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Global Technology Roadmap for CCS in Industry
Policy Workshop – Report Annexes – Part I

7th and 8th April 2011

Rio de Janeiro, Brazil

Petrobras Research Centre, CENPES

(Centro de Pesquisa e Desenvolvimento Leopoldo A Miguez de Mello)



UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

Annexes

Annex 1: Annotated agenda

Annex 2: Participants list

Annex 3: Presentations 1 to 5

- 1) Mr Luis Fernando Mendonça Frutuoso - Welcome address: Petrobras and its R&D programme
- 2) Ms Jessica Morton Global CCS Institute welcome address
- 3) Ms Bettina Schreck Introduction to the Roadmap project
- 4) Ms Nathalie Trudeau Introduction modelling results IEA
- 5) Ms Heleen de Coninck Preliminary outcomes of the Roadmap

Thursday April 7
Global Technology Roadmap for CCS in industry

Time	Title	Moderator/Speaker
9:00 – 9:15	Registration	
9:15 – 9:25	Welcome address UNIDO	Ms Bettina Schreck (UNIDO)
9:25 – 9:35	Welcome address: Petrobras and its R&D programme	Mr Luis Fernando Mendonça Frutuoso (Petrobras Research Center R&D Energy, Gas and Sustainable Development General Manager)
9:35 – 9:45	Welcome addresses sponsors	Ms Jessica Morton (Global CCS Institute)
9:45 – 10:00	Introduction to the Roadmap project	Ms Bettina Schreck (UNIDO)
10:00 – 10:30	Introduction modelling results IEA	Ms Nathalie Trudeau (IEA)
10:30 – 11:00	Discussion	
11:00 – 11:20	Break	
11:20 – 11:40	Preliminary outcomes of the Roadmap	Ms Heleen de Coninck (Energy Centre of the Netherlands)
11:40 – 12:00	Sector focus: emissions sources and reservoirs matching	Mr Yann Le-Gallo (Geogreen)
12:00 – 12:20	Sector focus: Enhanced Oil Recovery	Mr Michael Godec (Advanced Resources Int)
12:20 – 12:40	Discussion	
12:40 – 14:00	Lunch	
14:00 – 15:30	Groups focussing on specific assignments 1. Needs for capacity development and international cooperation 2. Identification of light house projects 3. Business model actions and milestones 4. Policy and financial actions and milestones 5. EOR actions and milestones	Small groups to allow for open discussion and targeted outcomes
15:30 – 16:00	Break	
16:00 – 17:00	Feedback and discussion	Speakers and Rapporteurs from group session to provide feedback on the group findings

Friday April 8
Focus on Brazil and Latin America

Time	Title	Moderator/Speaker
9:00 – 9:30	Additional registration	
9:30 – 9:50	Welcome : Petrobras initiatives on CCS	Mr Paulo Negrais (Petrobras)
9:50 – 10:10	An overview of the Brazilian centre for excellence in the R&D of CO ₂ geological storage technologies (CEPAC's) activities	Ms Claudia Machado (Pontifical Catholic University of Rio Grande do Sul, PUCRS)
10:10 – 10:30	Brazil's government position on CCS	Jose Domingos Miguez (Ministry of Science and Technology, Brazil)
10:30 – 10:45	Q&A, discussion	
10:45 – 11:15	Break	
11:15 – 12:30	Discussion on specific barriers to CCS in industry in Brazil and Latin America	Panel of speakers <ul style="list-style-type: none"> • Mr Leonardo Beltran (Energy Secretariat, SENER, Mexico) • Ms Cristina Giusti (Energy Secretariat, Argentina) • Mr Jose Domingos Miguez (Ministry of Science and Technology, Brazil) Chair Ms Nathalie Trudeau (IEA)
12:30 – 14:00	Lunch	
14:00 – 14:30	Practical examples of CCS on industrial sources in Petrobras	Mr Paulo Negrais (Petrobras)
14:30 – 15:00	Renewable CCS from Sugar Fermentation project – GEF financing	Mr Jose Roberto Moreira , Brazilian Reference Center on Biomass (CENBIO), University of Sao Paulo
15:00-15:15	Q&A, discussion	
15:15 – 15:30	Break	
15:30 – 16:30	Discussion on Latin American applicability of Roadmap	Panel of speakers <ul style="list-style-type: none"> • Mr Rodolfo Lacy (Mario Molina centre for strategic studies on energy and environment, México) • Mr Francisco Almendra (World Resources Institute) Chair Ms Heleen de Coninck (ECN)
16:30 – 17:00	Wrap-up Flash, three-minute presentations on results of the day in terms of main gaps and barriers, possible pilot projects and demonstrations and specific Latin American issues	Ms Bettina Schreck (UNIDO)

Participants list

Mr. Felipe Almeida Brandao, Petrobras

Mr. Francisco Almendra, World Resources Institute

Mr. Leonardo Beltran, Mexico Secretary of Energy (SENER)

Mr. Luiz Germano Bernartt, Votorantim Cimentos, Brazil

Ms. Ameena Camps, IEA Greenhouse Gas R&D Programme (IEAGHG)

Ms. Lucila Caselato, Brazil Steel Institute

Mr. Fabio Cavalcanti Caldas, Shell Brasil Ltda

Ms. Viviana Canhao Coelho, Petrobras

Mr. Alberto Sampaio de Almeida, Petrobras

Ms. Heleen de Coninck, Energy research Centre of the Netherlands (ECN)

Ms. Angela De Souza, Petrobras

Mr. Rodolfo Dino, Petrobras

Ms. Juliana Falcao, British Embassy Brazil

Mr. João Baptista Farah Emiliano, Braskem SA

Ms. Cristina Giusti, Secretaría de Energía, Argentina

Mr. Michael Godec, Advanced Resources International (ARI)

Mr. Jose Domingos Gonzalez Miguez, Ministry of Science and Technology, Brazil

Mr. Ricardo Gutierrez, Petrobras

Ms. Silvia Gutierrez, United Nations Industrial Development Organization (UNIDO)

Ms. Sueli Akemi Hatimondi, Petrobras

Mr. Wolfgang Heidug, International Energy Agency (IEA)

Mr. Jonas Helseth, Bellona Europa

Mr. Florian Kraxner, International Institute for Applied Systems Analysis (IIASA)

Mr. Rodolfo Lacy, Centro Mario Molina para Estudios Estratégicos en Energía y Ambiente, Mexico

Mr. Yann Le Gallo, Geogreen

Ms. Claudia Machado, Pontifical Catholic University of Rio Grande do Sul

Mr. Ricardo Mastroti, Camargo Correa Cimentos, Brazil

Mr. Leonardo Bacellar Mendes, Petrobras

Mr. Luis Fernando Mendonça Frutuoso, Petrobras

Mr. Thomas Mikunda, Energy research Centre of the Netherlands (ECN)

Mr. Luiz Molle, Petrobras

Mr. Jose Roberto Moreira, Brazilian National Reference Center on Biomass (CENBIO)

Ms. Andrea Cristina Moreira, Petrobras

Ms. Jessica Morton, Global CCS Institute

Ms. Ana Paula Musse, Petrobras

Mr. Paulo Negrais, Petrobras

Mr. Utomo Prasetyadi, Ministry of Environment of Indonesia

Ms. Cristina Quintella, Universidade Federal Da Bahia (UFBA)

Mr. Leonardo da Silva Ribeiro, Petrobras

Ms. Glenda Rodrigues, Petrobras

Ms. Isabella Rodrigues Loureiro, Petrobras

Mr. Leonardo São Paulo Sambaquy, Gerdau S.A.

