ENVIRONMENTAL EFFECTS FROM CCS

Environmental Effects related to the mining of coal

An additional energy consumption of 40% in the capture stage of CCS will lead to a relative increase in total coal consumption of 40%.

Mining of coal, which is the first step of the process, involves a broad spectrum of environmental effects that include

- Mechanical destruction of soil and water, housing areas, habitats for animals and plants etc.

- Destruction of miners' health (black lung disease, asthma, fatal accidents (floods, crashes, etc.), heart and other lung disorders)

- Noise (blasting, construction and operation of equipment)

- Coal dust

- Runoff and wastewater

- Coal slurry

- Leaching of heavy metals

- Air emissions from diesel and gasoline powered equipment, including:

- Carbon monoxide (CO)

- Nitrogen compounds (NOx)

- Sulphur compounds (SOx)

- VOCs (Volatile Organic Compounds) including methane (CH4)

- Particles.

Environmental Effects related to the transportation of coal

An additional increase of energy use of 40% at the capture stage of CCS will lead to a parallel increase in the volume of coal to be transported. Environmental effects resulting from transport will grow proportionally.

Transportation of coal, which is the second step of the CCS chain leads to air emissions primarily from diesel and fuel oil. The environmental effects depend on the mode of transport.

Emissions include:

- carbon monoxide (CO)

- nitrogen compounds (NOx)

- sulphur compounds (SOx)

- VOC (Volatile Organic Compounds)

- particles.

In addition, transport gives rise to accidents, noise and dust nuisances.

China

China is the world's largest coal producer with 49.5% of total world production.

Coal is the largest source of air pollution, the largest source of CO2 emissions and a major source of water pollution. Wastewater from the washing of coal accounts for 25% of all wastewater. 30% of China's land area is affected by acid rain, and the coal industry in 2007 had left 3.6 billion tonnes of tailings, which was 40% of all waste. [1]

In China, the transportation of coal is a huge environmental problem in itself. It takes place by truck, barge and rail. For example, 18% of coal production takes place in Mongolia, far from population centers and industrial centers closer to the coast.

USA

In the U.S., the cost of transportation of coal by rail is the largest share of the price of coal to the consumer. It requires a lot of energy, thus causing pollution and it is directly responsible for 400 deaths.

Alternatives

One alternative to transport by rail is the "mouth-of-mine" power plant where coal is running on a conveyor belt directly into the power plant and the electricity is then transmitted by power lines to consumers. It can reduce transport costs by 45%, but it increases CO2 emissions by 45% as it requires more electricity to compensate for transmission losses in the network. [2] Lack of water can be a hurdle for "mouth-of-mine" plants. [3]

Coal is transported over long distances around the world primarily via ship or rail. But the very large domestic shipments are not reflected in the two tables below of the ten largest coal-exporting and importing countries. U.S. exported for example 83 Mt in 2010, but produced 993 Mt. China exported 23 Mt and imported 195 Mt, but China's own production was 3,520 Mt.

Top Coal Exporters 2010 [4]	
Australia	328 Mt
Indonesia	316 Mt
Russia	122 Mt
U.S.	53 Mt
South_Africa	77 Mt
Colombia	76 Mt
Canada	37 Mt
Kazakhstan	36 Mt
Vietnam	25 Mt
China	23 Mt

Top Coal Importers	
Japan	207 Mt
China	195 Mt
South Korea	126 Mt
India	102 Mt
Taiwan	71 Mt
Turkey	30 Mt
UK	29 MT
Italy	48 Mt
The Netherlands	46 Mt
(Mt = Million tonnes)	

Sources:

[1] Greenpeace: The True Cost of Coal

[2] Joule A. Bergerson, Lester B. Lave: Should We Transport Coal, Gas or Electricity: Cost, Efficiency & Environmental Implications.

[3] Union of Concerned Scientists: How Coal Works - briefing

[4] EIA (via Wikipedia august 2012)

Environmental Effects related to feasibility studies

Creating a CCS storage requires a series of surveys to determine whether the underground is suitable for storage of CO2.

Conducted onshore such surveys may involve explosions, drilling and operation of heavy equipment containing a number of immediate environmental effects such as crop damages, noise and air emissions.

Environmental Effects related to the construction of a CCS plant

CCS facilities are huge physical installations - often the size of the power plant itself. The CCS plant that was planned at Mongstad in Norway (cancelled in 2013), for example, would have required an area the size of 20 football fields.

Construction of a CCS plant involves a series of environmental impacts associated with

- Production, processing and transport of iron, steel, aluminium, cement, etc.,
- Excavations,
- Construction of buildings,
- Manufacture of machinery,
- Setup of machinery.

