Imperial College London

Overview of large-scale CO_2 capture projects in Europe, Asia and Africa

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What is "Large-Scale" ?

❑ Development stage

- Technology Readiness Levels 7-8

❑ Size

- > 0.8 Mt CO_2/yr for coal-fired plants
- > 0.4 Mt CO_2/yr for other emissions-intensive industrial facilities

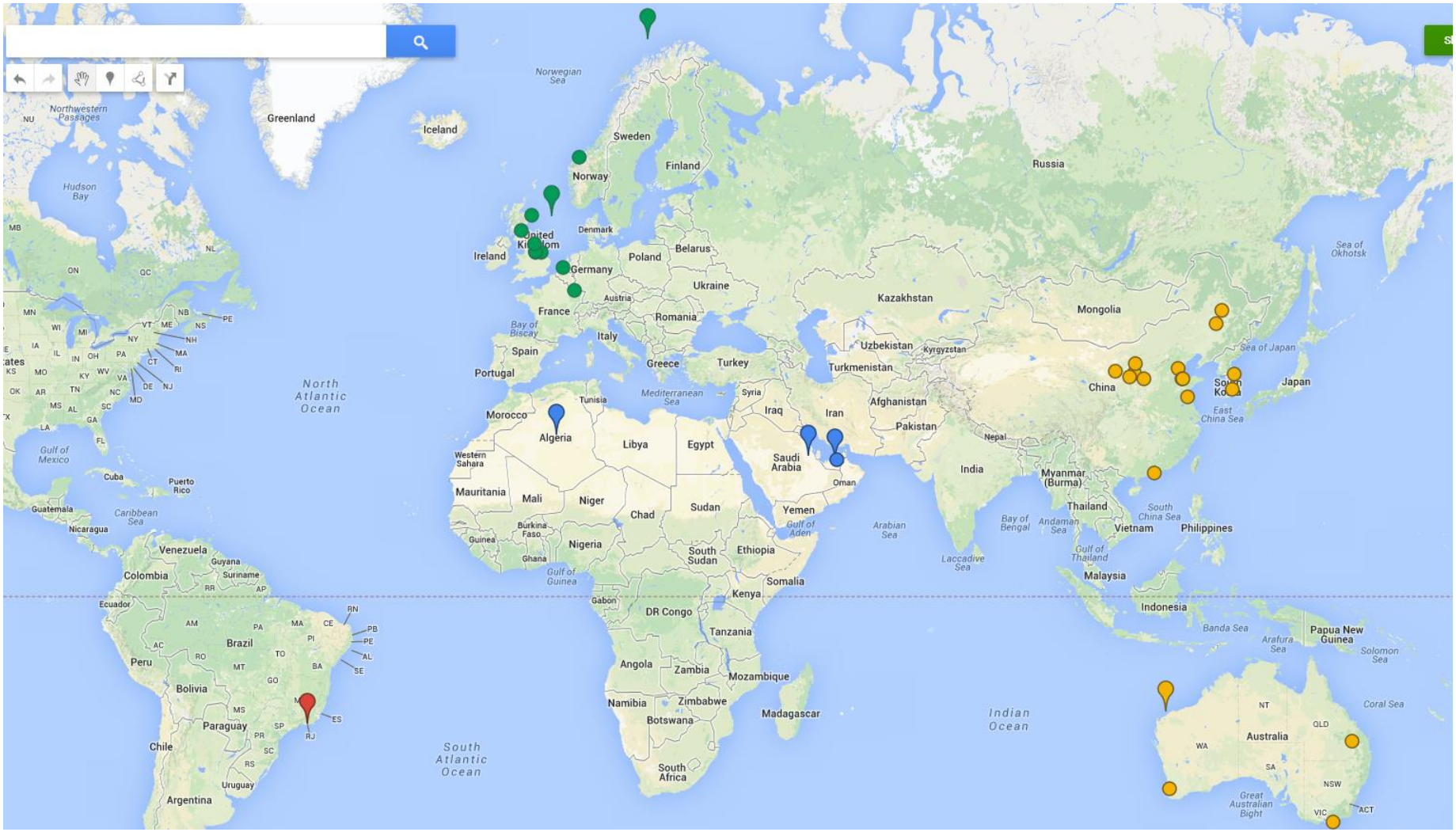
❑ Comparison to pilot-scale

- ~ Tens and hundreds kt CO_2/yr

❑ What are "integrated" large-scale projects ?