Mr. Vicente Schmall, Petrobras

Ms. Bettina Schreck, United Nations Industrial Development Organization (UNIDO)

Mr. Seiiti Suzuki, Camargo Correa Cimentos, Brazil

Mr. Gustavo Torres Moure, Petrobras

Ms. Nathalie Trudeau, International Energy Agency (IEA)

Mr. Marcio Vasconcelos Netto, General Electric

Mr. Paulo Vieira Rocha, Petrobras

Ms. Natasha Weisert, United Nations Industrial Development Organization (UNIDO)

Ms. Maria Cristina Yuan, Brazil Steel Institute

Mr. Fernando Zancan, Brazil Coal Association



CENPES
Centro de Pesquisa
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Petrobras and Innovation



Luis Fernando Mendonça Frutuoso

Petrobras' R&D Energy, Gas and Sustainable Development General Manager

UNIDO Global Technology Roadmap on CCS in Industry

Rio de Janeiro, 7-8 April 2011



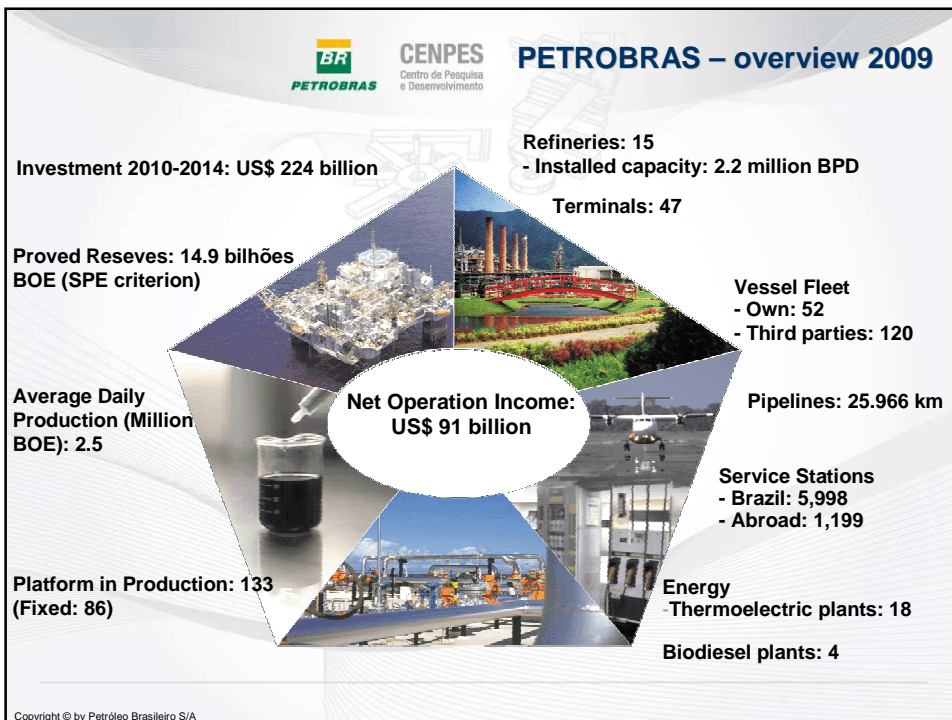
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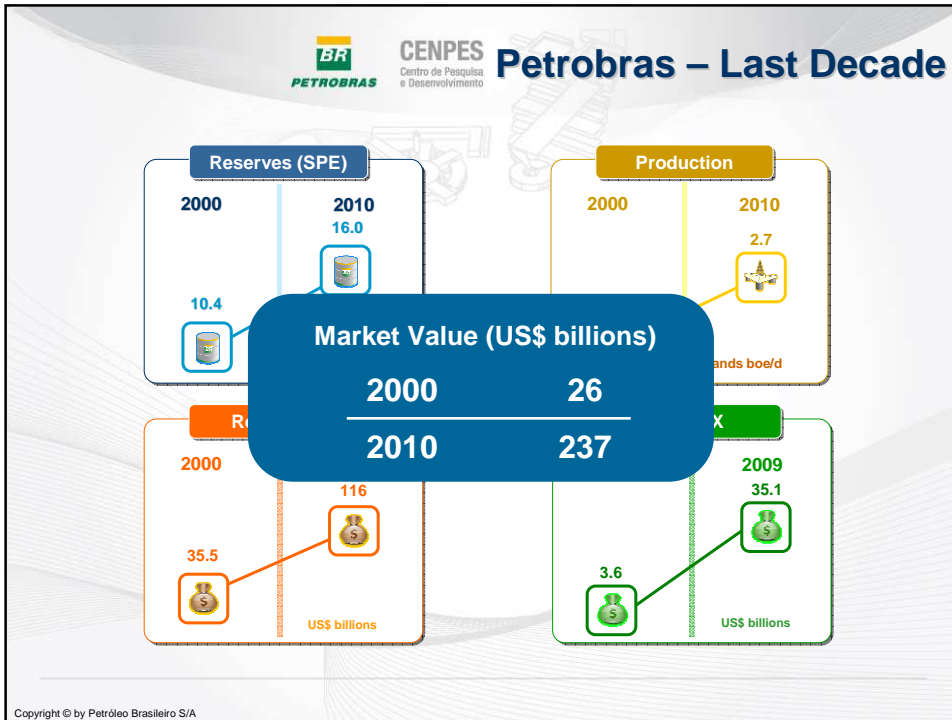
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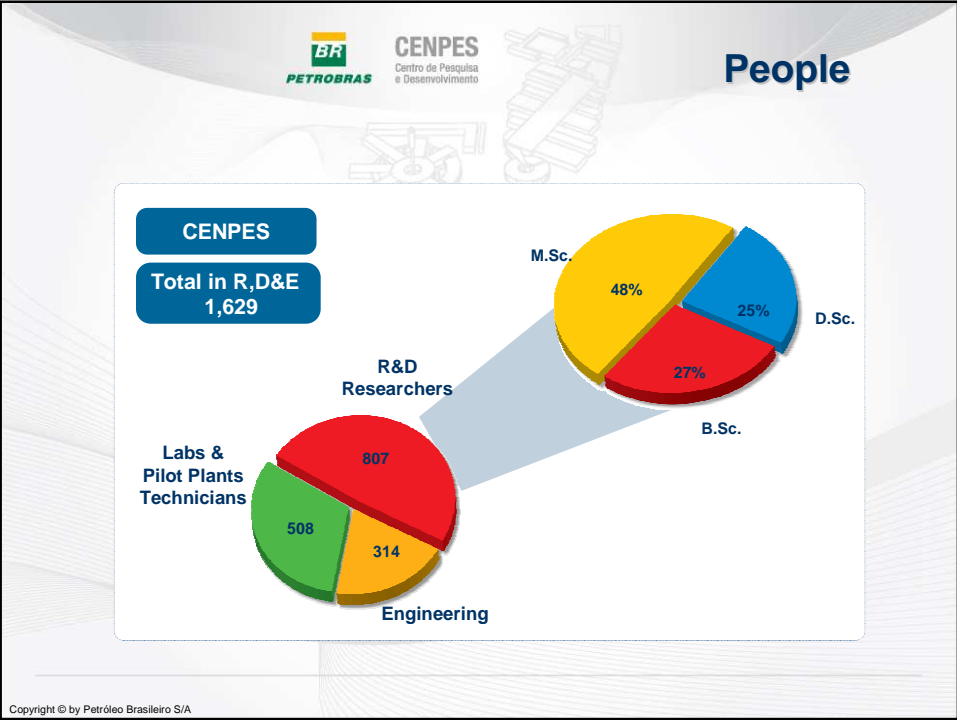
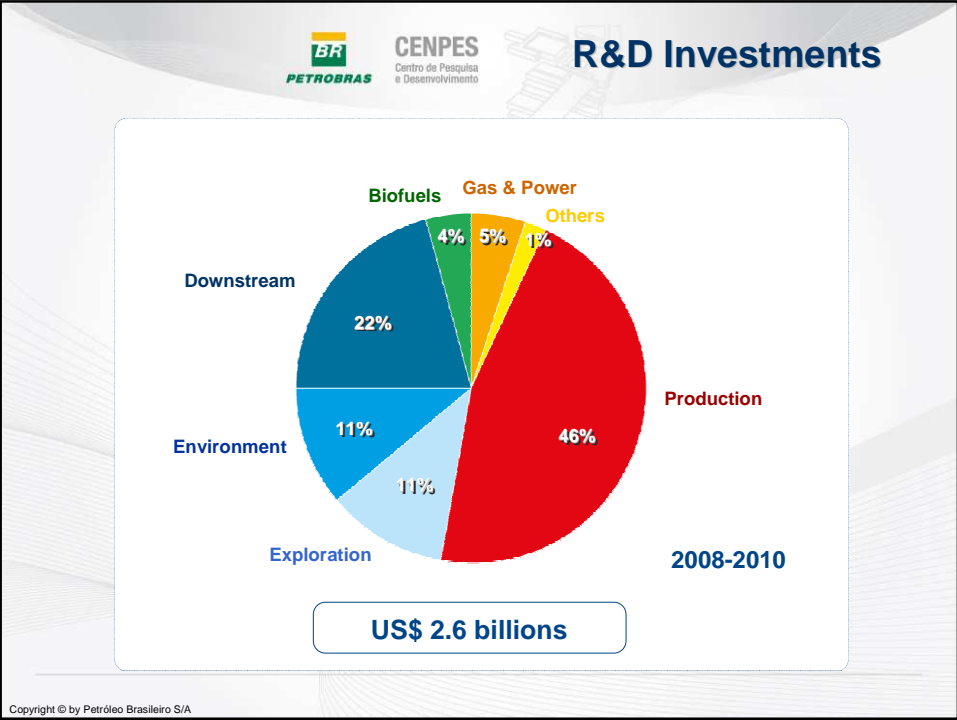
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CAUTIONARY STATEMENT FOR US INVESTORS

