DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2005/59

CO_2 Capture and Storage from European steel mills

ULCOS, deliverable D-6.1

Michael Larsen, Niels Peter Christensen & Finn Dalhoff (GEUS)
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MINISTRY OF THE ENVIRONMENT

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G E U S

Introduction

This report forms deliverable D-6.1 of the ULCOS project. The project was launched in 2004 by the major players in the European Steel Industry and its main partners in other industries and academia (47 partners, 15 European countries) as part of the EU-6FP (Contract no.: 515960).

ULCOS is a major RTD program, which plans to find innovative and breakthrough solutions to decrease the CO_2 emissions of the Steel industry. The context is the post-Kyoto era. The target is an expected reduction of specific CO_2 emissions of 50% as compared to a modern Blast Furnace. Within 5 years, the project will deliver a concept process route, based on iron ore, with a verification of its feasibility in terms of technology, economic projections and social acceptability. CO_2 capture and storage forms one of the concept routes investigated in the project.

CO_2 capture and storage raises specific question in the case of its application to the steel industry. Existing technology, based either on VPSA or amine washing, has been focused on recovering CO rather than on producing CO_2 that can be easily stored. Moreover, the scale-up of existing technologies to iron-making size is not completely trivial. Finally, storage locations, including the EOR option, suitable for the steel industry have to be identified in Europe, as close as possible enough to the smokestacks.

The work in SP 6.4 comprises mapping of quantity and quality of CO_2 emitted from Steel mills in EU followed by assessment of potential geological storage sites or oil fields in the vicinity of steel works, using methods and evaluation tools developed by the geological surveys in the GESTCO project.

Sedimentary basins with potential for underground storage in the vicinity of selected steel mills have been identified and evaluated with respect to general suitability. Depending on the location, characteristics and concentration of the steel mills, one or several geological storage options will be considered among storage in deep aquifers, in hydrocarbon reservoirs or in deep coal seams, possibly associated with enhanced oil or methane recovery. Once identified individual structures will be evaluated, with respect to location, safety and storage capacity.

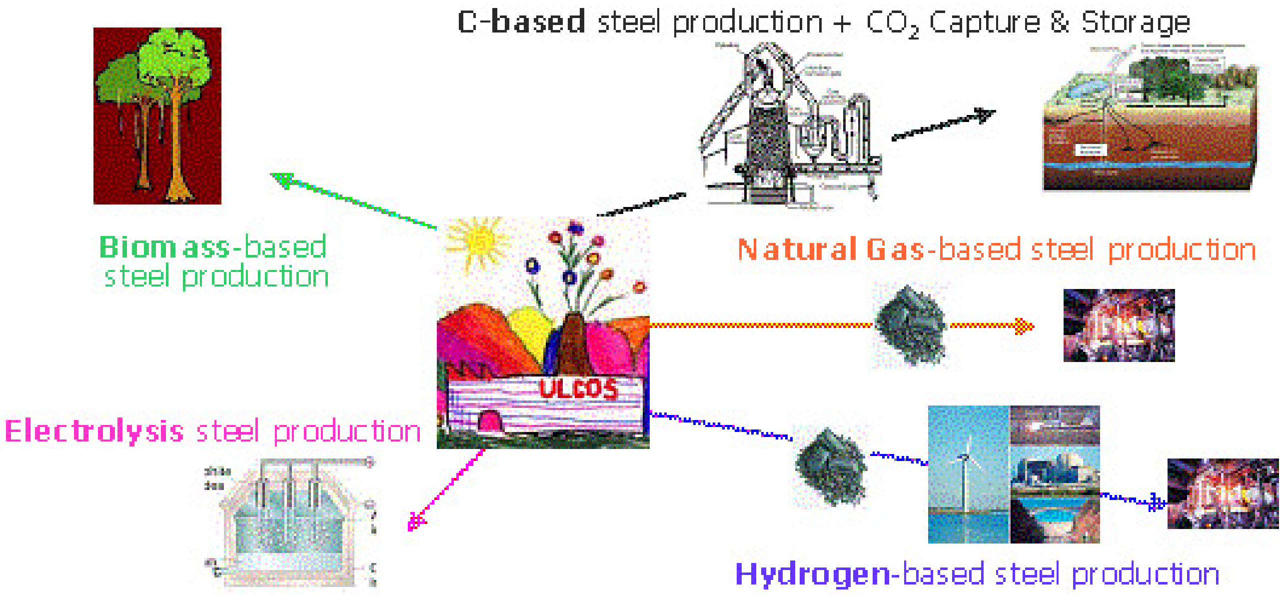

Figure 1: Conceptual representation of the various candidate technologies examined in the first stage of the ULCOS project. Note that both C-based and hydrogen-based steel production may involve CO_2 capture and storage.

CO_2 emissions from steel mills

In order to identify potential sites for CO_2 capture and storage an inventory of CO_2 emissions from steel mills has been build within the ULCOS project. The data is collected from several sources.

Databases

CO_2 emissions from the steel industry are routinely reported to the National Environmental Agencies of the European countries. The data are made available to the public through Web-based databases. Inventories of CO_2 emissions from point sources have also been reported in other EU projects investigating the European potential for CO_2 capture and storage; JOULE II, GESTCO, CASTOR and the future EU-GEOCAPACITY.

Three main data sources were used to build the ULCOS database. The database was updated and completed with data from other databases and the ULCOS partners.

1. GESTCO

The GESTCO database only contains information for the GESTCO countries (7 countries).

⇨ 113 references with geographic co-ordinates but 25 have no reported or estimated CO_2 emission value.

2. IEA–GHG International Energy Agency Greenhouse Gas

IEA-GHG is holding a database that contains an inventory of steel mills in an area wider than the GESTCO countries. The information is for OECD Europe and a few entries that IEA-GHG has for Eastern Europe too.

⇨ 264 references, 235 have geographic co-ordinates, and 177 have a reported or estimated CO_2 emission value.

3. EBFC European Blast Furnace Committee

EBFC indicates 58 blast furnaces, which represents 28 sites, considered as major production units. According to EBFC these sites correspond about 90% of the effective EU-15 production/emission.

⇨ 28 references without geographic co-ordinates and with estimated CO_2 emission

We had to merge these data sources in order to retrieve what was common, what was different and to homogenise the format.

We have made an ACCESS database as clean as possible, based on the GESTCO fields (filled or empty). A field was added in the ULCOS database to remind the origin of data (GESTCO, IEA-GHG, and EBFC).

It was not possible to achieve all information specified in the ULCOS database for all plants. We completed the ULCOS database for geographic co-ordinates and CO_2 emission value as far as possible with:

- Data given by the steel mill owners participating in the ULCOS project that have provided detailed information on CO_2 emissions from their plants.
- EPER_EU database (European Pollutant Emission Register) that reported on the emissions of industrial facilities into the air and waters in 2001. It concerned at that time only the UE-15.

The ULCOS inventory

The ULCOS inventory represents a collection of data from european steel-mills. It concerns 30 european countries. The inventory contains information on 271 Iron and Steel production sites, listing names, location, technology, steel production and key CO_2 emission data. The reference year for most of the CO_2 estimated or CO_2 reported emissions is 2001 but for the 28 sites provided by the EBFC, with contributions from Corus, Arcelor, Ilva and SSAB Sweden, the reference year is 2004.

The most representative technology for the ULCOS project is **integrated plants.** The ULCOS inventory counts 61 integrated plants, 121 minimills plants, 80 specialty plants. For 9 plants the technology is unknown.

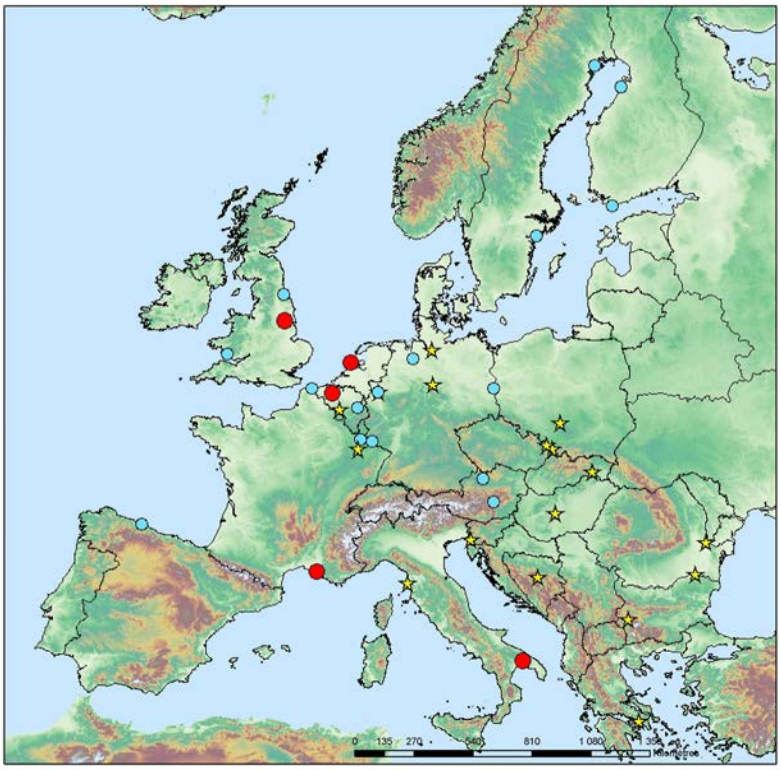

Figure 2. GIS map of 40 steel mills on shortlist The total emissions of CO_2 from these amount to approximately 170 MTonnes and represent between 80 % to 90 % of the CO_2 emissions from the European steel industry.

Yellow stars: steel plants with reported or estimated CO_2 emission value > 1 Mton
Blue points: important steel plants pointed out by EBFC
Red points: important steel plants pointed out by EBFC and selected as case studies for storage sites

