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# **Global Technology Roadmap for CCS in Industry**

## **Roadmap Review Workshop Report**

24th September, 2010  
Amsterdam, the Netherlands



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## **Annexes**

Annex 1: Annotated agenda

Annex 2: Participants list

Annex 3: Introductory presentations

Annex 4: Break Group Session summary presentations

## Global Technology Roadmap on CCS in Industry

### Roadmap Review Meeting – Shell Global Solutions, Amsterdam, 24th September, 2010

The development of any Roadmap is an iterative process. The starting points, data, recommendations, actions and milestones are reviewed by a broad group of stakeholders, and the balance of the reviews is incorporated into the final product. The first meeting of the Global Technology Roadmap on CCS in Industry was held on June 30 and July 1 in Abu Dhabi. This meeting successfully helped refine and shape the direction of the next stage of work.

A second meeting will take place in Amsterdam on the 24<sup>th</sup> of September, hosted by Shell Global Solutions. The objective of the meeting is to undertake a comprehensive discussion of the draft Roadmap, with emphasis placed on assessing the policy recommendations and the suggested actions and milestones. It will also serve as a platform to discuss concrete steps to deploy industrial CCS. This meeting, coinciding with the GHGT-10, represents a final opportunity, prior to the deadline of the completed Roadmap, to obtain feedback from a broad audience, involving industry stakeholders, but also policy-makers and representatives from financial institutions.

Inputs to the second meeting include:

- The draft Roadmap, including the deployment potentials, policy recommendations and proposed actions and milestones

As well as:

- The final report of the Abu Dhabi meeting
- The final sectoral assessments for iron and steel, cement, high-purity sources, refineries and biomass-based sources.

The programme of the meeting includes a brief introduction to the project and the draft Roadmap, and several breakout sessions with the following topics:

- Actions and milestones for government (policy)
- Actions and milestones for industry
- Outreach to developing countries and economies in transition
- Matching sources and sinks
- Business models for CCS in industry
- Identification of near-term projects

The breakout sessions will start with a brief presentation to highlight the related key outcomes from the draft roadmap. The participants will then provide feedback on those outcomes and help identify and address any remaining gaps. In addition, questions can be drafted and presented to the moderator prior to the meeting in order to trigger discussions. The comments and ideas generated from the discussions can then also be incorporated into the final draft.

A draft agenda follows.

## 24 September 2010

08:30 *Welcome, coffee and registration*

### 09:00 **Opening**

*Chaired by Dolf Gielen, UNIDO*

#### **Welcome by the hosting organization**

- *Marja Zonneville, Shell Technology Centre Amsterdam*

#### **Introduction by project funders**

- *Kristoffer Stabrun, Norwegian Ministry of Petroleum and Energy*
- *Bob Pegler, Global CCS Institute*

#### **Shell and CCS – a brief overview**

- *Tim Bertels, Shell International*

#### **Project overview and objectives**

- *Dolf Gielen, UNIDO*

#### **Progress report: Introduction to the draft Roadmap, including Q&A**

- *Heleen de Coninck, ECN*

10:30 *Coffee Break*

### 11:00 **Parallel workshops: Session 1**

- **Technology characterization** (Moderator: *Dolf Gielen*)
- **Business models for CCS in industry, including EOR** (Moderator: *Wilfried Maas*)
- **Bringing industrial CCS higher on the global agenda, and engaging developing countries and economies in transition** (Moderator: *Bob Pegler*)

12:30 *Lunch*

### 13:30 **Parallel workshops - Session 2**

- **Actions and milestones** (Moderators: *Kristoffer Stabrun; Bob Pegler*)
- **Matching sources and sinks** (Moderator: *Mohammad Abuzahra*)
- **Identification of early opportunity projects** (Moderator: *Nathalie Trudeau*)

15:00 *Coffee Break*

### 15:30 **Synthesis session**

*Moderated by Heleen de Coninck*

### 16:30 **Closing and way forward**

*Dolf Gielen*

17:00 *Drinks offered by Shell International*

# **Global Technology Roadmap for CCS in Industry**

## Roadmap Review Meeting

List of Participants

## List of Participants

Mohammad Abuzahra  
IEA Greenhouse Gas R&D Programme - UK

Mobin Arab  
Research Institute of Petroleum Industry (RIPI) - Iran

Uwe Athmann  
Dezentec - Germany

Duncan Barker  
Mott MacDonald Ltd - United Kingdom

Maher Aziz Bedrous  
Egyptian Electricity Holding Company and CDM - Egypt

Kamel Bennaceur  
Schlumberger – USA

Tim Bertels  
Shell International Exploration and Production B.V. - The Netherlands

Ghaniya Salim Bin-Dhaaer Al-Yafei  
Abu Dhabi Company for Onshore Oil Operations (ADCO) - United Arab Emirates

