Introduction to Class Work

15th January 2019

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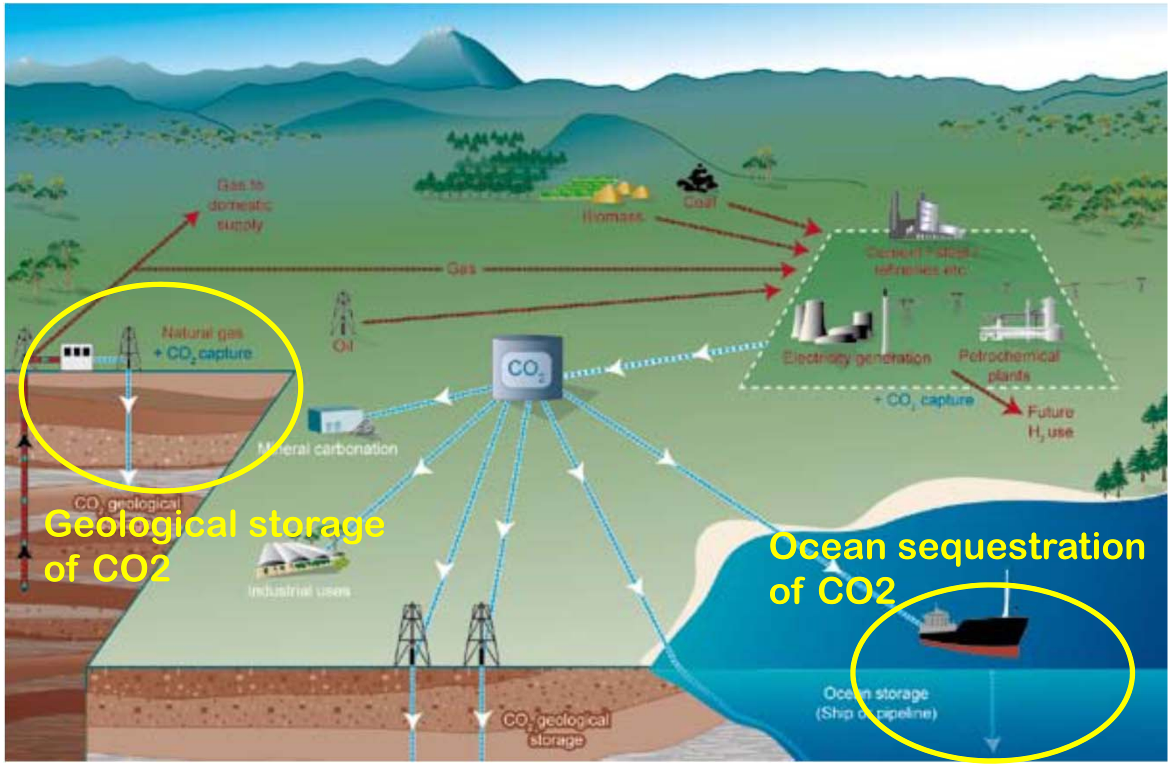
Objectives

- This class work is **an interdisciplinary program** designed to help students integrate what they have been learning in the whole series of lectures through their experience in solving a practical problem in the area of environmental and energy policy.
- The objectives are three-fold:
  1) develop **an understanding of the multiplicity of values, norms, interests, incentives, and scientific information** that influence decisions on environmental issues,
  2) learn to **critically examine the social, political, and economic contexts** for decisions on environmental issues,
  3) engage in **interdisciplinary dialogue** and apply **systems thinking** to address current and projected environmental problems.

Possible CCS systems and storage options

CCS = (**Separation** of CO_2 from industrial and energy-related sources)
+ (**Transport** to a storage location)
+ (**Long-term isolation** from the atmosphere)

