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Reducing Emissions with Natural Gas and Carbon Capture and Storage

20 November 2014

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LARGE SCALE CCS PROJECTS

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GAS WEEK 2014

“REDUCING EMISSIONS WITH NATURAL GAS AND CARBON CAPTURE AND STORAGE”

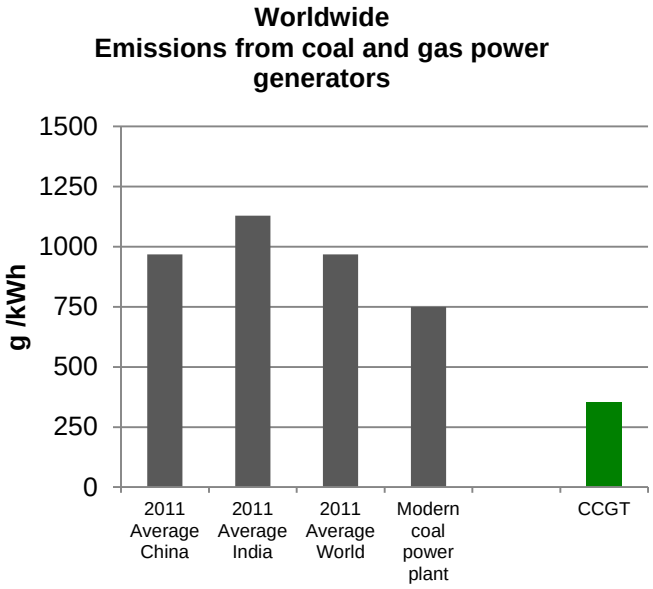
Dominique Copin Total,

Natural Gas and CCS,

Feedback from the Lacq CCS industrial pilot,

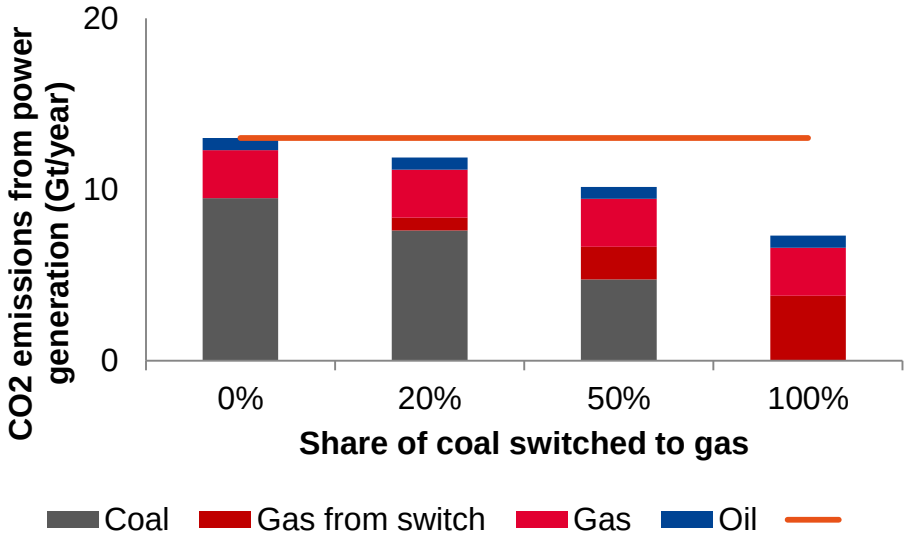
20 November 2014

SWITCH FROM COAL TO GAS: A SIGNIFICANT GHG EMISSION REDUCTION POTENTIAL WORLDWIDE



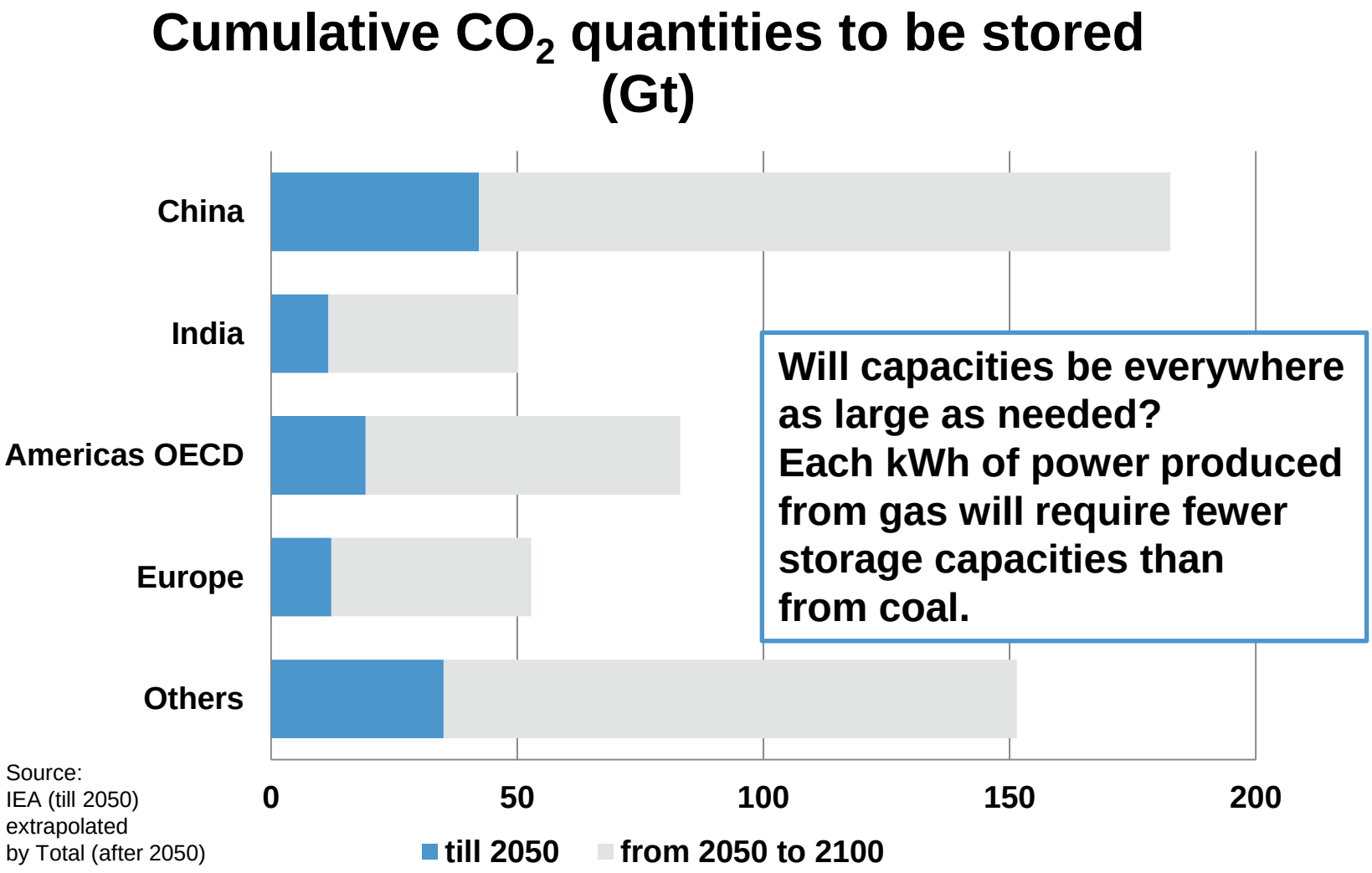
Gas power plants emit much less CO_2 than Coal power plants

Switch from Coal to Gas to produce power has the potential to significantly reduce GHG emissions



