

# **“2nd Biennial CO<sub>2</sub> for EOR as CCUS Conference”**

## ***“Market Drivers and Issues for CCUS and CO<sub>2</sub>-EOR”***

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Executive Director-North American Carbon Capture Storage Association (NACCSA)

Houston October 5, 2015



# Areas of Interest

- Commodity Markets
- Oil prices
- Carbon markets
- Changing market dynamics

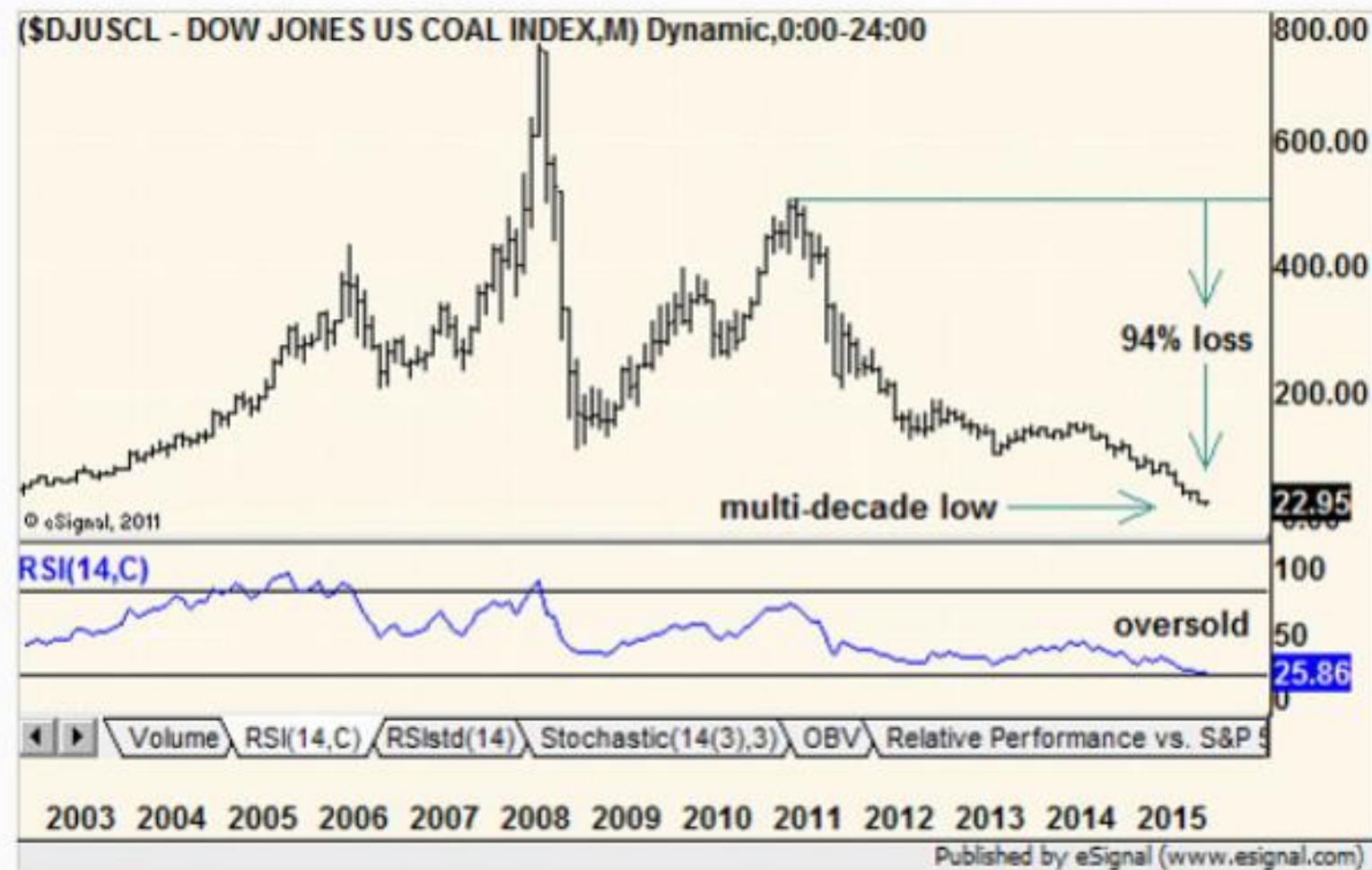
# Commodity Markets



# Overall Commodity Markets Uncertain

- **Glencore's Wild Ride Has Investors Asking: Can It Happen Again? Oct 1, 2015** [www.bloomberg.com/news/articles/2015-10-01/glencore-s-wild-ride-has-investors-asking-can-it-happen-again-](http://www.bloomberg.com/news/articles/2015-10-01/glencore-s-wild-ride-has-investors-asking-can-it-happen-again-)
- What began that morning in London, with a sudden plunge in Glencore's share price, cascaded across oceans and time zones and left the company's billionaire chief executive, Ivan Glasenberg, scrambling to calm anxious shareholders, creditors and trading partners.
- Days later, even as Glencore regained most of the \$6 billion of shareholder wealth erased in a few hours, many investors wondered if Glasenberg can hold the markets at bay.
- Commodity prices should continue to fall, as Glencore predicts that the supply of iron ore, oil, and other products will outpace demand in 2015.
- Top 10 global natural resources companies

# Coal's Dramatic Change

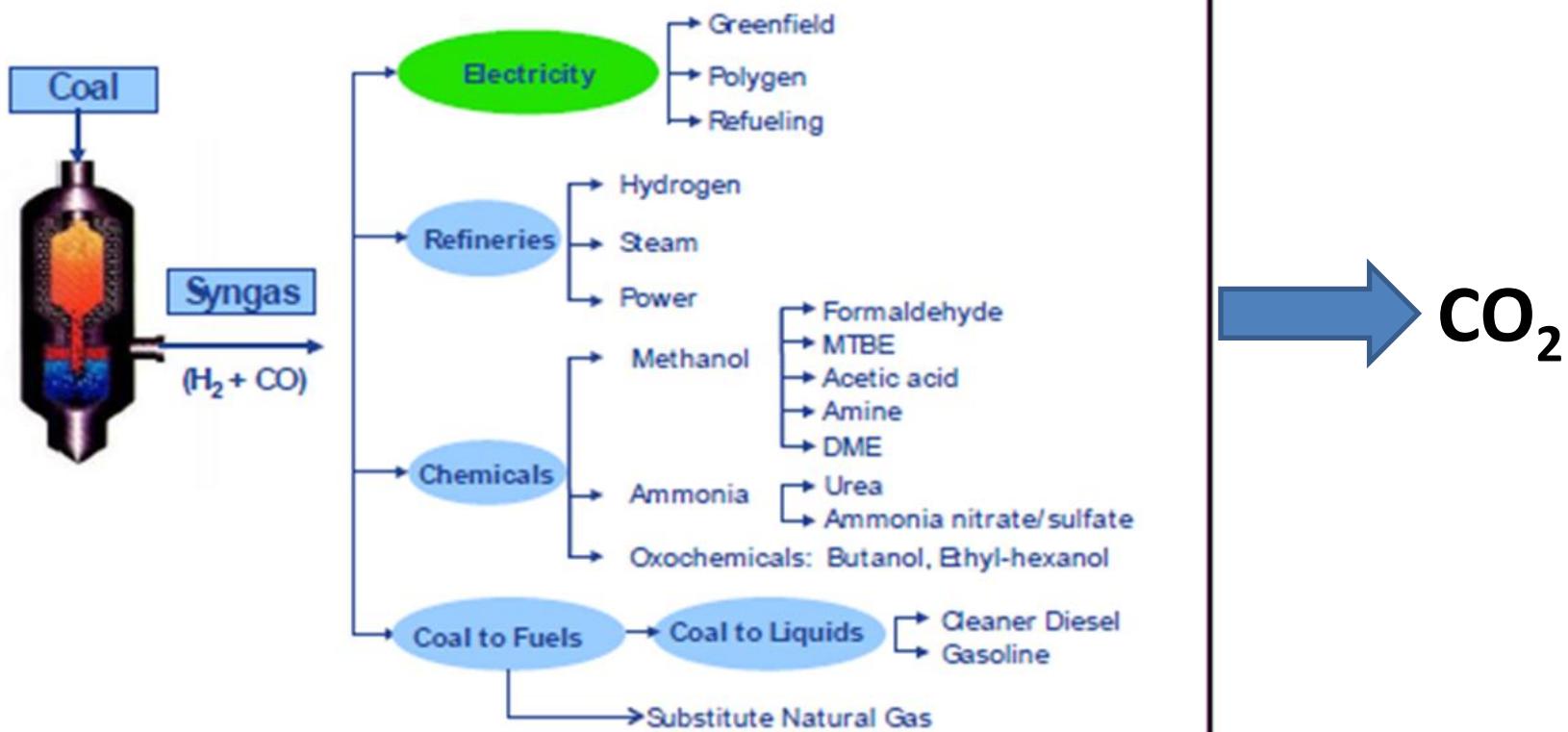


<http://www.marketwatch.com/story/jump-on-the-george-soros-coal-train-2015-10-02>

