CARBON CAPTURE AND STORAGE

International Energy Agency

CCUS AG Working Group analysis to date

Workshop on behalf of
Clean Energy Ministerial CCUS Action Group
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Process

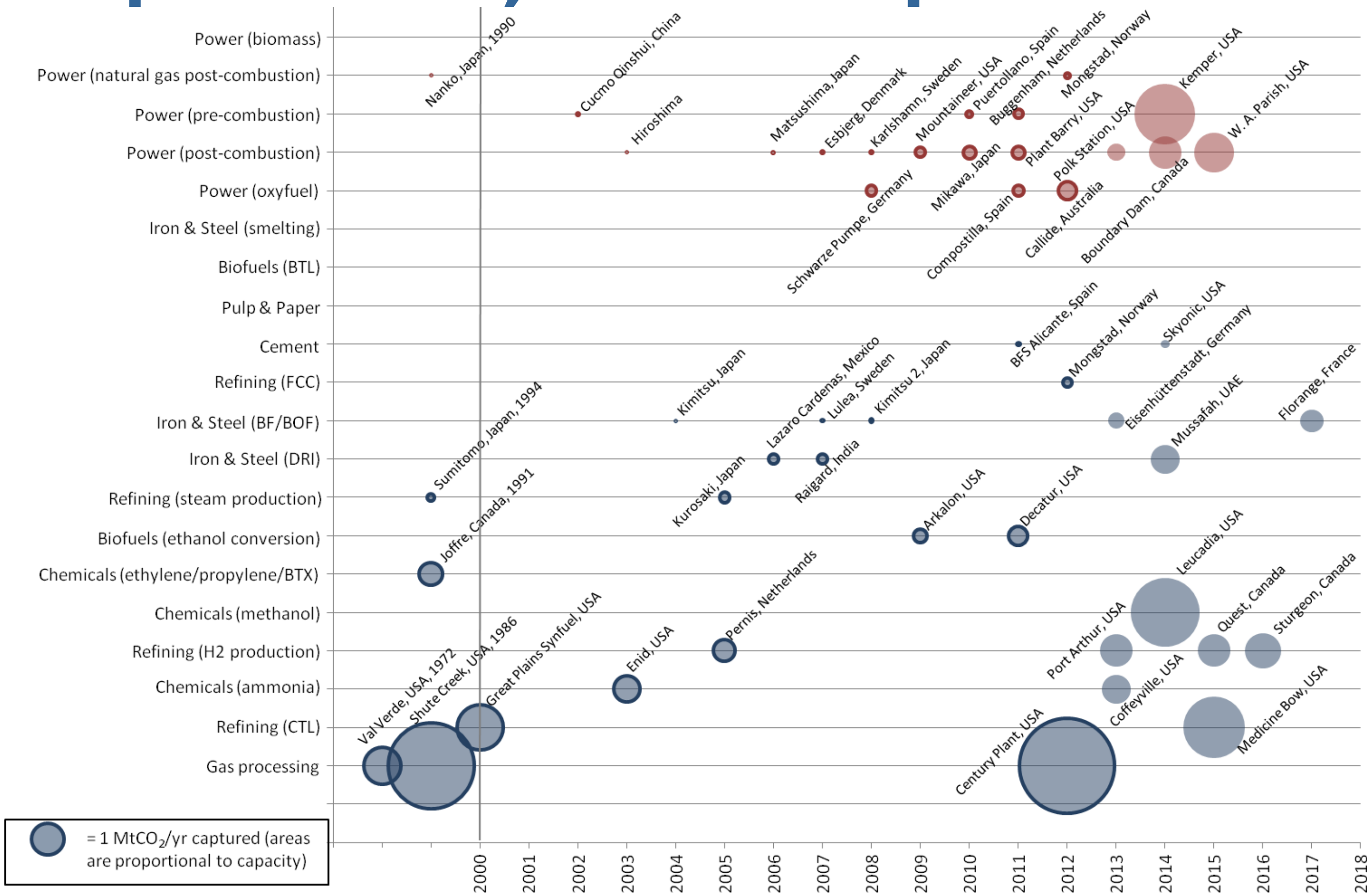
July	Webinar
September	Working Group convened
October	Background paper drafted and circulated
November	Interviews and surveys
December	Policy paper drafted
January	Policy paper circulated / Background paper finalised / Workshop
February	Comments received by 6 February 2013 Policy paper finalised by 28 February 2013
April	CEM4 17-18 April 2013, New Delhi

