The Economics of CCS

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April 01, 2019

Presentation plan

What is CCS?

- Methods for capturing CO_2

Why CCS is important?

Economic drivers of CCS - a basic approach

What is CCS?

- CCS is a technology that comprises the separation of CO_2 from industrial- and energy-related activities and the transportation to storage locations such as saline aquifers and depleted oil and gas reservoirs
- Its main goal in this regard is to prevent CO_2 emissions from entering the atmosphere.

- CCS can be used by large stationary point sources such as fossil fuel-fired power plants and emission-intensive industrial facilities.
- The rates of carbon captured can be as high as 85–95%.
- There are three methods for capturing CO_2.
    1. *Post-combustion* carbon capture
    2. *Pre-combustion* carbon capture
    3. *Oxy-fuel combustion process*

Methods for capturing CO_2

- *Post-combustion* carbon capture removes carbon from coal fired power generation or natural gas combined cycles after combustion. Here, CO_2 is separated from the flue gases using a liquid solvent.

Post-combustion carbon capture)

Burning of coal

Post-combustion carbon capture

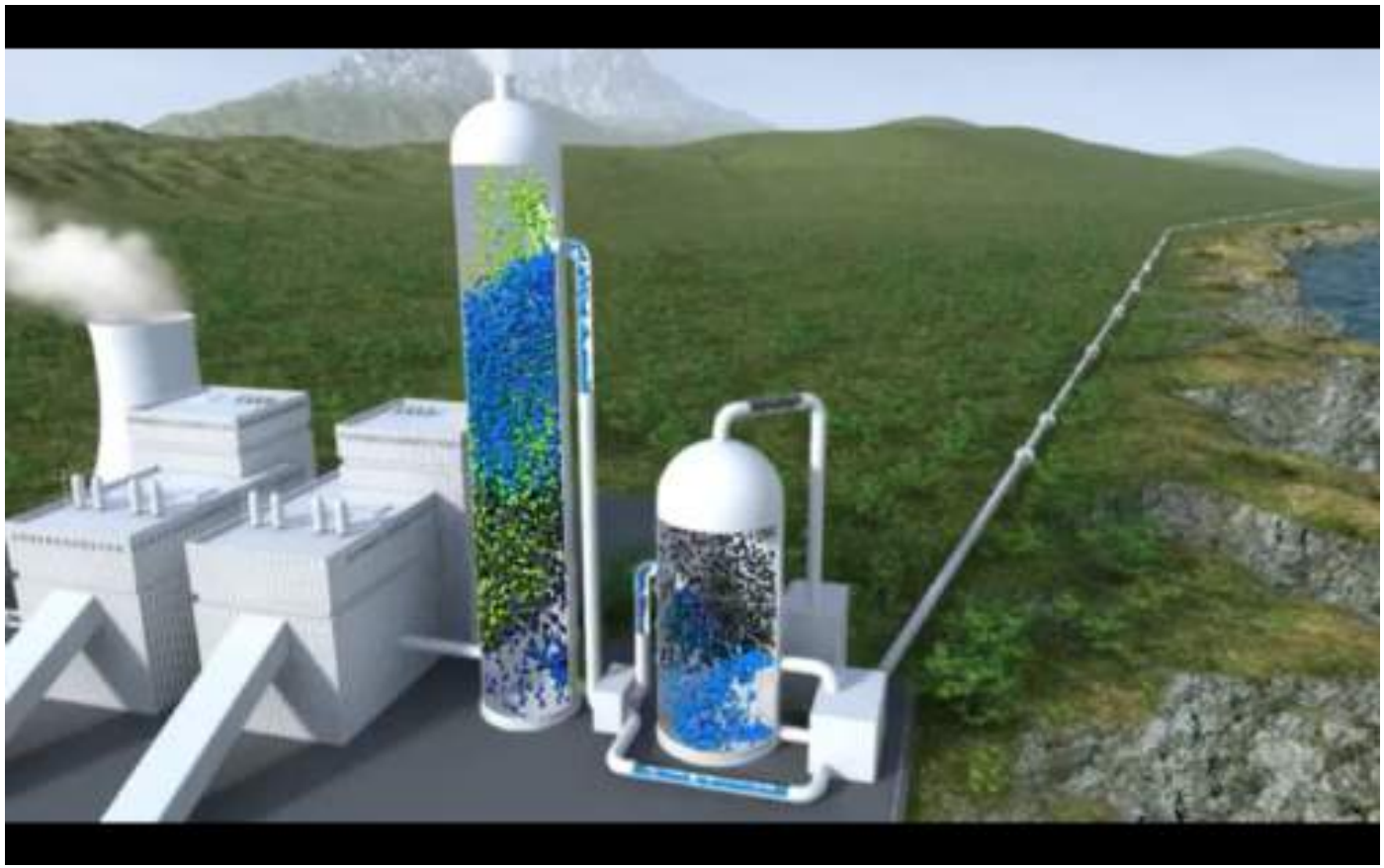
CO_2 emissions upon combustion

Post-combustion carbon capture

Emissions can be eliminated by implementing CCS

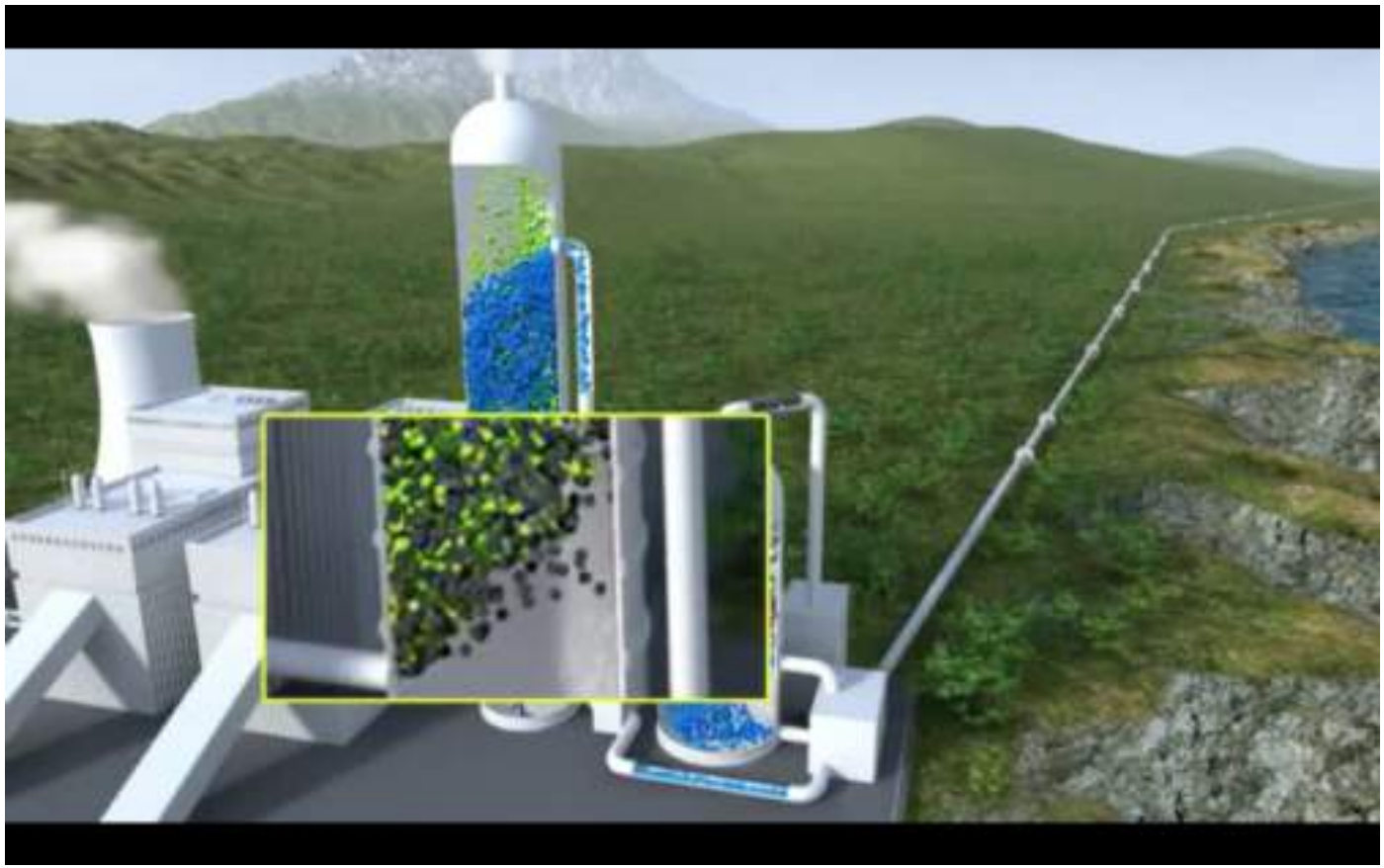
Post-combustion carbon capture

The cleaning system: the flue gas enters the first tank of the CO_2 capture plant.