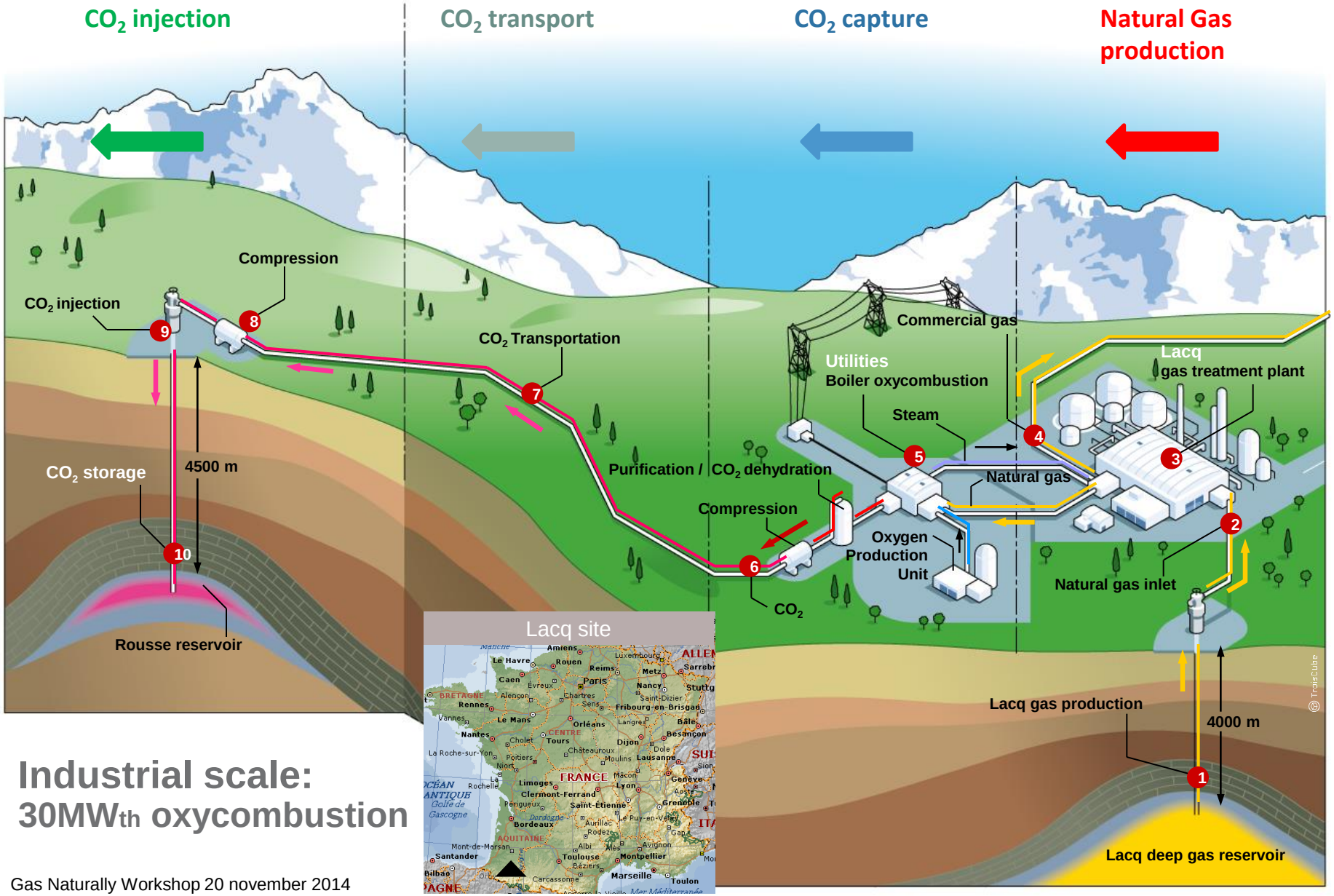
Source IEA CO_2 emission from fuel combustion 2013

CO_2 QUANTITIES TO BE STORED



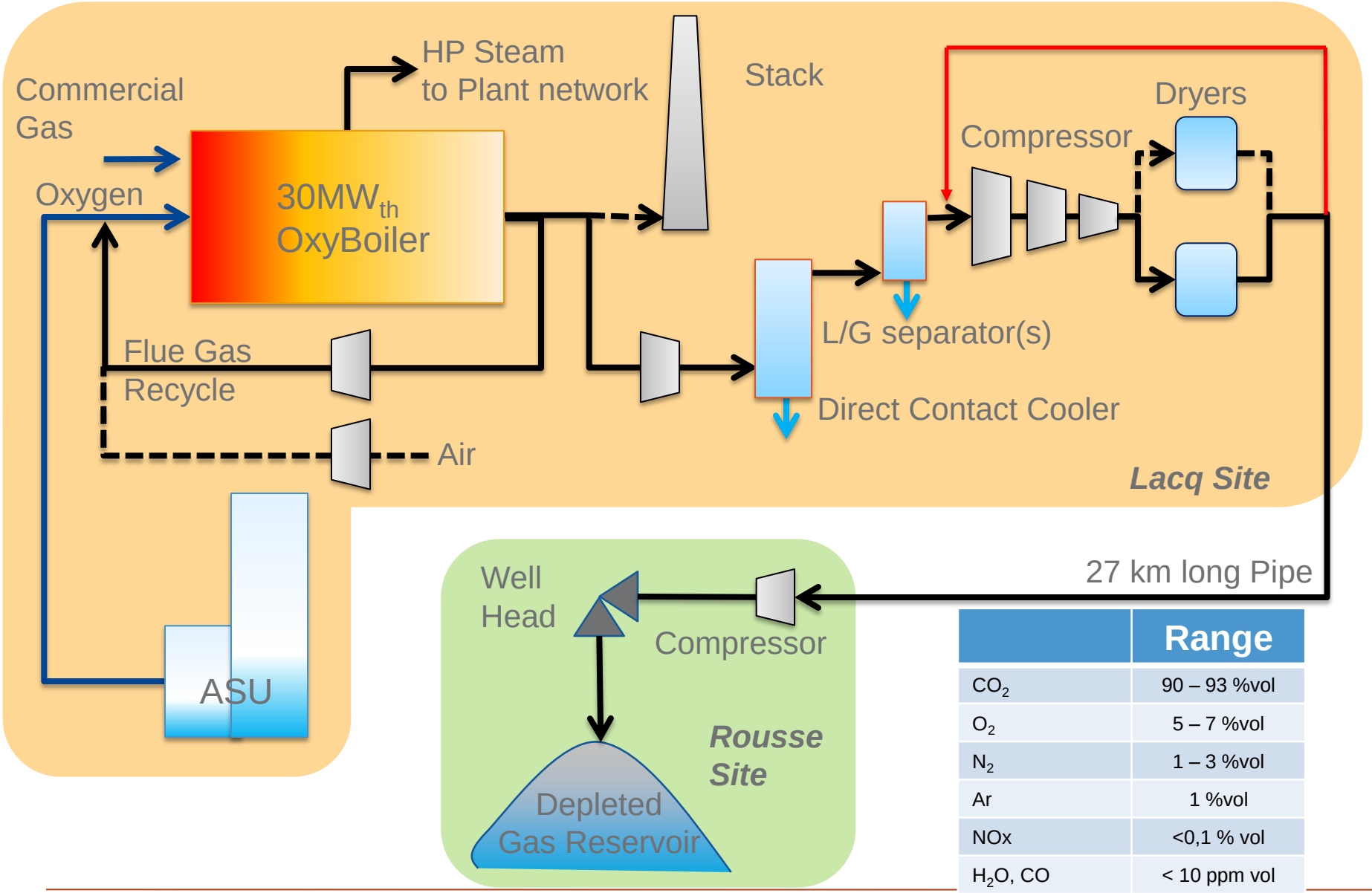
Source:
IEA (till 2050) extrapolated by Total (after 2050)

A COMPLETE INDUSTRIAL CHAIN



Industrial scale:
30MW$_{th}$ oxycombustion

PLANT OVERVIEW



	Range
CO_2	90 – 93 %vol
O_2	5 – 7 %vol
N_2	1 – 3 %vol
Ar	1 %vol
NOx	<0,1 % vol
H_2O, CO	< 10 ppm vol

TRANSPORT AND STORAGE OVERVIEW

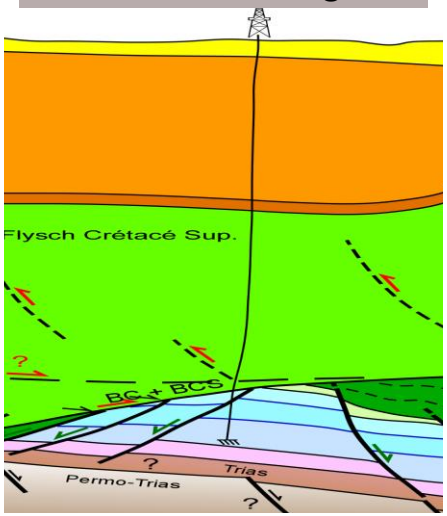
Capture

Rousse compressor

P inlet: 27 bar P outlet: 51 bar

RSE-1 injection well head

Rousse storage



Depleted gas reservoir @ 4500m/GL

	Range
CO_2	90 – 93 %vol
O_2	5 – 7 %vol
N_2	1 – 3 %vol
Ar	1 %vol
NOx	<0,1 % vol
H_2O, CO	< 10 ppm vol

CCS PILOT, LACQ, FRANCE

Permitting and public acceptance

- **Permit obtained in May 2009 for capture, transportation and storage**
  - ➢ A « Regulatory » pilot, 1st in Europe
- **Public dialogue – transparency policy**
  - Identification of Stakeholders (NGOs, mayors…)
  - Early public meetings in 2007 (3 public meetings)
  - Follow up information committees (13 meetings)
  - Information letter every quarter (21 letters)
  - Dedicated Hot line
- **Scientific Advisory Committee since 2007**
- **Scientific collaboration program with National Institutes and Universities on Rousse storage**
- **Project endorsed by the Carbon Sequestration Leadership Forum (CSLF)**

A scientific book on lessons learned from Lacq CCS pilot will be edited early 2015 and available on Global Carbon Capture and Storage Institute (GCCSI) website.

