

Emerging Industrial Technology Strategy Review Board Meeting

Taipei, 11/19-22/2007

**Science & Technology Advisory
Group**



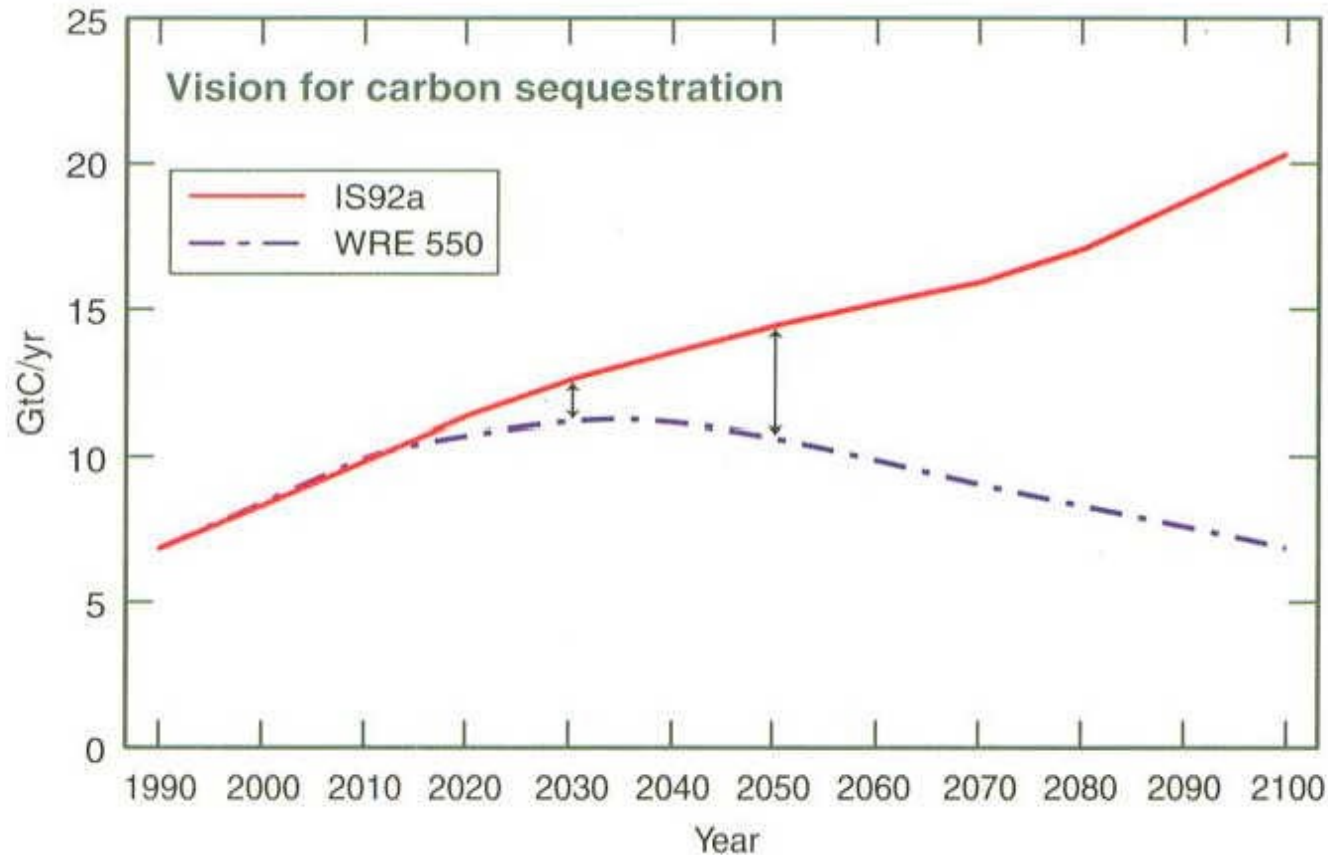
Review Board was asked to consider 3 broad topics:

- 1. Energy Conservation Technologies**
- 2. Renewable Energy Technologies**
- 3. Emerging Energy Technologies**

In addition we considered:

- The basis for these topics**
- The state of development**
- Some overall observations**

DoE 1999 Target for Reduction in CO₂ for 550 ppm Stabilization (WRE550 model projections)