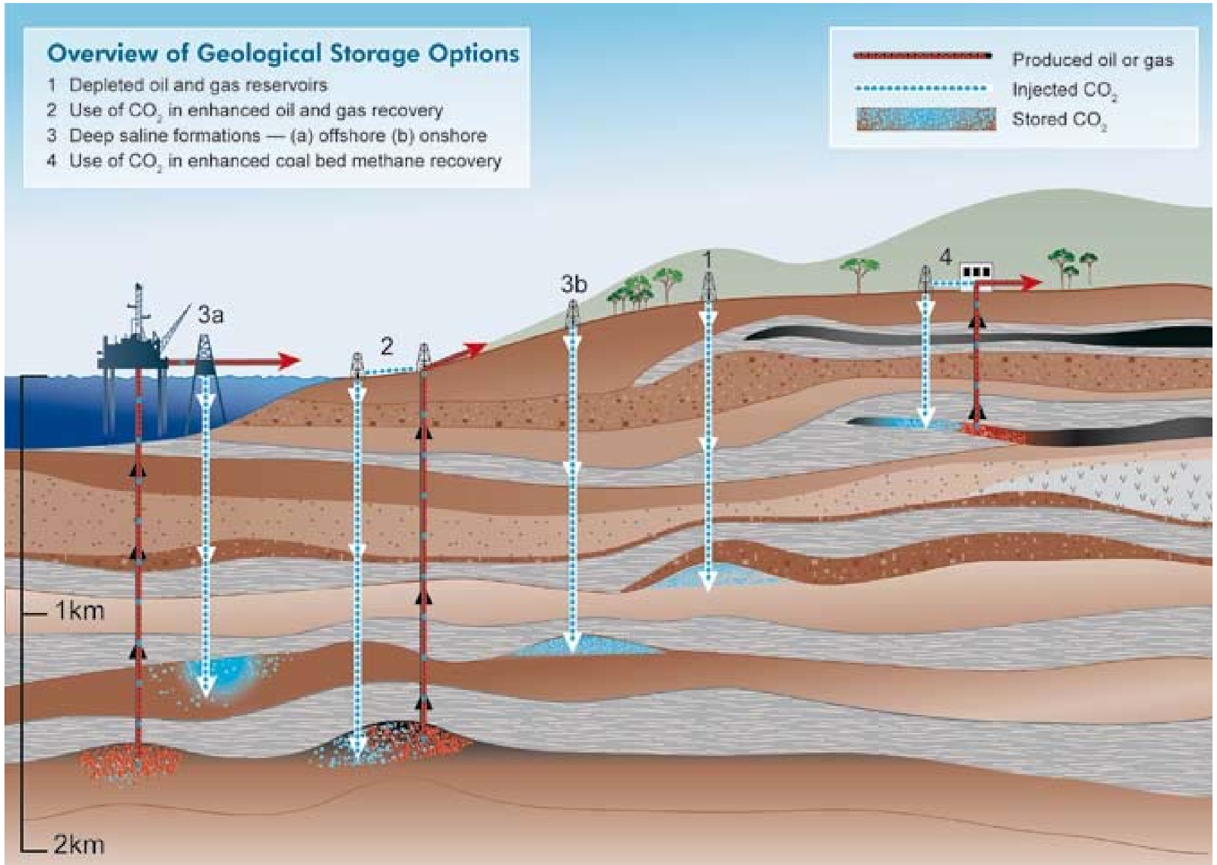


IPCC Special Report, 2005, Carbon Dioxide Capture and Storage.

CCS, as an option in the portfolio of mitigation actions, has the potential to **reduce overall mitigation costs** and **increase flexibility** in achieving greenhouse gas emission reductions.

Geological storage of CO2

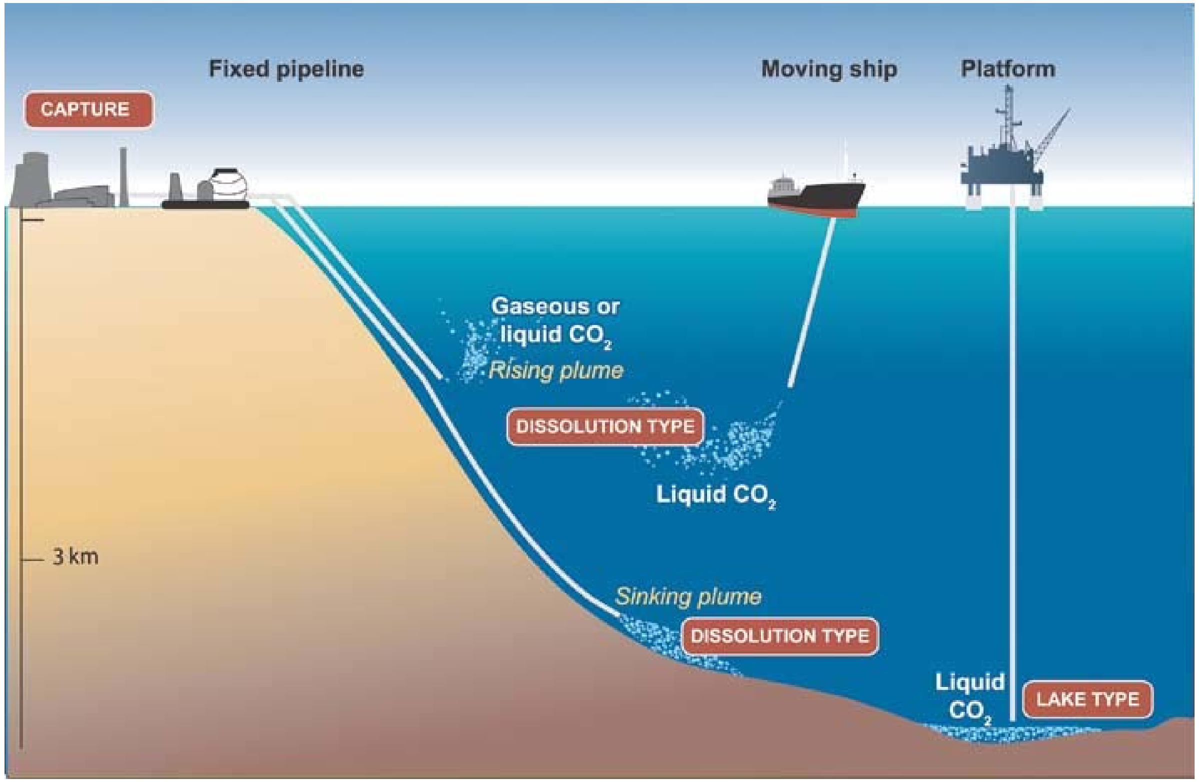
- If CO2 is injected into suitable **saline formations or oil or gas fields, at depths below 800 m**, various physical and geochemical trapping mechanisms would prevent it from migrating to the surface. In general, an essential physical trapping mechanism is the presence of a **caprock**.
- Geological storage uses many of the same technologies that have been developed by the oil and gas industry.



