Commodity CO_2 for EOR and Utilization-Current Market Dynamics, Issues and Opportunities

Michael E. Moore

VP Energy Commodities and Advisory Services
FearnOil Inc. a division of Astrup-Fearnleys

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

March 8th, 2016 Washington, DC

Astrup Fearnley

http://astrupfearnley.no/

- 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 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

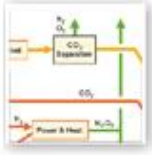
North American Carbon Capture Storage Association

NACCSA
North American Carbon Capture & Storage Association

www.naccsa.org

- ABOUT US
- MEDIA CENTER
- CONCEPT OF CCUS
- CONTACT US
- MEMBERS

Benefits of CCUS



CCUS holds the promise of storing large volumes of CO_2 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

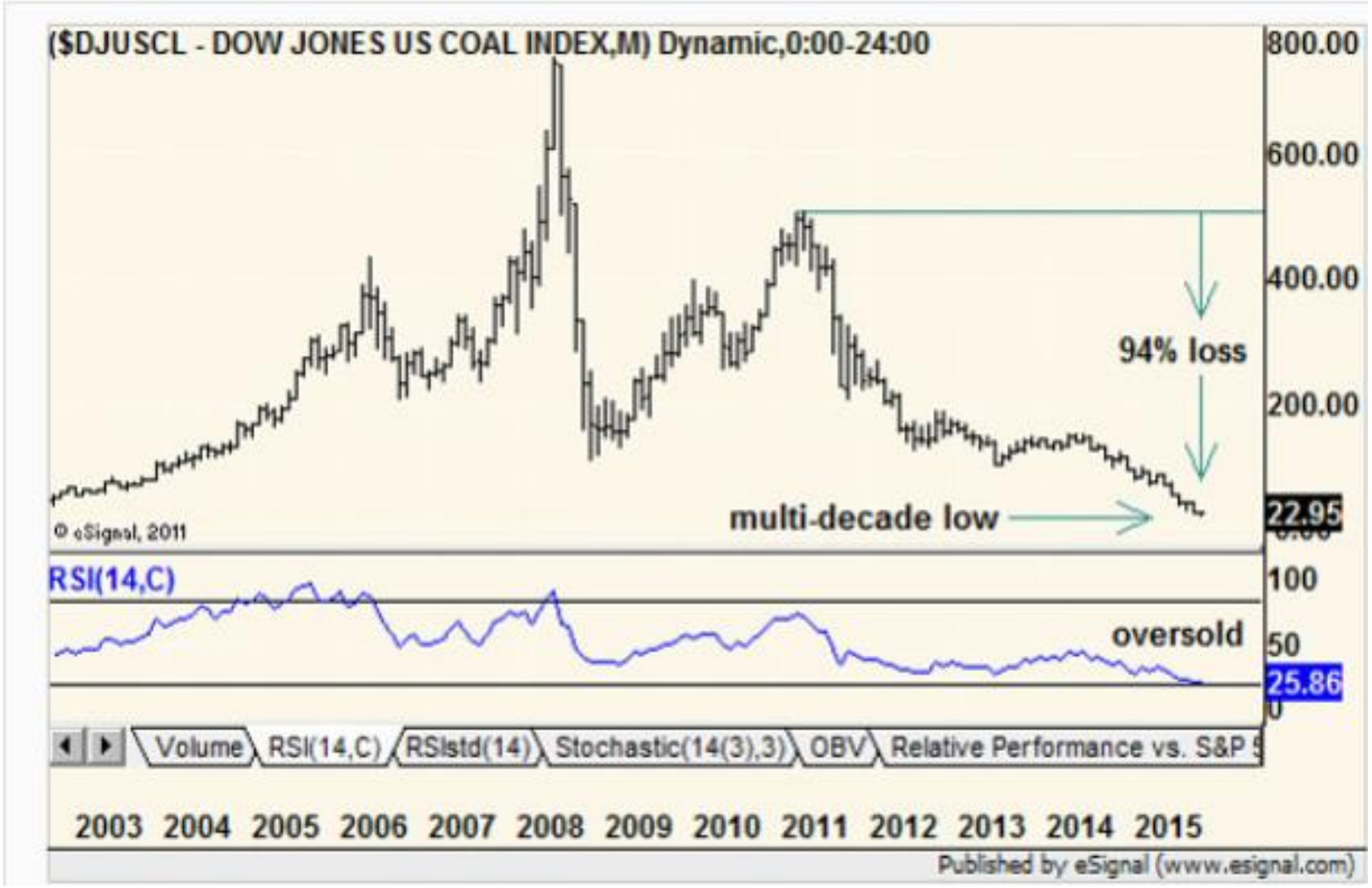
The North American Carbon Capture & Storage Association (NACCSA) is a nonprofit organization of companies in North America that support the development of a sustainable carbon dioxide (CO_2) capture use and storage (CCUS) industry in the United States and Canada. Policymakers and companies are interested 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).

Today

- **The “Trifecta” of very cheap fossil fuels**
- **CO_2 utilization**
- **CO_2 EOR**
- **Carbon**

The “Trifecta” Of Very Cheap Fossil Fuels

US Coal's Dramatic Change



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

Natgas (HH) Collapse

Historically, Natural gas reached an all time high of 15.39 in December of 2005 and a record low of 1.02 in January of 1992.

www.tradingeconomics.com/commodity/natural-gas

Crude Oil's Dramatic Crash

www.tradingeconomics.com/commodity/crude-oil

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

India Poised To Replace China As The World's Center Of Oil-demand Growth

- **3-7-16 India seen setting oil-demand growth pace**
- India is poised to replace China as the world's center of oil-demand growth, according to authors of a study published by the Oxford Institute for Energy Studies.
- As growth of Chinese oil demand slows, India's is increasing, note Amrita Sen, chief oil analyst of Energy Aspects, and Anupama Sen, senior research fellow at the Oxford Institute.
- And India's development has characteristics similar to those of China 10-15 years ago, the analysts say.
- A demand surge comparable to China's of the early 2000s would strengthen an oil market now struggling with surplus.
- **Demand trends**
- Chinese oil-demand growth has retreated to below 300,000 b/d/year from an average exceeding 500,000 b/d/year in the 10 years prior to 2015. In response to governmental efforts to rebalance the economy, China's economic growth has slowed.
- Indian oil demand, meanwhile, grew by 300,000 b/d last year after rising by 100,000-150,000 b/d/year in the previous decade.
- "This jump in demand reflects a number of underlying dynamics at play, which indicate that India's oil demand may be on the verge of 'taking off,'" write the authors.
- They add, "Indian oil demand is demonstrating trends that were visible in China around a decade or a decade and a half ago during the country's industrialization 'boom.'"
- The pace of growth in Indian demand for oil products, especially gasoline, is rapidly approaching that of China just before that country's rapid expansion.
- And India's car ownership as a function of population has reached the Chinese level of a decade ago while its per-capita income on a purchasing power parity basis has "breached the threshold beyond which motorization rapidly ensues."

www.ogj.com/articles/2016/03/india-seen-setting-oil-demand-growth-pace.html?cmpid=EnlDailyMarch72016

China Expects To Lay Off 1.8 Million Workers In Coal, Steel Sectors

- 2-29-16 China said on Monday it expects to lay off 1.8 million workers in the coal and steel industries, or about 15 percent of the workforce, as part of efforts to reduce industrial overcapacity, but no timeframe was given.
- It was the first time China has given figures that underline the magnitude of its task in dealing with slowing growth and bloated state enterprises. Yin Weimin, the minister for human resources and social security, told a news conference that 1.3 million workers in the coal sector could lose jobs, plus 500,000 from the steel sector.

- China's coal and steel sectors employ about 12 million workers, according to data published by the National Bureau of Statistics. "This involves the resettlement of a total of 1.8 million workers. This task will be very difficult, but we are still very confident," Yin said. For China's stability-obsessed government, keeping a lid on unemployment and any possible unrest that may follow has been a top priority.

- DOWNWARD PRESSURE

- The world's second-largest economy grew 6.9 percent in 2015, the weakest in 25 years, and the government aims to achieve economic growth of 6.5-7 percent in 2016. "The economy faces relatively big downward pressures and some firms face difficulties in production and operation, which would lead to insufficient employment," Yin said, adding that increasing graduates this year would also add pressure in the job market.

http://finance.yahoo.com/news/china-expects-lay-off-1-023140846.html?mkt_tok=3RkMMJWWfF9wsRoguajLdO%2FhmjTEU5z17ukkWqW3g4kz2EFye%2BLIHETpodcMSMpgM7vYDBceEJhqyQJxPr3FJNANysRuRhDgCw%3D%3D

Japan Environment Ministry's Coal Plant Reversal Casts Doubt On CO_2 Pledge

- 2-22-16 The environment ministry issued rare objections to five new coal-fired stations last year but has been pushed by the powerful industry ministry to accept voluntary steps by power companies to curb emissions.

- ***As Japan gets ready to open up its power retail market in April, companies are rushing to build 43 coal-fired plants or 20.5 gigawatt of capacity in coming years, about a 50 percent increase.***

- "Global opinion is increasingly shifting away from coal but Japan's environmental ministry is switching sides to approve new coal power plants. This runs counter to the global action," said Kimiko Hirata international director of lobby group Kiko Network.

- As part of the agreement, the Ministry of Economy, Trade and Industry is set to tighten its rules over coal-fired power stations from April 1, including issuing new non-binding requirements on the heat efficiency of new and existing plants to curb emissions.

- ***Coal is attractive because it is the cheapest fossil fuel source and prices have slumped in recent years. Japan has turned to the energy source in record amounts since the Fukushima disaster in 2011 led to the shutdown of reactors.***

- A group of 36 power companies, which supply 99 percent of the country's electricity, have also formed a new body to take measures to trim emissions and meet the industry's voluntary goal to cut emissions by 35 percent in 2030, compared with 2013.

www.reuters.com/article/us-japan-emissions-idUSKCN0VW0EV

Today: "Trifecta" of Very Cheap Fossil Fuels

IEA Program Dec 17, 2015

IMF: The Price of Oil And The Price Of Carbon

http://blog-imfdirect.imf.org/2015/12/02/the-price-of-oil-and-the-price-of-carbon/

- "The human influence on the climate system is clear and is evident from the increasing greenhouse gas concentrations in the atmosphere, positive radiative forcing, observed warming, and understanding of the climate system." —Intergovernmental Panel on Climate Change, Fifth Assessment Report

- Fossil fuel prices are likely to stay "low for long." Notwithstanding important recent progress in developing renewable fuel sources, low fossil fuel prices could discourage further innovation in and adoption of cleaner energy technologies. The result would be higher emissions of carbon dioxide and other greenhouse gases.

