



# CO2 Capture and Storage Update

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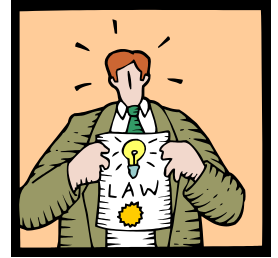
# Update – CO2 Capture and Storage (CCS)



- New Ideas are out there but so far, no “Silver Bullet” technology
- Slow progress at scale but some plans are being built – most tied to Enhanced Oil Recovery (EOR) Government \$
- Expensive -US and Europe both have funding issues on demonstrations
- Policy driven via different mechanisms
  - US new source performance standards
  - EU directives
  - Australian trading scheme

**Policy - Finance - Technology**

# Gas and Regulations Change the US CCS Outlook



- Less pressure for CCS
- No new climate legislation plus proposed NSPS favors gas
- Gas price now makes natural gas cheaper than some coal for dispatch (e.g., Central Appalachian coal)
- Coal use declines (1<sup>st</sup> Q EIA data says coal generation MWh now at 36% vs. 46% one year ago)
- CCS not needed on gas for new units so coal firing declines and gas gets built for capacity needs and renewable back-up

# LNG Prices in early 2012 (in US \$/MMBtu)

Natural Gas Overview: World LNG Prices

Federal Energy Regulatory Commission • Market Oversight • [www.ferc.gov/oversight](http://www.ferc.gov/oversight)

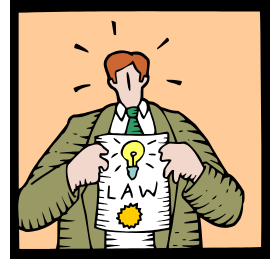
## World LNG Estimated April 2012 Landed Prices



Source: Waterborne Energy, Inc. Data in US\$/MMBtu

Updated: March 6, 2012 2199

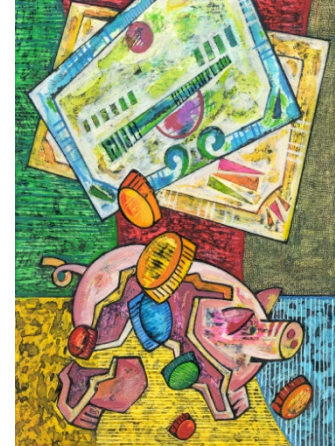
# Regulation/ policy



- In the USA the regulatory drivers are not pushing CCS for existing units (CCS not needed soon)
- Proposed NSPS for CO<sub>2</sub> means new coal will need CCS (>40% capture based on 1000 pounds/MWh gross)
- New natural gas-fired combined cycle should be able to meet this so would not need CCS under this requirement and peaking gas is exempt
- Gas is cheap therefore new fossil units are very likely to be gas

# Finance

- Many large announced projects have failed to get financing
- Those projects that are going forward often have financial backing from several sources including:
  - Grants ( US Clean Coal power Initiative etc)
  - Loan guarantees
  - Enhanced Oil Recovery (EOR) revenues
  - Ratepayer support (public utility commissions)
  - Shareholder support
  - Additional , non-power commodity products
  - All or several of the above are common



# SLOW Progress -Technology



- CCS is making some progress
- Processes are coming out of the lab and being scaled up
- Most are still sub-scale not ready to pilot
- ARPA-e and DOE NETL sponsor significant work
- EPRI has evaluated many pilots but most are not at advanced technology readiness levels (TRL's) or ready for demonstration

**If it likes to catch CO<sub>2</sub> it does not like to let go**



# How are we doing on Large Scale CCS?

- The Global CCS Institute has been tracking what they call “Large Scale Integrated Projects” (LSIPs) of CCS around the world
- At the end of 2011 they were tracking 74 LSIPs
  - 15 are operating or in construction
  - They have a total capacity of 35 million CO<sub>2</sub> tons/yr
  - That is an increase of 7.6 million tons/yr since 2010
- IEA’s “Blue Map” scenario will require the addition of an average of 182 million tons/yr of CCS *each year* over the next 24 years