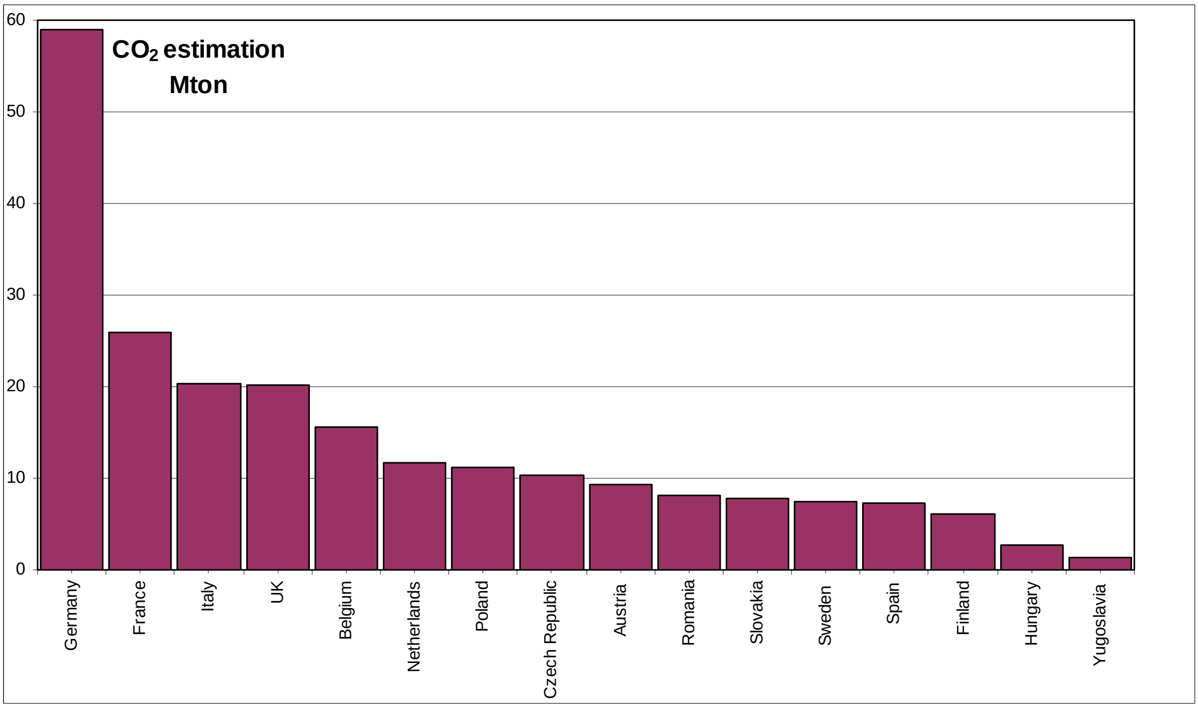

Figure 3. CO_2 estimation 2003 Source: http://www.worldsteel.org/csm_iron.php

	COMPANY	WORKS	COUNTRY	CO2 REPORTED	YEAR	CO2 ESTIMATED	YEAR	ORIGIN of DATA
1	TKS	Duisburg	Germany	24510.00	1998	15300.00	2004	EBFC
2	ILVA	Taranto	Italy			11200.00	2004	EBFC
3	Sidex S.A.	Galati	Romania			9611.99	2001	IEA
4	Corus	IJmuiden	Netherlands	7356.00	1998	8500.00	2004	EBFC
5	ARCELOR	Dunkerque	France			8400.00	2004	EBFC
6	HKM	Hückingen	Germany	8930.00	1998	6600.00	2004	EBFC
7	Rogesa	Dillingen	Germany	8550.00	1998	6100.00	2004	EBFC
8	ARCELOR	Fos-sur-Mer	France			5900.00	2004	EBFC
9	ARCELOR	Gijon	Spain			5800.00	2004	EBFC
10	Sidmar NV	Gent	Belgium			5700.00	2004	EBFC
11	Voest-Alpine	Linz	Austria			5300.00	2004	EBFC
12	Salzgitter Flachstahl	Salzgitter	Germany	8550.00	1998	5200.00	2004	EBFC
13	U.S. Steel	Kosice	Slovakia			5088.70	2001	IEA
14	Corus	Scunthorpe	UK	6485.00	2001	5000.00	2004	EBFC
15	Corus	Port Talbot	UK	5196.00	2001	4800.00	2004	EBFC
16	Corus	Redcar	UK	5636.00	2001	4400.00	2004	EBFC
17	Arcelor StW.	Bremen	Germany	7600.00	1998	4300.00	2004	EBFC
18	Ruukki	Raahe	Finland	4640.00	2001	3500.00	2004	EBFC
19	Nova Hut	Ostrava	Czech Republic			3392.47	2001	IEA
20	ARCELOR	Florange	France			3200.00	2004	EBFC
21	SSAB	Lulea	Sweden	1470.00	2001	3100.00	2004	EBFC
22	Ispat	Ruhrort	Germany			3053.20	2001	GESTCO
23	EKO Stahl	Eisenhüttenstadt	Germany	3800.00	1998	3000.00	2004	EBFC
24	Trinecke Zelezarny	Trinec	Czech Republic			2713.97	2001	IEA
25	Siderca	Calarasi Cod	Romania			2487.81	2001	IEA
26	Halyvourgiki	Eleusis	Greece			2487.80	2001	GESTCO
27	Lucchini	Piombino	Italy			2400.00	2004	EBFC
28	Duferco Clabecq SA	Marcinelle	Belgium			2400.00	2004	EBFC
29	SSAB	Oxelosund	Sweden			2300.00	2004	EBFC
30	Kremikovtzi Corp	Sofia-Botounetz	Bulgaria			2261.64	2001	IEA
31	Zenica-Rudarsko-Metalurski Kominat	Zenica	Bosnia and Herzegovina			2035.48	2001	IEA
32	Cockerill Sambre	Liege	Belgium			1800.00	2004	EBFC
33	Voest-Alpine	Donawitz	Austria			1800.00	2004	EBFC
34	Vitkovice Steel	Ostrava	Czech Republic			1526.61	2001	IEA
35	DUNAFERR	Dunaujvaros	Hungary			1470.07	2001	IEA
36	Huta	Czestochowa	Poland			1130.82	2001	IEA
37	Ispat	Hamburg	Germany			1017.70	2001	GESTCO
38	Saint-Gobain PAM	Pont-à-Mousson	France	917.00	2001	1000.00	2004	EBFC
39	Ruuki	Koverhar	Finland	859.00	2001	800.00	2004	EBFC
40	SERVOLA	Trieste	Italy			700.00	2004	EBFC
	TOTAL					**166778**		

Table 1. Largest single contributions around the North Sea with 20 important steel mills. The CO_2 emissions are the total emissions reported or estimated for the steel mill. Parts of this total emission, however, is not relevant for SP6-4 because some sources in the steel mills (like sinter plant or lime plant) is less or not suitable to CO_2 capture due to a low CO_2 concentration in the off gases. Only the CO_2 estimated emission values given by EBFC are taking this into account.

Underground storage of CO2

Geological storage of gases and liquids is a well-known technology applied mostly for natural gas, which is stored close to consumers, thus securing supply in case of failure of delivery, or to level out seasonal fluctuations in consumption. In Northern America, natural gas storage facilities are found at more than 200 geological sites, while in Europe the number is approximately 100. Experience and studies from around the world show that CO_2 can be stored safely below the surface following broadly the same prerequisites as for natural gas storage (Christensen *et al.* 2004).

From oil and gas exploration and from exploration for geothermal energy, we know many different types of reservoirs suitable for storage of CO_2. Storage sites may consist of highly porous geological layers with a large CO_2 storage capacity and high permeability, allowing CO_2 to be pumped down quickly. A typical example is deeply buried sandstone formations. In order to make sure that the CO_2 will not migrate to the surface and escape to the atmosphere, the storage site must be tightly sealed, for instance by claystone.

Suitable geological formations are connected to sedimentary basins, which are found throughout central and southern Europe outside the major mountain ranges. Sedimentary basins are present both onshore and offshore.

Pressure and temperature are higher the deeper into the subsurface we get, and, at a depth of approximately 800 m, the CO_2 gas starts behaving like a supercritical fluid. As a fluid, CO_2 takes up less space and, by storing it under pressure at depth ranges of 800 m or more, much larger CO_2 volumes can be stored. Moreover; by locating the storage in layers this deep, with mostly saline reservoirs, we avoid conflicts with aquifers supplying drinking water.

The technical aspects of CO_2 storage in deep geological formations are very much the same as for natural gas storage. However, there are a number of important differences: CO_2 dissolved in water becomes a week acid that may affect the wells, the rocks in the reservoir and the cap rock. Measures must be taken to make sure that injected CO_2 remains in the reservoir for thousand years. This requirement in particular has given rise to debate, and the scientific community is still discussing the time span required.

Geological storage of CO_2 is already used in practice. For environmental reasons, the method is used in the Sleipner Gas Field in the North Sea (Statoil and the SACS project). In North America, Hungary, Slovenia; Turkey, Brazil and Trinidad; CO_2 is injected into the subsurface in order to enhance recovery of oil from existing oil fields by mixing CO_2 with oil, thus making the oil flow more easily towards the production wells.

A number of international research projects under the vestiges of the EU are working on assessing the possibilities regarding separation and geological storage of CO_2. This is being done with a view to developing reliable methods for storage and in order to map suitable geological structures.

If CO_2 storage is to gain wider application as a generally accepted method for reduction of CO_2 emissions in the future, we must be certain that the geological storage facilities are impermeable and secure, and that methods are designed to monitor the facilities. Several groups of experts are working with these problems in connection with ongoing storage projects (e.g. CO2STORE, CO2SINK).

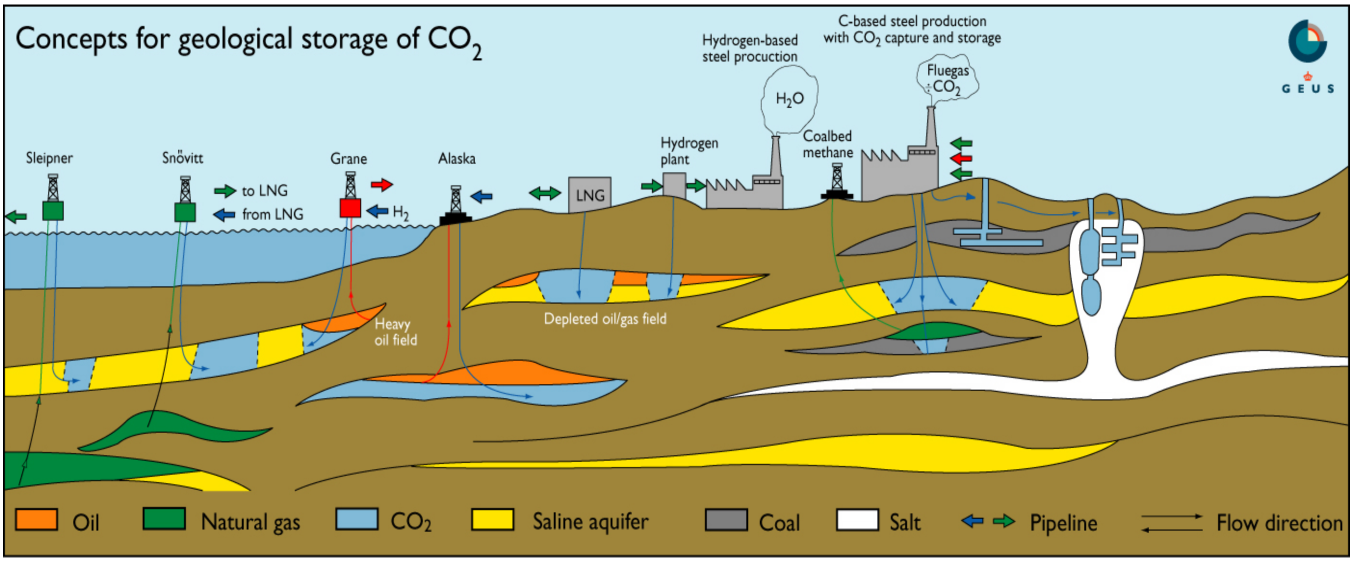

Figure 3. Experience and studies from around the world show that CO_2 can be stores safely below the surface if a number of prerequisites are fulfilled. In order to store CO_2, the gas is compressed and is pumped down into porous sandstone layers, exhausted oil (gas reservoirs or unminable coal measures. Storage takes place a depth of more than 800 meters where CO_2 behaves like a liquid (supercritical fluid). Impermeable claystone layers stop the –CO_2 from escaping to the atmosphere. Dry CO_2 can be transported in ordinary pipelines, like those used for natural gas. In water CO_2 becomes a weak acid (carbonic acid) which is corrosive. Transport of dry CO_2 in pipelines and ships is a well-known technology, and there are more than 3000 km of pipelines transporting CO_2 in the USA and Canada. Modified from Christensen et al. (2004).

Mapping of storage capacities in Europe

The first estimate of CO_2 storage capacities in Europe was done in the Joule II study. This study considered the total storage capacity of on- and offshore aquifers and hydrocarbon structures in North West Europe (Holloway *et al.* 1996). The results where promising; 806.1 Gigatonnes of CO_2 storage capacity, although regarded as highly provisional.

A more detailed study of storage capacities in 8 European countries was initiated by the GESTCO project in 1999. The primary goal of the GESTCO project was to determine whether the geological storage of carbon dioxide captured at large industrial plants is a viable method of reducing greenhouse gas emissions in Europe (Christensen 2000; Gale *et al.* 2001; Christensen & Holloway 2003). This was established by a series of case studies that evaluated the CO_2 storage potential of the four most promising types of geological storage:

1. Onshore/offshore saline aquifers with or without lateral seal
2. Low enthalpy geothermal reservoirs
3. Deep methane bearing coal beds and abandoned coal and salt mines
4. Exhausted or near exhausted oil and gas reservoirs.