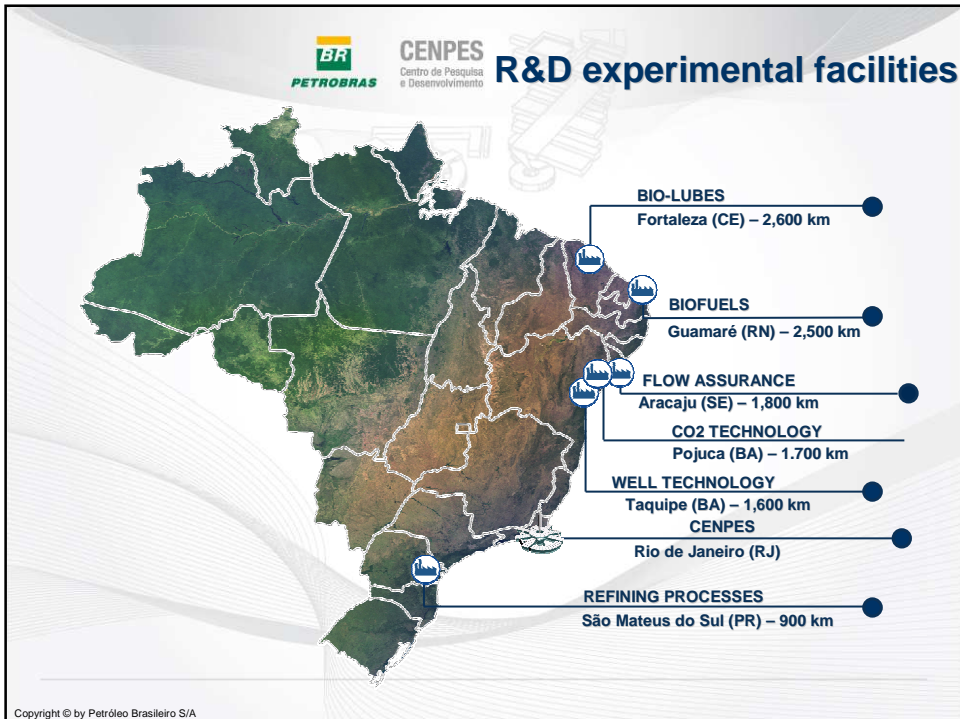
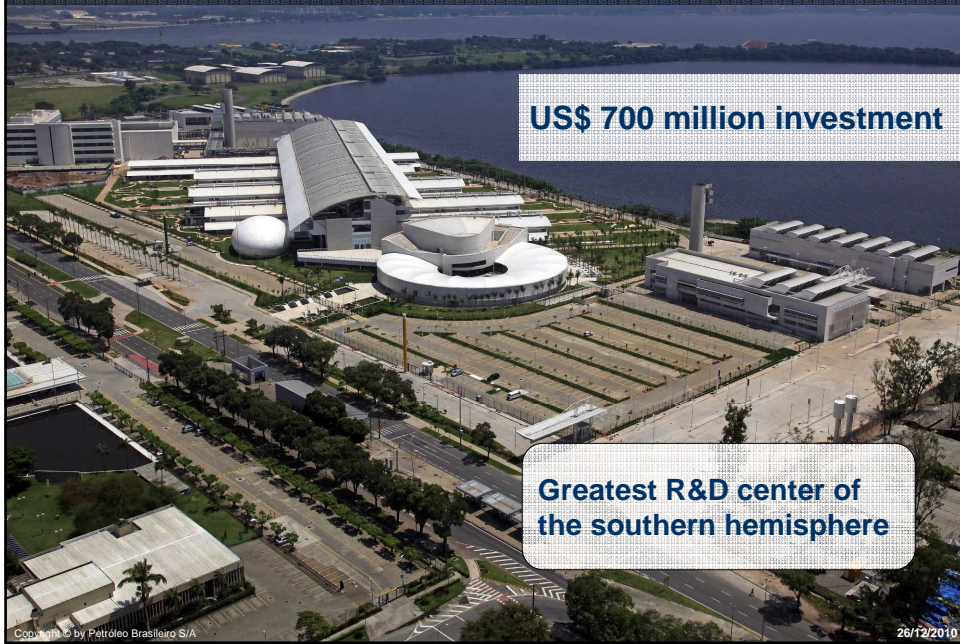
The United States Securities and Exchange Commission permits oil and gas companies, in their filings with the SEC, to disclose only proved reserves that a company has demonstrated by actual production or conclusive formation tests to be economically and legally producible under existing economic and operating conditions. We use certain terms in this presentation, such as oil and gas resources, that the SEC's guidelines strictly prohibit us from including in filings with the SEC.







Expanding Petrobras R&D capacity

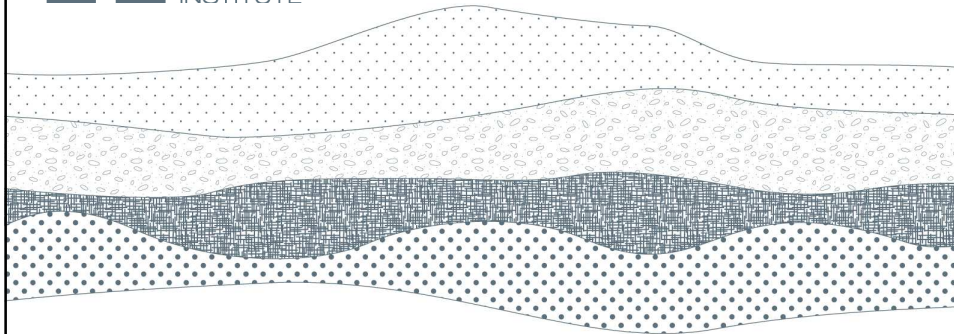




CENPES
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e Desenvolvimento



Thank you!



GLOBAL CCS INSTITUTE – Sponsor Address

Jessica Morton – Capacity Development Officer

Third Workshop of the Global Technology Roadmap for CCS in Industry

Rio de Janeiro, 7 – 8 April 2011

GLOBAL CCS INSTITUTE

FOCUS

The Global CCS Institute connects parties around the world to solve problems, address issues and learn from each other to accelerate the deployment of CCS projects by:

1.SHARING KNOWLEDGE

- providing a central repository for CCS information; and
- analysing and disseminating information to fill knowledge gaps and build capacity.

2.FACT-BASED ADVOCACY

- using facts to inform and influence domestic and international low carbon policies;
- supporting the commercialisation of CCS by advancing the understanding of appropriate funding and financing solutions and risk regimes; and
- increasing the awareness of the benefits of CCS and the role it plays within a portfolio of low carbon technologies.

