CCS CASE
EU ACTIONS:ENABLING FRAMEWORK –FLAGSHIP PROGRAM

CCS CASE

- **Need to stabilize CO2e < 450 ppm to avoid 2.4 C < Δt < 6.4 C by 2100 if fail to < 2 C → devastating & irreversible climate change impact**

  → 50 % decrease of emissions by 2030 while:
  - Energy demand increase X2
  - Renewables max 30 % of energy mix
- **Portfolio of solutions**
  - Energy efficiency increase
  - Renewable share increase
  - CCS
- **CCS potential**
  - Decrease in EU 0.6 to 1.7 Gt CO2, 9 to 16 Gt CO2 ww by 2050
  - Bridge to a truly sustainable energy system
- **Risk of not deploying CCS**
  - Time is the essence as if BAU, → CO2e will keep increasing **2ppm/y**

EU ACTIONS

- Council calls for up to 12 large scale CCS projects in operation for 2015
- Impact when looking forward :
  - Conjunctive efforts between Industry, MS and EU institutions could lead to 80-120 commercial projects in Europe by 2030 avoiding 400 $MtCO_2$ / y with potential to reduce EU emissions by 0.6 Gt/y to 1.7Gt/y by 2050

- Enabling Framework;
  - Legal:
    - CCS directive for CGS (CO_2 geological storage)
    - Waste directive amended for CO_2 exception
    - Water directives (WFD,GWD) amended
    - ELD directive being adapted for CCS compliance

- CCS directive approved after amendment 146 12/15/08

  Does not apply to research projects with total intended storage<100Kt

  - **Chapter 2: Site selection and exploration permit**
    - 4. selection: MS retain right of sites selectable pursuant to directive req^{ts}
    - 5. explo permit: responsibility of MS
  - **Chapter 3: Storage permit**
    - Responsibility of MS ,inclusion of financial responsibility from operator before injection . Commission review and opinion.
  - **Chapter 4: Operation, closure, post-closure obligations**
    - 12. CO_2 stream acceptance criteria & procedure
      - Overwhelmingly CO_2 , contaminants below limits set for storage integrity and transport infrastructure operation infrastructure
    - 13. Monitoring
      - Comparison actual/modeled behavior of CO_2 & formation water in storage site
      - Detection of irregularities (migration of CO_2 , CO_2 leakage)
    - 15. Inspection
      - CA (Competent Authority) to organize routine & non routine inspection of storage complexes, routine: once/year until 3 y after closure & every 5y after responsibility transfer to CA
    - 16. Measures in case of significant irregularities or leakage
      - Corrective measures required by CA to operator

- 17. **Closure & Post-closure**
  - After closure: operator remains responsible for monitoring & corrective or remedial measures & surrender of allowances in case of leakages
  - CA responsible for ensuring monitoring , corrective measures & obligation to surrender allowances
  - CA shall recover costs incurred for corrective & remedial actions by drawing on financial security fund.
- 18. **Transfer of liability**
  - Minimum period after closure to be determined by CA but not < 20y unless CA convinced of stored CO_2 completely & permanently contained
- 19. **Financial security**
  - Requested from operator as part of application for storage permit before commencement of injection
  - Periodically adjusted to assessed risk of leakage
  - Remains valid until storage site transferred to CA
  - Provision shall be made by operator to cover cost of monitoring for a period of 30y post transfer , monitoring reduced to need for identification of leakages or significant irregularities

- Chapter 5: Third party access
  - 20. Access to transport network & storage sites
    - MS should ensure transparent & non discriminatory access to Network & storage sites in accordance with geocapacity & transport capacity available & complying with technical specifications for safe transport and storage
- Chapter 6: General provisions
  - 23. Transboundary cooperation
    - CAs of MS concerned shall meet the requirements of directive jointly
- Chapter 8: Final provisions
  - 35a. Emission performance standards
    - Once environmental security & economical feasibility of CCS is demonstrated. Review of whether performance standards are needed & practical

