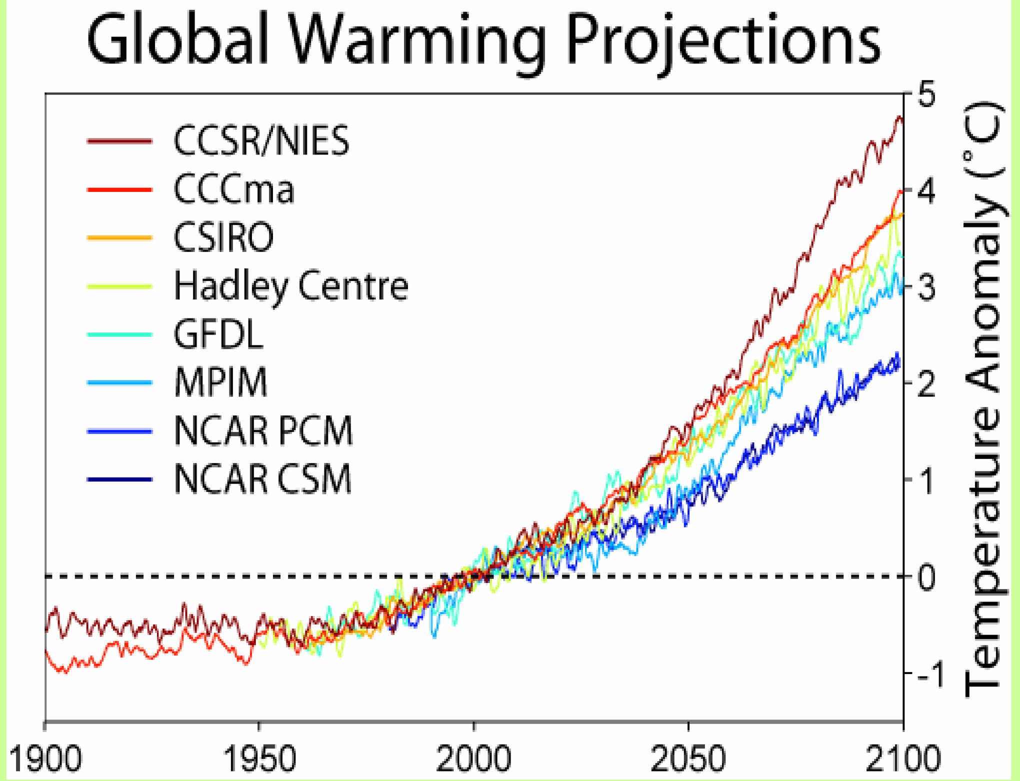
LONG-TERM STORAGE OF CO_2

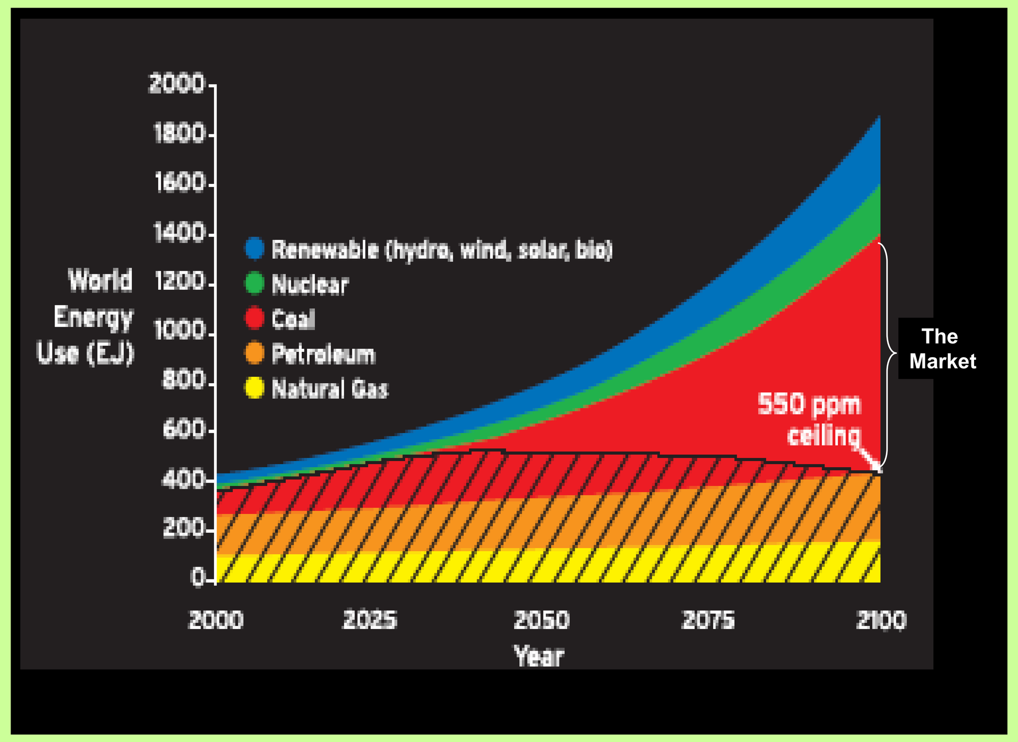
Cheaper than Solar & Just as Nice to the Climate