# Value of Coal is Enormous

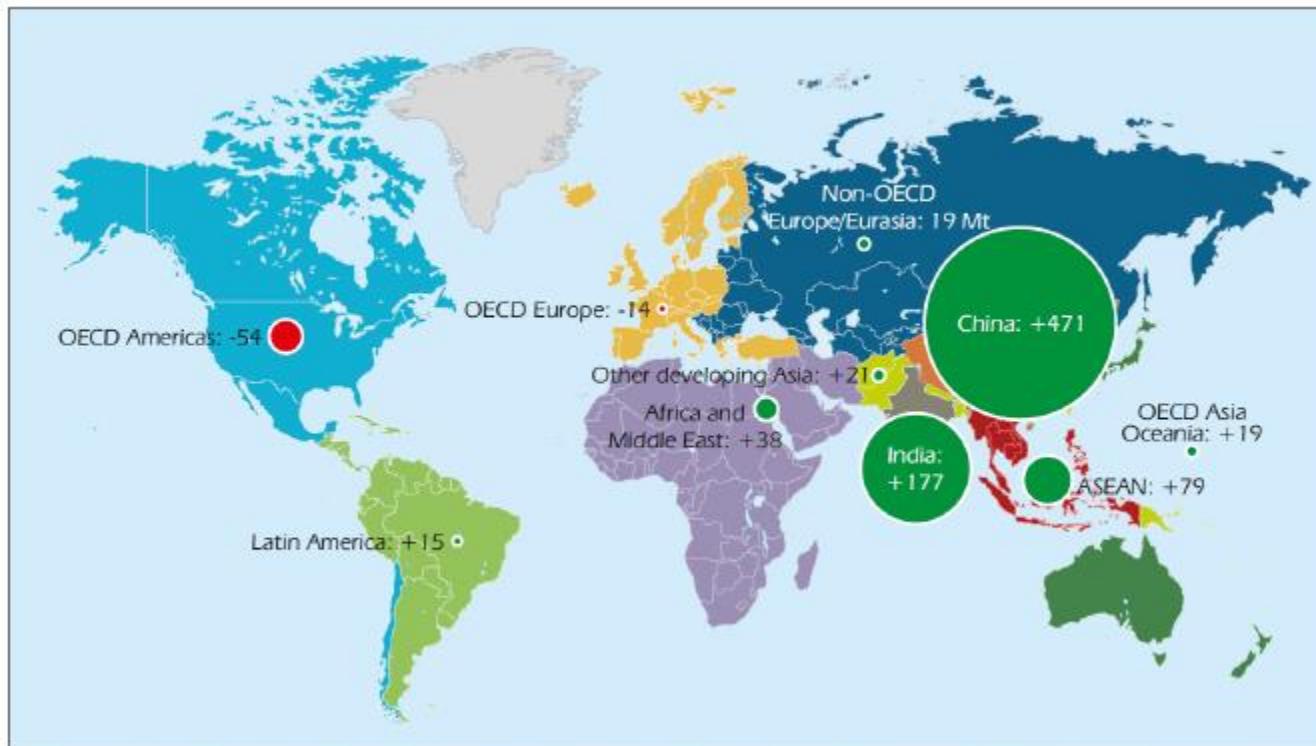
Potential product slate from coal gasification

## Coal Flexibility

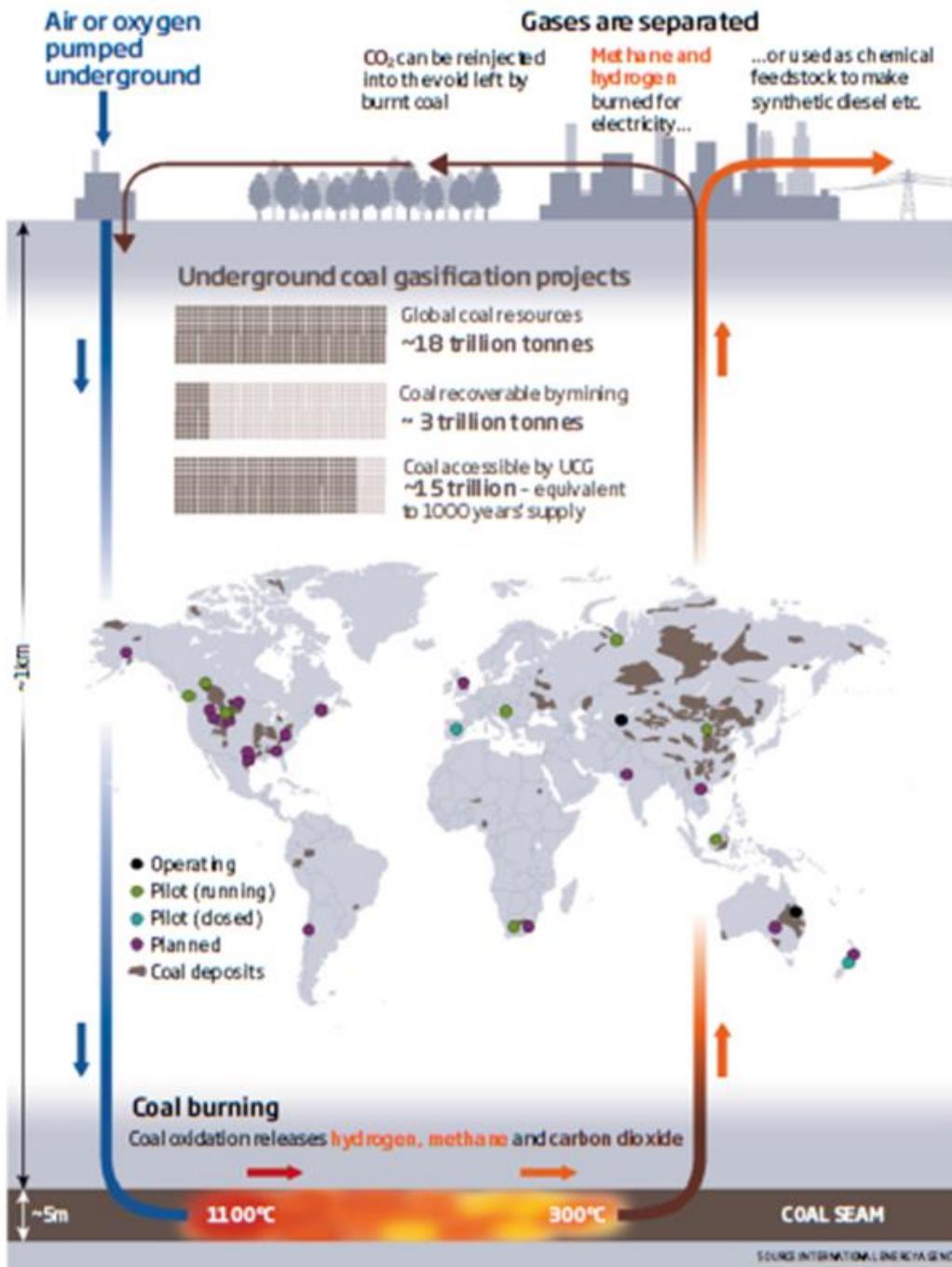


Above picture source: The CURC-EPRI Tech Roadmap pg. 24

# Incremental Coal Demand to 2019



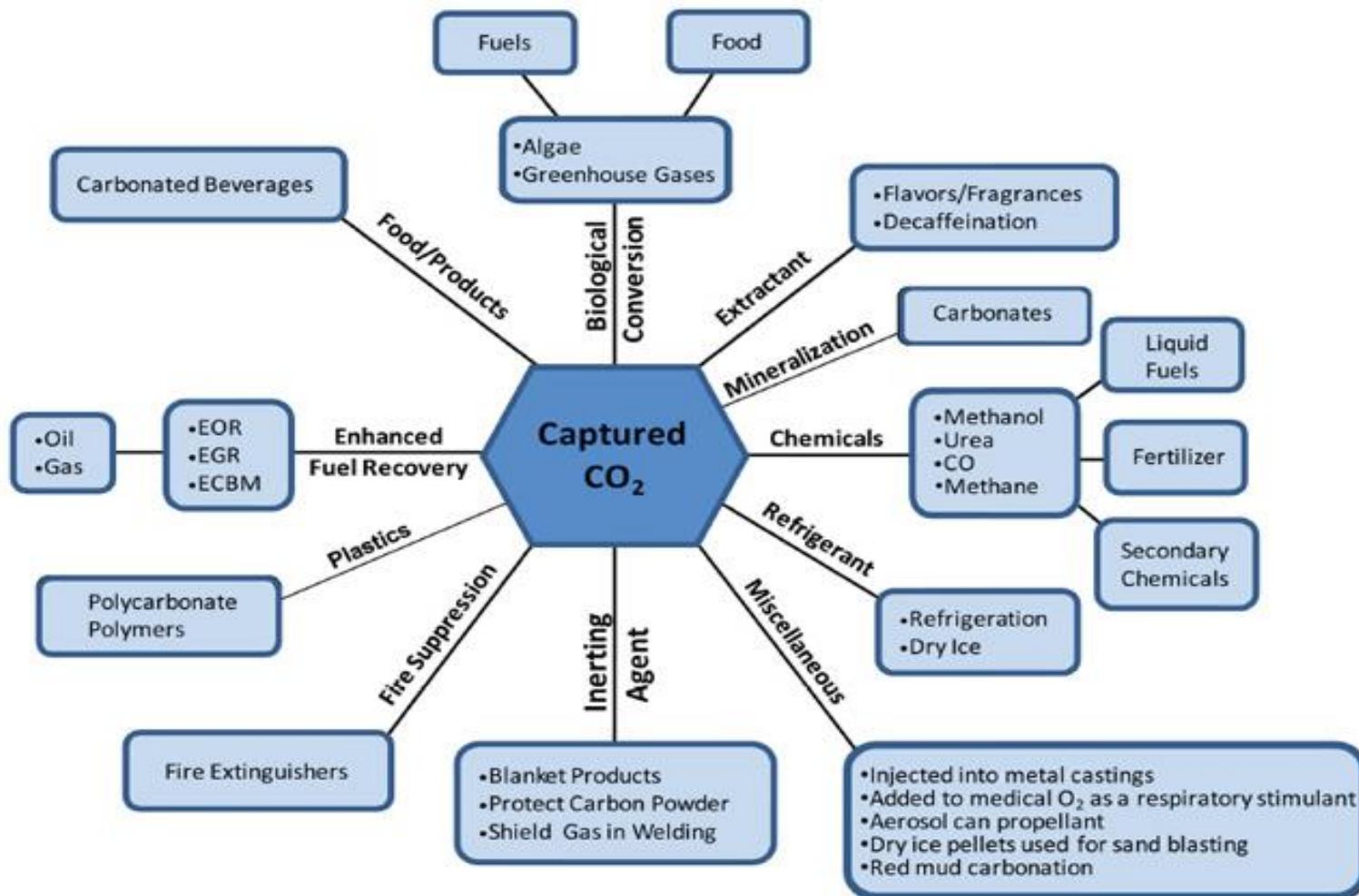
- [http://www.iea.org/newsroomandevents/speeches/141215\\_MTCMR2014\\_Presentation.pdf](http://www.iea.org/newsroomandevents/speeches/141215_MTCMR2014_Presentation.pdf)