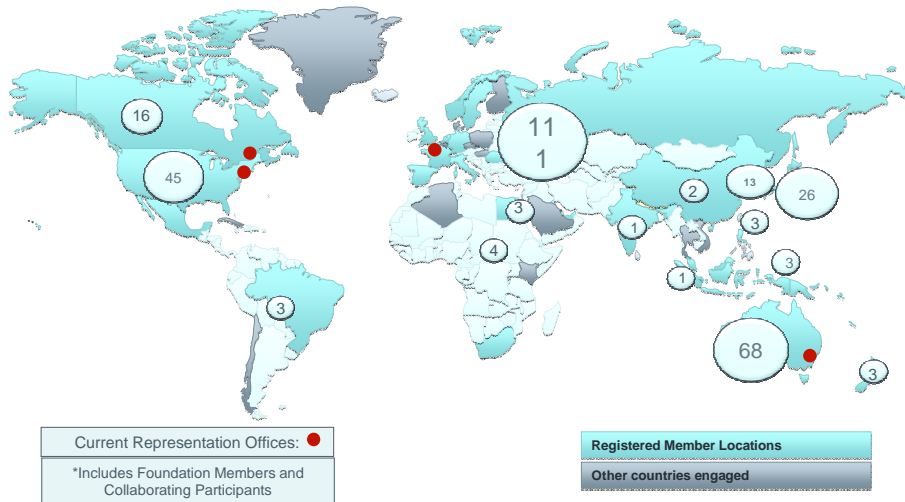
3.ASSISTING PROJECTS

- bridging knowledge gaps between demonstration efforts; and
- developing project-specific solutions particularly amongst early movers.

CURRENT MEMBERSHIP

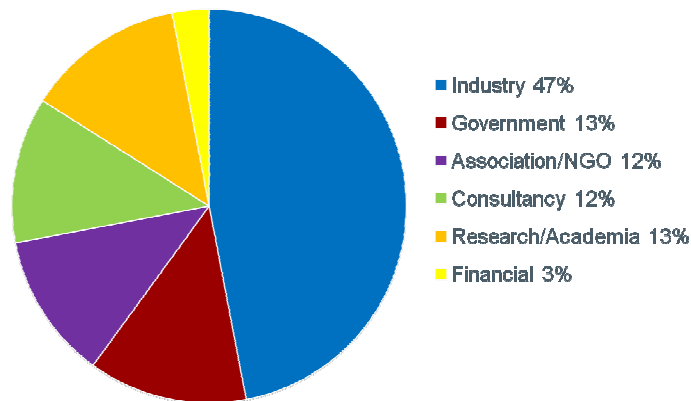
Member Region breakdown – March 2011

Total Membership: 302*



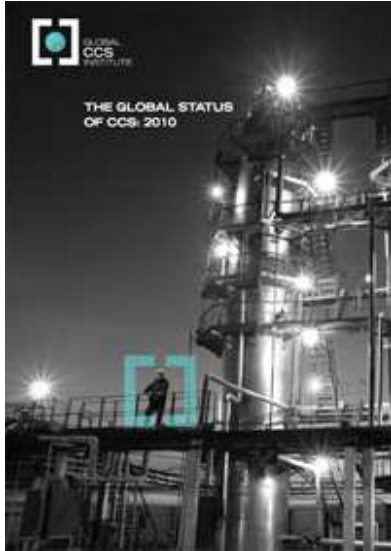
MEMBERSHIP BREAKDOWN

302 Members as at March 2011



The Institute's Membership accounts for over 80 per cent of the world's Carbon Dioxide emissions from energy and industrial sources.

THE GLOBAL STATUS OF CCS: 2010

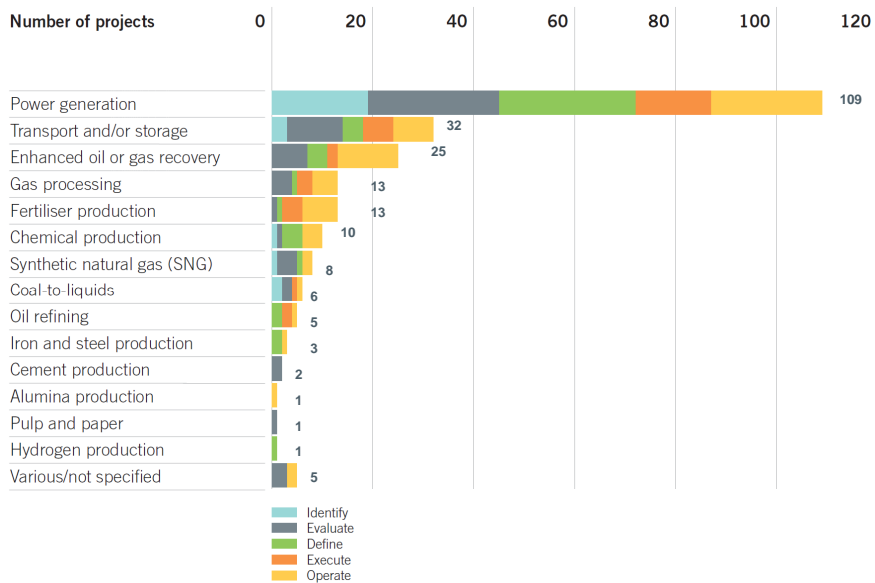


In March the Institute released the Global Status of CCS: 2010 report.

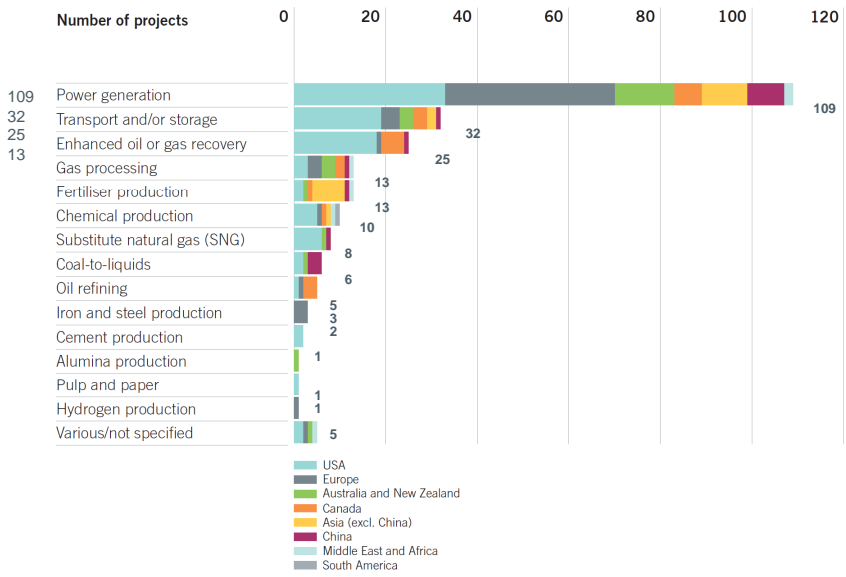
The Report is intended as a comprehensive reference guide for industry, government, research bodies and the broader community.