The case study approach was used so that currently available, largely theoretical generic information could be applied to real geological situations. Underground storage capacities in the case study areas were evaluated by seismic mapping, analysis of well logs and reservoir simulation. The results are summarised in Christensen & Holloway (2003). The major part of the mapped storage capacity was related to deep saline aquifers in onshore and nearshore sedimentary basins in Denmark, Germany, southern UK and northern France. In the Netherlands and Belgium the storage potential is primarily related to exhausted gas fields and coalmines. A huge potential exists in aquifers offshore Norway, and it is likely that very large additional offshore aquifer potential exists in British and Danish sectors of the North Sea. The Greek storage potential is composed of aquifers as well as a few hydrocarbon fields. Significant storage capacity is related to the gas and oil fields of northern Europe, particularly in the North Sea and onshore in the Netherlands and Germany. The storage capacities of Eastern Europe, Italy, Spain, southern France and Portugal were not evaluated in the GESTCO project, but forms part of the EU-GeoCapacity project, which will start in 2006.

In the ULCOS project existing knowledge of potential storage structures and storage capacities are combined with the location of major steel mills in order to investigate the potential (technical and economical) for CO_2 storage from steel mills. A number of storage sites will be evaluated in more detail by building storage scenarios.

Criteria for selection of storage sites

From the ULCOS inventory a shortlist of 40 sites were produced based on steel technology and size of emission. The main criteria were the CO_2 emission from site (may include more than one furnace) greater than approximately 1 Mtonnes and the representative technology (Blast furnaces and Integrated Plants (IP). In addition only plants operating and which are believed to have a future in EU steel production was considered.

Steel mills and geological setting

General geology and storage options have been evaluated for the sites on the shortlist. Available information comes from published geological maps, national reports on storage potential and the GESTCO GIS. It have not been the intention to identify individual storage structures at this stage, but to get an overview of the general geology in the surrounding of the 40 major steel mills. Details of the tectonic setting of the 40 sites are given in appendix 2 (table)

1. Sedimentary basin: The plant is located within an undeformed or weakly deformed sedimentary basin (e.g Paris Basin, North Sea).
2. Edge sedimentary basin: The plant is located on the margin of the basin or in a different tectonic setting but at the edge of the basin, with the same storage potential within the basin itself.
3. Graben: Down-thrown structure (e.g. Rhine valley) with possible trap in a confined area with low deformation.
4. Palaeozoic Massif: Old sedimentary basin where porous and seal rocks can have been preserved (e.g. Campine basin) or containing coal seams for Enhanced Coal Beds Methane (ECBM).
5. Folded sedimentary basin: The basin was deformed by phases of folding and faulting, with more complex and smaller structures, and possible porosity loss.
6. Edge foreland basin: A foreland basin is a trough at the front of a mountain range linked to the compression effect during the uplift of the range. It is highly dissymetrical and weakly deformed in the portion the most distal to the range.
7. Foreland basin: Closer to the range this basin is generally affected by compression structures (faulted folds) which can be prospected for storage but with uncertainty in a fairly complex setting.
8. Intra-montane basin: Within a mountain range, small e.g. pull apart, basins can be preserved with a lower degree of deformation, due to local extensional effects in a regional compression stress
9. Folded range: The mountain range, due to high stress and tight deformation structure are not appropriate for finding large scale storage structure. With more simple structure, some of them are nevertheless prospected for hydrocarbons (e.g. Zagros mountains). With higher degree of deformation, autochthonous units can be explored under detached allochtonous tectonic units.

10. Old shields: (e.g. Norway, Sweden, Finland), consisting of crystalline or highly metamorphosed rocks they are inappropriate for finding storage structures.

The information was compiled in a series of maps (Figs 4–9) showing location of important steel mills in Europe in their geological context. Yellow stars indicate steel plants with reported or estimated CO_2 emission value > 1 Mton, blue points indicate important steel plants pointed out by EBFC and red points indicate important steel plants pointed out by EBFC and selected as case studies for storage sites.

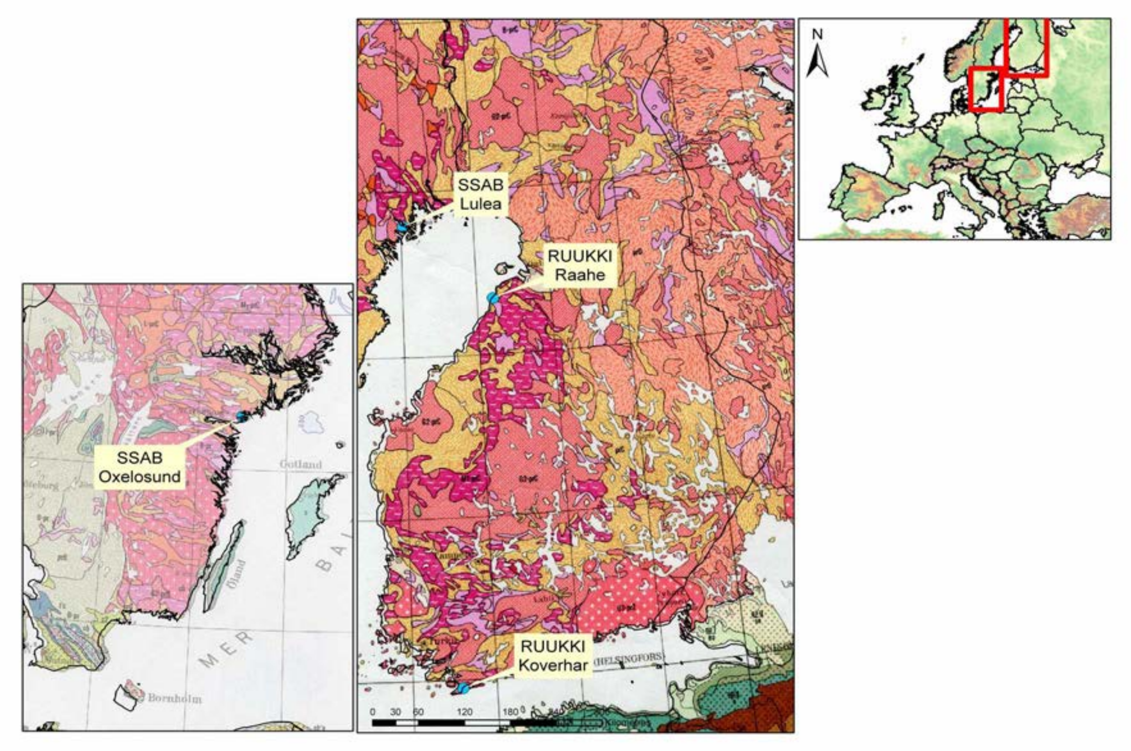

Figure 4. Scandinavian area – Norwegian Shield (Sweden and Finland)

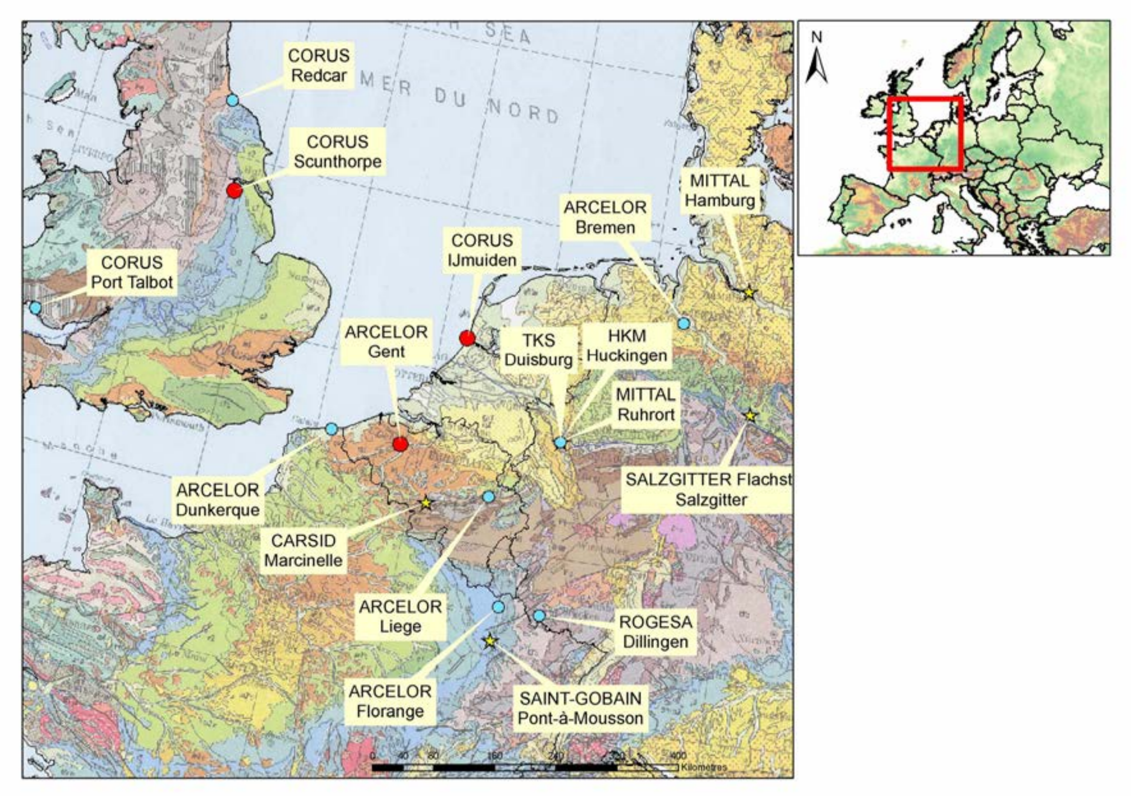

Figure 5. North Sea area – North Sea basin (UK, Belgium, France, Netherlands), Ardennes massif (Belgium), Ruhr Graben (Germany), Paris basin (France).

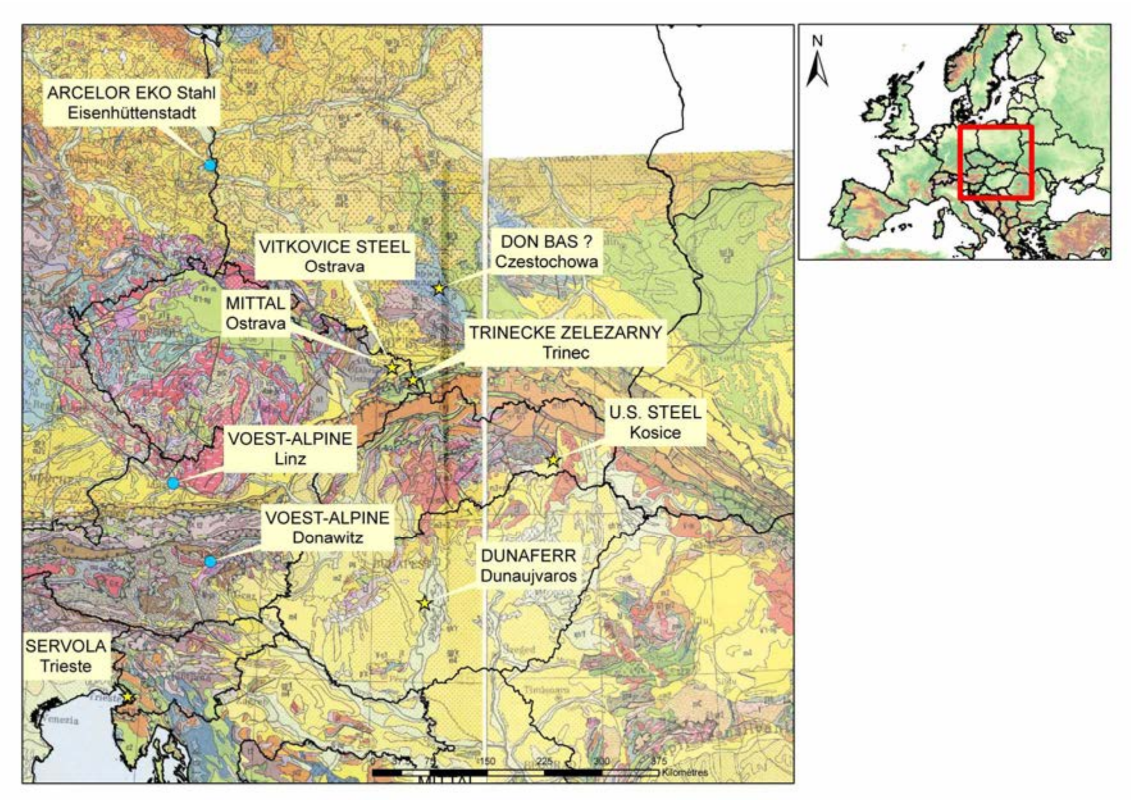

Figure 6. North east area: Donau basin (Austria), Polish basin (Poland, Czech Republic) and Panonian basin (Slovakia, Hungary)