Background paper

Focus on technological readiness, technical options and sectoral dynamics

- **Some sectors have mature technologies for CO_2 capture**: refining (H_2), chemicals (ammonia, methanol), gas processing, biofuels (ethanol)
- **Some sectors have not yet passed the pilot stage**: cement, iron and steel, chemicals (crackers). The costs and options are not well understood
- **Potentials change widely between sectors/regions**: depends whether production is expanding or contracting, and what fuel is used
- **Some demo projects are under development:** US, CAN, FR, JP, KOR, CHN
- **Many CCUS countries have no activities ongoing in the key sectors**
- **Few incentive policies**: most industries are protected from full impacts of carbon pricing where it exists
- **Some good examples of collaboration:** ECRA, ULCOS, COURSE50

Lots of processes, lots of experience



But, while gas processing, refining and chemicals lead, others lag

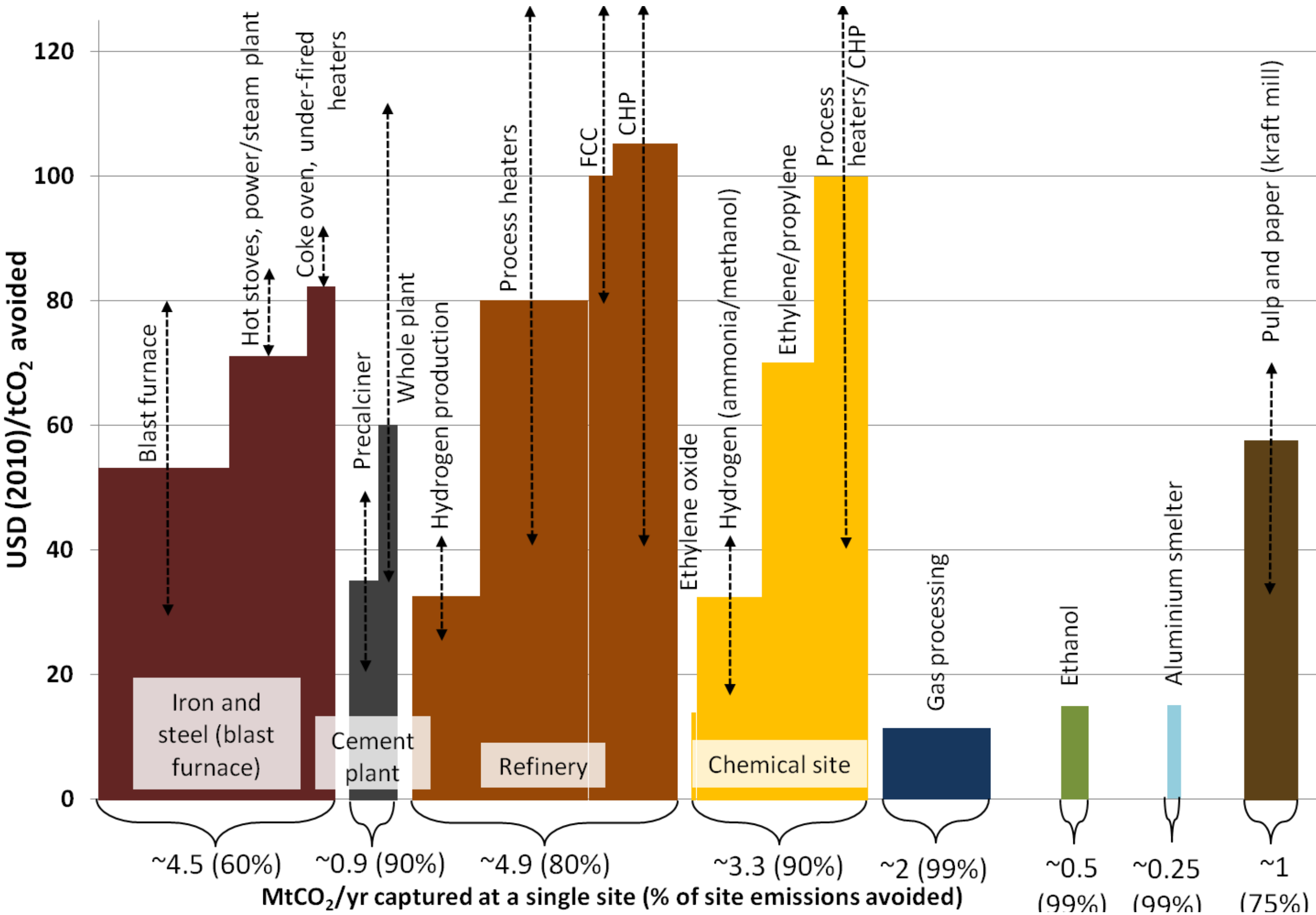
Purity & pressure influence technology & cost