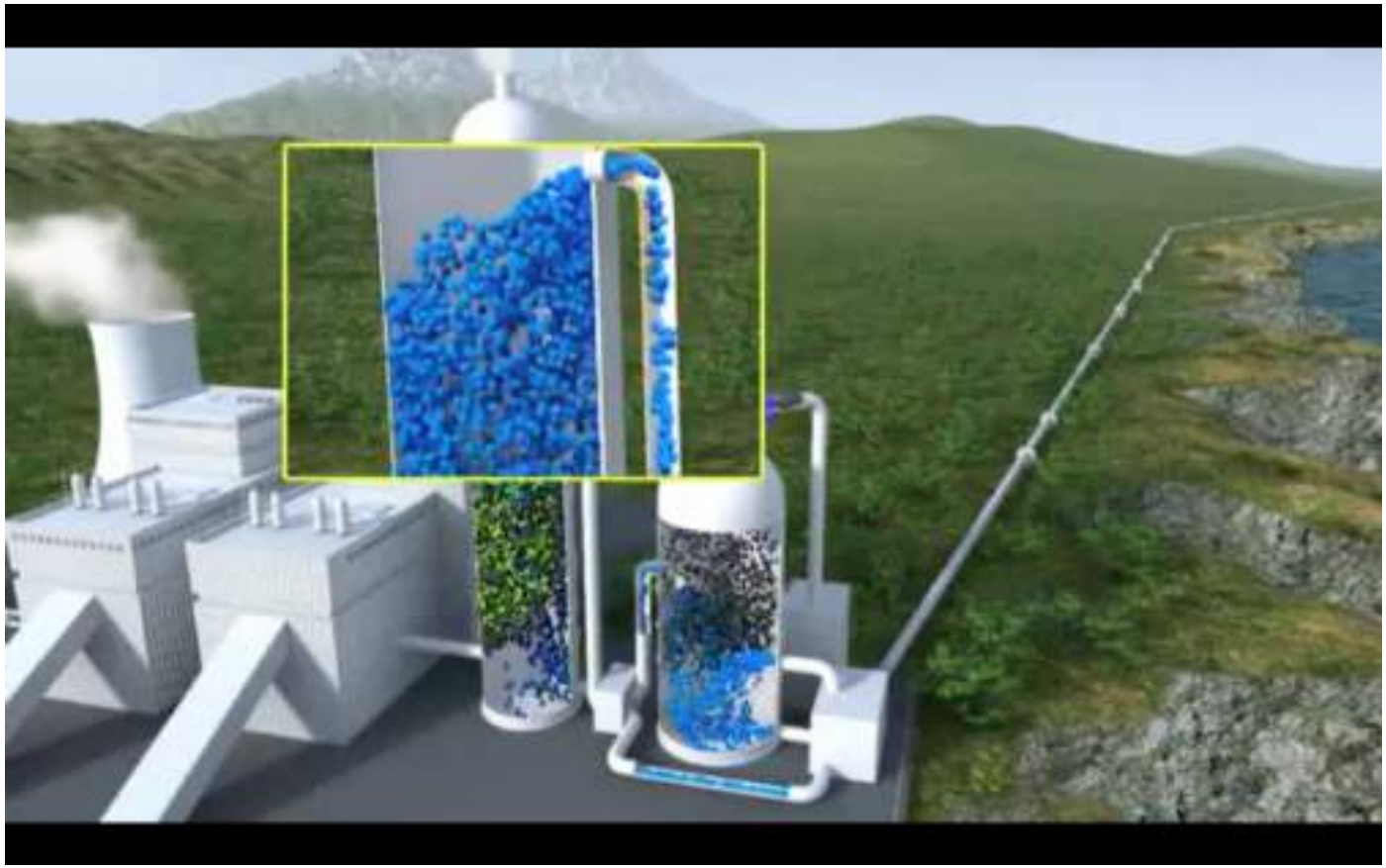
Post-combustion carbon capture

It mainly consists of CO_2 (black particles), nitrogen and water vapor (green particles).