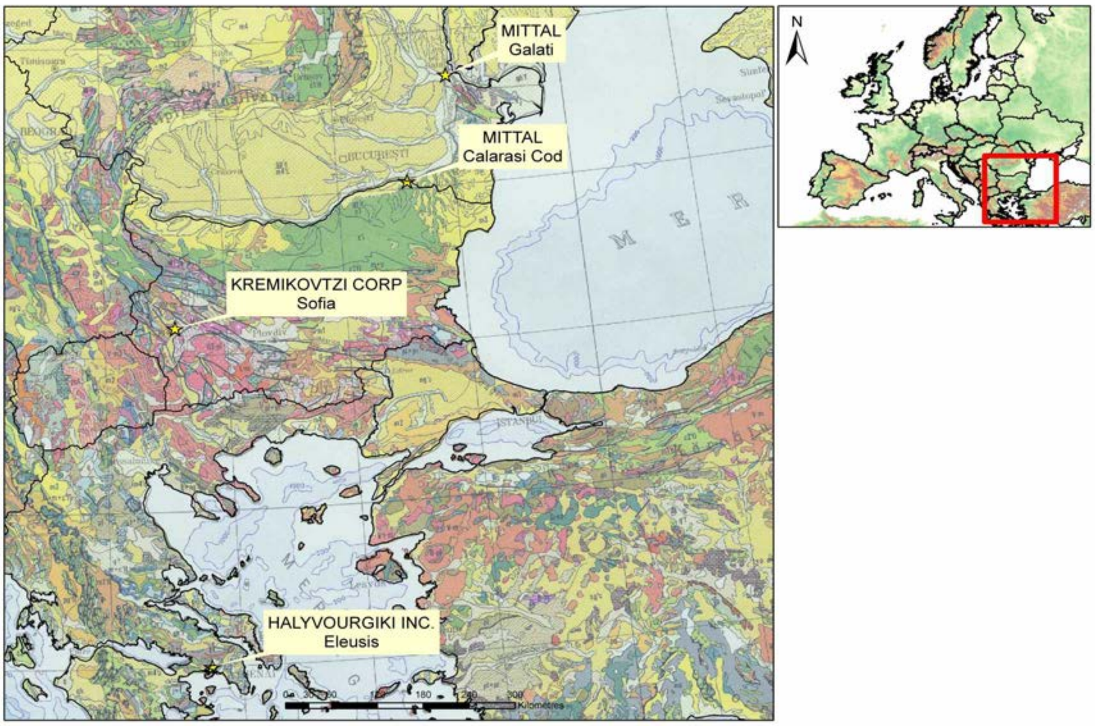

Figure 7. Southeast area: Duna delta (Romania), Carpathian arc (Bulgaria) and Attiké (Greece)

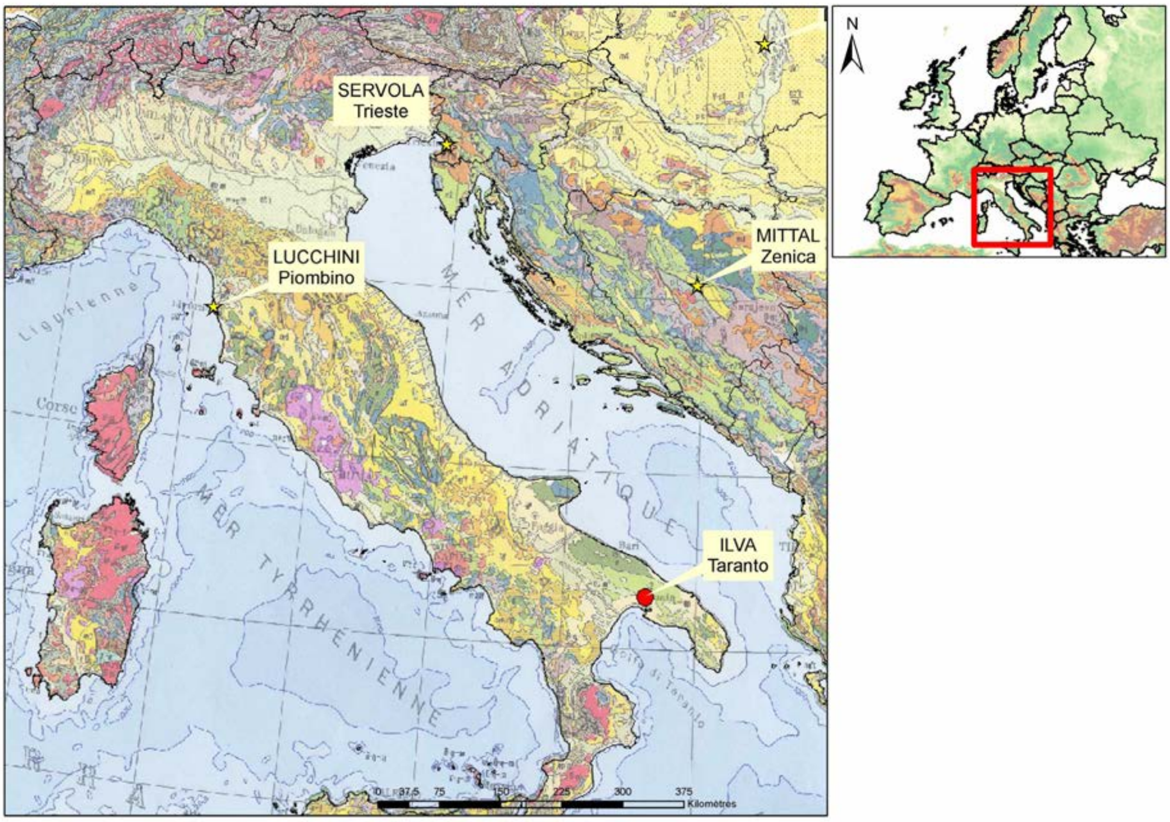

Figure 8. South east area: Bosnian (Bosnia and Herzegovina), Adriatic and Po foreland basin (Italy)

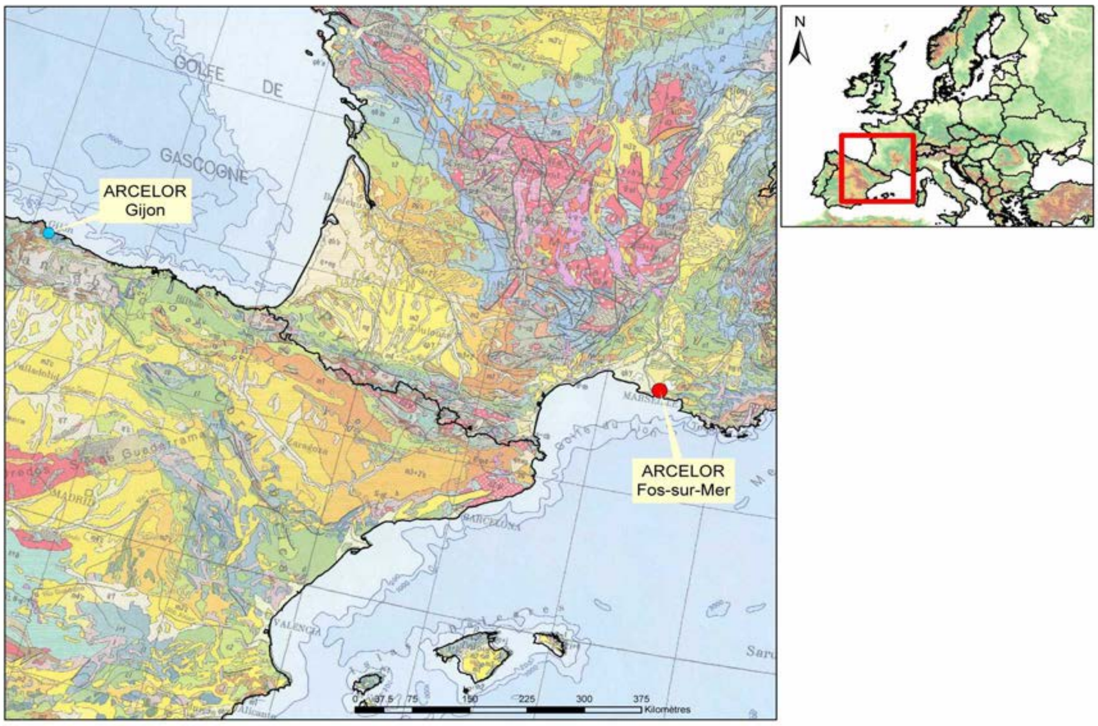

Figure 9. Southwest area: South-East Basin (France) and Cantabrica zone (Spain).

Selection matrix

The ranking method was as follows:

1. First, limit the investigation to the steel mills which emit more than 1 Mt of CO_2 per year (40 sites identified).
2. Second, for each site, look at the possible geological basin(s) in the vicinity, which would be suitable to storage
3. Third, the features of these basins are looked at more in details: age, thickness, fractures, folding etc.
4. Finally, this information is cross-checked with that available in GESTCO, and a rank is given to the steel mill for estimating its suitability to storage. 10 categories have been defined for this ranking. (Appendix 2).

This approach has lead to build the selection matrix presented below, with the CO_2 production as one parameter and the rank as the other parameter (Fig. 10).