- ***Policymakers should not allow low energy prices to derail the clean energy transition. Action to restore appropriate price incentives, notably through corrective carbon pricing, is urgently needed to lower the risk of irreversible and potentially devastating effects of climate change.***

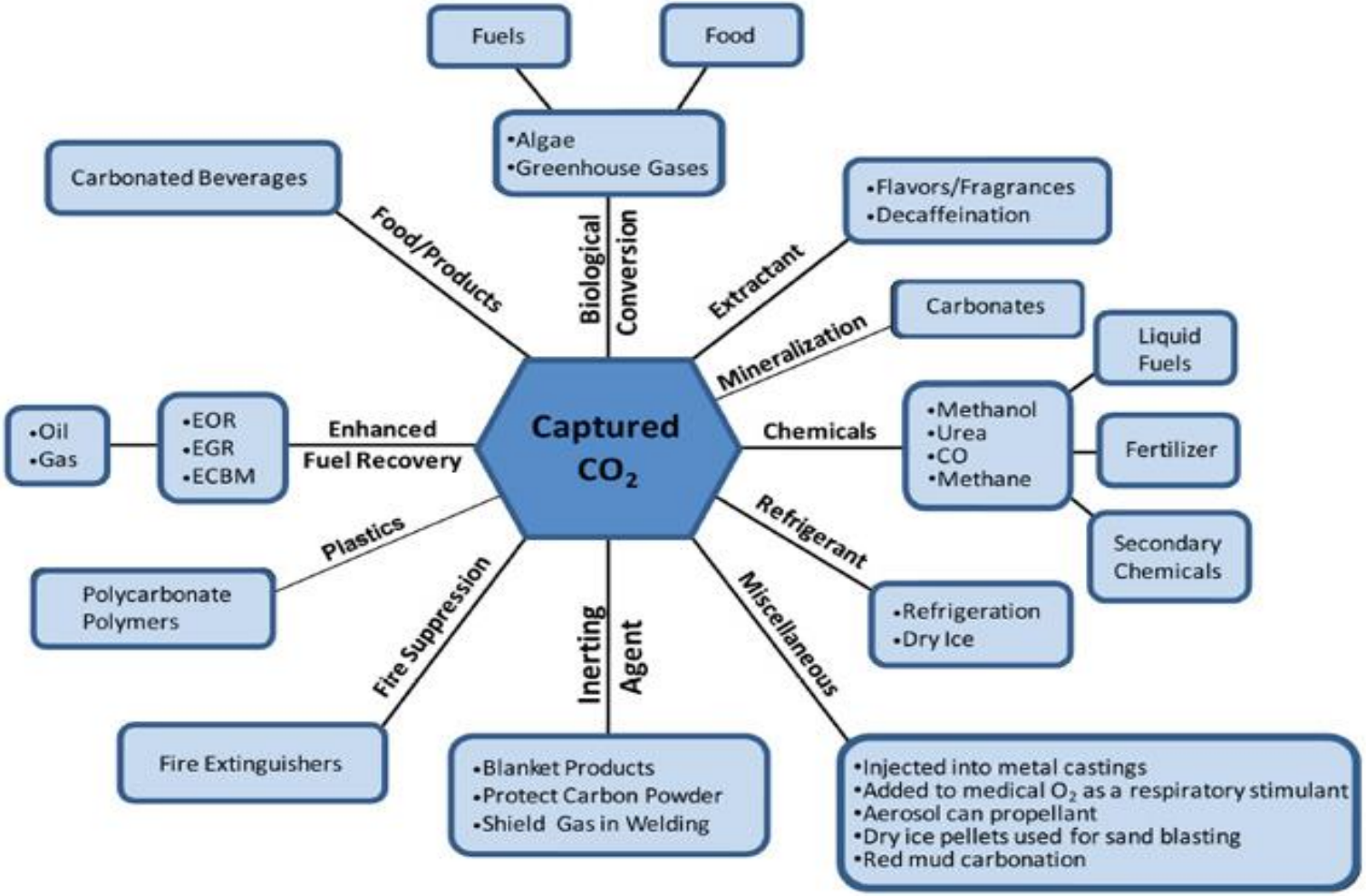
Alternative

- Innovative ways to make fossil fuels low carbon and competitive to renewables
- Pricing/policy parity
- Tax incentives
- Financing vehicles
- Feed in tariffs
- Contracts for differences

Commodity CO_2 for Utilization and EOR

- CO_2 utilization as a commodity feedstock
- Conventional mature MPZ CO_2-EOR
- CO_2-EOR in ROZ under MPZ and green field fairways
- CO_2-EOR in oil shale such as the Bakken

Physical CO_2: A Valuable Commodity

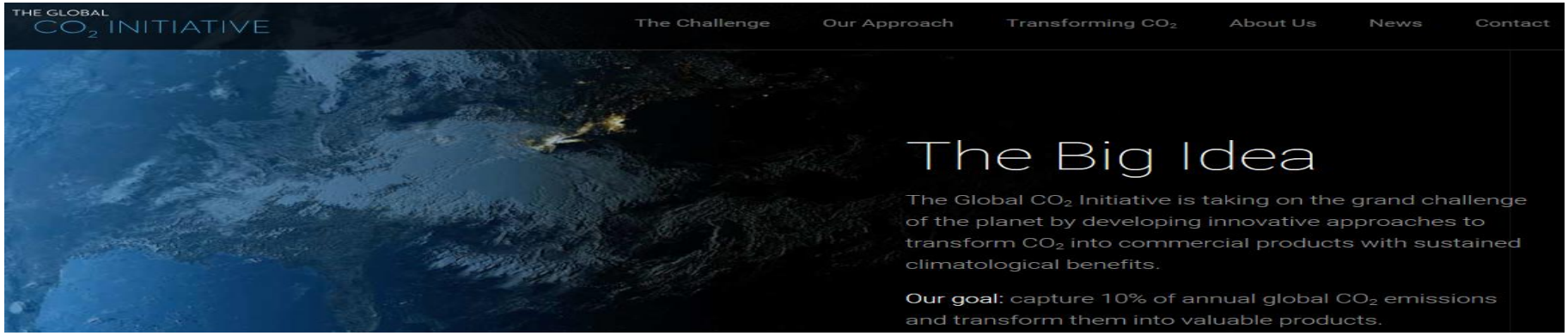


Source: www.netl.doe.gov/research/coal/carbon-storage/research-and-development/co2-utilization

CO_2 Utilization

The Global CO_2 Initiative

www.co2sciences.org/



THE GLOBAL
CO_2 INITIATIVE

Turning a Liability into an Asset

A SPECIAL INVITATION TO BE A PART OF HISTORY
AN EVENT HIGHLIGHTING HOW CO_2 CAN BE TRANSFORMED INTO AN ASSET

WHEN
Thursday, January 21, 2016 from 6:00 p.m. - 8:00 p.m.

WHERE
Rotary Room, Belvedere Hotel, Davos, Switzerland

OVERVIEW
The Global CO_2 Initiative is a market-based solution to address one of the grand challenges of our planet: the catastrophic impact of excessive CO_2 emissions in our atmosphere and oceans. By investing in innovative approaches to capture and transform CO_2 into commercial products, we believe we can create economically viable solutions that offer sustained climatological benefits.

THE NEED
Global CO_2 emissions, currently at 35 gigatons per year, continue to accelerate. At an all-time high, the atmospheric concentration and longevity of CO_2 create a multi-generational problem. Without significant intervention, the impact will be catastrophic for society and the environment. Government awareness is rising, but progress is limited and uncertain. With the COP21 agreement to target a 1.5°C global temperature rise, we urgently need a multifaceted strategy to decarbonize, adapt to the changing climate, and create new uses for existing CO_2.

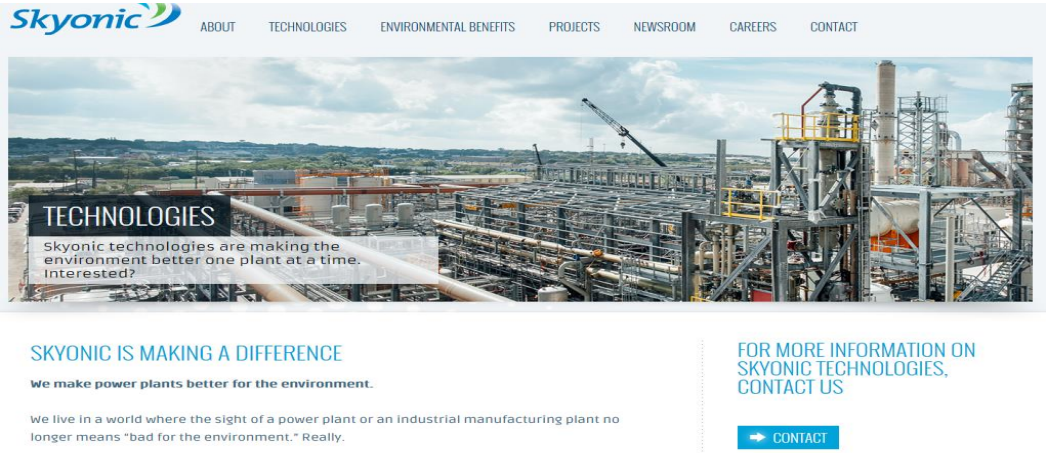
THE OPPORTUNITY
Rather than view CO_2 as a worthless and overabundant environmental hazard, the Global CO_2 initiative is taking a fresh perspective, approaching CO_2 as an asset that can be transformed into useable products for which there is current market demand. Early efforts have demonstrated that it can be transformed into many products, including bio-fuels, methanol, cement, aggregates, fertilizer, carbon fiber, plastics, food, beverages, chemicals, refrigerants, fragrances and it can be used to enhance recovery of oil. However, more scientific innovation is needed and current transformation efforts remain small and disparate. We will invest in both the science, product creation and commercialization in order to transform more CO_2 on a larger scale.

THE SESSION AT THE WORLD ECONOMIC FORUM
We invite you to attend our session at the World Economic Forum which will highlight the market-based approach we are pursuing. It will include a high level explanation of the grand challenge and findings from an exciting new global market assessment of applications for CO_2, currently being created by McKinsey & Company for the Global CO_2 Initiative.

- The Global CO2 Initiative was created to realize the ambitious goal of capturing 10% of global CO2 emissions and transforming it into valuable products.
- CO2 Sciences, Inc., our innovation platform, is designed to aggressively catalyze innovative research in carbon capture and reuse by granting $100 million per year for ten years to scientific research.
- In parallel, the Global CO2 Initiative will accelerate the commercialization of carbon capture and transformation products and services. We will partner with investment funds, joint ventures and corporations to invest in companies to enable them to grow market demand for carbon-based products.
- In order to achieve these ambitious goals, we have brought together a multidisciplinary group of the world's leading scientists and business leaders

Skyonic

www.skyonic.com/



Skyonic's three primary technologies include: SkyMine®, SkyScraper™, and SkyCycle™. These processes require less energy to remove harmful pollutants and safer ways to store carbon.

- Capitol SkyMine Plant -- Located in San Antonio, Texas, Capitol SkyMine is expected to capture 75,000 tons annually of otherwise-emitted CO2 from the coal-fired Capitol Aggregates Cement plant, and offset another 225,000 tons of annual US CO2 emissions by shipping CO2-negative chemicals to market and displacing CO2-intensive products. Our process also removes mercury, metals, sulfur dioxide, nitrogen oxides and particulate – and returns clean air and clean water.

- Capitol SkyMine produces commercially saleable products of hydrochloric acid, baking soda (sodium bicarbonate) and bleach, which can be sold through chemical off-take contracts, and generate annual revenue even without an active CO2 credit market. The project is traditionally debt-financed, fixed-price, performance bonded, and on-time and on-budget.

- The SkyMine® process requires 30% less energy use to remove CO2 than the more common amine-based CO2 capture technology, which led to the US Department of Energy awards (2009-2010) of $28 million to develop this first commercial CO2-beneficial reuse SkyMine® commercial project. It was the largest grant of six carbon-reuse projects funded through the American Recovery and Reinvestment Act and the only one completed. The Capitol SkyMine plant created more than 250 jobs during design and construction of the plant. During operation, there are permanent jobs at the plant and another 200+ permanent jobs in the general US economy. Of the permanent on-site positions, approximately 1/3rd are engineers, 1/3rd operational technicians, and 1/3rd a combination of professional management and engineers—high-paying technical jobs.

CO_2 Utilization Work in Saudi Aramco

SABIC Carbon Capture and Utilization

- Designed to compress and purify around 1,500 tonnes per day (500,000 tonnes/year)
- CO2 is pipelined through the Royal Commission of Jubail to three SABIC-affiliated companies
- Used for enhanced methanol and urea production.

