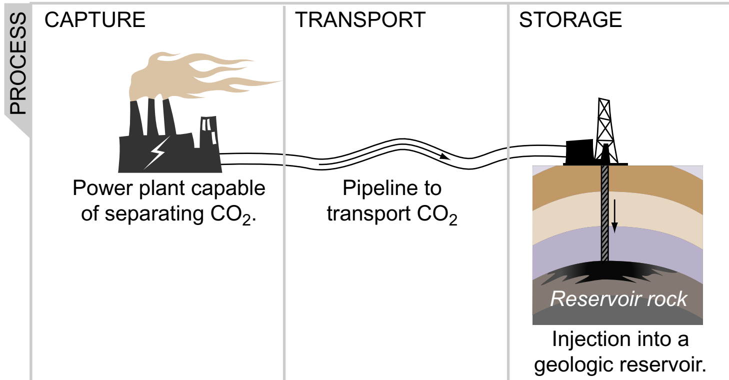
Low Carbon Coal

Carbon Capture and Sequestration

Alaska contains some of the largest coal reserves in the nation. If we choose to tap these reserves for potential power plants or coal-based fuel, we need to ensure that an appropriate balance is struck between power needs, cost, and environmental impact. Coal produces more greenhouse gases than any other energy source. The impact of these emissions is especially great in northern regions. Alaska is warming faster than the continental US, leading to eroding coastlines, warming salmon streams, melting permafrost, and receding glaciers. Technology to capture and store (sequester) carbon dioxide could potentially reduce some of the emissions associated with coal usage, but this technology is in its infancy, and faces major technological hurdles.

CHALLENGES OF CARBON CAPTURE AND SEQUESTRATION (CCS)



	CAPTURE	TRANSPORT	STORAGE
CHALLENGES	*CO_2 separation from coal combustion is expensive, still releases 10-30% of the CO_2, and would have to be combined with additional processes to remove other emissions.*	*Pipelines are expensive. Also, they present a danger to the public since escaped CO_2 can displace air and asphyxiate anyone breathing that air.*	*Reservoirs are scarce in some regions where many coal plants operate. Also it is difficult to predict the rate of leakage from a reservoir.*

What is Low-carbon Coal?

Low-carbon coal aims to prevent the carbon dioxide (CO_2) produced in coal combustion from entering the atmosphere and causing global warming. To achieve this, coal plants would use carbon capture and sequestration (CCS). They would capture CO_2, compress it to a liquid, then transport and store it away from the atmosphere (see Fig. 1).

Is CCS the same thing as "Clean Coal"?

The marketing term "clean coal" originated in reference to coal-fired power plants that implemented scrubbers to reduce emissions of the sulfur dioxides and nitrous oxides that contributed to acid rain. More recently, some people have used the term to refer instead to the idea of low-carbon coal. The capture and sequestration technology discussed here would only address the problem of CO_2 emissions and does not by itself affect the emissions of mercury, sulfur dioxide, and nitrous oxides.

"***Capture***" refers to removing carbon dioxide from the other combustion gases and getting it into a storable form.

Carbon capture units are expensive to build. Integrating carbon-capture technology into new power plants built with capture in mind is the most promising avenue, but there are still many hurdles to be overcome. For example, the proposed FutureGen zero emissions coal power plant in Illinois was scrapped when estimated costs reached $1.8 billion. However, retrofitting current coal-fired power plants is expected to be even more expensive due to mismatches in technology.

◇ Ninety nine percent of coal power plants in the US (including all of those operating in Alaska) burn crushed "pulverized coal" that produces a variety of gaseous emissions. CO_2 makes up only 10-15% of these emissions, so it becomes difficult and expensive to try to run all those gases through a filtration system, (i.e. a "stack scrubber"). Therefore it is unlikely that current power plants will be retrofitted with expensive carbon capture equipment.

◇ Coal can be "gasified" during chemical manufacturing. When the gasified coal is burned CO_2 makes up most of the emissions stream and it is easier to capture. However, coal gasification is expensive; this method was recently researched for using coal as feedstock at the Agrium

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fertilizer plant and was rejected due to cost. A similar process called integrated gasification combined cycle (IGCC) could be used to gasify coal for power. Unfortunately, in addition to the expense, IGCC pilot tests at coal-fired power plants in the US, including one at Healy, Alaska, have had significant technological problems.