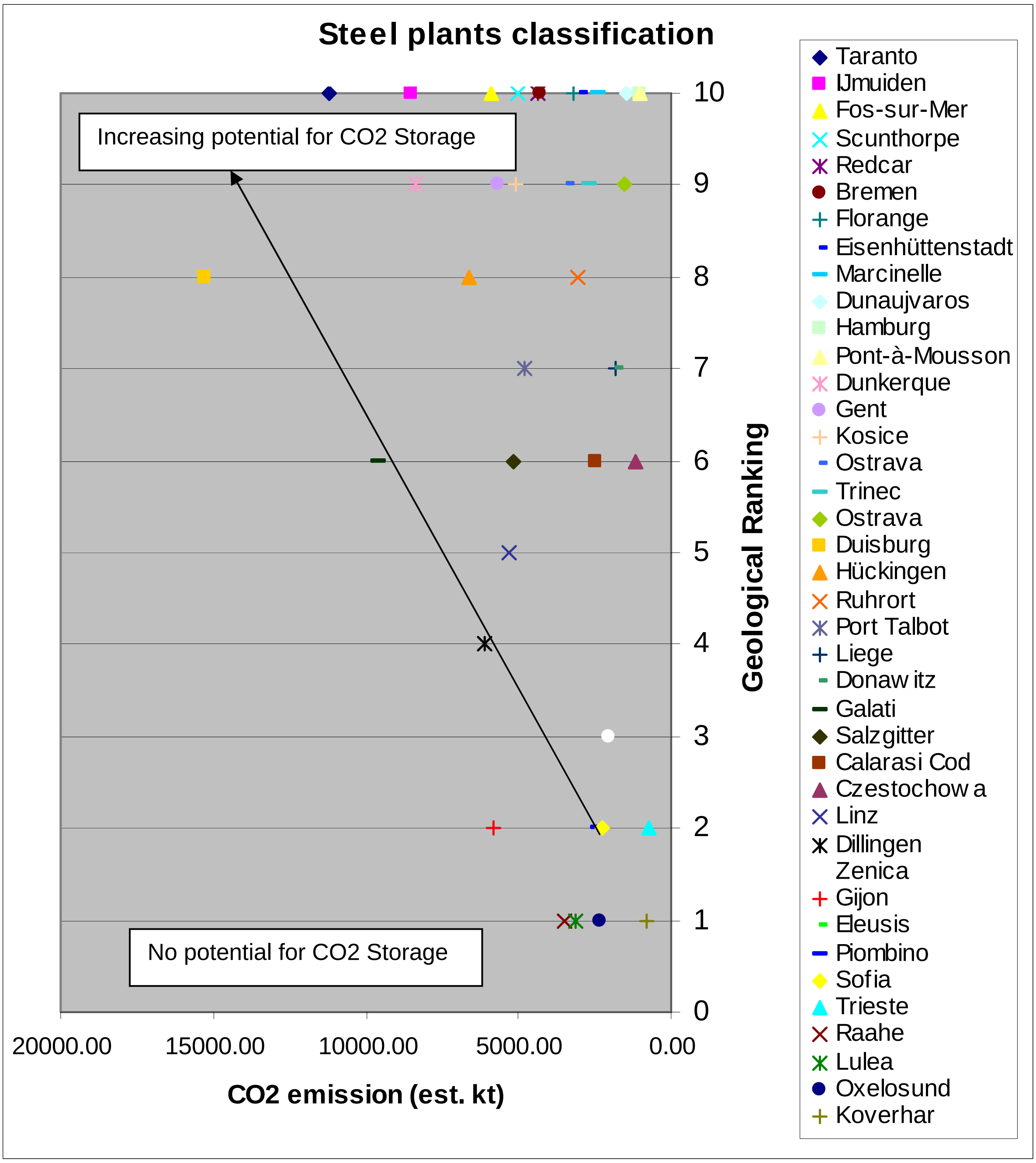

Figure 10. Selection matrix showing the ranking of the 40 major steel sites in Europe. The figure shows the CO_2 production as one parameter and the geological rank as the other parameter. Steel sites with the best potential for storage will plot in the upper left of the diagram. For details see text and Appendix 2.

Proposal for selection of four steel mills for future work

From the ranking of the 40 sites in the selection matrix (distance to potential storage sites and total CO_2 emissions) a further selection of four sites were made with one additional option :

1. Scunthorpe (Corus)
2. Taranto (Ilva)
3. Gent (Sid-Mar)
4. Ijmuiden (Corus)

5. Fos-sur-Mer (Arcelor)

The selection reflects a number of more subjective choices including a wish to have a geographical spread throughout Europe; variation in type of geological storage e.g. aquifers, hydrocarbon structures, coal beds; preference of steel sites considered in other subprojects (SP1 and SP3); sites owned by the partners of ULCOS (data availability). The final choice of 4-6 plants was proposed accounting on the one hand for CO2 emission, but on the other hand for a set of characters, namely convergence of several storage possibilities. The selection of the four sites have been presented at the SP6 meeting in Trondheim and afterwards approved by the ULCOS technical committee. Final selection was agreed on at the SP 6 meeting at Corus, IJmuiden with Fos-sur-Mer as a back-up if one of the four priority plants is to complicated to work on.

Scunthorpe

Scunthorpe is an IP owned by Corus and located in East England (Fig. 11). Steel production in year 2001 was 3500 Kton steel in year 2004 reached 3637 Kton with emission of 6485 Kton and 6700 Kton of CO_2 respectively, of which approximately 5000 Kton are concentrated enough to be suitable for CO_2 capture The location of the plant within the sedimentary basin of the southern North Sea provides several possibilities for geological storage of CO_2. Suitable geological sites for CO_2 storage from Scunthorpe would be the sandstone of the Triassic Bunter Sandstone Formation, oil fields in the offshore sector or Carboniferous coal measures.

Distance from the plant to potential saline aquifer within the Bunter Sandstone Formation is in the order of 1-200 km. For that reason it is suggested that future work would be to focus on the potential of the Bunter Sandstone Formation which is present in the subsurface beneath much of eastern England. It continues eastward beneath the UK sector of the Southern North Sea and across into the Dutch Sector, the Netherlands, Germany and Poland. The Bunter Sandstone has many of the characteristics required for CO_2 storage, including large closed structures (domes) above salt diapirs, good average porosity and permeability, and a good seal in the overlying Haisborough Group. Furthermore, it is a proven gas reservoir in the Southern North Sea Basin (Brook *et al.* 2003). Due to Scunthorpe being part of the work in SP1 detailed data are available on the flue gas composition and CO_2 stream.

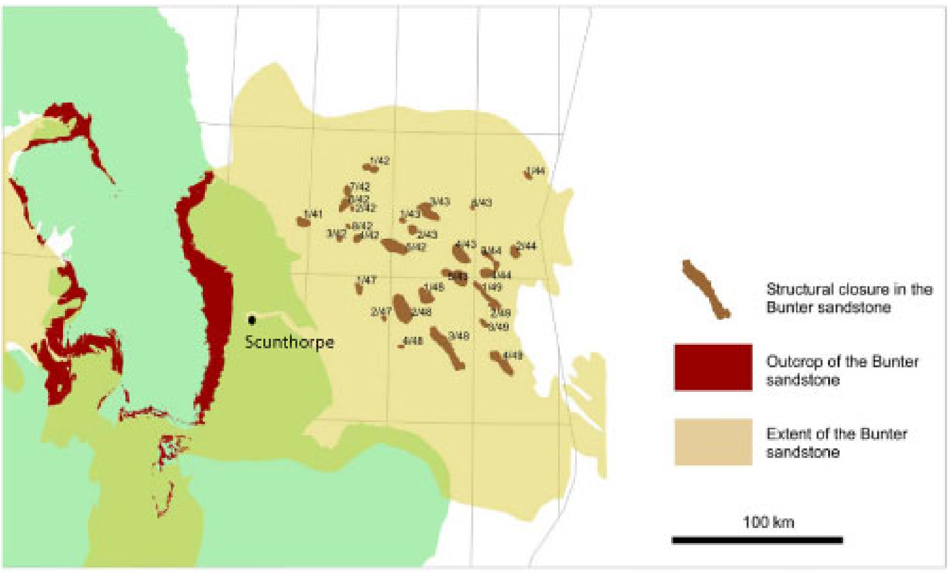

Figure 11. Geological map showing the extension of the Triassic Bunter sandstone in southern U.K. Structural closures forming potential storage structures for CO_2 is indicated. Map compilation from Brook *et al.* (2003).

Taranto

The IP plant Taranto owned by ILVA is located in southern Italy (Fig. 12) has an emission of c. 10405 Kton CO_2 per year, 14800 Kton in 2004 of which 11200 Kton are enough concentrated to be suitable for CO_2 capture, from the production of 7350 Kton steel. It is expected that data are available on the flue gas composition and CO_2 stream from SP1. With Taranto's location in southern Italy, the plant is located in an area with complex and active geological processes and possible storage for CO_2 storage could be aquifers in the Adriatic Sea. In addition the possibilities for storing CO_2 in exhausted hydrocarbon structures both on and offshore in the region should be investigated.

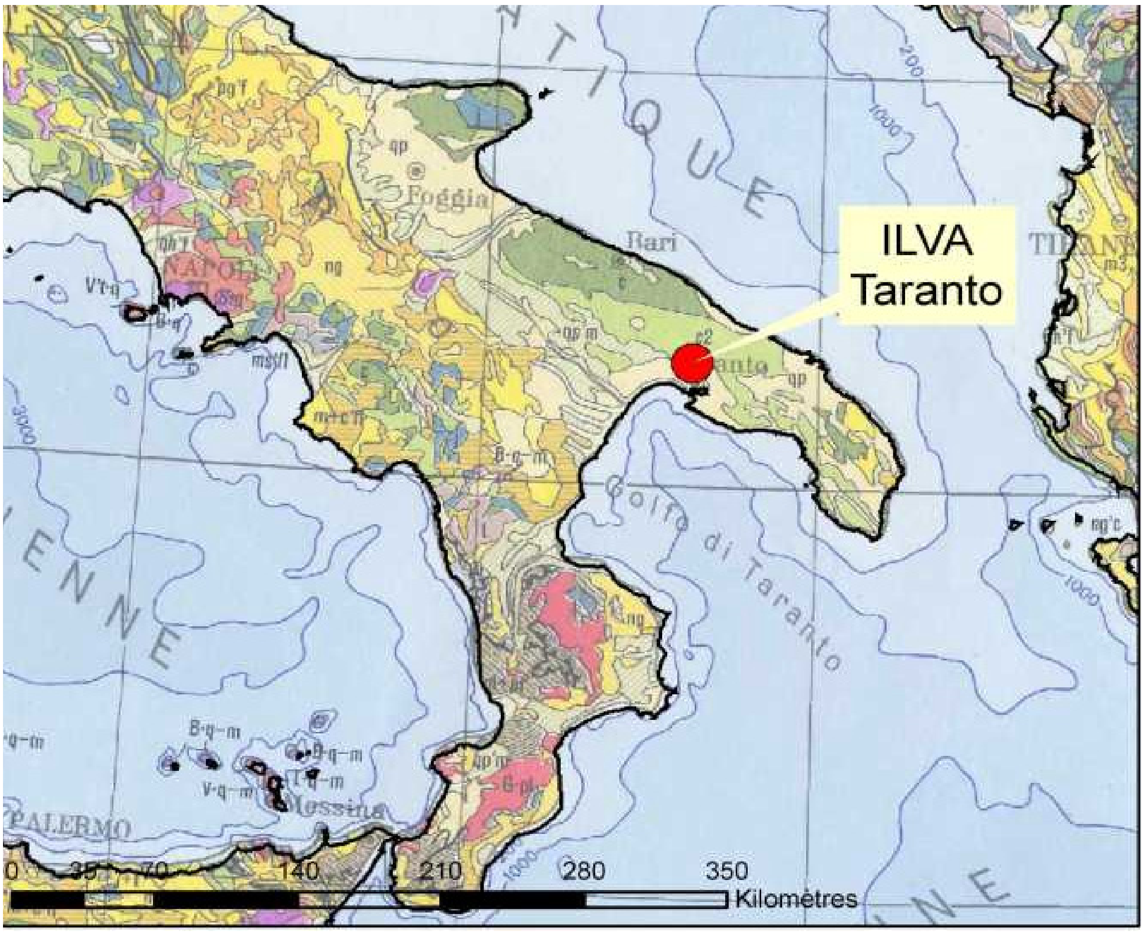

Figure 12. Geological setting of the Taranto plant. Cretaceous basin (Adriatica) Apulian platform, Bradanic and Taranto troughs.

Gent (Sidmar)

Gent is an integrated plant owned by Sidmar located in Belgian. Estimated CO_2 emission in 2004 was 5700 Kton with a reported production of 3406 Kton steel. The plant at Gent is located not far from the Belgian Campaine Basin leave several targets for CO_2 storage. The nearby storage possibilities were mapped by Gestco as illustrated in Fig. 13.