**1999 Reduction/Sequestration
Projection:**

- **3.7 Gt CO₂ by 2025**
- **15 Gt CO₂ by 2050**

A critical role for renewables is already built in to the IPCC projections

IPCC 1990 “Business As Usual” Assumptions

- ***In 100 years renewable and nuclear technologies will provide more than 75% of all electric power, compared to 24% in 1990.***
- ***Non-carbon technologies (including solar and wind) are assumed to grow to about twice the size of the entire global energy system in 1990.***
- ***Energy consumed per unit of economic activity declines to 1/3 of 1990 levels.***
- **These assumptions pose huge technical and societal challenges.**

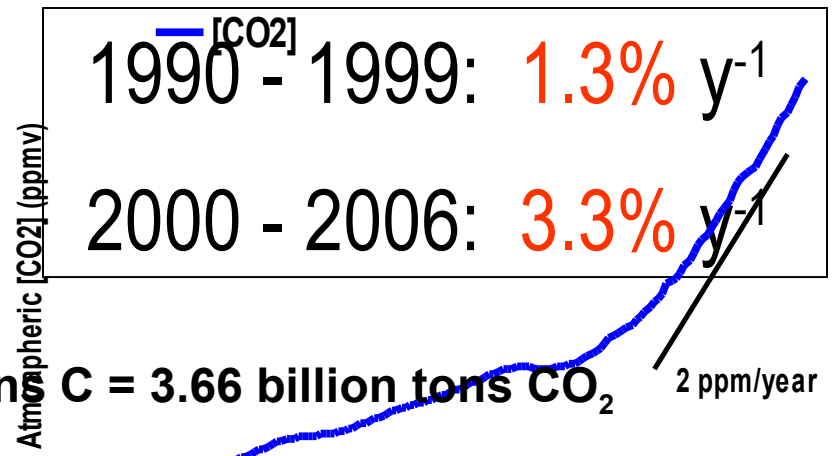
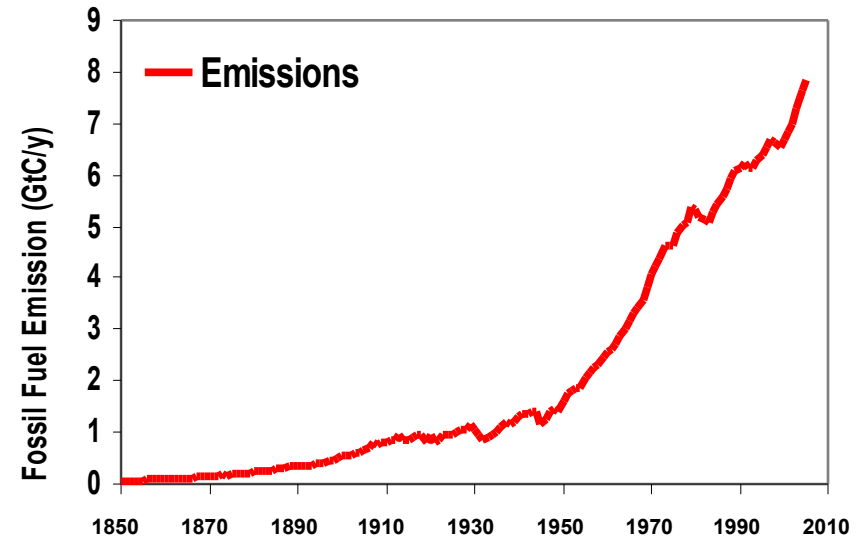
Anthropogenic C Emissions: Fossil Fuel