- Implementation and further work:
  - Ratification of OSPAR amendments
    - Proposal for a Commission Decision
  - Finalization of MRG (Monitoring & Reporting of GHG) guidelines
    - Proposal for a Commission Decision to Climate Change Committee
  - Establishment of a scientific panel
    - Commission decision
  - Transposition for MS

- Financial
  - ETS directive with CCS elligibility in phase 3 / 2013
  - Adaptation of State Aid Rules to allow support to demo plants
  - Allocation of 300 M EUAs from new entrants reserve / 12 – 2015 from which to support the ZEP 12 demos of the flagship project
  - Around 300 M€ support for R&D for solving technology gaps
  - Stimulus package ERP 1.5 B€ (250 M€ for CCS??)
- Logistics
  - Launch of the European CCS Demo Projects Network (awarded to DNV)

ZEP FLAGSHIP PROGRAM -1

- Goal:
  - Demo program up and running by 2015 for CCS to be commercially viable by 2020

- Coverage:
  - Necessary to cover full range of CCS technologies & fuel sources, geographical and geological conditions and EU-wide
  - Over 40 CCS demo projects already lined up – industry is ready to proceed

From McKinsey contracted study

ZEP FLAGSHIP PROGRAM -2

- Necessary to cover the full CCS value chain
  - Carbon capture (pre-c, post-c, oxy-f), plant efficiency, transportation (pipes, ships) and storage (Depleted O&G fields, Deep Saline formations)
  - Technologies gaps , infrastructures, HSE
  - Regulatory framework
  - Financing mechanisms
    - ppp (public private partnership)
      - Industry for plant base cost
      - Public for the CCS incremental cost
      - Tendering process

ZEP FLAGSHIP PROGRAM -3

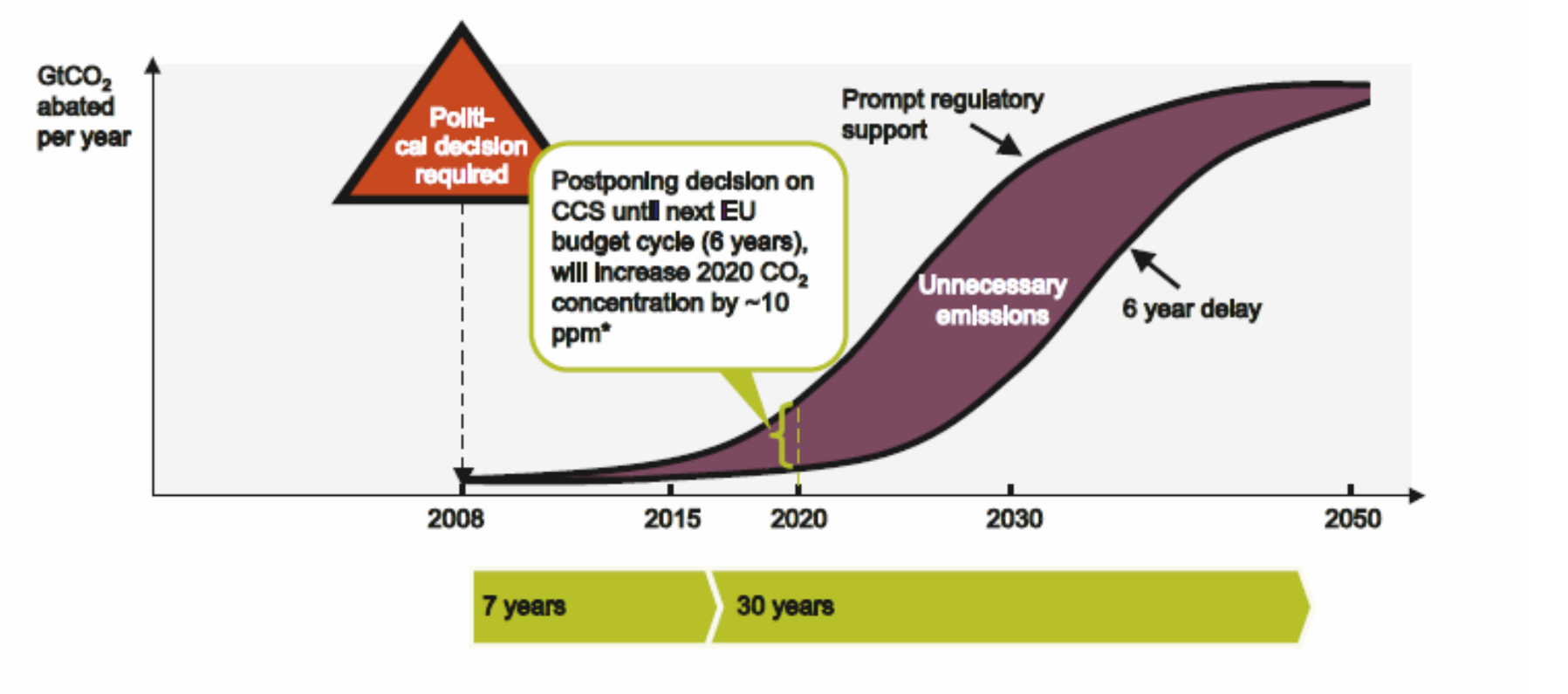
- **Demo projects selection criteria:**
  - **Portfolio criteria**
    - Fuel source (coals, gas, lignite, biomass)
    - Capture techno
    - Storage type (field, offshore/onshore)
    - Transport logistics (Conveyance, cross-border issues,..)
  - **Project criteria**
    - Size
    - Emission reduction performance
    - Timing
    - Partnership consortia
    - K sharing
  - **Elligibility criteria**
    - Info disclosure and K sharing
    - Process to maximize public acceptance
    - Demonstration of construction feasibility
    - Demonstration of safe , stable, long term CGS
    - Financial support on the basis of actual performance (CO2 avoided t/CCS MWh delivered)

