Reducing Greenhouse Gas (GHG) Emissions - The Path Forward in the Near Term to Meet Global GHG Emission Reduction Goals...and Enhance U.S. Energy Security

Presentation by Edward L. Helminski, President and Publisher of ExchangeMonitor

Publications & Forums, Inc.

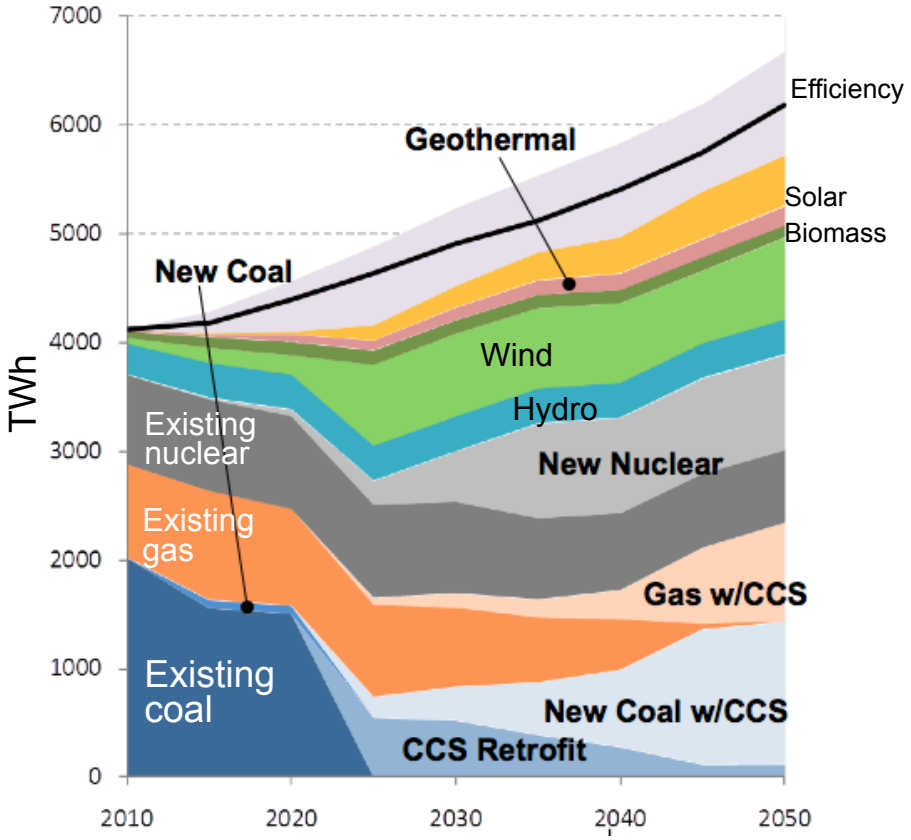
- ***at the Metro New York Section, AIChE's Seventh Annual Energy & Resources Conference - Thursday, May 30th, 2013 Con Edison Building, New York, NY***

Sooner or later…

…we will have to get serious about limiting CO_2 emissions. Doing that will take "everything we've got," including a significant amount of CCS.

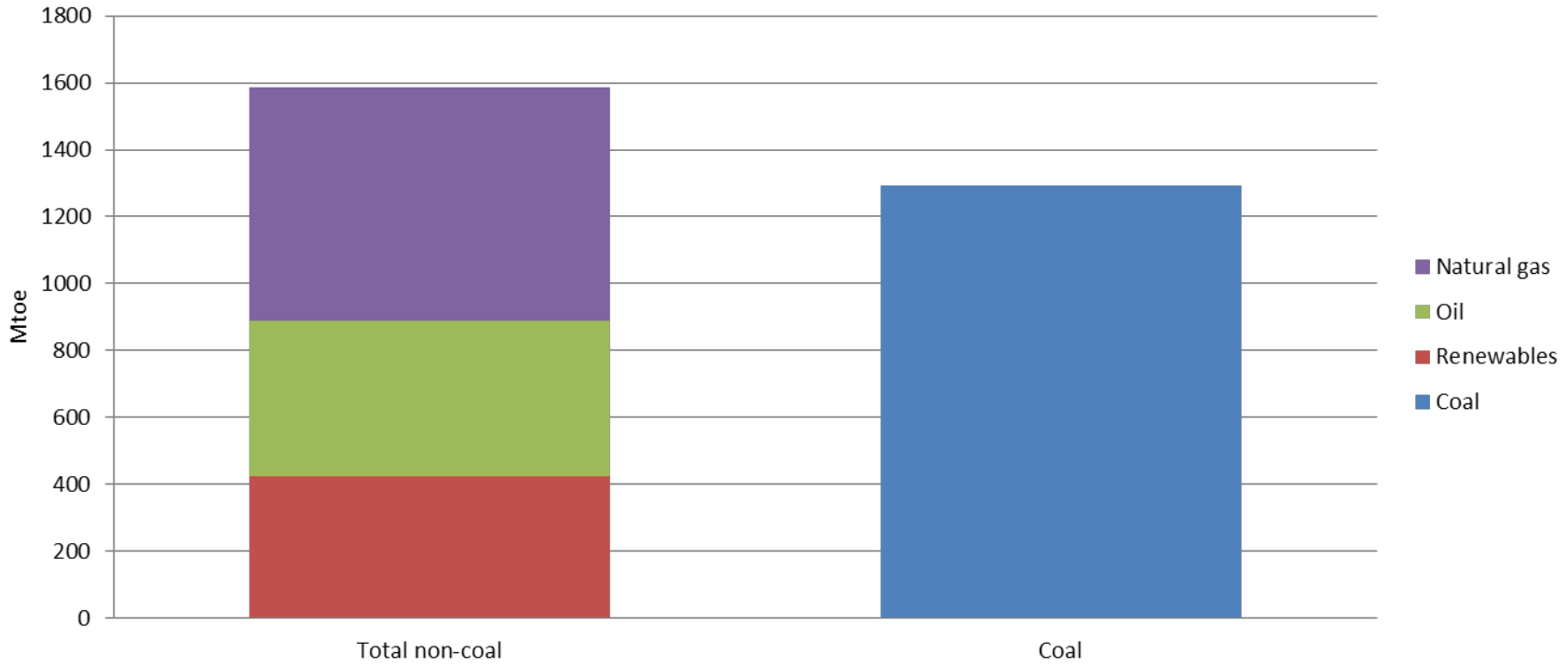
Here, for example, is one EPRI scenario.

You don't have to buy the details. The point is that virtually every scenario to decarbonize the energy system, in a cost effective way, requires CCS.



Source: http://mydocs.epri.com/docs/Environment/electric-utilities-environmental-conference/EUEC_2012_Hannegan_2012-01-31.pdf

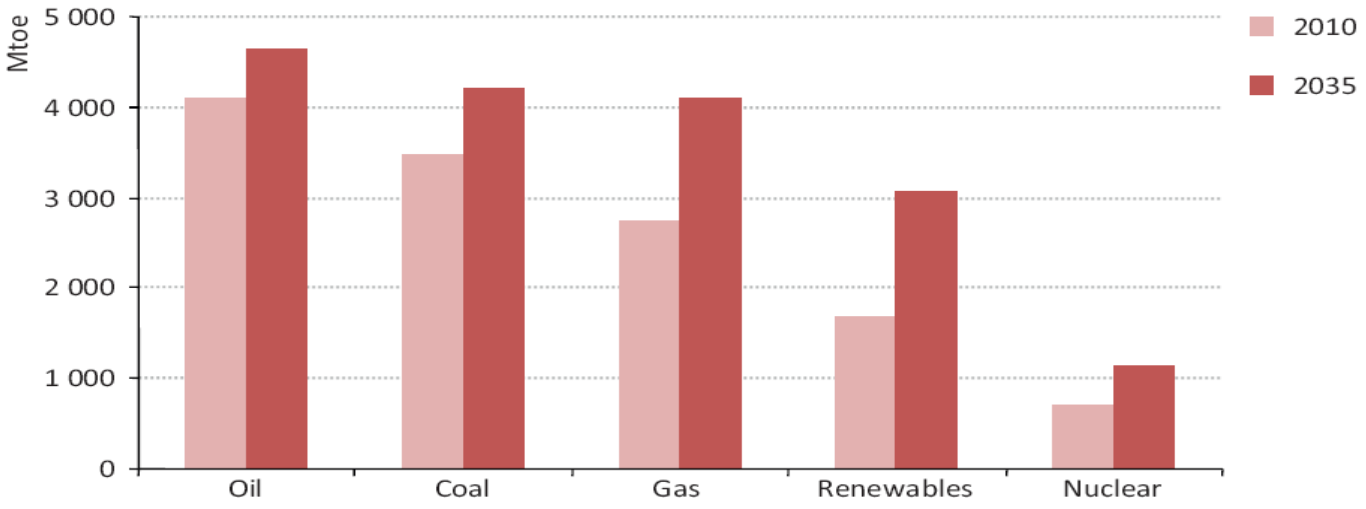
Fossil fuels in the energy mix: the past