Raupach et al. 2007, PNAS; Canadell et al 2007, PNAS

2006 Fossil Fuel: 8.4 Pg C

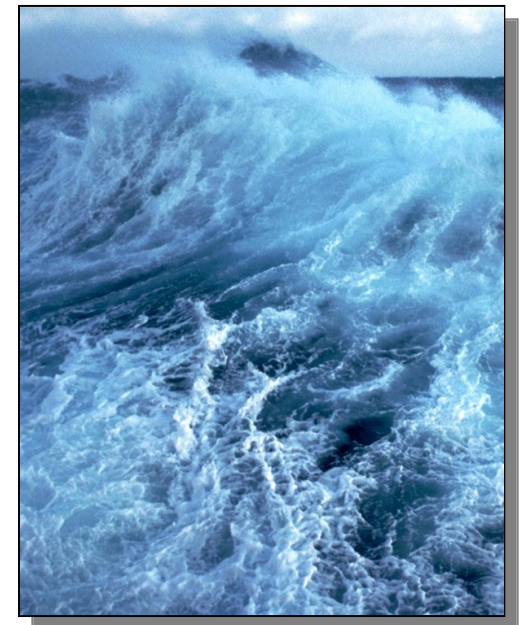
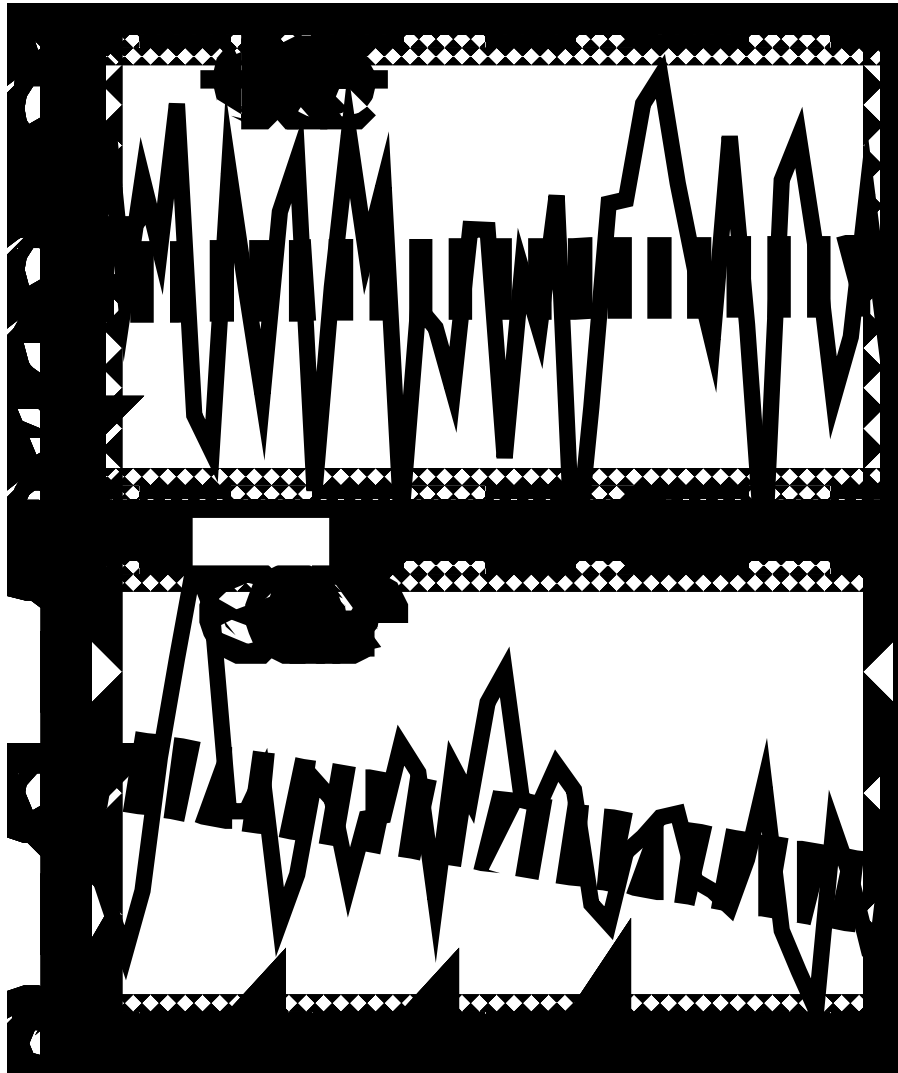
[2006-Total Anthrop. Emissions: 8.4+1.5 = 9.9 Pg]



1 Pg = 10¹⁵g = 1 billion tons C = 3.66 billion tons CO₂

The Efficiency of Natural Sinks: *Land and Ocean Fractions*

Land



Ocean

Energy Conservation Technologies

A. LED lighting and Refrigeration and A/C

- ✓ **Small-size and energy-loading niche** devices that contributing to energy saving and economics.
- ✓ **Excellent knowledge, roadmap, strategic targets and accomplishments.**
- ✓ **Needs of performance quality improvement**, global name recognition and aggressive continued R&D efforts.
- ✓ **Excellent overall progress.**

B. Energy information communication technology

- Important **smart** energy saving **system** applications rooted on the strength of **silicon industry**.
- Developing **monitoring** and sensing devices and **management platform**.
- Needs of aggressive R&D.
- **Excellent potential**.