Jean-Pierre Birat  
European Coordinator of the ULCOS program - France

Alexander Boehringer  
Federal Environment Agency (Umweltbundesamt) - Germany

Jock Brown  
Det Norske Veritas - Norway

Alexander Böhringer  
Federal Environment Agency – Germany

Michiel Carbo  
Energy Research Centre of the Netherlands

Benjamin Court  
Princeton University - USA

Rodolfo Dino  
PETROBRAS - Brazil

Tim Dixon  
IEA Greenhouse Gas R&D Programme

Heleen de Coninck  
Energy Research Centre of the Netherlands

Åsa Ekdahl  
World Steel - Belgium

Amir Mohammad Eslami  
Rahbord Energy Alborz Ltd

Erlend Fjøsna  
Bellona Foundation

Dolf Gielen  
United Nations Industrial Development Organization (UNIDO)

Michel Gimenez  
Lafarge - France

Wolfgang Heidug  
International Energy Agency - France

Hauke Hermann  
Öko-Institut e.V. - Institute for Applied Ecology - Germany

Volker Hoenig  
VDZ / German Cement Works Association - Germany

Samuel Höller  
Wuppertal Institute for Climate, Environment and Energy - Germany

Pernille Holtedahl  
UK Det Norske Veritas

Dao Huang  
China Iron & Steel Association

Bas Kikkert  
Shell International Exploration and Production B.V. - The Netherlands

Takeshi Kuramochi  
Utrecht University - The Netherlands

Wilfred Maas  
Shell International Exploration and Production B.V. - The Netherlands



Claudia Machado  
CEPAC - Brazilian Carbon Storage Research Center

Thomas Mikunda  
Energy Research Centre of the Netherlands

Ana Paula Musse  
PETROBRAS/CENPES/PDEDS/BTA - Brasil

Taher Najah  
Organization of the Petroleum Exporting Countries (OPEC)

Egmont Ottermann  
Pretoria Portland Cement Company - South Africa

Bob Pegler  
Global CCS Institute

Jacek Podkanski  
European Investment Bank - Luxemburg

Utomo Patrama  
Indonesian Energy Ministry

Michael C.N.C.G. Putra  
Indonesia CCS Working Group

Cintia Quintella  
Petrobras

Carolien Quispel  
Shell Global Solutions International BV - The Netherlands

Massoud Rostamabadi Sofla  
University of Illinois at Urbana-Champaign - USA

Deger Saygin  
Utrecht University – The Netherlands

Bettina Schreck  
United Nations Industrial Development Organization (UNIDO)

Katja Schumacher  
Öko-Institut e.V. - Institute for Applied Ecology – Germany

Sanjaya Shrestha  
United Nations Industrial Development Organization (UNIDO)

Fuad Siala

## Organization of the Petroleum Exporting Countries (OPEC)

Tichakunda Simbini  
Biofuels Botswana

Kristoffer Stabrun  
Norwegian Ministry of Petroleum and Energy

Gøril Tjetland  
Bellona Foundation - Norway

Tore Torp  
Statoil - Norway

Nathalie Trudeau  
International Energy Agency - France

Rob van der Meer  
Heidelberg Cement - Germany

Peter Viebahn  
Wuppertal Institute for Climate, Environment and Energy - Germany

Shujuan Wang  
Tsinghua University - China

Luke Warren  
Carbon Capture & Storage Association - UK

Christophe Yvetot  
United Nations Industrial Development Organization (UNIDO) - Belgium

Paul Zakkour  
Carbon Counts - UK

Marja Zonneville  
Shell International Exploration and Production B.V. - The Netherlands

Annex 3 and 4:  
Introductory and Breakaway Session presentations



Green Industry

# Global Technology Roadmap for CCS in Industry

## Project Overview and Objectives

2<sup>nd</sup> Workshop  
24 September 2010, Amsterdam

**Dolf Gielen**  
Chief, Industrial Energy Efficiency Unit



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### Funders

- Global CCS Institute
- Ministry of Petroleum and Energy



### Implementing Agency

- United Nations Industrial Development Organization




### Partners

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




### Host of the 2nd workshop

- Shell International



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**Objective**


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

**Expected outcomes**

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




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**Rationale**

- **Industry** accounts for approx. 40% of total energy-related CO<sub>2</sub> emissions
- The majority of industrial energy use and CO<sub>2</sub> emissions takes place in **developing countries**; therefore developing countries stakeholders should be **informed** and **participate** in technology development and deployment
- CCS is **one of the few low-carbon options** for energy-intensive industries
  - Cement clinker making: no alternative !
  - Biomass + CCS = net negative emissions (backstopping option)
- Not considering CCS is expected to **increase mitigation costs** significantly (by about 70%) – if significant emissions reduction is aimed for
- **Half** of the CO<sub>2</sub> emission reduction **potential** from CCS is in **industry**
- Lots of attention for CCS in the power sector, but **limited for industry** thus far
- Interesting opportunities for CO<sub>2</sub> Enhanced Oil Recovery (EOR)



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**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**

**Approach**


- Desktop review and analysis informed by **sectoral assessments and specific studies**
- Series of **workshops** with selected stakeholders
- Will **build on past and on-going work**, e.g. IEA CCS Roadmap, Cement Technology Roadmap, etc.