The Problem

FACT: The global economy produces about 25 billion tons of carbon dioxide per year.

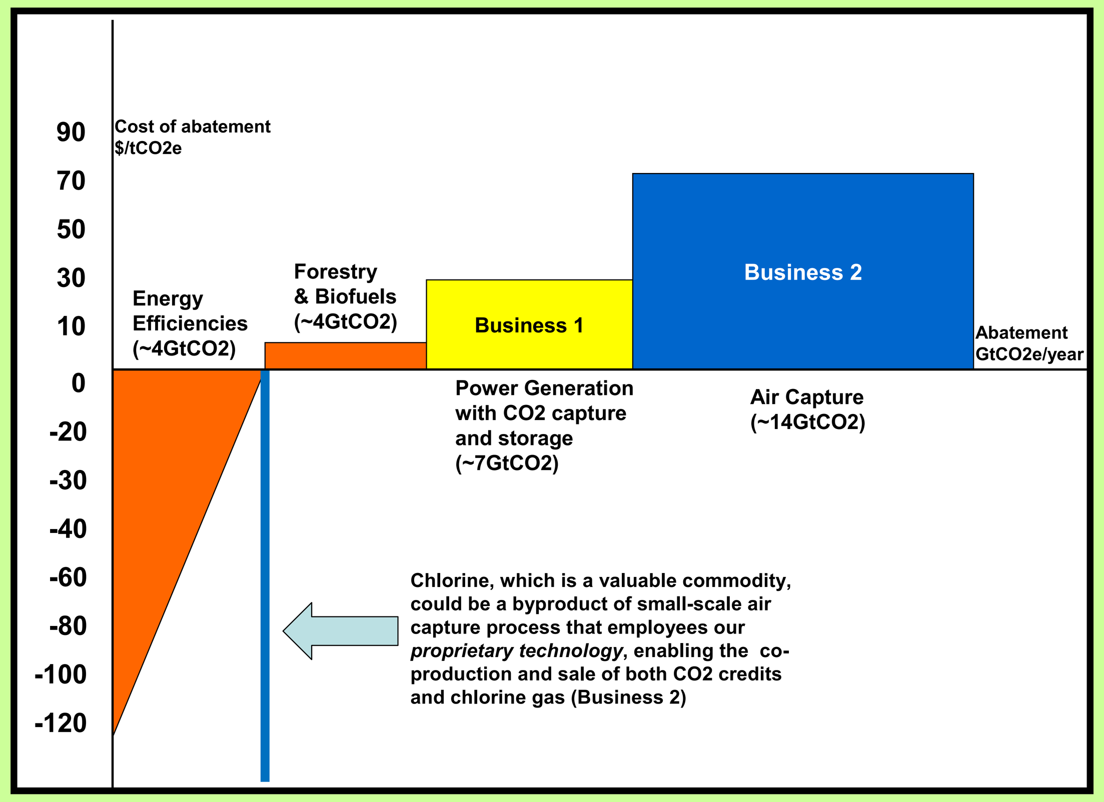


•If CO2 emissions are not controlled, the earth's temperature might rise up to five degrees in the next 90 years.



•Fossil fuels will continue to dominate energy production, presenting a huge opportunity for technologies that aim for carbon dioxide neutrality.

Market of Solutions



•A range of possible emissions approaches/ technologies exists. These technologies vary in cost and potential scale.

•We have technology and intellectual property that play the yellow and blue boxes in the above chart.

•Our technology is dependent on regulations that put a pollution price on carbon dioxide.

•The supply curve indicates that our business 1 technology becomes commercially viable once regulations drive the penalty to emit CO2 into the atmosphere above ~$35/tCO2.