# Major Coal OxyCombustion projects in Development Worldwide – End 2011

Country	Project	Location	MW	Technology	Notes
US	FutureGen 2	Meredosia, IL	200	B&W, Air Liquide	FG Alliance for Storage. Est. S/U 2016
<del>Germany</del>	<del>Vattenfall</del>	<del>Janeschwalde</del>	<del>250 MWe</del>	<del>Alstom, Linde</del>	<del>S/U 2015</del>
Spain	Endesa	Compostella	300 MWe CFB	Foster Wheeler CFB	In FEED. Est S/U 2016
Australia	CS Energy	Callide	90 MWt	IHI, Air Liquide	S/U 2011
Korea	KOSEP-KEPCO	Yongdong Power station	125 MW	TBD	S/U 2017

**Only 1 under construction. Will the others follow?**

# Major PC Post-Combustion Capture Projects in Development Worldwide – End 2011

Country	Project	Location	MW	Technology	Notes
US	NRG	Parish, Texas	60	Fluor MEA	CCPI 3 EOR
Canada	SaskPower	Boundary Dam	100	Cansolv	In construction
	TransAlta	Wabamun, Alberta	125	TBD	EOR & Saline
<del>Germany</del>	<del>Vattenfall</del>	<del>Janeschwalde</del>	<del>125</del>	<del>Chilled Ammonia</del>	<del>On shore Saline</del>
Netherlands	E.ON et al.	Maasvlakte	250 MW of new 1100 MW	Amine	Offshore gas field
Poland	PGE Elektrownia	Belchatow	250 MW of 858 MW	Advanced Amine	Saline reservoir
Romania	Turceni		330	TBD	Saline
<del>UK</del>	<del>Scottish Power</del>	<del>Longannet</del>	<del>300</del>	<del>Aker</del>	<del>North Sea storage</del>

**Only 1 is under construction, will the others follow?**

# Major IGCC + CCS Projects in Development Worldwide – End 2011

Country	Project	Location	MW Net	Gasification Technology	Gas turbine	Coal	Notes
US	HECA SCS	California	250	MHI	MHI	Western Bit & Pet coke	In FEED. EOR. Urea.
	Southern	Mississippi	524	Southern TRIG™ Air blown	Siemens	Lignite	Under construction EOR
	Summit Power	Texas	200	Siemens	Siemens	PRB	In Financing. EOR. Urea.
	Future Fuels	Pennsylvania	250	TPRI (China)	TBD	Anthracite	Permits obtained
UK	Don Valley	Yorkshire	800	Shell	GE		EU NER 300 candidate
Australia	Wandoan	Queensland	350	GE Radiant	GE	Queensland	Pre FEED

**Only 1 under construction. Will the others follow?**

# Carbon Pollution Standard

## CO<sub>2</sub> limit for Coal



- Published April 13, 2012 applies to new units. Comments through June 25
- Aimed at mid-range and base load not peaking units (exempts simple cycle CT.- 1000 pounds/MWh implies >40% removal from coal)
- Allows some early year larger emissions with higher removal in out years
- Technically possible though not at scale via CCS. Cost of power is likely increased >50% for 40% removal
- Cost makes this prohibitive if gas is well over \$2/Million Btu
- One unit (just discussed Mississippi Power Kemper County) under construction with ~ 60% CO<sub>2</sub> removal

# CCS for Gas



- Some of the technology may be similar so R&D for coal and screening of processes may help gas CCS.
- But... huge gas flows out of a Combustion Turbine = big absorbers for CO<sub>2</sub>
- Or CO<sub>2</sub> can be increased in the outlet of the combined cycle by recirculation of CO<sub>2</sub> in the CT – new dynamics, flows and combustion/ flow
- Cost per ton of CO<sub>2</sub> avoided or removed may be higher than for coal
- High O<sub>2</sub> loads so may cause oxidation of some sorbents (e.g., some amines) is possible
- No SO<sub>2</sub> , metals, particulate so that is easier with gas

# Conclusions

- Natural gas availability is shifting power and US CCS, economics
- Technology is slowly progressing and being demonstrated
- Finance is difficult everywhere for demos and first of a kind CCS
- EOR is a help but not enough to drive CCS into use by itself
- Policy driver is for little or no new coal under the MATs and NSPS requirements

**POLICY-FINANCE-TECHNOLOGY**

## For More Information

- A “roadmap” report is available for download at no cost at [www.epri.com](http://www.epri.com)
  - “Advanced Coal Power Systems with CO<sub>2</sub> Capture”  
Update 2011 EPRI report 1023468

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