PERSPECTIVES

- **Switch from Coal to Gas is a significant driver to reduce GHG emissions.**
- **This switch will result in fewer constraints for CCS development due to CO_2 potential storage capacity limits or costs.**
- **Gas CCS demonstrators and R&D are needed.**
- **CO_2 Storage Capacity estimations are key to the assessment of the development potential of CCS.**

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“Reducing emissions with natural gas and Carbon Capture and Storage”

Lamberto Eldering Statoil

The Sleipner CCS project

20 November 2014

Outline – Key questions

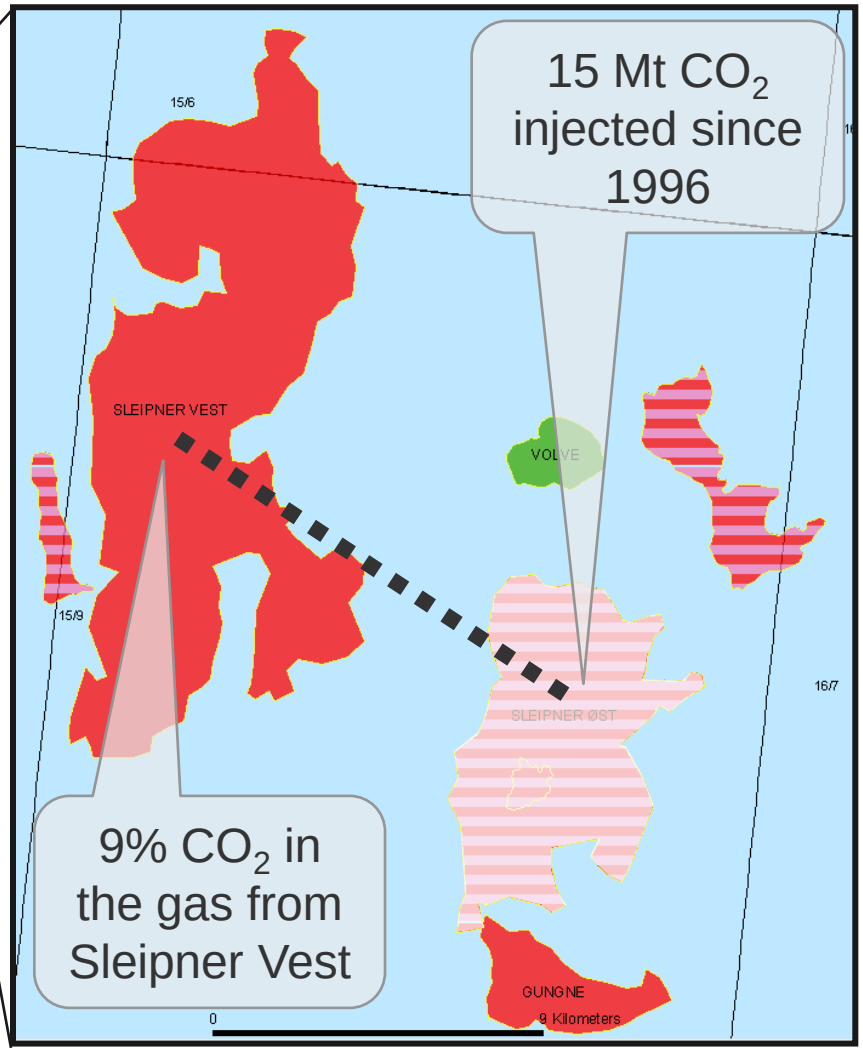
- What have we learned about CCS operations and long-term CO_2 storage at Sleipner?

  - **18 years of successful CO_2 storage site operations**

Statoil

Sleipner overview

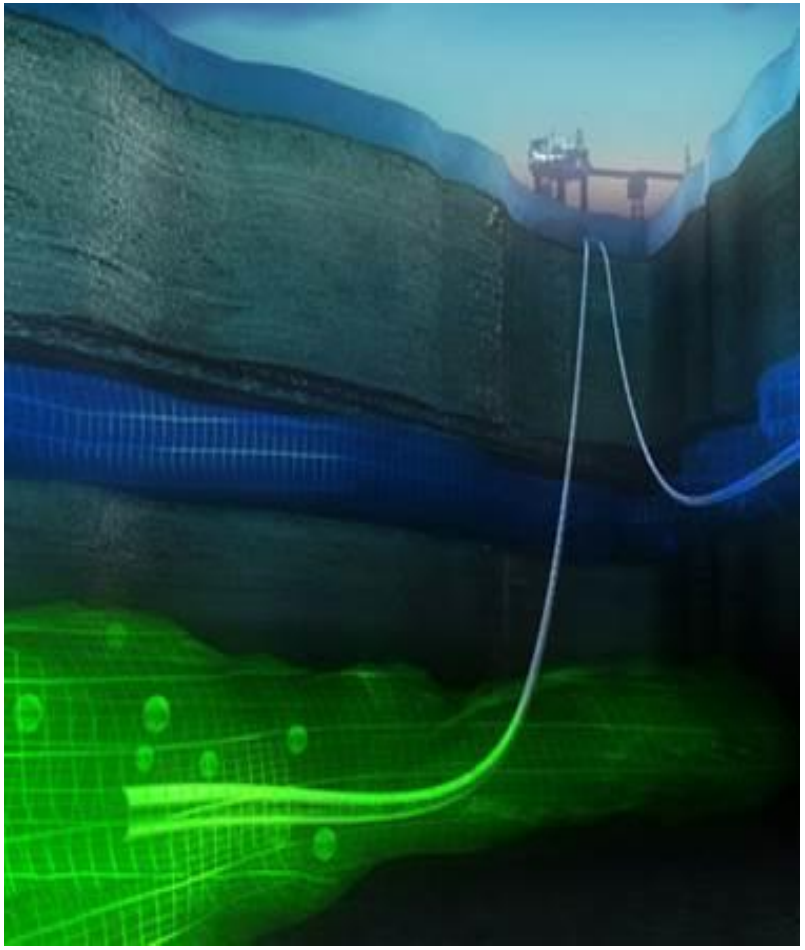
- Sleipner gas fields
- Amine capture from natural gas
- 0.9 Mtpa stored
- 15Mt stored by end 2014
- Injection started in Sept. 1996
- CO_2 is injected in the Utsira Fm at ~ 900 m depth (above the condensate reservoir)
- Operated by Statoil with licence partners ExxonMobil and Total
- Since April 2014 CO_2 from Gudrun field gas (north of Sleipner) is also injected



Statoil

Main achievements

- 18 years of successful CO_2 storage site operations
- Used globally as a role model for CCS
- Significant contribution to Norway's emissions reductions
- Important learnings for science and technology of CO_2 capture, transport and storage
- Used to pioneer and demonstrate a range of monitoring technologies:
  - Time-lapse seismic
  - Gravity monitoring
  - Seabed mapping