- Involving capture, transportation and storage

Locations


Greenland
Iceland
Norwegian Sea
Sweden
Finland
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Norway
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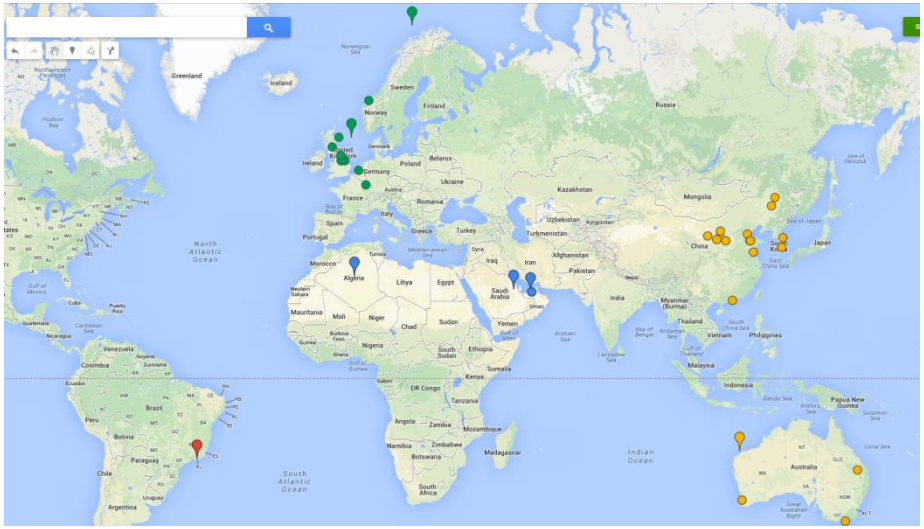
Mongolia
Spain
Italy
Uzbekistan
Kyrgyzstan
Portugal
Greece
Turkey
Turkmenistan
China
Japan
Tunisia
Syria
Iraq
Iran
Afghanistan
Pakistan
Morocco
Algeria
Libya
Egypt
Saudi Arabia
India
Nepal
Myanmar (Burma)
Thailand
Vietnam
Philippines
Western Sahara
Mauritania
Mali
Niger
Chad
Sudan
Yemen
Oman
Malaysia
Indonesia
Nigeria
South Sudan
Ethiopia
Somalia
Kenya
Gabon
DR Congo
Tanzania
Angola
Zambia
Mozambique
Namibia
Zimbabwe
Botswana
Madagascar
South Africa
Cuba
Puerto Rico
Guatemala
Nicaragua
Venezuela
Colombia
Guyana
Suriname
Ecuador
Peru
Brazil
Bolivia
Paraguay
Chile
Uruguay
Argentina
North Atlantic Ocean
South Atlantic Ocean
Indian Ocean
Mediterranean Sea
Gulf of Mexico
Caribbean Sea
Gulf of Guinea
Arabian Sea
Laccadive Sea
Bay of Bengal
Andaman Sea
South China Sea
East China Sea
Sea of Japan
Sea of Okhotsk
Banda Sea
Arafura Sea
Coral Sea
Australia
Papua New Guinea
Solomon Sea
Hudson Bay
Northwestern Passages
Bay of Biscay

Locations

- **34 large-scale projects**
  - 18 in Asia and Australia
  - 11 in Europe
  - 4 in Africa and the Middle East
  - 1 in South America