**Timeframe**

Roadmap expected to be completed by the **first quarter of 2011**



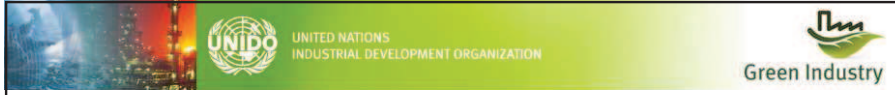
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**Sectoral focus**

- High-purity CO<sub>2</sub> sources
  - Natural gas processing
  - Coal-to-liquids
  - Hydrogen from refineries
  - Ammonia production
- Cement
- Iron and steel
- Refineries
- Biomass-based industrial CO<sub>2</sub> sources




**CCS: Status today**

- About 50 million tons/yr transported and used for Enhanced Oil Recovery since 40 years – not a single accident
- CO<sub>2</sub> capture technologies have long been used in gas streams treatment (ammonia and hydrogen production, natural gas processing) – 15-30 Mt/yr – all chemical absorption based
- Three main methods: post-combustion (chemical absorption), pre-combustion and oxy-fuel
- For industry, process re-design can reduce cost substantially (eg FINEX, black liquor gasification)
- Transport and storage >600 m underground “supercritical stage” – depleted oil & gas fields or aquifers
- About 10 demonstration projects for CCS are operational worldwide – technical feasibility is proven
- Tens of plants are in planning/construction phase




**CO<sub>2</sub>-EOR**

- Suited for certain types of oil reservoirs
- Interesting opportunities in the Middle East and elsewhere in the developing world
- Can generate revenues that can offset (part of) capture cost
- CO<sub>2</sub>-EOR targeting storage requires special care
- Successful Weyburn demonstration project in Canada
- A niche for early deployment
- Try to identify and characterize some projects for industrial CCS + EOR




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Resume of Activities

- 1st workshop 30 June-1 July, Abu Dhabi
- Workshop proceedings completed
- Five consultants papers revised
- DRAFT roadmap prepared
- Decided to expand work on source-sinks matching
- Decided additional study on CO2-EOR
- Discussed possible presence at COP16



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1<sup>st</sup> Workshop, 30 June – 1 July 2010, Abu Dhabi, UAE

- Participants: 45 experts from both industrialised and developing countries
- 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





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Proposed Next Steps

- Uniform technology characterization
- Commission two supplementary studies
- Complete roadmap
- Identify 50-100 lighthouse projects (early opportunities)
- Engage developing countries more
- Continue elaboration demonstration project plans



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**Thank You !**

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## CCS in Industry – insights from Shell's activities, issues to be addressed

Tim Bertels,  
Manager CCS Portfolio,  
Shell Upstream International

Global Technology Roadmap for CCS  
in Industry (UNIDO)

Amsterdam, September 24, 2010



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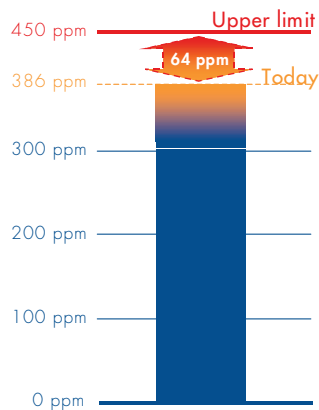
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## THE ENERGY AND CO<sub>2</sub> CHALLENGE

### ENERGY DEMAND WILL DOUBLE WHILE CO<sub>2</sub> IS NEARING ITS LIMIT

#### CO<sub>2</sub> CONCENTRATION IN ATMOSPHERE

Science warns of a 450 ppm upper limit



Emissions are rising at over **2 ppm** per year

#### MEETING DEMAND WITH LESS CO<sub>2</sub>

The world will need ALL options it has



**Energy efficiency**

AND



**Renewables**

AND



**Nuclear**

AND



**CO<sub>2</sub> Capture and Storage**

AND



**Forestry,**

All five pathways are essential and will be needed **at scale** to meet energy demand this century and to limit CO<sub>2</sub> emissions.

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## SHELL'S RESPONSES TO THE CO<sub>2</sub> CHALLENGE

1. Natural Gas
2. Biofuels
3. Carbon Capture and Storage (CCS)
4. Energy efficiency



Perdido, USA



Biofuels, Brazil (Sugar cane for proposed Cosan joint venture)