<http://www.globalccsinstitute.com/global-status-ccs-2010>

ALL ACTIVE AND PLANNED PROJECTS BY INDUSTRY SECTOR AND BY ASSET LIFECYCLE STAGE



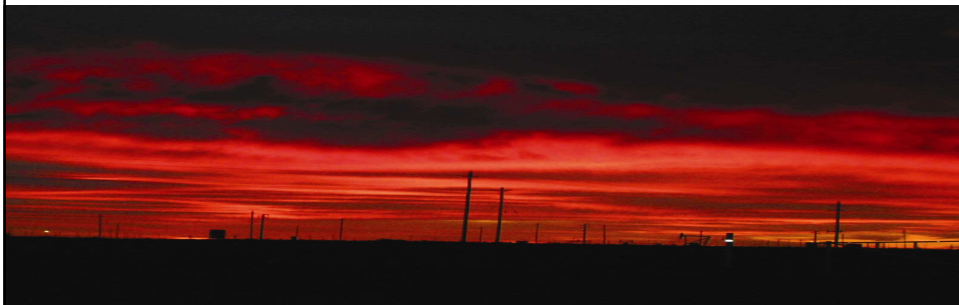
ALL ACTIVE AND PLANNED PROJECTS BY INDUSTRY SECTOR AND BY REGION





PARTNER FOR PROSPERITY

Global Technology Roadmap for Carbon Capture and Storage for Industry



Policy Workshop
7-8 April 2011 – Rio de Janeiro

Poverty Reduction through Productive Activities • Trade Capacity Building • Energy and Environment

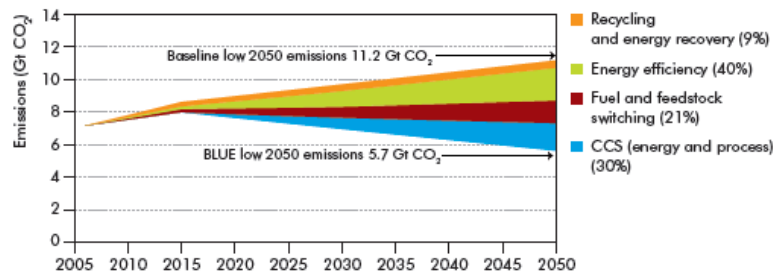
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PARTNER FOR PROSPERITY

Technologies for reducing GHG in industry

Figure ES.1 ▶ Technologies for reducing direct CO₂ emissions from industry, 2006 to 2050



From IEA Energy Technology Transitions for Industry (2009)

By undertaking international technical cooperation projects, UNIDO promotes mitigation activities across all technical “wedges”

Poverty Reduction through Productive Activities • Trade Capacity Building • Energy and Environment



Carbon Capture and Storage, Trends in Industry

Why is CCS relevant to the industry sector?

1. Industry accounts for approx. 40% of total energy-related CO₂ emissions
2. The majority of industrial energy use and CO₂ emissions takes place in developing countries
3. 50% of the CO₂ emission reduction potential from CCS is in industry
4. Lots of attention for CCS in the power sector, but limited for industry
5. CCS is one of the few low-carbon options for energy-intensive industries (eg, cement clinker making: no alternative)
6. Biomass + CCS = net negative emissions (backstopping option)
7. Interesting opportunities for CO₂ Enhanced Oil Recovery (EOR)
8. “clustering” industry emissions may lower storage costs



The Global CCS Roadmap for Industry, Context

- ✓ The need to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system
- ✓ Request from the international community to develop and deploy advanced technologies for moving towards a low-carbon economy, and explicit request for the preparation of Energy Technology Roadmaps
- ✓ Will build on past and on-going work, e.g. IEA CCS Roadmap, Cement Technology Roadmap





The Global CCS Roadmap for Industry, Objectives and Outcomes

Objectives

To advance the **global uptake of low-carbon technologies** in industry, whilst involving developing countries and transition economies, by **developing a Global Technology Roadmap** for CCS in Industry and to build the analytical foundation allowing to **identify early opportunities** for pilot/demonstration projects

Outcomes

1. To provide relevant stakeholders with a vision of industrial CCS up to 2050
2. To strengthen the capacities of various stakeholders with regard to industrial CCS, particularly in selected developing countries
3. To inform policymakers and investors about the potential of CCS technology
4. To identify a number of potential early opportunities



Partners and their roles

✓ Funders

- Norwegian Ministry of Petroleum
- Global CCS Institute



✓ Implementing Agency

- United Nations Industrial Development Organization



✓ Partners

- International Energy Agency
- IEA Greenhouse Gas R&D Programme
- Energy Research Centre of the Netherlands



✓ Host and sponsors of the 3rd workshop

- UK Department of Energy and Climate Change
- Petrobras





The Global CCS Roadmap for Industry, Approach

✓ Desktop review and analysis informed by sectoral assessments and specific studies

- Iron and Steel
 - Biomass sources
 - High purity sources
 - Refineries
 - Cement
 - Enhanced oil recovery
 - Matching emissions sources and sinks
- } Technology Synthesis Report

✓ Series of workshops with selected stakeholders

- Sectoral Review Workshop, Abu Dhabi
- Roadmap Review Workshop, Amsterdam
- Policy Workshop, Rio de Janeiro



Workshops, Outcomes

1st Workshop, 30 June – 1 July 2010, Abu Dhabi

- ✓ Objective: review sectoral assessments underpinning the Roadmap
- ✓ Main outcomes:
 - Better understanding of various technology options by sector,
 - Discussions around data, uncertainty, and emission projections and CCS potential,
 - Identification of gaps and barriers to CCS deployment,
 - Information sharing and dissemination,
 - Initial thoughts on potential early opportunities

2nd Workshop, 24 Sep 2010 Amsterdam

- ✓ Objective: review main assumptions from the Roadmap
- ✓ Main outcomes:
 - detailed technology and economic aspects including technology characterization,
 - business models for CCS in industry,
 - bringing industrial CCS higher on the global agenda, and engaging developing countries and economies in transition
 - defining actions and milestones



Policy Workshop, Objectives Day 1

✓ Objective:

- to review the additional sectoral studies
- to review the main policy and business recommendations, as well as actions and milestones

✓ Programme

✓ a brief introduction to the project and the draft Roadmap, and

✓ several breakout sessions with the following topics:

1. capacity needs for Industrial CCS
2. identification of light house projects
3. business actions and milestones
4. policy and financial actions and milestones
5. EOR actions and milestones



Policy Workshop, Objectives Day 2

✓ Objective:

- provides a forum to discuss CCS in industry related issues in Brazil and Latin America.

✓ Programme

Brazilian experience (policy and technology perspectives)

✓ Brazilian case studies

✓ Expert panels

1. specific barriers to CCS in industry in Brazil and Latin America
2. Latin American applicability of Roadmap



The Global CCS Roadmap for Industry, Next Steps

Complete roadmap

- Finalise data modeling
 - Validate actions and milestones
 - Complete the Identification of 50-100 lighthouse projects (early opportunities)
 - Peer Review
- ✓ Disseminate results
- Selected launch events at government and sub-sectoral level
- ✓ Continue elaborating demonstration project plans



Further details @ the project website:

<http://www.unido.org/index.php?id=1000821>

www.unido.org/energy >> [Energy Efficiency](#) >> [Selected Projects](#)
>> [Carbon Capture and Storage - Industrial Sector Roadmap](#)

Thanks for your attention
b.schreck@unido.org



The Global CCS Roadmap for Industry, Outputs

Clear policy message for CCS in industry

- ✓ CCS is a key emissions abatement option in industry for which, unlike in the power sector, there is no viable alternative.

