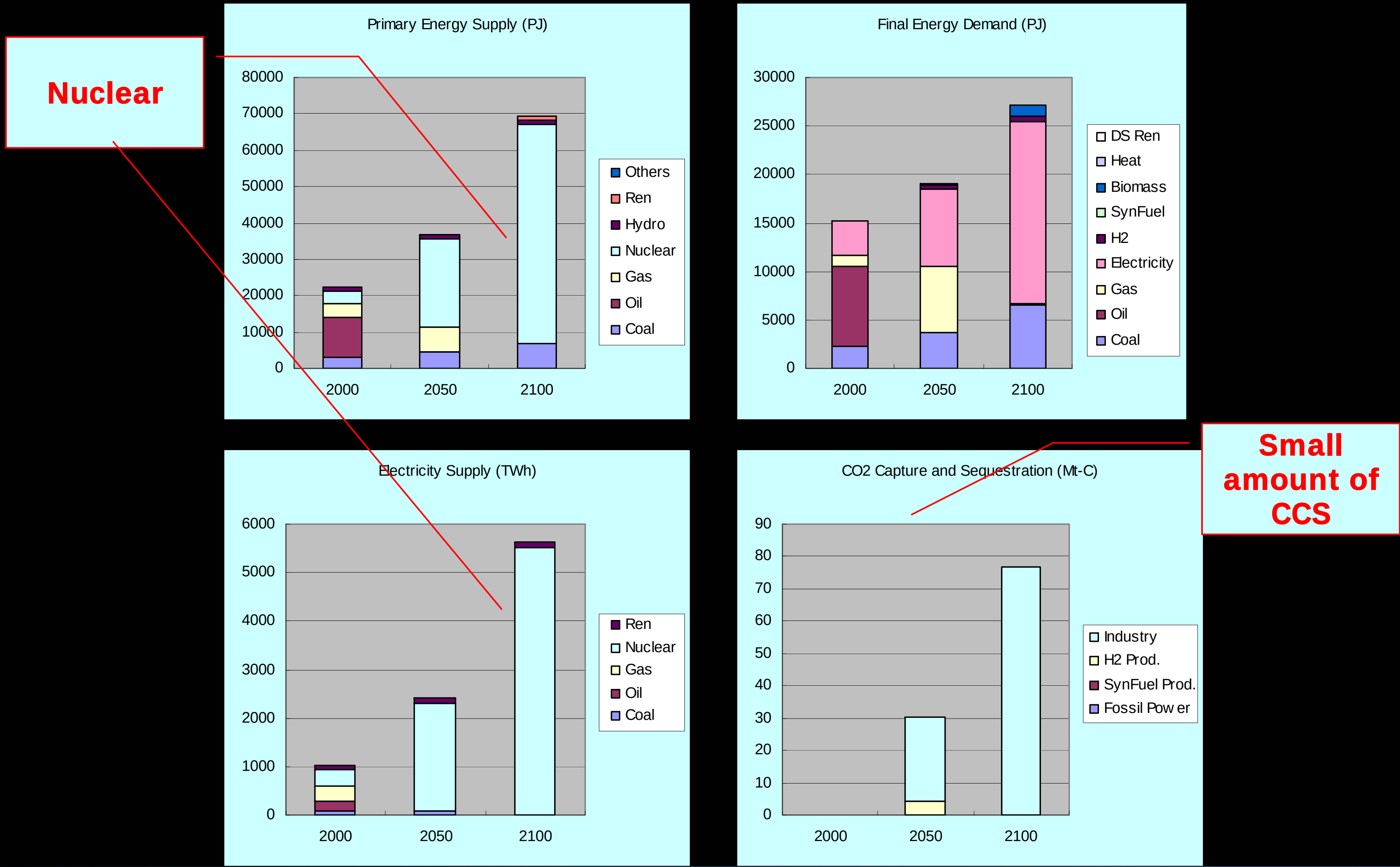


Hydrogen Society with CCS is NOT a Sustainable Option