Carbon Capture Research, Mongstad, Norway



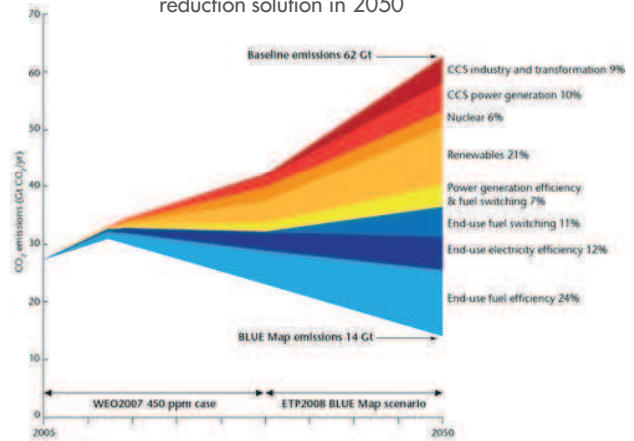
SEPC, Singapore (part of the global energy efficiency programme)

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## THE BENEFITS OF CCS

- The International Energy Agency (IEA) confirms that CCS is the only technology that can cut CO<sub>2</sub> emissions from large-scale fossil fuel use today.
- The IEA states that CCS technology could remove over 10 billion tonnes of CO<sub>2</sub> emissions a year by 2050 if rapid deployment starts this decade.
- This is equivalent to a third of current fossil fuel emissions.
- CCS has the potential to deliver significant CO<sub>2</sub> emissions reductions needed but prompt deployment is essential.

CCS can deliver one-fifth of the lowest-cost GHG reduction solution in 2050



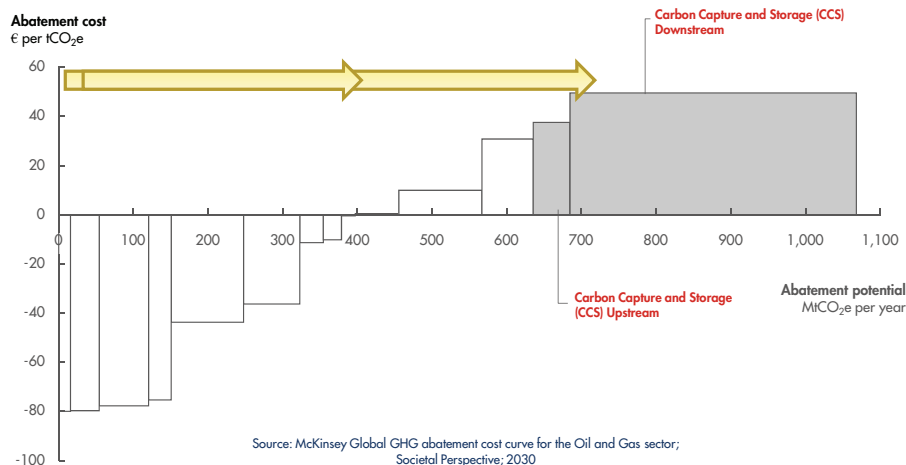
Source: IEA, Energy Technology Perspectives (2008a)

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## CCS IN THE OIL & GAS INDUSTRY

- CCS will be an essential element of GHG mitigation in the **Oil & Gas Sector**, constituting up to 45% of abatement potential by 2030
- Q: by how much will GHG emissions have to be reduced in industry?



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## SHELL FOCUSING ON CCS

- Shell is involved in a number of demonstration projects with industry partners to help advance the technologies and understanding of CCS.

### These include:

- CCS demonstration project in Mongstad, Norway, which is expected to capture up to 100,000 tonnes of CO<sub>2</sub> a year from 2011.
- The Gorgon liquefied natural gas project in Australia will capture up to 4 million tonnes of CO<sub>2</sub> a year.
- The Quest project in Canada will capture and store over 1 million tonnes of CO<sub>2</sub> a year from oil sands.

Technology Centre Mongstad (TCM), Norway



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## SHELL DEVELOPING CCS TECHNOLOGIES FOR THE FUTURE



## O&G INDUSTRY BUILDS ON EXPERIENCE IN ALL ELEMENTS OF CCS



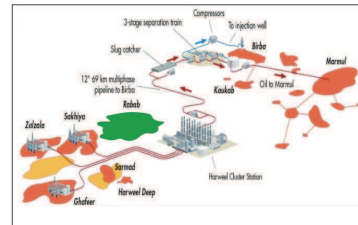
### Underground Gas Storage in Europe

- Balancing gas market in W. Europe
- Designed for 60 years operation
- Much relevant learning extracted



### CO2-EOR Operations in Denver Unit, USA

- Tertiary oil recovery using CO2 pioneered by Shell in 1970
- More than 40 years experience in CO2-EOR



### Sour Gas Injection in Harweel/Birba, Oman

- Almost 100 Bscf of sour gas injected at pressures over 7,000 psi
- Multiphase transportation over 69 km

