

HOW DO YOU DO?

Makoto Akai

National Institute of
Advanced Industrial Science and Technology (AIST)

- **Background: Nuclear Engineering**
- **Research Area:**
 - Two Phase Flow Dynamics; MHD; etc.
 - CO₂ Sequestration; H₂ Energy System
 - Technology Assessment
 - Energy Modeling; Life Cycle Assessment; Externality
 - Public Communication
- **Other Activities:**
 - R&D Projects under METI
 - International Collaboration
 - IEA: Technology Assessment; Hydrogen Agreement;
 - GHG Programme
 - Bilateral and Multilateral Projects

M. Akai, AIST

Environmental Technology and Policy Making

Revised Lecture Plan

- **Overview (June 7)**
 - Background
 - The Road to Kyoto and Beyond
 - Toward Deep Reduction of GHGs
- **Environmental Policy in Japan (June 21)**
 - Including R&D policy
- **Global Challenge towards Climate Change & Recent Topics (July 12)**

M. Akai, AIST

Background

Recent Findings on Climate Change

M. Akai, AIST

IPCC TAR Suggestions

WG1: Scientific Basis-SPM



- An increasing body of observations gives a collective picture of a **warming world** and other changes in the climate system,
- There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to **human activities**,
- Human influences **will continue** to change atmospheric composition throughout the 21st century.

M. Akai, AIST

IPCC TAR Recommendations

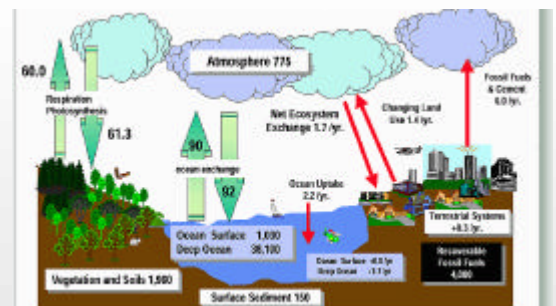
WG3: Mitigation-SPM



- **Earlier actions**, including a portfolio of emissions mitigation, technology development and reduction of scientific uncertainty, **increase flexibility** in moving towards stabilization of atmospheric concentrations of greenhouse gases,
- **Rapid near-term action would decrease** environmental and human risks associated with rapid climatic changes.

M. Akai, AIST

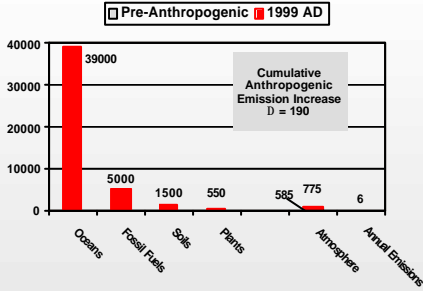
Global Carbon Cycle



Carbon Fluxes in Gt/yr

M. Akai, AIST

Carbon Reserves and Flows (GtC = 10⁹ Tonnes C)



M. Akai, AIST

7

The Road to Kyoto

M. Akai, AIST

8

History of Global Warming (1/2)

1827	French mathematician Jean-Baptiste Fourier suggests the existence of an atmospheric mechanism keeping the Earth warmer than it would otherwise be. He likens it to a greenhouse.
1863	Irish scientist John Tyndall publishes a paper describing how atmospheric water vapor could contribute to this mechanism.
1890s	Swedish scientist Svante Arrhenius and American P.C. Chamberlain independently investigate the potential problems that could be caused by carbon dioxide (CO ₂) building up in the atmosphere. They both suggest that burning fossil fuels could lead to global warming, but neither suspect the process might already have started.
1890s - 1940	Average surface air temperatures increase by about 0.25 C. Some scientists see the American Dust Bowl (a devastating, persistent drought in the 1930s) as a sign of the greenhouse effect at work
1940 - 1970	Global temperatures cool by 0.2 C. Scientific interest in global warming declines. Some climatologists predict a new ice age.