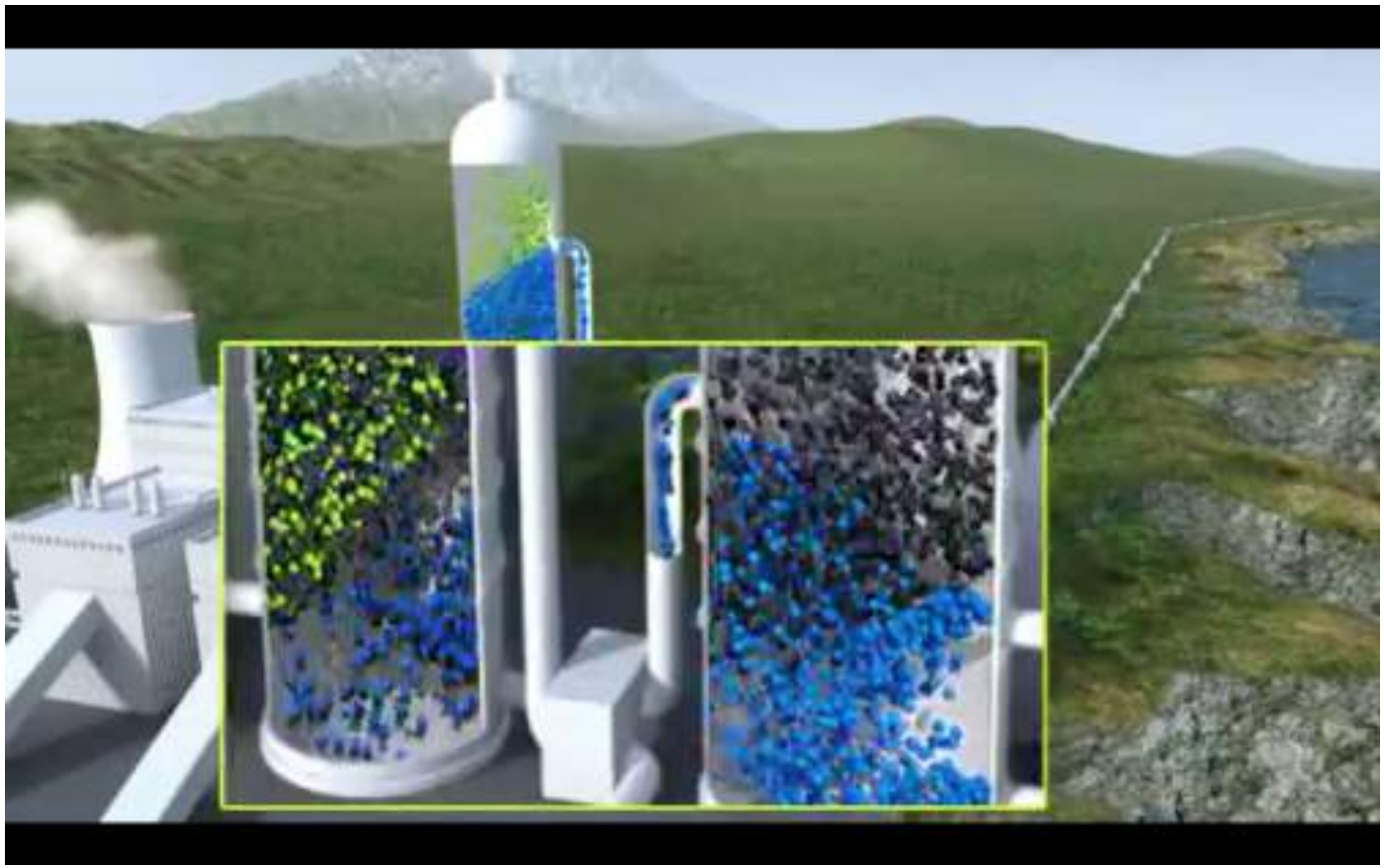
Post-combustion carbon capture

Blue particles entering the top of the capture plan are a chemical –also called solvent– that can react with CO_2