Industrial Applications (Conversion)

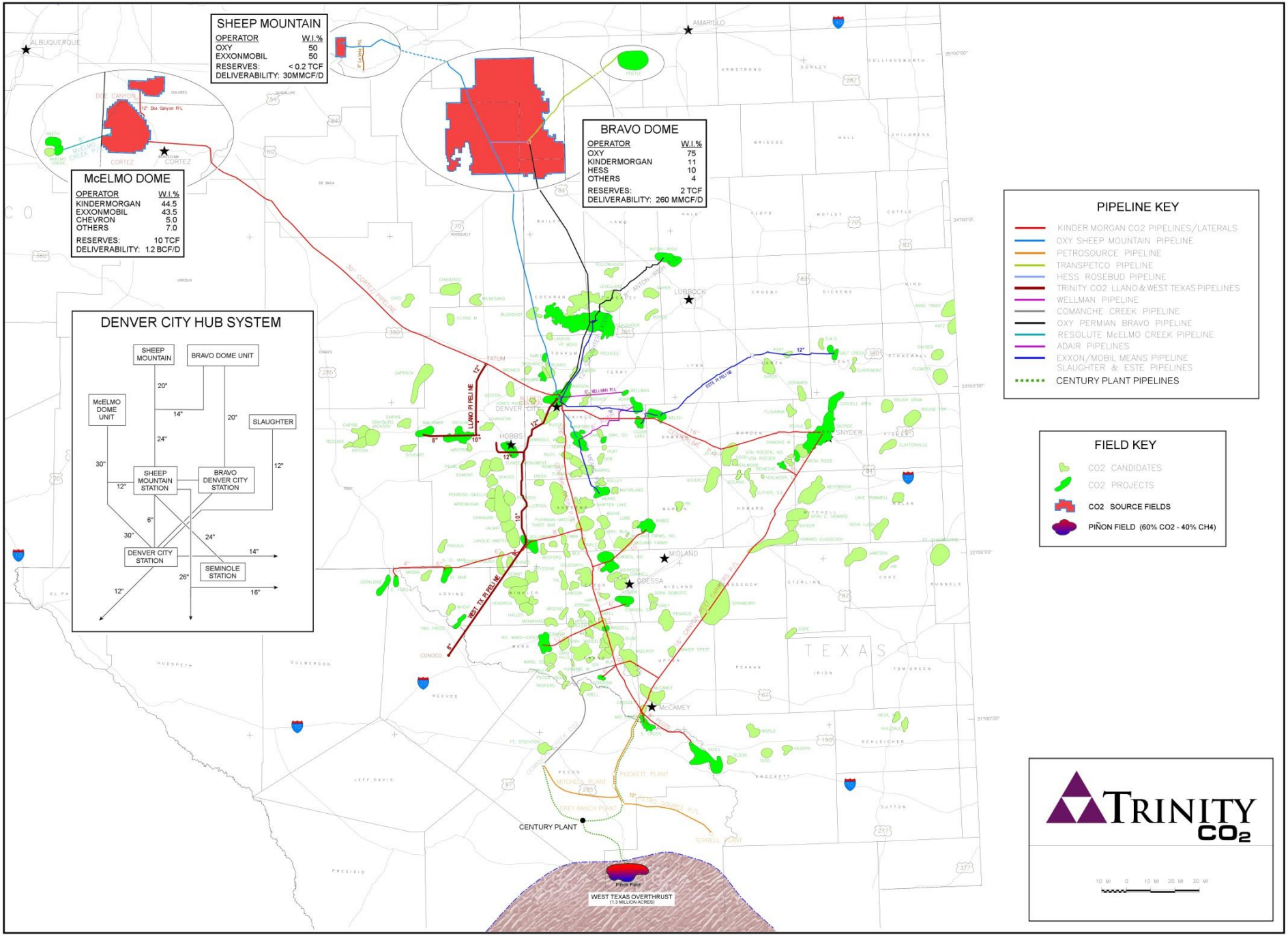
Saudi Arabia investing in CleanTech startups to convert CO2 in value added products (up to 50% CO2 in end products)

www.cslforum.org/meetings/riyadh2015/index.html

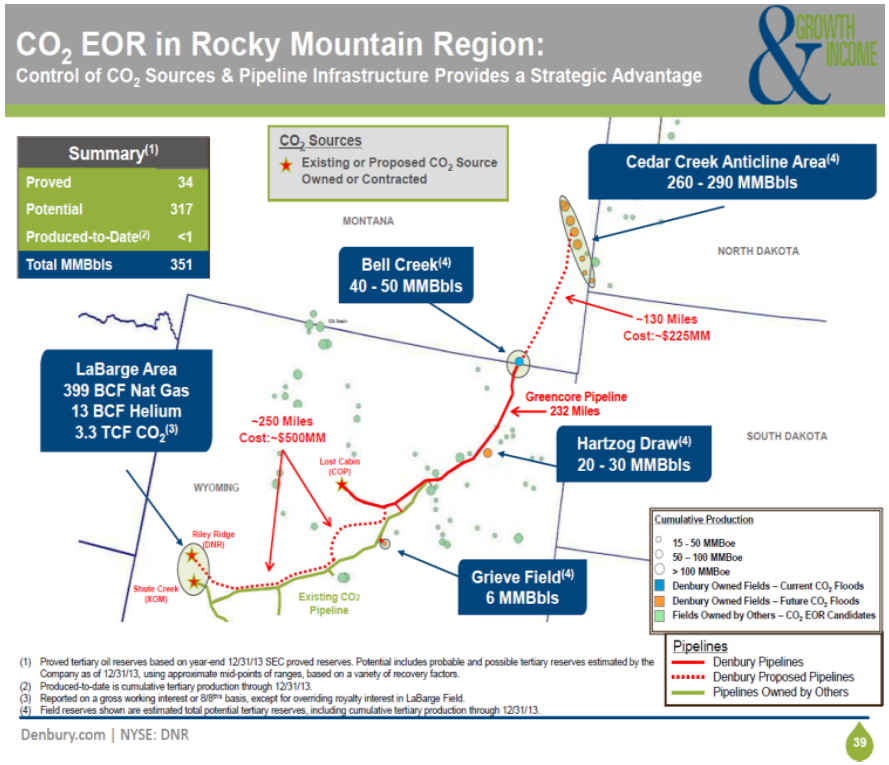
www.cslforum.org/publications/documents/riyadh2015/Meshari-SaudiArabiaCCSOverview-TG-Riyadh1115.pdf

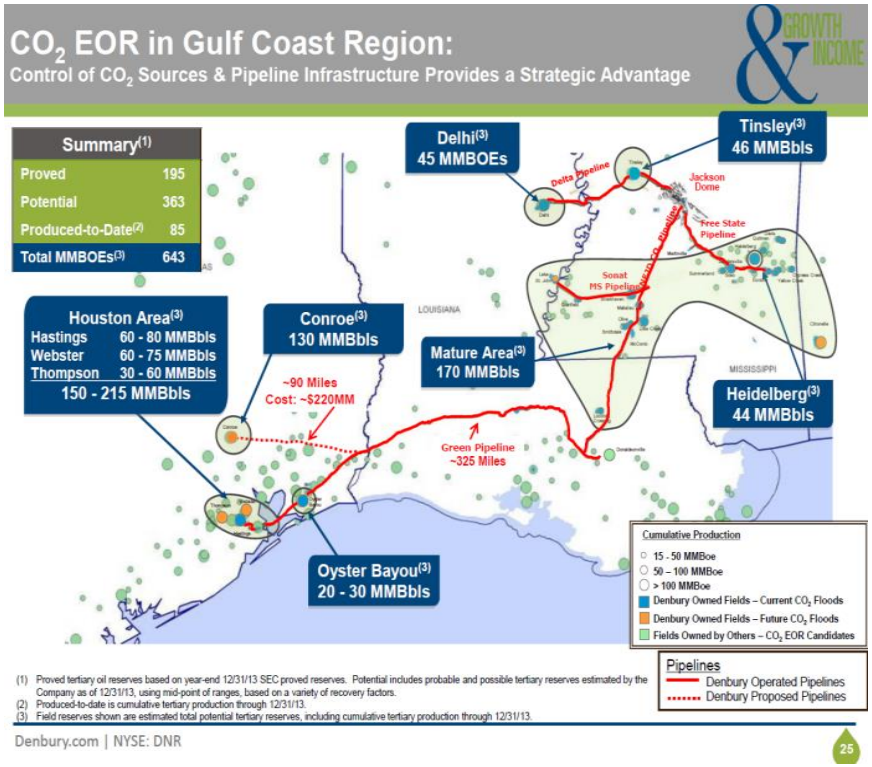
CO_2 EOR

- Conventional mature MPZ CO_2-EOR
- CO_2-EOR in ROZ under MPZ and green field fairways
- CO_2-EOR in oil shale such as the Bakken


SHEEP MOUNTAIN
OPERATOR W.I.%
OXY 50
EXXONMOBIL 50
RESERVES: < 0.2 TCF
DELIVERABILITY: 30MMCF/D
McELMO DOME
OPERATOR W.I.%
KINDERMORGAN 44.5
EXXONMOBIL 43.5
CHEVRON 5.0
OTHERS 7.0
RESERVES: 10 TCF
DELIVERABILITY: 1.2 BCF/D
BRAVO DOME
OPERATOR W.I.%
OXY 75
KINDERMORGAN 11
HESS 10
OTHERS 4
RESERVES: 2 TCF
DELIVERABILITY: 260 MMCF/D
DENVER CITY HUB SYSTEM
SHEEP MOUNTAIN
BRAVO DOME UNIT
McELMO DOME UNIT
SLAUGHTER
SHEEP MOUNTAIN STATION
BRAVO DENVER CITY STATION
DENVER CITY STATION
SEMINOLE STATION
PIPELINE KEY
KINDER MORGAN CO2 PIPELINES/LATERALS
OXY SHEEP MOUNTAIN PIPELINE
PETROSOURCE PIPELINE
TRANSPETCO PIPELINE
HESS ROSEBUD PIPELINE
TRINITY CO2 LLANO & WEST TEXAS PIPELINES
WELLMAN PIPELINE
COMANCHE CREEK PIPELINE
OXY PERMIAN BRAVO PIPELINE
RESOLUTE McELMO CREEK PIPELINE
ADAIR PIPELINES
EXXON/MOBIL MEANS PIPELINE
SLAUGHTER & ESTE PIPELINES
CENTURY PLANT PIPELINES
FIELD KEY
CO2 CANDIDATES
CO2 PROJECTS
CO2 SOURCE FIELDS
PIÑON FIELD (60% CO2 - 40% CH4)
CENTURY PLANT
Pinon Field
WEST TEXAS OVERTHRUST
(1.3 MILLION ACRES)
TRINITY CO2
ALBUQUERQUE
AMARILLO
LUBBOCK
MIDLAND
ODESSA
McCAMEY
DENVER CITY
HOBBS
SNYDER
TEXAS