M. Akai, AIST

9

History of Global Warming (2/2)

1957	U.S. oceanographer Roger Revelle warns that people are conducting a "large-scale geophysical experiment" on the planet by releasing greenhouse gases. Colleague David Keeling establishes the first continuous monitoring of atmospheric CO ₂ . He rapidly confirms a regular year-on-year rise.
1970s	A series of studies by the U.S. Department of Energy increases concerns about possible long-term effects of global warming.
1979	First World Climate Conference adopts climate change as major issue and calls on governments "to foresee and prevent potential man-made changes in climate".
1985	First major international conference on global warming in Villach (Austria) warns that average global temperatures in the first half of the 21 st century could rise significantly more than at any other time in human history. Warmest year on record. The 1980s is the warmest decade on record, with seven of the eight warmest years of the century.
1987	Global temperatures cool by 0.2 C. Scientific interest in global warming declines. Some climatologists predict a new ice age.

M. Akai, AIST

10

Road to Kyoto

1988	<ul style="list-style-type: none"> • Heat wave in U.S. granary • Testimony by Dr. Hansen • Toronto Conference • Establishment of IPCC
1990	• IPCC First Assessment Report
1992	• Earth Summit → UNFCCC
1995	<ul style="list-style-type: none"> • COP-1 (Berlin) → Berlin Mandate • IPCC Second Assessment Report
1996	• COP-2 (Geneva)
1997	• COP-3 (Kyoto) → Kyoto Protocol

M. Akai, AIST

11


1988 - Year of Breaking Out

- Dr. Hansen testified before the U.S. Senate
 - 99 percent sure ... the greenhouse effect has been detected and it is changing our climate now.
- *World Conference on the Changing Atmosphere: Implications for Global Security (Toronto)* called for 20 % cuts in global CO₂ emissions by the year 2005
- WMO and UNEP established the Intergovernmental Panel on Climate Change (IPCC).

M. Akai, AIST

12

Road to Kyoto

1988	<ul style="list-style-type: none"> • Heat wave in U.S. granary • Testimony by Dr. Hansen • Toronto Conference • Establishment of IPCC
1990	• IPCC First Assessment Report
1992	• Earth Summit ⊃ UNFCCC 
1995	<ul style="list-style-type: none"> • COP-1 (Berlin) ⊃ Berlin Mandate • IPCC Second Assessment Report
1996	• COP-2 (Geneva)
1997	• COP-3 (Kyoto) ⊃ Kyoto Protocol

M. Akai, AIST

13

Earth Summit

UN Conf. on Environment and Development

- The centerpiece was the ratification of the UNFCCC and was signed by 154 nations.
- UNFCCC does not contain binding targets for GHG emission reductions, but recognizes the importance of reducing GHG emissions in order to prevent “**dangerous interference**” with the climate system.

M. Akai, AIST

14


UNFCCC

- Sets an initial target for industrialized countries to reduce their GHG emission to 1990 levels by the year 2000.
- Demanded each industrialized nation to submit national communication on GHG emission inventory, and to provide financial and technical assistance to developing countries for the reporting.
- Came into force on 21 March 1994.

M. Akai, AIST

15

Road to Kyoto

1988	<ul style="list-style-type: none"> • Heat wave in U.S. granary • Testimony by Dr. Hansen • Toronto Conference • Establishment of IPCC
1990	• IPCC First Assessment Report
1992	• Earth Summit ⊃ UNFCCC
1995	<ul style="list-style-type: none"> • COP-1 (Berlin) ⊃ Berlin Mandate • IPCC Second Assessment Report 
1996	• COP-2 (Geneva)
1997	• COP-3 (Kyoto) ⊃ Kyoto Protocol

M. Akai, AIST

16

COP-1


Conference of the Parties on its First Session

- **Berlin Mandate**
 - To initiate a process to enable Governments to take appropriate action for the period beyond 2000, including a strengthening of developed country commitments.
 - The work should be completed as early as possible so that the results can be adopted at COP-3 in 1997.
 - Developing countries are explicitly exempted from these new commitments.