Incremental world primary energy demand – by fuel, 2001 to 2011

Source: IEA WEO 2012

Fossil fuels in the energy mix: the future

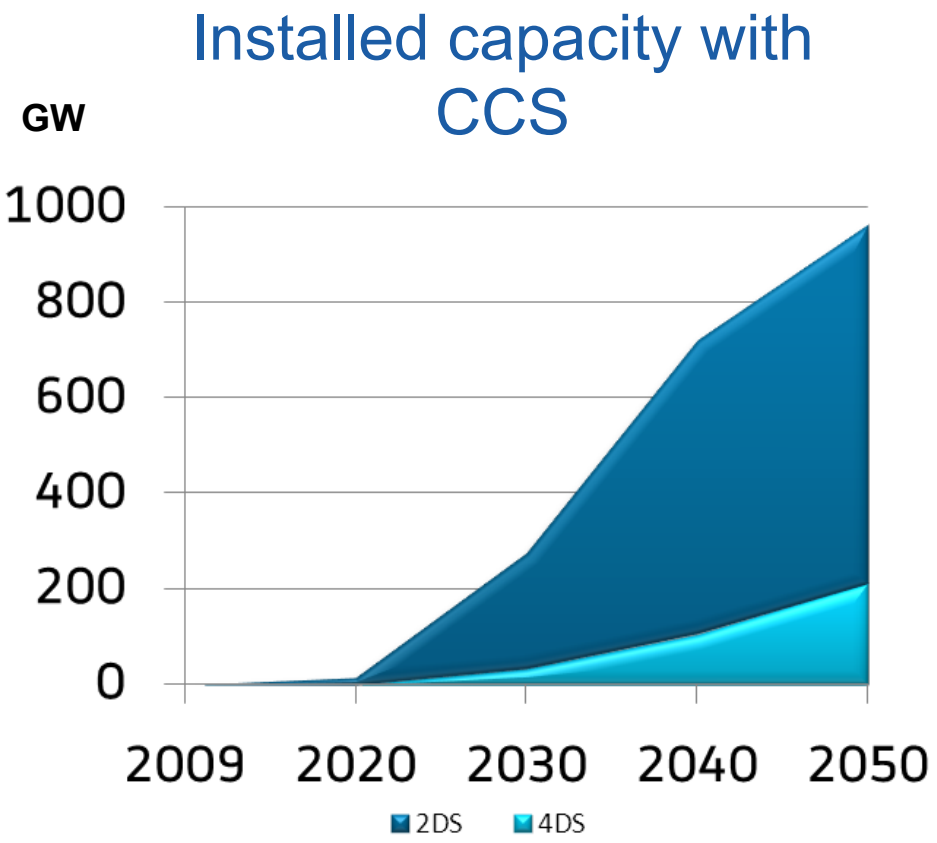


Source: IEA WEO 2012 – New Policies Scenario

CCS in Power

- For all fossil fuels, CCS must be applied by around 2030 in order to reach the de-carbonisation targets.
- Gas may become a low carbon technology, but without CCS, gas may be limited to a backup and balancing capacity where renewable energy supplies are variable.

CCS is essential alongside renewables – A reminder

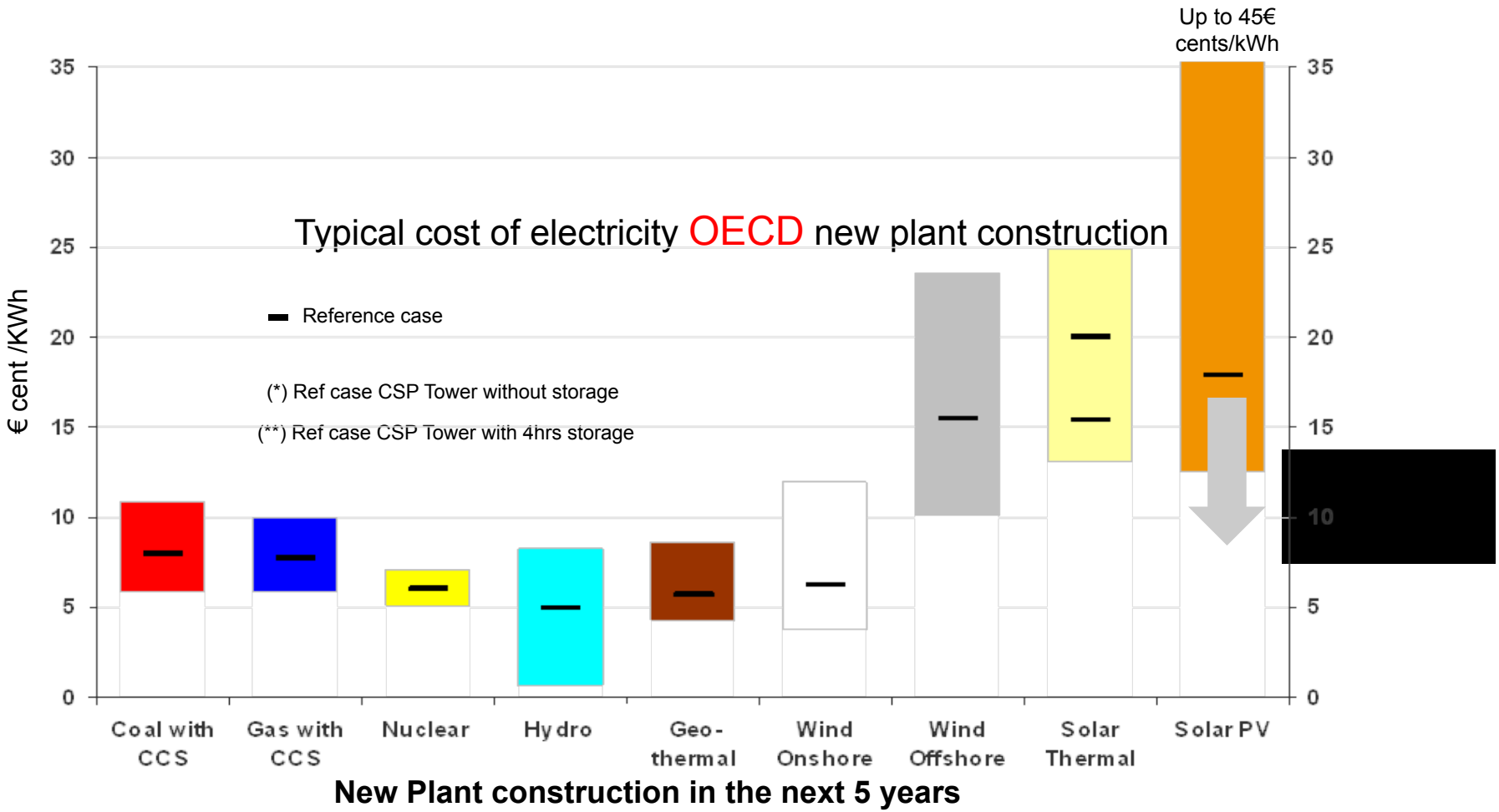


Data from © OECD/IEA, Energy technology Perspectives 2012

- 2/3 of global power from fossil fuels in 2035
- Emissions reductions from:
  - Efficiency increase
  - Increase in Renewables
  - **Huge investments in CCS**
- **Without CCS => 40% more expensive** (*)
- CCS alone can massively reduce **CO2 emissions**
- Also a key option for **Industry** (Cement, I&S, refineries, etc)

(*) IEA – 2 °C Scenario

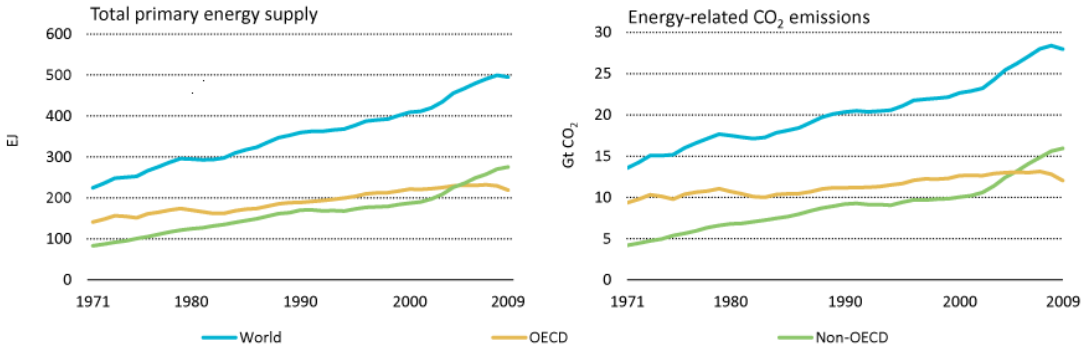
CCS will be a competitive low carbon solution



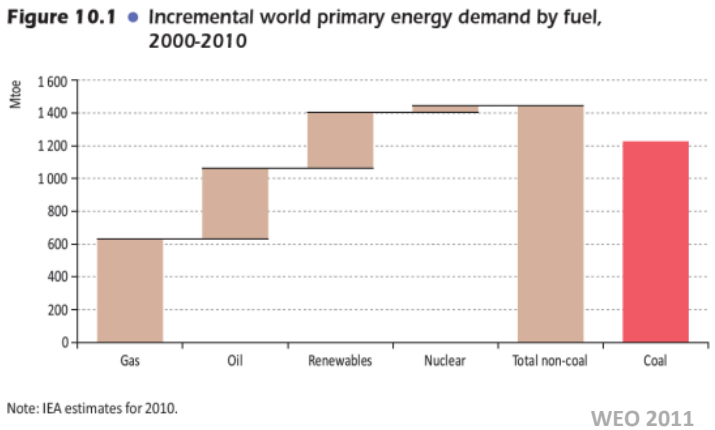
Source : Alstom analysis 2012. CCS w Post amine 2017 costs, including on shore T&S & CO_2 price (Flue Gas Recirculation for CCS Gas CC)
CoE do not include “externalities” of Intermittent power (Back-up cost, balancing cost, grid enhancement if required)
OECD includes Europe and NAM