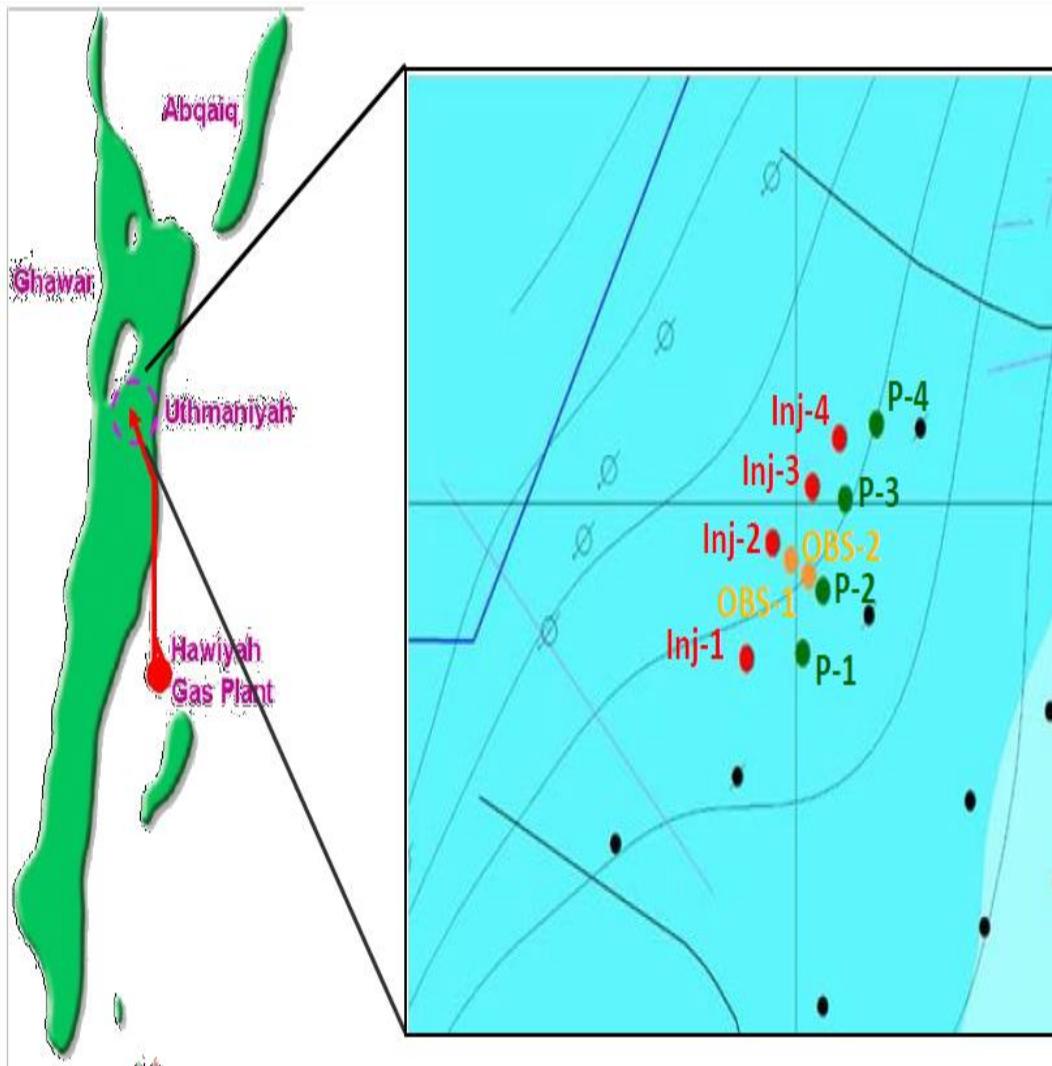
# Underground Coal Gasification

[http://  
www.newscientist.com/article/mg22129560.400-  
fire-in-the-hole-after-fracking-comes-coal.html](http://www.newscientist.com/article/mg22129560.400-fire-in-the-hole-after-fracking-comes-coal.html)

# Physical CO<sub>2</sub>: A Valuable Commodity



# Saudi Arabia: Uthmaniyyah CO<sub>2</sub> EOR Demonstration



## **Uthmaniayah Fact Sheet: Pilot EOR using Anthropogenic Carbon Dioxide**

**Company/Alliance:** Saudi Aramco

**Location:** Saudi Arabia

**Start Date:** Operational 2015

**Size:** 0.8 Mt/yr

**CO<sub>2</sub> Source:** Hawiyah gas plant

**Transportation:** 70 Km onshore pipeline

**Oil Field EOR Storage Site:** Ghawar field

**Injection Depth:** N/A

**Reservoir Type:** Jurassic Carbonate limestones

### **Comments:**

The objectives of the project are determination of incremental oil recovery (beyond water flooding), estimation of sequestered CO<sub>2</sub>, addressing the risks and uncertainties involved (including migration of CO<sub>2</sub> within the reservoir), and identifying operational concerns. Specific CO<sub>2</sub> monitoring objectives include developing a clear assessment of the CO<sub>2</sub> potential (for both EOR and overall storage) and testing new technologies for CO<sub>2</sub> monitoring.

Approximately 60–65% of all Saudi oil produced between 1948 and 2000 came from Ghawar. Cumulative production until April 2010 has exceeded 65 billion barrels. It was estimated that Ghawar produced about 5 million barrels of oil a day (6.25% of global production) in 2009. Ghawar also produces approximately 2 billion cubic feet of natural gas per day.

After 60 years of production, the field is depleted and Saudi Aramco is going to start CO<sub>2</sub>-EOR. The project will consist of 4 injection wells, 2 observation wells and 4 production wells.

**Project Link:** [Uthmaniayah Gas Plant webpage](#)

### **Other Sources and Press Releases:**

Saudi CO<sub>2</sub>-EOR project to be presented at CSLF meeting in Washington (October 2013)

CSLF endorses five new carbon capture projects (November 2013)

<https://sequestration.mit.edu/tools/projects/uthmaniayah.html>

## **Launching the Kingdom's first carbon capture project**

DHAHRAN, July 29, 2015

In the pilot project, 40 million standard cubic feet per day of CO<sub>2</sub> will be captured at Hawiyah gas recovery plant and then piped 85 kilometers to the 'Uthmaniayah field. At 'Uthmaniayah, it will be injected — and sequestered, or stored — into flooded oil reservoirs under high pressure to enhance oil recovery, making it a win-win solution.

The project aims to enhance oil recovery beyond the more common method of water flooding, and is the largest of its kind in the Middle East.

"This breakthrough initiative demonstrates that we, as an industry leader, are part of the solution to proactively address global environmental challenges," said Amin H. Nasser, acting president and CEO. "Saudi Aramco is carrying out extensive research to enable us to lower our carbon footprint while continuing to supply the energy the world needs."