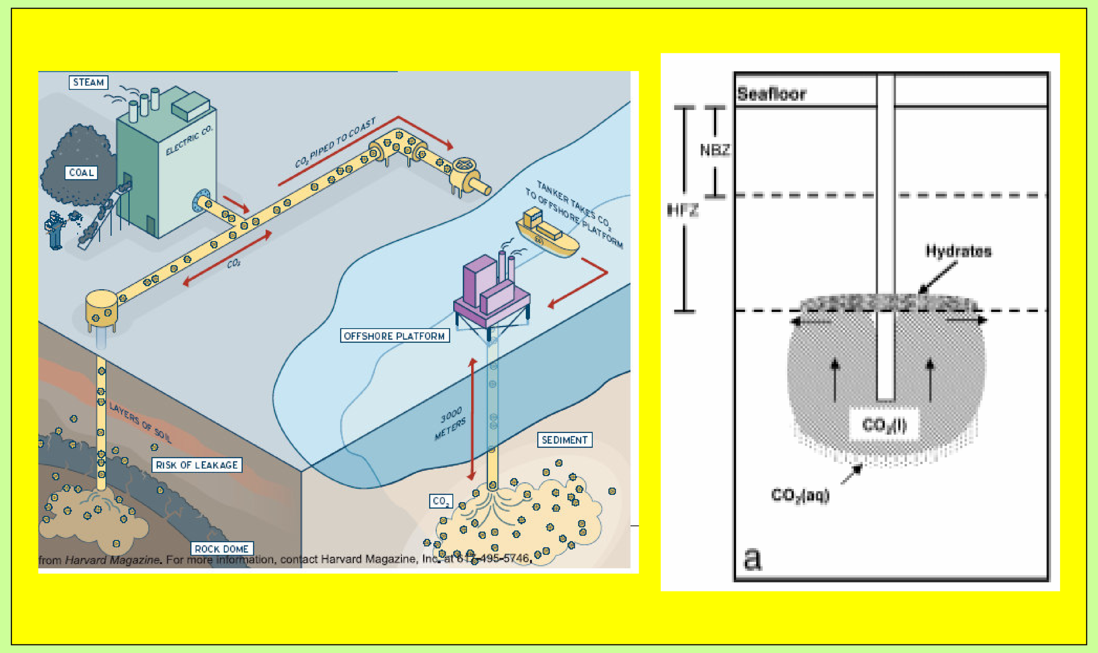
•In addition, our business 2 technology becomes commercially viable at ~$70/tCO2.

FACT: If 60% of the CO2 produced from U.S. coal-based power generation were to be captured and compressed to a liquid for geologic sequestration, its volume would about equal the total U.S. oil consumption of 20 million barrels per day.