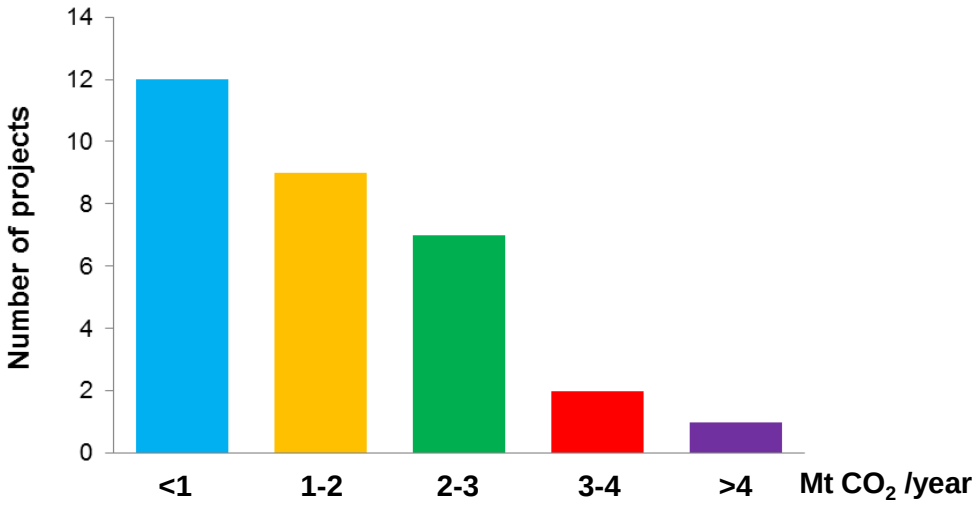
- **26 projects currently in the US and Canada**

- In continental Europe, the number of projects dropped from 14 in 2011 to 5 today

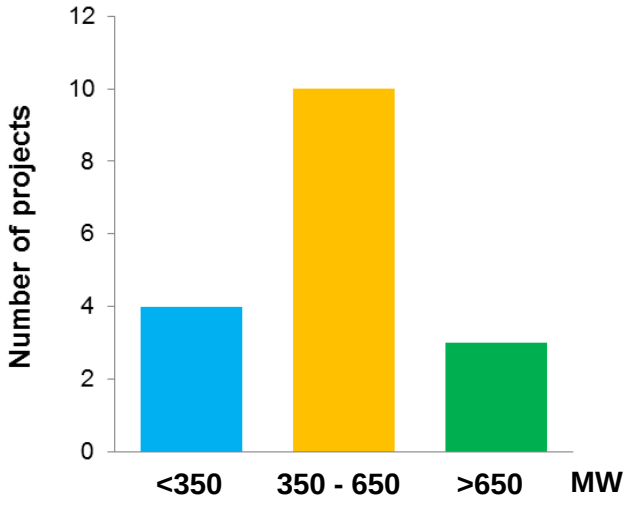
- In China, the number of projects doubled from 6 in 2011 to 12 today

Projects' "Size Distribution"