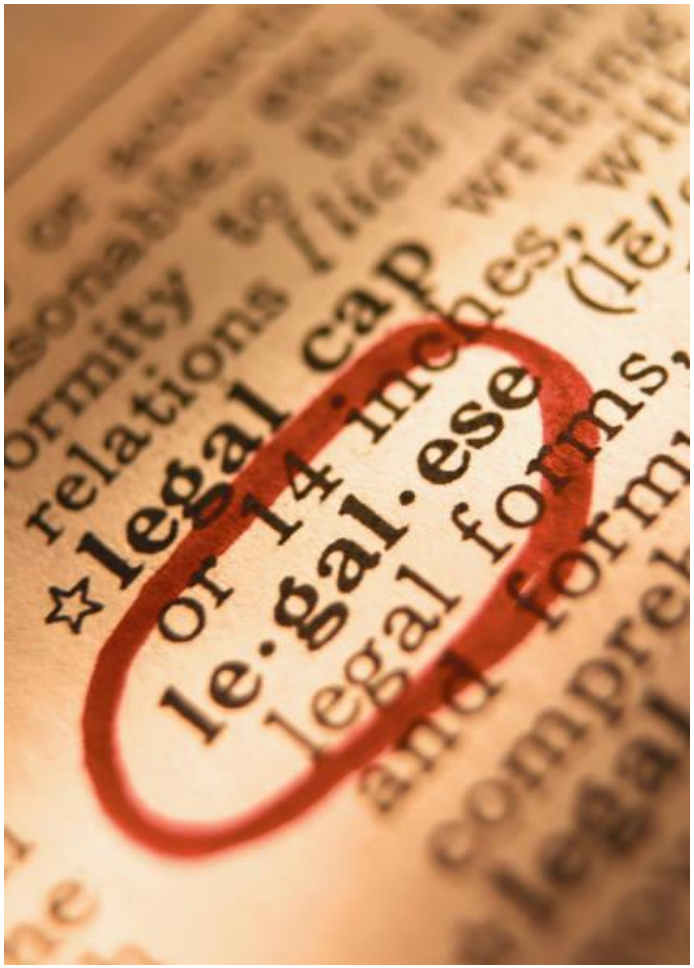


Main challenges and barriers

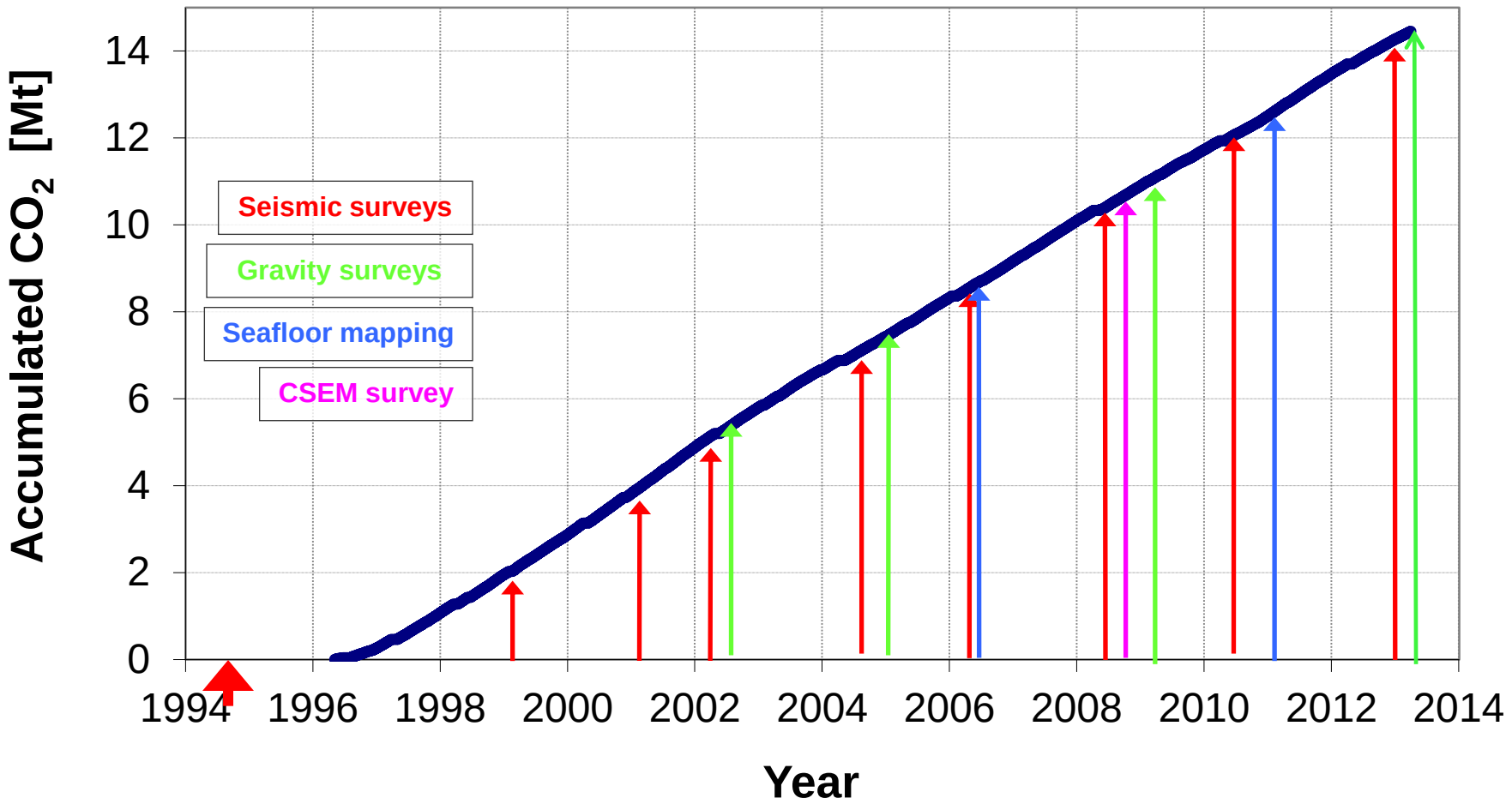
- Project permitted under Norwegian Petroleum law
- During the project other conventions came into play
  - OSPAR
  - EU CCS Directive
- External interest leads to additional expectations on the operator – data sharing and technical clarifications
- Geophysical monitoring data has led to significant improvements in understanding CO_2 flow behaviour and storage capacity
- Gained experience on how much monitoring data is needed for CO_2 storage sites in general

EU CCS Directive

- Implementation of the Directive in Norway may impose additional requirements beyond todays practise.
  - Possible technical implications
    - Increased requirements on future monitoring plan
  - Liabilities
    - Long term liabilities after injection stop
    - Financial security for leakage risk



Injection and monitoring history



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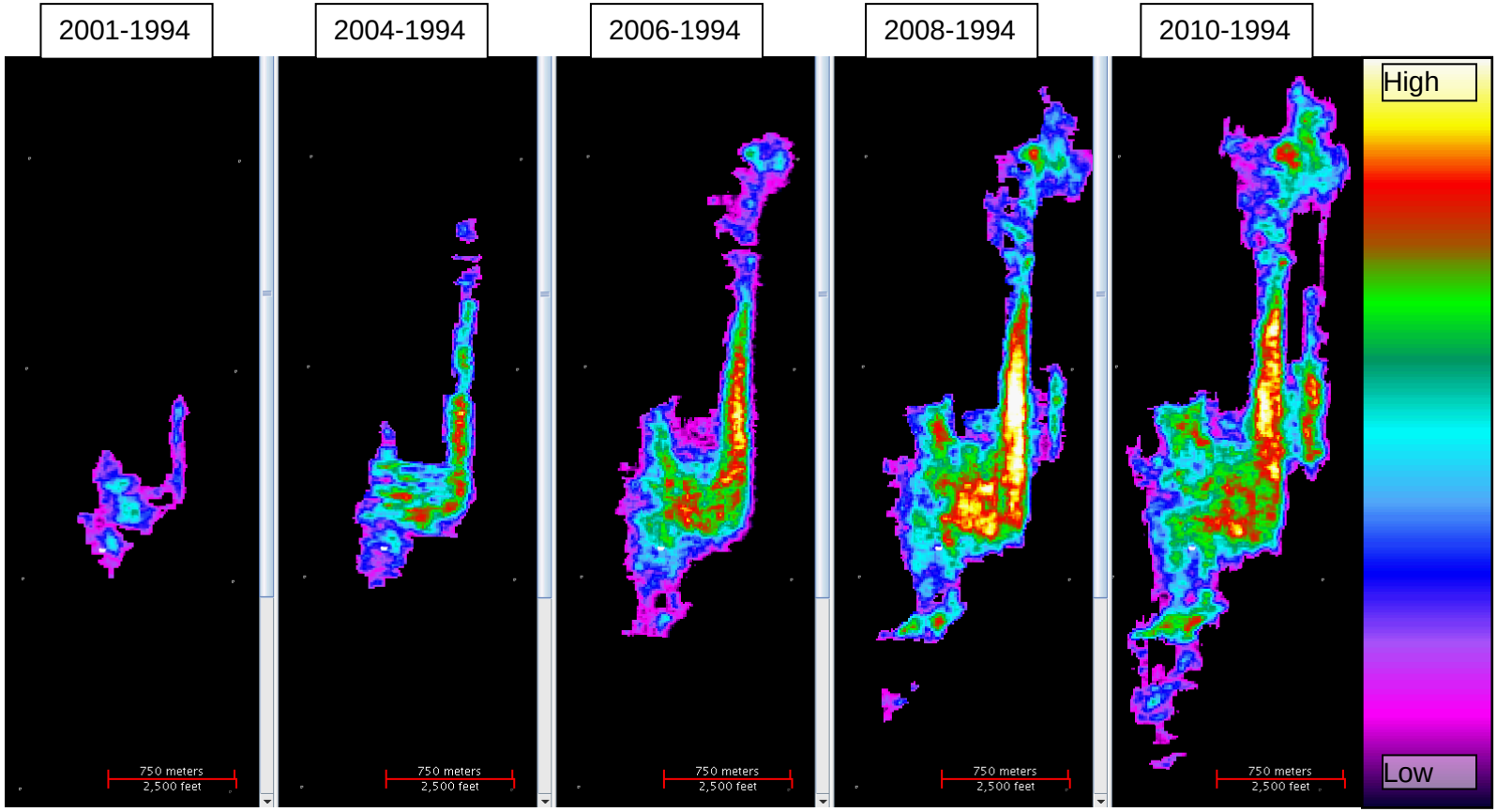
CO_2 plume - 4D seismic



Seismic time-lapse monitoring shows that CO_2 stays in place in the Utsira Fm at Sleipner and gives a detailed description of where the CO_2 is

Furre & Eiken, 2012

Statoil

Main lessons learned

- Geophysical monitoring has proven essential for site management
  - Safe CO_2 storage confirmed
- Monitoring of pressures is as important as saturation:
  - Down-hole gauges are highly desirable
- Practical learnings about capacity and injectivity from well operations experience
- Monitoring the overburden is as important as the reservoir:
  - External interest may require analysis of regional and near-surface datasets
- Time-lapse seismic imaging of CO_2 plume development gives much improved understanding of flow processes
  - Builds confidence in model forecasts
- Well defined governmental framework and regulations have contributed to the stable and predictable operation

Test Center Mongstad (TCM)

- **Capture technologies ready for implementation**
- **Measure technologies developed at TCM bridged knowledge- gap on amine emissions**
- **Unique centre available for further testing**

Statoil

There's never been a better time for good ideas

Thank you for your attention!