Advancing CCS remains critically important

1. **Energy-related CO_2 emissions have doubled in the past 40 years**

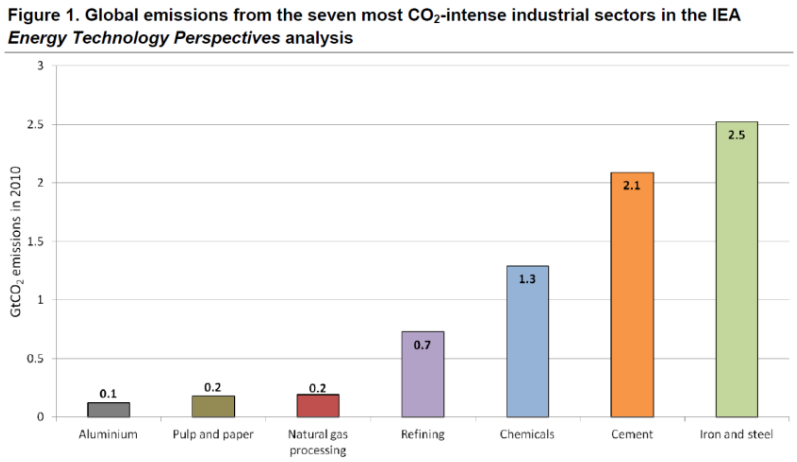


2. **Fossil fuels accounted for 85% of all incremental energy demand in the last decade**

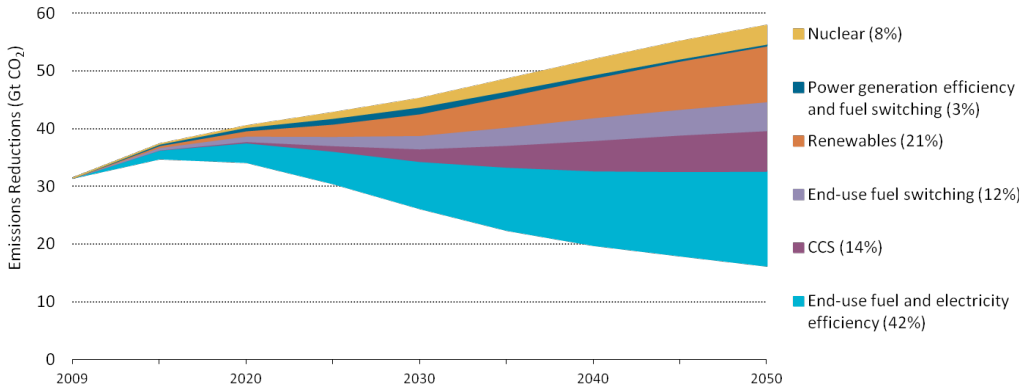


Advancing CCS remains critically important

3. **CCS is the only option for many energy-intensive industries**

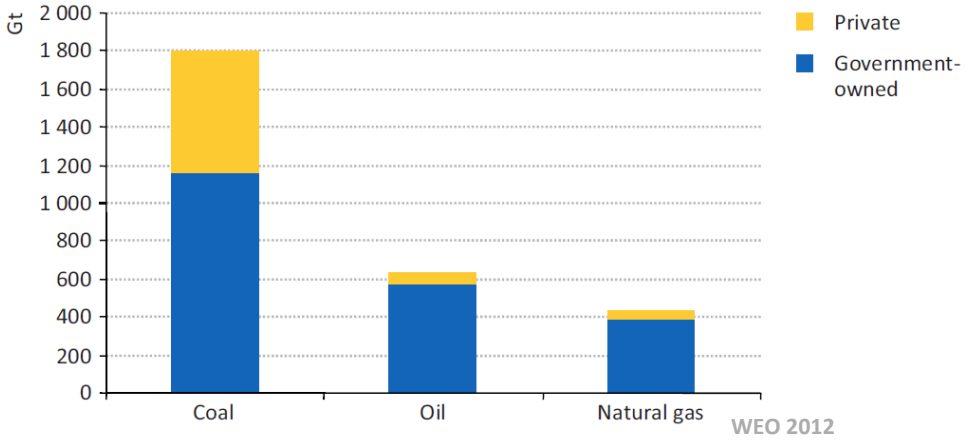


4. **CCS is part of a cost-effective portfolio of technologies in any ambitious scenario**



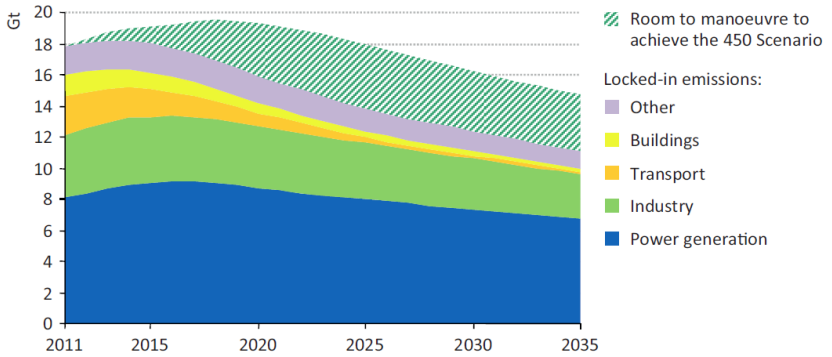
Advancing CCS remains critically important

5. **CCS can help preserve an economic value of fossil fuel reserves**



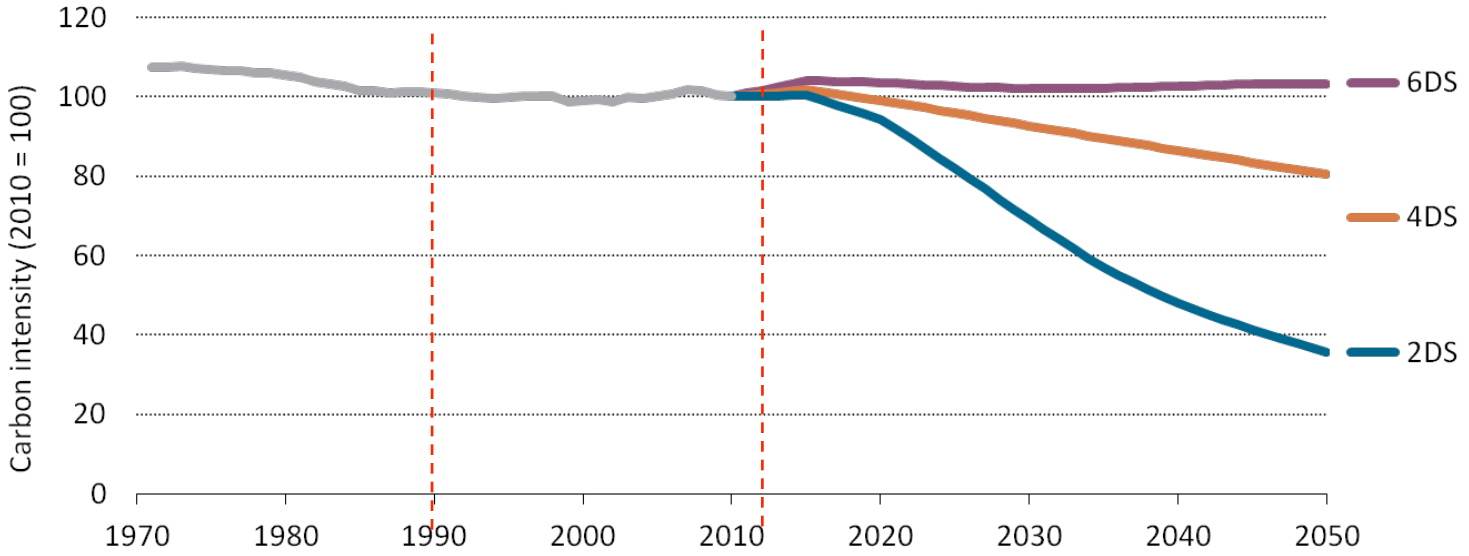
6. **CCS can help "unlock" emissions already locked in**

Figure 8.14 ▷ Energy-related CO_2 emissions from locked-in infrastructure in 2011 and in the 450 Scenario in non-OECD countries