M. Akai, AIST

17

Road to Kyoto

1988	<ul style="list-style-type: none"> • Heat wave in U.S. granary • Testimony by Dr. Hansen • Toronto Conference • Establishment of IPCC
1990	• IPCC First Assessment Report
1992	• Earth Summit ⊃ UNFCCC
1995	<ul style="list-style-type: none"> • COP-1 (Berlin) ⊃ Berlin Mandate • IPCC Second Assessment Report
1996	• COP-2 (Geneva)
1997	• COP-3 (Kyoto) ⊃ Kyoto Protocol 

M. Akai, AIST

18

Kyoto Protocol to the UNFCCC

- 38 developed countries agreed to reduce their emissions of six GHGs by a total of 5.2% between 2008 and 2012 from 1990 levels
 - CO₂, CH₄, N₂O, HFCs, PFCs, SF₆
- Party quantified emission limitation or reduction commitment include (% reduction):
 - Austria (8); Canada (6); Japan (6); Romania (8); Russian Federation (0); Switzerland (8); USA (7); UK (8);

19

M. Akai, AIST

Kyoto Mechanisms

- Kyoto Protocol provided the basis for **mechanisms** to assist Annex I Parties in meeting their targets cost effectively, i.e.
 - Emissions trading system,
 - Joint implementation (JI) of emissions reduction projects between Annex I Parties,
 - Clean Development Mechanism (CDM) to encourage joint projects between Annex I and non-Annex I Parties. However,
 - It was left for subsequent meetings to decide on most of the rules and operational details that will determine how these cuts in emissions are achieved, measured and assessed.

20

M. Akai, AIST

Towards Effectuation of Kyoto Protocol

- In order for the Kyoto Protocol to enter into force, it must be ratified by 55 Parties to the UNFCCC, including Annex I Parties representing at least 55% of the total carbon dioxide emissions for 1990.

21

M. Akai, AIST

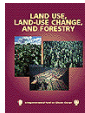
Continued Negotiations

- Carbon sink --- **What is Kyoto Forest?**
 - Land Use, Land Use Change and Forestry (LULUCF)
- Rules and operational details of Kyoto Mechanisms
- Involvement of and assistance to developing countries
- Compliance, etc.

22

M. Akai, AIST

IPCC Special Report on LULUCF - SPM -



1. Introduction
2. Global Carbon Cycle Overview
3. Issues Associated with Definitions
 - 3.1. Forests, Afforestation, Reforestation, and Deforestation
 - 3.2. Additional Activities
4. Carbon Accounting
5. Methods for Measuring and Monitoring
6. Estimates of Average Annual Carbon Stock Changes /Accounted for ARD Activities and Some Additional Activities
 - 6.1. Afforestation, Reforestation, and Deforestation
 - 6.2. Additional Activities
7. Project-Based Activities

23

M. Akai, AIST

After Kyoto

1998	• COP-4 (Buenos Aires) • The warmest year in the warmest decade of the warmest century of the millennium.
1999	• COP-5 (Bonn)
2000	• COP-6 (The Hague)
2001	• COP-6 Part II (Bonn) • COP-7 (Marrakesh) • IPCC Third Assessment Report
2002	• COP-8 (New Delhi, Oct 23-Nov 1) • Rio + 10: World Summit on Sustainable Development (Johannesburg, Sep 2-11)

24

M. Akai, AIST

Japan's Domestic Approach *Government*

25

M. Akai, AIST

Guidelines of Measures to Prevent Global Warming

June 19, 1998

- Decision by “Global Warming Prevention Headquarters” chaired by Prime Minister
- Establish the basic policy to meet with the Kyoto Protocol

26

M. Akai, AIST

The Guidelines *Energy Related Reductions*

- In order to achieve a 6% reduction targets stated in the Kyoto Protocol:
 - Regarding CO₂, CH₄ and N₂O emissions, a 2.5% reduction will be achieved through steadfastly promoting measures relating to both energy supply and demand focusing on promoting **energy saving**, introduction of **new energy** and the construction of **nuclear power** plants with rigid nuclear safety measures, introducing **innovative technologies**, and accelerating the efforts of each social actor.