ZEP FLAGSHIP PROGRAM - 4

- Critical issues
  - Timing
  - Financing economic gap
  - Develop public and deciders education and awareness
  - Develop convincing arguments and strategy to stop the perceived competition between support to CCS and support to renewables, key impediment to CCS deployment goals

ZEP FLAGSHIP PROGRAM -5

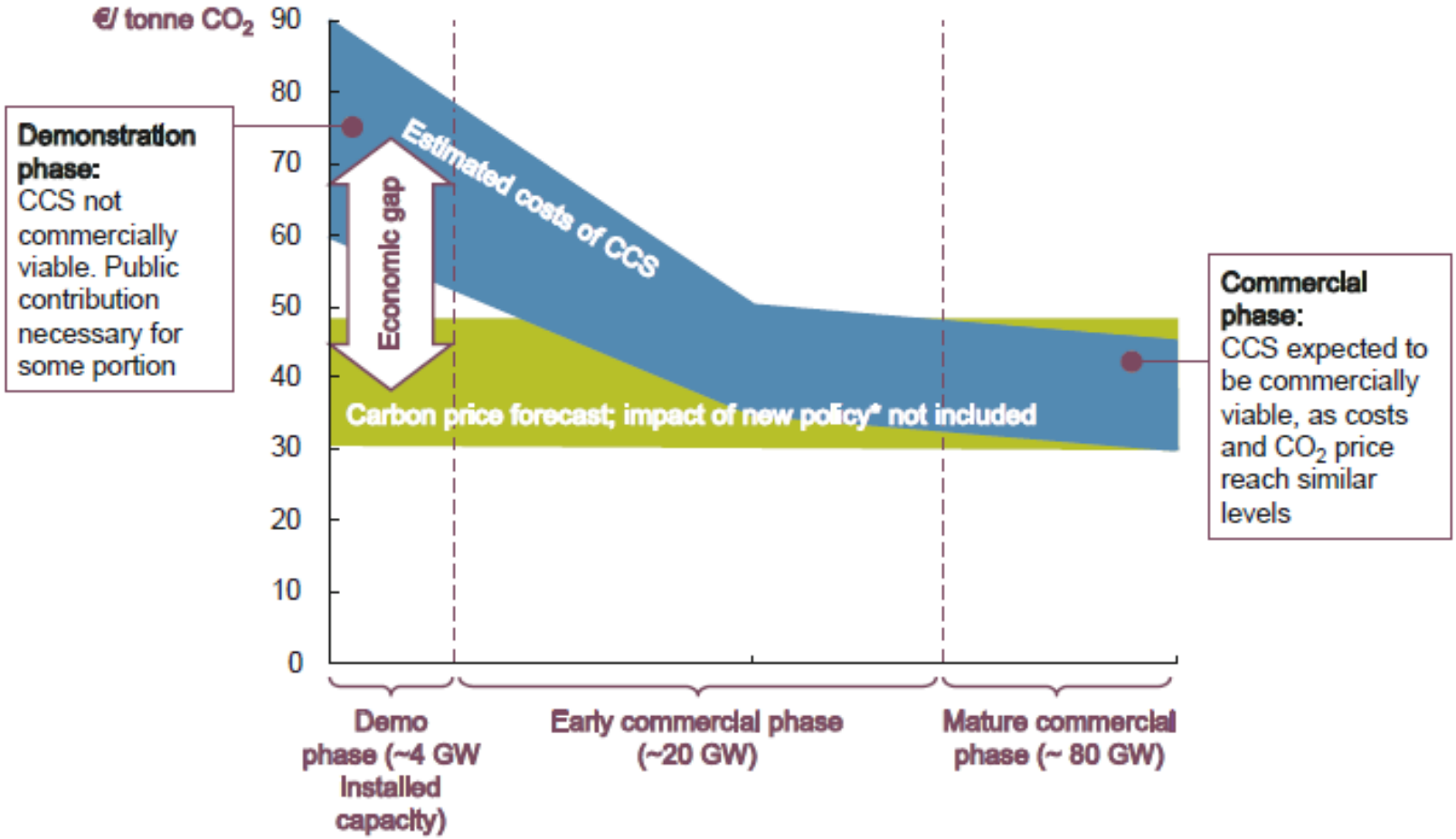
TIMING IS CRITICAL



TIMING

- Need to
  - Shorten permitting
  - Shorten tendering process
  - Balance the risk taken by industry by sizeable public support

FINANCING THE ECONOMIC GAP



* Carbon price band for 2015 from 2008-15 estimates from Deutsche Bank, New Carbon Finance, Soc Gen, UBS, Point Carbo. Impact of the (possible) new ETS directive and the Copenhagen conference are not included in the analysis

Source: McKinsey & Company "CCS – Assessing the Economics" for the cost numbers; policy implications drawn by ZEP

ZEP FLAGSHIP PROGRAM - 6

- Public & Political education and awareness
  - Industry is not perceived as the trustable channel
  - Need for the industry to strongly participate in training credible trainers:
    - ie: combination of:
      - Academia
      - NGOs
      - Medias
    - Need to use support of dedicated associations:
      - CCSA
      - CO2Geonet
      - CO2Net
      - EIA-GHG
      - …

COMMENTS ON PERCEIVED COMPETITION WITH RENEWABLES

- Energy efficiency actions , renewables share increase and CCS deployment must all be taken into account if we are serious about CC mitigation
- The huge park of installed FF based power plants will not be replaced by centralized renewable based plants in any foreseeable future.
- The only hope to curtail their huge GHG emissions is to retrofit CCS solutions for the part of the park which will not be phased out soon. This is critical and in no way in competition with renewables
- Renewables on the other hand could be deployed very efficiently on the distributed energy generation network again here not in competition with CCS.