- ✓ Demonstration plants are needed to prove its feasibility, ascertain smooth operation and create more clarity concerning costs. It is recommended to build demonstration plants in both developed and developing countries
 - Involvement of China - critical accounts for half of global primary steel, cement and clinker production.
 - The Middle East could play a critical role in the demonstration phase because of interesting CO₂-EOR opportunities.
 - Brazil has a significant role to play in both the energy intensive and biomass industries



Timeframe



Global Technology Roadmap for CCS in industry – Policy workshop

Petrobras Research Centre,
Rio de Janeiro, Brazil
7 April 2011

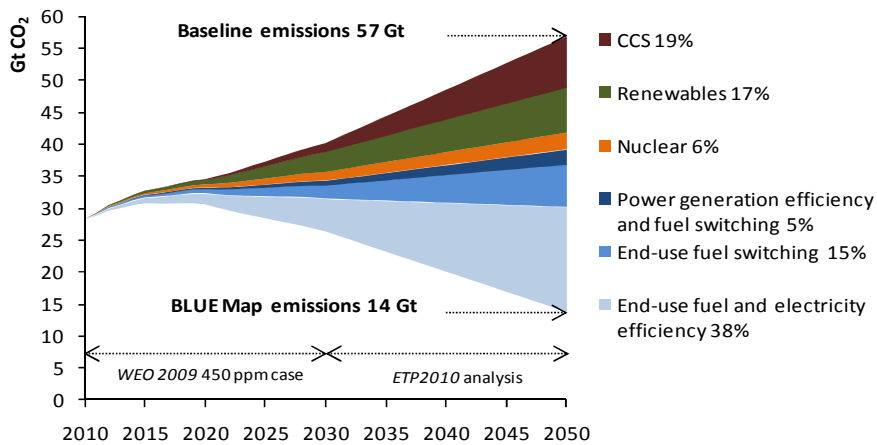


Introduction to Modelling Results

Nathalie Trudeau
Energy Technology Policy Division
International Energy Agency

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Blue Map results



A wide range of technologies will be necessary to reduce energy-related CO₂ emissions substantially

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Roadmap process



- IEA is developing technology roadmaps for key low-carbon energy technologies
- Process begins by convening experts to establish the current technology baseline
- Assume a 50% reduction in energy-related CO₂ by 2050
 - Use BLUE Map scenario to map growth pathway
- Create technical, policy, legal, financial, and public acceptance milestones to achieve 2050 targets
- Identify priority near-term actions
- Create a process for enhanced collaboration
- Implement actions and track progress

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Rationale for a CCS roadmap



- Without new policies, global emissions increase by 130% by 2050, leading to a 4°C to 7°C temperature rise
- CCS provides one-fifth of the needed CO₂ reductions in 2050
- Without CCS, cost of stabilisation rises by 70%
- CCS is the main low-carbon solution for gas/coal, cement, and iron & steel sectors

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Findings from IEA CCS roadmap International Energy Agency

CCS financing today

- Australia: Aus\$2bn; Aus\$300 for GCCSI
- Canada: Can\$1.3bn; Can\$2bn from Alberta
- EU: €1.05bn from Economic Recovery Energy Programme and 300m allowances in the EU ETS
- Japan: JPY10.8bn
- Norway: ~US\$40/tonne CO₂ tax on offshore oil and gas operations; NOK1.2bn government investment
- UK: GBP 7.2-9.5 billion to cover additional costs for 1-4 CCS plants raised thru levy on electricity suppliers
- US: US\$3.4bn from Economic Recovery Act US\$3.3bn in other federal government RD&D support

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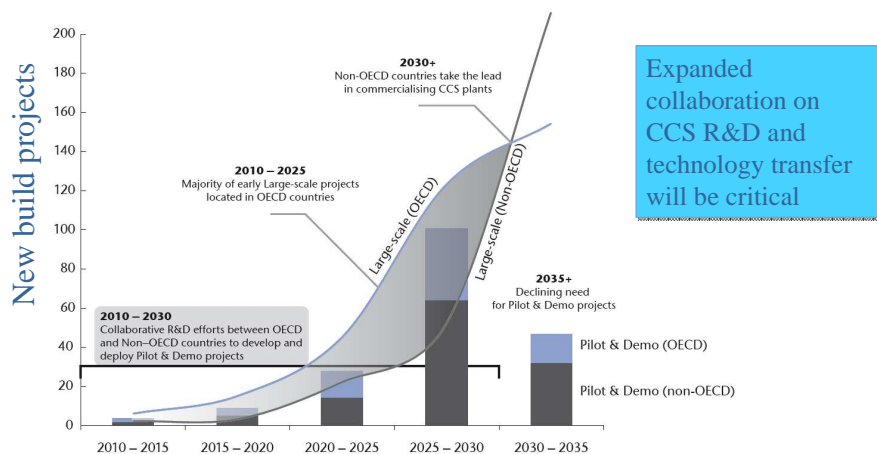
Findings from IEA CCS roadmap International Energy Agency

CCS laws and regulations today

- UNFCCC
 - IPCC 2006 *Inventory Guidelines*
 - CCS does not qualify under the CDM
- London Protocol, OSPAR treaty amendments
- EU CCS Directive, EU ETS Directive
- National legal & regulatory developments
 - Australia has a comprehensive framework
 - US, Canada, Japan, Norway more piecemeal

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Demonstration to Commercial



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The next ten years: a critical period for CCS

■ Demonstration milestones

- Meet G8 goal of 20 project announcements by 2010
- Achieve commercialisation with 100 projects by 2020

■ Financial milestones

- Provide USD42 bn for near-term demonstrations; also need to fund longer-term R&D
- Finance and plan CO₂ transport infrastructure
- Incentivise CCS via bonus allowances in cap-and-trade schemes, emissions performance standards or carbon taxes

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The next ten years: a critical period for CCS



■ Legal/regulatory milestones

- Amend existing frameworks to regulate demonstration projects
- By 2015, all countries with CCS potential should have comprehensive frameworks

■ Public engagement milestones

- Increase government investment in outreach in 2010-2012
- Provide greater (and earlier) information on planned projects

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The next ten years: a critical period for CCS



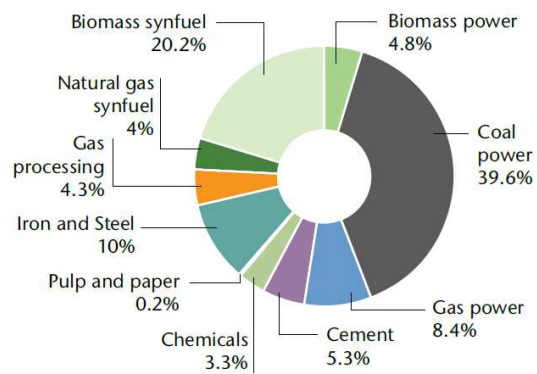
■ International development milestones

- By 2050, non-OECD regions will account for 64% of captured CO₂
- By 2050, China and India will account for around 26% of the cumulative CO₂ captured
- ◆ Expand capacity building efforts in non-OECD countries with fossil fuel economies such as China, India, South Africa
- ◆ An average annual investment of \$1.5-2.5bn between 2010-20 in non-OECD regions

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Why another roadmap on CCS?

CCS is not just about "clean coal"



Coal power makes up just 40% of stored emissions in 2050

Rationale for CCS in industry



- Achieving the ambitions of the BLUE Map scenario will require the industry to reduce its direct emissions by 24% from today level in 2050
- CCS represents the most important new technology option; it provides one-third of the needed CO₂ reductions in 2050
- Without CCS, emissions in 2050 could only be brought back to current levels

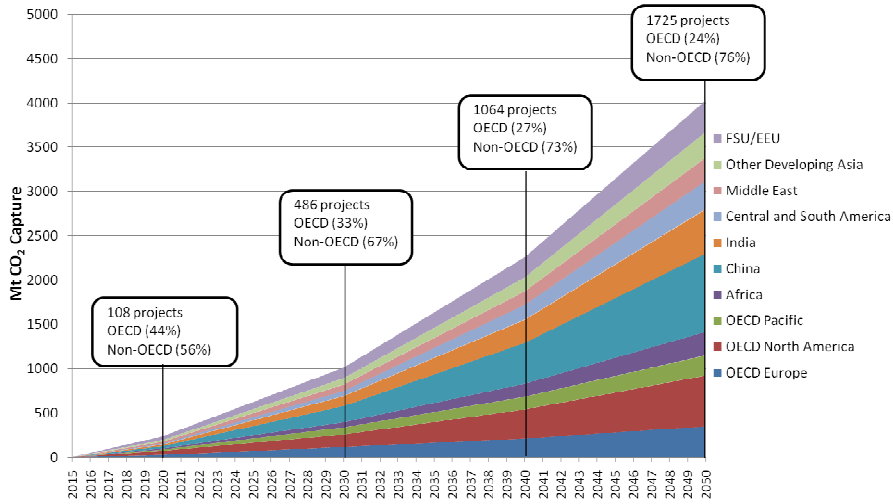
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Initial modelling results