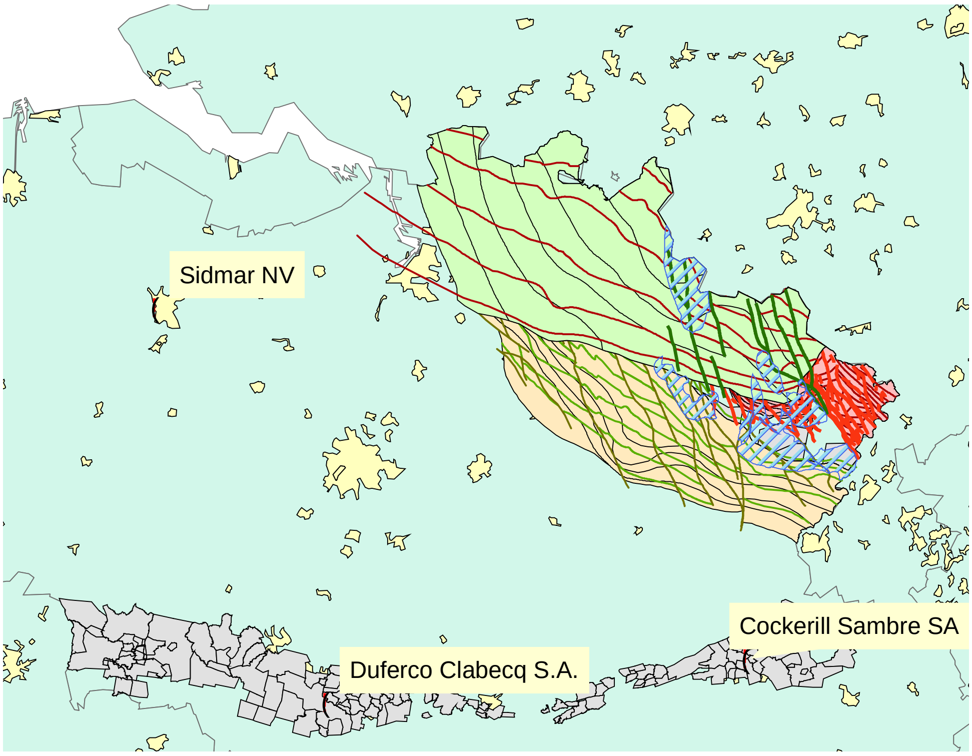

Figure 13. Opportunity for storage near Gent/Sidmar: The Dinantian aquifer (beige), the Bunter aquifer (pink) the Cretaceous aquifer (green) and the coal fields. A set of structures where identified. The Cretaceous aquifer is to shallow but possibility exist in the lower reservoirs. Possible injection points are in the dashed area.

IJmuiden

The Corus plant, IJmuiden is an IP (Fig. 14). IJmuiden has from 1998 reported a steel production of 6900 Kton with emission of 7356 Kton CO_2, Total CO_2 emission in 2004 was 11700 Kton from the production of 6103 Kton steel, of which 8500 Kton are enough concentrated to be suitable for CO_2 capture. The location in western central Netherlands within the southern North Sea sedimentary basin provides several storage possibilities. These are the oil and gas fields offshore, the saline aquifers in the Triassic Bunter Sandstone Formation and the Permian sandstones of the Upper Rotliegend Slochteren Formation, Late Jurassic / Early Cretaceous sandstones of the Schieland Group and the Rijnland Group although some of these aquifers are reported to be oil bearing and may therefore not be available for CO_2 storage in spite of their excellent reservoir properties (Wildenborg *et al.* 2003). Within the CASTOR project studies of an exhausted oil field (K12B) for the purpose of CO_2 is taking place. Results from this very detailed study may possibly be integrated in the future ULCOS work. Distance to a potential injection point would not have to be more than 100-200 km. The distribution and physical parameters of the sandstone units differ quite a lot and further work has to be done for selection of the appropriate aquifer. Due to IJmuiden being part of the work in SP1 detailed data are available on the flue gas composition and CO_2 stream.

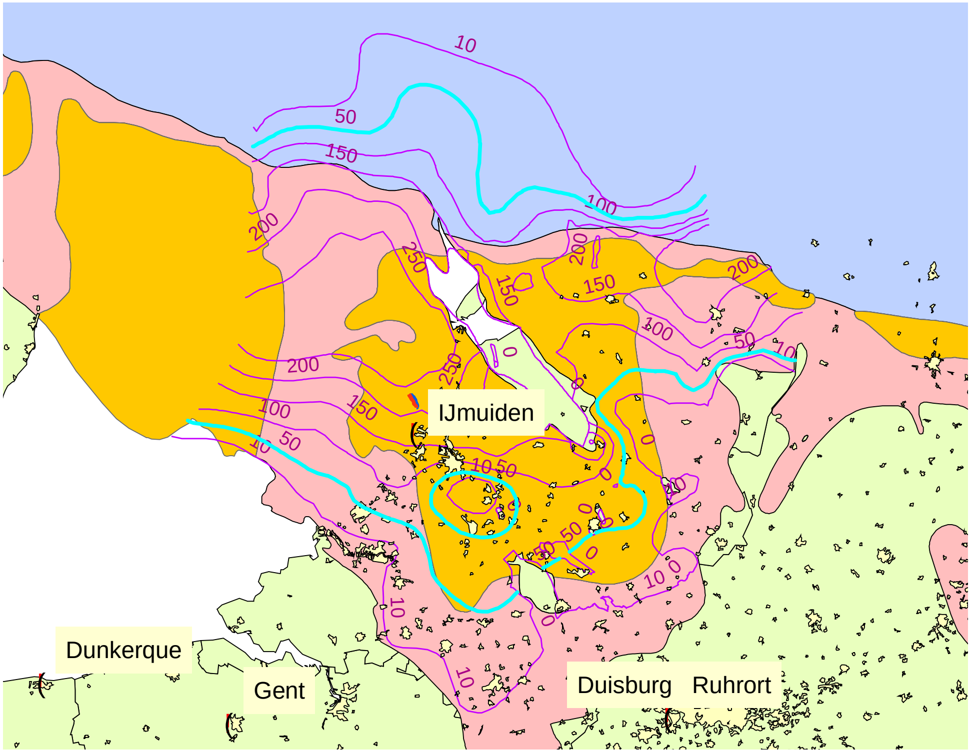

Figure 14. First target for storage near IJmuiden: the Permian Rotliegend reservoir (red spot in the north of IJmuiden is the Bunter gas field). Facies and isopachs of the Rotliegend Sandstone (blue = 50 m).

Additional site: Fos-sur-Mer

In addition to the four sites listed above Fos-sur-Mer owned by Arcelor was selected. The additional site will investigated in case any of the four is rejected as storage scenario due to lack of data or failure to identify suitable storage structure. The geology in the surrounding of Fos-sur-Mer has not been investigated in any detail but, storage opportunities could be examined in the French South-East Basin or the Gulf of Lion margin and in the neighbouring Gardanne Coal field:

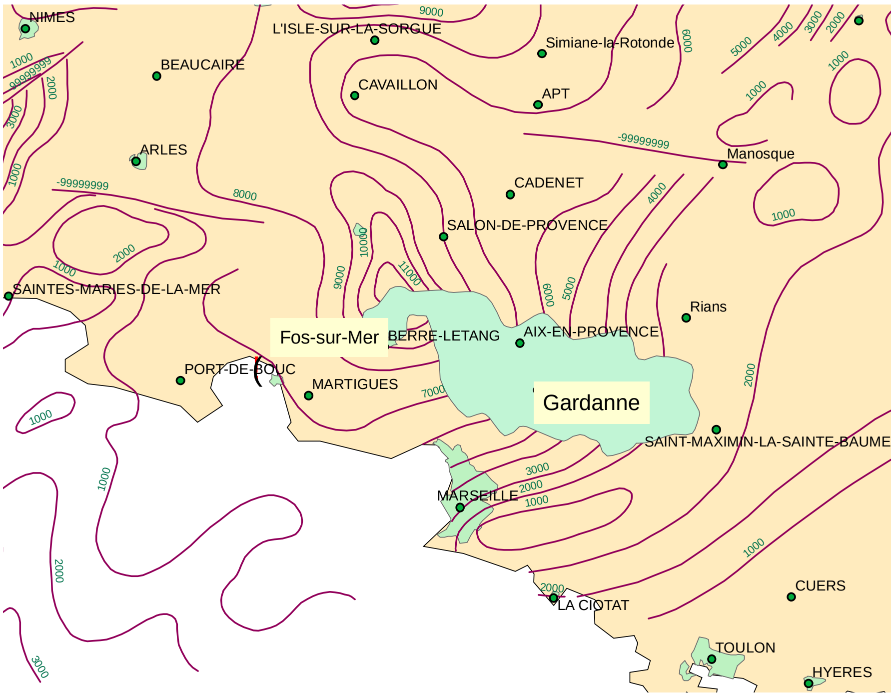

Figure 15. Setting of Fos-sur Mer from Gestco with the basement contour lines and major faults and the Gardanne coal field.

Future work

The screening analysis has identified four steel mills with high CO_2 emissions and situated close to sedimentary basins with geological formations suitable for underground storage of CO_2. More detailed analysis is, however, needed to validate the storage options and identify individual formations/storage structures. The analysis will be based on existing geological information.

In the next phase of the work package different scenarios of steel CO_2 source + transport + geological storage will be evaluated for the four cases with respect to storage capacity, short and long term safety, local environment, conflicts of use and economic impact. The technical and economic feasibility of CO_2 sub-surface storage will be evaluated with an extended version of the GESTCO Decision Support System.

In the analysis of the scenarios different aspects need to be addressed not only on geological storage structures, but also on capture, transport and CO_2 management. The analysis should thus address the technical requirements (concentration, temperature, pressure, allowed and not allowed impurities) for transport, storage of CO_2 in aquifers, CO_2 for EOR, and CO_2 for methane recovery from coal seams. The work is linked to ULCOS work packages 6.2 and 6.3.

Technical and economic analysis of specific logistics for the Steel Industry as a CO_2 source needs to be done. The Steel Industry has its own specific characteristics like amount of CO_2, vicinity to potential geological reservoirs, harbours, and oil fields. These characteristics are yet unknown and will have their effect on the logistics, e.g. for offshore transportation the choice between ship and pipeline transport, size of ships, diameter and length of pipelines.

Finally, the scenarios should advice how CO_2 management in the Steel Industry can be co-ordinated with other industries, like power plants, production of petrochemicals, natural gas treatment, production of cement. This co-ordination is essential since the various sectors will have economic bebefits by sharing the storage sites and probably the transport facilities as well.

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CO_2 Databases:
http://www.eper.cec.eu.int/
http://www.bgs.ac.uk/gestco/
http://www.worldsteel.org/
http://www..ieagreen.org.uk/

Appendix 1: UlCOS inventory of european steel mills

In red bold the 5 selected sites for case studies of CO_2 capture storage.
In blue bold the 16 sites pointed out by the EBFC
In black bold the 19 sites with CO_2 estimated or reported emission > 1000 Kton
In strikethrough the sites wich are closed

Note that the information in the inventory is a compilation of public available data reported in the year listed. Sites may have been closed or otherwise changed after the year of reporting.