CO_2 Captured



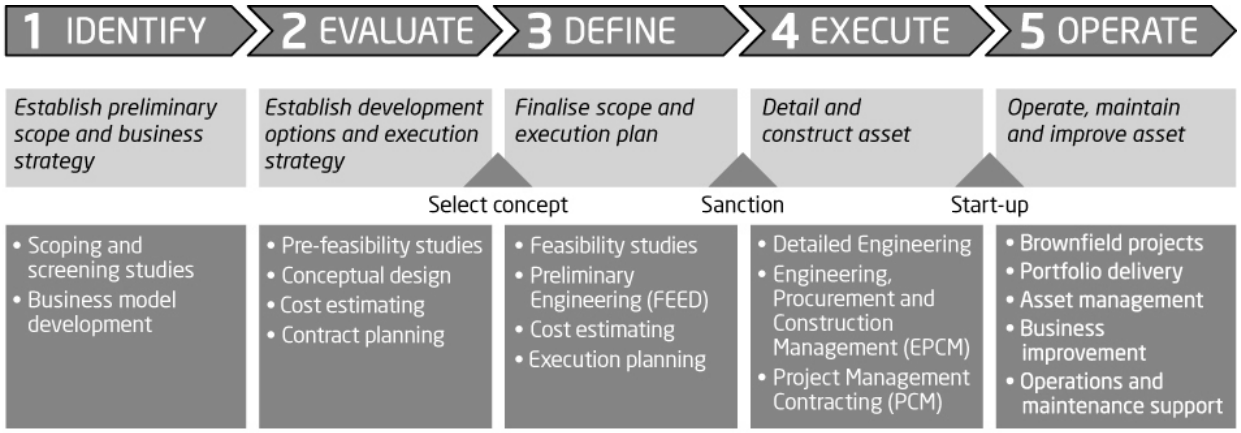
Power Generation



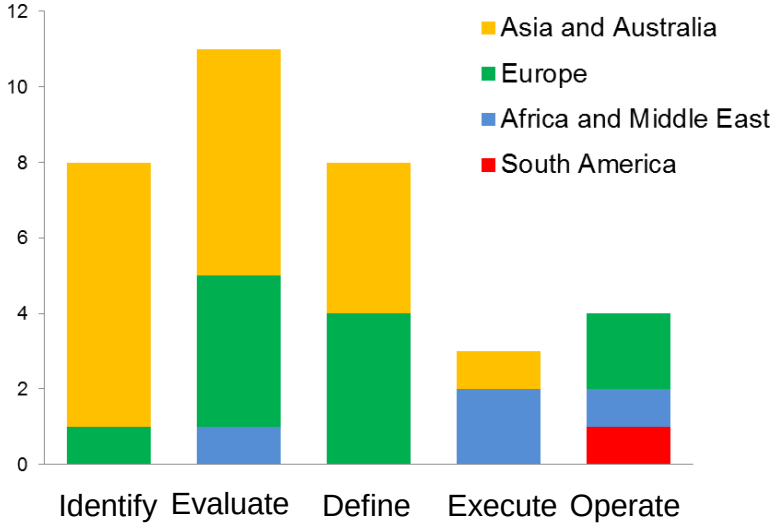
- The largest project outside North America in terms of CO_2 captured is in the UK (Don Valley Power project)
- The largest project worldwide captures 8.4 Mt CO_2 /year (Century Plant)
- The largest project in terms of power generation is in China (Lianyungang IGCC)