CO2 Source		CO2 Purity (by volume)	CO2 pressure		Possible Capture Processes					
Process	**Sector**	High purity ⇐ Oxygen enhanced ⇐ Syn-gas ⇐ Flue Gas	Typical Stream Pressure (kPa)	Typical partial pressure (kPa)	Clean up only (e.g dehydration)	Cryogenic	Physical solvents	Adsorbents	Membranes	Chemical Solvents
Ethylene oxide	Chemicals	100%	2500	2500	✓					
Fermentation	Biofuels	100%	100	100	✓					
Cement kiln (oxyfuel)*	Cement	>90%	100	95	✓					
Oxyfired and chemical looping coal	Power	80-98%	100	90	✓	✓				
DRI (coal- or gas-fired)	Iron and steel	?	100	?						
IGCC (oxy blown)*	Power	20-40%	2000 to 7000	500 to 3000			✓			
Acid gas clean-up	Gas processing	2-65%	900 to 8000	20 to 5000			✓		✓	✓
Blast furnace gas (Top gas recycling)	Iron and steel	60-75%	100	60 to 75				✓		
Ethylene production	Chemicals	8-18%	2800	200 to 500				✓	✓	
Hydrogen production	Chemicals, Refining	15-20%	2200 to 2700	300 to 550				✓		
IGCC (air blown)	Power	12-14%	2000 to 7000	250 to 1000					✓	
Blast furnace gas	Iron and steel	14-33%	100	14 to 33						✓
Cement kiln (airfired)	Cement	14-40%	100	14 to 40						✓
Pulverised coal	Power	12-14%	100	12 to 14						✓
Process heaters	Refining, Chemicals	3-13%	100	3 to 13						✓
Gas boiler	Power	7-10%	100	7 to 10						✓
Gas turbine	Power	3%	100	3						✓

Note: *oxyfired processes require additional energy for the separation of air to produce oxygen.

There are opportunities for collaboration between sectors

Sizes & costs vary within & between sectors



- Steel mills and refineries often bigger than power plants
- Ammonia plants integrated with urea can be small
- Large uncertainties
- Depends on location

What are the messages for policymakers?

- **Sectors are at different levels of technical development**
  - Some industrial applications are the cheapest options for demonstrating the integrated CCS value chain today
  - Flue gas scrubbing can be applied to a range of processes, but needs to be tailored. There is much scope for collaboration between sectors
  - Optimising costs may mean redesigning plants, which has a perceived risk in conservative sectors. Pilot and then demonstration is needed
- **Countries need nuanced CCS and climate policies**
  - For sectors that trade internationally, the consequences of a rising carbon price need to be thoroughly understood for each region
  - Different CCUS AG countries will have different priority sectors, depending on trade exposure, fuel sources and importance of sectors
  - Most countries are not investing in developing CCS in a range of industrial applications. This suggests that collaboration will be crucial