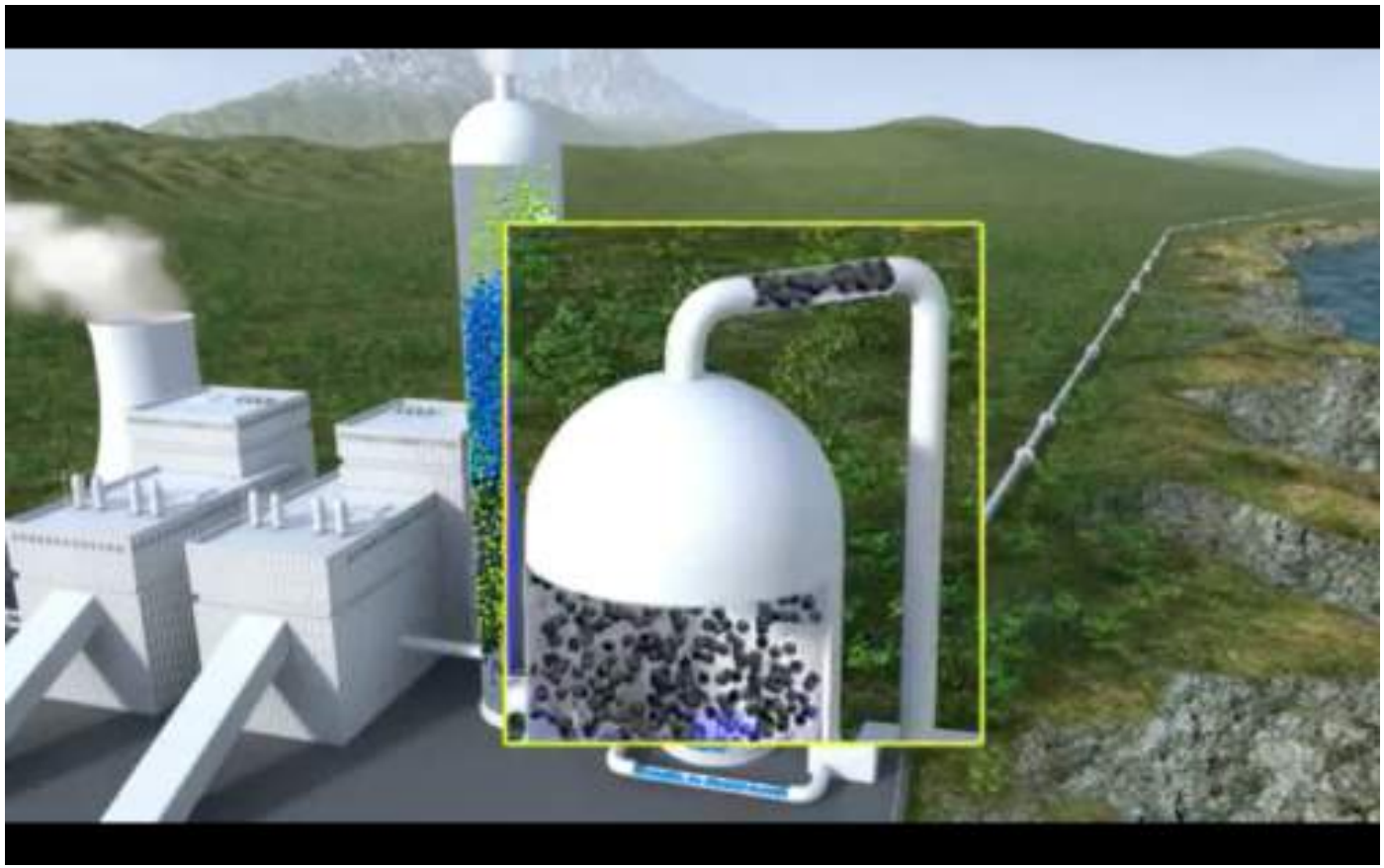
Post-combustion carbon capture

Once the solvent is reacted with CO_2, it leaves the first tank and is pumped in to the second tank