Advancing CCS remains critically important

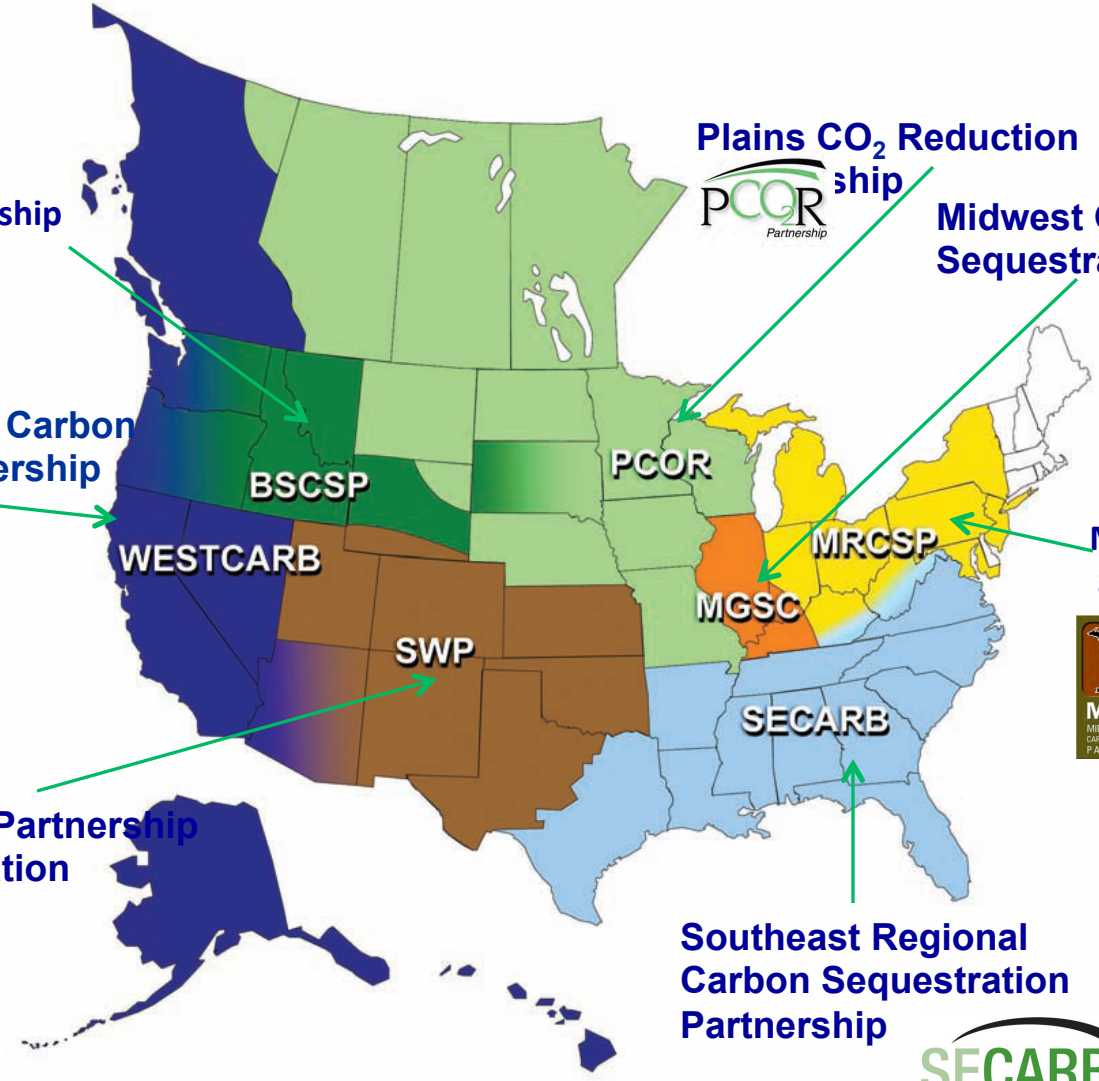
7. **Global energy supply is as carbon-intensive today as it was in 1990**



IEA Energy Sector Carbon Intensity Index, ESCII

Regional Carbon Sequestration Partnerships

Developing the Infrastructure for Wide Scale Deployment



Big Sky Carbon Sequestration Partnership

Plains CO_2 Reduction Partnership

Midwest Geological Sequestration Consortium

West Coast Regional Carbon Sequestration Partnership

Midwest Regional Carbon Sequestration Partnership

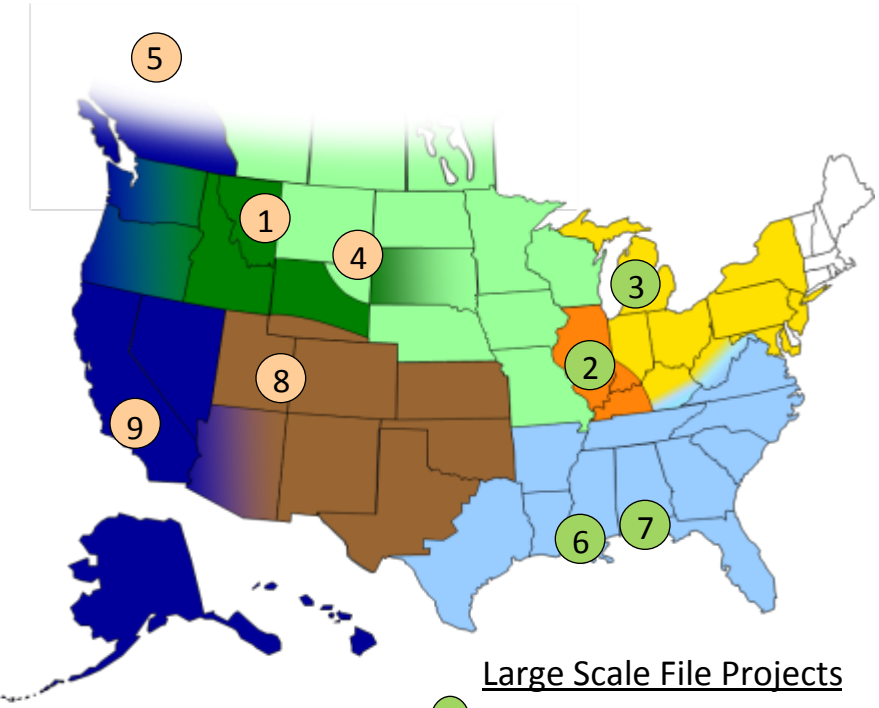
Southwest Regional Partnership on Carbon Sequestration

Southeast Regional Carbon Sequestration Partnership

Seven Regional Partnerships *- 400+ distinct organizations, 43 states, 4 Canadian Provinces*

Regional Carbon Sequestration Partnerships

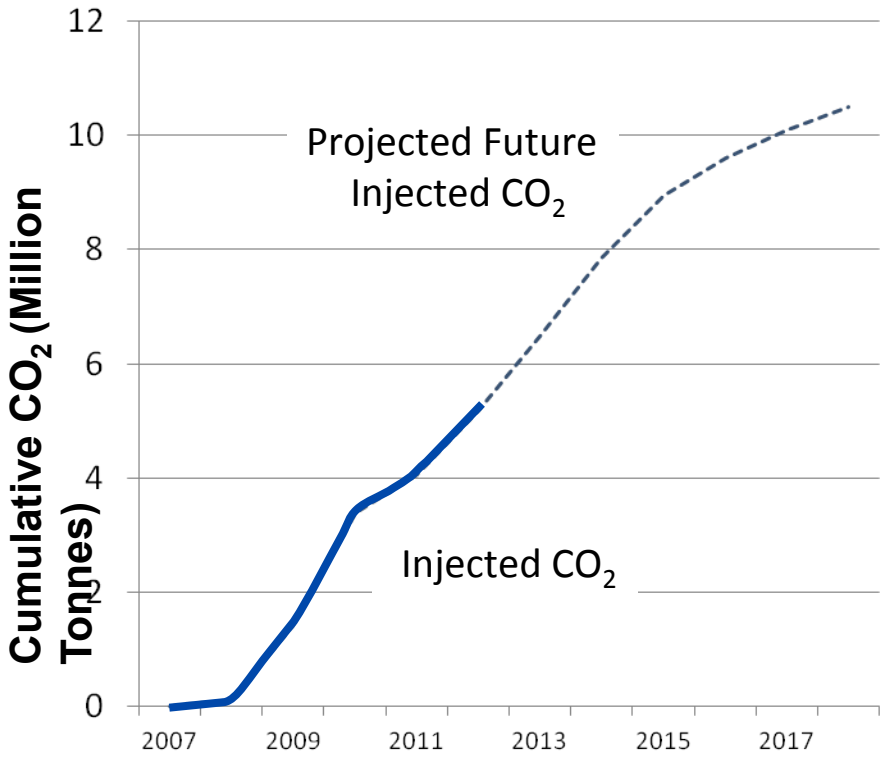
Validating CCS through Small- and Large-Scale Injections