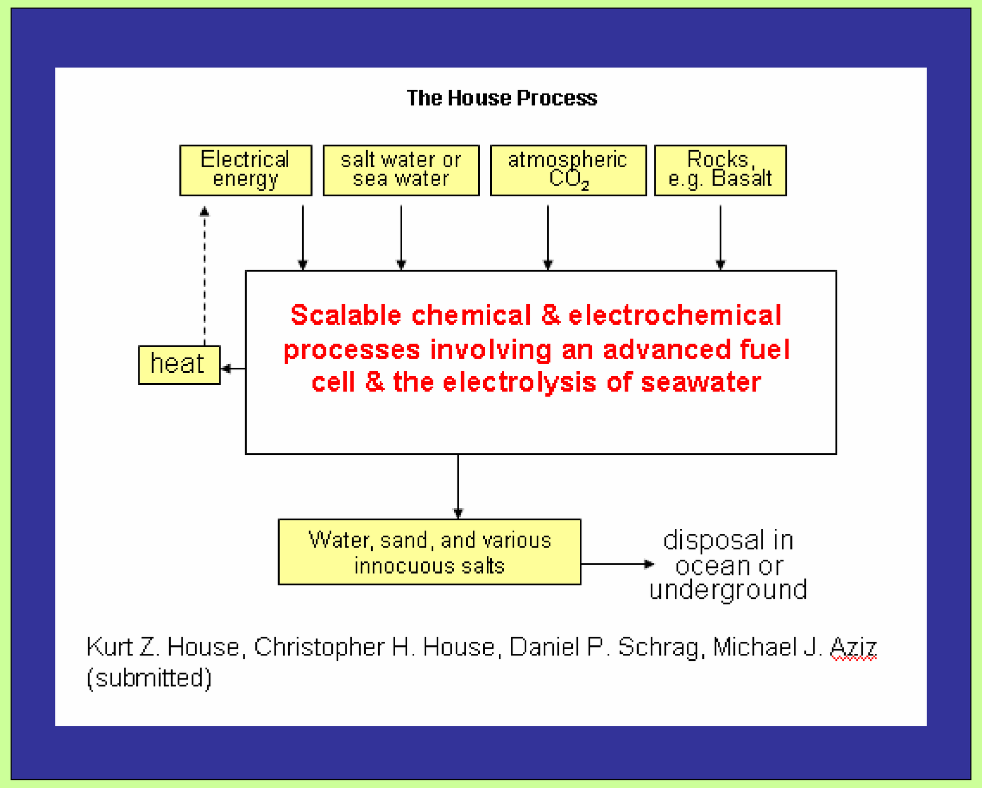
Our Solution

•Nearer-term solution (Business 1) calls for large scale carbon capture and sequestration (CCS) from coal-fired power plants.

•Diagram below highlights the benefits of our process of CO2 storage in deep ocean sediment, which is much safer than storage of CO2 in geological reservoirs where you risk leakage.



•Long-term solution (Business 2) calls for deep CO2 cuts by deploying our proprietary technology to capture CO2 from the atmosphere and chemically store it.



FACT: All of the CO2 projected to be emitted by the U.S. in the 21st century could be stored in a 100km x 100km oceanic sediment field.

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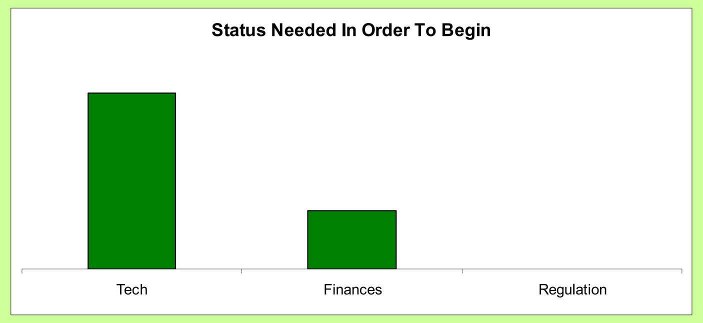
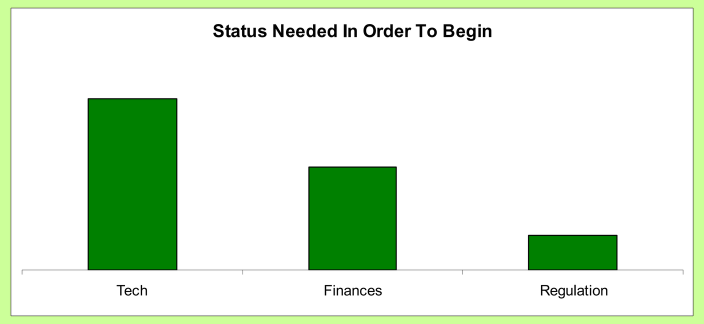
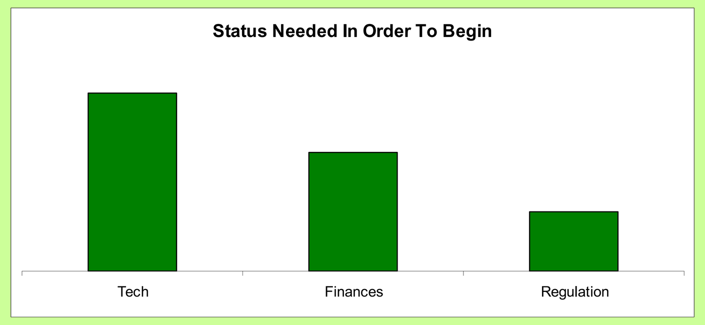
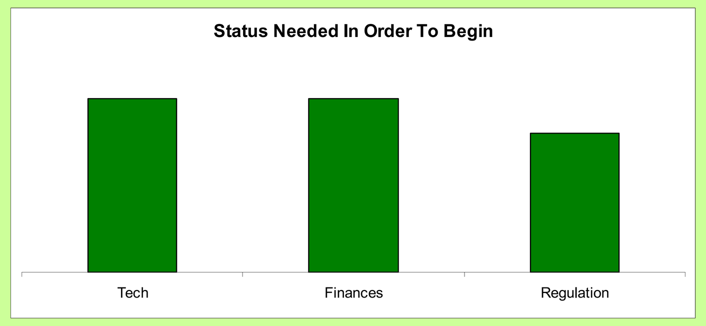
Business 1: Long-term Storage of CO_2 in Deep Sea Sediments

The ultimate scope of business 1 will be determined by the rate at which technology development, carbon dioxide regulations, and financial capitalization progress. The opportunity already exists to create and sell software for storage site characterization. Depending on how quickly carbon regulations emerge, Business 1 will have the opportunity to expand its scope to include additional levels of expertise and vertical integration.

