ATTACHMENT B

Carbon Management Topics

Below is a list of specific topical areas we feel would be appropriate for the industrial consortium to address. A topic could be the subject of an assessment study, a session at the annual forum, and/or a seed grant. Within each topic, we list researchers at MIT with expertise in this area. Brief backgrounds and interests of the researchers are given in Attachment C.

- **Integrative Assessment of Carbon Management** (Elisabeth Drake, Denny Ellerman, Howard Herzog, John Heywood, Henry Jacoby, John Reilly, Peter Stone). This topic can be divided into two sub-topics, one being a top-down assessment, the other bottom-up. Top-down assessments help quantify the benefits of carbon management. This includes incorporating carbon management strategies in large economic models (i.e., general equilibrium models) to see the magnitude of their impact in the future under different scenarios. Bottom-up assessments integrate the different components of carbon sequestration (i.e., sources, transport, sinks) and analyze them as a system. This helps identify both barriers and opportunities.

- **Reducing the Cost of CO$_2$ Capture** (Janos Beer, Alan Hatton, Howard Herzog, Jack Howard, Jeff Tester). This is a critical issue to any future deployment of these technologies. What are achievable targets with current technology? What types of new technology (e.g., membranes) are worth pursuing? What work needs to be done today versus waiting until there are market incentives?

- **Injecting CO$_2$ into Underground Reservoirs** (Jeff Tester, Nafi Toksoz, Roger Turpening). Major reservoirs under consideration are oil and gas reservoirs, unmineable coal seams, and deep saline aquifers. Questions include: What are the capacities of these reservoirs and how much of that capacity can be practically utilized? What happens to the CO$_2$ in these reservoirs over different timescales (from years to centuries)? What are the costs associated with each option? How can we convince the public and policy makers that underground sequestration is both safe and effective?

- **Monitoring CO$_2$ in Underground Reservoirs** (Jeff Steinfeld, Jeff Tester, Roger Turpening). One key component for understanding injection of CO$_2$ in the underground and eventually gaining public acceptance will be monitoring. The Earth Resources Laboratory at MIT is a leader in developing seismic monitoring for underground reservoirs. How can these technologies be applied to CO$_2$ sequestration? What will be the costs associated with monitoring?

- **Direct Injection of CO$_2$ into the Ocean** (Eric Adams, John Edmond, Mick Follows/Prof. John Marshall, Howard Herzog). Besides underground, the ocean is the other major sink for captured CO$_2$. Developing as many useable sinks as possible will lead to lower costs. Note that location will play an important role in determining the best sink for any given source. We have on-going projects in ocean carbon sequestration under DOE support.
• **Role of Gas Hydrates in Sequestering CO₂** (Ken Smith, Jeff Tester, Bernhardt Trout). Under proper conditions of temperature, pressure, and composition, CO₂ will form a hydrate (i.e., a solid, snow-like compound). Can we use this property to our advantage for long-term sequestration of CO₂? Are there any synergies between storing CO₂ as hydrates and producing methane from methane hydrates?

• **Applying Biotechnology to Carbon Management** (Charles Cooney, Anthony Sinskey, Gregory Stephanopoulos). Biotechnology is revolutionizing several of our industries (e.g., agriculture, pharmaceuticals). Can these technologies be applied in carbon management? A workshop on this subject was held at MIT in December 1998. Our conclusion was that while difficult, there are some opportunities worth pursuing.

• **Public Outreach and Acceptance of Carbon Management Technologies** (Larry Bacow, Nazli Choucri, Elisabeth Drake, Howard Herzog). While our work in carbon sequestration has been mainly technical, even at this early stage of the field, we have had to deal with social aspects of the problem. Our experience has led us to believe that it is critical to become pro-active. Developing protocols to get out the message in positive ways are critical. So is listening to the concerns of the public and addressing them in an open manner.

• **Increasing Sequestration via Natural Processes** (Penny Chisholm, John Reilly). The natural cycles of interest here are carbon exchange between the atmosphere and the terrestrial biosphere (soils and vegetation) and the atmosphere and the ocean. We are fortunate to have experts in each of these areas. Claims to how inexpensively this strategy can be implemented need to be critically assessed. Other issues include environmental impacts, measurement and verification, durability (i.e., how long will carbon remain sequestered?), and additionality (i.e., would this have happened anyway).