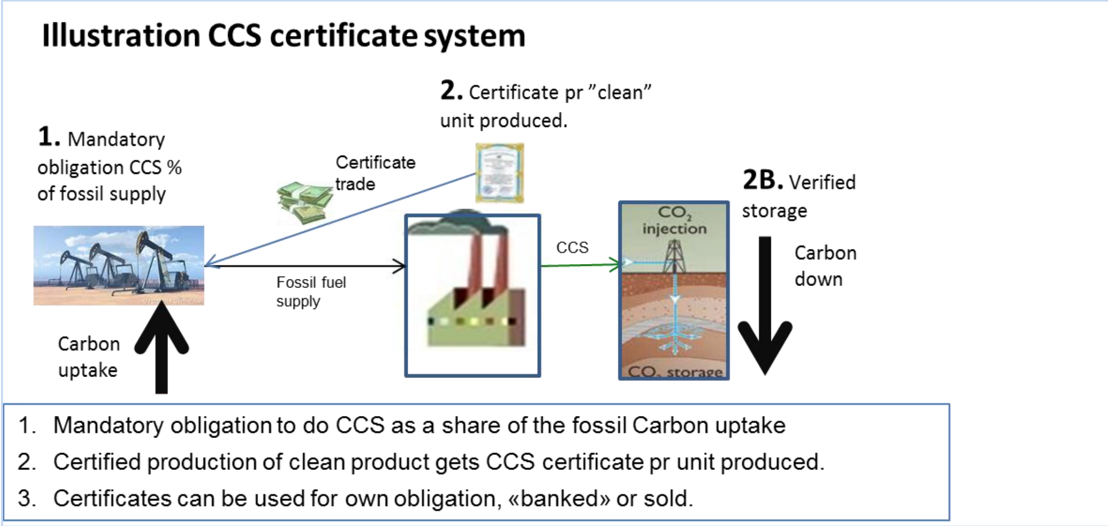
Appendix: How to design a certificate system for large scale CCS

The logic of a CCS certificate system is simple: if you take carbon up from the ground you are obliged to capture and put a share of it back into the ground. The core element is a yearly target for the volume of carbon and a legally binding amount of certificates that each obliged company has to deliver.



For a more detailed illustration, see Appendix I.

The main issues for designing a certificate system are:

- Who will get the certificate obligation (who shall pay for them)
- Who will receive the certificates (who will get paid to do ccs - which industries to cover)
- Quota obligation, escalation plan
- Certificate mechanism/design to ensure a well-functioning system
- Geographical scope

Who will get the certificate obligation (who shall pay)

Producers of fossil fuels[1] are obliged to have certificates equivalent to a certain percentage of their embedded emissions, calculated on the basis of the carbon content of their fuels sold in the EU. Import of fossil fuels gets the same obligation as production inside the certificate area. The companies can receive certificates by doing CCS themselves, by cooperating with other companies, or by buying certificates from other CCS projects. The cost for the certificate will be included in the fossil fuels value chain.

Who will receive the certificates (who will get paid)

The CCS certificate is given to production of "clean" products from certified facilities with verified storage[2]. The certificate amount is calculated on the basis of the product benchmark

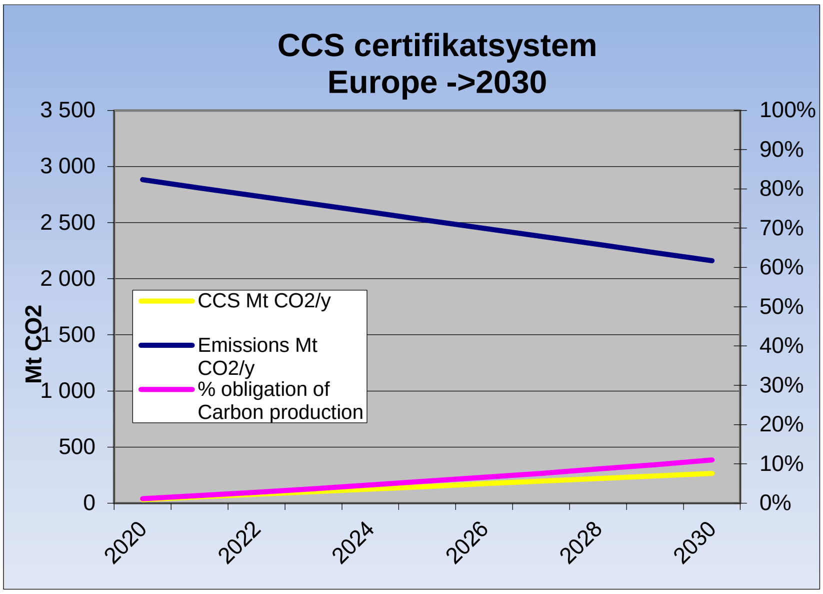
[1] Carbon uptake from mining for industry use such as cement may be considered to be included. Shared obligation between carbon uptake and the emissions source can also be possible.