GROUP NAME	COMPANY NAME	CITY	COUNTRY	LATITUDE	LONGITUDE	CO2 REPORTED	YEAR REPORT	CO2 ESTIMATED	YEAR ESTIMATE	PRODUCTION kton steel	YEAR PRODUCTION	TECHNOLOGY
	Elbasan Steelworks	Elbasan	Albania	41.1	20.1			226	2001	178		Integrated Plant
	Bohler Edelstahl GmbH	Kapfenberg	Austria	47.4	15.3	110	2001			107		Specialty Plant
	Breitenfeld Edelstahl GmbH	Mitterdorf	Austria	47.1	15.1					53		Specialty Plant
	Marienhutte GmbH	Graz	Austria	47.1	15.5			31	2001	223		Minimill
VOEST-ALPINE	**Voest-Alpine Stahl Donawitz GmbH**	**Donawitz**	**Austria**	**47.4**	**15.1**	**1720**	**2001**	**1800**	**2004**	**1231**	**2003**	**Integrated Plant**
VOEST-ALPINE	**Voest-Alpine Stahl Linz GmbH**	**Linz**	**Austria**	**48.3**	**14.3**	**6720**	**2001**	**5300**	**2004**	**3484**	**2003**	**Integrated Plant**
	ALZ NV	Genk	Belgium	51.0	5.5	177	2001			561		Specialty Plant
ARCELOR	**Cockerill Sambre SA**	**Liege**	**Belgium**	**50.6**	**5.6**	**677**	**2001**	**1800**	**2004**	**2633**	**2003**	**Integrated Plant**
DUFERCO	Duferco La Louvière S.A.	La Louviere	Belgium	50.5	4.2	260	2001	62	2001	445		EAF
	Ellwood Steel Belgium	Seraing	Belgium	50.6	5.5			13	2001	89		Minimill
	FAFER - Fabrique de Fer de Charleroi	Charleroi	Belgium	50.4	4.4			66	2001	472		Minimill
ARCELOR	**Sidmar NV**	**Gent**	**Belgium**	**51.1**	**3.7**			**5700**	**2004**	**3406**	**2003**	**Integrated Plant**
CARSID	**Duferco Clabecq S.A.**	**Marcinelle**	**Belgium**	**50.4**	**4.4**			**2400**	**2004**	**1775**	**2003**	**Integrated Plant**
MITTAL	**Zenica - Rudarsko-Metalurski Kominat Zenica**	**Zenica**	**Bosnia and Herzegovina**	**44.2**	**17.9**			**2035**	**2001**	**1603**		**Integrated Plant**
KREMIKOVTZI CORP	**Kremikovtzi Corp**	**Sofia**	**Bulgaria**	**42.4**	**23.2**			**2262**	**2001**	**1781**		**Integrated Plant**
	Stomana Iron & Steel Works	Pernik	Bulgaria	42.6	23.0			100	2001	712		Minimill
	Jadranska Zelejezara Split (Adriatic Steelworks, Split)	Split	Croatia	43.5	16.3			15	2001	107		Minimill
	Sisak - SP MK Zeljezare Sisak	Sisak	Croatia	45.5	16.4			452	2001	356		Integrated Plant
MITTAL	**Nova Hut AS**	**Ostrava**	**Czech Republic**	**49.8**	**18.3**			**3392**	**2001**	**2671**		**Integrated Plant**
	Poldi Steel	Kladno	Czech Republic	49.8	16.0							Specialty Plant
	Poldi Steel	Kladno	Czech Republic	49.8	16.0							Specialty Plant
TRINECKE ZELEZARNY	**Trinecke Zelezarny AS**	**Trinec**	**Czech Republic**	**49.7**	**18.7**			**2714**	**2001**	**2137**		**Integrated Plant**
VITKOVICE STEEL	**Vitkovice Steel a.s.**	**Ostrava**	**Czech Republic**	**49.8**	**18.3**			**1527**	**2001**	**1202**		**Integrated Plant**
	ZDB Bohumin a.s.	Bohumin	Czech Republic	49.9	18.4							Specialty Plant
FERROMET	Zelezarny Hradek a.s.	Hradek u Rokycan	Czech Republic	50.1	15.5			25	2001	178		Minimill
	Danish Steel Works Ltd (Det Danske Stalvalsevaerk A/S)	Frederiksvaerk	Denmark	56.0	12.0			106	2001	757		Minimill
	AvestaPolarit Oyj Abp	Tornio	Finland	65.9	24.2	531	2001					Specialty Plant
RUUKKI	**Fundia AB, Wire Rod Division**	**Koverhar**	**Finland**	**59.9**	**23.3**	**859**	**2001**	**935**	**2003**	**585**	**2003**	**Integrated Plant**
	Imatra Steel Oy Ab	Imatra	Finland	61.2	28.8							Minimill
	Outokumpu Polarit Oy	Tornio	Finland	65.9	24.2							Specialty Plant
RUUKKI	**Rautaruukki Oy**	**Raahe**	**Finland**	**64.7**	**24.5**	**4640**	**2001**	**3500**	**2004**	**2517**	**2003**	**Integrated Plant**
	Acieries et Forges d'Anor	Anor	France	50.0	4.1							Minimill
	Alpa -- Acieries et Laminoirs de Paris SA	Gargenville	France	49.0	1.8			100	2001	712		Minimill
	ALST SA	Saint Juery	France	44.0	2.2							Minimill
	Ascometal	Le Cheylas	France	45.4	6.0							Minimill
	Ascometal	Fos	France	42.9	0.7			59	2001	423		Minimill
	Ascometal	Hagondange	France	49.3	6.2			56	2001	401		Minimill
	Ascometal	Les Dunes	France	50.6	1.6			55	2001	392		Minimill
	Aubert et Duval	Les Ancizes Comps	France	45.9	2.8							Specialty Plant
	CLI - Creusot Loire Industrie	Chateauneuf	France	48.2	-3.8			13	2001	89		Minimill
	CLI - Creusot Loire Industrie	Le Creusot	France	46.8	4.4			22	2001	156		Minimill
	Erasteel Commentry	Commentry	France	46.3	2.8							Minimill
	Imphy SA	Imphy	France	46.9	3.3			11	2001	80		Minimill
MITTAL	Ispat Unimetal	Amneville	France	49.3	6.2							EAF
	Iton Seine SA	Bonnieres sur Seine	France	49.0	1.6			81	2001	579		Minimill
	L.M.E. sa (Lamines Marchands Europeens)	Trith St Leger	France	50.3	3.5			75	2001	534		Minimill
	SAM -- Ste des Aciers d'Armature pour le Beton	Montereau	France	48.4	3.0			100	2001	712		Minimill
	SAM -- Ste des Aciers d'Armature pour le Beton	Neuves-Maisons	France	48.6	6.1			112	2001	801		Minimill
ARCELOR	**Sollac**	**Dunkerque**	**France**	**51.1**	**2.4**			**8400**	**2004**	**5600**	**2003**	**Integrated Plant**
ARCELOR	**Sollac**	**Florange**	**France**	**49.3**	**6.1**			**3200**	**2004**	**2196**	**2003**	**Integrated Plant**
ARCELOR	**Sollac**	**Fos-sur-Mer**	**France**	**43.4**	**5.0**	**2150**	**2001**	**5900**	**2004**	**4246**	**2003**	**Integrated Plant**
	Ugine S.A.	Isbergues	France	50.6	2.5	105	2001					Minimill
	Ugine S.A.	L'Ardoise	France	44.1	4.7							Minimill
	Ugine Savoie	Ugine Savoie	France	45.8	6.4			20	2001	142		Minimill
SAINT-GOBAIN	**SAINT-GOBAIN PAM**	**Pont-à-Mousson**	**France**	**48.9**	**6.1**	**917**	**2001**	**1000**	**2004**	**609**	**2003**	**Integrated Plant**
ROGESA	**Dillinger Huttenwerke**	**Dillingen**	**Germany**	**49.3**	**6.9**	**8550**	**1998**	**6100**	**2004**	**3891**	**2003**	**Integrated Plant**
	Badische Stahlwerke GmbH (BSW)	Kehl/Rhein	Germany	48.6	7.8	185	2001	187	2001	1336		Minimill
	Benteler AG	Lingen	Germany	51.2	7.5							Minimill
	BES - Brandenburger Elektrostahlwerke GmbH	Brandenburg	Germany	52.3	9.2			200	2001	1425		Minimill
	BGH Edelstahl Siegen GmbH	Siegen	Germany	50.9	8.0					107		Specialty Plant
	Bohler AG, Edelstahlwerke	Dusseldorf	Germany	51.2	6.8							Specialty Plant
	Buderus - Edelstahlwerke Buderus AG	Wetzlar	Germany	50.6	8.5	565	2001					Specialty Plant
ARCELOR EKO Stahl	**EKO Stahl GmbH**	**Eisenhüttenstadt**	**Germany**	**52.2**	**14.6**	**3800**	**1998**	**3000**	**2004**	**2128**	**2003**	**Integrated Plant**
	Elbe-Stahlwerke Feralpi GmbH (ESF)	Riesa	Germany	51.3	13.3							Minimill
	Georgsmarienhutte GmbH	Georgsmarienhutte	Germany	52.2	8.1	161	2001	75	2001	534		Minimill
	Groditzer - Edelstahl Gröditz GmbH	Groditz	Germany	51.2	14.6							Specialty Plant
	HES - Hennigsdorfer Elektrostahlwerke GmbH	Hennigsdorf	Germany	52.6	13.2			150	2001	1068		Minimill
	Hoesch Hohenlimburg GmbH	Hagen	Germany	52.0	9.2							Specialty Plant
	Hoesch Hohenlimburg GmbH	Schwerte	Germany	51.5	7.6							Specialty Plant
HKM	**Huttenwerke Krupp Mannesmann GmbH (HKM)**	**Huckingen**	**Germany**	**51.4**	**6.8**	**8930**	**1998**	**6600**	**2004**	**4854**	**2003**	**Integrated Plant**
MITTAL	**Ispat Hamburger Stahlwerke GmbH**	**Hamburg**	**Germany**	**53.6**	**10.0**	**324**	**2001**	**1018**	**2001**	**801**		**Integrated Plant**
MITTAL	**Ispat Stahlwerk Ruhrort Gmbh**	**Ruhrort**	**Germany**	**51.4**	**6.8**	**275**	**2001**	**3053**	**2001**	**2404**		**Rolling Mill**
TKS	Krupp Edelstahlprofile GmbH	Siegen	Germany	50.9	8.0							Specialty Plant
TKS	Krupp Thyssen Nirosta GmbH	Bochum	Germany	53.6	7.6	108	2001					Specialty Plant
	Lech-Stahlwerke GmbH	Meitingen	Germany	48.6	10.9	491	2001					Minimill
	Lemmerz-Werke KGaA	Konigswinter	Germany	50.7	7.2							Specialty Plant
	Moselstahlwerk GmbH & Co KG	Trier	Germany	49.8	6.6							Minimill
	Neue Maxhuette-NMH Stahlwerke GmbH	Sulzbach-Rosenberg	Germany	49.5	11.8	950	1998	486	2001	383		Integrated Plant
	Rohrenwerke Bous/Saar GmbH (RBS)	Bous	Germany	49.3	6.8							Minimill
	Saarstahl A.G.iK.	Volklingen	Germany	49.3	6.9							Integrated Plant
	Sachsische Edelstahlwerke GmbH Freital	Freital	Germany	51.0	13.7							unknown
SALZGITTER FLACHSTAHL	**Salzgitter AG**	**Salzgitter**	**Germany**	**52.1**	**10.3**	**8550**	**1998**	**5200**	**2004**	**3853**	**2003**	**Integrated Plant**
SALZGITTER FLACHSTAHL	Salzgitter AG	Peine, Ilsede	Germany	52.3	10.2	224	2001					EAF
	Schmidt & Clemens GmbH & Co	Lindlar	Germany	51.0	7.4							Specialty Plant
	Stahlwerk Thuringen GmbH (Maxhutte Unterwellenborn GmbH)	Unterwellenborn	Germany	50.7	11.4			79	2001	561		Minimill
ARCELOR	**Stahlwerke Bremen GmbH**	**Bremen**	**Germany**	**53.1**	**8.8**	**7600**	**1998**	**4300**	**2004**	**3128**	**2003**	**Integrated Plant**
TKS	**Thyssen Krupp Stahl AG**	**Duisburg**	**Germany**	**51.4**	**6.8**	**24510**	**1998**	**15300**	**2004**	**10827**	**2003**	**Integrated Plant**
TKS	Thyssen Krupp Stahl AG	Oberhausen	Germany	48.1	12.6			76	2001	545		Minimill
TKS	Thyssen Krupp Stahl AG	Witten	Germany	51.4	7.3			66	2001	470		Minimill
~~TKS~~	~~Thyssen Krupp Stahl AG~~	~~Dortmund~~	~~Germany~~	~~51.5~~	~~7.5~~			closed				~~Integrated Plant~~
	Halyvourgia Thessalias SA	Volos	Greece	39.4	23.0							Minimill
HALYVOURGIKI INC.	**Halyvourgiki Inc.**	**Eleusis**	**Greece**	**38.0**	**23.5**			**2488**	**2001**	**1959**		**EAF**
	Sidenor SA (Greece)	Thessaloniki	Greece	40.7	23.0			62	2001	445		Minimill
	Sovel S.A.	Almyros	Greece	39.2	22.8			75	2001	534		Minimill
	Csepel Tubes Co Ltd	Budapest	Hungary	47.5	19.1							Specialty Plant
	DAM Steel Rt (Diosgyori Acelmuvek)	Miskolc	Hungary	48.1	20.8							Minimill