◇ Coal can be burned in pure oxygen instead of air. It is expensive to produce the oxygen, but it is easier to subsequently capture the CO_2. A 12 MW pilot plant in Germany began operating in September 2008 using "oxyfuel" combustion and carbon capture and sequestration. The 3 year project is expected to power 1000 homes and cost $100 million, at a cost of $100,000 per home

"***Transport***" will likely be by pipeline from where the coal is burned to where the CO_2 would be stored. In the US, we currently transport about 50 million metric tons of CO_2 by pipeline annually. This CO_2 is produced in pure form by some industrial processes (so stack scrubbing is not needed), and is injected into oil and gas wells to enhance recovery. However, this existing capacity would need to increase to 3,600 million metric tons in order to move all the CO_2 produced in the US. Pipelines to carry CO_2 are very expensive, estimated to cost around $7 million for every 10 miles. Failure of a CO_2 pipeline would be potentially catastrophic. Escaped CO_2 can displace air and asphyxiate humans or animals breathing that air. Natural releases of CO_2 in the past have resulted in the death of forests, livestock, and humans.

"***Storage***" is currently being undertaken at a handful of natural gas and oil fields, where CO_2 is injected into wells to enhance recovery of the oil and gas. If CO_2 storage was to be undertaken on a large scale, more storage sites would need to be found, with both sufficient capacity and proximity to the power plants where CO_2 is burned. Any amount of CO_2 beyond what is useful for oil and gas recovery would be significantly more costly to store. Areas deep underground where saltwater fills rock pores, called "saline aquifers", may present more storage opportunity. CO_2 could also potentially be pumped into deep ocean trenches where it would pool and remain as a liquid. However, all of these options store CO_2 in its native form, allowing the possibility of a future accidental release. Releases on land pose similar hazards to a pipeline failure. Releases in the ocean would potentially acidify ocean waters and damage marine ecosystems. A more difficult but safer option is to react CO_2 with mafic rocks that have high amounts of iron and magnesium oxides, producing stable limestone-like rocks. However, this would entail mining at least two tons of rock per ton of coal burned.

The world's largest CO_2 sequestration project is located at the Sleipner gas fields (Norway), under the control of Statoil Hydro. The plant has pumped one million tons of CO_2/year since 1996 below the ocean floor of the North Sea, into a reservoir that is capped with impermeable rock that keeps the CO_2 from escaping. At this rate of sequestration, it would take 5-10 of these projects to store the CO_2 emissions of a single large full scale coal-fired power plant, and 1500 to store CO_2 emissions from all US coal power plants. There is only one sequestration project in the US: a chemical plant that gasifies coal to make methane, captures the CO_2, and pipes it to Canada for enhanced oil recovery.

CCS EMISSIONS

It takes power to run the carbon capture scrubbers and the compressors that move CO_2 to sequestration sites. This means 10-40% more coal needs to be burned to generate the same end use amount of electricity for consumers. Since not all pollutants would be captured with CCS technology, its implementation would most likely cause some emissions to increase.

◇ Mercury, SO_X and NO_X are emitted when coal is burned and CCS as such would not reduce these emissions.

◇ Ammonia emissions increase with some methods of CO_2 capture technology.

◇ CO_2 would still be emitted - about 10-30% of what a plant without CCS emits.

THE BIG PICTURE

Commercial scale CCS projects are not expected to deploy until 2030 at the earliest, and even then only 70-90% of carbon emissions would be available for capture. Climate experts say that in order to prevent major social and economic consequences of global warming (such as increased droughts, larger storms, impacts on fisheries, etc...) we need serious mitigation by 2015, long before CCS will be ready. Currently, CO_2 emissions are still increasing. In 2007, the US and China increased their CO_2 emissions by 2% and 7.5%.

FURTHER READING

Intergovernmental Panel on Climate Change. 2005. IPCC Special Report on Carbon Dioxide Capture and Storage. B. Metz, O. Davidson, H. de Coninck, M. L. L. Meyer (eds). Cambridge University Press. Cambridge, UK and New York, NY. 442 pp. http://www.ipcc.ch/ipccreports/srccs.htm

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