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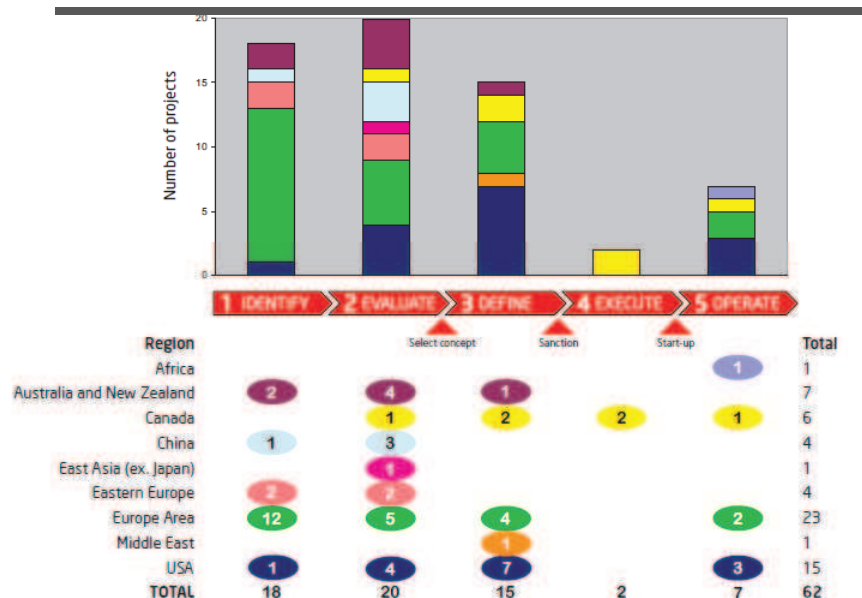
## EARLY INSIGHTS FROM OUR CCS PROJECTS

- Most CCS projects will not be commercially feasible without significant funding support.
- Uncertainties on conditions for post-injection liability handover to governments hampers CCS project progress.
- Public support for CCS projects is essential.
- There is no "one size fits all" technology.
- Existing transportation infrastructure and agreed fit-for-purpose CCS standards must support project economics.
- CCS projects experience first-mover cost disadvantages and risks without an upside.
- Large-scale integrated frontier CCS projects are difficult to mature in the current business environment

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## GLOBAL CCS PROJECTS FUNNEL – CASE FOR ACTION

### GLOBAL OVERVIEW – CCS MATURATION FUNNEL



Source – GCCSI; Strategic Analysis of the Global Status of Carbon Capture and Storage

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## NEXT STEPS FOR CCS

- **Urgency** – Speed is vital if demo projects are to be operational by 2015.
- **Knowledge sharing** - Policy makers and industry need to share at regional level to progress the technical understanding of CCS.
- **Public acceptance** – Industry, governments and public must join together to further understanding and acceptance.
- **Infrastructure** - Demonstration is key but we need to look now at how infrastructure is to be set up (plant clusters, pipelines, hub stations sinks) and how it is to be planned and operated.
- **Roadmap** – global co-operation to develop roadmaps for rapid CCS deployment.

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**Thank you !**



## Developing a roadmap and insights so far

Heleen de Coninck - [deconinck@ecn.nl](mailto:deconinck@ecn.nl)  
Abu Dhabi, June 30 2010



### Outline

- What is a roadmap?
- Steps in a roadmap process
- Current status and insights
- Aim and process of this meeting

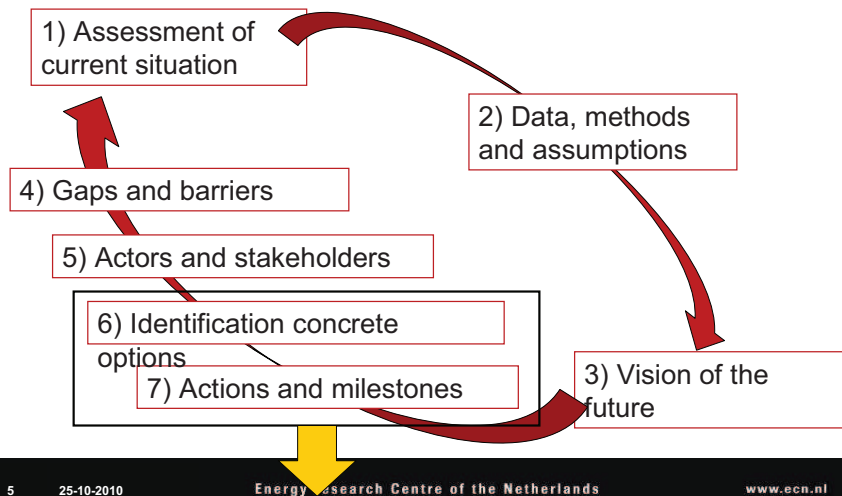
## A roadmap is a first step

- A document that provides an exhaustive overview of opportunities, gaps, barriers and measures to achieve 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
- The process of making and agreeing is important

## This roadmap...

- Has a focus on CO<sub>2</sub> capture in five industries:
  - High-purity CO<sub>2</sub> sources, including gas processing, chemical industry
  - Cement
  - Iron and steel
  - Refineries
  - Biomass-based industrial sources of CO<sub>2</sub>
- Has a global scope, but a focus on developing countries where relevant
- Builds on earlier roadmaps (e.g. CCS roadmap from IEA)