THANK YOU FOR YOUR ATTENTION

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POTENTIAL EU CCS FULL SCALE DEMONSTRATION PROJECTS

Claude ROULET

EU CCS CLUSTERS

CO_2 Emissions*	Mt / yr
Very high	> 30
High	15-30
Medium-high	10-15
Medium	6-10
Medium-low	3-6
Low	1-3
Very low	0-1

Capture cluster

CO_2 Emitters	Mt / yr
Very large	> 13
Large	8-13
Medium-large	5-8
Medium	3-5

Rationale for CCS clusters
- Economics: fewer pipelines lead to lower transport cost
- Feasibility: public acceptance, permitting and local coordination of infrastructure are all simpler in a region where CCS is already taking place

- **Though clusters are most cost-effective, individual countries may decide to stimulate CCS outside of clusters**
- **In addition, above a certain CCS ambition level, development outside of key clusters becomes a crucial requirement**

* Emissions from stationary point emitters

Source: IEA GHG Emissions database; Google earth; NASA; Tele Atlas; Europe Technologies & TerraMetrics

POTENTIAL EU CCS PROJECTS- 1

	Overview				CO_2 capture
Project name	Partners/participants	Country	Location	Industry	Capture technology
MARITSA		Bulgaria	Maritsa	Power	Pre-combustion
HODONIN CEZ	CEZ	Czech Republic	Hodonin, SE	Power	Post-combustion
LEDVICE CEZ	CEZ	Czech Republic	Ledvice, N	Power	Post-combustion
KALUNDBORG DONG	DONG Energy	Denmark	Kalundborg	Power	Post-combustion
AALBORG V.FALL	Vattenfall	Denmark	Aalborg	Power	Post-combustion
MERI PORI FORTUM	Fortum, TVO	Finland	Meri Pori	Power	Oxy-fuel or post-combustion
LACQ TOTAL	Total, ALSTOM, Air Liquide	France	Lacq plant and Rousse field	Power	Oxy-fuel
FLORANGE ARC.MIT	ArcelorMittal	France	France	Steel	Post-combustion
JANSCHWALDE V.FALL	Vattenfall	Germany	Jänschwalde, Brandenburg	Power	Oxy-fuel & post-combustion
WILHELMSHAVEN E.ON	E.On CE	Germany	Wilhelmshaven	Power	Post-combustion
EISENHUTTENSTADT ARC.MIT	ArcelorMittal	Germany	Eisenhüttenstadt	Steel	Post-combustion
GREIFSWALD DONG	DONG Energy	Germany	Greifswald, Mecklenburg	Power	Post-combustion
HUERTH RWE	RWE	Germany	Huerth, North Rhine-Westfalia	Power	Pre-combustion
ENEL CCS1	ENEL	Italy		Power	Post-combustion
ENEL CCS2	ENEL	Italy		Power	Oxy-fuel
SALINE JONICHE SEI	SEI (Rätia Energie & Partners)	Italy	Saline Joniche (RC)	Power	Post-combustion
BARENDRECHT SHELL	Shell	Netherlands	Barendrecht (storage), Pernis (capture)	Chemicals, Refinery	H2 production
EEMSHAVEN RWE	RWE Power, BASF, Linde	Netherlands	Eemshaven	Power	Post-combustion
ROTTERDAM E.ON	E.On Benelux	Netherlands	Maasvlakte, Rotterdam	Power	Post-combustion
ROTTERDAM ENECO	ENECO, International Power	Netherlands	Pistoolhaven, Rotterdam	Power	Post-combustion
EEMSHAVEN NUON	Nuon	Netherlands	Eemshaven	Power	Pre-combustion
ROTTERDAM CGEN	CGEN NV	Netherlands	Europoort Rotterdam	Power	Pre-combustion
ROTTERDAM ESSENT	Essent	Netherlands	Rotterdam	Power	Pre-combustion