C. Large Energy Generation Systems (e.g., Power Plants)

- Mostly relying on **imports**, impact on energy saving can be huge if efficiency improved.
- **Partnering and leveraging** with domestic or foreign firms required.

D. Energy Conservation Practice

Government conservation policy needs for citizens or industrial users to conserve energy.

Government introduces:

- modest but escalating energy **efficiency standards** on industry.
- mandated energy efficiency standards or codes for all new **buildings** and considering subsidizing energy efficiency standards in existing buildings.
- setting efficiency standards for **appliances**.
- supporting the development of energy **management technologies** for the export market.

Energy Conservation Practice (cont.)

- providing support for development of technologies such as the organic Rankin cycle to **make use of the waste heat for power generation.**
- carrying out a comprehensive **analysis of the nation energy system** including historic development, scenario analysis using state-of-the-art tools like MARKAL for providing a quantitative (scenario) basis for energy planning including detailed analysis of the technical, economic and implementation potentials for renewables, CCS and energy efficiency improvement.
- **formulating progressive energy efficiency standards for industrial** sectors and possibly implemented through voluntary agreements.

Energy Conservation Practice (cont.)

- improving **material** (e.g. plastics, paper, metals, inert material, etc) **efficiency** by improved recycling, better product design and maximized use of recyclable materials.
- providing indirect **energy savings credits** through a subsidy (eg. equivalent to carbon tax).
- setting ambitious efficiency and **emission standards for vehicles and motorcycles**.
- considering **nuclear energy as an option** in the nation's overall energy strategy.

E. Investment on Quantum-Leap Technologies

- ✓ Leading to **major benefits, if successful.**
- ✓ Exemplified by **chemical looping processes and membrane processes** for converting carbon based materials (eg., biomass) to hydrogen (for fuel cell), chemicals (methanol for fuel cell), liquid fuels (for automobiles) and electricity.
- ✓ Balancing the government funding of projects with high risk and low risk and fostering ***strong national team efforts*** for major industrial product development for world market competition.

F. Education

- ✓ An extremely important topic.
- ✓ Providing the public with **accurate, impartial view points** of energy issues which are technologically, socially, and often politically challenging.
- ✓ *The energy conservation can indeed be best accomplished through carefully planned public education.*

Renewable Energy Technologies

Observations & General Remarks

- **Impressive sound ‘no-nonsense’ focus on business opportunities and industry development.**
- **Especially around PV and H₂ industrial capacities.**
- **Importance of renewable energy for Taiwan without debate (energy security, GHG’s, future markets, strength of national economy)**

General Remarks (cont.)

- **The (factual) information base for understanding (national) potentials for renewable energy seems limited; more thorough work is needed (in particular economic and implementation potentials).**
- **Energy infrastructure issues (grid, logistics) should be integral part of the strategy.**
- **Societal support unclear?**
- **International benchmark of national capabilities could be improved (to understand real market opportunities); Taiwan could participate more in international networks (e.g. IEA).**
- **Not yet fully clear what the key objectives/priorities of the total energy policy & strategy are...(security, GHG, costs, industrial development, environment, macro-economic...)**

Solar Energy

- **Impressive strategy; aggressive approach to develop the sector seems justified. Strong research and industrial capacities; collaboration with world leaders recommended (Germany, Japan).**
- **Development of the national market insecure due to unclear situation for market support.**
- **Attention to solar heat and CSP seems (too) limited.**
- **System issues (grid, built environment, implementation) seems to get limited coverage.**

Bio-Energy

- **Bio-energy key option for coming decades.**
- **Potential not well understood; key route is import of (sustainable) biomass; link up to world leaders here.**
- **Use of organic waste = no regret; could be enhanced with advanced options; optimize waste treatment to energy.**
- **But not based on agricultural (annual) crops (costs, potential, impacts); develop lignocellulosic resources & infrastructure.**
- **Lack of emphasis on power (co-firing!), heat and gasification for synfuels.**
- **International position of Taiwan for ethanol from lignocellulose seems weaker: collaborate.**
- **Innovations on international supplies, specific crops (bamboo) and large scale co-firing & gasification and research on algae promising**