Wyoming and US Gulf Coast

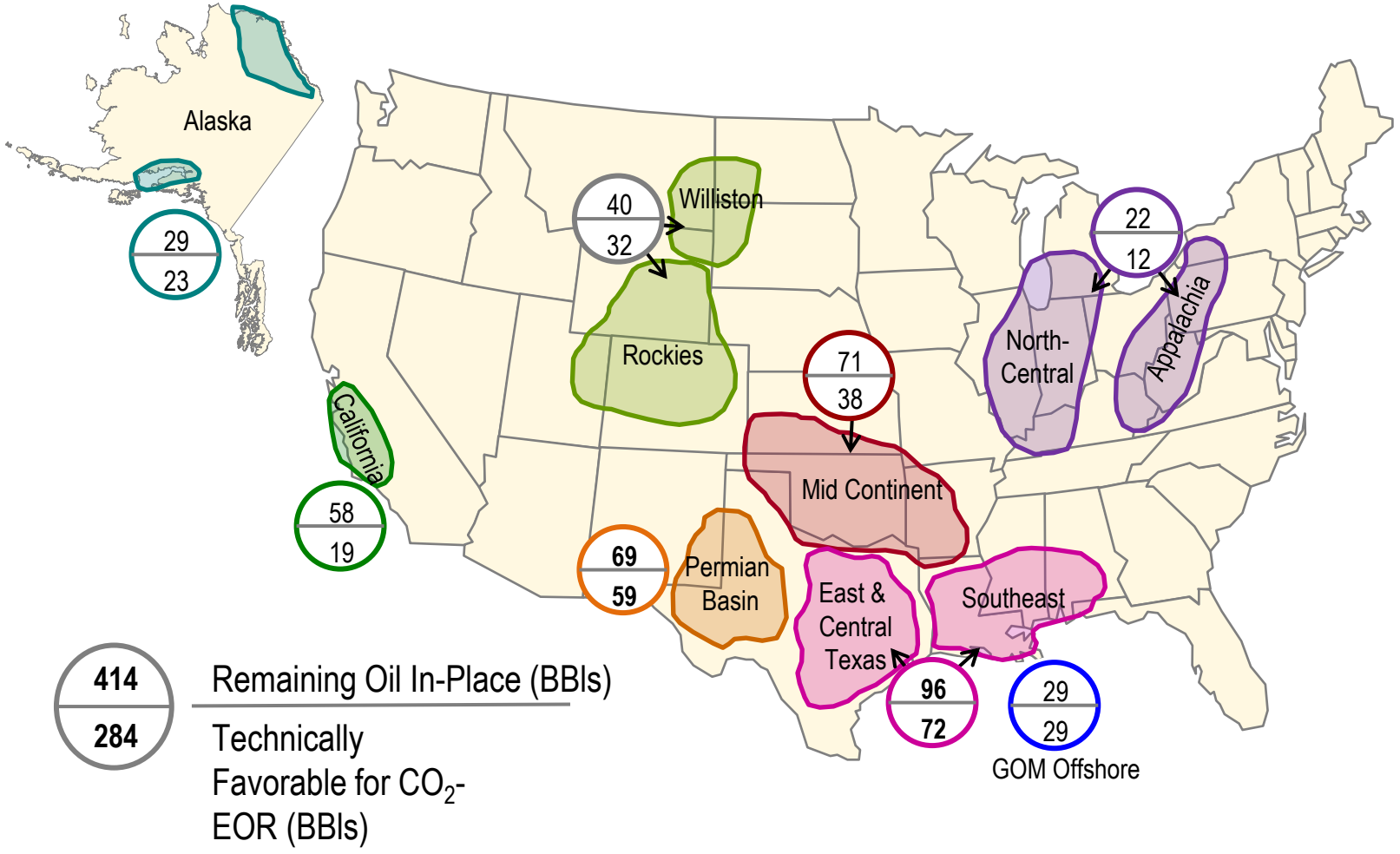




www.denbury.com/files/2014-11%20UPLOADS/2014-11-Analyst-Day-FINAL.pdf

The Regional CO_2-EOR Targets

Much of the domestic oil resource favorable for CO_2-EOR is in the Permian Basin, Gulf Coast and East/Central Texas.



Presentation on "ROZ" December 8th 2015 CO_2 Conference Week Midland, TX

Office Locations
Washington, DC
4501 Fairfax Drive, Suite 910
Arlington, VA 22203
Phone: (703) 528-8420

Houston, Texas
11931 Wickchester Ln., Suite 200
Houston, TX 77043-4574
Phone: (281) 558-9200

Cincinnati, Ohio
1282 Secretariat Court
Batavia, OH 45103
Phone: (513) 460-0360

Acknowledgements

This study, entitled **"Defining an Overlooked Domestic Oil Resource: A Four-County Appraisal of the San Andres Residual Oil Zone (ROZ) "Fairway" of the Permian Basin",** draws on the extensive geological and log analyses performed by Advanced Resources International, in partnership with the University of Texas of the Permian Basin (Dr. Robert Trentham) and Melzer Consulting (Mr. Steve Melzer), sponsored by the Research Partnership to Secure Energy for America (RPSEA).

The geological work for the four-county ROZ "fairway" study area, sponsored by RPSEA, has been combined with the reservoir engineering and economics analyses work for the study area performed by Advanced Resources International, sponsored by the U.S. DOE National Energy Technology Laboratory.

The Size of the "Main Pay" CCUS "Prize"

- With "Current Technology," the economically viable* oil recovery and demand for CO_2 from the main pay of domestic oil fields (lower-48) is:
  - 22 billion barrels of crude oil
  - 9 billion metric tons of CO_2
- Use of "Next Generation" technologies increases these values to:
  - 78 billion barrels of crude oil
  - 26 billion metric tons of CO_2
- This demand for CO_2 is equal to CO_2 capture from 45 to 130 GWs of coal-fired power.

Oil Recovery and CO_2 Demand: Current and "Next Generation" EOR Technology

Resource Area	Economic Oil Recovery (BBbls)*		Demand for Purchased CO_2 (Billion Metric Tons)	
	Current Tech.	Next Gen. Tech.	Current Tech.	Next Gen. Tech.
Lower-48, Onshore	21	63	9	21
Lower-48, Offshore	1	15	**	5
Total	**22**	**78**	**9**	**26**

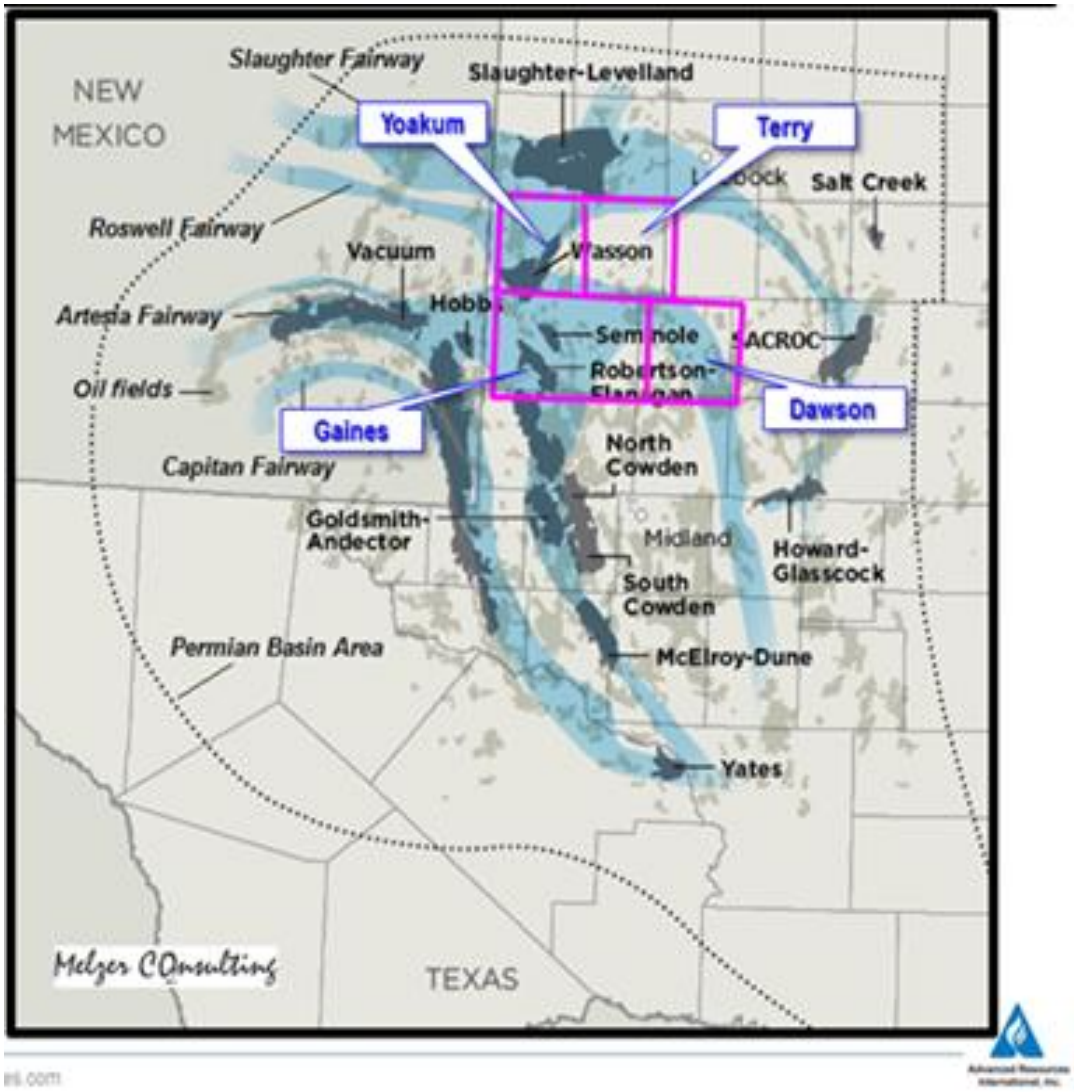
*At oil prices of $80 to $90/B, CO2 costs of $36 to $40/mt and 20% ROR (before tax).
**Less than 0.5 Bmt.

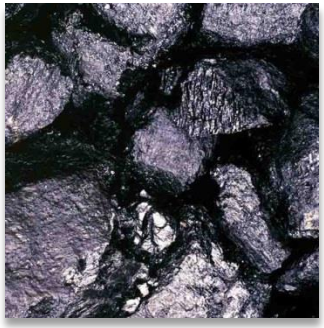
Residual Oil Zone ("ROZ") Four Counties >100 billion Bbls Oil in Place

- DOE sponsored four county assessment indicates that over 100 billion barrels of oil in-place in the ROZ "Fairway".
- Work is required to establish its recoverability, economic feasibility and CO_2 requirements. (Four county study released in December 2014)
- Follow on study of additional 10 counties initiated.

- So far ROZ also present in: Australia, North Sea, Wyoming..

- The catch-CO_2 is needed to produce the oil.



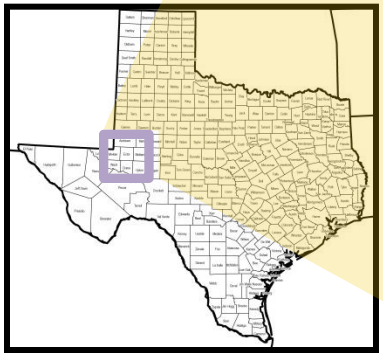


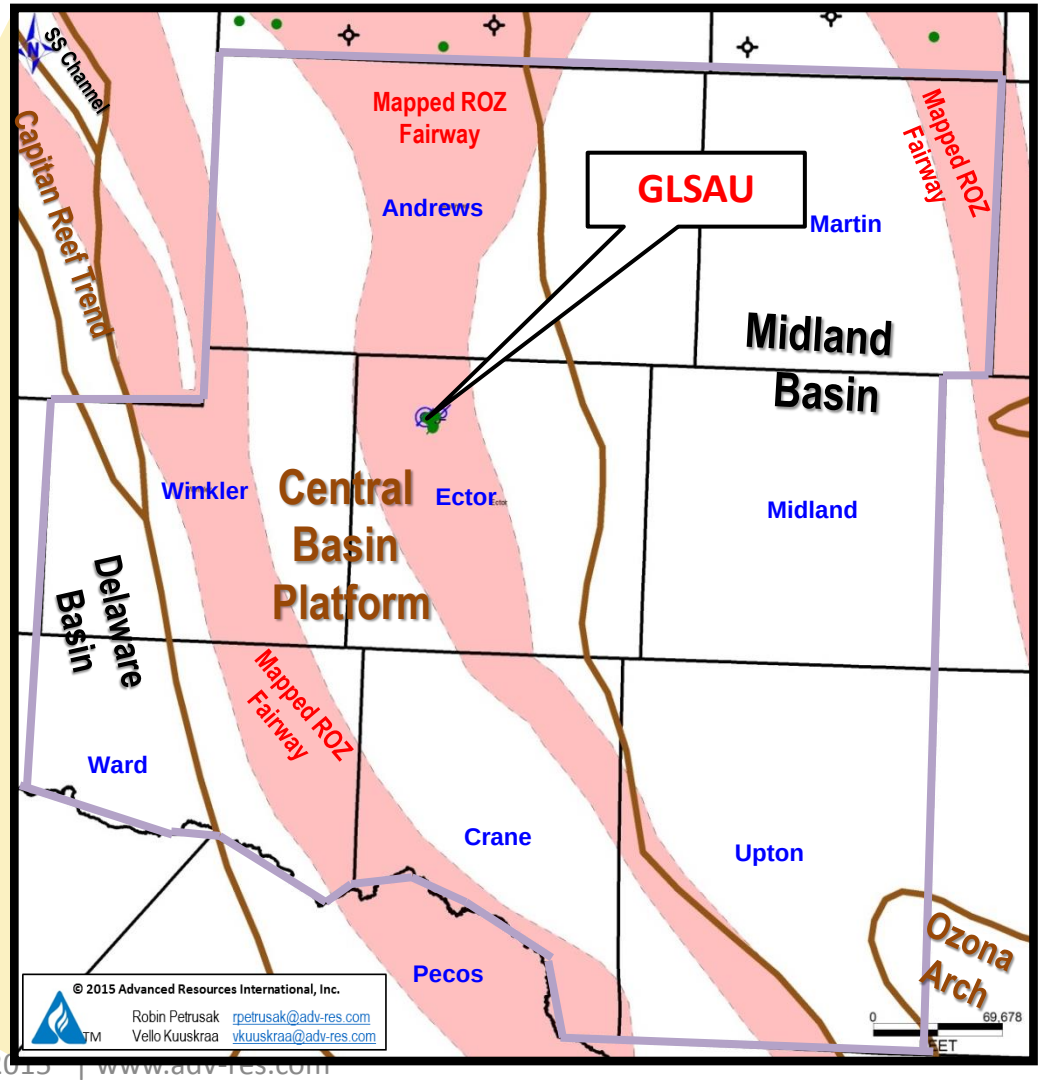
Overview of the Eight County ROZ Resource Assessment December 8th 2015

Eight County Study Area of Permian Basin ROZ "Fairway"

We recently extended the San Andres ROZ "fairway" resource assessment to eight additional Permian Basin counties - - Andrews, Martin, Winkler, Ector, Midland, Ward, Crane and Upton.