27

M. Akai, AIST

The Guidelines - Summary - *GHG reduction target of Japan for 2010*

-2.5%	Emission reduction of CO ₂ , CH ₄ , N ₂ O ±0%: Energy related CO ₂ -0.5%: CH ₄ and N ₂ O -2.0%: R&D and introduction of innovative technologies, and effort of each citizen
+2.0%	CFC alternatives, etc. (HFC, PFC and SF6)
-3.7%	Sinks of Japan's forests
-1.8%	The balance: utilization of international mechanisms

28

M. Akai, AIST

Reinforcement of Existing Law *- Top Runner Approach -*

- Introduced as part of a package to further strengthen the Law Concerning the Rational Use of Energy.
- Promotes energy efficiency in consumer products, by setting a product of the **highest energy efficiency** as a standard in its product category, e.g. television, and establishing that as a goal for industry to come up with.

29

M. Akai, AIST

Statement by Global Warming Prevention Headquarters after COP-7

- Japanese Government has decided to take the necessary measures and actions in order to ratify the Kyoto Protocol in FY 2002.

30

M. Akai, AIST

R&D Program by METI

- New R&D programs from FY 2002
 - *R&D Program for Innovative Technologies to Prevent Global Warming* which includes 21 specific projects for the technologies that have a certain level of contribution in GHG reduction by 2010, and,
 - *R&D Program for CO₂ Fixation and Utilization* which deals with mid- and longer term technologies, including CO₂ sequestration technologies.

31

M. Akai, AIST

Industry

Voluntary Action by KEIDANREN

32

M. Akai, AIST

Keidanren

Japan Federation of Economic Organizations

- Keidanren was established in 1946 as a nationwide business association.
- The membership includes more than 1,000 of Japan's leading corporations, as well as more than 100 industry-wide groups:
 - manufacturing, trade, distribution, finance, and energy, etc.

33

M. Akai, AIST

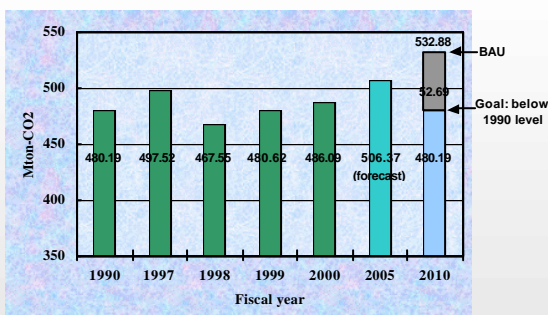
Keidanren Voluntary Action Plan

- In 1991, as part of its *Global Environment Charter*, Keidanren committed to seek positive and voluntary methods for promoting environmental conservation.
- By recognizing the importance of reducing CO₂ emission from the industrial sector, the member have agreed upon continued drafting voluntary action plans when possible and reviewing those periodically.

34

M. Akai, AIST

CO₂ Emissions by 36 Industries in the Industrial and Energy Sectors



35

The results of fourth follow-up study M. Akai, AIST

Keidanren's statement

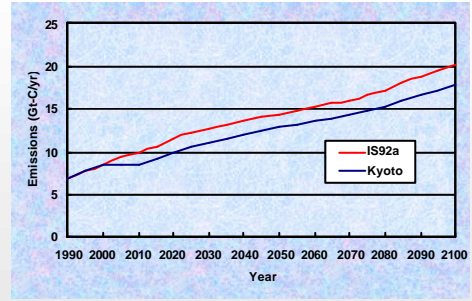
- The Voluntary Action Plan on the Environment is an ongoing process in which efforts are being made each year to expand the number of participating industries and to increase the amount of information that is disclosed;
- Keidanren is also examining an idea to establish a domestic system of third-party certification that would be conducted by the private sectors in order to assure their continued efforts to reduce emissions through the voluntary action plan.