Phases of Development

IEA Development Phase Classification



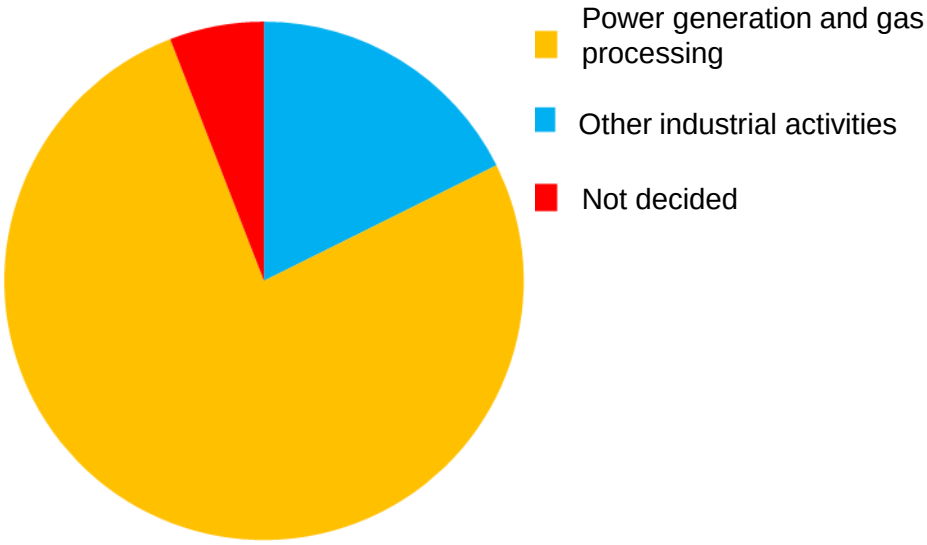
Development stages



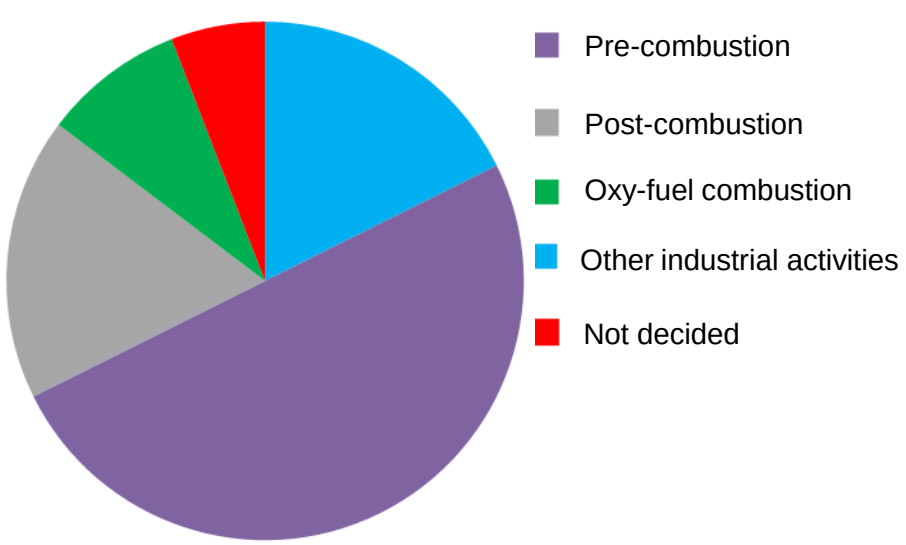
- Target: 30 projects worldwide at the "execute" or "operate" stage by 2020 (2013: 21 projects)
- Less mature stage than in the US and Canada:
  Identify: 0 Evaluate: 5 Define: 7
  Execute: 6 Operate: 8

Sector and Type of Capture

Sectors

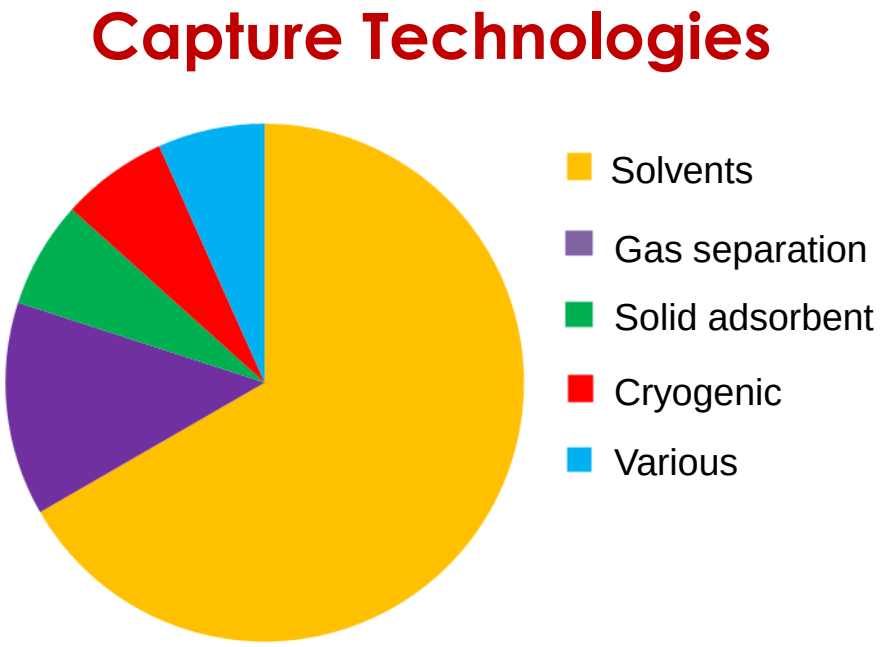


Type of Capture



- Capture units for power generation and gas processing facilities are dominant
- The industrial facilities correspond to chemicals, iron and steel and fertilizer productions