- The study used an extensive set of log- and core-based reservoir data to estimate the size of the ROZ oil in-place.
- Data were assembled for wells both inside and outside the currently mapped ROZ "fairway" boundaries.
- The Goldsmith-Landreth San Andres Unit (GLSAU) provided valuable core data for calibrating the log-based San Andres ROZ resource assessment.





Results of Eight County ROZ "Fairway" Resource Assessment

Our detailed analysis of 155 study area logs (with 121 log-based data points used in the quantitative portion of the resource assessment) identifies 79 billion barrels of San Andres ROZ oil in-place in this expanded eight county area:

- Nearly three-quarters of this San Andres ROZ resource, 58 billion barrels, is higher quality, with porosity greater than 8% and oil saturation greater than 25%.
- The remainder of the San Andres ROZ resource, 21 billion barrels, is lower quality, with porosity less than 8% and oil saturation less than 25%.
- Significant portions of the eight county area, including much of the Midland County, contain Grayburg Formation ROZ "fairway" resources.
- The technically recoverable and economically viable portion of this second ROZ resource has yet to be determined.

Is That All There Is?

The San Andres ROZ "fairways" of the Permian Basin are but one of a much larger set of ROZ resources. Additional potential exists:

1. In the ROZ interval below existing oil fields, excluded from this ROZ "fairway" study.
2. In ROZ intervals in the Grayburg and Glorieta formations of the Permian Basin.
3. In other basins, such as the Big Horn and Williston, with confirmed ROZ presence.
4. In numerous international basins and oil fields - - Australia, the Middle East, South America and Lithuania.

Concluding Thoughts

Utilization of CO_2 for enhanced oil recovery, the "U" in CCUS, is a key component of essentially all major CO_2 capture and storage projects:

- Summit Power's Texas Clean Energy IGCC project
- Petra Nova's (NRG & JX Nippon) WA Parish Post-Combustion project
- Saskpower's Boundary Dam Post Combustion project
- Southern Company's Kemper County IGCC project

With the addition of ROZ resource, the CO_2-EOR market is sufficiently large to serve as the primary storage option for captured CO_2 emissions.

The revenues from the sale of CO_2 combined with potential incentives (tax credits) of $30 to $40/mt ("son of 45Q") would enable a large number of additional coal-fired electric power plants to undertake CO_2 capture, helping keep coal- and natural gas-fired power generation part of the energy mix while revitalizing the CO_2-EOR industry.

Presentation on Bakken December 8th 2015 CO_2 Conference Week Midland, TX

Latest Developments to Examine the Use of CO_2 and Ethane for EOR in the Bakken and Williston Basin Conventional Reservoirs

13th Annual (2015) EOR Carbon Management Workshop
Midland, Texas
December 8, 2015

John Harju
Vice President for Strategic Partnerships

Contact Information

Energy & Environmental Research Center
University of North Dakota
15 North 23rd Street, Stop 9018
Grand Forks, ND 58202-9018

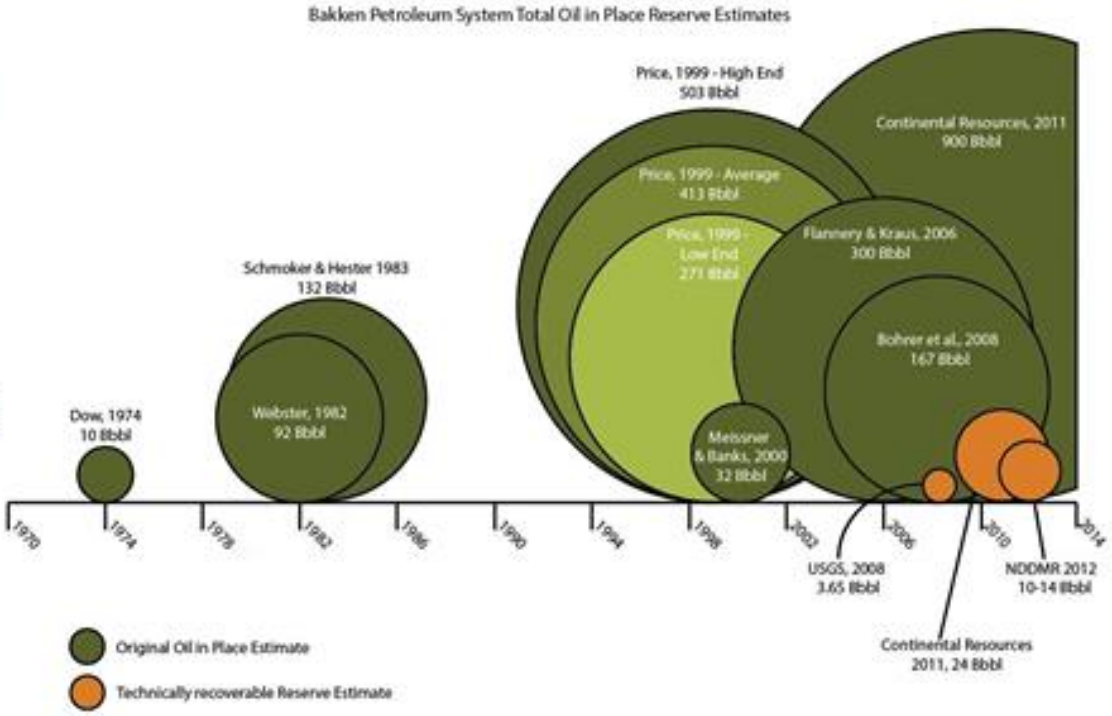
World Wide Web: **www.undeerc.org**
Telephone No. (701) 777-5157
Fax No. (701) 777-5181

John Harju, Vice President for Strategic Partnerships
jharju@undeerc.org

EERC

How Do We Get More Oil Out of the Bakken?

- The more we understand about the Bakken petroleum system, the more oil we recognize in it.
- Currently, only a 3%–5% recovery factor.
- Small improvements in recovery yield billions of barrels of oil.
- **Can CO_2, or other gases, be a game changer in the Bakken?**

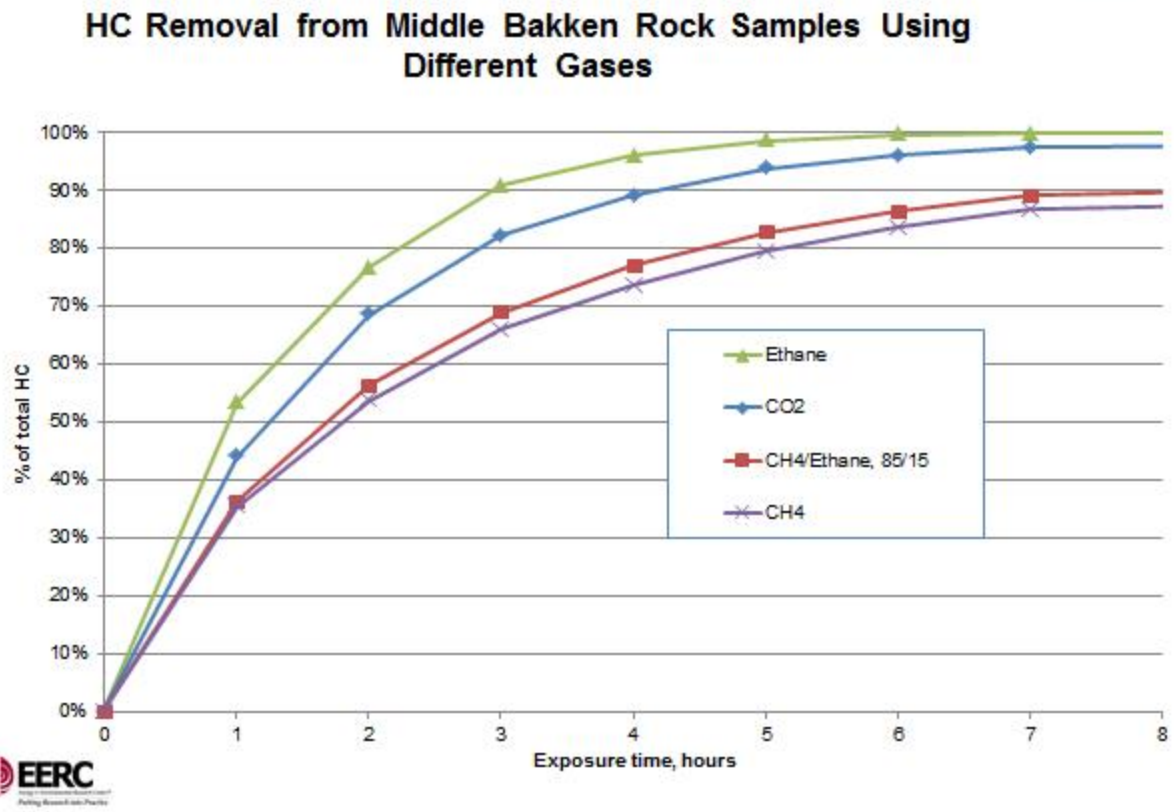


As a Commodity to Enhance Oil Recovery

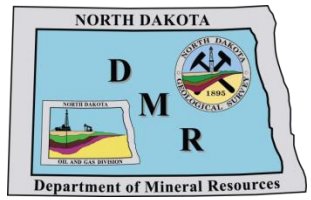
EERC

CO_2, CO_2 + Ethane, Ethane…for EOR

How Do Other Fluids Compare to CO_2 for Getting Oil Out of the Bakken?