	Software Company →	Services Company →	Site Prospecting Company →	Site Developer and Operator
	Anticipated timeline: 2007-2010.	Anticipated timeline: 2010-2012.	Anticipated timeline: 2012-2015.	Anticipated timeline: 2015-2020.
What to Sell	**What we sell:** Software for characterization of potential sequestration sites.	**What we sell:** Engineering information and analysis of particular sites that sequestration developers are considering.	**What we sell:** Development rights to sites for which we have done engineering characterization and regulatory permitting.	**What we sell:** Carbon sequestration.
Who to Sell To	**Who we sell to:** Likely initial customers include energy consulting firms, oil-field services companies, engineering companies, governments, and others interested in exploring the possibility of developing particular offshore carbon sequestration sites.	**Who we sell to:** Likely initial customers include energy consulting firms, oil-field services companies, engineering companies, governments, and others interested in exploring the possibility of developing particular offshore carbon sequestration sites.	**Who we sell to:** Customers would be sequestration project developers and the partners to whom they have contracted work.	**Who we sell to**: Industrial carbon dioxide emitters and pipeline operators. Coal-fired power plants are the predominant industrial source of CO2.
Why They Buy	**Why they buy:** Our software has been validated by field-test data, and improves the customer's ability to rapidly identify and characterize the potential value of various sequestration sites.	**Why they buy:** Our engineering analyses are the fastest, most accurate means of getting the information necessary to bid on, acquire, design, and ultimately operate a sequestration site.	**Why they buy:** By purchasing a pre-permitted site from us, a developer can avoid the time and uncertainty associated with selecting a site and shepherding it through regulatory hurdles.	**Why they buy:** Sequestration of carbon dioxide at our site is less expensive and / or operationally disruptive than other options (e.g. discontinuing CO2 generation or buying emissions allowances).
Product Development Needed	**Product development needed:** •Complete the basic science. •Validate model in laboratory. •Develop software product capable of integrating hydrate formation dynamics, liquid CO2 flow behavior, and site characterization data. •Conduct field experiments and model calibration.	**Product development needed:** •Gather data on a number of potential sequestration sites. •Expand the scope of information included in the site characterization model, to include factors such as features of the pipeline route, the cost of necessary equipment, and the optimal layout of the CO2 injection field.	**Product development needed:** •Use internal capabilities to select and buy development rights to one or more of the most promising sequestration sites. •Shepherd the site(s) through the permitting process.	**Product development needed:** •Financial engineering of a large-scale project, to manage market price and performance risk. •Contract development between industrial carbon dioxide emitters and traders.
Internal Drivers	**Internal drivers:** •K. House finishes PhD, moves into ½ postdoc, ½ commercialization role. •Initial capitalization of $2M raised, and team assembled.	**Internal drivers:** •Data from field tests will need to be gathered in as cost-efficient a manner as possible. This will likely involve additional government research funding (e.g. via SBIR).	**Internal drivers:** •Moving into permitting will require a substantial expansion of the scope of the management team's expertise to include capacity to manage regulatory processes.	**Internal drivers:** •Developing and operating a site will require shifting the company's core competencies away from information management and toward operations. This is where we believe the money will be for this to shift to happen.
External Drivers	**External drivers:** •Software development is not dependent on any further progress in the CO2 regulatory regime. 	**External drivers:** •Preliminary site characterization and engineering is not likely until developers believe that an economic value will be placed on carbon dioxide emissions in the foreseeable future. 	**External drivers:** •Site permitting and rights acquisition is not likely until developers believe that carbon dioxide emissions will hold economic value in the foreseeable future. 	**External drivers:** •Projects will not be financed until a market price of CO2 is established such that operation of a sequestration site is financially attractive. 

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Business 2: Direct Air Capture of CO_2 with Chemical Storage

The ultimate scope of business 2 will be determined by the rate at which technology development, carbon dioxide regulations, and financial capitalization progress. The opportunity already exists to provide waste management services for chlorine producers. Depending on how quickly carbon regulations emerge and how easily the technology is refined, Business 2 will have the opportunity to expand its deployment of its proprietary technology for CO_2 capture from the air.