36

M. Akai, AIST

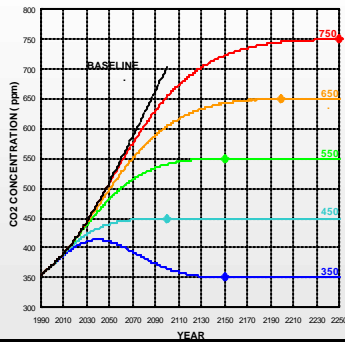
Towards a Deep Reduction

Effect of Kyoto Protocol *It's just an entrance to a sustainable society*



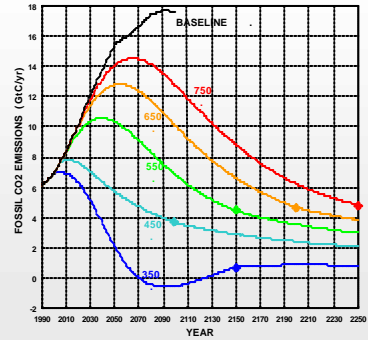
(Pacific Northwest National Laboratory)

CO₂ Stabilization Profiles - Atmospheric Concentration -



M. Akai, AIST

CO₂ Stabilization Profiles - Atmospheric Emissions -



M. Akai, AIST

“Kaya” Equation

$$\text{Net C} = [P \cdot (\text{GDP}/P) \cdot (\text{E}/\text{GDP}) \cdot (\text{C}_a/\text{E})] - S$$

- Net C = Net Carbon Emissions
- P = Population
- GDP = Gross Domestic Product
- E = Total Energy Use
- C_a = Anthropogenic Carbon Emissions
- S = Natural and Induced Sequestration of Carbon

- GDP/P = GDP per Capita ∩ Wealth
- E/GDP = Energy Intensity ∩ Energy Use
- C_a/E = Carbon Intensity ∩ Technology

Technological Options for Deep Reduction of GHG Emissions

- Improvement of energy efficiency
- Switching to lower carbon fuels, e.g. coal to natural gas
- Use of non carbon fuels, e.g. renewables, nuclear
- Enhancement of natural sinks for CO₂, e.g. forestry
- Capture and sequestration of CO₂.

β

- Importance of Technology Assessment

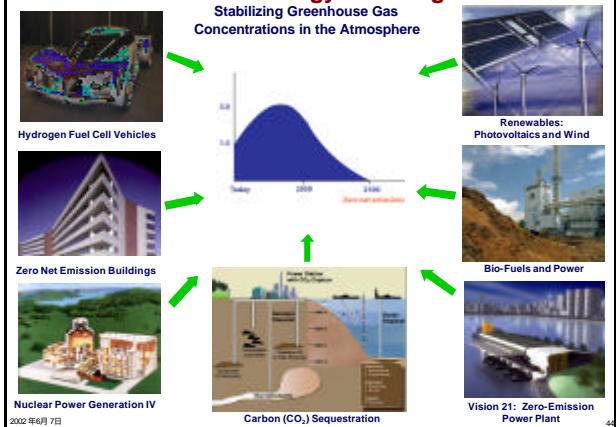
Possible Technology Areas

- **Transforming Energy Supply**
 - Hydrogen
 - Renewable Energy and Distributed Energy Resources
 - Nuclear Energy
 - Fossil Power Generation (ZEPP)
 - Infrastructure of the Electricity Delivery System (Energy Storage)
- **Transforming Energy End-Use**
 - Transportation; Buildings; Industry
- **Capturing and Sequestering GHGs**
 - Geological; Ocean; and Terrestrial Sequestration
- **Reducing non-CO₂ Greenhouse Gas Emissions**
- **Measuring and Monitoring GHG Emissions**
 - Measurement, Monitoring and Verification