<http://www.saudiaramco.com/en/home/news-media/news/capturing-carbon.html>

# CO<sub>2</sub>-Pricing for EOR at Field

- Each thousand cubic feet of CO<sub>2</sub> prices as a % of the value of a barrel of crude produced by the field delivered to that field.
- Variables such as:
  - Utilization efficiency of the CO<sub>2</sub> to crude*
  - Quality of the produced crude oil*
  - Distance to market of the produced crude oil*
  - Overhead and operations costs per barrel*
- Note: There is still “cost of sourcing” and “transportation” to be figured

# Oil Markets

Graph of historical monthly WTI crude oil prices per barrel back to 1948. Data is adjusted for inflation using the headline CPI and is shown by default on a logarithmic scale

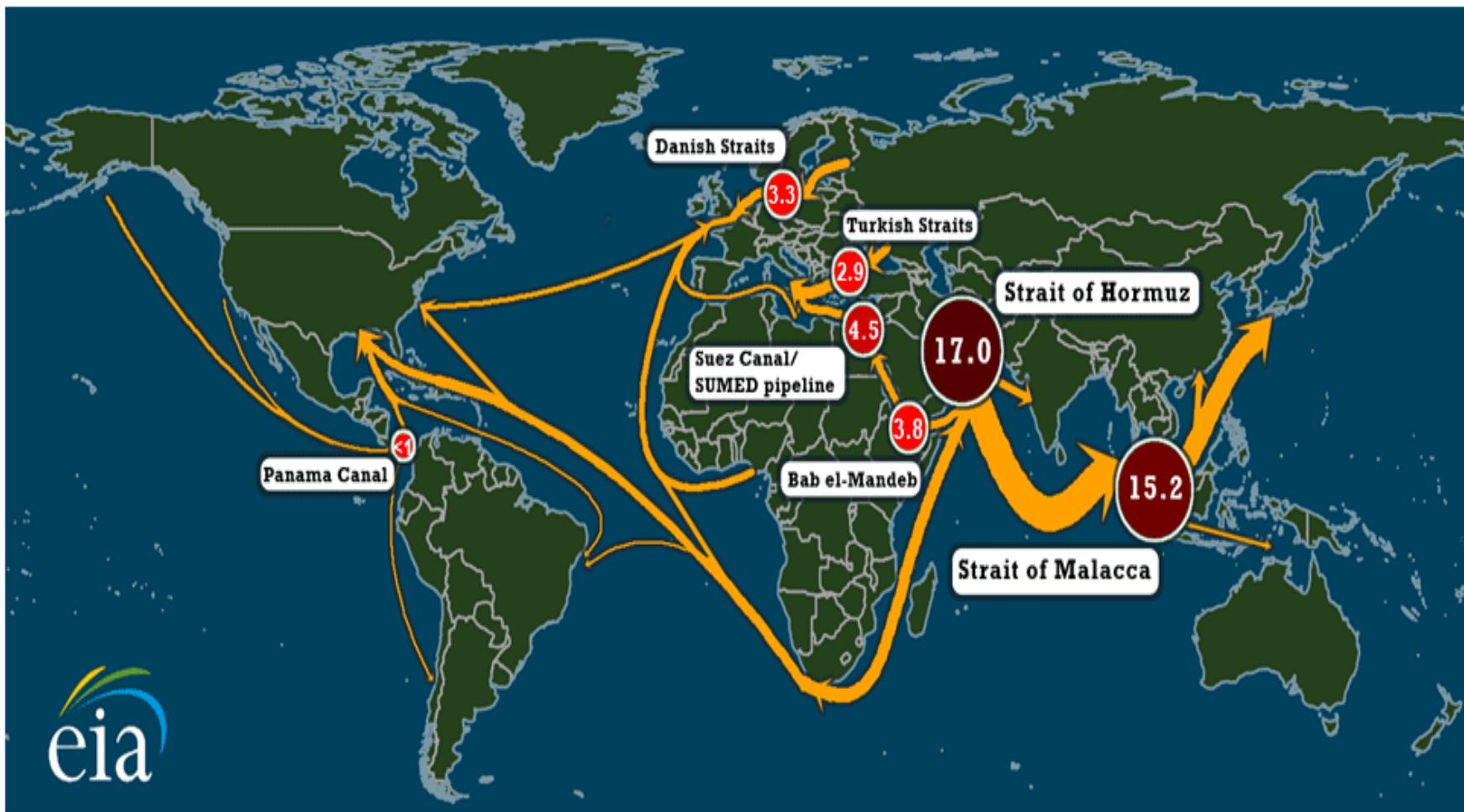


<http://www.macrotrends.net/1369/crude-oil-price-history-chart>

# Russia and Saudi Arabia to Continue Pumping Oil

- World's two biggest oil producers indicate that they won't crimp production despite price falls
- The output from those two countries adds to an already oversupplied global oil market, even with American output showing signs of weakness. Oil prices have fallen more than 50% in the past year as world supplies outpace demand by around 2 million barrels on any given day. On Friday, they turned higher as weekly data showed a sharp drop in U.S. drilling activity.
- It is also the latest indication that Russia isn't prepared to join the Organization of the Petroleum Exporting Countries in trimming production to prop up prices. OPEC has indicated that it will only consider a cut if other big suppliers, such as Russia, join it and several OPEC members have tried to woo the country.
- Oct 2, 2015 <http://www.wsj.com/articles/russian-oil-output-rises-to-post-soviet-high-in-september-1443777432>

# Oil Shipping Choke Points



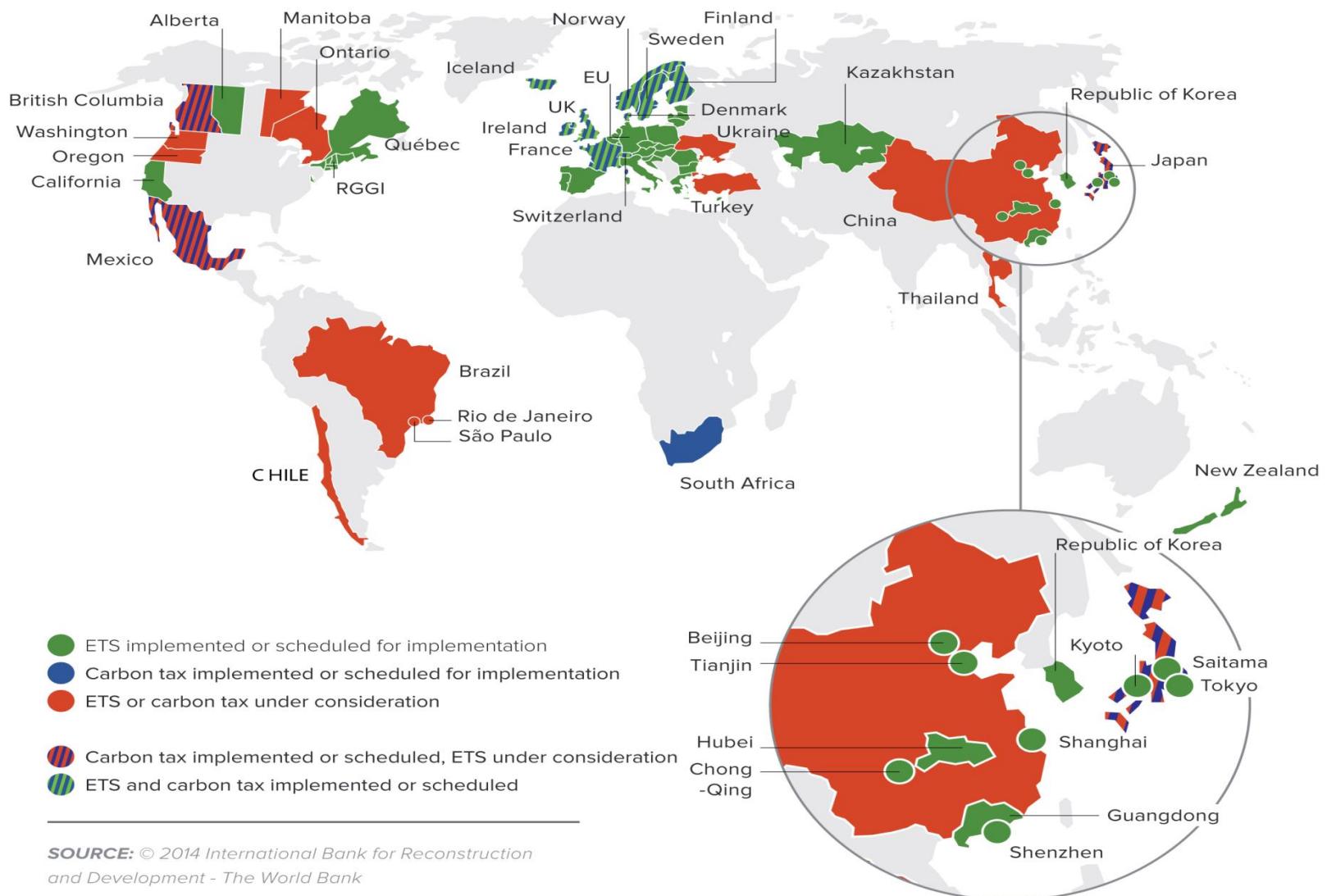
All estimates in million barrels per day. Includes crude oil and petroleum products. Based on 2013 data.

# Carbon Markets



<http://uk.reuters.com/article/idUKN0830630220080708>

# International Carbon Markets



# China Announces World's Largest Cap and Trade Program

<http://news.discovery.com/earth/global-warming/china-announces-worlds-largest-cap-and-trade-program-150927.htm>

- Sept 24, 2015 Chinese President Xi Jinping announced that China will develop a carbon trading system as a way to reduce the country's greenhouse gas emissions.
- The announcement, made jointly with U.S. President Barack Obama, comes as both countries prepare to strike a global carbon emissions agreement at the Paris climate negotiations in December. The U.S. and China are the top greenhouse gas emitting nations in the world.
- China plans to launch the world's largest emissions trading program in 2017, creating a carbon market for electric power generation, steel, cement and other industries producing most of the country's greenhouse gas emissions. The program is meant to complement the Obama administration's Clean Power Plan, which was finalized in August and aims to slash carbon emissions from electric power plants by 32 percent below 2005 levels by 2030.