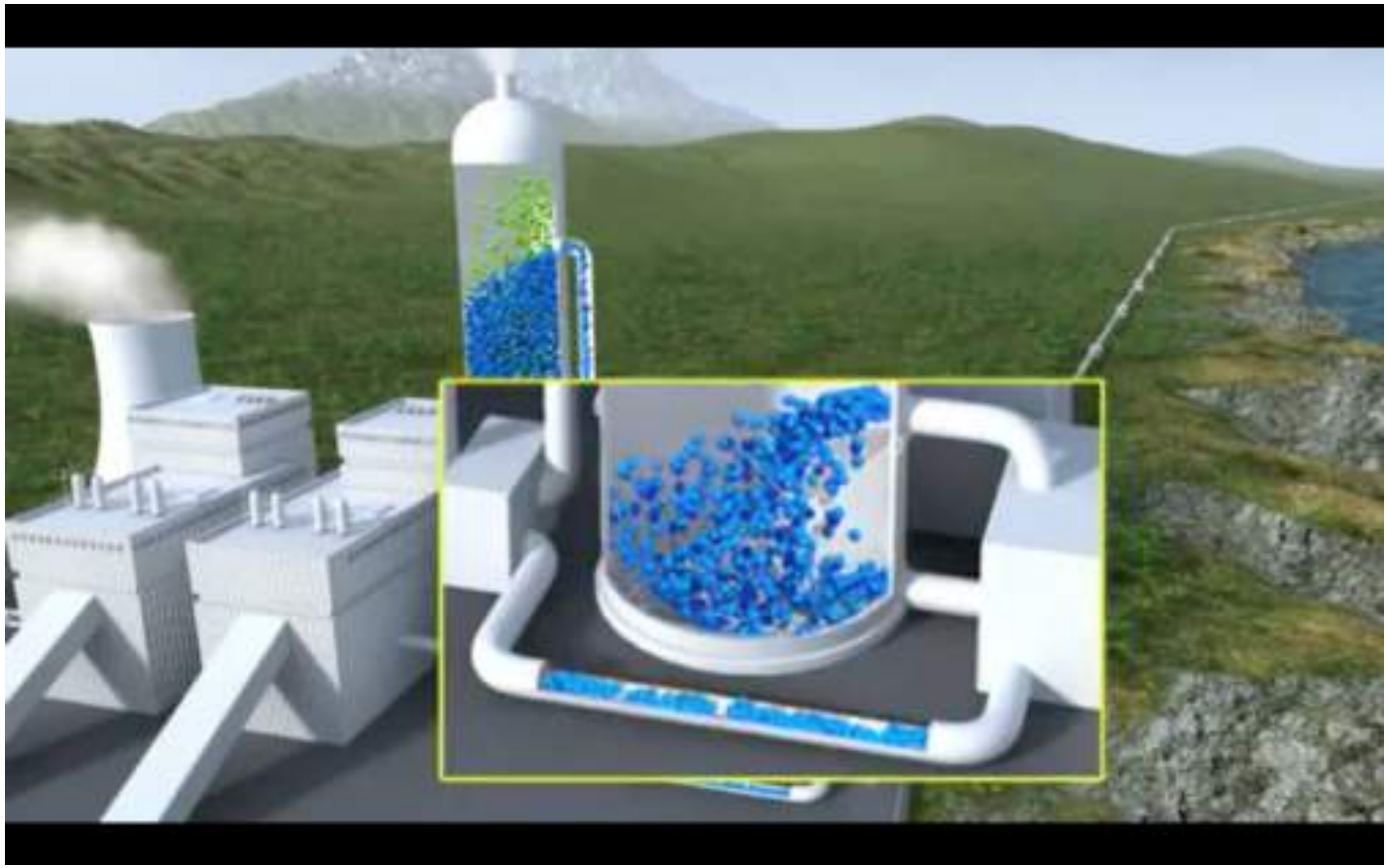
Post-combustion carbon capture

To separate CO_2 from the solvent, the solvent is heated (*requires a lot of energy*).
This process produces a gas stream of CO_2 and...



Post-combustion carbon capture

...a liquid stream of pure solvent

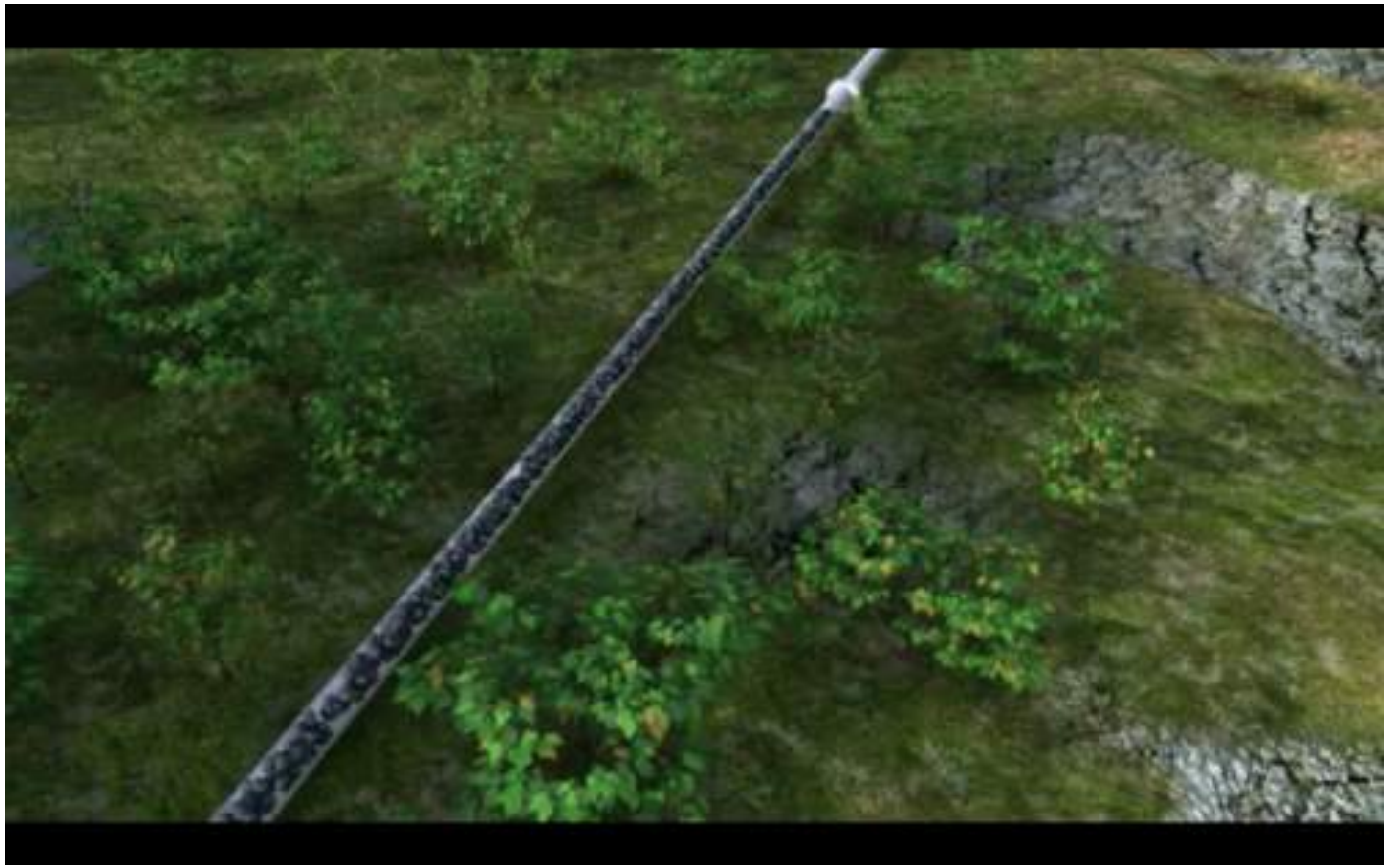


Post-combustion carbon capture

Pure CO_2 leaves the top of the tank...