Presented by Lamberto Eldering, Statoil ASA
Special thanks to the Sleipner Production License

www.statoil.com

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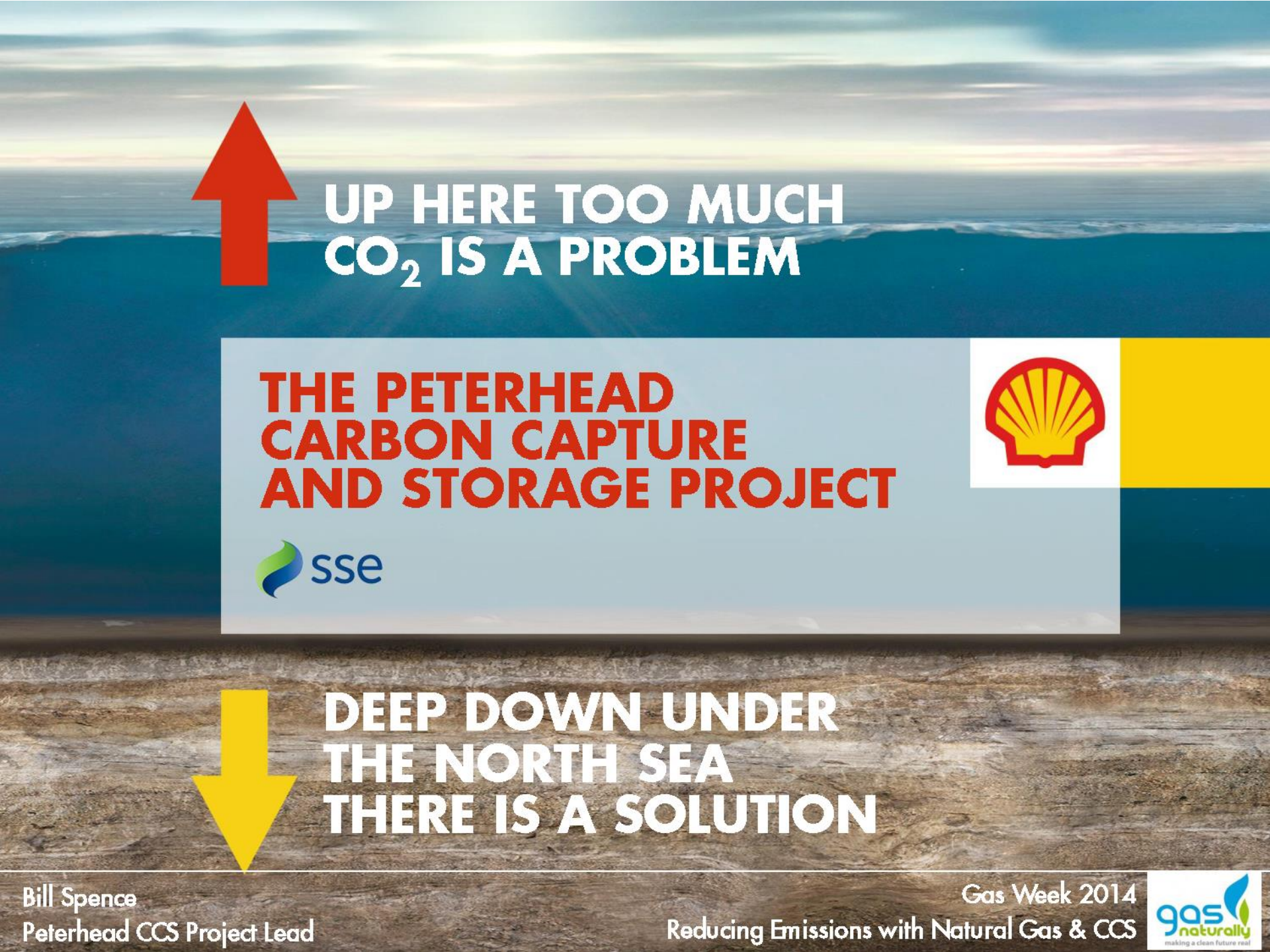

Bill Spence
Peterhead CCS Project Lead

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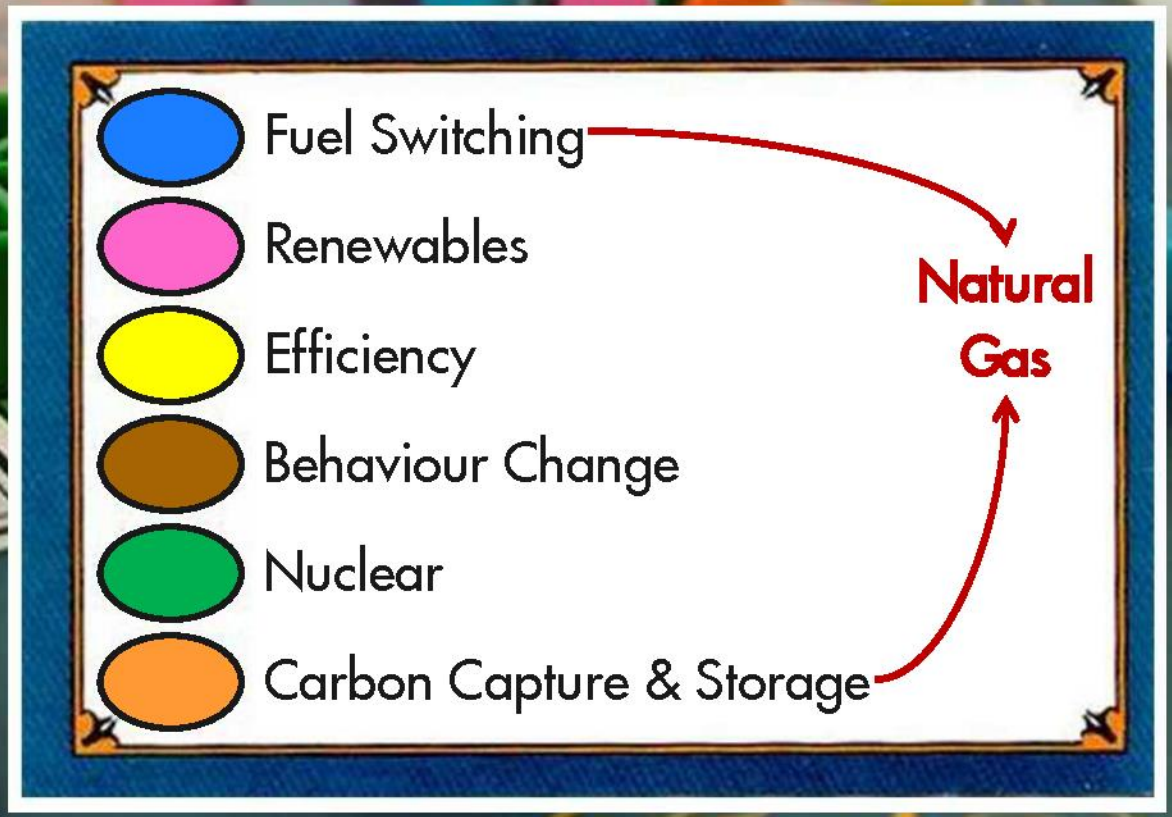
The companies in which Royal Dutch Shell plc directly and indirectly owns investments are separate entities. In this presentation "Shell", "Shell group" and "Royal Dutch Shell" are sometimes used for convenience where references are made to Royal Dutch Shell plc and its subsidiaries in general. Likewise, the words "we", "us" and "our" are also used to refer to subsidiaries in general or to those who work for them. These expressions are also used where no useful purpose is served by identifying the particular company or companies. "Subsidiaries", "Shell subsidiaries" and "Shell companies" as used in this presentation refer to companies over which Royal Dutch Shell plc either directly or indirectly has control. Companies over which Shell has joint control are generally referred to "joint ventures" and companies over which Shell has significant influence but neither control nor joint control are referred to as "associates". In this presentation, joint ventures and associates may also be referred to as "equity-accounted investments". The term "Shell interest" is used for convenience to indicate the direct and/or indirect (for example, through our 23% shareholding in Woodside Petroleum Ltd.) ownership interest held by Shell in a venture, partnership or company, after exclusion of all third-party interest.