# **US Clean Power Plan**

<http://www2.epa.gov/cleanpowerplan>

- On August 3, 2015, President Obama and EPA announced the Clean Power Plan - a historic and important step in reducing carbon pollution from power plants that takes real action on climate change.
- CCUS and carbon trading are components of this program

# **Six Oil and Gas Majors Call for Carbon Pricing June 1, 2015**

- Major oil and gas companies BG Group plc, BP plc, Eni S.p.A., Royal Dutch Shell plc, Statoil ASA and Total SA, today announced their call to governments around the world and to the United Nations Framework Convention on Climate Change (UNFCCC) to introduce carbon pricing systems and create clear, stable, ambitious policy frameworks that could eventually connect national systems. These would reduce uncertainty and encourage the most cost effective ways of reducing carbon emissions widely.
- The six companies set out their position in a joint letter from their chief executives to the UNFCCC Executive Secretary and the President of the COP21. This comes ahead of the UNFCCC's COP21 climate meetings in Paris this December.
- With this unprecedented joint initiative, the companies recognise both the importance of the climate challenge and the importance of energy to human life and well-being.
- [http://www.statoil.com/en/NewsAndMedia/News/2015/Pages/01Jun\\_carbon.aspx](http://www.statoil.com/en/NewsAndMedia/News/2015/Pages/01Jun_carbon.aspx)

# Norway Confirms \$900bn Sovereign Wealth Fund's Major Coal Divestment

## May 27<sup>th</sup>, 2015

- The decision to divest Norway's \$945m fund from coal assets was made on 27 May, when an agreement between political parties was reached. It was formally passed by a parliamentary vote on Friday. Svein Flaatten, of the governing Conservative party, said coal investments were both a global warming risk and financial risk. A global deal to cut carbon emissions at a crunch UN summit in December could leave some fossil fuel reserves unburnable and worthless.
- Norway's parliament has formally endorsed the move to sell off coal investments from its \$900bn sovereign wealth fund, the world's biggest.
- It is the largest fossil fuel divestment yet, affecting 122 companies across the world, and marking a new success for the fast-growing and UN-backed climate change campaign.
- A new analysis said the fund would sell off over \$8bn (£5bn) of coal-related investments as a result.
- The biggest single sell-off from Norway's fund will be the UK utility SSE, in which the fund holds \$956m of shares. The fund is also set to sell its \$49m stake in Drax, which runs the UK's biggest coal-fired power station.
- Other major energy companies identified in the analysis by German and Norwegian NGOs are Germany's E.ON (\$685m) and RWE (\$320m) and the Danish company Dong (\$30m), which is often associated with wind energy but has a significant coal business.
- Sweden's Vattenfall and Italy's Enel are also set to be affected by the coal ban as are 35 groups in the US, including Duke Energy (\$434m). A dozen coal-related companies on China are set to lose their Norwegian investment, as are eight in Japan and five in Australia.
- <http://www.theguardian.com/environment/2015/jun/05/norways-pension-fund-to-divest-8bn-from-coal-a-new-analysis-shows>

# Significant Carbon Events

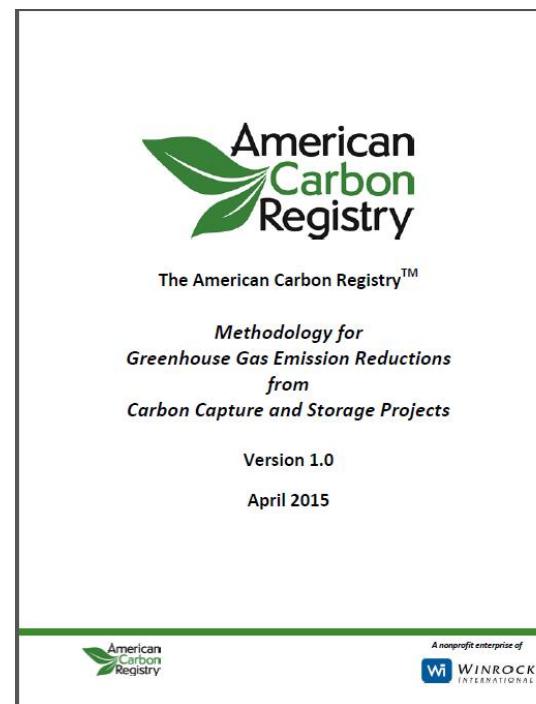
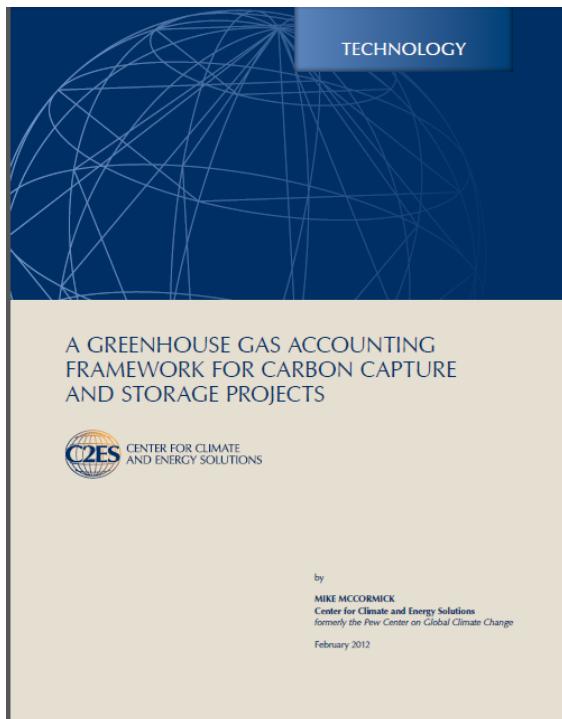
- November 7<sup>th</sup> 2013 'Unburnable' carbon fuels investment concerns - Investors group with €7.3tn of assets asks energy giants about their exposure and response to the risk of falling demand for oil and coal.  
<http://www.theguardian.com/sustainable-business/unburnable-carbon-investment-agenda>
- June 12<sup>th</sup> 2013 Obama Quietly Raises 'Carbon Price' as Costs to Climate Increase. The increase of the so-called social cost of carbon, to \$38 a metric ton in 2015 from \$23.80, adjusts the calculation the government uses to weigh costs and benefits of proposed regulations. The figure is meant to approximate losses from global warming such as flood damage and diminished crops.  
<http://www.bloomberg.com/news/2013-06-12/tougher-regulations-seen-from-obama-change-in-carbon-cost.html>

# ISO-CCS Standards for Geologic Storage under Development

- International Standards Organization - 31000, 17024, 14064, 14065
- International Performance Assessment Centre for Geologic Storage of CO<sub>2</sub> – Seed document
- Canadian Standards Association - ISO Secretariat, standards developer
- Bi-national agreement between USA & Canada
- International Organization for Standardization (ISO) Technical Committee TC-265
- Title: Carbon dioxide capture, transportation, and geological storage-includes CO<sub>2</sub>-EOR
- Acceptance of Z-741 by Standards Council of Canada and American National Standards Institute (ANSI) is “seed document” for TC-265
- 26 countries participating and NGOs

# US Carbon Markets and CCUS/CO<sub>2</sub>-EOR Protocol Framework and Storage Protocols

- PEW/C2ES CCS Protocols- released 2012
- ACR CCS CO<sub>2</sub>-EOR Offsets released April 2015



<http://americancarbonregistry.org/carbon-accounting/standards-methodologies/carbon-capture-and-storage-in-oil-and-gas-reservoirs/acr-ccs-methodology-v1-0-final.pdf>

[www.c2es.org/docUploads/CCS-framework.pdf](http://www.c2es.org/docUploads/CCS-framework.pdf)

# Changing Market Dynamics

**Man Shoots Down  
Drone, Lawyers  
Scratch Their  
Heads---Is it wrong  
to shoot a robo-  
trespasser?**

10-2-2014

[www.popsci.com/article/technology/man-shoots-down-drone-raises-legal-questions?src=SOC&dom=tw](http://www.popsci.com/article/technology/man-shoots-down-drone-raises-legal-questions?src=SOC&dom=tw)