## Steps in a roadmap process



## Hypothetical examples of actions and milestones

- In order to overcome awareness barriers for CO<sub>2</sub> capture in gas processing in developing countries, a demand-driven capacity building programme is initiated for local industry and government stakeholders
- Reduce energy penalty of CO<sub>2</sub> capture through process design and heat optimisation
- Optimise integration, particularly for retrofit applications, to achieve plant availabilities and capture rates above 85% by 2020

## The (draft!) sectoral assessments:

1) Assessment of current situation

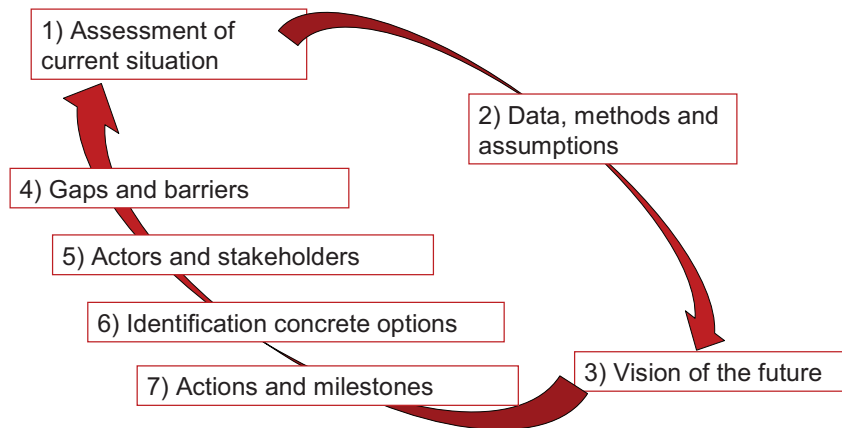
2) Data, methods and assumptions

3) Vision of the future

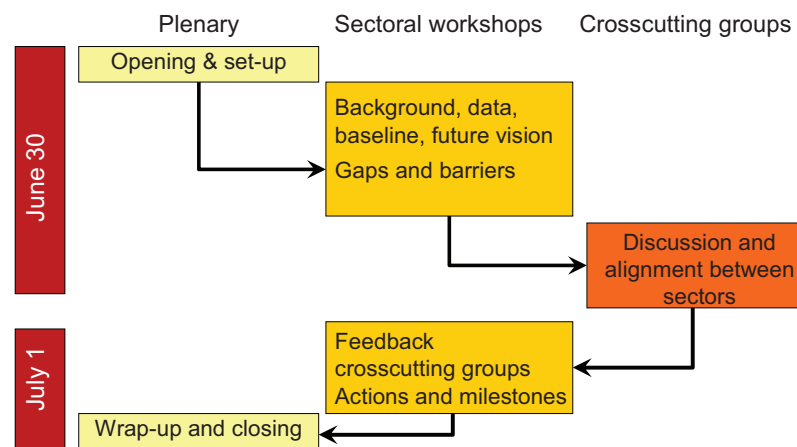
## Current status and insights so far

- Data, methods and assumptions being discussed between sectoral specialists, UNIDO and IEA
- Overlap handled as much as possible
- Sectoral assessments good progress but not complete
- Need for industry-specific future vision
- (Probably most actions and milestones will also be industry-specific)
- Data are a problem, in particular in developing countries

### This meeting:



### Structure of this meeting



## Structure of this meeting

- Sectoral workshops
  - Please remain in your group!
  - Moderates chair
  - Sectoral consultants provide substance
  - Rapporteur reports back to plenary tomorrow
- Crosscutting groups for consistency and interaction
  - Do not report back to plenary but to sectoral workshops
  - Except for special crosscutting group on Middle East

**Thank you!**



# Technology Characterization

Dolf Gielen

CCS Roadmap Workshop 24/9/2010



## Key Variables

- ✓ Central value plus sensitivity
- ✓ Inclusion/exclusion transport & storage
- ✓ Inclusion captured CO<sub>2</sub> pressurization (100 bar)
- ✓ Capture cost and mitigation cost
- ✓ Three locations (NW Europe, China, Middle East)
- ✓ Definition of reference – needs more thought
- ✓ Greenfield vs. retrofit
- ✓ Plant size (minimum size and standard size)
- ✓ Energy prices
- ✓ Discount rate
- ✓ Today/2030/2050
- ✓ Capture efficiency
- ✓ Define purity CO<sub>2</sub>
- ✓ Specify capture efficiency
- ✓ Plant age
- ✓ Give annualized cost and investment cost
- ✓ Electricity average CO<sub>2</sub> intensity



## Technology List

- ✓ Iron and Steel
  - Post combustion capture blast furnace (before after power generation)
  - Oxyfuel blast furnace
  - Gas DRI
  - FINEX
  - HISARNA
- ✓ Cement
  - Chemical absorption
  - Oxyfuel
  - Carbonate looping
- ✓ Refinery
  - Hydrogen SGR (new/old plant design)
  - Hydrogen gasification residues
  - FCC
  - Process heat – pre-combustion and post-combustion (retrofit)
- ✓ Ammonia
- ✓ Gas processing
  - Onshore/offshore
- ✓ LNG production
- ✓ Ethanol fermentation
- ✓ FT-synthesis coal
- ✓ FT-synthesis biomass (incl black liquor processing)
- ✓ SNG - biomass