This presentation contains forward-looking statements concerning the financial condition, results of operations and businesses of Royal Dutch Shell. All statements other than statements of historical fact are, or may be deemed to be, forward-looking statements. Forward-looking statements are statements of future expectations that are based on management's current expectations and assumptions and involve known and unknown risks and uncertainties that could cause actual results, performance or events to differ materially from those expressed or implied in these statements. Forward-looking statements include, among other things, statements concerning the potential exposure of Royal Dutch Shell to market risks and statements expressing management's expectations, beliefs, estimates, forecasts, projections and assumptions. These forward-looking statements are identified by their use of terms and phrases such as "anticipate", "believe", "could", "estimate", "expect", "goals", "intend", "may", "objectives", "outlook", "plan", "probably", "project", "risks", "schedule", "seek", "should", "target", "will" and similar terms and phrases. There are a number of factors that could affect the future operations of Royal Dutch Shell and could cause those results to differ materially from those expressed in the forward-looking statements included in this presentation, including (without limitation): (a) price fluctuations in crude oil and natural gas; (b) changes in demand for Shell's products; (c) currency fluctuations; (d) drilling and production results; (e) reserves estimates; (f) loss of market share and industry competition; (g) environmental and physical risks; (h) risks associated with the identification of suitable potential acquisition properties and targets, and successful negotiation and completion of such transactions; (i) the risk of doing business in developing countries and countries subject to international sanctions; (j) legislative, fiscal and regulatory developments including regulatory measures addressing climate change; (k) economic and financial market conditions in various countries and regions; (l) political risks, including the risks of expropriation and renegotiation of the terms of contracts with governmental entities, delays or advancements in the approval of projects and delays in the reimbursement for shared costs; and (m) changes in trading conditions. All forward-looking statements contained in this presentation are expressly qualified in their entirety by the cautionary statements contained or referred to in this section. Readers should not place undue reliance on forward-looking statements. Additional risk factors that may affect future results are contained in Royal Dutch Shell's 20-F for the year ended December 31, 2012 (available at www.shell.com/investor and www.sec.gov). These risk factors also expressly qualify all forward looking statements contained in this presentation and should be considered by the reader. Each forward-looking statement speaks only as of the date of this presentation, 20-November-2014. Neither Royal Dutch Shell plc nor any of its subsidiaries undertake any obligation to publicly update or revise any forward-looking statement as a result of new information, future events or other information. In light of these risks, results could differ materially from those stated, implied or inferred from the forward-looking statements contained in this presentation.

We may have used certain terms, such as resources, in this presentation that United States Securities and Exchange Commission (SEC) strictly prohibits us from including in our filings with the SEC. U.S. Investors are urged to consider closely the disclosure in our Form 20-F, File No 1-32575, available on the SEC website www.sec.gov. You can also obtain these forms from the SEC by calling 1-800-SEC-0330.

6 'MUST DO' ACTIONS TO AVOID EXCEEDING 2°C



Being good at 4 or 5 categories is <u>not</u> good enough

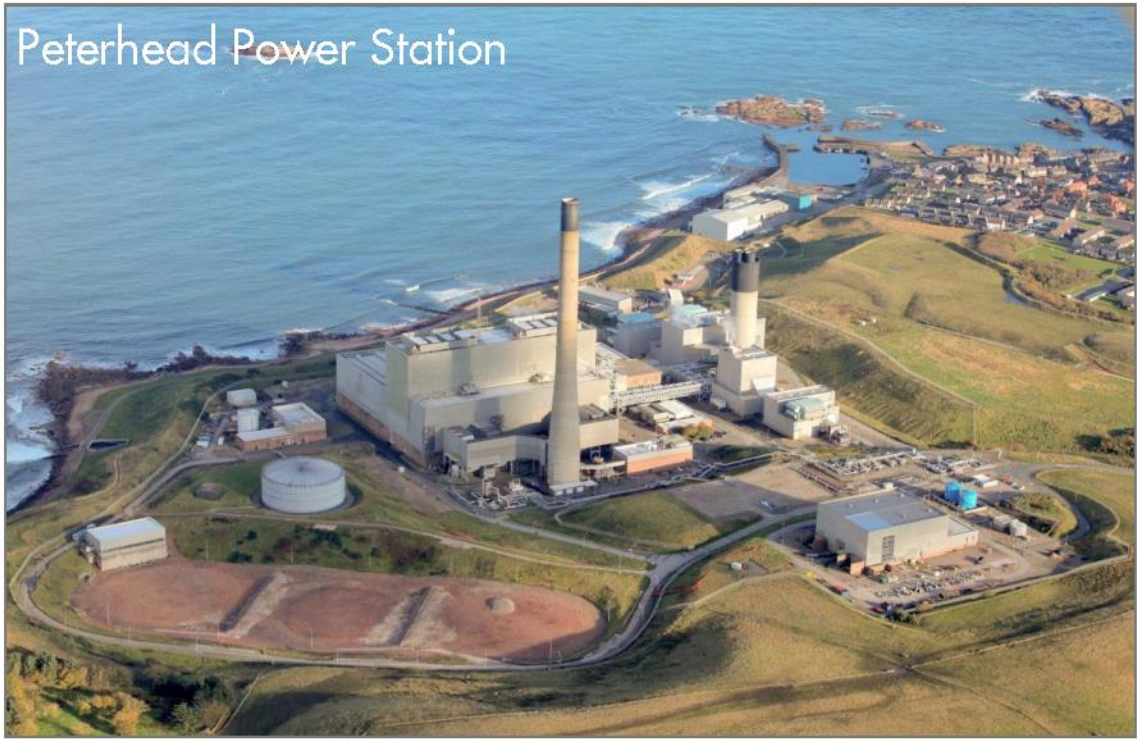
http://www.theboardgamefamily.com/2014/01/trivial-pursuit-leave-box/

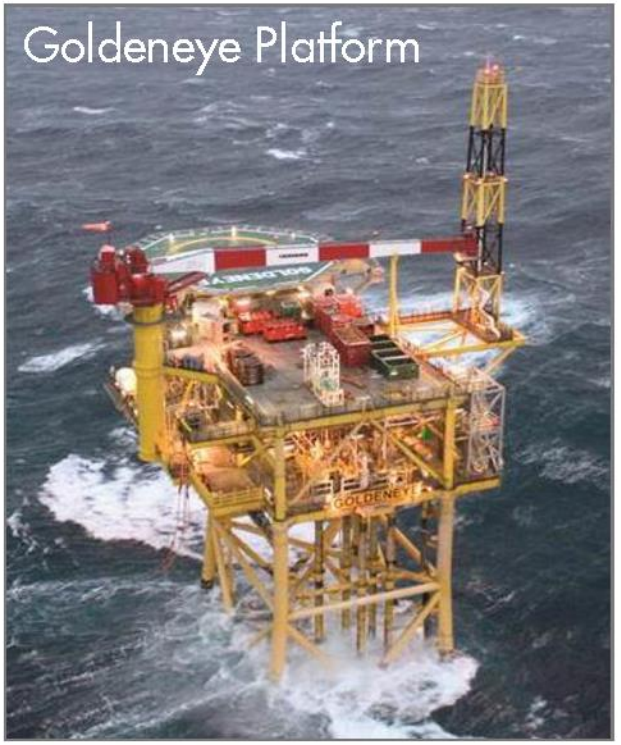
1. PETERHEAD CCS OVERVIEW
2. GOOD FOR GOVERNMENT, SHELL, COMMUNITY
3. ENABLING CCS
4. MAKING CCS VIABLE

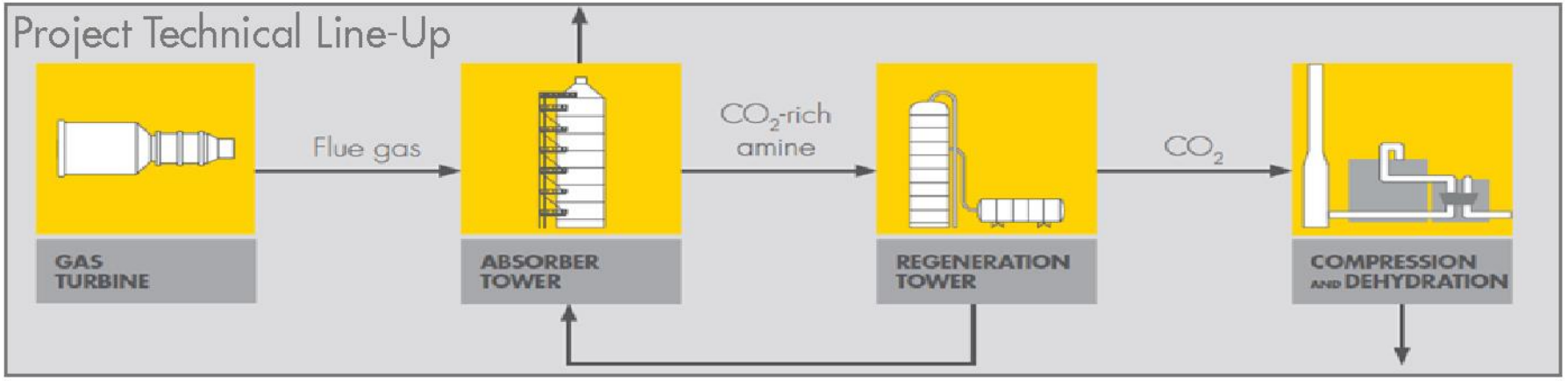
PETERHEAD AT A GLANCE

- **World First** – first full-scale CCS project on a gas-based power station
- **Where** – capture at Peterhead Power Station; storage in depleted Goldeneye gas reservoir (100 KM offshore)
- **Impact** –10 million tonnes of CO_2 captured over a ten-year period (90% CO_2 capture from one turbine)
- **Funding** – UK Government support for both capital & operating expenses
- **Technology** – post-combustion capture using amines

RETROFIT CCS TO GAS FIRED POWER







CLEAN ELECTRICITY TO 500,000 HOMES

http://www.vacation-rentals.com/blog/2013/01/18/top-10-beautiful-places-you-should-visit-in-edinburgh,-scotland/

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IT IS GOOD FOR THE UNITED KINGDOM

Prize for Britain

32 Billion

£/Annum

Without CCS, the additional costs to run a decarbonised UK economy in 2050 will be £32Billion.