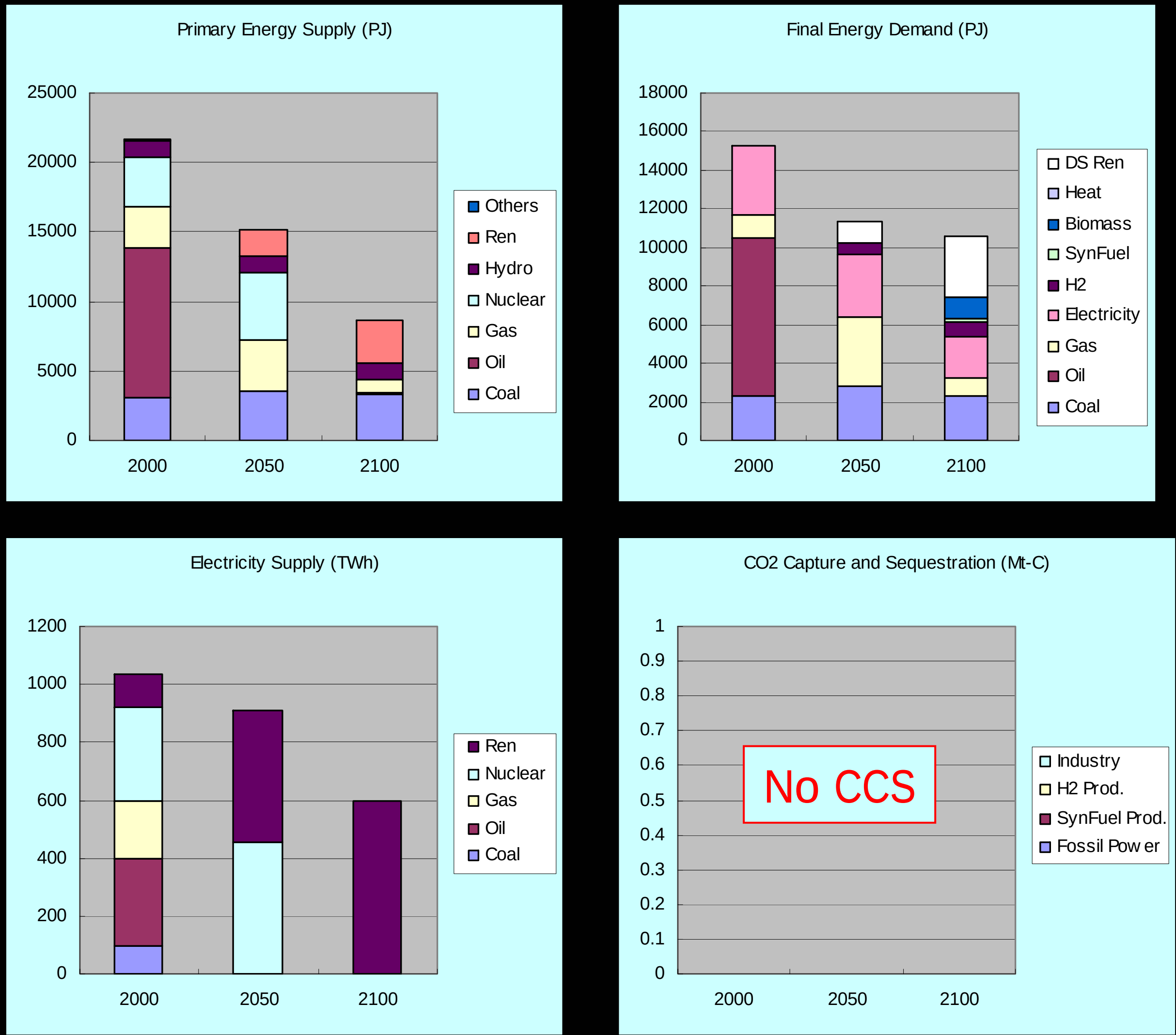
World's Primary Energy Supply (MTOE)



Energy Scenario of Japan
≈ Case-B (Nuclear)