	NaOH Disposal for Chloralkali Operator →	Low Grade Acid Extraction from Seawater →	Acid Extraction & Neutralization Plant
	Anticipated timeline: 2008-2011.	Anticipated timeline: 2010-2015.	Anticipated timeline: 2015-2020.
What to Sell	•NaOH disposal service to Chloralkali Operator •CO2 emissions offsets and/or credits	•Low grade acid separated from ocean seawater •CO2 emissions offsets and/or credits	•CO2 emissions offsets and/or credits
Who to Sell To	•Chloralkali Operator (e.g., Dow Chemical) •The chlorine industry produces ~50 million tonnes of NaOH per year representing ~75 million tonnes of potential CO2 capture. •CO2 credits sold to emissions trading markets	•Mining industry for purification of ore into mineral •CO2 credits sold to emissions trading markets	•CO2 credits sold to emissions trading markets
Why They Buy	•The Chloralkali process necessarily co-produces Cl_2, H_2, & NaOH. Inconsistencies in the NaOH market limit a given plant's ability to produce high value chlorine. Utilizing excess NaOH allows a given plant the ability to operate continuously, increasing it's market share.	•Low grade acid needed for purificaton of mined ore into mineral for sale. Purification process neutralizes acid preventing return of CO2 into the environment.	•Credits are less expensive than emissions penalty
Product Development Needed	•Regulatory approval to add NaOH to ocean surface water in order to enhance oceanic uptake of atmospheric CO2. Thereby increasing permanent CO2 capture. •Development of a process to neutralize NaOH to NaHCO3 (baking soda) with atmospheric CO2 (e.g spray towers) prior to disposal.	•Regulatory approval to allow acid extraction from ocean •Refine technology for acid separation on large scale from impure ocean water	•Regulatory approval to allow acid extraction from ocean •Refine technology for acid separation on large scale from impure ocean water •Refine technology for acid neutralization on large scale
Internal Drivers	•K. House finishes PhD, moves into ½ postdoc, ½ commercialization role. •Initial capitalization of $2M raised, and team assembled.	•$6M raised for research and development of acid extraction process • $30M capitalization raised for development of ocean water separation facility	•$6M raised for research and development of acid neutralization process •$1B capitalization raised for development of large scale acid separation and neutralization facility
External Drivers	•Chloralkali producer interested in partnering on CO2 project •Development of a market for CO2 emissions offsets and/or credit •Regulatory approval stipulating that NaOH neutralization with CO2 generates CO2 credits	•Development of a market for CO2 emissions offsets and/or credits to provide incentive to mineral industry to purchase acid for carbon neutral mining •Regulatory approval stipulating that low grade acid extraction from the ocean generates CO2 credits	• Regulatory approval stipulating that low grade acid extraction and neutralization from the ocean generates CO2 credits •Price of CO2 credits must reach approximately $70/ton

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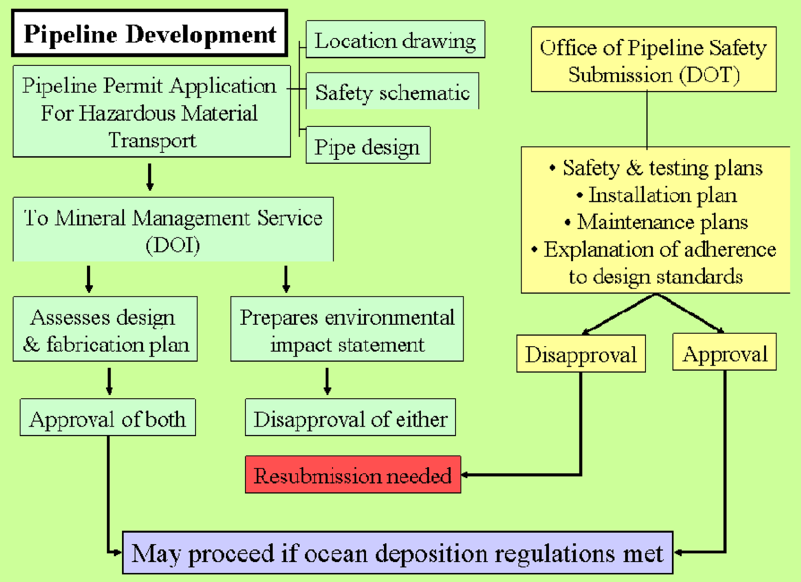
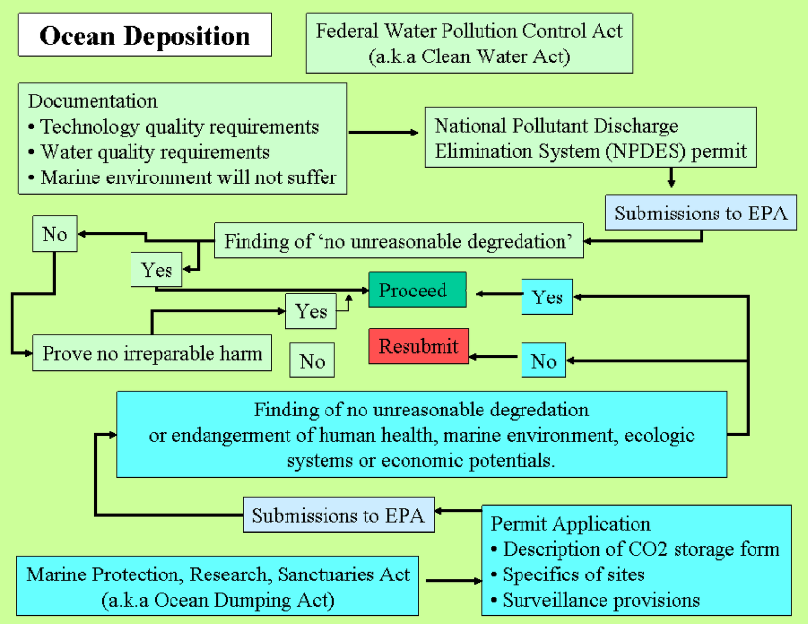
Commercialization Recommendation