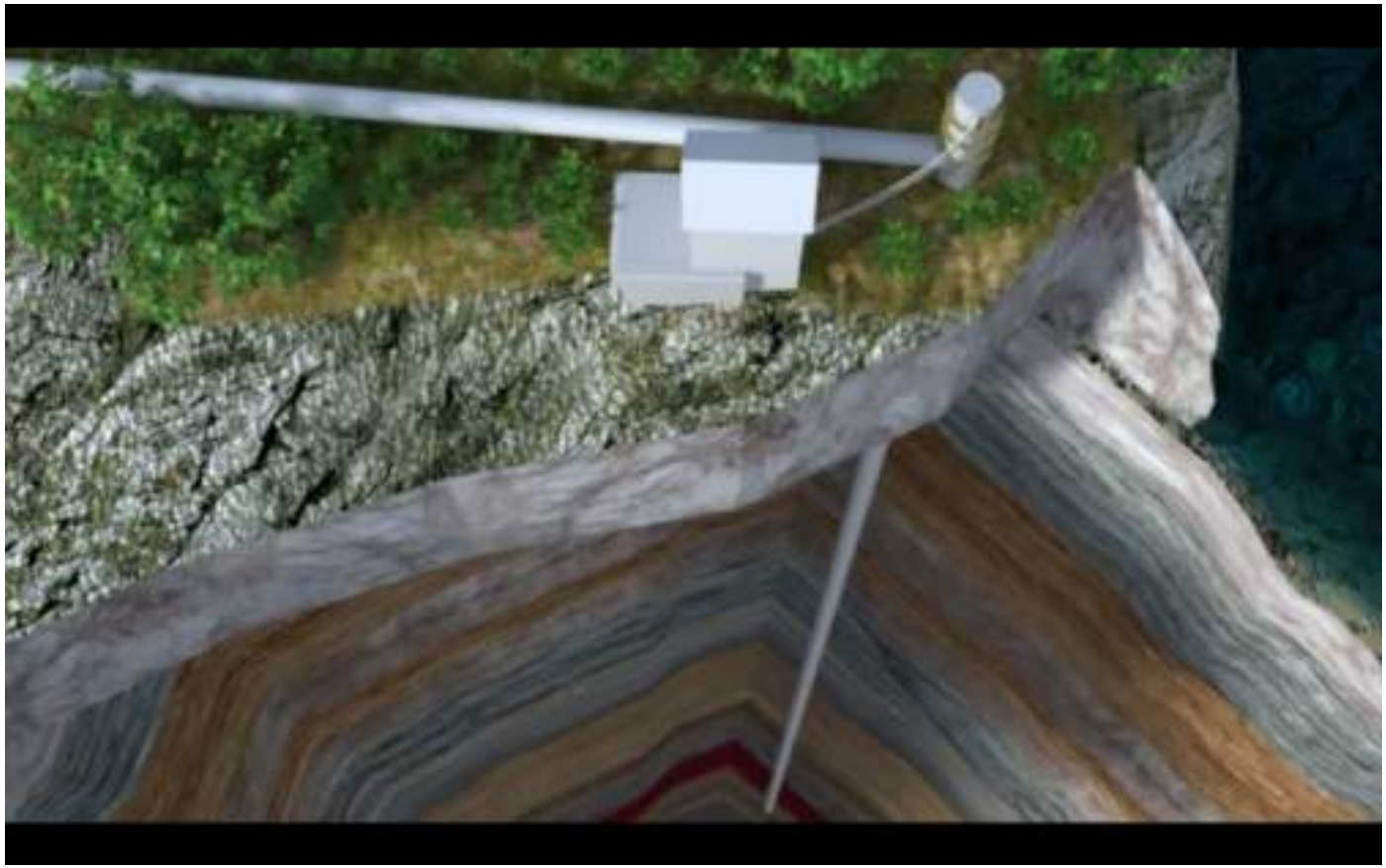
Post-combustion carbon capture

...is compressed and transported, ...



Post-combustion carbon capture

...and injected to convenient storage locations such as porous rock formations.



Methods for capturing CO_2

- In *pre-combustion* carbon capture, fuel is pretreated and converted into a mix of CO_2 and hydrogen. The hydrogen is then separated from the carbon before being burned to produce electricity.
- In the *oxy-fuel combustion process*, the fuel is burned using oxygen rather than air. The result is a flue stream of CO_2 and water vapour. Because no nitrogen is present, CO_2 can be easily removed

Cost estimates for CO_2 avoided:

- Post-combustion CO_2 capture from coal-fired power generation using amines (58 USD_{2010}/tCO_2 - 63% mark-up)
- Pre-combustion CO_2 capture from integrated gasification combined cycles (43 USD_{2010}/tCO_2)
- Oxy-combustion CO_2 capture from pulverized coal power generation (52 USD_{2010}/tCO_2)
- Post-combustion CO_2 capture from natural gas combined cycles (80 USD_{2010}/tCO_2)