Environmental effects are emissions to air, waste water, noise and visual degradation of landscape, etc. These effects are inevitable with CCS and should therefore be included in full on the debit side of the environmental accounts of the technology (extra environmental load).

Energy and raw material consumption and associated environmental impacts during the construction phase depend on the size of the CCS plant.

Environmental Effects related to the operation of a CCS system

The operation of a CCS installation involves environmental effects associated with processes designed to make the CO2 stream fit for transport and storage underground. Such processes can, depending on the type of CCS technology, imply combustion, cleansing of gases, CO2 separation, compression and pumping.

In the case of oxyfuel CCS, atmospheric nitrogen is removed, so that combustion can take place in an atmosphere of pure oxygen. The extra energy, these processes involve today equals around 40%. I.e. 40% more fuel is demanded for the power plant to deliver the same energy output with CCS as without CCS, which increases the environmental impacts in all stages of the process.

Environmental effects of the operation of CCS plants are predominantly linked to energy consumption and related emissions to the air. Such effects cannot be avoided in the CCS system and should therefore be fully included on the debit side of the environmental account in relation to CCS (discharge of waste, greenhouse gases, etc.).

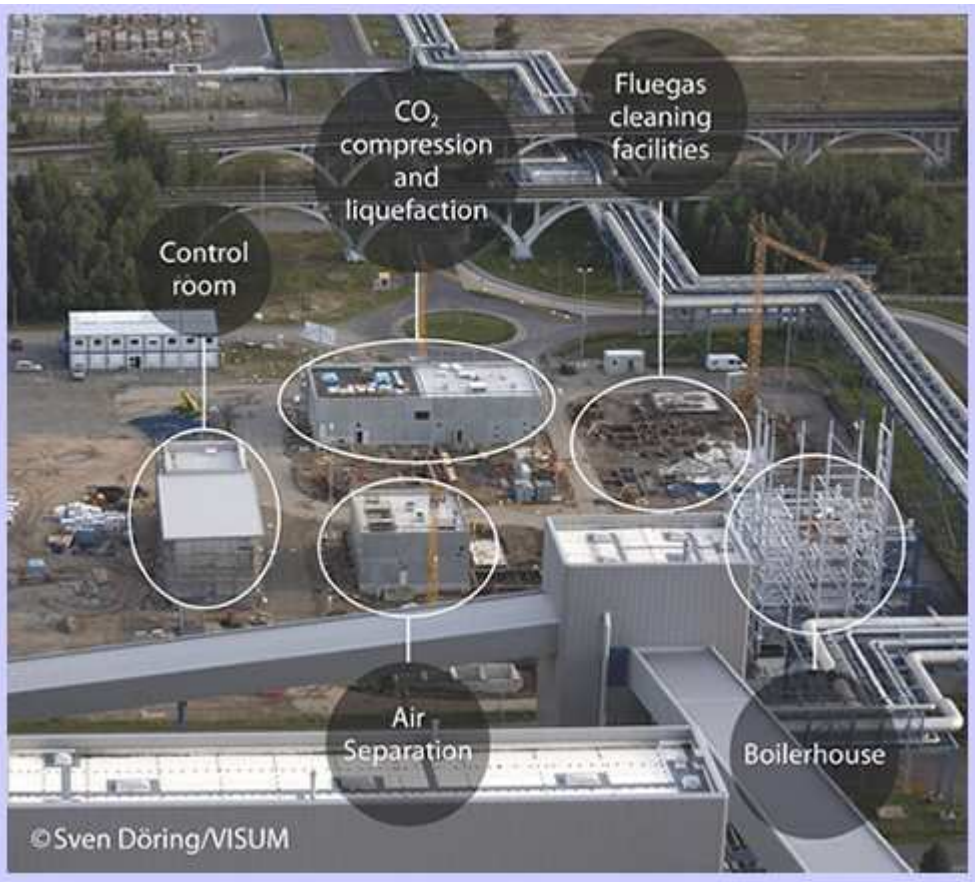
Further on a significantly increased consumption of water will be a consequence of CCS.

"*NETL [DOE's National Energy Technology Laboratory] analyses indicate that efforts to capture 90 percent of carbon emissions by using current near-commercial carbon capture and storage (CCS) technologies on PC plants would more than double the amount of water consumed per unit of electricity generated*."

(STATEMENT OF CARL O. BAUER DIRECTOR NATIONAL ENERGY TECHNOLOGY LABORATORY, March 2009).