# THANK YOU !

[d.gielen@unido.org](mailto:d.gielen@unido.org)





## UNIDO Business models



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## Business models - summary

- Regulators react to public signals, resulting in policy, needed for viable business models
- Clarity on capture, transport and storage business models required (example: agree on who gets the credits; what are reasonable returns)
- Ample examples of internalisation of environmental burden and actions; learn from those for business models for CCS
- EOR in specific cases can lead to integrated affordable value chains
- ECBM and EGR have lots of questions: can they be business models?
- Sectoral agreements or measures, possibly easier to implement than carbon pricing (trade-sensitive sectors)
- CO<sub>2</sub> cost or price?: model that storage provider can pay for taking CO<sub>2</sub> (thanks to a government tax/subsidy?)
- Sharing infrastructures: incentives but also monopoly issues
- R&D will not drive commercial deployment
- Financing and underwriting models needs to get ample attention given large capital exposure of CCS

— [Business models for CCS: a review of the literature](#) (2014) | [CCS Business Models](#) (2014) | [CCS Business Models](#) (2014)

## Business models

### Enhanced oil recovery

- Could be a “leading-in” technology. Not enough potential for the longer term CO2 storage needs, but a good start
- Cost recovery not always sufficient (example from Indonesia). Retrofitting on wells; modification of units and installations cost-intensive for EOR; NPV for EOR may be low
  - Incentive from government needed
  - Environmental regulation needed
- On land and in new facilities EOR might be economic. Offshore?
  - Need to build expertise on offshore EOR – all present experience is onshore
  - Environmental impacts of offshore EOR: research and knowledge-sharing needed – IMO discussions
  - Potentially delay abandonment of offshore oil operations
- Re-use of CO2 in developing countries
- Combining EOR and storage because of the profile of CO2 demand in an EOR field
- EOR has a time window – need to look at optimal implementation over time (after water. Miscible gas is getting more valuable leading to CO2 more attractive)
- Not for everywhere; depends on the field and crude in it
- Pilots are needed. ADCO doing pilot; need more of that
- Fiscal regime for EOR; clever mechanisms (US forward ..)

## Business models

### Enable storage providers with a commercial model

- Regulation and reasonable post-storage liability transfer needed
- Help them overcome demonstration/first-mover barriers
- Oil and gas industry have competency and skills most readily available for storage
- What would a storage provider charge? What is the ownership model?

### Financing/incentives

- Essential for business models – financial models: learn from renewable energy
- Price on CO2 (CDM (but small incentive), ETS (rules clear for all sectors?), JI), performance standards (including making CCS mandatory), international sectoral agreements (UN-driven?)
- Refinery sector: CCS for low-carbon fuel standards?
- Incentives for high first-mover costs for demonstration

### Other revenue-generating storage: ECBM and EGR

- ECBM operations increasing worldwide – what is the potential?
- Is the K12b project (GdF) still doing EGR?
- Examples of EGR in Croatia and Hungary

## Business models

Sharing infrastructures

- Looking for places where this can be done
- Transport often only part of the cost
- Quality standards in the case of shared infrastructure

Price, cost: degree to which cost can be included in the price

Steel: CCS would add 15% to the cost of steel. Steel market is highly competitive; leakage will happen. Level-playing field important in trade-sensitive sectors

- Sectoral agreements: first needs to agree on the basic data; that is hard. In the steel sector, still at the stage of identifying data

Cement industry: does not stand to make money out of CCS.

- CCS is a cost to cement. How much will cement have to pay? Cost should decrease
- Cost-reducing options exist (oxyfiring) that can reduce costs significantly, but still cost
- “plug, pull and store” model
- Sectoral agreement: succeeded to agree on basic data but has not moved on

Indonesia: possibilities in NG-processing CO<sub>2</sub> and EOR. Currently R&D, project in 5 years. Currently not viable business model, yet

Amount of industries involved and needing to work together

## Business models

CO<sub>2</sub> transport sector: how will it be organised and operated?

Capture and storage: opex and capex very different; how is the return on investment done? (important for financiers)

Purity of the CO<sub>2</sub> could be additional cost element in the value chain

Models involving industries where CO<sub>2</sub> needs to be captured anyway; carbon price incentive can be lower (but still necessary)

Enabling by governments; consumers; voters. Learn from successful solutions in the case of other pollutants

First focus on the low-hanging fruit

R&D not leading to implementation



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## Bringing industrial CCS higher on the global agenda and engaging developing countries and economies in transition

Bob Pegler



## Bringing industrial CCS higher on the global agenda and engaging developing countries and economies in transition

### 1) Getting industrial application of CCS on the political agenda

Why is CCS not in the agenda in DC and TE?