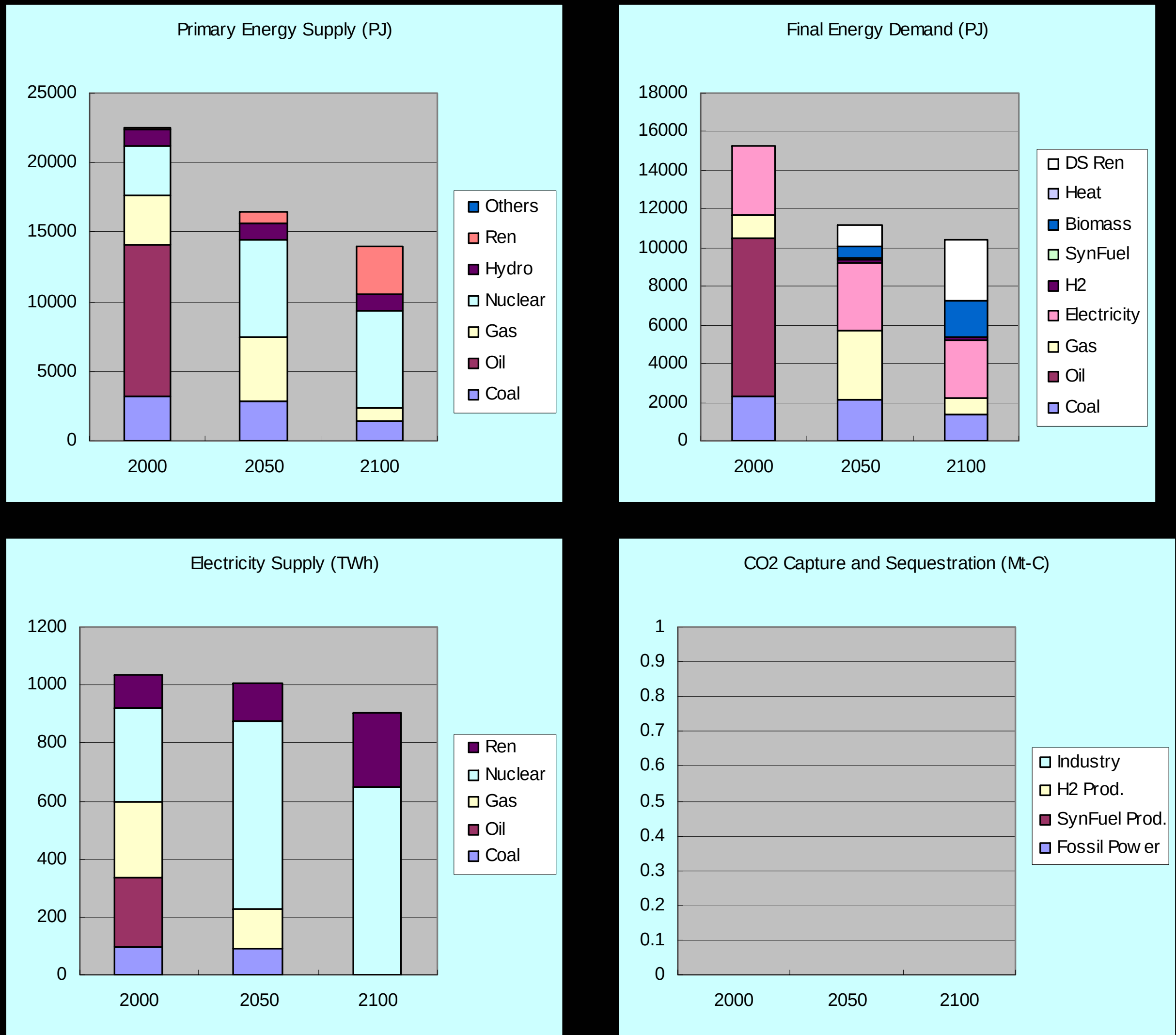


Energy Scenario of Japan
≈ Case-C (Renewable)



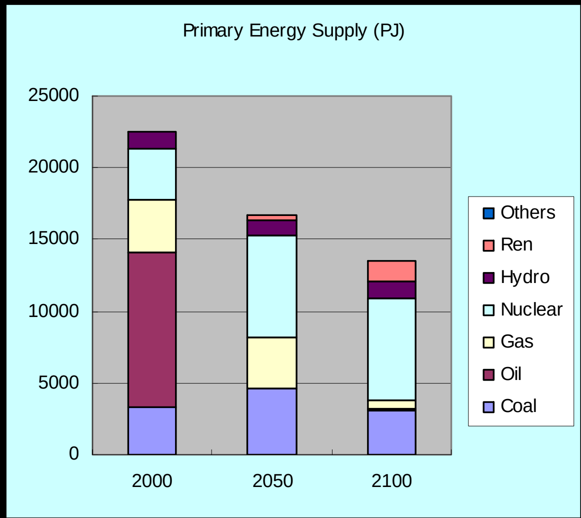
Energy Scenario of Japan

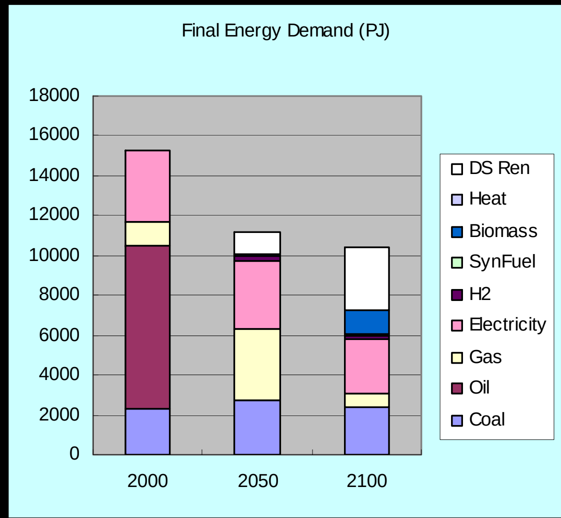
≈ Mix (Moderate limit for Nuc. + Case-C; w/o. CCS)