IPCC Special Report, 2005, Carbon Dioxide Capture and Storage.

Ocean sequestration of CO2

- Ocean storage potentially could be done in two ways: by injecting and **dissolving CO2 into the water column (typically below 1,000 meters) via a fixed pipeline or a moving ship**, or by **depositing it via a fixed pipeline or an offshore platform onto the sea floor at depths below 3,000 m**, where CO2 is denser than water and is expected to form a "lake" that would delay dissolution of CO2 into the surrounding environment.
- The dissolved and dispersed CO2 would become part of the global carbon cycle and **eventually equilibrate with the CO2 in the atmosphere**.



IPCC Special Report, 2005, Carbon Dioxide Capture and Storage.

Tasks

- **Preparation** (before 22nd January)
  - All the students are grouped into two.
  - **Group A** to collate information concerning **geological storage of CO_2** so that this option can be evaluated with respect to the six key attributes, i.e., **overall potential**, **cost**, **risks and environmental issues**, **technical maturity**, **regulatory aspects**, and **public perception**.
  - **Group B** to be in charge of **ocean sequestration of CO_2** to carry out the same task.
- **Presentation** (22nd January)
  - Groups A and B to give presentations on characterization and evaluation of the two options respectively.
  - Each student is supposed to make a brief presentation on evaluation of the option that his/her group is in charge of with regard to one of the key attributes listed above.
- **Group work** (22nd January)
  - **Group A to evaluate total "score" of ocean sequestration** based on the presentation by Group B using MAA technique, while **Group B to evaluate geological storage** based on the presentation by Group A.
  - Each group should present results with explanation of reasoning behind their judgments.
- **Discussion** (22nd January)
  - Students are encouraged to comment on how to reflect the results of MAA to corresponding decision making, taking into account of its uncertainty and limitations.

Key attribute 1: Overall potential

- **Permanence**
  - How long should CO_2 be kept away from surface environment and atmosphere to contribute to mitigating global warming depending on scenarios of CO_2 emission?
  - **Expected longevity** of geological storage and ocean sequestration
- **Capacity**
  - **Abundance of locations** in/around Japanese islands suitable for geological storage and ocean sequestration respectively.
  - **Estimated capacity** of CO_2 to be stored underground or sequestration in ocean relative to total emission of CO_2 in Japan

Key attribute 2: Cost

- Cost could be **a critical factor** in forming an environmental and energy policy.
- **Total cost** for capturing, transporting and storing/ sequestrating CO_2 should be considered. Difference in the two options we consider lies mainly in the last component but the transport cost may be affected depending on location of sources/sinks of CO_2.
- Cost could be evaluated relative to a number of indices, e.g., **predicted carbon prices, willingness to pay, cost of alternative technologies such as renewables**.

Key attribute 3: Risks and environmental issues

- Risks
  - Any process or event that are unlikely but could lead to sudden and unexpected return of CO_2 to surface environment and atmosphere if they occurred should be regarded as a risk since it could damage effectiveness as a mitigating option, carbon credit and, hence, profitability of a CCS project, as well as human health and environment.
  - In addition, possibility of accidents during transport and operation should be regarded as risks in general.
  - In Japan, induced or triggered seismicity also requires careful consideration if its causal relationship with operations during the options of interest may leave some room for dispute.
- Other environmental issues
  - Apart from risks due to unlikely events, CO_2 itself or its interaction with host medium, decrease in pH of groundwater or sea water for example, could have some impacts on human health and environment, e.g., marine ecosystems in case of ocean sequestration, under normal conditions.
  - Transport and building infrastructure could also affect local environment.

