Optimization of CCUS Supply Chains for Some European Countries under the Uncertainty

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Table S1 Data about CO_2 source sites for the CCUS supply chain of Italy

CO_2 source	CO_2 emissions (Mton/year)	CO_2 in flue gas (mol%)	Flue gas (mol/s)
Puglia	68.6	17	$2.91 \cdot 10^5$
Lombardy	46.8	18	$1.87 \cdot 10^5$
Sicily	41.5	4	$7.48 \cdot 10^5$
Lazio	28.2	14	$1.45 \cdot 10^5$
Sardinia	26.4	13	$1.46 \cdot 10^5$
Veneto	22.5	21	$7.72 \cdot 10^6$
Emilia Romagna	21.8	13	$1.21 \cdot 10^5$
Piedmont	19.7	18	$7.89 \cdot 10^4$
Liguria	17.6	15	$8.45 \cdot 10^4$
Tuscany	16.8	11	$1.11 \cdot 10^5$

Table S2 Data about CO_2 source sites for the CCUS supply chain of Germany

German regions	Node	Flue gas type	CO_2 emissions (Mton/year)	CO_2 in flue gas (mol%)	Flue gas (mol/s)
Northrhine-Westphalia	Dusseldorf	Iron & Steel	307.3	17	$1.30 \cdot 10^6$
Bavaria	Munich	Iron & Steel	80	18	$3.2 \cdot 10^5$
Baden-Württemberg	Stuttgart	Power Plant	69.3	4	$1.25 \cdot 10^6$
Lower Saxony	Hannover	Power Plant	69	14	$3.55 \cdot 10^5$
Brandenburg	Potsdam	Power Plant	55	13	$3.05 \cdot 10^5$
Saxony	Dresda	Cement	48.7	21	$1.67 \cdot 10^5$
Hessen	Wiesbaden	Power Plant	42.9	13	$2.38 \cdot 10^5$
Saxony-Anhalt	Magdeburg	Iron & Steel	27.4	18	$1.10 \cdot 10^5$
Berlin	Berlin	Power Plant	19.8	15	$9.51 \cdot 10^4$
Saarland	Saarbrucken	Cement	19.1	22	$6.26 \cdot 10^4$

Table S3 Data about CO_2 source sites for the CCUS supply chain of the UK

Region	Node	Flue gas type	CO_2 composition (mol%)	CO_2 (Mton/year)	Flue gas (mol/s)
Wales	Cardiff	Power plant	10	14.2	102313
Scotland	Edinburgh	Power plant	12	13.3	79857
North West	Manchester	Power plant	14	15.5	79771
Yorkshire and the Humber	Leeds	Power plant	13	18	99763

Table S4 Data cost for capture and compression technologies

Process	Material	α	β	γ	n	m
		investment cost ($/year)				
Absorption	MEA	7719	67871	901.000	0.660	0.800
Absorption	PZ	0	59956	226.932	0.566	0.800
PSA	13X	220462	26720	895.262	0.508	0.804
PSA	AHT	214535	17833	4607.297	0.744	0.813
PSA	MVY	162447	22468	6408.791	1.000	0.797
PSA	WEI	142320	19332	6076.357	0.610	0.779
VSA	13X	91060	23096	7688.408	0.470	0.763
VSA	AHT	113969	24939	2659.383	0.468	0.786
VSA	MVY	119259	21652	8101.014	1.000	0.795
VSA	WEI	180953	15644	7751.257	0.874	0.802
Membrane	FSC PVAm	177500	16505	18912.000	0.880	0.770
Membrane	POE-1	568	19151	29669.274	0.778	0.735
Membrane	POE-2	53960	19967	28462.417	0.656	0.744
		investment cost (€/year)				
Absorption	IL	7590.52	2606878.23	33119.84		0.67
		operating cost ($/year)				
Absorption	MEA	0	24088	0	1.000	1.000
Absorption	PZ	0	26825	0	0.945	0.966
PSA	13X	0	11352	3115.833	1.000	0.974
PSA	AHT	0	7040	983.893	0.626	1.000
PSA	MVY	0	7265	1328.677	0.756	1.000
PSA	WEI	0	6398	1257.721	0.554	0.991
VSA	13X	0	8167	1580.419	0.590	0.985
VSA	AHT	0	8545	1725.654	0.842	0.996

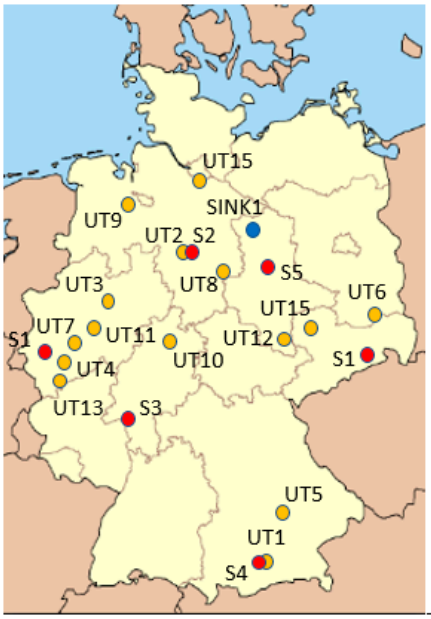
VSA	MVY	0	9117	1839.193	1.000	1.000
VSA	WEI	0	7378	1493.500	0.753	1.000
Membrane	FSC PVAm	0	11619	0	0.210	1.000
Membrane	POE-1	0	12798	0	0.134	0.980
Membrane	POE-2	0	13556	0	0.135	0.984
		operating cost (€/year)				
Absorption	IL	33172.59	897224.41	187421.22		0.65

Table S5 Maximum storage capacity of storage site in the CCUS supply chain of Italy, Germany and the UK

Storage site	Maximum storage capacity ($MtonCO_2$)
Altmark	508
Bunter Sandstone	10
Off-shore Adriatic sea	820

Figure S1 Topology of the CCUS supply chain of Italy for the scenario with the highest probability

Figure 2 Topology of the CCUS supply chain of the UK for the scenario with the highest probability



CO_2 utilization/storage site		CO_2 Production route	CO_2 source	
SINK1	Altmark		S5	Magdeburg
UT1	Munich	Wheat		
UT2	Hannover	Concrete curing and Wheat		
UT3	Ennigerloh	Concrete curing		
UT4	Cologne	Lignin		
UT5	Munchsmunster	Lignin		
UT6	Schwarzheide	Polyurethane	S1	Dresda
UT7	Leverkusen	Polyurethane	S2	Hannover
UT8	Salzgitter	Calcium carbonate	S3	Wiesbaden
UT9	Bremen	Calcium carbonate	S4	Munich
UT10	Kassel	Urea	S5	Magdeburg
UT11	Hagen	Urea		
UT12	Leuna	Methanol		
UT13	Wesseling	Methanol		
UT14	Hamburg	Concrete by red mud		
UT15	Rackwitz	Concrete by red mud		

Figure S3 Topology of the CCUS supply chain of Germany for the scenario with the highest probability