- Continue to develop site characterization software, using SBIR and DOE research funds.
- Move rapidly from software to prospecting.
- Identify, characterize and permit one site off the coast of the Northeast United States, as well as a site off Northern Europe.
- Establish proprietary site characterizations.
- Use site characterization and permitting leadership to gain leverage with governments and strategic partners.
- Wait for CO2 market to near the $35/ton level before commencing site development, and hold off on Business 2 until proprietary technology is fully refined.

Regulatory Considerations

Site Permitting: Getting approval to create a storage site requires approvals for both Pipeline Development and Ocean Deposition.





Carbon Dioxide Constraints: The process of creating regulations on CO2 is likely to continue to move in a haphazard manner.

Investments in storage site characterization and demonstration projects will both establish market leadership for the firm and accelerate the CO2 regulatory process.

A market price of $35 / ton of CO2 will make oceanic storage commercially viable. Of the $35, storage is expected to account for $5 per ton, with the balance going primarily to the other stages of carbon capture, pressurization and transportation.

Business 1 Market Selection

US Coastal Regions: The East Coast is the prime commercial market, due to the density of nearby coal power plants. The Gulf Coast is a likely testing ground, due to its streamlined regulations and existing infrastructure, and has enough coal plants to be a potential commercial market as well.

Coastal Region	Coal Plant Density	Political Will	Complexity of Regulatory Regime
Atlantic	High	High	Medium
Pacific	Low	High	High
Gulf	Medium	Medium	Low

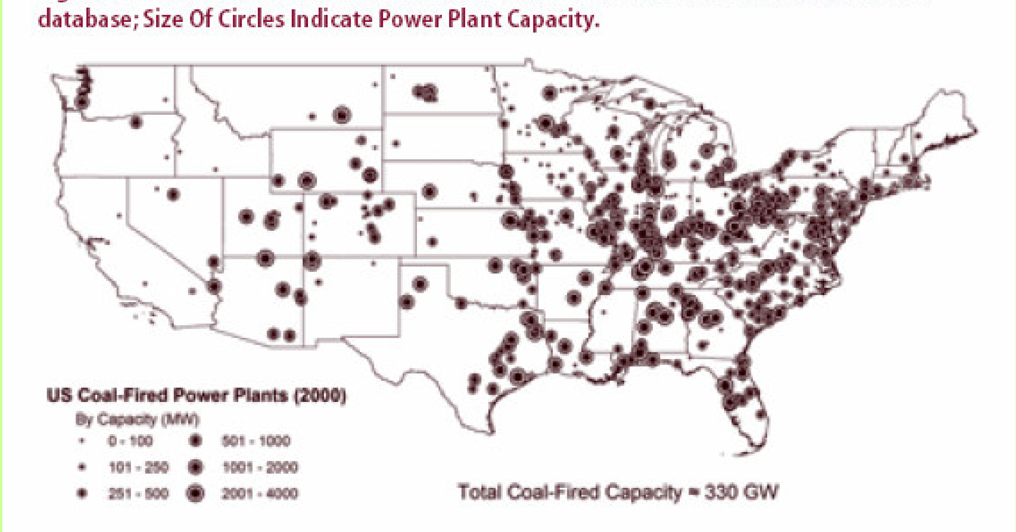


Figure 3.1 Distribution of U. S. Coal-Based Power Plants. Data from 2002 USEPA eGRID database; Size Of Circles Indicate Power Plant Capacity.