[2] According to the CCS storage directive.

for emissions from each production type already made for free allocation to the industry in EU ETS (Table, se Appendix).

Quota obligation and escalation plan
The quota obligation should be set in line with the 2°C target, with a yearly[3] increase. With an implementation in 2015, the first year of operation could be 2020. This allows companies sufficient time to plan and build the first projects within the first year of certificate obligation[4].

Based on the numbers from the IEA WEO 450 ppm scenario and IEA CCS Roadmap, the graph below shows a scenario for quota obligation for a CCS certificate system in Europe:



2020: ~2,9 Gt CO2 emissions & 30 Mt CCS, 2035: 1,8 Gt CO2 emissions & ~380 Mt CCS.

Certificate mechanisms and design to ensure a well-functioning system

Duration

Long term predictability is necessary to ensure investments in large CCS projects. Start-up can be realistic in 2015 and the first CCS projects in operation financed by the certificates in 2020. Duration to 2030[5], will then give a 10 year up-scaling period from 2020-2030. The future need for a certificate system after 2030 can be evaluated together with the results from ETS and other climate instruments.

Penalty in case of insufficient amount of certificates

[3] The period between each certificate delivering could be longer than 1 year to increase the flexibility for the companies. A longer period before certificate delivery and penalty cost may give less incentive for early investments.

[4] Some projects can be completed faster than within 5 years, so the first year with obligation could be earlier.

[5] After the final year, a period of 15 years is needed to complete the certificate period for all projects. This is how it is done in the Swedish-Norwegian renewable certificate system where the projects receive certificates for the first 15 years of production. This is for a shorter period than the lifetime of the projects, but enough to make projects economical for investment decisions. Income after 15 years has little influence on NPV, and it limits the total cost for the system. CCS projects will have extra operation cost and it may be a risk for the project to stop capturing the CO2 if the certificates ends. This can be solved by including an obligation to continue CCS or by giving the projects certificates for all years of operation.

Each year the companies have to deliver the obliged amount of certificates[6]. A penalty for not delivering is needed to ensure sufficient investment to avoid penalty.
One possible design of a penalty is to increase the amount of certificates to be delivered next year in addition to a fee[7] to a CCS fund[8].

Early starter risk and floor price

There is a risk of under-/oversupply of certificates, resulting in price uncertainty. This can be a major challenge in the beginning with a small volume of certificates. One design to provide security for investments is to have a floor price for a start period/volume[9] e.g. for the volume for the first year of obligation (e.g. 30 Mt in 2020).

Obligatory CCS fund/pool to ensure investments

To reduce the policy risk of investments in CCS projects not going ahead, a mandatory obligation for the companies to either build CCS themselves or to participate in a common CCS fund/pool could be a solution. The fund/pool will invest in CCS projects delivering the needed amount of certificates to the companies in the pool. This can be organized fully by the companies participating, or there could be government involvement[10].

Relation to EU ETS

A swift integration with the EU ETS system is simply by reducing the amounts of ETS allowances as the volume of CCS certificates increase. A practical solution will be if the companies who receive the CCS certificates have to deliver ETS allowances for the same volume in return, to be permanently withdrawn from the ETS.