Partners in EERC's Bakken Research Efforts



Expertise/Developers Exists for CCUS CO_2-EOR Development

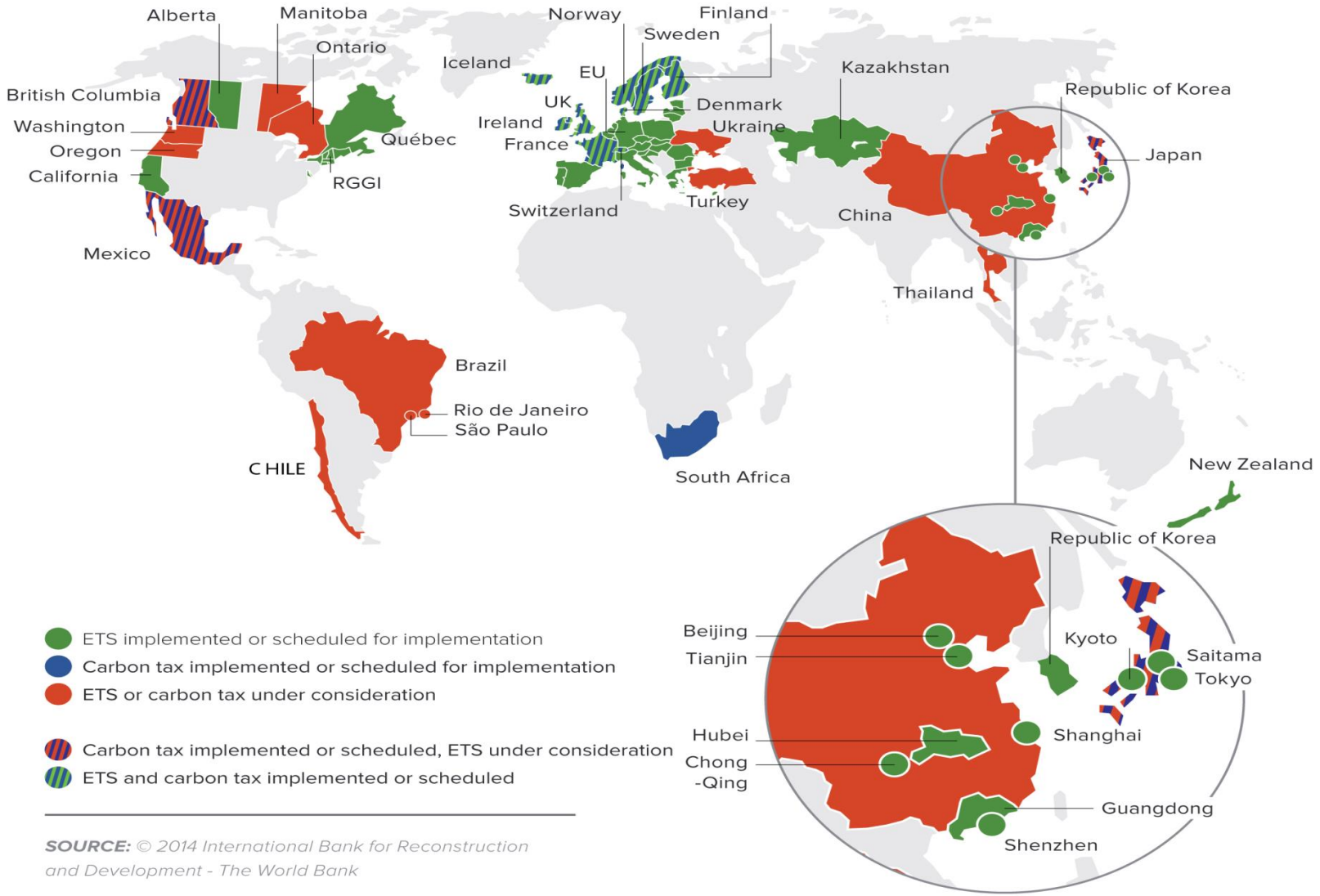
Status	Project	Site	Volume CO2 (Mt)	Start Date	Type	Pipeline Length (km)
Operate	Air Products Steam Methane Reformer EOR	USA	1	2013	Hydrogen	101-150
Operate	Century Plant	USA	8.4	2010	Natural Gas	69
Operate	Coffeyville Gasification Plant	USA	1	2013	Fertiliser	112
Operate	Enid Fertilizer CO2 EOR	USA	0.7	1982	Fertiliser	225
Operate	Great Plains Synfuel Plant & Weyburn-Midale	CAN	3	2000	SynGas	315
Operate	Lost Cabin Gas Plant	USA	0.8-1.0	2013	Natural Gas	N/S
Operate	Petrobras Lula Oil Field CCS	BRZ	0.7	2013	Natural gas	On-Site
Operate	Shute Creek Gas Processing Facility	USA	7	1986	Natural Gas	403
Operate	Val Verde Natural Gas Plants	USA	1.3	1972	Natural Gas	132
Execute	Alberta Carbon Trunk Line ("ACTL") with Agrium CO2 Stream	CAN	0.4-0.6	2015	Fertiliser	240
Execute	Alberta Carbon Trunk Line ("ACTL") with North West Sturgeon Refinery CO2 Stream	CAN	1.2-1.4	2016	Oil Refining	240
Execute	Boundary Dam Integrated CCS Demonstration	CAN	1	2015	Power Gen.	100
Execute	Kemper County IGCC	USA	3.5	2016	Power Gen.	75
Execute	Uthmaniyah CO2 EOR Demonstration	Saudi Arabia	0.8	2015	Natural gas	70

Carbon

In 2013---Turning Point

November 7th 2013'Unburnable' carbon fuels investment concerns-Investors group with €7.3 trillion 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

International Carbon Markets



http://newclimateeconomy.report/economics-of-change

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.

Norway Confirms $900bn Sovereign Wealth Fund's Major Coal Divestment May 27th, 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

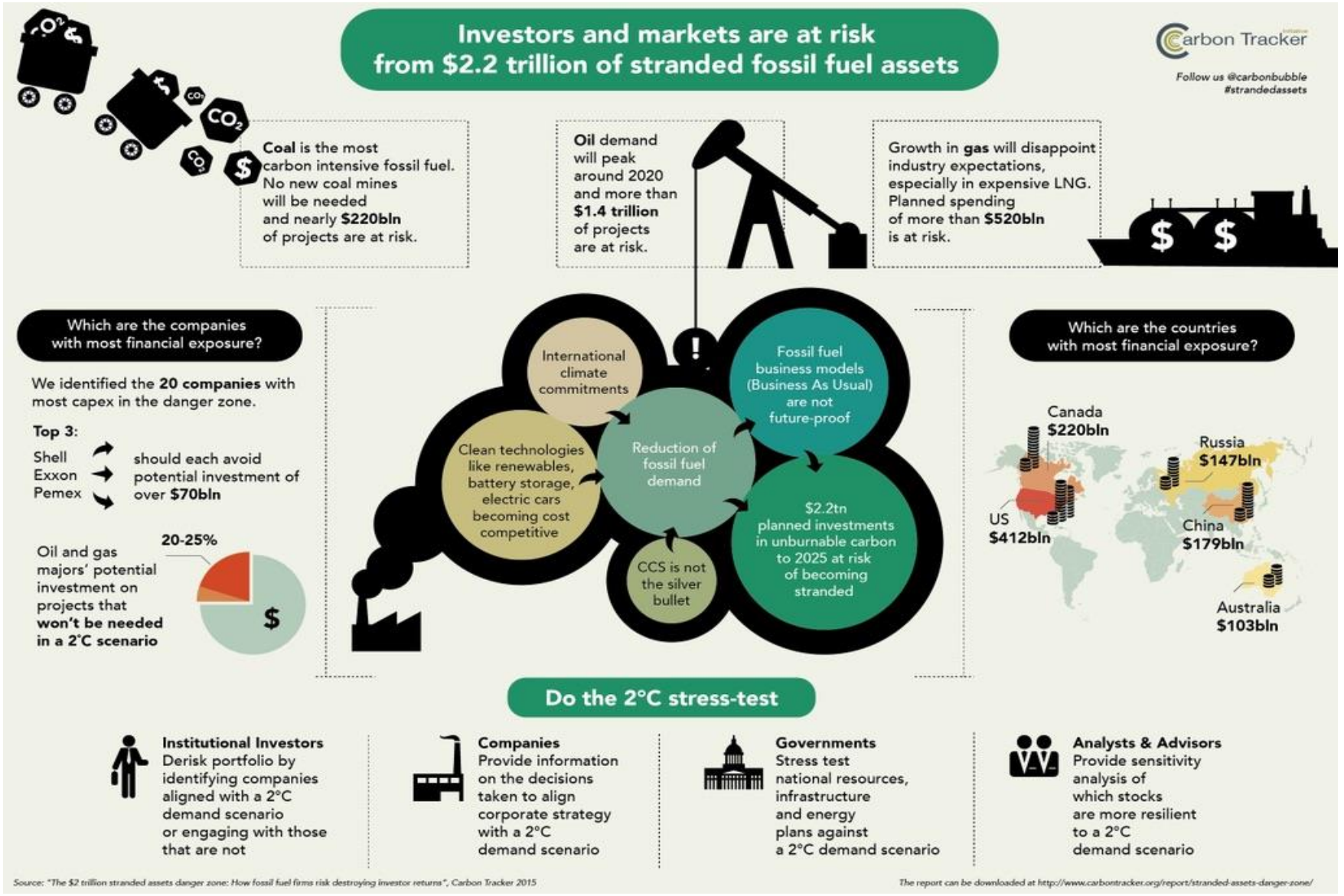
Historic Paris Agreement on Climate Change

195 Nations Set Path to Keep Temperature Rise Well Below 2 Degrees Celsius

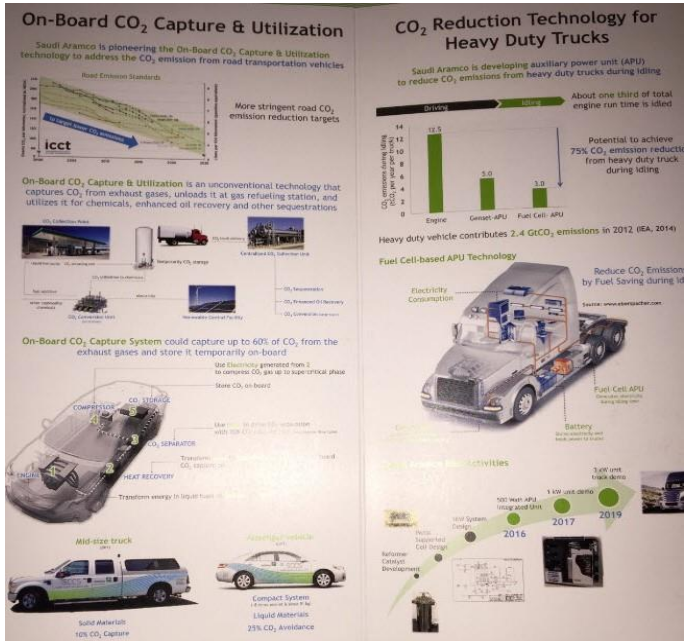
What does "de-carbonization of energy (fossil fuels) by 2050….." mean?

http://newsroom.unfccc.int/paris/

$2.2 Trillion Fossil Fuel Assets At Risk



Saudi Aramco and Mobile Sources CO_2 Capture



Solid Materials
10% CO2 Capture

Liquid Materials
25% CO2 Avoidance

- Oil does not emit CO_2
- But our customer's customers do..
- So we have given them the option to capture their CO_2 if they want to…

أرامكو السعودية
saudi aramco

www.cslforum.org/publications/documents/riyadh2015/Meshari-SaudiArabiaCCSOverview-TG-Riyadh1115.pdf

LCA CCUS

How Green is My Oil?
A Detailed Look at Carbon Accounting for CO_2-EOR Sites

Nicholas A. Azzolina and David V. Nakles (The CETER Group, Inc.)
Wesley D. Peck, John A. Hamling, and Charles D. Gorecki (EERC)
L. Stephen Melzer (Melzer Consulting)

Presented at the
21st Annual CO_2 Flooding Conference

December 8, 2015

Midland, Texas

Given 12-8-15 Midland Texas CO_2 Conference Week on the "Life Cycle Analysis of CO_2-EOR/CCUS

Questions & Thank You!