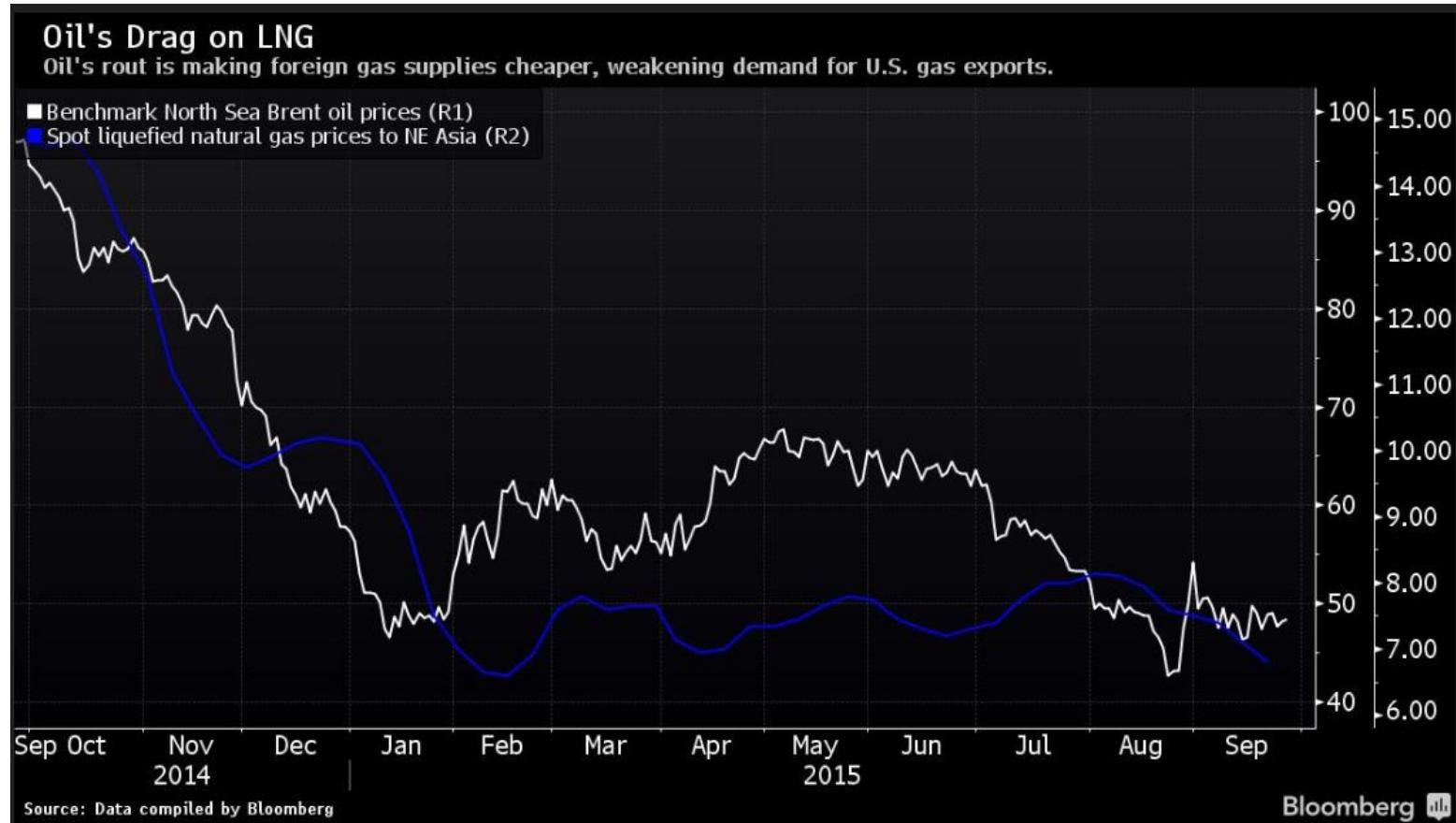


# Impactors to CCUS Deployment

- Cheap natural gas easy route for power generation
- Is cheap money about to disappear?
- Contracting global economies
- Changing commodity players, sourcing and expectations
- Issues of conflicts in consuming/producing areas
- Traditional labor pools changing
- Commodity trade routes are changing
- Carbon management pricing and markets are taking a bigger role in commodity pricing, policy decisions and capital use

# Oil and LNG

Bloomberg 9-23-15 <http://www.bloomberg.com/news/articles/2015-09-25/oil-s-killing-u-s-power-generators-and-they-don-t-even-burn-it>



# Navajo Free Trade Zone Rail Hub

THE NAVAJO NATION



BEN SHELLY PRESIDENT  
REX LEE JIM VICE PRESIDENT

Contact: Erny Zah  
Director of Communications  
Cell: (928) 380-0771

[najavonationpress@navajo-nsn.gov](mailto:najavonationpress@navajo-nsn.gov)

For Immediate Release  
Aug. 27, 2013

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## **President Shelly Honors Former Leaders and Meets about Navajo Mine**

The Navajo Nation is working with BSNF to build a railroad spur in Thoreau, New Mex. Plans call for an inland port authority for imports and exports. ship coal on the transcontinental for export to foreign countries. The railroad spur is expected to be in project initiation by December. Coal from the Navajo mine can be used for the local power plants, and for foreign shipment.

- [http://www.navajo-nsn.gov/Archived\\_Webpages\\_News\\_Releases/2013/aug13\\_combined.pdf](http://www.navajo-nsn.gov/Archived_Webpages_News_Releases/2013/aug13_combined.pdf)

# Norwegian Visit to Navajo Nation

- *Dr. Jostein added that Norway has a strong interest in working with the Navajo Nation and hopes to aid in the development of a more efficient avenue of clean coal burning,...*
- *One of those techniques is an Integrated Gasification Combine Cycle Power Generation Unit, which would utilize coal and preserve remaining resources acquired from the purchase of Navajo Mine from BHP Billiton near Farmington, NM.*
- *Note: Captured CO<sub>2</sub> would move to the Permian Basin for EOR.*



Speaker Naize welcomes Royal Norwegian General Consulate to discuss future renewable energy initiatives on the Navajo Nation

Navajo Nation Speaker Johnny Naize met with Royal Norwegian Consul General Dr. Jostein Mykland to discuss Norway's interest in working with the Navajo Nation in regards to energy rich resources and potential renewable energy on Navajo land.

"We are interested in Norway's interest in the abundant energy resources of the Navajo Nation. I invited Consul General Dr. Jostein Mykland to our land and participated as an honored guest at one of our Naashk'iyish Committee meetings," said Speaker Naize.

Speaker Naize and legislative staff assisted and advised on energy issues Anthony Peterson, recently met with Dr. Jostein in Monument Valley to tour the Navajo Nation's utilized lands and the Navajo Tribal Park, as a gesture of welcome and appreciation for Norway's interest in a relationship with the Navajo Nation.

The intent of the visit was to discuss possible renewable energy initiatives with the hope of beginning dialogues between the Navajo Nation and Norway. The visit will also provide the foreign diplomat has met with the Navajo Nation to examine alternative energy solutions for commercial and economic development projects to benefit Navajo Nation.

Currently, Norway is the world's third largest exporter of natural gas and the fifth largest exporter of oil, illustrating the opportunity for both nations to benefit from the potential partnership.

"Now that the Navajo Nation owns its own mine, it is the opportunity to begin investing in clean coal but also natural gas with the potential to create additional jobs for the Dine people," said Speaker Naize. "This potential initiative is going to generate a lot of interest which includes many energy companies in the U.S. and internationally, and to become an energy independent Nation."

At a recent Naashk'iyish Committee, Dr. Jostein was able to address Navajo Nation law makers and the general public regarding his one-day conference visiting the Navajo Nation.

"Visiting the Navajo Nation is one of the best experiences I have had since coming to the United States many years ago," said Dr. Jostein. "I have been to Monument Valley for a whole day has left a lasting appreciation for this land for the rest of my life," said Dr. Jostein.

Dr. Jostein added that Norway has a strong interest in working



Legislative Staff Assistant Anthony Peterson, VP of Fleets Michael Moore, Speaker Johnny Naize, and Royal Norwegian Consulate General Dr. Jostein Mykland.

with the Navajo Nation and helps to aid in the development of a more efficient avenue of clean coal burning, as well as taking advantage of other scientific techniques that allow for renewable energy to be used.

One of those techniques is an Integrated Gasification Combine Cycle Power Generation Unit. This would utilize coal and preserve remaining resources acquired from the purchase of Navajo Mine from BHP Billiton near Farmington, NM.

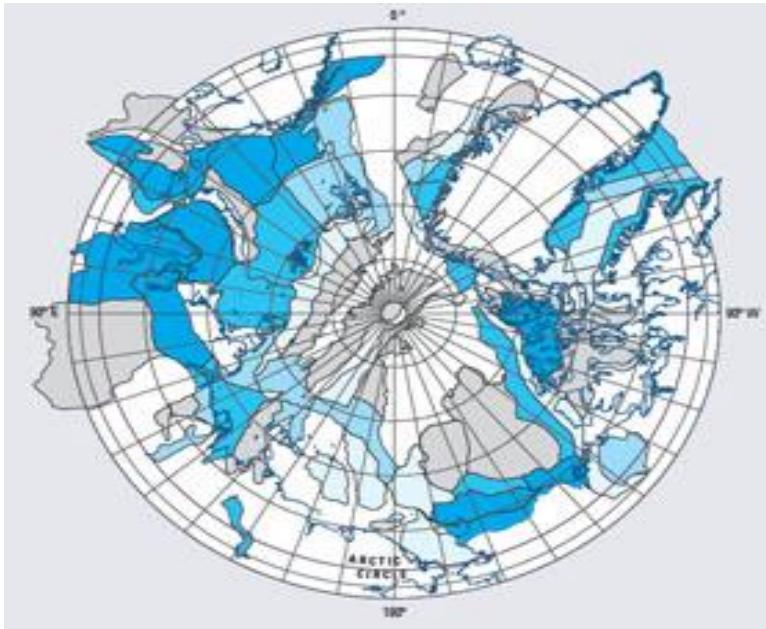
Following Dr. Jostein's presentation, Council Delegate Leonard Tsoie conveyed his appreciation for the Norwegian Consul General for observing the Navajo Council and the Navajo Nation's rich energy resources.

"This is the first time I've seen anyone from an international nation in the Navajo Council Chamber. I implore the Council to begin working with Norway and recognize this is an opportunity to allow our energy resources to begin working for our Nation," said Delegate Tsoie.



Speaker Johnny Naize pointing out petroglyphs to Dr. Jostein in Monument Valley Navajo Tribal Park, UT.