Large Scale File Projects

Injection Ongoing

2013/2014 Injection Scheduled



BIG SKY CARBON SEQUESTRATION PARTNERSHIP

MGSC

MRCSP MIDWEST REGIONAL CARBON SEQUESTRATION PARTNERSHIP

PCOR Partnership

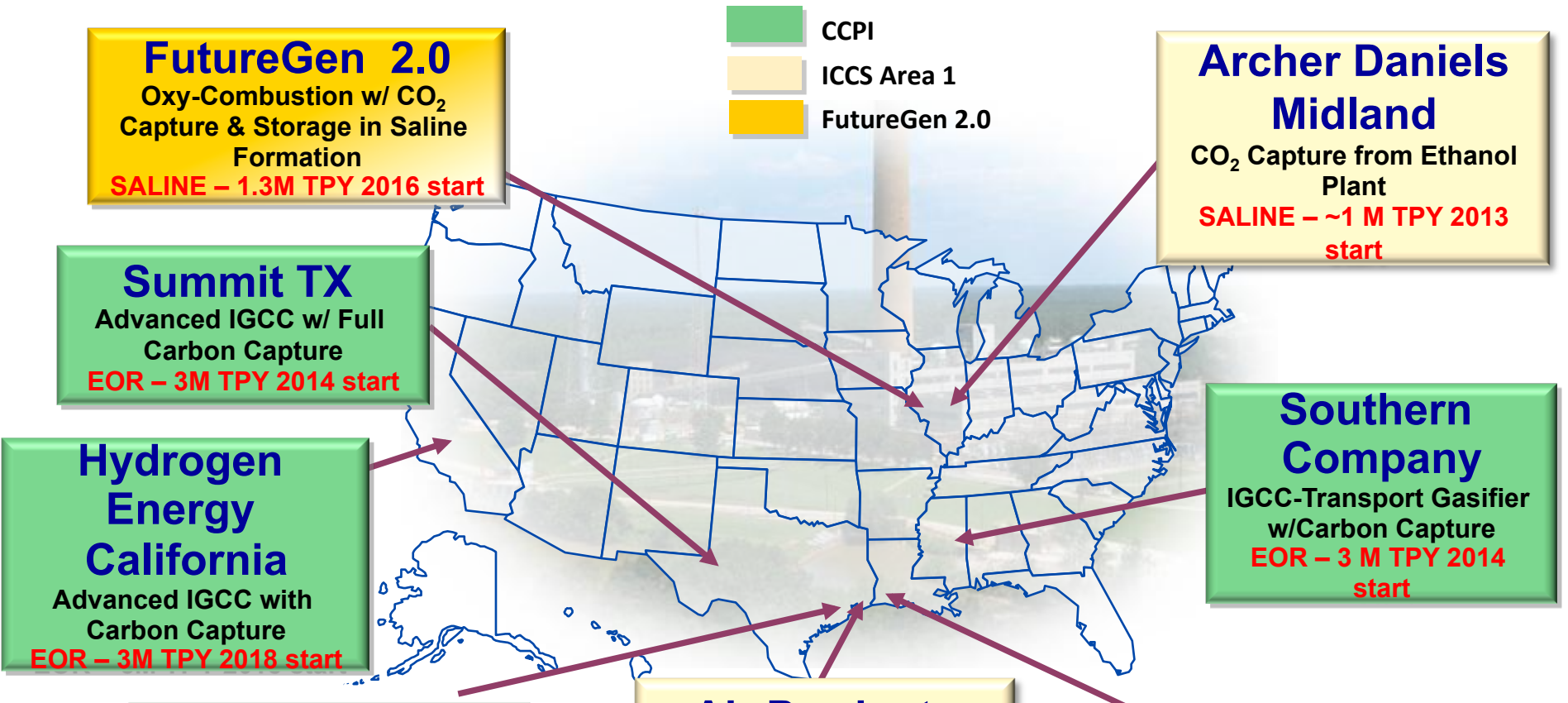
SECARB

SWP

WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP westcarb.org

Major U.S. Demonstrations

Using Existing Infrastructure, Creating New Markets



FutureGen 2.0
Oxy-Combustion w/ CO_2 Capture & Storage in Saline Formation
SALINE – 1.3M TPY 2016 start

Archer Daniels Midland
CO_2 Capture from Ethanol Plant
SALINE – ~1 M TPY 2013 start

Summit TX
Advanced IGCC w/ Full Carbon Capture
EOR – 3M TPY 2014 start

Hydrogen Energy California
Advanced IGCC with Carbon Capture
EOR – 3M TPY 2018 start

Southern Company
IGCC-Transport Gasifier w/Carbon Capture
EOR – 3 M TPY 2014 start

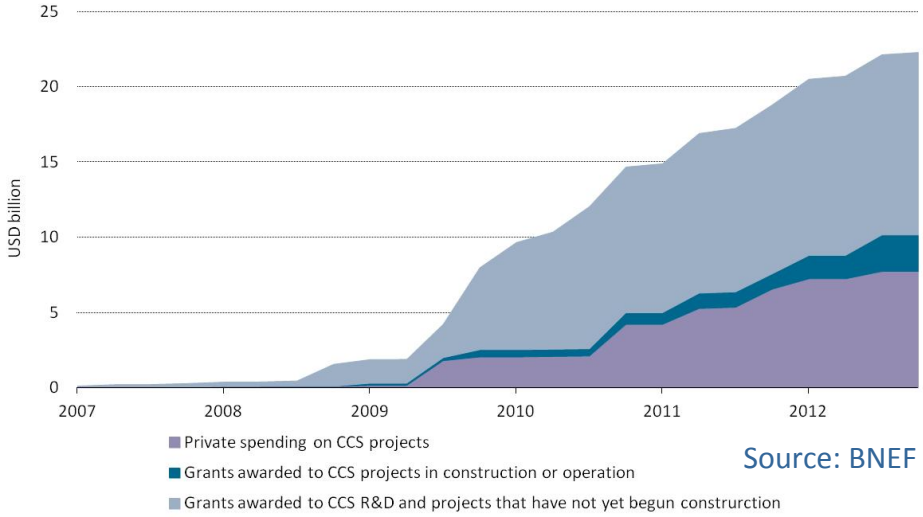
NRG
W.A. Parish Generating Station
Post Combustion CO_2 Capture
EOR – 1.4M TPY 2014 start

Air Products and Chemicals
CO_2 Capture from Steam Methane Reformers
EOR – 1M TPY 2013 start

Leucadia Energy
CO_2 Capture from Methanol Plant
EOR – 4.5 M TPY 2015 start

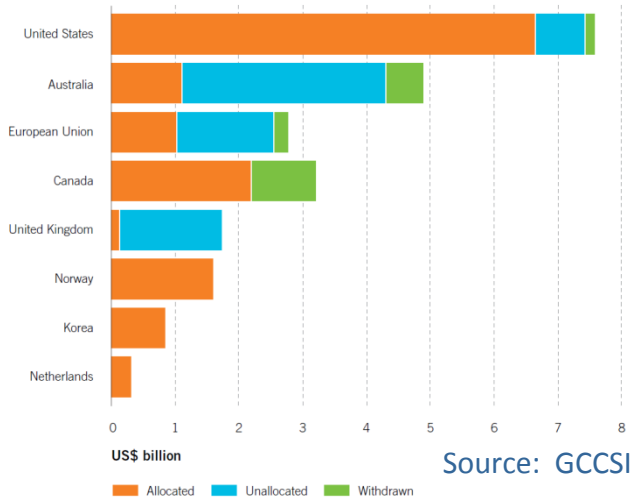
Inputs into CCS are not negligible...