Michael E. Moore

- **VP Energy Commodities and Advisory Services**
- **FearnOil Inc. (a division of Astrup-Fearnleys)**
- **http://astrupfearnley.no/**

- **Executive Director**
- **North American Carbon Capture Storage Association**
- **www.naccsa.org**

- **mmoore@fearnoil.com Tel: 281-759-0245**

FearnOil Inc. Astrup Fearnley NACCSA North American Carbon Capture & Storage Association

Mississippi Power Kemper IGCC Project

http://www.mississippipower.com/kemper/docs/Q4_2013KemperProgressReport.pdf

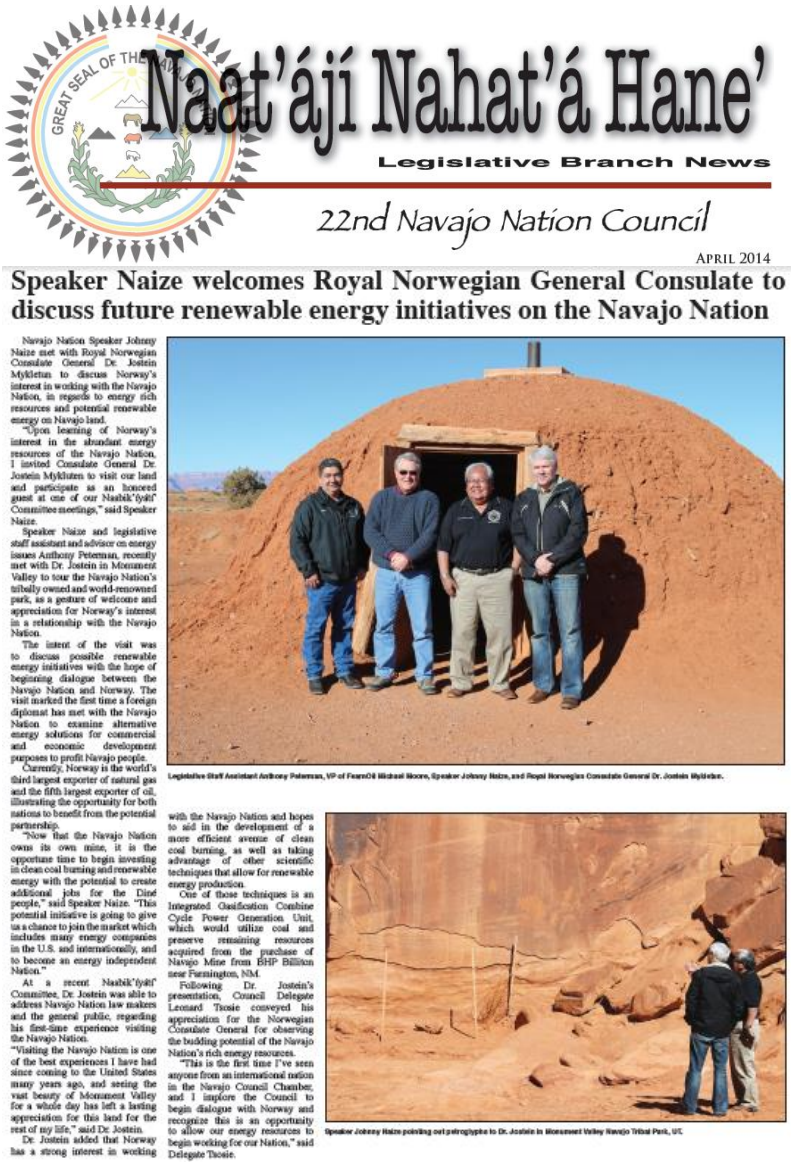
Aerial view of the facility taken in October 2013.

Tord Lien (left), Norweigan Energy Minister, meets Southern Company President and CEO Tom Fanning (right) and Mississippi Power President and CEO Ed Holland.

- 582-megawatt integrated gasification combined-cycle (IGCC) power plant in Kemper County uses lignite
- ~98% complete-only commercial scale CCUS power project in the US
- CO_2 going for EOR and utilization
- Visited on January 22nd 2015 the power block was operational and running delivering power to the grid in Mississippi-full system up fall 2016

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_2 would move to the Permian Basin for EOR.***



Naat'áji Nahat'á Hane'

Legislative Branch News

22nd Navajo Nation Council

APRIL 2014

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 Consulate General Dr. Jostein Mykletun to discuss Norway's interest in working with the Navajo Nation, in regards to energy rich resources and potential renewable energy on Navajo land.

"Upon learning of Norway's interest in the abundant energy resources of the Navajo Nation, I invited Consulate General Dr. Jostein Mykluten to visit our land and participate as an honored guest at one of our Naabik'íyáti' Committee meetings," said Speaker Naize.

Speaker Naize and legislative staff assistant and advisor on energy issues Anthony Peterman, recently met with Dr. Jostein in Monument Valley to tour the Navajo Nation's tribally owned and world-renowned 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 dialogue between the Navajo Nation and Norway. The visit marked the first time a foreign diplomat has met with the Navajo Nation to examine alternative energy solutions for commercial and economic development purposes to profit Navajo people.

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 opportune time to begin investing in clean coal burning and renewable energy with the potential to create additional jobs for the Diné people," said Speaker Naize. "This potential initiative is going to give us a chance to join the market which includes many energy companies in the U.S. and internationally, and to become an energy independent Nation."

At a recent Naabik'íyáti' Committee, Dr. Jostein was able to address Navajo Nation law makers and the general public, regarding his first-time experience 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, and seeing the vast beauty of 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 with the Navajo Nation and hopes 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 production.

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.

Following Dr. Jostein's presentation, Council Delegate Leonard Tsosie conveyed his appreciation for the Norwegian Consulate General for observing the budding potential of 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, and I implore the Council to begin dialogue with Norway and recognize this is an opportunity to allow our energy resources to begin working for our Nation," said Delegate Tsosie.

Legislative Staff Assistant Anthony Peterman, VP of FearnOil Michael Moore, Speaker Johnny Naize, and Royal Norwegian Consulate General Dr. Jostein Mykletun.

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

China's NDRC and CO_2-EOR/CCUS

CSLF Pre-Paris Meeting

Carbon Sequestration Leadership Forum

www.cslforum.org

6th CSLF Ministerial Meeting

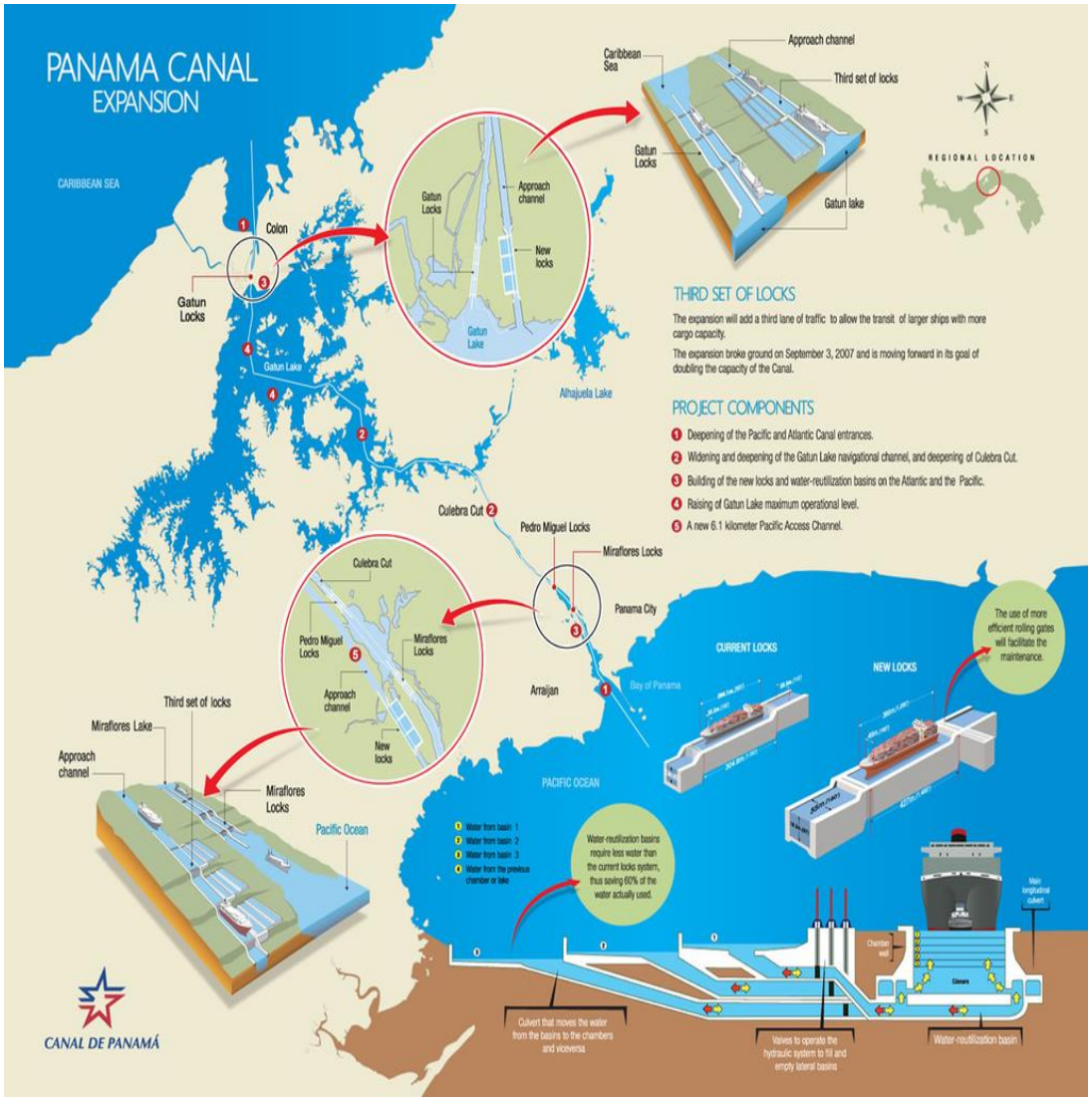
Riyadh, Kingdom of Saudi Arabia

01-05 November 2015

	Sunday 01 November 2015	Monday 02 November 2015	Tuesday 03 November 2015	Wednesday 04 November 2015	Thursday 05 November 2015
Morning		CSLF Technical Group Meeting	CSLF Policy Group Meeting CSLF Stakeholders Meeting *(continues)*	Ministerial Conference and Roundtable	Visit to Saudi Aramco's Dhahran Facility *(intended for Ministers and Heads of Delegations only)*
Afternoon	Task Force Meetings	CSLF Technical Group Meeting *(continues)* CSLF Stakeholders Meeting	CSLF Policy Group Meeting *(continues)*	Ministerial Conference and Roundtable *(continues)*	Visit to Dhahran *(continues)*
Evening		Dinner		Dinner	