# Arctic Resources

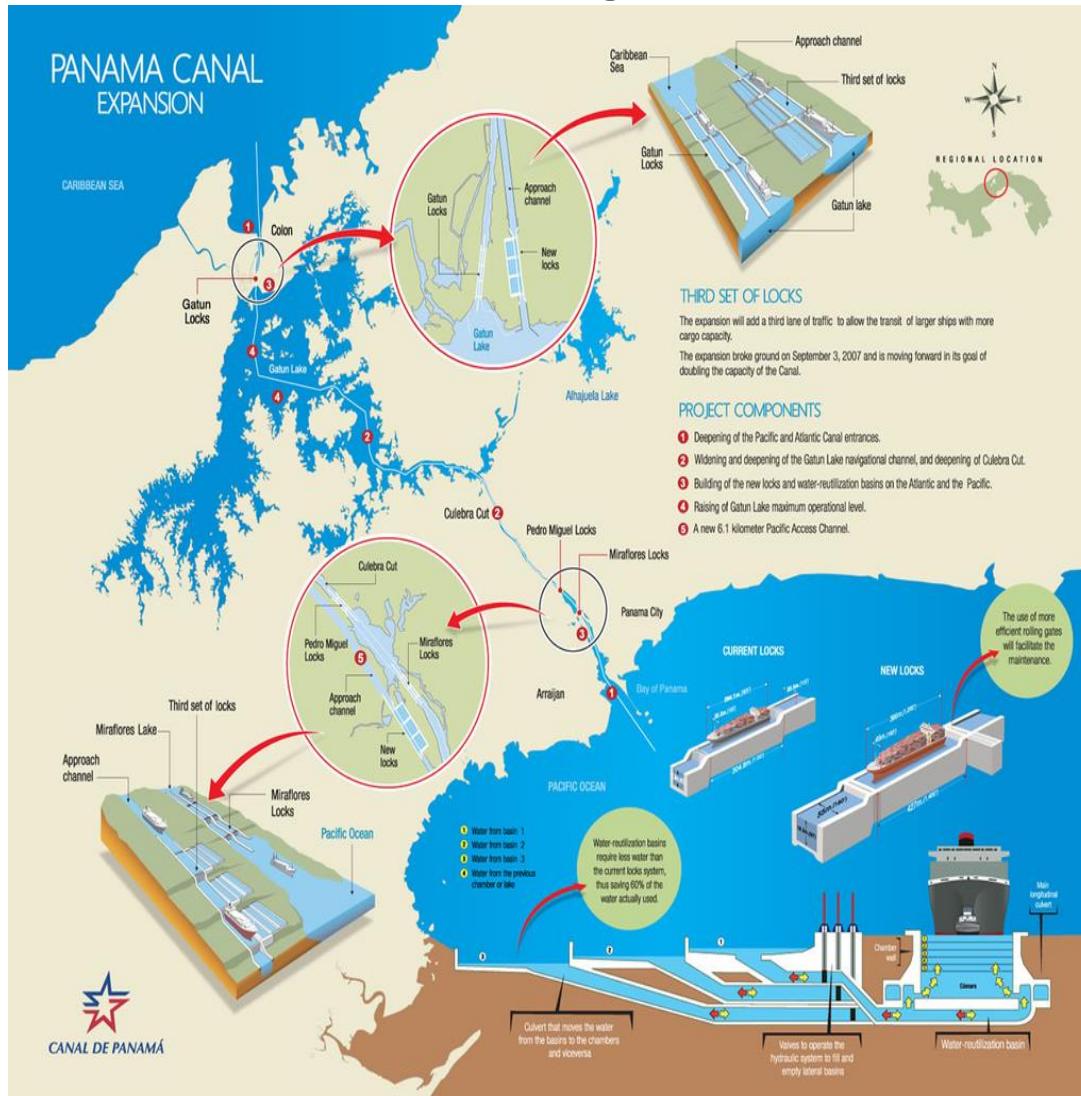


The U.S. Geological Survey (USGS) has completed an assessment of undiscovered conventional oil and gas resources in all areas north of the Arctic Circle. Using a geology based probabilistic methodology, the USGS estimated the occurrence of undiscovered oil and gas in 33 geologic provinces thought to be prospective for petroleum. The sum of the mean estimates for each province indicates that 90 billion barrels of oil, 1,669 trillion cubic feet of natural gas, and 44 billion barrels of natural gas liquids may remain to be found in the Arctic, of which approximately 84 percent is expected to occur in offshore areas.

<http://pubs.usgs.gov/fs/2008/3049/fs2008-3049.pdf>

Province Code	Province	Oil (MMBO)	Total Gas (BCFG)	NGL (MMBNGL)	BOE (MMBOE)
WSB	West Siberian Basin	3,659.88	651,498.56	20,328.69	132,571.66
AA	Arctic Alaska	29,960.94	221,397.60	5,904.97	72,765.52
EBB	East Barents Basin	7,406.49	317,557.97	1,422.28	61,755.10
EGR	East Greenland Rift Basins	8,902.13	86,180.06	8,121.57	31,387.04
YK	Yenisey-Khatanga Basin	5,583.74	99,964.26	2,675.15	24,919.61
AM	Amerasia Basin	9,723.58	56,891.21	541.69	19,747.14
WGEC	West Greenland-East Canada	7,274.40	51,818.16	1,152.59	17,063.35
LSS	Laptev Sea Shelf	3,115.57	32,562.84	867.16	9,409.87
NM	Norwegian Margin	1,437.29	32,281.01	504.73	7,322.19
BP	Barents Platform	2,055.51	26,218.67	278.71	6,704.00
EB	Eurasia Basin	1,342.15	19,475.43	520.26	5,108.31
NKB	North Kara Basins and Platforms	1,807.26	14,973.58	390.22	4,693.07
TPB	Timan-Pechora Basin	1,667.21	9,062.59	202.80	3,380.44
NGS	North Greenland Sheared Margin	1,349.80	10,207.24	273.09	3,324.09
LM	Lomonosov-Makarov	1,106.78	7,156.25	191.55	2,491.04
SB	Sverdrup Basin	851.11	8,596.36	191.20	2,475.04
LA	Lena-Anabar Basin	1,912.89	2,106.75	56.41	2,320.43
NCWF	North Chukchi-Wrangel Foreland Basin	85.99	6,065.76	106.57	1,203.52
VLK	Vilkitskii Basin	98.03	5,741.87	101.63	1,156.63
NWLS	Northwest Laptev Sea Shelf	172.24	4,488.12	119.63	1,039.90
LV	Lena-Vilyui Basin	376.86	1,335.20	35.66	635.06
ZB	Zyryanka Basin	47.82	1,505.99	40.14	338.95
ESS	East Siberian Sea Basin	19.73	618.83	10.91	133.78
HB	Hope Basin	2.47	648.17	11.37	121.87
NWC	Northwest Canada Interior Basins	23.34	305.34	15.24	89.47
MZB	Mezen' Basin	NQA	NQA	NQA	NQA
NZAA	Novaya Zemlya Basins and Admiralty Arch	NQA	NQA	NQA	NQA
TUN	Tunguska Basin	NQA	NQA	NQA	NQA
CB	Chuckhi Borderland	NQA	NQA	NQA	NQA
YF	Yukon Flats (part of Central Alaska Province)	NQA	NQA	NQA	NQA
LS	Long Strait	NQA	NQA	NQA	NQA
JMM	Jan Mayen Microcontinent	NQA	NQA	NQA	NQA
FS	Franklinian Shelf	NQA	NQA	NQA	NQA
Total		89,983.21	1,668,657.84	44,064.24	412,157.09

# Panama Canal Expansion ~2016



<http://micanaldepanama.com/expansion/>

<http://micanaldepanama.com/expansion/faq/#prettyPhoto>

# Chinese Backed “Nicaragua Interoceanic Grand Canal”

Dec 22, 2014 Groundbreaking

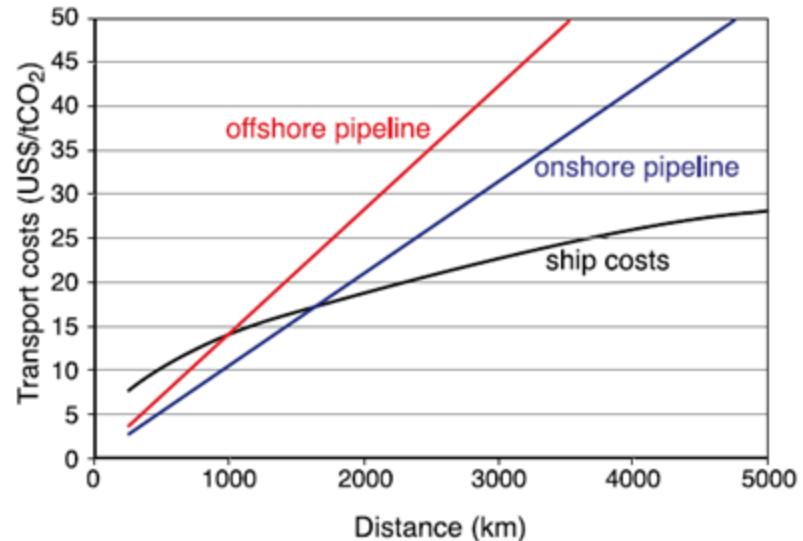


- [http://www.washingtonpost.com/blogs/worldviews/wp/2014/12/23/why-the-chinese-backed-nicaragua-canal-may-be-a-disaster/?Post+generic=%3Ftid%3Dsm\\_twitter\\_washingtonpost](http://www.washingtonpost.com/blogs/worldviews/wp/2014/12/23/why-the-chinese-backed-nicaragua-canal-may-be-a-disaster/?Post+generic=%3Ftid%3Dsm_twitter_washingtonpost)