Money spent on CCS projects globally



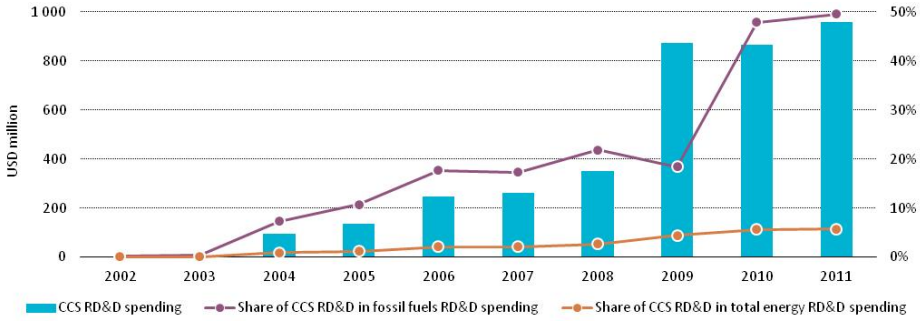
Source: BNEF

Government pledges for CCS support



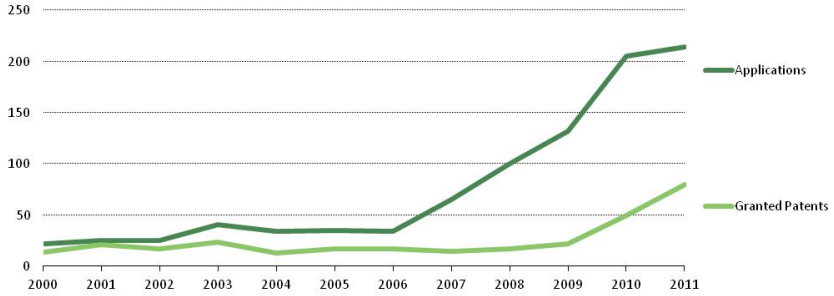
Source: GCCSI

R&D spending on CCS technologies by IEA countries



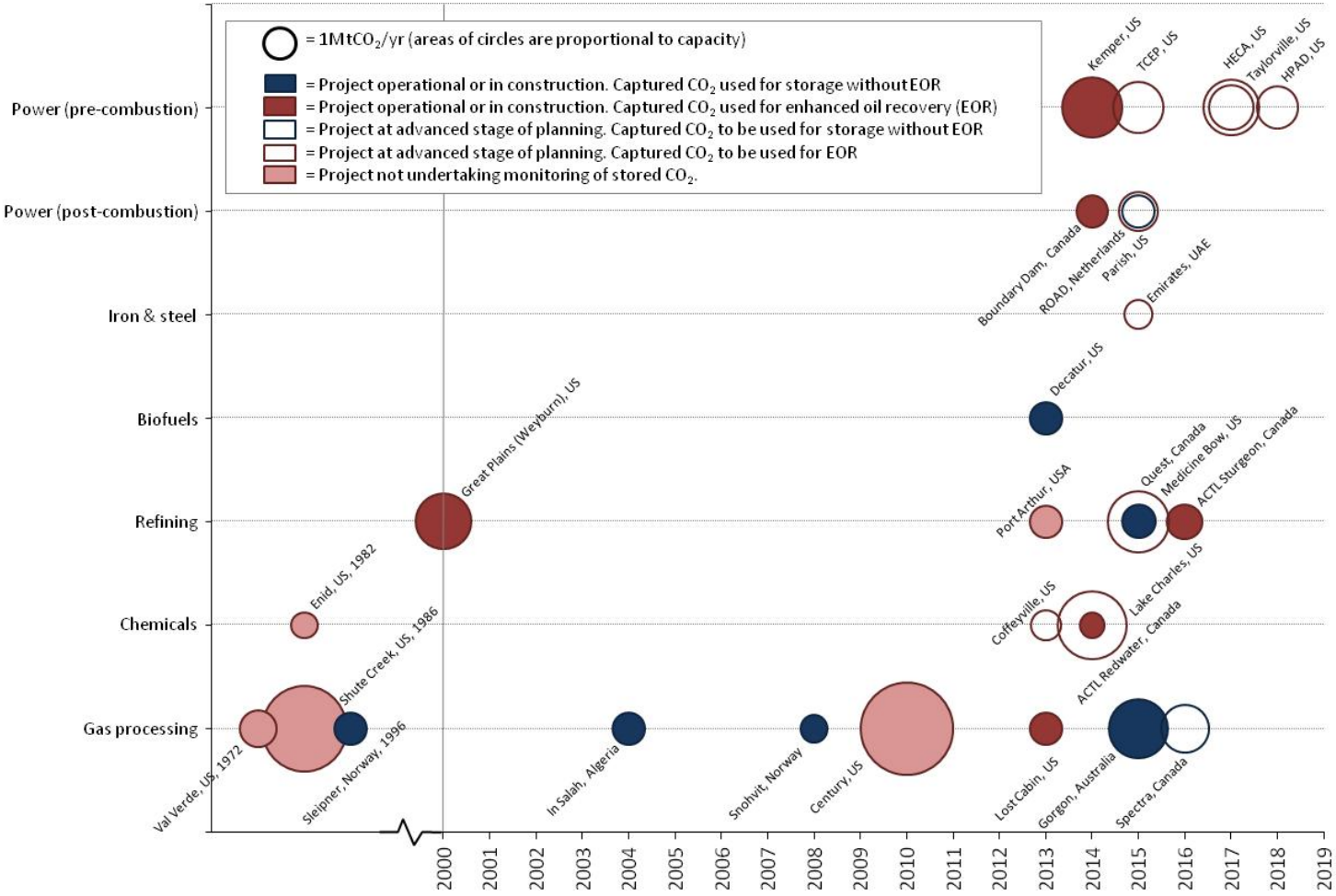
Source: IEA

Numbers of CCS-related patents



Source: IEA

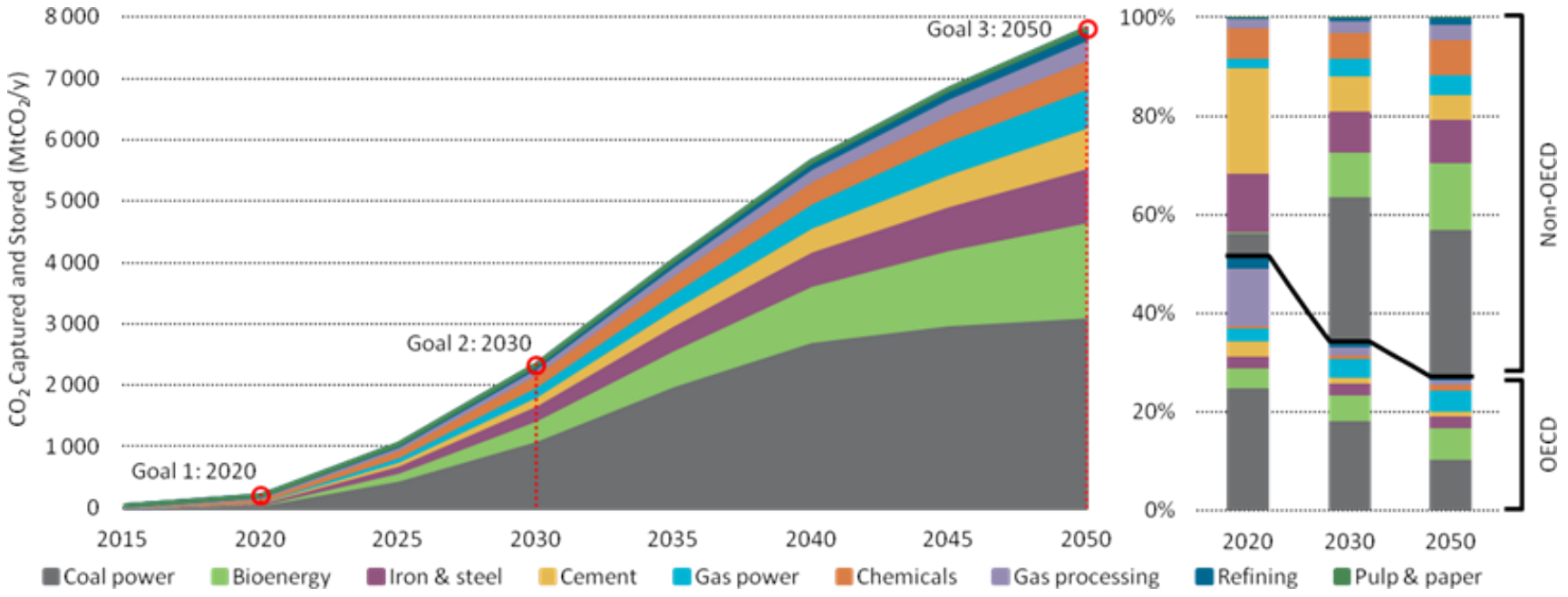
CCS *is* making progress



Source: GCCSI, BNEF

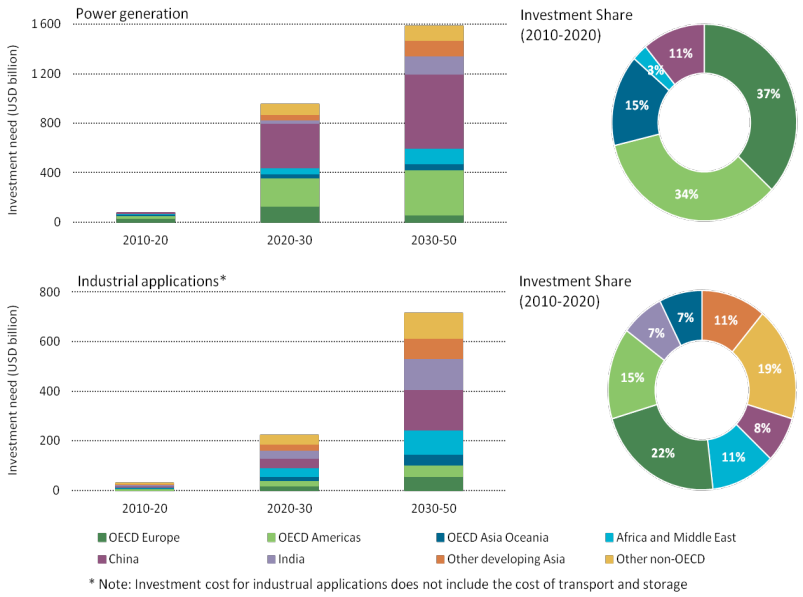
Projects in “execute” and “define” phases according to GCCSI criteria.

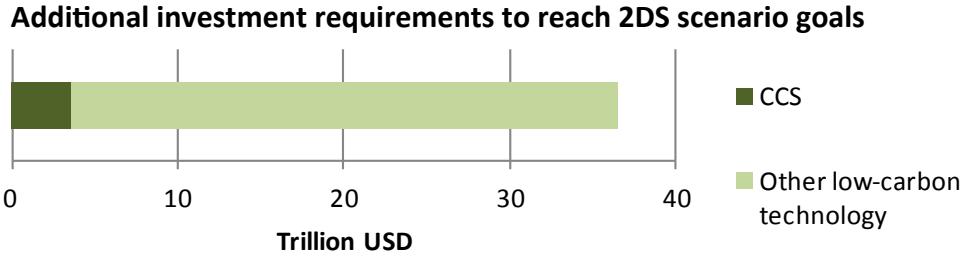
By 2050: 120Gt of CO_2 safely stored



- **<u>2020:</u> Several dozen** large-scale projects in coal and gas power and 1st phase industry
- **<u>2030:</u>** > **2000Mt** CO_2 stored pa; CCS routinely used in power and industry; ready for deployment in 2nd phase industry
- **<u>2050</u>**: > **7000Mt** CO_2 stored pa; CCS **routinely used** in all applicable power and industry

Total investment in CCS: 3.6 trillion USD



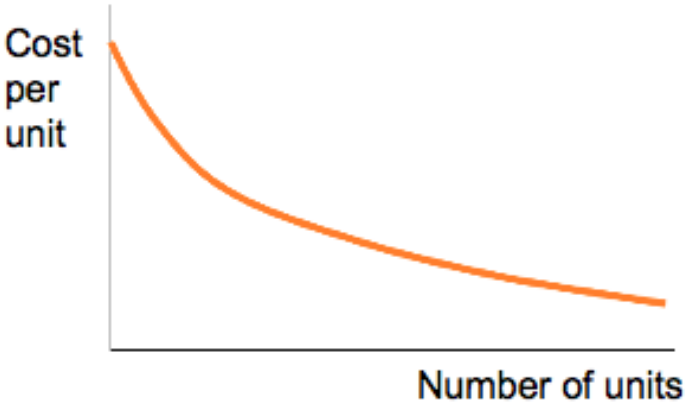


- 2013-2020: **USD 100 bn**
- 2020-2050: **USD 3,5 trn**
- Economic benefit: if CCS removed from portfolio, investment cost in the power sector increases by 40% until 2050

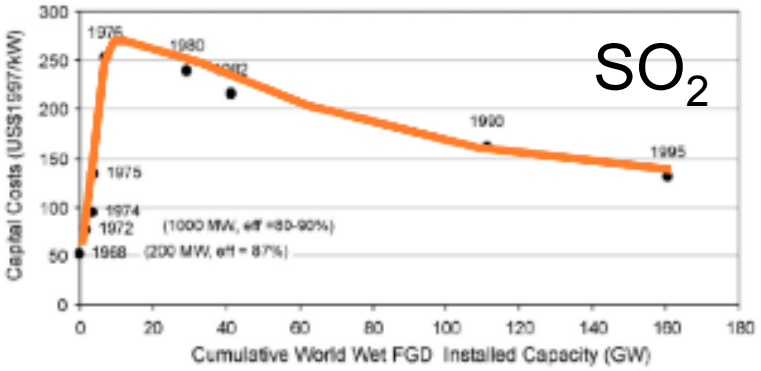
- Note: investment needs in other low-carbon energies are equally significant

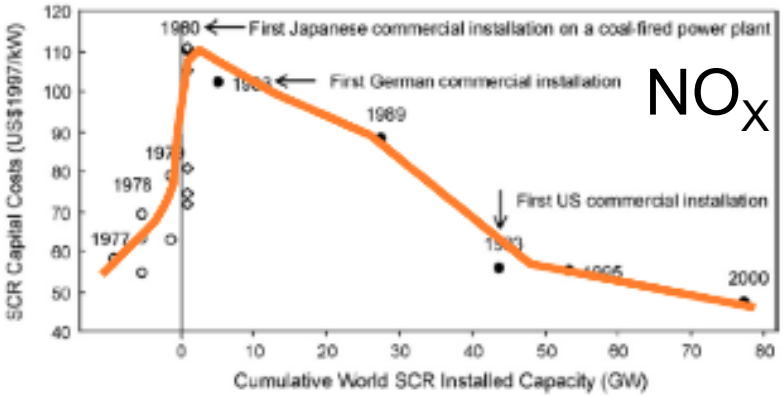
But, developing CCS will take time and money

We expect learning curves to look like this:



Ed Rubin and his colleagues argue they will more likely look like this:



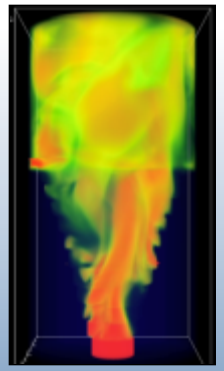


Rubin et al, IIJGGC, 2007

We need to get started *now* building CCS at commercial scale.