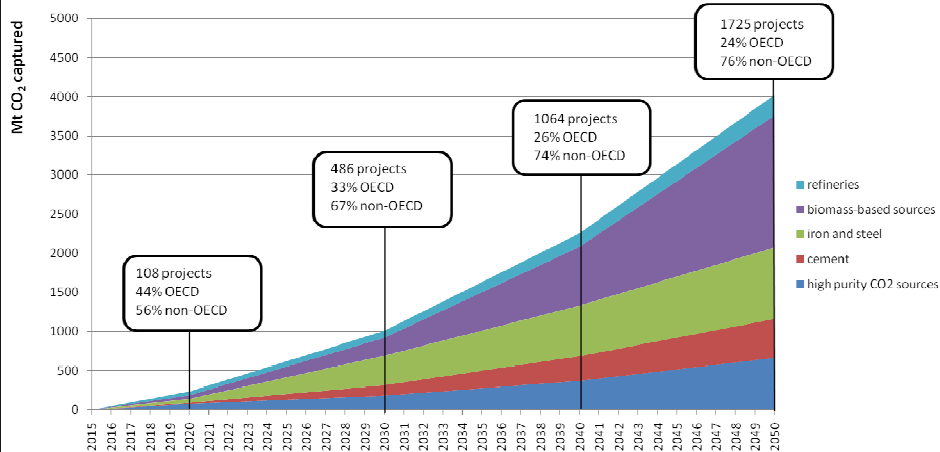
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An ambitious growth pathway



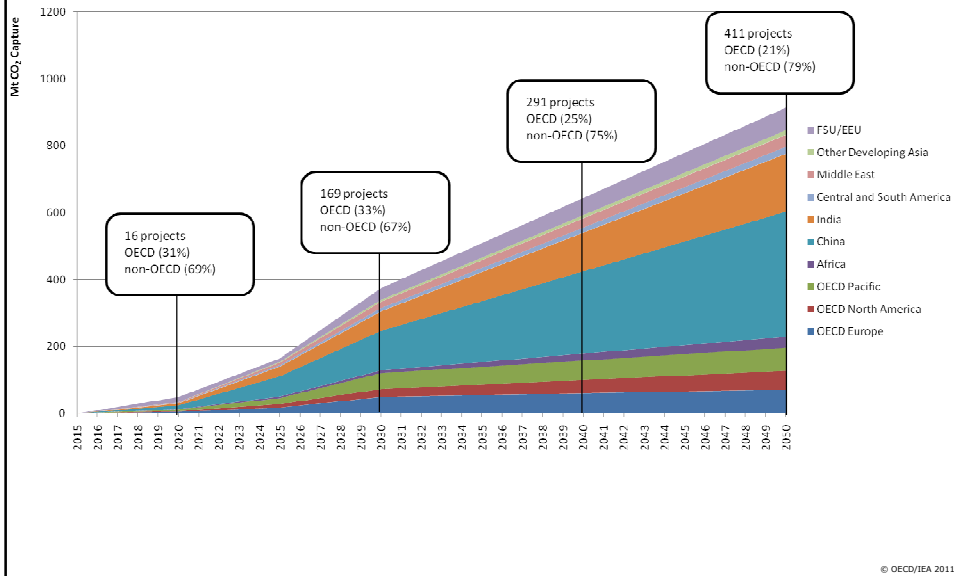
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An ambitious growth pathway

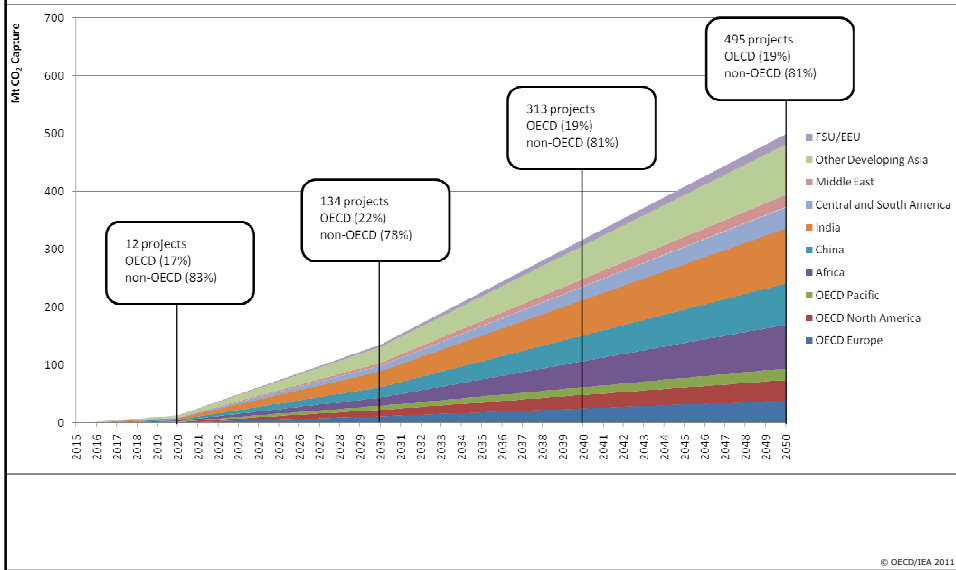


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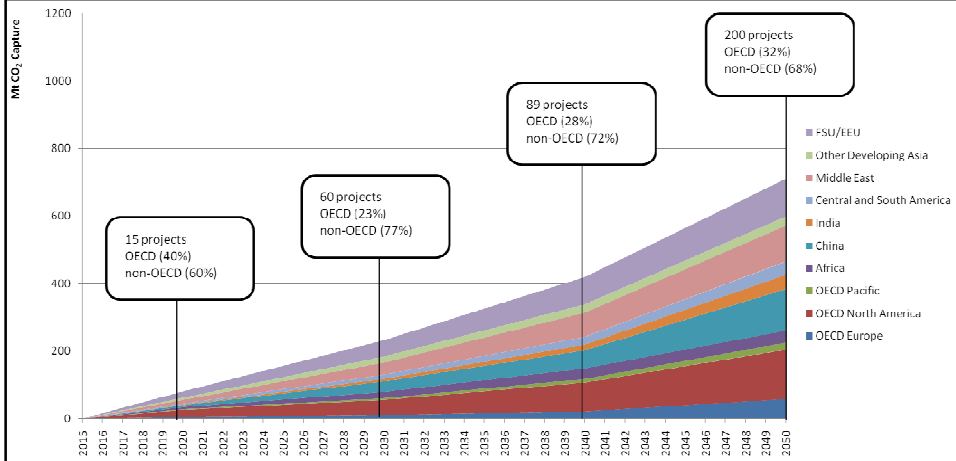
CCS in the iron and steel sector