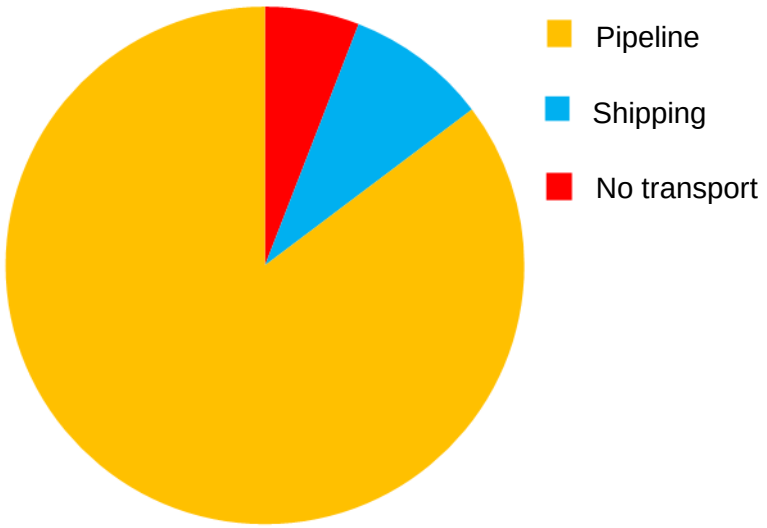
Technologies Involved



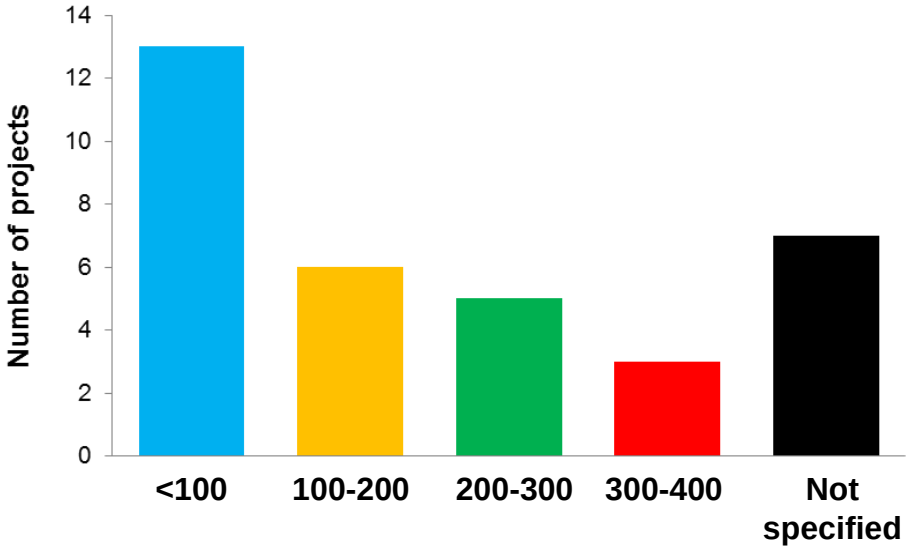
- Half of the projects have not yet decided on the technology
- Among the solvents: MEA, MDEA, Fluor, ethanol + amine

CO_2 Transportation

Type of transport



Transport length (km)



- Most technically mature step
- Most of the transportation occurs via pipeline
- Most of the storage is relatively far from the capture site

CO_2 Utilization

Overview

- 32% of the projects have a utilization components
- Among those projects, 100% correspond to EOR

EOR

- Limited information on EOR: Net amount of CO_2 stored? No systematic monitoring, measurement and verification
- EOR can only be considered at a local scale
- EOR can initially serve as an economic driver

Other utilization approaches

- Long-term: plastics, chemicals, fuels production

Challenges

Technological challenges

- Absorption rate
- Sensible heat requirement
- Cost
- Degradation
- Absorption capacity

Environmental challenges

- Solvent emissions
- Co-products emissions
- Waste handling

Equipment-related challenges

- Construction and transport of equipment
- Heat integration (e.g., waste heat utilization)
- Heat exchanger optimization
- New design (i.e. not used before)
- Integration
- Improved controls

Why some projects fail ?

Reasons of project cancellation

- Underestimated complexity
- Timeline not respected
- Cost overruns
- No clear financial structure
- Not enough funding
- Missing legal framework
- Public opposition

Examples of recently cancelled projects

- Porto Tolle (Portugal)
- Mongstad (Norway)
- OXYCFB 300 Compostilla Project (Spain)
- Getica (Romania)

Steps Forward (by 2020)

CO_2 capture

- Address the technological, environmental and equipment-related challenges
- Demonstrate carbon capture at full-scale in the industrial sector
- Support R&D for new capture technologies

CO_2 transport

- Locate future CCS units to develop the pipeline infrastructure
- Provide legal framework for cross-countries pipelines

CO_2 utilization

- Identify local solutions
- Improve the EOR monitoring, measurement and verification

Examples of current trends

- UK - UK Energy Act (2013): "No new coal-fired power plants approved unless equipped with a CCS unit"

References

- **Reports**
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  - IEA, *Post-combustion CO_2 capture scale-up study*, Feb. 2013
  - Members and Committees of Congress, *Carbon Capture: A Technology Assessment*, Jul. 2010
- **Database**
  - Global Institute large-scale
  - DOE/NETL
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