CLIMATE CHANGE

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PROJECT LOCATION

New York City and Lower Hudson River Valley, New York. Source: E&S Environmental Chemistry, Inc.

CONTACT INFORMATION
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PROJECT NUMBER 10113

KEYWORDS
- Carbon dioxide
- CO_2 Injection
- Ocean sediments
- Seabed
- Sequestration

0908

New York Energy Smart EMEP Environmental Monitoring, Evaluation, & Protection

NYSERDA New York State Energy Research and Development Authority

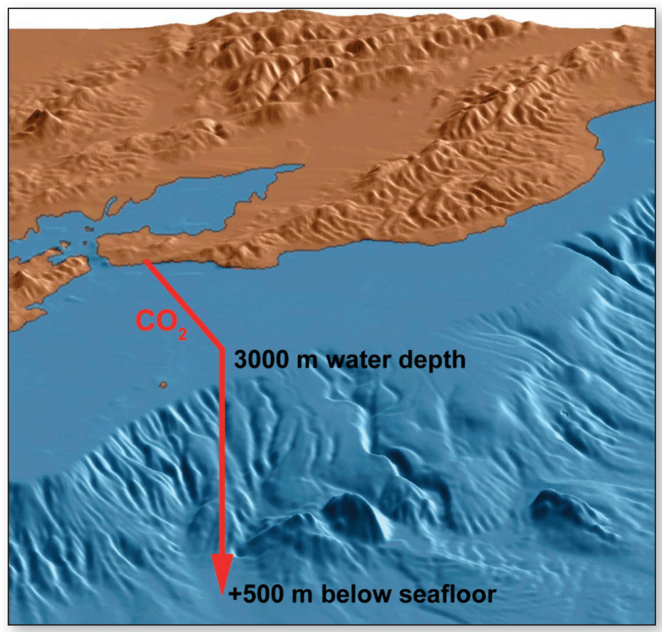
Permanent CO_2 Sequestration in Ocean Sediments: Flow-Through Reactor Studies

PROJECT FOCUS

This project investigates the potential for offshore carbon dioxide (CO_2) sequestration, a method of greenhouse gas emissions reduction that may be suitable for New York State. The objective is to evaluate, through laboratory experiments, the feasibility of CO_2 injection in deep ocean sediments along the New York coast. The volume of relevant ocean sediments along the New York coast is massive and could likely handle a large part of the state's current anthropogenic CO_2 emissions.

CONTEXT

Reducing CO_2 emissions to the atmosphere may require the safe and stable long-term storage of vast quantities of CO_2 captured from anthropogenic emission sources, such as power generation plants. Geological CO_2 sequestration aims to confine CO_2 by injecting it into depleted gas or oil wells, unminable coal seams, or deep saline formations capped by low-permeability formations. Saline formations are important due to their large potential storage capacity and geographic ubiquity. However, suitable onshore deep saline formations are not widespread along the New York coastline. This results in a mismatch between CO_2 emission sources and potential sinks.



In order to achieve the necessary depth, sub-seabed sequestration would take place beyond the edge of the continental shelf. Source: Jonathan Levine, Columbia University.

In offshore carbon sequestration, the relatively low density of the pore fluid in sub-seabed sediments provides a cap to the denser liquid CO_2 and ensures permanent storage; additionally, marine sediments act as a physical barrier to slow diffusion into the ocean and prevent the resulting ocean acidification and long-term atmospheric release of CO_2. To better understand the fate of the injected CO_2 and potentially guide the way to an industry-led demonstration project, this study will attempt to characterize: the flow of injected CO_2 in deep-sea sediments; potential chemical reactions with minerals; and the role of clathrate formation, which occurs when CO_2 and water combine to form a solid that fills the pore space.

PROJECT IMPLICATIONS

Carbon dioxide, the primary global warming gas, is a product of fossil fuel combustion; in order to slow the buildup of CO_2 in the atmosphere, significant amounts may have to be captured from power plant emissions and stored for very long periods of time. This project explores a new, potentially massive resource for carbon sequestration in deep ocean sediments off the New York coast, which could help resolve the mismatch between the location of coastal CO_2 sources and potential sinks.