Other Areas to Watch

Panama Canal Expansion ~2016



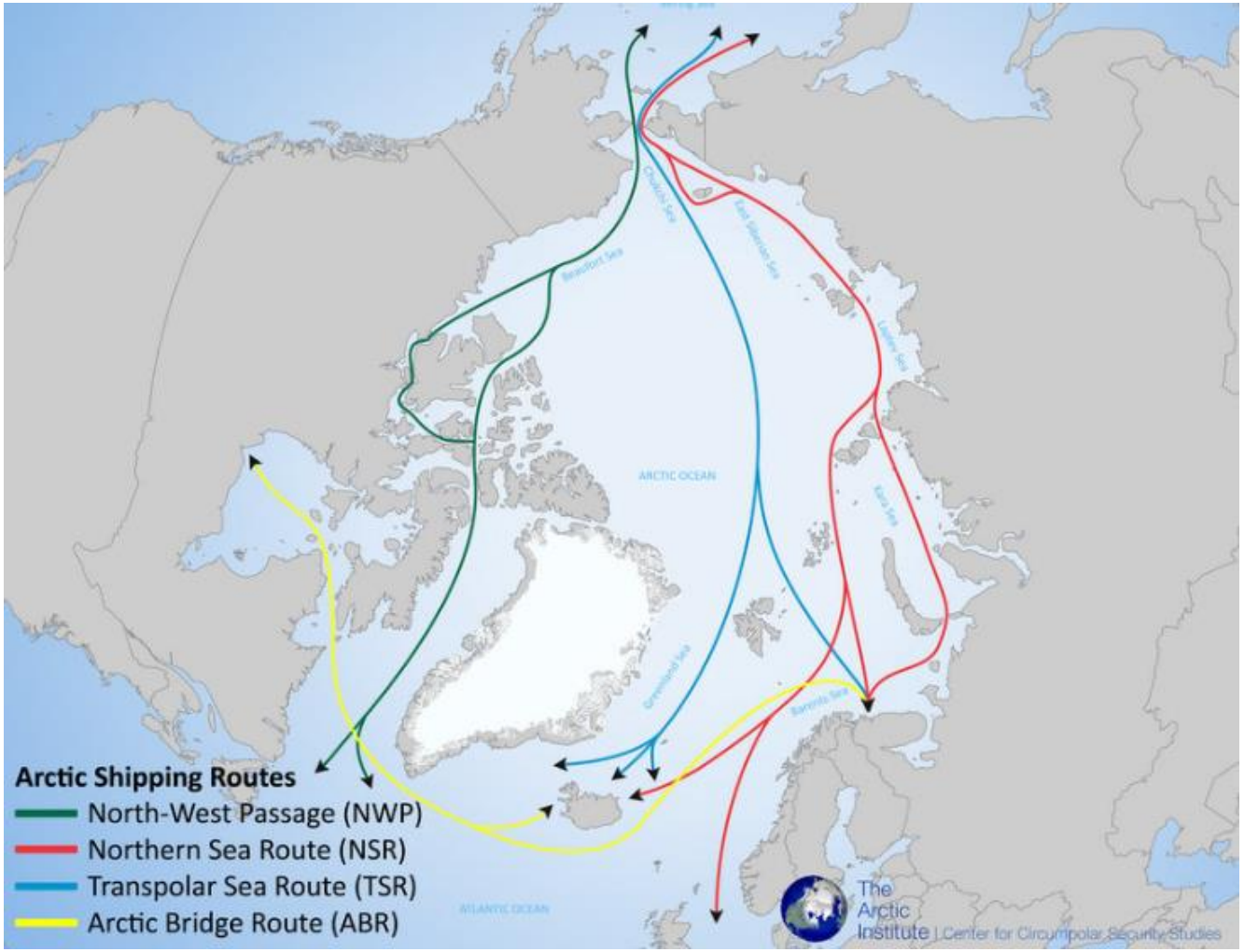
http://micanaldepanama.com/expansion/
http://micanaldepanama.com/expansion/faq/#prettyPhoto

Chinese Backed "Nicaragua Interoceanic Grand Canal"

Dec 22, 2014 Groundbreaking

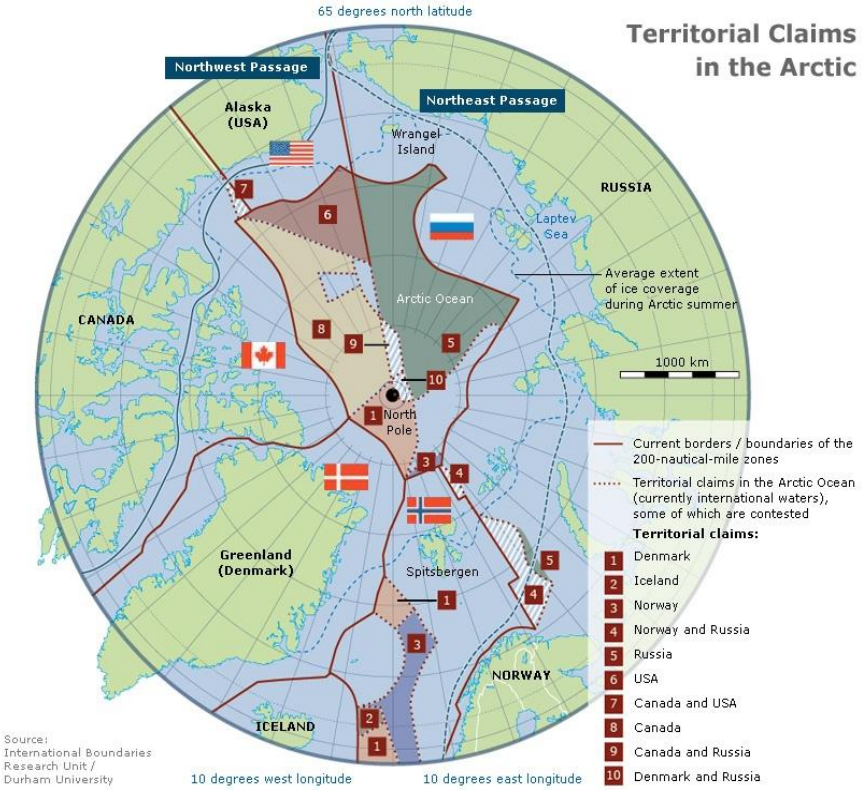
- http://www.washingtonpost.com/blogs/worldviews/wp/2014/12/23/why-the-chinese-backed-nicaragua-canal-may-be-a-disaster/?Post+generic=%3Ftid%3Dsm_twitter_washingtonpost

Arctic Sea Routes



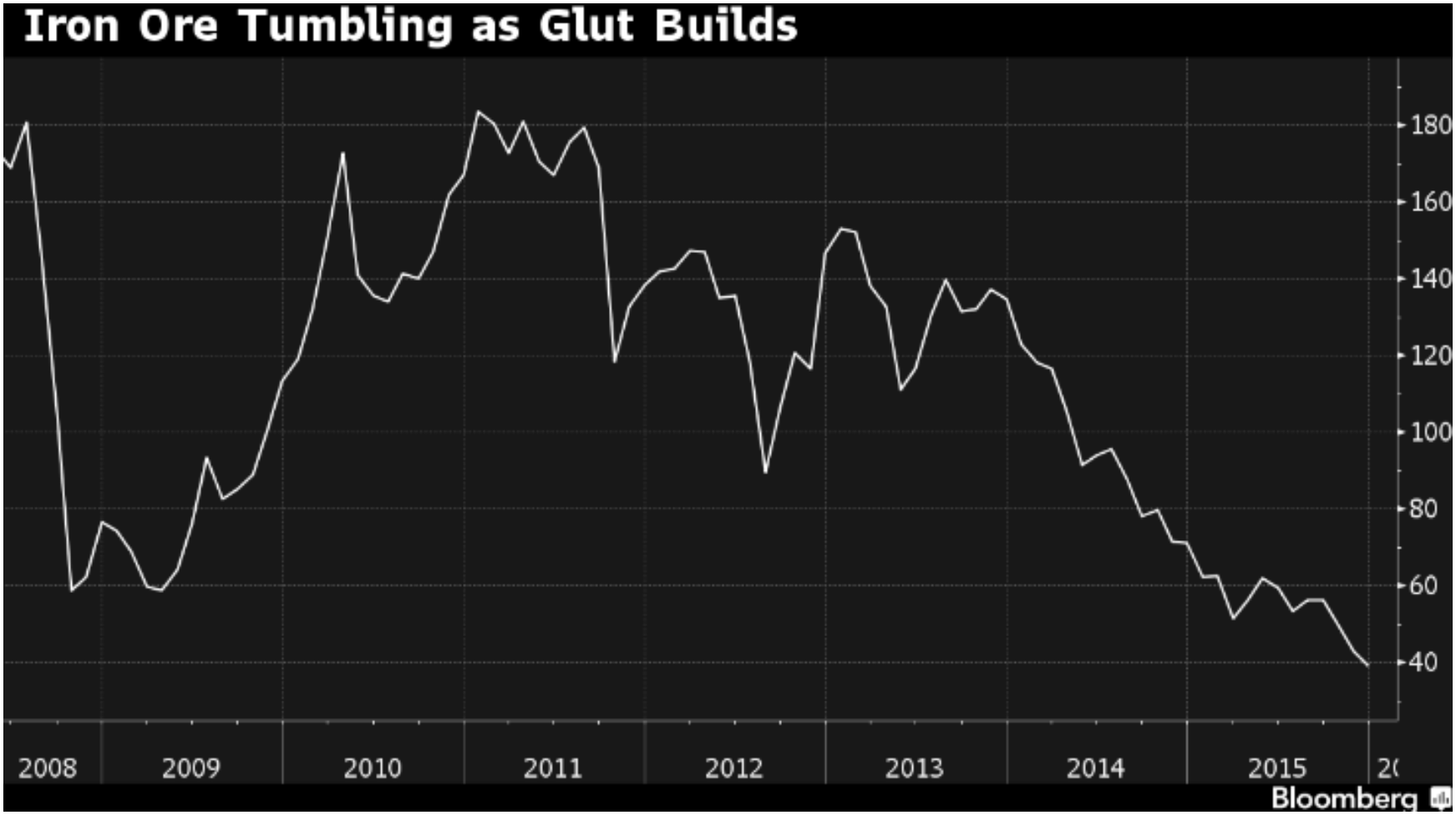
- The Artic Institute http://www.thearcticinstitute.org/2012/10/the-future-of-arctic-shipping.html
- NSR Information Office: http://www.arctic-lio.com/

Country Claims in the Arctic



- As of September 5, 2013 the NSR Administration has issued 495 permits to navigate and operate on the NSR so far this year. However, most of these permits are for only parts of the route, predominantly the western part of Russian waters, i.e. the southwestern Kara Sea.
- As of 31 July 2013, of the 296 permits granted only 18% (58 permits) are for actual transits and 45% (133 permits) are approved for voyages only in the southwestern Kara Sea, primarily shipping goods within the region or bringing them south-westwards to Europe.

It’s Not Just Oil, Natgas & Coal…



www.bloomberg.com/news/articles/2015-12-15/rio-ceo-says-iron-ore-rivals-hanging-on-by-their-fingernails-

India's GDP Seen Rising But Skepticism Remains-Up 7.3% Year On Year.

- November 30, 2015 http://www.cnbc.com/2015/11/30/
- Growth in Asia's third-largest economy likely picked up pace during the July-September period but don't cheer just yet, economists warn.

- India's real gross domestic product (GDP) is expected to expand 7.3 percent on year, up from 7 percent in the April-June quarter, on the back of improved consumption and rising industrial production, according to widespread estimates from private sector economists.

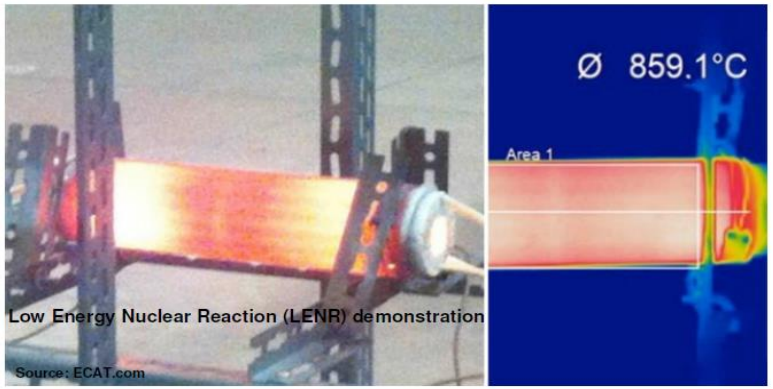
- Discretionary consumer spending has been holding up better, reflected by a 9.5 percent annual rise in September car sales, Morgan Stanley pointed out in a Monday report. Meanwhile, positive factory production is another bright spot, with annual industrial output expanding 4.2 percent in July, 6.3 percent in August and 3.6 percent in September.

- The upshot is ultimately buoyed growth, but it's still far from full-throttle, said Vishnu Varathan, senior economist at Mizuho Bank.

Over the Horizon Disruptor….

What if …

… claims of a clean energy breakthrough are true?



Power density of LENR fuel is 108* times higher than jet fuel in Parkhomov demonstration

Jet-A	LENR Ni
18,500 BTU/lb	3,084,000 J of power produced in 40 min = 1285 W (4385 BTU) 1285 W/ 1 gram Ni (4385 BTU/ 0.0022 lb) = 1285 W/g (1,993,182 BTU/lb)

1,993,182 BTU/lb /18,500 BTU/lb= 108

or 108X higher than Jet-A*

** Probably much higher as experiments were terminated before fuel was exhausted.*

Bill Gates briefed on LENR by Dr. Vittorio Violante at the ENEA* labs in Frascati, Italy

* The Italian National Agency for New Technologies, Energy and Sustainable Economic Development

Photo: E-catalyzer.it

Rob Duncan (VP of Research) recently founded Center for Emerging Energy Sciences (*CEES*) at Texas Tech for R&D of LENR