Energy consumption and associated environmental impacts during the operational phase of CCS depend on the size of the CCS plant.

The picture below shows Vattenfall's 30 MW pilot plant Schwarze Pumpe in Germany. New coal fired power plants are at least 600 MW – 20 times larger than Schwarze Pumpe. So it is very large industrial complexes that are being planned.



Environmental effects related to the building of transport infrastructure

The majority of the captured CO2 is assumed to be pumped in liquid form under high pressure from the capture part of the power plant all the way to the storage (onshore or offshore) through a pipeline – a smaller part may be pumped to ports where it will go onto tankers. In the latter case the liquid CO2 is carried to injection sites at sea. A smaller fraction is expected to be transported by tanker trucks or trains.

Environmental effects associated with the building of CO2 infrastructure are related to consumption of energy in extraction and transport of iron ore and the steel production. (Predominantly emissions to air and the pollution connected with mining).

These effects are inherent in the CCS system and should be fully included on the debit side of the environmental account of the technology. Energy consumption and associated environmental effects related to building of transport infrastructure primarily depend on the distance between CO2 sources and stores.

The capture part of a plant is in itself a large industrial plant, but a transport infrastructure able to move the quantities of liquid CO2 anticipated in the most optimistic scenarios will be enormous.

IEA points out that in the long run, **the total CO2 transport could be of the same order of magnitude as the current transport of all existing goods put together**. Therefore, the challenge of establishing appropriate transport of CO2 should not be underestimated.

IEA. 2004. Prospects for CO2 Capture and Storage. Energy Technology Analysis. (Page 80)

Environmental effects related to transportation and injection of captured CO2

Once CO2 is captured, purified and compressed it needs to be transported from the plant through a pipeline network or otherwise to the storage area where it will be pumped into the underground from an injection plant.

Environmental effects associated with transportation and injection of captured CO2 are related to energy consumption in boosting, operation of tankers, pumping etc.

Risks for people and animals

CO2 is an odorless gas that poses a danger to humans and animals. At concentrations above 10%, it is fatal. As the gas is heavier than air and in case of unintended releases it will accumulate in hollows or basements and here pose a real danger.

J. Barrie, K. Brown, P.R. Hatcher and H.U. Schellhase:

CARBON DIOXIDE PIPELINES: A PRELIMINARY REVIEW OF DESIGN AND RISKS

This paper discusses the risks that may be in the transport of CO2 and the precautions that needs be taken.

Environmental effects related to CO2 storage

The captured CO2 is stored in deep geological formations after transport from the plant. The storage requires monitoring and maintenance, which in itself will involve (minor) environmental impacts.

The potential environmental effects associated with the storage are primarily related to the risk of leakage of CO2 into groundwater and the marine environment.

The risk of leakage to the atmosphere is according to the IPCC not high: "The special report suggests that geological storage is very likely to result in 99 per cent of the carbon dioxide (CO2) being retained over 100 years, and is likely to result in 99 per cent of the CO2 being retained over 1,000 years."

However, it is an open question what weight should be attached to these reviews because we have seen throughout history that technical expert assessments have been quite misleading because the real world is much more complex and unpredictable than first thought. Serious accidents in the chemical industry and the nuclear power industry (Chernobyl, Fukushima) show this.

Another, more fundamental change in environmental policy, would be the legalization of the use of the underground as landfill. It is uncertain to what extent the authorities will permit substances other than CO2 to go with the liquid CO2-stream into the underground (what purity must be demanded of the deposited CO2?).

This would make possible a fundamental change in the current waste strategy, which requires the amount of waste (fly ash, sulphur, CO2, etc.) to be minimized, and that efforts as far as possible are directed towards the source – i.e. less coal burning versus the 40% increase that CCS entails.

The risk to humans and animals

It should also be mentioned that CO2 concentrations in excess of 10% is fatal to humans and animals, which implies that there is a theoretical risk associated with future CO2 storage of fatal environmental effects of sudden massive leaks caused by e.g. pressure-induced cracks or earthquakes.

The debate about who should be responsible for the storage, it is often mentioned that there is a theoretical risk that the injection of CO2 in itself can trigger earthquakes due to the changes in pressure conditions in the subsurface.

In December 2008, an area 15 kilometers north-east of Ystad, Sweden was hit by an earthquake measuring 4.7 Richter. Whether quakes of this strength carry risks of leakage from CO2 storage is unknown.

In August 1986 a dramatic leak from a natural source took place at Lake Nyos in Cameroon in which 1,700 people and 3,500 livestock died from suffocation. See this link.

The risk to humans and animals is probably greater in transport through pipelines. (See above)