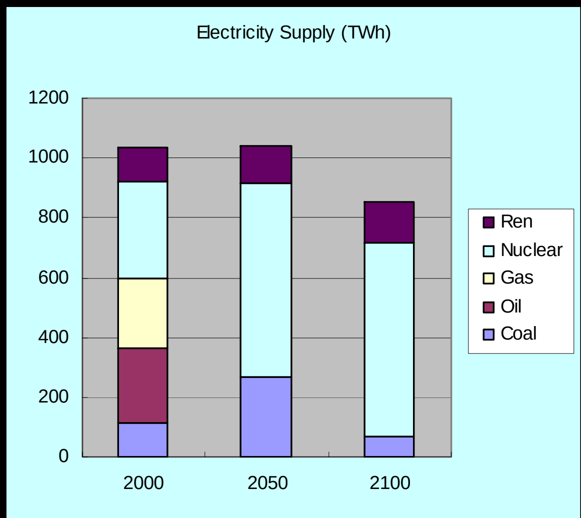


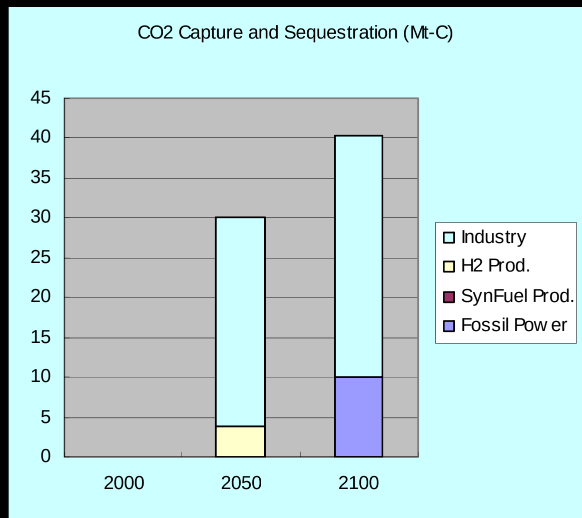
Energy Scenario of Japan

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









Implications from Scenario Study

- Case-A "Fossil + CCS" would contribute to hydrogen economy but not be a sustainable option from the viewpoint of resource depletion.
- Nuclear and CCS (especially as a mid-term option) would increase the flexibility of energy supply and demand structure.
- Energy efficiency is the key!

Concluding Remarks

- On-going R&D under METI
- Towards the Future of CCS

Towards the Future of CCS

- Bridging over Science and Society -

- Social acceptance for the technology

⇑

- Conformity with regulations
  - London Convention, OSPAR, Domestic Laws, etc.
  - Action for amendment, if necessary
- Definite recognition by IPCC and UNFCCC
- Better communication
  - Audience: general public, scientists, industries, policy makers, NGOs, etc.

⇑

- Accumulation of scientific knowledge

CCS R&D Projects under METI

- **Ocean Sequestration**

  (Environmental Assessment for CO_2 Ocean Sequestration)

  - **1997 - 2001 (Phase-1)**
  - **2002 - 2006 (Phase-2)**

- **Geological Sequestration**
  - **2000 - 2004 (Phase-1)**
  - **2005 - (Phase-2)**

- **ECBM**
  - **2002 - 2006 (Phase-1)**

Other CCS Research under METI

- Accounting Rules on CO_2 Sequestration for National GHG Inventories [ARCS] (2002 -)
  - Development of accounting methodology
  - Contribution to NGGIP
  - Policy studies including CCS-CDM
- Environmental Impact and Safety Management based on Natural Analogue (2005 -)
- Methodology of Applicability of CCS to Kyoto Mechanism including CDM (2004 -)
- Public Perception on CCS (2002 -)
  - Cooperation with AGS Project

Strategic Action Plan on Putting CO_2 Sequestration on the Viable Policy Agenda

- Establish a epistemic community
  - Forums by the stakeholders/policy makers
- Establish validation methodologies of emissions reduction
  - Analysis/assessment of existing scientific works on the technologies
  - Evaluation of the effectiveness, provision for monitoring requirements, etc.
- Establish communication strategy
  - Audience includes general public, scientists, industries, policy makers, etc.

98.01; 00.10: M. Akai to USDOE – MITI Meeting

Thank you!