UK Energies Technology Institute

Government Objective

... by the 2020's, private sector electricity companies can take investment decisions to build CCS equipped fossil fuel electricity generation facilities without Government capital subsidy at an agreed contract for difference strike price that is competitive with the strike price for other low carbon generation technologies"

IT IS GOOD FOR THE UNITED KINGDOM

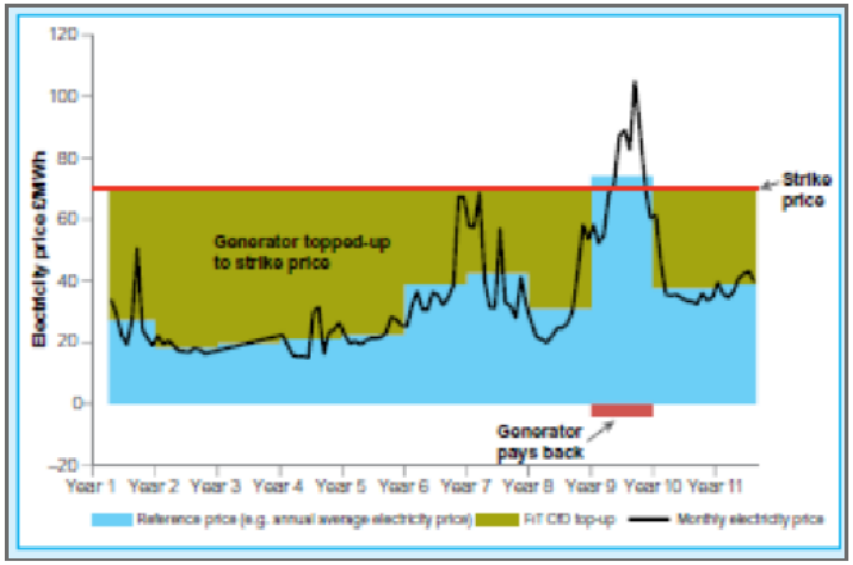
Prize for Competitors & Competition History

Prize – DECC grants £1 billion capital to project(s)

History

- July 2012 – Eight initial bids
- October 2012 – DECC select four bidders
- January 2013 – Bid Improvement
- 20 March 2013 – DECC announce Peterhead & White Rose as preferred bidders..
- 24 February 2014 – FEED contract signed

Contract for Difference



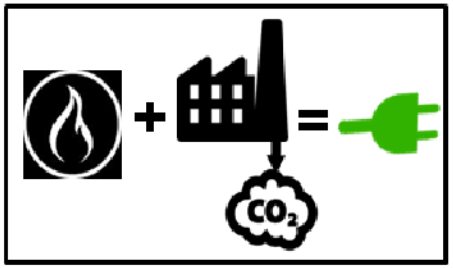
- Mechanism to guarantee a pre-defined price per MWh which the Generator will receive for its clean electricity ("Strike Price")

IT IS GOOD FOR SHELL

Facility Re-Use

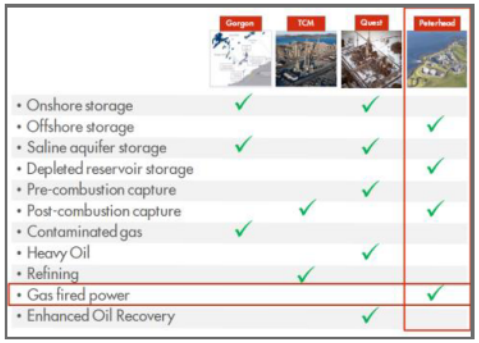
- The recently depleted Goldeneye reservoir has more than sufficient capacity for the project
- The existing wells are relatively new (<10yrs) and in good condition
- Pipelines are recent and in good condition.

Natural Gas



- Gas is crucial for the transformation of the energy system in the short and long term

CCS Competence



Peterhead CCS– key to Shell's competence development programme

- Offshore Storage
- Depleted Reservoir
- Post Combustion Capture
- Gas+CCS

The Carbon Bubble

- Shareholders and analysts question whether our planet can really accommodate all the CO_2 related to fossil fuel providers and have coined the term 'Carbon Bubble'
- CCS operating at scale is an important proof point

THE LOCAL COMMUNITIES

COMMUNITY BENEFITS

Power Station Life

Construction Jobs

Operations Jobs

Future Industry Hub

PETERHEAD COMMUNITY

1. PETERHEAD CCS OVERVIEW
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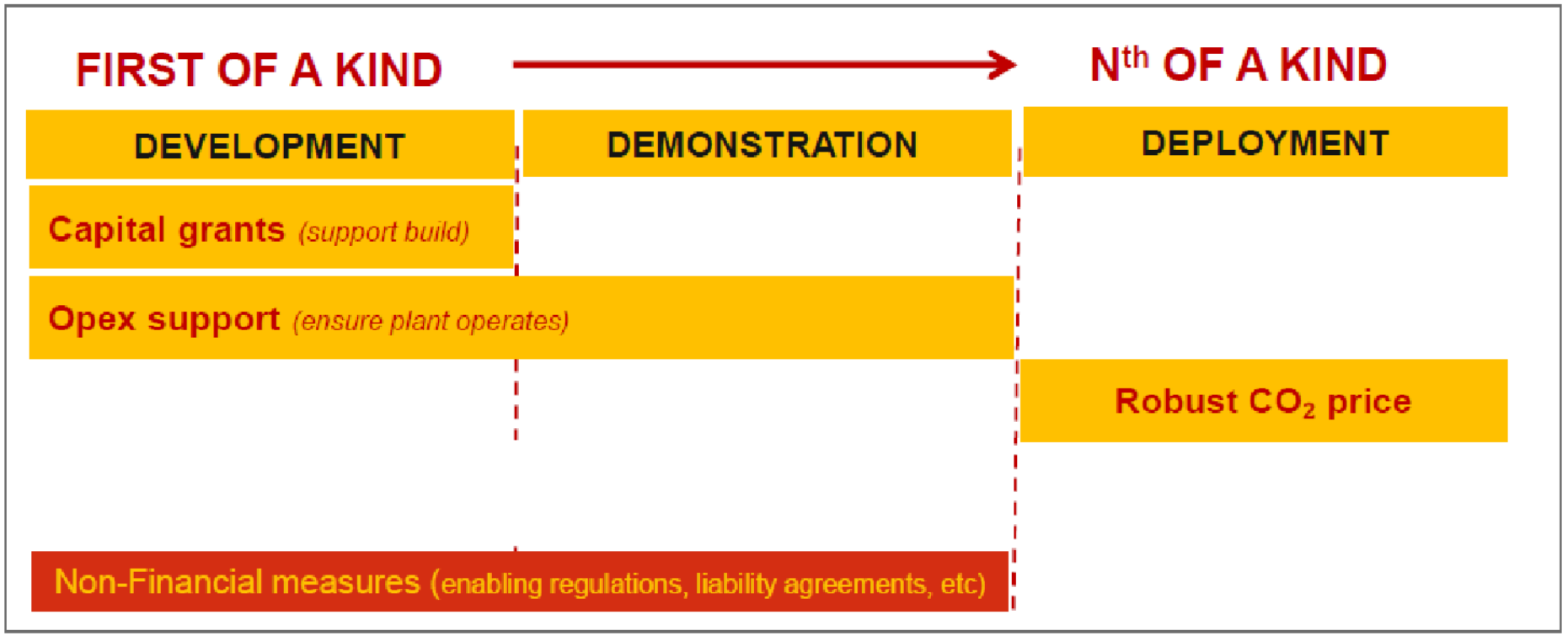
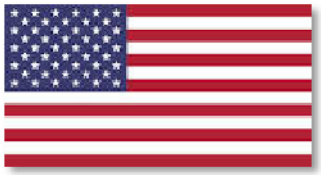
4. MAKING CCS VIABLE

FUNDING CCS DEMONSTRATION



Capex – CCS Competition

Opex – Contract for Differences



Capex – DOE Support

Opex – CO_2 EOR Use

Capex – NER300/ NER400

Opex – CO_2 Price

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PETERHEAD – A TRUE FIRST OF A KIND