Geographical scope

A CCS certificate system is well suited for international cooperation. The certificates issued in one country can be used to fulfil the obligation in another country with free trade of certificates across borders. This will increase the flexibility and cost effectiveness, but can be more politically challenging to establish.
A certificate system can also be used to fund CCS deployment in development countries. A limited part of the obligation can be fulfilled with certificates from CCS projects in specific developing countries[11].

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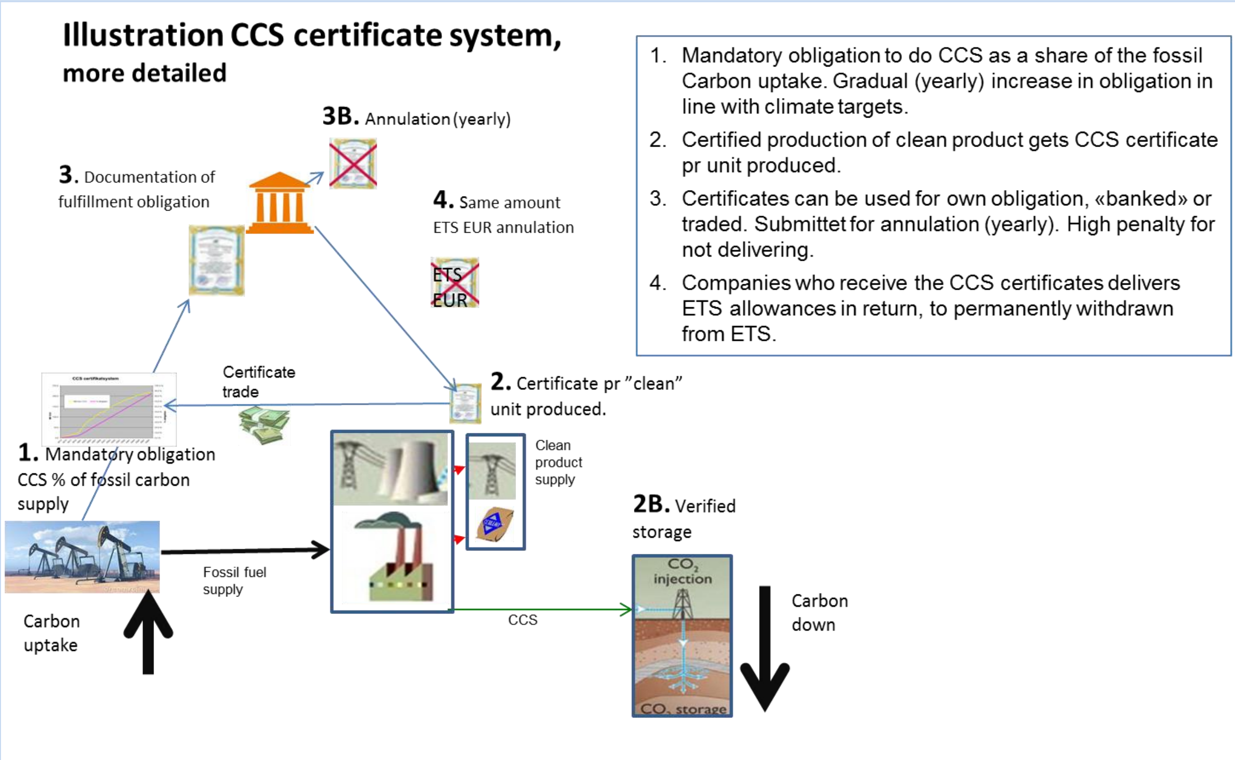
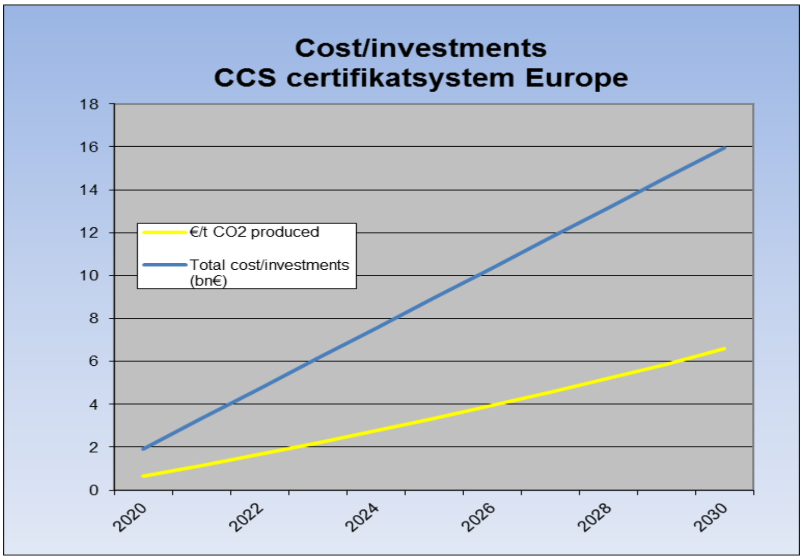
[6] The Union Registry can be used as the certificate administration system (?)
[7] E.g. 120 % obligation at next delivery date and fee of 50 €/certificate. Another design of the penalty is 150 % of the average price for all certificates trading the last year, as in the Swedish-Norwegian renewable certificate system.
[8] A CCS fund can be used for investments in CCS infrastructure to get more projects up and running.
[9] In the first two years of the Swedish renewable electricity certificate system, a top- and floor price was used to reduce the price risks. This can be used also for a CCS certificate system, at least the floor price to reduce the price risks for investments. Top price to reduce price risks for buyers of certificates can have the adverse result in setting the price level for certificates. Since the certificate buyers are companies in position to do CCS themselves, this is not needed.
[10] This can be done for the start-up phase, but can also be permanent to ensure sufficient investments and reduce risks and challenges for smaller companies with certificate obligation. This fund/pool can possible be the buyer of the floor price.
[11] This can be limited to projects done by the obliged companies themselves in developing countries.
It can also be possible to have a common system with a “discount” for the CCS obligation in the developing countries.