GROUP NAME	COMPANY NAME	CITY	COUNTRY	LATITUDE	LONGITUDE	CO2 REPORTED	YEAR REPORT	CO2 ESTIMATED	YEAR ESTIMATE	PRODUCTION kton steel	YEAR PRODUCTION	TECHNOLOGY
	Azma SA	Getafe	Spain	40.3	-3.7			62	2001	445		Minimill
	CELSA - Cia Espanola de Aceros Laminados SL	Castellbisbal	Spain	41.5	2.0			87	2001	623		Minimill
	Esteban Orbegozo SA	Zumarraga	Spain	43.1	-2.3			81	2001	579		Minimill
	Global Steel Wire SA	Santander	Spain	43.5	-3.8			94	2001	673		Minimill
	GSB Acero SA	Azkoitia	Spain	43.2	-2.3					196		Specialty Plant
	GSB Acero SA	Legazpia	Spain	43.1	-2.3					178		Specialty Plant
	Marcial Ucin SA	Azpeitia	Spain	43.2	-2.3							Minimill
	Megasa Siderurgica SA (Metalurgica Galaica SA)	Naron	Spain	42.8	-7.7			62	2001	445		Minimill
	Nervacero SA	Bilbao	Spain	43.3	-3.0							Minimill
	Productos Tubulares SA	Vizcaya	Spain	43.2	-2.7							Specialty Plant
	Rico y Echeverria SA	Zaragoza	Spain	41.6	-0.9			56	2001	401		Minimill
	Roldan SA	Ponferrada	Spain	42.6	-6.6							Specialty Plant
	Sidenor SA	Reinosa	Spain	43.0	-4.1							Specialty Plant
	Sidenor SA	Basauri	Spain	43.2	-2.9			93	2001	668		Minimill
	Sidenor SA	Basauri	Spain	43.2	-2.9							Specialty Plant
	Sidenor SA	Vitoria	Spain	42.9	-2.7							Specialty Plant
	Siderurgica Sevillana SA	Alcala de Guadaira	Spain	37.3	-5.8			114	2001	815		Minimill
	Tubos Reunidos SA	Amurrio	Spain	43.1	-3.0							Specialty Plant
	Anval	Torshalla	Sweden	59.4	16.5							Specialty Plant
	AvestaPolarit Oyj Abp	Avesta	Sweden	60.2	16.2	126	2001					Specialty Plant
	AvestaPolarit Oyj Abp	Degerfors	Sweden	59.2	14.4					102397		Specialty Plant
	Erasteel Kloster AB	Soderfors	Sweden	64.6	15.5							Specialty Plant
RUUKKI	Fundia AB, Special Bar Division	Smedjebacken	Sweden	60.1	15.4							Specialty Plant
	Lesteel AB	Lesjofors	Sweden	60.0	14.2							Specialty Plant
	Ovako Steel AB	Hofors	Sweden	60.6	16.3							Specialty Plant
	Sandvik Steel AB	Sandviken	Sweden	57.5	18.8							Specialty Plant
SSAB	**SSAB --Svenskt Stal AB**	**Oxelosund**	**Sweden**	**58.7**	**17.1**	**2380**	**2001**	**2300**	**2004**	**1473**	**2003**	**Integrated Plant**
SSAB	**SSAB --Svenskt Stal AB**	**Lulea**	**Sweden**	**65.6**	**22.2**	**1470**	**2001**	**3100**	**2004**	**2296**	**2004**	**Integrated Plant**
	Uddeholm Tooling AB	Hagfors	Sweden	60.0	13.7					142		Specialty Plant
	Ferrowohlen AG	Wohlen	Switzerland	47.4	8.3							Minimill
	Monteforno Acciaierie e Laminatoi SA	Bodio	Switzerland	46.4	8.9							Minimill
	Swiss Steel AG	Emmenbrueche	Switzerland	47.1	8.3							Minimill
	Von Roll AG	Gerlafingen	Switzerland	47.2	7.6							Minimill
	Allied Steel and Wire Ltd	Cardiff	UK	51.5	-3.1	29.9	2001					unknown
	Allied Steel and Wire Ltd	Cardiff	UK	51.5	-3.2	49.4	2001					unknown
	Allied Steel and Wire Ltd	Cardiff	UK	51.5	-3.1	107.4	2001	125	2001	890		Minimill
	ASW Sheerness Steel Ltd	Sheerness	UK	51.4	0.8	50.1	2001	50	2001	39		Integrated Plant
	ASW Sheerness Steel Ltd	Sheerness	UK	51.4	0.8	31.5	2001	137	2001	979		Minimill
	Avestapolarit Ltd	Wincobank	UK	53.4	-1.4	74	2001					Specialty Plant
CORUS	Corus UK Ltd	Shotton	UK	53.2	-3.0	12.7	2001					Coated Steel Products plant
CORUS	Corus UK Ltd	Port Talbot	UK	51.6	-3.8	632	2001	632	2001			Coke ovens
CORUS	Corus UK Ltd		UK	53.0	-2.2	43	1999					Rolling Mill
CORUS	Corus UK Ltd	Ebbw Vale	UK	51.8	-3.2	48.4	1999					unknown
CORUS	Corus UK Ltd	Llanelli	UK	51.7	-4.1	34.2	2001					unknown
CORUS	Corus UK Ltd	Corby	UK	52.5	-0.7	34.9	2001					unknown
CORUS	Corus UK Ltd	Skinningrove	UK	54.6	-0.9	32.3	2001					unknown
CORUS	Corus UK Ltd	Workington	UK	54.6	-3.6	20.2	2001					unknown
CORUS	**Corus UK Ltd**	**Scunthorpe**	**UK**	**53.6**	**-0.6**	**6485**	**2001**	**5000**	**2004**	**3627**	**2003**	**Integrated Plant**
CORUS	**Corus UK Ltd**	**Redcar**	**UK**	**54.6**	**-1.1**	**5636**	**2001**	**4400**	**2004**	**3290**	**2003**	**Integrated Plant**
CORUS	Corus UK Ltd	Newport	UK	51.6	-2.9	154.9	2001	155	2004	122		Integrated Plant
CORUS	**Corus UK Ltd**	**Port Talbot**	**UK**	**51.6**	**-3.8**	**5196**	**2001**	**4800**	**2004**	**3338**	**2003**	**Integrated Plant**
CORUS	Corus UK Ltd (Corus Engineering Steels Ltd)	Rotherham	UK	53.5	-1.3	258.5	2001	259	2001	204		Integrated Plant
CORUS	Corus UK Ltd (Corus Engineering Steels Ltd)	Rotherham	UK	53.5	-1.6	102.3	2001					unknown
CORUS	Corus UK Ltd (Corus Engineering Steels Ltd)	Rotherham	UK	53.4	-1.4	23.9	2001	24	2001	19		Integrated Plant
	Sheffield Forgemasters Engineering Ltd	Sheffield	UK	53.4	-1.4	73	2001	73	2001	57		Integrated Plant
	Sheffield Forgemasters Engineering Ltd	Crewe	UK	53.1	-2.4	11	2001	11	2001	9		Integrated Plant
	Alphasteel Ltd	Newport	UK	52.8	-2.4			187	2001	1336		Minimill
	Avesta Sheffield Ltd	Pontypool	UK	51.7	-3.0							Specialty Plant
	Avesta Sheffield Ltd	Sheffield	UK	53.4	-1.5							Specialty Plant
	Barworth Flockton Ltd	Sheffield	UK	53.4	-1.5							Specialty Plant
	British Rollmakers Corp Ltd	Coatbridge	UK	55.9	-4.0							Specialty Plant
	Coal Products Ltd		UK	51.6	-3.4	78	1999					Coking plant
	Co-Steel Sheerness PLC	Sheerness	UK	51.4	0.8			137	2001	979		Minimill
	ELG Carrs Special Steels	Sheffield	UK	53.4	-1.5							Specialty Plant
	Howmet Ltd, Exeter Alloy	Exeter	UK	50.7	-3.5							Specialty Plant
	Sanderson Kayser Ltd	Sheffield	UK	53.4	-1.5							Specialty Plant
	Sanderson Kayser Ltd	Sheffield	UK	53.4	-1.5							Specialty Plant
	Stelax Industries Limited		UK	51.4	-3.5							Specialty Plant
	T. W. Pearson Ltd	Sheffield	UK	53.4	-1.5							Specialty Plant
	Unsco Steels Ltd	Sheffield	UK	53.4	-1.5							Specialty Plant
	Wiggin Alloy Products Ltd	Hanley	UK	53.0	-2.2							Specialty Plant
~~CORUS~~	~~Corus UK Ltd~~	~~Newport~~	~~UK~~	~~51.6~~	~~-2.9~~	closed						~~Integrated Plant~~
	Sartid 1913 -- Smederevo	Smederevo	Yugoslavia	43.2	18.8							Integrated Plant

Appendix 2: Selection matrix

WORKS	COMPANY	COUNTRY	CO2_ESTIMATED	TECT_RNK
Taranto	ILVA	Italy	11200.00	10
IJmuiden	Corus	Netherlands	8500.00	10
Fos-sur-Mer	ARCELOR	France	5900.00	10
Scunthorpe	Corus	UK	5000.00	10
Redcar	Corus	UK	4400.00	10
Bremen	Arcelor StW.	Germany	4300.00	10
Florange	ARCELOR	France	3200.00	10
Eisenhüttenstadt	EKO Stahl	Germany	3000.00	10
Marcinelle	Duferco Clabecq SA	Belgium	2400.00	10
Dunaujvaros	DUNAFERR	Hungary	1470.07	10
Hamburg	Ispat	Germany	1017.70	10
Pont-à-Mousson	Saint-Gobain PAM	France	1000.00	10
Dunkerque	ARCELOR	France	8400.00	9
Gent	Sidmar NV	Belgium	5700.00	9
Kosice	U.S. Steel	Slovakia	5088.70	9
Ostrava	Nova Hut	Czech Republic	3392.47	9
Trinec	Trinecke Zelezarny	Czech Republic	2713.97	9
Ostrava	Vitkovice Steel	Czech Republic	1526.61	9
Duisburg	TKS	Germany	15300.00	8
Hückingen	HKM	Germany	6600.00	8
Ruhrort	Ispat	Germany	3053.20	8
Port Talbot	Corus	UK	4800.00	7
Liege	Cockerill Sambre	Belgium	1800.00	7
Donawitz	Voest-Alpine	Austria	1800.00	7
Galati	MITTAL	Romania	9611.99	6
Salzgitter	Salzgitter Flachstahl	Germany	5200.00	6
Calarasi Cod	MITTAL	Romania	2487.81	6
Czestochowa	Huta	Poland	1130.82	6
Linz	Voest-Alpine	Austria	5300.00	5
Dillingen	Rogesa	Germany	6100.00	4
Zenica	Zenica-Rudarsko-Metalurski Kominat	Bosnia and Herzegovina	2035.48	3
Gijon	ARCELOR	Spain	5800.00	2
Eleusis	Halyvourgiki	Greece	2487.80	2
Piombino	Lucchini	Italy	2400.00	2
Sofia	Kremikovtzi Corp	Bulgaria	2261.64	2
Trieste	SERVOLA	Italy	700.00	2
Raahe	Ruukki	Finland	3500.00	1
Lulea	SSAB	Sweden	3100.00	1
Oxelosund	SSAB	Sweden	2300.00	1
Koverhar	Ruukki	Finland	800.00	1

The table shows the ranking of the 40 major steel mills in Europe concerning the total CO2 emission and the tectonic setting. Selected plants for the next phase of ULCOS SP6.4 work is indicated. For further explanation see report.