CCSI: Accelerating Technology Development






Identify promising concepts → Reduce the time for design & troubleshooting → Quantify the technical risk, to enable reaching larger scales, earlier → Stabilize the cost during commercial deployment

National Labs

- Berkeley Lab
- Pacific Northwest National Laboratory
- NETL
- Los Alamos National Laboratory
- Lawrence Livermore National Laboratory

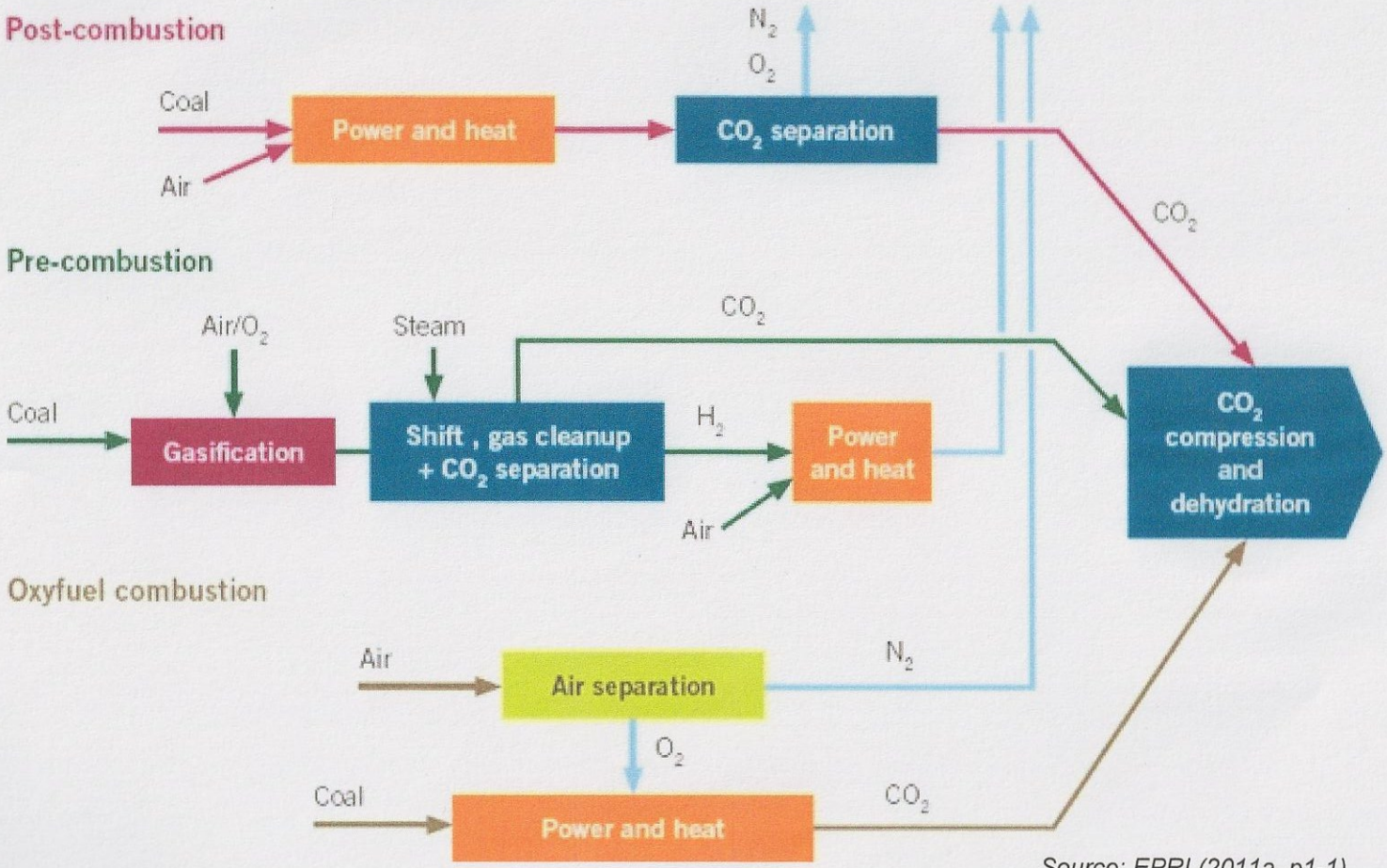
Academia

- Carnegie Mellon
- Princeton University
- West Virginia University
- Boston University
- The University of Texas at Austin
- Institute for Clean and Secure Energy, The University of Utah

Industry

- Fluor
- ADA
- B&W
- GE
- EPRI Electric Power Research Institute
- Air Products
- Burns & McDonnell
- Southern California Edison
- Alstom
- Southern Company
- Duke Energy
- URS
- Boeing
- DuPont
- ExxonMobil
- Chevron
- Phillips 66
- WorleyParsons
- Eastman

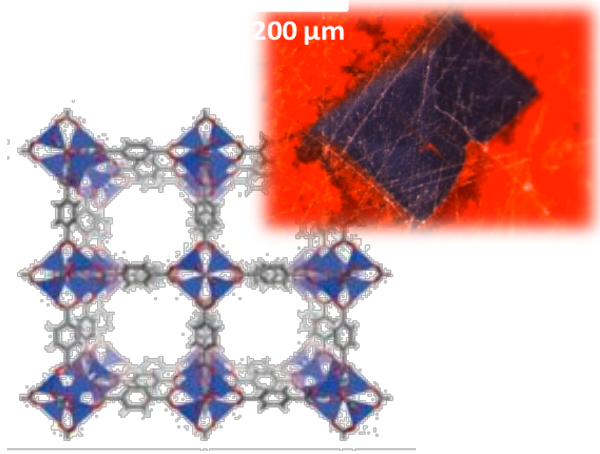
CO2 Capture Routes



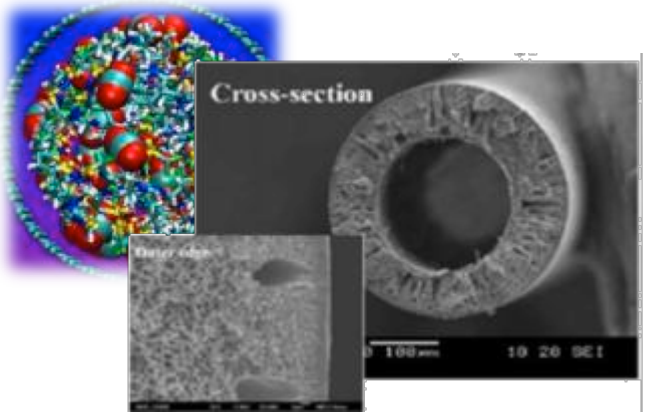
Source: EPRI (2011a, p1-1)

Advanced CO_2 Capture Program
Leveraging an "integrated development" approach

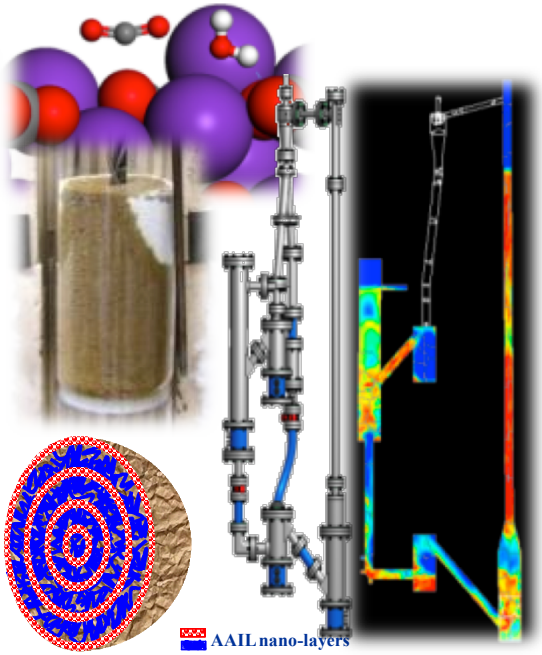
MIXED-MATRIX COMPOSITES



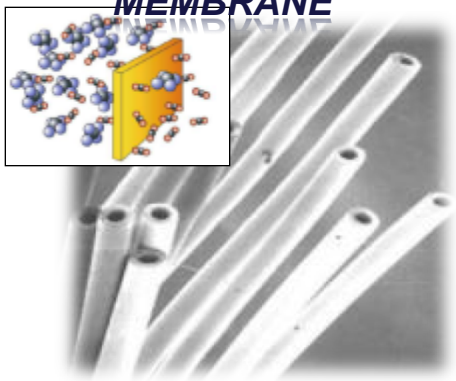
SUPPORTED LIQUIDS



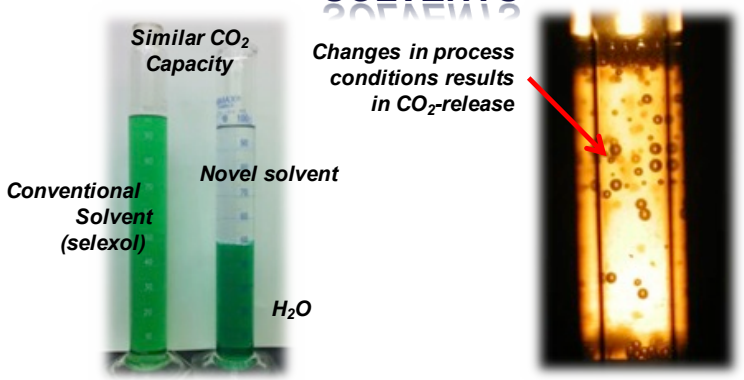
NOVEL SORBENTS



CRYOGENIC/ MEMBRANE



CHEMICAL/PHASE CHANGE SOLVENTS



The Capture Technology is Ready……

….. The Market is not!