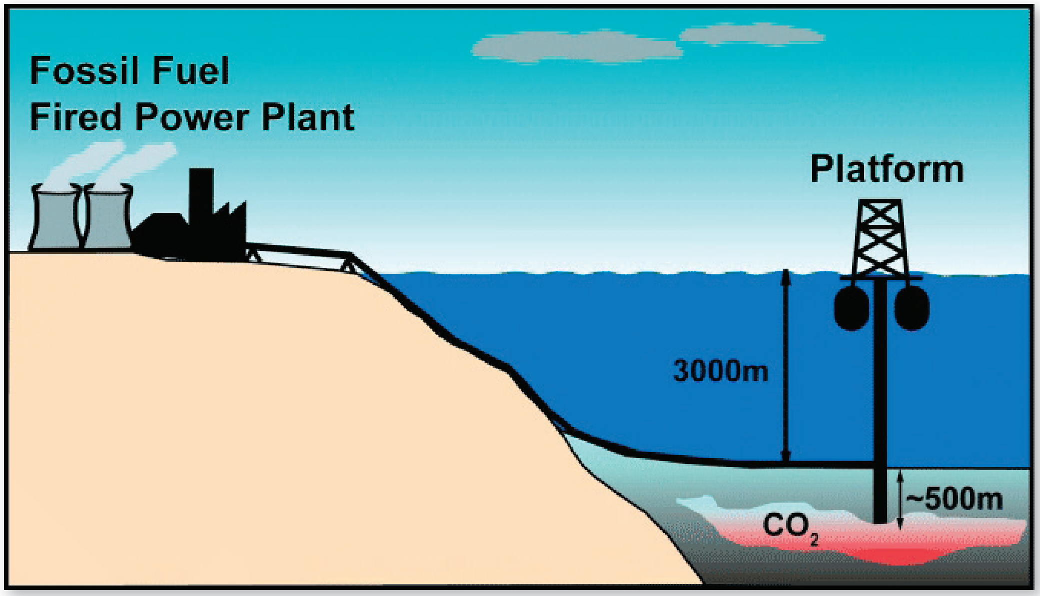
PROJECT STATUS
Ongoing

Northport Power Station, located on Long Island, New York, is the largest oil-fired, electric-generating power station on the East Coast. Source: National Grid.

New York Energy Smart
Public Service Commission NYSERDA

Since 1975, the New York State Energy Research and Development Authority (NYSERDA) has developed and implemented innovative products and processes to enhance the State's energy efficiency, economic growth, and environmental protection. One of NYSERDA's key efforts, the Environmental Monitoring, Evaluation, and Protection (EMEP) Program, supports energy-related environmental research. The EMEP Program is funded by a System Benefits Charge (SBC) collected by the State's investor-owned utilities. NYSERDA administers the SBC program under an agreement with the Public Service Commission.

METHODOLOGY



This diagram shows how CO_2 captured from electric power plant emission streams could be sequestered in deep ocean sediments. Source: Juerg Matter, Columbia University.

The project methodology consists primarily of a series of liquid CO_2 experiments to study the flow behavior of liquid CO_2 within brine-saturated ocean sediments. Key components of the study include the following:

- **Geomechanical experiments** will test whether the low mechanical stability of loosely consolidated ocean sediments may have an impact on the storage stability of CO_2. Since CO_2 injection at high pressure may lead to hydraulic fracturing, buoyant fractures, and the destabilization of the sediment formation, knowing the geomechanical parameters of ocean sediments is critical.
- **Core flooding (plug flow) experiments** will test the multiphase transport of liquid CO_2 and brine within porous ocean sediments, which will define relative permeability, wettability conditions, saturation, and capillary pressures for different sediment types.
- **Dissolution experiments** will test the potential for increased permeabilities due to calcite dissolution. As the liquid CO_2 expands out into the formation, dissolved CO_2 (carbonic acid) will form at the front of liquid CO_2 and pore water, resulting in the dissolution of calcite. As a result, the simulation of the productions of carbonic acid and its effect on permeability will occur.
- **CO_2 clathrate formation testing** is necessary to understand the depth requirements for CO_2 injection as well as the long-term sealing role of clathrates in sub-seabed CO_2 sequestration. Depending on how long they remain, clathrates may pose a nuisance to injection, or they may form a sealing layer, which would act as an additional obstacle to CO_2 migration. Quantifying this effect and the time scales it operates on is essential. Experiments will be conducted with liquid CO_2 under low-temperature conditions to study the potential formation of CO_2 clathrates as a function of pressure and temperature, sediment composition, permeability/porosity, and water saturation. Planned experiments include flowing liquid CO_2 through brine-saturated core plugs of different mineralogical compositions and permeabilities, including those that represent the dominant mineralogical composition of offshore marine sediments along the New York coastline.

FINDINGS

Initial experiments have probed the issue of CO_2 transport in loosely consolidated, low-permeability sediments. Geomechanical measurements to characterize elastic and plastic properties of ocean sediments, using the indentation technique, are ongoing, and the possibility of hydraulic fracturing and buoyant fractures is being tested in experiments using transparent material such as gelatin or transparent clay as a proxy for weak, low-permeability sediment. Quantification of the relevant parameters is ongoing.

An experimental plan was designed in preparation for the core-flooding experiment at higher pressure and low temperature. The simulations showed that the amount of mixing will control the rate of carbonic acid formation and therefore the chemical reactivity, as well as the potential of CO_2 hydrate formation. Construction and initial testing of the core-flooding device has begun.