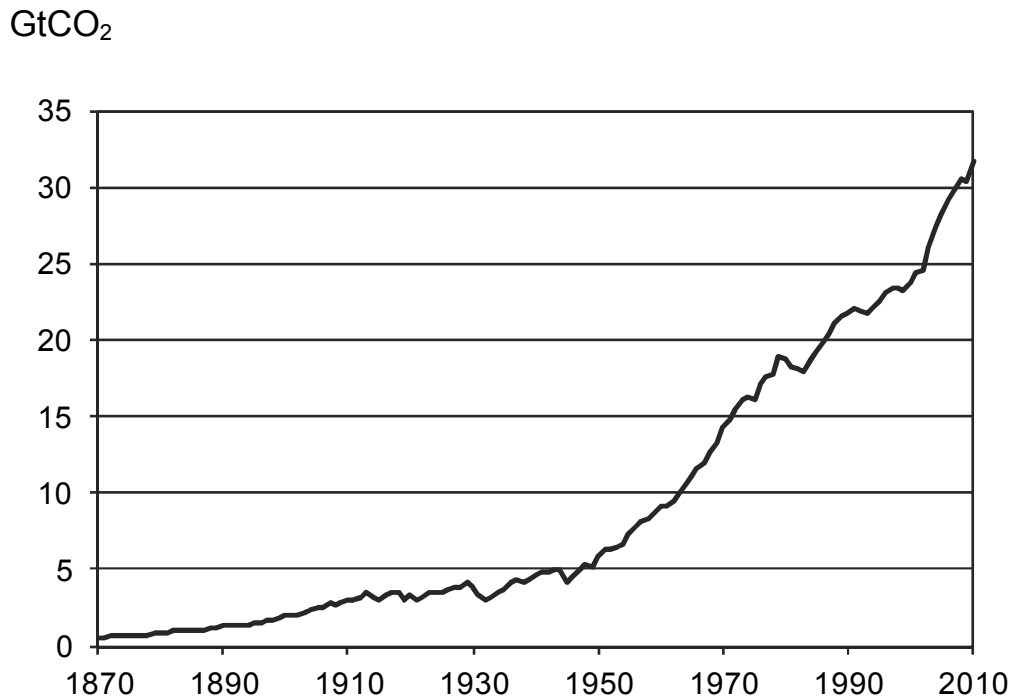
Why CCS is important?

Greenhouse effect (GE)

- Earth's surface would be below the freezing point of water if it was not for the GE
  - GE is a process by which the solar energy that reaches the Earth's surface is radiated back and partially absorbed by the atmosphere, making the atmosphere and hence the earth's surface warmer (**??**).
- GE originate from greenhouse gases (GHGs).
  - CO_2 is the primary GHG emitted through human activities
  - It has hundreds of years of atmospheric lifetime.
  - Thus, adding more of CO_2 to the atmosphere intensifies the GE and warms the Earth's climate.

- More than half of the observed increase in global average surface temperature caused by the anthropogenic increase in GHG concentrations (IPCC).
- Rising global temperatures, which change the Earth's climate, has already started to take its toll
  - retreat of glaciers
  - increased surface melting of the Greenland ice sheet
  - global mean sea level rise
  - extreme weather events such as higher incidences of heat waves / destructive storms / changes to rainfall patterns.
- Unless GHG emissions decrease substantially, there will be further warming, long-lasting changes in all components of the climate system, and severe, pervasive and irreversible impacts for people and ecosystems (**?**).

- Yet, the share of fossil fuels within the world energy supply is relatively unchanged over the past 40 years.
- These fuels still supply over 80% of all primary energy needs and will remain the dominant source of energy for the decades to come (**?**).
- Current trend in CO_2 emissions from fossil fuel combustion. Source: **?**:



- Current trend of the CO_2 emissions and the dominant role that fossil fuels maintain can prove disastrous for future generations unless.
- Given that fossil fuels will continue to supply a major share of energy needs, CCS appears to be the only technology that can substantially reduce CO_2 emissions (**?**).

Important role envisioned for CCS

- Several international and intergovernmental agencies, including IEA, IPCC, EIA, envision an important role for CCS and recommend its use in order to achieve the environmental goals.
- To bring down GHG emissions to 50% of their 2005 level by 2050, **?** shows that about 20% of the reductions should come from CCS activities.

- IEA Energy Technology Perspectives (2012)
  - Under the 2DS, CCS contributes one-sixth of CO_2 emission reductions required in 2050, and 14% of the cumulative emissions reductions between 2015 and 2050 (compared to 6DS)

- Yet, the progress in CCS is slow and far below than what is required to limit the global temperature rise to 2°C (**?**).
- The technology still absent in a number of key industrial sectors (iron, steel, cement...)
- Even though CCS is a key (carbon intensive) technology,
  - what can be the reason for these technologies not to have had an international breakthrough?

Economic drivers of CCS - a basic approach

Bibliography