- ✓ Lack of climate commitments or concern for domestic mitigation
- ✓ Language structured by power sector – domestic based sector (no benefit of being carbon neutral) and facing RE competition
- ✓ Discussion seems to still very academic or technical - not matured yet

What to do to shape the agenda?

- ✓ Certain global actors promoting it even when stakeholders are unaware not engaged (such as multilateral banks and international companies)
- ✓ Identifying sources for funding (R&D) but also develop knowledge in real finance to scale up and other support systems (eg insurers )



## Bringing industrial CCS higher on the global agenda and engaging developing countries and economies in transition

### 2) Countries to get involved

What to do?

- ✓ Do not advocate CCS for industry on its own – it is key to address the global CCS community as a whole
- ✓ Prevent CCS fatigue! Too many CCS initiatives divert attention of developing country governments. Raise the discussion level
- ✓ Path for DCs: Define CC policies --- identify need for mitigation actions -- identify technical opportunities - include CCS amongst them

Which countries?

- ✓ Time and impact – where it may take up faster
- ✓ Regions where there is interest and CCS will be part of the mix
- ✓ Countries which could serve as role models for regions

## Actions and milestones

- Industrial hotspots/hubs and networks
- Global framework:
  - Long list of policy options, including exotic ones
- Specific technology and regional roadmaps
- Low-cost CO<sub>2</sub>/EOR
- We need an official statement (e.g. G20) on industrial CCS
- Incorporation into WB and other multilateral donor positions, including CCS-ready
- Leadership from industry



## Matching sources and sinks

Tore Torp /  
Mohammad Abuzahra



## Matching sources and sinks

- ✓ Transport – technology and costs are known
- ✓ Define the capacity and type of reservoirs available as sinks
- ✓ Specification of gas to be injected: O<sub>2</sub> levels, sour gases, water content
- ✓ Suitability and eligibility/validation of sinks
- ✓ Mapping of sink – start early
- ✓ Global regulations - crossborder opportunities and limitations
- ✓ EOR and EGR – early opportunities

### **Matching is driven by storage rather than sources**



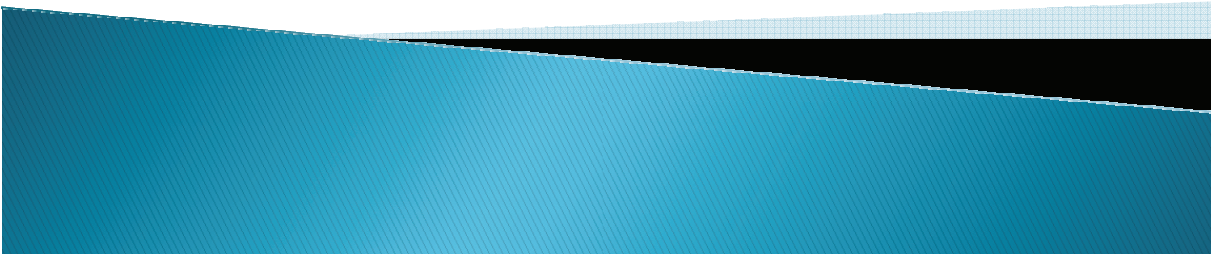
## Matching sources and sinks

- ✓ Public awareness in DC is still not formed on these issues
- ✓ Influence leadership
- ✓ Industry need to learn on the economic factors and growth from O&G sector

### Prioritise options:

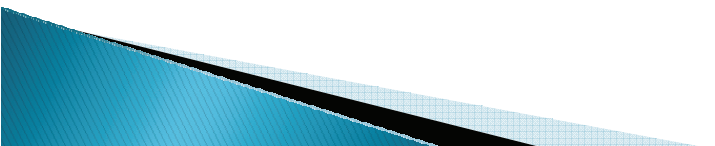
- ✓ first prioritise opportunities - even under limited data conditions
- ✓ Need for agreement on **global** guidelines/minimum parameters on critical issues
- ✓ Transport technology and costs is well known – improve knowledge of capture
- ✓ Sink mapping and geological monitoring of future sinks starting at an early stage

# Identification of early opportunities



## Possible projects

- ▶ Petrobras – Reconco basin 120 tonnes per day from an ammonia plant for EOR – and test storage in saline aquifer. Capacity for 4000 tonnes, but CO<sub>2</sub> needed. Possibly from new hydro cracker – pipeline needed.
- ▶ Jilin oil fields, China – EOR from DME plant
- ▶ Mexico, Canteral, current EOR with nitrogen, possible substitution with CO<sub>2</sub>
- ▶ Opportunities in the Persian Gulf, EOR





# Possible projects cont...

- ▶ Iran: Possible capture from a natural gas processing plant – 0.9 Mt/yr – 96% CO<sub>2</sub> – storage potential. Significant engineering expertise.
- ▶ Inventory of sources available
- ▶ Monitoring and compression potential problems.
- ▶ Ammonia production in middle-east



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