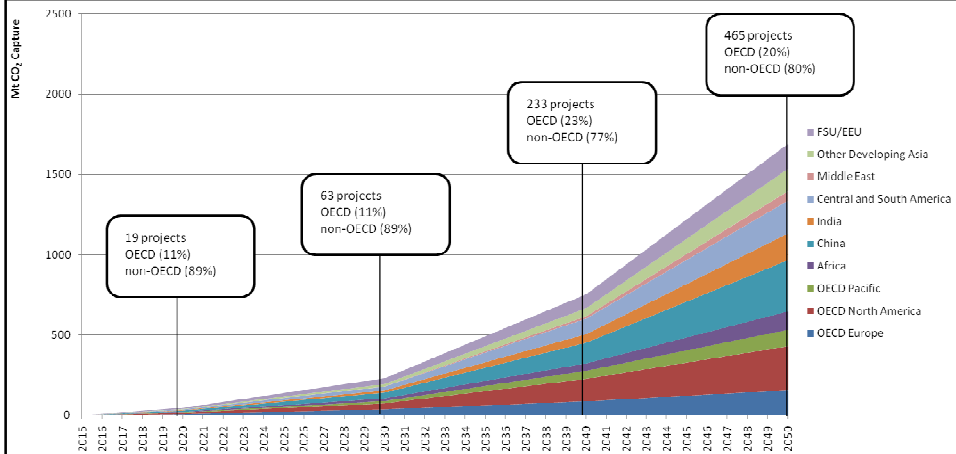
CCS in the cement sector



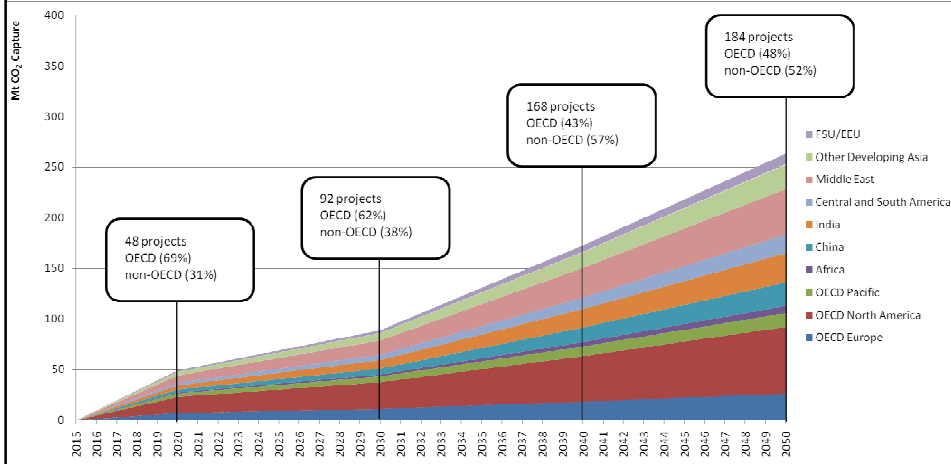
CCS in the high-purity sector



CCS in the bio-based sector



CCS in petroleum refining



Additional investments

	Total additional investments (USD billion)				Capture MtCO ₂
	2010-2020	2020-2030	2030-2050	Total 2010-2050	2050
OECD Europe	12	55	62	129	350
OECD North America	17	44	103	164	576
OECD Pacific	9	60	62	131	226
Africa	1	21	85	108	266
China	16	109	302	427	911
India	10	57	157	224	506
Central and South America	3	20	76	99	319
Middle East	8	35	68	112	267
Other Developing Asia	6	32	89	126	290
FSU/EEU	6	37	72	115	363
World	89	469	1076	1634	4073

Next steps



- Refine/review the modelling results
 - Number of plants
 - Demonstration projects needed
 - Costs and investment

- Thorough review by stakeholders
 - Governments
 - Industry
 - Other interested parties

- Chapter on results to be finalised and distributed for stakeholders comments

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Thank You!

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Roadmap on CCS in industrial CO₂ sources: Key findings

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Outline

- Message upfront
- Coverage of sectors and technologies
- Key findings
- Aim and process of this meeting

A roadmap is a first step

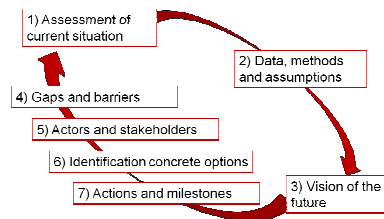
Provides an exhaustive overview of opportunities, gaps, barriers and measures towards a specific technological aim

The technological aim can be RD&D or commercialisation of a technology, but can also comprise the full innovation chain

A roadmap is actionable and should provide an agenda to act for government, industry and financial sector stakeholders

A roadmap could be made measurable by defining milestones associated with actions, including timing

The process of making and agreeing is important



Sectors and technologies

Sector	Production process	Capture technology
High-purity industrial sources	Natural gas processing (onshore/offshore)	Existing industrial gas separation techniques
	Coal-to-liquids (CtL)	
	Ethylene oxide production	
	Ammonia production	
Iron and steel	Blast furnace (pig iron)	Top gas recycling (TGR) or oxyfuel blast furnace
	Direct reduction of iron (DRI)	Pre combustion (gasification) + Pressure Swing Absorption (PSA), Vacuum PSA (VPSA) or chemical absorption
	FINEX technologies	PSA
	The Hlsarna process	PSA or VPSA
Cement	Kiln/calcination	Post combustion technology using chemical solvents or oxyfuel technology

Sectors and technologies

Sector	Production process	Capture technology
Refineries	Hydrogen production	Chemical absorption, PSA
	Hydrogen gasification residues	Pre combustion (gasification) + chemical absorption
	Fluidised catalytic cracking	Post combustion using chemical absorption, or oxyfuel technology
	Process heat	Post combustion using chemical absorption, or oxyfuel technology
Biomass conversion	Synthetic natural gas	Pre combustion (gasification) + chemical absorption
	Ethanol production	Dehydration only
	Hydrogen production from biomass	Pre combustion (gasification) + chemical absorption
	Black liquor processing in pulp and paper manufacturing	Pre combustion (gasification) + chemical absorption

Technology findings

High-purity sources of CO₂

- CO₂ could be abated at an approximate cost of between 5-30 USD/tCO₂
- If storage is near and ready, strongly encourage CCS on selected sectors

Awareness, storage, incentives, regulation

Oxyfuel technology

- Relevant for cement, iron/steel and refineries
- In the demonstration phase, pilots needed for development, optimisation
- Synergies with technologies developed in power and other industry sectors

Awareness, storage, R&D and demonstration, synergies

Technology findings

Post-combustion

- Iron/steel, cement, refineries
- Improving solvents and catalysts
- Environmental impacts
- Demonstrate in iron/steel, cement

Awareness, storage, environment R&D and demonstration synergies

Pre-combustion

- Biomass, refineries, iron/steel
- More pilots needed
- R&D in integrated reactions, novel catalysts, tar removal
- Negative emissions awarded?

Awareness, more pilots and scale-up, synergies, incentives, regulation

CCS: more than coal-fired power



- The potential for CO₂ emission reduction in key industry sectors is as large
- Costs can be much lower, but also much higher than in power
- Greater international competition in industrial sectors, carbon leakage may take place
- Data are poorer than in power generation
- For some sectors, CCS is the only realistic way to achieve deep emission reductions
- Role of CCS may increase in upstream fuel sectors as the importance of unconventional oil and gas increases

CCS in industry provides early opportunities

- Of current CCS projects in operation, most are in industry (gas processing)
- The early opportunity potential is far from depleted
- Current business models
 - Moderate carbon pricing or taxing (ETS, Norway)
 - High-purity sources with Enhanced Oil Recovery (Middle East, South-East Asia, Brazil)
 - High-purity sources with site competition and high profit margins (In Salah, Gorgon)
 - Clustering of emission sources
- Given carbon leakage and absence global carbon price, national policies key



Targeted government intervention needed

- Organise data collection
- R&D and demonstration funding specifically for industry sectors justified; over time more technology-neutral
- Preference could be given to technologies benefitting both power and various industry sectors
- Form public-private partnerships between
 - Government, industry and equipment suppliers to test new technology
 - Government and financiers to develop and enable dedicated finance products that make use of the economically favourable parts of CCS in industry
- Consider mandates for specific sectors

Capacity and international collaboration

- Awareness and available information essential
- New instruments in Cancun agreements and CDM: Can they benefit CCS in industry?
- Agreements for trade-sensitive sectors that specifically include CCS in industrial sectors
- Industry-specific awareness and capacity development programmes; urgent in those industrial sectors and regions with short-term potential
- Develop and disseminate best practices for CO₂ capture in industry
- Education programmes at universities and technical schools
- Regional networks and knowledge circles



Challenges

- There is literature
 - But often numbers are reported using vastly different assumptions
- Aggregate numbers in projections
 - Often hide lack of detailed underpinning data
- Projections
 - Hard to get by on the sector and technology level
- Cost data
 - Are often in industry hands and commercially sensitive

Aim of this meeting

- Check and discuss, detail the key findings
- Review and complement actions
- Think of lighthouse projects
- Add timelines to milestones
- Breakout groups
 - Ca. 8 people per group
 - Constructive and open discussions
 - Led by moderators, notes by UNIDO/ECN team
 - Rapporteur to report back to meeting
- Tomorrow: more regional focus in Latin America Day

Thank you!



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