43

M. Akai, AIST

The Technology Challenge



Technology Challenge

Target: UNFCCC Stabilization Goal

- **Assess current R&D portfolios and climate change technology**
 - Acknowledge “Core Programs”
 - Identify gaps and opportunities
- **Assess supporting basic research needs**
- **Recommendations to policy makers from scientists:**
 - Regarding Climate Change Portfolios
 - Regarding Supporting Basic Research
 - Regarding Supporting Policy Scenarios

45

M. Akai, AIST

Appraisal of CO₂ Mitigation Technology

Approach

- **Evaluation as a technology**
 - Process evaluation for energy penalty and cost
 - Life cycle aspects of the technology
- **Comparative evaluation of the technology among a resource and technology mix under CO₂ emission constraint**
 - **Energy Model**
- **Decision making**
 - Cost-benefit relationship
 - Externality, etc.

46

M. Akai, AIST

Scenario Study using a Global Energy Network Model

- **Term: 1990 to 2100**
- **Area: Global**
 - 18 world regions considering future energy demand, energy supply potential, geographical condition, etc.
- **Energy technologies include:**
 - Conventional energy technologies (production, transportation, power generation, etc.)
 - Hydrogen energy system
 - Global renewable energy transportation systems.
 - CO₂ mitigation technologies such as capture and sequestration
- **Methodology: Optimization by LP**

47

M. Akai, AIST

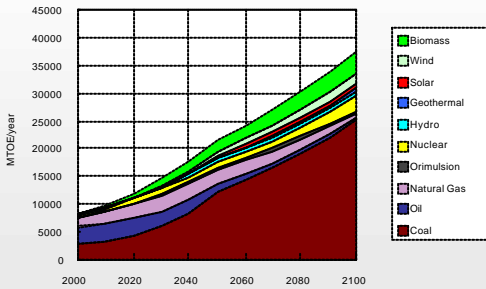
48

M. Akai, AIST

Primary Energy Supply

- 550ppm Stabilization -

Secondary Energy Demand: IS92d

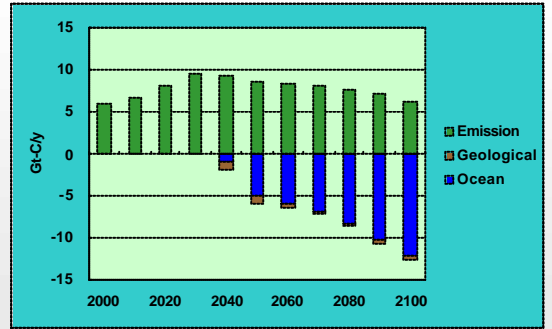


49

M. Akai, AIST

Stabilization and CO₂ Sequestration

- 550ppm Stabilization -



50

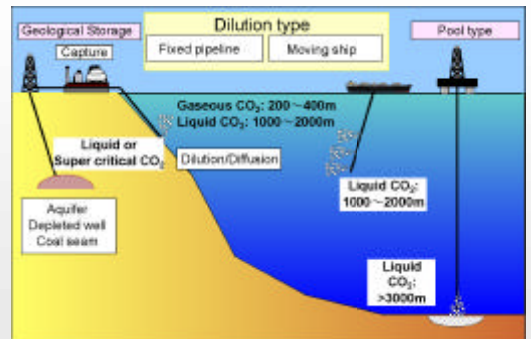
M. Akai, AIST

R&D on CO₂ Sequestration Technologies

51

M. Akai, AIST

Concept of CO₂ sequestration



52

M. Akai, AIST

CO₂ Capture and Sequestration

Bridging Technology?

or

Last Resort?

53

M. Akai, AIST

Questions?

Send e-mail to:

m.akai@aist.go.jp

54

M. Akai, AIST