Appendix I. Illustration CCS certificate system



Appendix II. Example of cost (investments) for certificate system Europe

This graph shows a simple calculation for the cost/investments for a CCS certificate system in Europe, based on the numbers from IEA WEO 450 ppm scenario and IEA CCS Roadmap, as showed for quota obligation graph.



Obligation and CCS amount from the IEA WEO 450 ppm emission scenario, and the IEA CCS Roadmap (2009).Cost for CCS used in this simple calculations: 60 €/t CO2 in average for all the projects for the whole period[12].

[12] Cost for CCS from different emissions sources and over time will vary. Economy of scale and technology development will bring cost down over time, while the cost for the first projects will be higher. 60 €/t is in the higher range of cost estimate from IEA CCS Roadmap 2013, from 40-80 $/t.

Appendix III. Product benchmark CCS certificate table

The amount of certificates per product is based on the numbers for carbon emissions per industry product from product benchmark for the free allocation in ETS[13]. The benchmark principle is 'one product = one benchmark', from the top 10% installations of conventional plants. This means the benchmark methodology does not differentiate according to the technology, fuel used, size of an installation or geographical location[14].The benchmarks level is then multiplied with the capture rate (in percentage) to get the CCS certificate numbers for each installation[15].

Product benchmark	Definition of products covered	Certificates /ton product
Coke	Coke-oven coke (obtained from the	0,286
Sintered ore	Agglomerated iron-bearing product (	0,171
Hot metal	Liquid iron saturated with carbon for	1,328
Pre-bake anode	Anodes for aluminium electrolysis u	0,324
Aluminium	unwrought non-alloy liquid aluminiur	1,514
Grey cement clinker	Grey cement clinker as total clinker	0,766
White cement clinker	White cement clinker for use as ma	0,987
Lime	Quicklime: calcium oxide (CaO) prc	0,954
Dolime	Dolime or calcined dolomite as mixt	1,072
Sintered dolime	Mixture of calcium and magnesium	1,449
Float glass	Float/ground/polish glass (as tons c	0,453
Bottles and jars of colourless glass	Bottles of colourless glass of a nom	0,382
Bottles and jars of coloured glass	Bottles of coloured glass of a nomir	0,306
Continuous filament glass fibre produc	Melted glass for the production of co	0,406
Facing bricks	Facing bricks with a density > 1000	0,139
Pavers	Clay bricks used for flooring accordi	0,192
Roof tiles	Clay roofing tiles as defined in EN 1	0,144
Spray-dried powder	Spray-dried powder for the productic	0,076
Plaster	Plasters consisting of calcined gyps	0,048
Dried secondary gypsum	Dried secondary gypsum (synthetic	0,017
Short fibre kraft pulp	Short fibre kraft pulp is a wood pulp	0,12
Long fibre kraft pulp	Long fibre kraft pulp is a wood pulp	0,06
Sulphite pulp, thermo-mechanical and	Sulphite pulp produced by a specific	0,02
Recovered paper pulp	Pulps of fibres derived from recovere	0,039
Newsprint	Specific paper grade (in rolls or she	0,298