1 of a Kind

1st of a kind

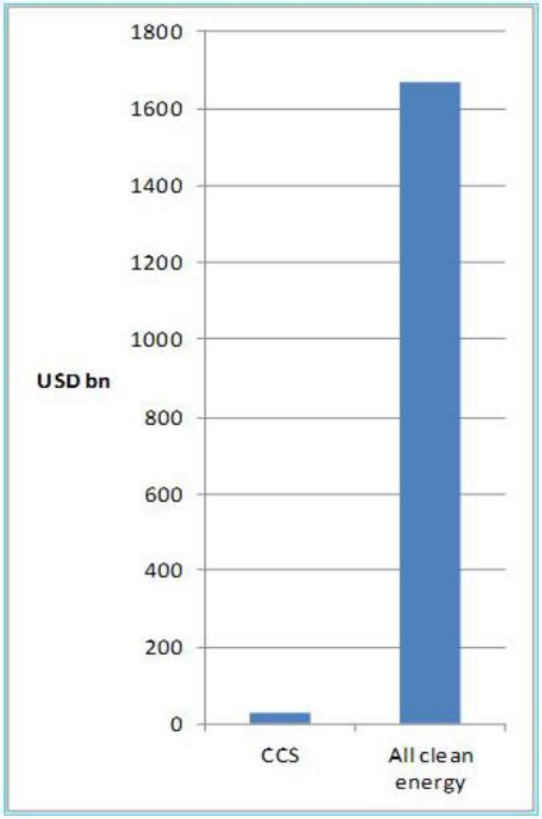
LOW CARBON ENERGY SPEND

Carbon capture and storage

International Energy Agency

Low-carbon & CCS investment to date

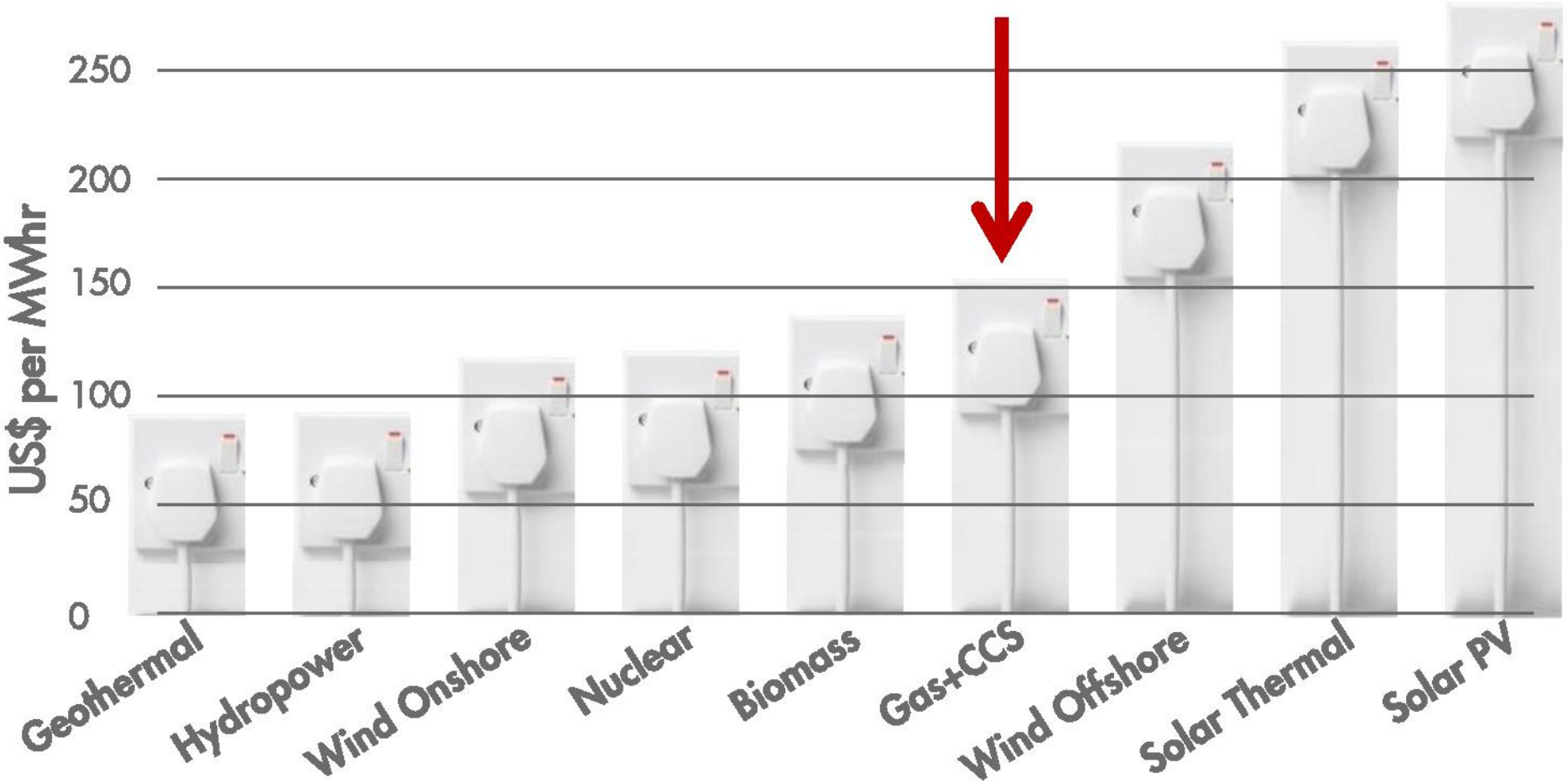
- Investment in CCS 2004-2012: USD**20**bn
- Investment in all clean energy in 2004-2012: USD**1670**bn



DEMONSTRATION PROJECTS – LEARNING CURVES

Credit; http://itsasmallweb.files.wordpress.com/2011/02/3.jpg

GAS + CCS – COMPETITIVE LOW CARBON ENERGY

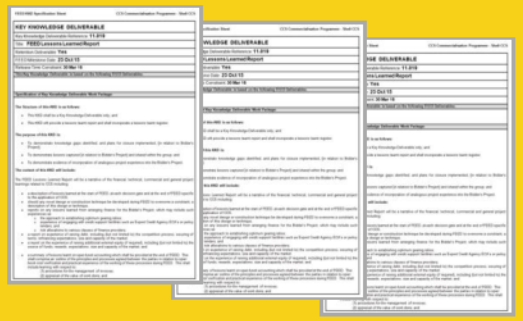


*Levelised cost of electricity of low-carbon technologies and conventional power generation – as presented in 'The costs of CCS and other low-carbon technologies' Global CCS Institute.

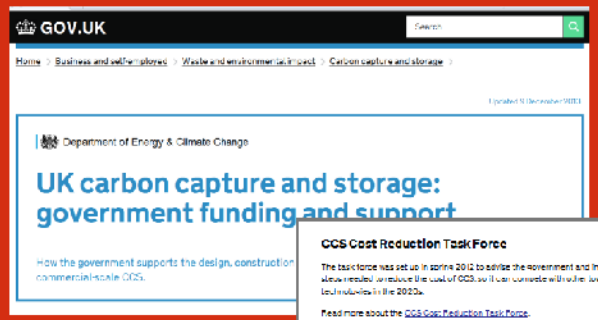
PETERHEAD KNOWLEDGE SHARING

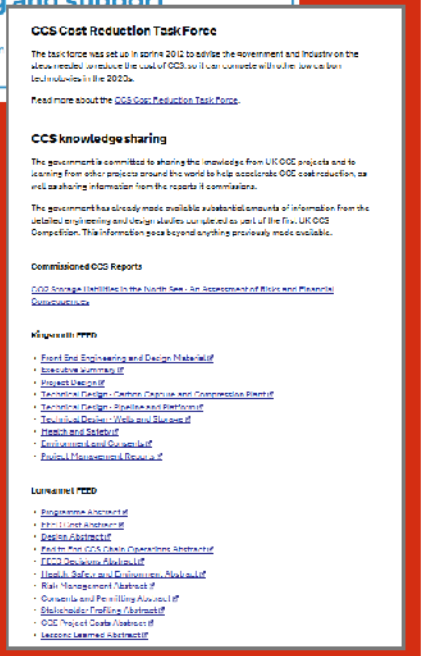
Knowledge Transfer Obligations

- Committed to providing 45 Key Knowledge Deliverables for public dissemination.
- These deliverables cover key project aspects such as Engineering, Subsurface, Commercial, and HSE.
- The deliverable content has been agreed in FEED negotiations between Shell and DECC.
- A specification sheet is provided for each deliverable describing the agreed content.
- Shell have a dedicated resource and process to manage the dissemination of these Key Knowledge Deliverables



DECC Knowledge Sharing Site





Public access to (non commercially sensitive) knowledge & information derived from the projects


IMAGINE CAPTURING THIS MUCH CO_2 EVERY HOUR
Find out how Shell plans to capture CO_2 at shell.co.uk/peterheadccs
LET'S GO

Thank you

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making a clean future real

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20 November 2014

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