POTENTIAL EU CCS PROJECTS- 2

					CO_2 transport and storage			Implementation
	Fuel type	New vs. retrofit	Plant size (MW)	CO_2 produced (Mt/yr)	Transport	Storage	On-/ offshore	Storage rate (Mt/yr)	Start of operation
	Lignite	New	650	3.43	Pipeline		Onshore		
	Lignite, biomass	Retrofit	105	0.5	Pipeline	Depleted oil & gas field	Onshore	0.3	2015
	Lignite	Retrofit (CCS-ready)	660	3.48	Pipeline	Saline aquifer (structural)	Onshore	0.9	2015
	Hard coal	Retrofit	600	3.58	Pipeline	Saline aquifer	Offshore		2015
	Hard coal	Retrofit	470 (310 after retrofit)	1.8	Pipeline	Saline aquifer (structural)	Onshore		2013
	Hard coal	Retrofit	560 (400-450 after)	3.35	Shipment		Offshore		2015
	Gas	Retrofit	30		Pipeline	Depleted oil & gas field	Onshore		2010
	Hard coal, petcoke	Retrofit			Pipeline	Saline aquifer	Onshore		
	Lignite	New & retrofit	250 (Oxy), ≤ 250 (post)	1.79	Pipeline	EGR or Saline aquifer	Onshore		2015
	Hard coal	New	500 (100 captured)	0.6	Pipeline	Saline aquifer	Onshore	0.6	2015
	Hard coal, petcoke	Retrofit			Pipeline	Saline aquifer	Onshore		
	Hard coal	New	1600	8	Pipeline				
	Lignite	New	450	2.8	Pipeline	Saline aquifer	Onshore	2.8	2014
	Hard coal	Retrofit	242 MWe net	1.5	Pipeline	Saline aquifer	Offshore	1.5	2014
	Hard coal	New	320 MWe net	2.1	Pipeline	Saline aquifer	Offshore	2.1	2016
	Hard coal	New (CCS-ready)	1320	3.94	Pipeline			up to 3.55 (90%)	
	Heavy oil			0.4	Pipeline	Depleted oil & gas field	Onshore	0.4	2011
	Hard coal	Retrofit	40	0.2	Pipeline	Depleted oil & gas field	Onshore	0.2	2015
	Hard coal	New (CCS-ready)	1070 (100 captured)	5.6	Pipeline	Depleted oil & gas field	Offshore		
	Gas	New	845		Pipeline				2011
	Hard coal, biomass	New	1200	4.14	Pipeline	Depleted oil & gas field			2013
	Hard coal, biomass	New	450	2.5	Pipeline/ Shipment	Depleted oil & gas field	Offshore	2.0	2014
	Hard coal, biomass	New	1000	4	Pipeline	Depleted oil & gas field		4	2016