Uncoated fine paper	Uncoated fine paper, covering both (	0,318
Coated fine paper	Coated fine paper covering both coa	0,318
Tissue	Tissue papers expressed as net sal	0,334
Testliner and fluting	Testliner and fluting expressed as n	0,248
Uncoated carton board	This benchmark covers a wide rang	0,237
Coated carton board	This benchmark covers a wide rang	0,273
Nitric acid	Nitric acid (HNO3), to be recorded i	0,302
Adipic acid	Adipic acid to be recorded in tons o	2,79
Vinyl chloride monomer (VCM)	Vinyl chloride (chloroethylene)	0,204
Phenol/acetone	Sum of phenol, acetone and the by-	0,266
S-PVC	Polyvinyl chloride; not mixed with a	0,085
E-PVC	Polyvinyl chloride; not mixed with a	0,238
Soda ash	Disodium carbonate as total gross		0,843

[13] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:130:0001:0045:EN:PDF (Table on page 19 ->)
If no other reference is given, all product benchmarks refer to 1 ton of product produced expressed as saleable (net) production and to 100 % purity of the substance concerned. All definitions of processes and emissions covered (system boundaries) include flares where they occur.

[14] http://ec.europa.eu/clima/policies/ets/cap/allocation/index_en.htm

[15] Minimum 50% capture rate during last year's production can be set to receive certificates. For the «low hanging fruits» for CCS from sources with pure CO2 sources, criteria for CCS cost could also be considered for adjustments for these products.

2. Definition of product benchmarks and system boundaries with consideration of exchangeability of fuel and electricity

Product benchmark	Definition of products covered	Certificates /ton product
Refinery products	Mix of refinery products with more tl	0,0295
EAF carbon steel	Steel containing less than 8 % met	0,283
EAF high alloy steel	Steel containing 8 % or more metal	0,352
Iron casting	Casted iron expressed as tons of lic	0,325
Mineral wool	Mineral wool insulation products for	0,682
Plasterboard	The benchmark covers boards, shee	0,131
Carbon black	Furnace carbon black. Gas- and lar	1,954
Ammonia	Ammonia (NH3), to be recorded in t	1,619
Steam cracking	Mix of high value chemicals (HVC) (	0,702
Aromatics	Mix of aromatics expressed as CO2	0,0295
Styrene	Styrene monomer (vinyl benzene, C	0,527
Hydrogen	Pure hydrogen and mixtures of hydr	8,85
Synthesis gas	Mixtures of hydrogen and carbon m	0,242
Ethylene oxide/ethylene glycols	The ethylene oxide/ethylene glycol	0,512

Specific product benchmark for different refinery products are in published, but not showed here.

Other emissions sources for CCS to add to the benchmark table

Some emissions sources suitable for CCS are not included for ETS free allowances and are therefore not in the industry product benchmark. As:

- Powerplants[16]
- CHP[17]
- CO2 from natural gas cleaning.
- BioCCS. Energy production[18], industry (pulp&paper), biofuel production.

[16] ~0,350 t/MWh is benchmark for best fossil power production (CCGT).
[17] Can the heat and fuel benchmarks numbers from ETS be used?
[18] Use the same benchmark numbers as power 0,35 t/MWh?