# CO<sub>2</sub> Shipping

- The Costs of CO<sub>2</sub> Transport ZEP  
<http://www.zeroemissionsplatform.eu/library/publication/167-zep-cost-report-transport.html>
- Anthony Veder CO<sub>2</sub> shipping.  
<http://www.anthonyveder.com/activities/new-business/co2-shipping/>
- AP Moeller/Maersk CO<sub>2</sub> shipping.  
<http://www.maersktankers.com/Activities/Pages/CO2%20Shipping.aspx>
- Yara CO<sub>2</sub> Business Unit.  
[http://www.yara.com/media/news\\_archive/Yara\\_co2\\_ships.aspx](http://www.yara.com/media/news_archive/Yara_co2_ships.aspx)
- GCCSI CO<sub>2</sub> Liquid tanker study Vopak.  
<http://cdn.globalccsinstitute.com/sites/default/files/publications/25491/co2-liquid-logistics-shipping-concept.pdf>
- GCCSI Chiyoda Preliminary Feasibility Study on CO<sub>2</sub> Carrier for Ship.  
<http://www.globalccsinstitute.com/publications/preliminary-feasibility-study-co2-carrier-ship-based-ccs>
- Lloyds Feasibility of Danish CCS Scheme Comprised of Capture at Power Plans, Ship Transport and CO<sub>2</sub>-EOR. Supports using modified chilled LPG carriers and modified ethane carriers for CO<sub>2</sub> in supercritical for long haul shipping.  
<http://www.dendanskemaritimefond.dk/public/dokumenter/2010/2010-71/Report%20-Feasibility%20of%20Danish%20CCS%20Scheme%20Comprised%20of%20Capture%20at%20Power%20Plants%20Ship%20Transport%20and%20CO2%20EOR.pdf>

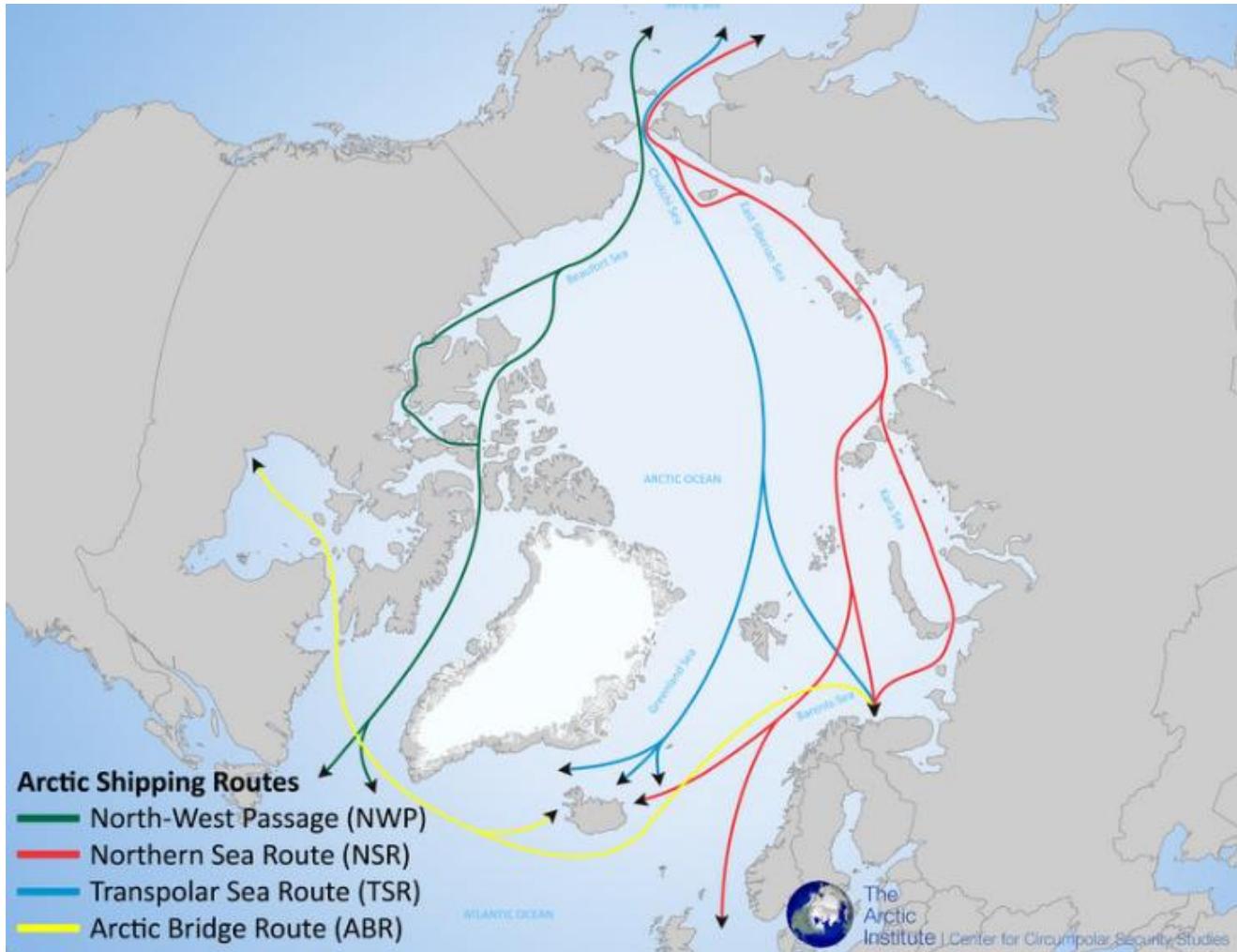
Transport costs for onshore and offshore pipelines per 250 km. High (broken lines) and low range (continuous lines) are indicated.



Costs, plotted as transportation cost in US\$/tCO<sub>2</sub> against distance, for onshore and offshore pipelines, and ship transport. The costs include intermediate storage facilities, harbour fees, fuel costs and loading/unloading activities. Costs also include additional costs for liquefaction compared to compression. There is a capital charge factor of 11% for all transport options.

[www.powerplantccs.com/ccs/tra/tra\\_ship\\_cost.html](http://www.powerplantccs.com/ccs/tra/tra_ship_cost.html)

# Arctic Sea Routes



- The Arctic Institute <http://www.thearcticinstitute.org/2012/10/the-future-of-arctic-shipping.html>
- NSR Information Office: <http://www.arctic-lio.com/>

# Questions & Thank You!

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# North American Carbon Capture Storage Association



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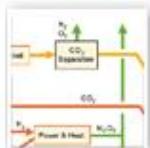
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## Benefits of CCUS



CCUS holds the promise of storing large volumes of CO<sub>2</sub> in geologic formations such as deep saline formations, depleting reservoirs (e.g. EOR, ECBM), depleted reservoirs, unminable coal seams and similar geologic structures... [Read more](#)

## What is NACCSA

The North American Carbon Capture & Storage Association (NACCSA) is a nonprofit organization of companies in North America that support the development of a sustainable carbon dioxide (CO<sub>2</sub>) capture use and storage (CCUS) industry in the United States and Canada. Policymakers and companies are interested in CCUS technology because it may be used for energy recovery and holds significant promise as a tool to manage man-made emissions of carbon dioxide, one of the principle greenhouse gases (GHG).

- The Astrup Fearnley group represents over a century of history, growth and excellence in the area of shipping services. This fascinating legacy is a success story created by generation after generation of the Astrup Fearnley family. We believe it is a story worth telling.
- Fearnleys traces its history back to the year 1869 when its founder, Thomas Fearnley, established a shipbroking and agency business in Christiania, as the city of Oslo was known in those days. The little company soon prospered and engaged in, among others, the trade in lumber, wine, pitch and ice.
- In connection with its trading activities the company bought shares in vessels and chartered vessels. Although the company began by chartering sailing vessels, by 1880 the age of the steamship had clearly begun. By 1881 the partnership of Fearnley & Eger established the Christiania Steamship Company which contracted two newbuildings at the Kockums Shipyard in Malmø, the 1235 deadweight 'Oslo' and the 1215 deadweight 'Bygdøy'.
- By the end of the 1880s the company had contracted a further six units. In the beginning of the 1900s Fearnley & Eger became, more or less, a shipowning company and invested in ever larger units. The company engaged in both liner and tramp activities and survived the two world wars. In addition to these shipowning activities, the firm continued to engage in developing its skills in the area of shipping services and was engaged primarily in the area of dry cargo shipbroking. As the tanker industry started to develop at the beginning of the 20th century, Fearnleys became enthusiastically involved in this new field of endeavour. Later on, when the transportation of gas by sea became an important area of commerce, Fearnleys developed a broking department which specialized in this new commodity. All in all, the history of the company has been closely focused on the concept of innovation; whenever new ideas and new industries developed which required seaborne transportation, Fearnleys was quickly on the scene.
- As the 20th century progressed, the need for brokerage services for the transportation industry became so great that Fearnleys began to develop these (along with related ancillary services) as its principal business area. Always on the cutting edge of new trends, the company became involved in car carrier transportation in the 1960s, offshore and rig broking in the 1970s, coinciding with the onset of the development of the Norwegian continental shelf offshore oil fields, and energy trading and financial services in the 1980s. Fearnleys was also a pioneer in the development of transportation industry research and consultancy services, and has been involved in monitoring and analysing shipping markets since the early 1960s when Fearnresearch was first established. Now at the dawn of the 21st century the little company which started in Christiania in 1869 is firmly established in every corner of the world and assumes a global perspective on transportation much to the benefit of its worldwide customer base.

Shipping	Offshore	Energy	Finance
 <p>Shipping is one of the group's major business areas.</p>	 <p>Fearnley Offshore and Fearnley Offshore Supply offer future-oriented broking and advisory services in the growing offshore sector.</p>	 <p>Libra Fearnley Energy AS is a sizeable participant in the oil broking market through its affiliates in Paris, London, Houston and Singapore.</p>	 <p>Fearnley Finans AS and Fearnley Securities AS offer a wide array of financial services</p>