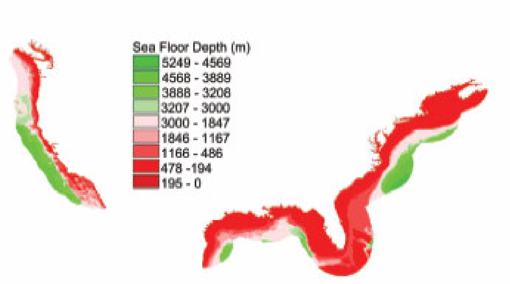
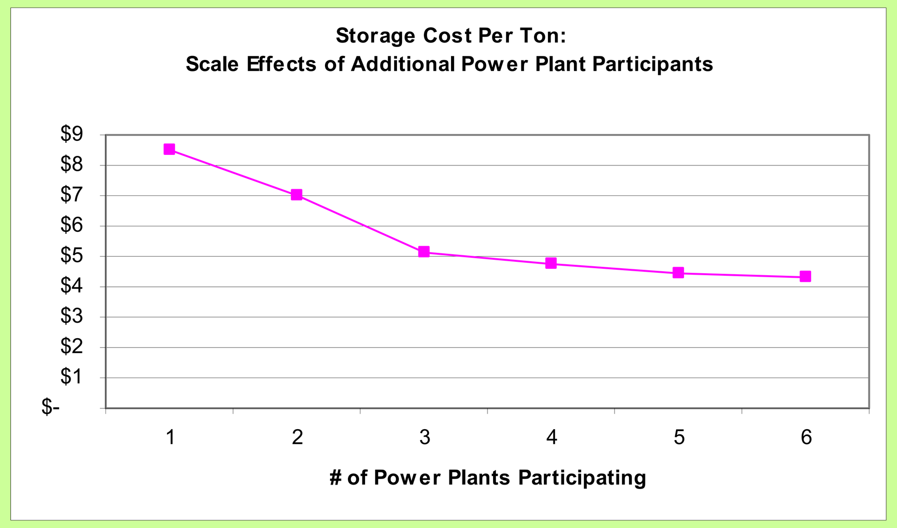


Fig. 5. More than 22% of the seafloor within the 200-mile economic zone of the U.S. coast is <3,000 m deep, which represents >1.3 × 10^6 km^2 of potential CO_2 storage area.

Overseas: Northern Europe, where carbon dioxide emissions already carry a market value and coal is heavily used, also has excellent prospects for storage site development.

Business 1 Scope

Project Size: There are significant economies of scale to the storage business. Greater utilization of equipment leads to lower storage costs per ton.



Due to the economies of scale, it is likely that most commercial facilities will be large enough to handle the output of at least 5 power plants.

Typical Projected CO2 Storage Facility	
Number of participating coal power plants:	5
Average size (MW):	750
Tons CO2 generated / plant / year	4,500,000
Total CO2 generated by plants (tons):	22,500,000
Capture rate:	60%
CO2 stored (tons):	13,500,000

Prospecting for High Returns: The CO2 storage site Prospecting business is a new market opportunity, with significant expertise required and no incumbents. This creates an opportunity for high financial returns.

Value Proposition of a Pre-Permitted Site	
Storage Savings Per Ton (relative to purchasing emission credits):	$10
Time Savings to Developer:	2
Financial Savings to CO2 Emitter:	$ 270,000,000
Cost to Study and Permit a Site:	$10,000,000
Profit Potential:	$ 260,000,000
Holding Period for the Prospector:	3
Potential ROI:	196%

Large Lower-Risk Opportunities for Developer Operator: Conversely, the Development / Operations business for energy infrastructure is well established, with incumbents such as Schlumberger and BP generating ROE in the 20-35% range.

Financial Returns to Developer / Operator	
Project Development Cost:	$ 150,000,000
Operating Cost per ton:	$0.65
Ongoing Monitoring Cost per ton:	$0.20
Debt financing:	60%
Annual Revenue:	$60,250,276.10
Annual Profit:	$18,075,082.83
ROE:	30%
NPV:	$90,375,414

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