Key attribute 4: Technical maturity

- Mitigation of global warming is **an urgent issue** that we are responsible to, not the next generations.
- **Japanese NDC** (Nationally Determined Contributions) in accordance with **the Paris agreement** defines **time frame for the emission reduction goals**.
- **Readiness of the technologies** that are required for large-scale deployment of geological storage and ocean sequestration to contribute to achieving the goals need to be critically evaluated.

Key attribute 5: Regulatory aspects

- There are international or domestic laws and regulations that are applicable to geological storage and/or ocean sequestration of CO_2, e.g., London convention, OSPAR convention, Law relating to the prevention of marine pollution and maritime disaster.
- They are not specifically designed for geological storage and/or ocean sequestration of CO_2 and, hence, there remain some vagueness and ambiguity in applying them to CCS.
- They pose some hard (non-negotiable) constraints on potential application of geological storage and/or ocean sequestration of CO_2 in Japan but some might be negotiable.
- Long-term liability issues associated with the leakage of CO_2 from underground reservoir to the atmosphere and local environmental impacts are generally unresolved.

Key attribute 6: Public perception

- **CCS is not widely recognized by general public** as an option for mitigating global warming. Unlike other well-known options such as nuclear and renewables, public perception of CCS is yet to be clarified.
- In the locality of a site for geological storage or area for ocean sequestration of CO_2, however, **perception by local community of the particular project** will be developed as the planning proceeds, which could have **a decisive impact on the business. (A case study is recommended.)**
- Public perception can be affected by many factors. Namely how people evaluate;
  - Benefit,
  - Cost,
  - Risks,
  - Potential conflict with their interest.
- The way an implementer of CCS communicate with the local communities may be the most important element and, thus, affect how local people think of the project.

Multi-Attribute Analysis (MAA) (1/2)

- Choosing among alternatives is complicated by the fact that each option involves **multiple attributes**, that are important to decision makers.
- Some attributes, such as cost and overall potential, can more readily be quantified. For others, such as technical maturity or public perception can only be described and evaluated qualitatively.
- Because both **quantitative and qualitative attributes** are important to consider in decisions about environment and energy policy, we handle both types of attributes within **a single integrated decision framework** based on multi-attribute analysis (MAA).
- The **utility function, U^i,** describes how the scores of the weighted attributes are added to arrive at an overall integrated score for a particular option *i*, using the weights applied to each attribute to take account of the user's judgments about the relative importance of each attribute.

$$U^i = \sum_{j=1}^{m} w_j u_j^i,$$

Where w_j: weight of j^{th} attribute, u^i_j: score of i^{th} option with regard to j^{th} attribute.

Multi-Attribute Analysis (MAA) (2/2)

Linguistic scale for scores

Very favorable	Favorable	Moderate	Poor	Very poor
5	4	3	2	1

Simple Multi Attribute Rating Technique (SMART)

- Barron and Barret (1996) believe that generated weights may be more precise than weights produced by the decision-makers who may be more comfortable and confident with a simple ranking of the importance of each attribute, especially if it represents the considered outcome of a group of decision-makers.
- Therefore a number of methods that enable the ranking to be translated into 'surrogate' weights representing an approximation of the 'true' weights have been developed. Among those methods, we use Rank sum weights defined as below.

$$w_i(RS) = {(n+1-i)}\big/{n(n+1)/2}, i = 1, \dots, n$$

	Criteria								
Rank	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1	0.6667	0.5000	0.4000	0.3333	0.2857	0.2500	0.2222	0.2000	0.1818
2	0.3333	0.3333	0.3000	0.2667	0.2381	0.2143	0.1944	0.1778	0.1636
3		0.1667	0.2000	0.2000	0.1905	0.1786	0.1667	0.1556	0.1455
4			0.1000	0.1333	0.1429	0.1429	0.1389	0.1333	0.1273
5				0.0667	0.0952	0.1071	0.1111	0.1111	0.1091
6					0.0476	0.0714	0.0833	0.0889	0.0909
7						0.0357	0.0556	0.0667	0.0727
8							0.0278	0.0444	0.0545
9								0.0222	0.0364
10									0.0182

RS for six attributes

Time table for class work (22nd January)

14:55 Introduction (Takase)

Preparation of presentation

15:10 – 15:40 Presentation by Group A on geological storage of CO_2 to cover six key attributes

Discussion

16:00 – 16:30 Presentation by Group B on ocean sequestration of CO_2 to cover six key attributes

Discussion

Coffee

17:00 – 17:30 Group work

17:30 – 17:45 Presentation by Group A on evaluation of ocean sequestration with explanation of reasoning behind weights (ranks) and scores

17:45 – 18:00 Presentation by Group B on evaluation of geological storage with explanation of reasoning behind weights (ranks) and scores

18:00 – 18:30 Discussion