Capture Technologies

- **Capture Technologies**
- **Chemical Looping**
- **Amine Based Capture**
- **Membrane Separation Systems**
- **Ionic Liquid-Based Systems**
- **Ammonia Based Capture Systems**
- **Oxycombustion**
- **Capture Utilizing Solvents/ Sorbents**
- **Adsorption Based Processes**
- **Systems Utilizing Enzymes and Ultrasonics**
- **Coal-fired Plant Solid Waste as a Sorbent**

Conclusions From ALSTOM'S Tom Stringer

- CCS Generation 1 Technologies are **ready for large-scale**
- Technology **development is on track** to support a large CCS market deployment into the 2020's
- Grant money is not enough
- Right **market support** needed – some good examples are emerging
- **CO2 utilization** can also stimulate CCS projects;
- Fossil-fuel power w/CCS can remain a major factor of future low-carbon energy mix :
  - **Competitive** with other forms of low-carbon power;
  - **Reliable and flexible** ;
  - **Complementary to renewables and nuclear**.

Specific support is needed to stimulate commercial CCS market development

- Before reaching full commercial status, the technology first needs to be demonstrated at **large-scale in real commercial conditions**,
- A **transport and storage infrastructure** also needs to be developed;
- Today, Power systems are not yet decarbonized : CCS extra cost to be compensated;
- Similar to renewables, CCS needs an **adapted market framework** for final demonstration and early deployment;
- Government programs allowed **several large-scale projects in NAM**
- However the first tranche of the **European funding program NER-300 did not select any CCS project.**

Example of a Supporting Market Framework – The UK

'Carbon Capture and Storage (CCS) has the potential to be one of the most cost effective technologies for decarbonisation of the UK's power and industrial sectors, as well as those of economies worldwide'

CCS Roadmap

Department for Energy and Climate Change

The UK has developed a CCS roadmap and planned a series of measures to support CCS deployment :

- A CCS commercialization program - 1 Billion GBD funding support
- Electricity Market Reform including a CfD (Contract for Difference) for clean energy producers
- Support to R&D programs dedicated to CCS.

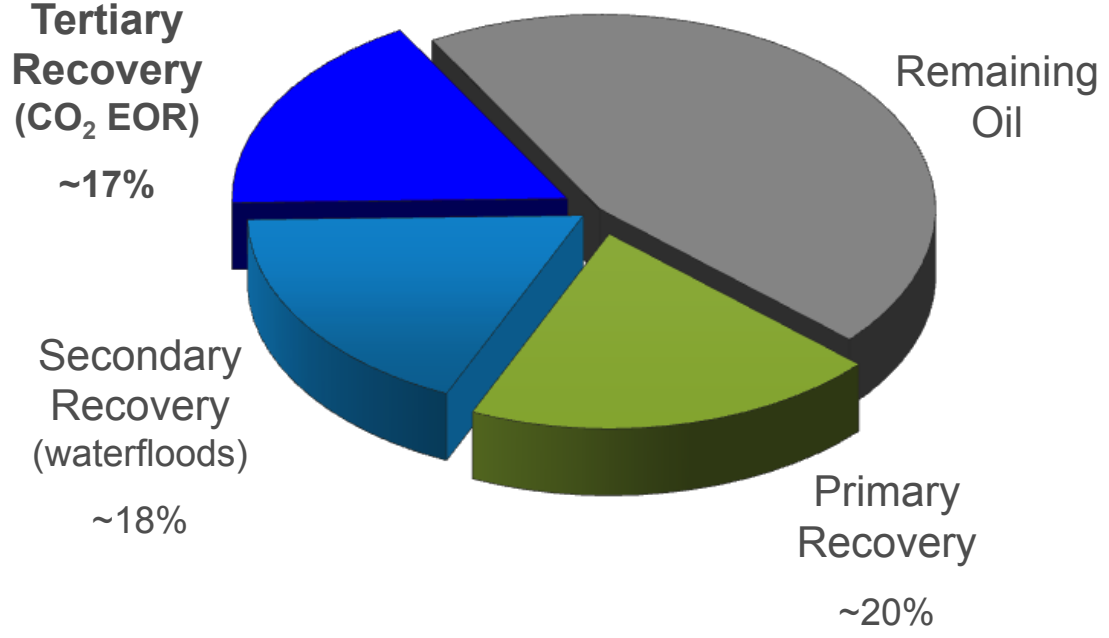
What is CO_2 EOR & How Much Does It Recover?

Secure CO_2 Supply

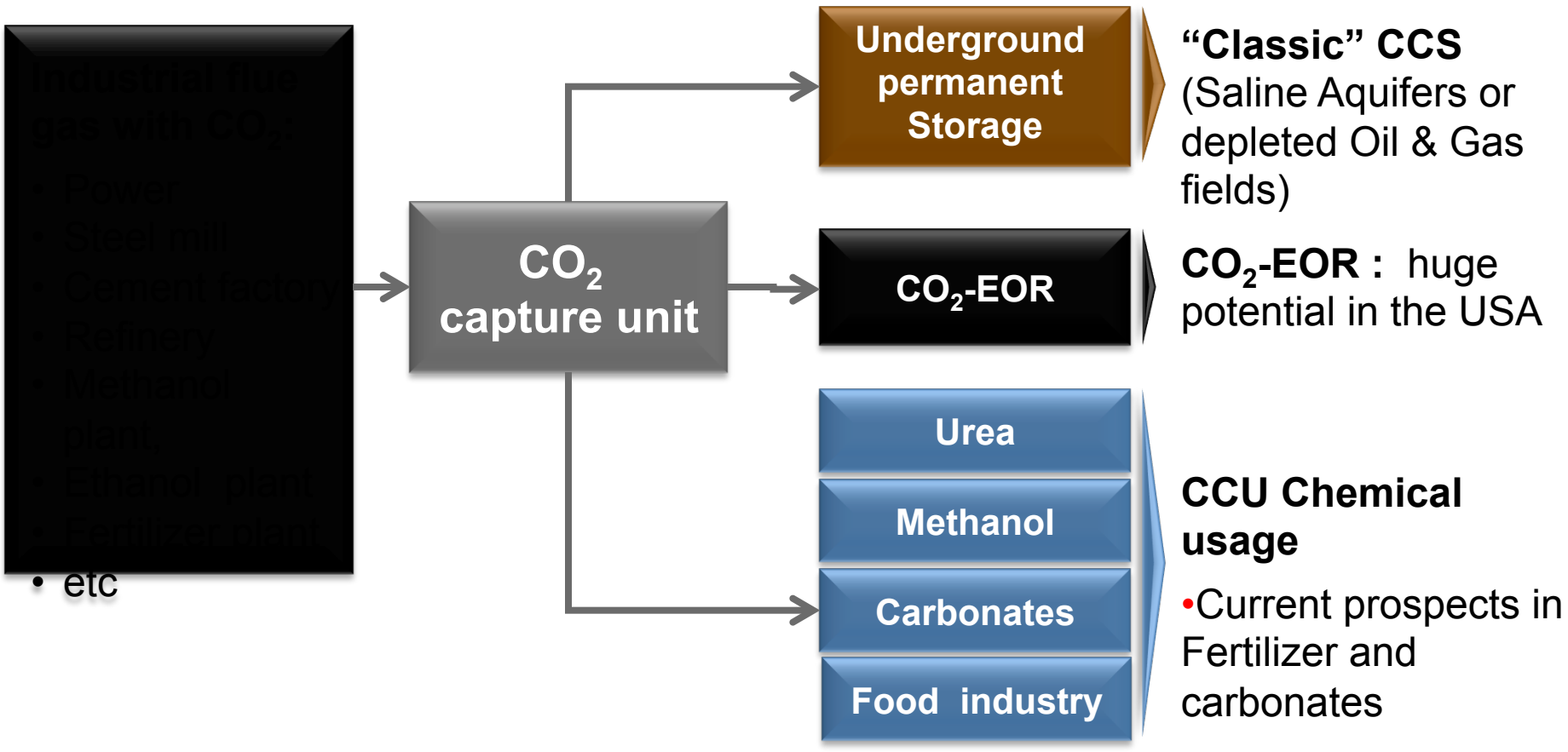
Transport via Pipeline

Inject into Oilfield

EOR Delivers Almost as Much Production as Primary or Secondary Recovery(1)



CO_2 utilization
Captured CO_2 for EOR or Chemical Production



CCU (especially EOR) can stimulate CCS/CCU through valuation of CO_2

For More Information

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Interested in Capture?

http://www.carbonsq.com/CarbonCaptureTechnologies.htm