Wind Energy

- **Rationale for wind energy in Taiwan very strong (off-shore in the whole region!)**
- **Industrial capacity and opportunities significant; market potential justifies more leading industries.**
- **Grid issues and (potential) storage poorly addressed.**
- **Support schemes unclear.**
- **Develop science base and interface with industry to become leading on world market (also large turbines); joint ventures and international collaboration?**

Emerging Energy Technologies

CO₂ Reduction Technologies

- CO₂ capture at large stationary sources is required to reduce the current CO₂ emission of the Taiwan economy.
- All three area of advanced coal-fired power generation technologies involving CCS (IGCC-CCS, pf boiler-PCC-S, Oxyfiring-S) are important, but the pf boiler-PCC-S technology is receiving a lot of attention world-wide.
- Both Carbon Capture and Sequestration are necessary to reduce emissions, therefore it is recommended that both are pursued simultaneously. Taiwan should identify both on-shore and under the sea bed sequestration sites.
- It is recommended that Taiwan considers early collaboration with counties with established CCS capability
- It is recommended that Taiwan take early action to consider developing an appropriate legal and regulatory framework for sequestration to be pursued.

CO₂ Reduction Technologies (cont.)

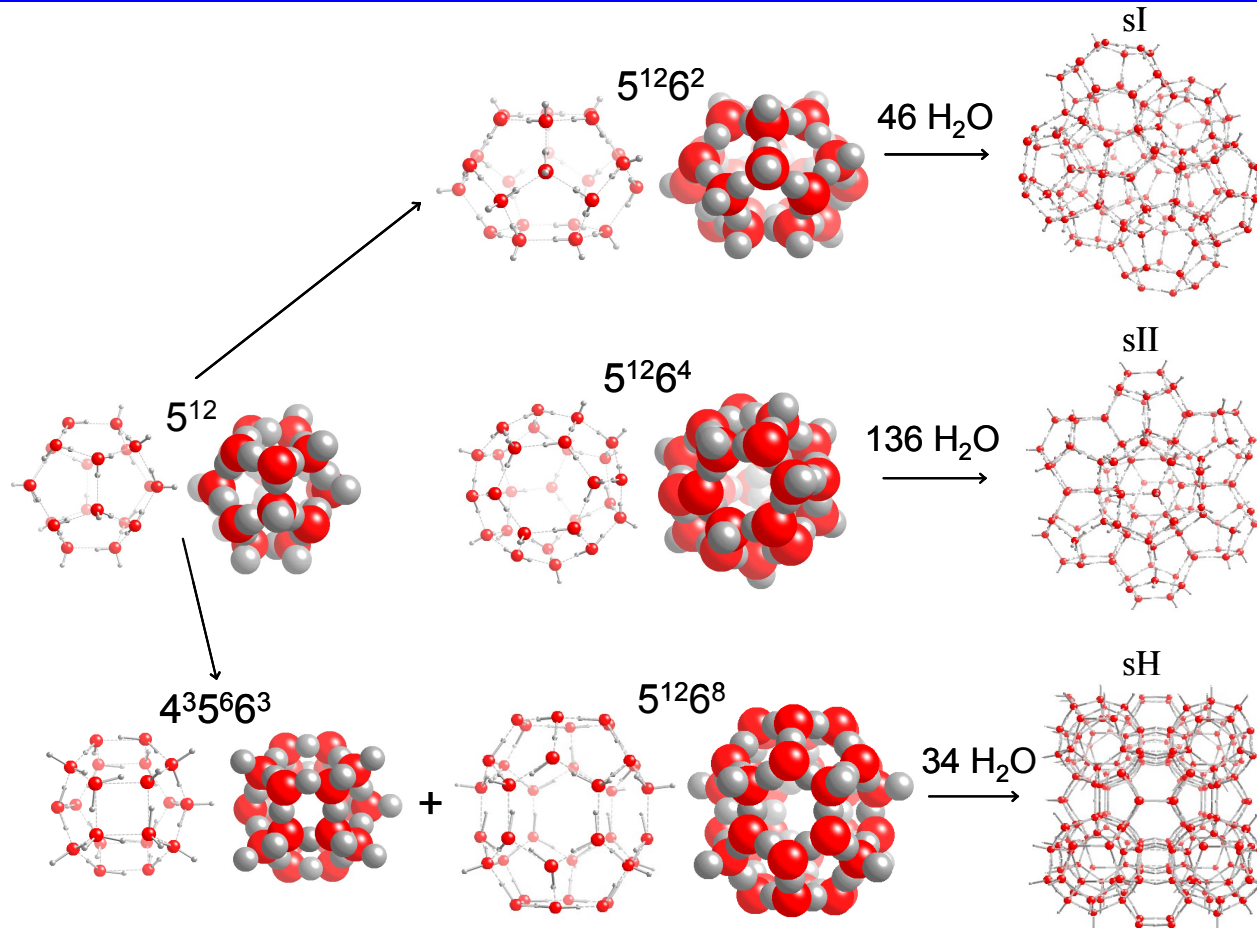
- A major challenge to sequestration could be misinformation on the topic, so early and well planned engagement with the community is desirable.
- While CO₂ will readily form a solid hydrate (CO₂·6H₂O) this does not in itself imply long term storage on the sea floor since hydrates dissolve rapidly in under-saturated water.
- Direct ocean CO₂ disposal in the ocean water column, or ocean fertilization to stimulate phytoplankton growth, are not recommended and would be subject to challenge by the U.N. International Maritime Organization (IMO).
- It remains to be seen whether a CO₂ disposal exemption could be considered e.g. for island nations such as Taiwan or Japan if no good geologic site can be found.
- As a practical matter CO₂ emitted to the atmosphere is already transferred by gas exchange to the surface ocean waters in very large quantities.