POTENTIAL EU CCS PROJECTS- 3

	Overview				CO_2 capture
Project name	Partners/participants	Country	Location	Industry	Capture technology
MONGSTAD STATOIL	StatoilHydro, Gasnova	Norway	Bergen	Power, refinery	Post-combustion
HAMMERFEST H.ENERGI	Hammerfest Energi, Sargas, Siemens	Norway	Hammerfest	Power	Post-combustion
HUSNES TINFOS	Tinfos, Sør-Norge, Eramet, Sargas	Norway	Husnes	Various	Post-combustion
KARSTO AKER	Aker, Fluor, Mitsubishi	Norway	Karsto	Oil/gas	Post-combustion
MONGSTAD BKK	BKK	Norway	Mongstad	Power	Post-combustion or pre-combustion
HAUGESUND HAUGALANDKRAFT	Haugaland Kraft	Norway	Haugesund	Power	
SIEKIERKI V.FALL	Vattenfall	Poland	Warsaw	Power	Post-combustion
KEDZIERZYN PKE	PKE/ ZAK	Poland	Kedzierzyn Kozle, Slaskie	Power/ Chemical	Pre-combustion
BELCHATOW BOT	PGE, ICPC, CMI, PGI	Poland	Belchatow	Power	Post-combustion
COMPOSTILLA ENDESA	Endesa	Spain	Compostilla, Leon	Power	Oxy-fuel (CFB)
UNION FENOSA	Union Fenosa	Spain		Power	Post-combustion
KINGSNORTH E.ON	E.ON UK	UK	Kingsnorth, South East England	Power	Post-combustion
SCUNTHORPE CORUS	CORUS	UK	Scunthorpe	Steel	Post-combustion
COCKENZIE SCOT.PWR	Scottish Power	UK	Scotland	Power	Post-combustion
FERRYBRIDGE S&S ENERGY	Scottish and Southern Energy	UK	Ferrybridge, West Yorkshire	Power	Post-combustion
TILBURY RWE	RWE nPower	UK	Tilbury, Thames Estuary	Power	Post-combustion
KILLINGHOLME E.ON	E.ON UK	UK	Humberside, Lincolnshire	Power	Pre-combustion
HATFIELD P.FUEL PWR	Powerfuel Power Ltd	UK	Hatfield, South Yorkshire	Power	Pre-combustion
TEESSIDE PROG.EN	Centrica, Progressive Energy, Coastal Energy	UK	Teesside, Northeast England	Power	Pre-combustion
DRYM PROG.EN	Progressive Energy, BGS, CO2STORE	UK	Onllwyn, South Wales	Power	Pre-combustion

POTENTIAL EU CCS PROJECTS- 4

					CO_2 transport and storage				Implementation
	Fuel type	New vs. retrofit	Plant size (MW)	CO_2 produced (Mt/yr)	Transport	Storage	On-/ offshore	Storage rate (Mt/yr)	Start of operation
	Gas	New	280 electricity + 350 heat	1.5	Pipeline	Saline aquifer	Offshore	1 - 3	2014
	Gas	New	100		Pipeline	Saline aquifer	Offshore		
	Hard coal	New	400	2.5	Shipment	Saline aquifer			
	Gas	Retrofit (CCS-ready)	420	1.2	Pipeline	Saline aquifer	Offshore		2012
	Gas	New	450	1.2	Pipeline	Saline aquifer	Offshore	1.05	2014
	Hard coal	New	400- 800				Offshore	2- 2.5	2015
	Hard coal	New	480	2.87	Pipeline		Onshore		2015+
	Hard coal	New	500 MWth syngas + 250 Mwe	3.4	Pipeline	Saline aquifer	Onshore	2.4	2014
	Lignite	New	858 MWe (V3 CCS)	5.1	Pipeline	Saline aquifer	Onshore	1.7	2015
	Sub-bit, bit & anth coal, pet coke, biomass	New	500 (400 MWe, net CCS)		Pipeline	Saline aquifer	Onshore	2.75	2015
	Hard coal	New	800 MWe (200 MWe CCS)		Pipeline	Saline aquifer	Onshore	1.0	2016-2017
	Hard coal	New (CCS-ready)	300	2	Pipeline	Depleted gas field	Offshore	2	2014
	Hard coal, petcoke	Retrofit			Pipeline	Depleted oil & gas field	Offshore		
	Hard coal	New			Pipeline	Saline aquifer			
	Hard coal (UK)	Retrofit (CCS-ready)	500		Pipeline	Saline aquifer		1.7	2015+
	Hard coal	New (CCS-ready)	1600	9.56	Pipeline	Saline aquifer			2016
	Hard coal	New	350	2.5	Pipeline	Depleted oil & gas field	Offshore	2.5	2016+
	Hard coal	New	900	4.75	Pipeline	Depleted oil & gas field	Offshore		2012-2014
	Hard coal, petcoke	New	800	4.22	Pipeline	Depleted oil & gas field	Offshore	4.22	2013
	Hard coal	New	450	2.4	Pipeline				