Ocean Energy Technologies

- **Wave Energy Technology** – Promising, emerging programs in UK and CA.
- **Ocean Thermal Energy Conversion (OTEC)** – Unpromising, fundamentally low efficiency.
- **Tidal Energy** – not suitable for Taiwan
- **Ocean Current Energy Extraction** – not feasible at this time.

Methane Hydrates – not reviewed at this meeting.

Taiwan has a first class research program and many sea floor gas vents and significant hydrate indicators have been located off-shore.



Fuel Cells and Hydrogen

- Taiwan is well skilled in technologies relevant to fuel cells.
- There is a strong case for on-going support for R&D and industry to ensure Taiwan's capabilities are further developed and products manufactured for export
- There is a strong case for development of large scale (>1MW) fuel cells that can operate directly on syngas from gasification of coal. This technology could offer a step improvement in efficiency of power generation with a consequent substantial reduction in CO₂ emissions per unit of power. With Taiwanese skills in fuel cells, a review of contributions that Taiwanese researchers and industry could make to large scale fuel cells is warranted.
- However, it should be appreciated that while the local fuel cell industry is important it will not have a material impact on reducing Taiwan's greenhouse gas emissions

Fuel Cells and Hydrogen

- Taiwan appears to have a number of small (sub-critical?) teams involved in various aspects of technologies focused on the "hydrogen economy"
- There is a need for an (international) critical review and analysis of the competitive advantage of a "hydrogen economy" compared to the established "electricity economy". Particular reference should be given to the costs and environmental consequences of the production, transport, storage and infrastructure required for H₂ and its use for industrial, domestic and transport applications. Since it is widely accepted that a "hydrogen economy" is a number of decades away and with current developments clean coal technologies, nuclear, and renewables for electricity production and developments in energy storage devices for vehicles, it can be argued that the case for a "hydrogen economy" is far less certain.

General Recommendations for SRB Meeting

- 1. The presentation materials be a summary of inputs gathered/provided from industries, governmental bodies, and academics at least one to three months before a SRB meeting like this one in the future. Performance partnership, role/responsibility, budget/spending, specific contributions, and achievements, etc. be clearly outlined or identified.**
- 2. Adequate representatives from all three parties be present in the meeting.**
- 3. Quantitative performance specifics be given on the subject, especially in the action plans.**
- 4. Stage-gate performance review on project deliverables/milestones be implemented in the action plans at the end of each performance time period.**

Thank You!

