



CCUS STUDENT WEEK 2018

“Whole Value Chain Carbon Capture, Utilization, and Storage (CCUS)”

Regulatory Challenges in CO₂ Storage

9:30-10:00

Michael E. Moore
Managing Partner East-West Strategic Advisors

October 17th, 2018
CSM Golden, Colorado



Global Coal, Oil and Gas are at a Crossroad

Historic Paris Agreement on Climate Change

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



What does “de-carbonization of all energy (fossil fuels) by 2050.....” mean?

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

Regulatory Challenges in CO₂ Storage



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

What is Happening

- Technology increasing fossil fuel production and consumption.
- Technology changing consumption patterns.
- Global population to increase to close to 10 billion people by 2050.
- Global initiative and desire to decarbonize ALL fossil fuels by 2050.
- Rapidly changing energy supply mix and demographics
- Rapidly changing demand and demographics.
- Institutional investors expecting more from their investments on energy and climate issues.
- Latest IPCC report
- US Energy Dominance.

The Regulatory Challenges

- CO₂ a commodity vs. pollutant
- Power generation-Industrial/capture systems
- Infrastructure
- Subsurface
- CO₂-EOR with storage
- Storage
- Interested parties

Commodity

- As a commodity, CO₂ has certain attributes that are unique.
- Gaseous, wide diffusion into the atmosphere - lethal in very high concentrations that cause asphyxiation.
- Solid – handled like ice in insulated containers. “Melts” directly into gaseous form.
- Condensed gas the consistency of light crude oil but under high pressure (~1200 psi) at room temperature. This state is most desirable for long haul transportation (pipe) and for CO₂-EOR.

Pollutant

- CO₂ is deemed a pollutant due to its greenhouse gas warming attributes.

Power Generation or Industrial Capture

- Air permits are required for any project that has certain air emissions. (State and/or EPA)
- Due to its GHG potential, any emissions must be monitored and reported. (EPA)

Infrastructure

- Any fugitive emissions from the process of transportation must be monitored and reported. (EPA)
- CO₂ pipelines (mainlines not field level gathering/distribution) and systems regulated under PHMSA (Pipeline and Hazardous Materials Safety Administration) rules(www.phmsa.dot.gov) which is under the Department of Transportation, not the FERC (Federal Energy Regulatory Agency) (www.ferc.gov) like natural gas and electricity for interstate systems and State government for intra-state systems for pipelines.

CO₂-EOR-Storage and Storage

- Injected CO₂ whether for CO₂-EOR or storage volumes must be accounted for and reported (EPA).
- CO₂ for EOR is injected under the UIC Class II (drinking water protection) for tertiary recovery (EPA) with incidental or associated storage.
- But if Storage only, under the UIC Class VI which is mainly Federally permitted except for several states like North Dakota that manages their own permitting.
- CO₂ for EOR-Storage and for Storage is done for either voluntary actions to access voluntary carbon credit markets and permitting for injecting would be under UIC Class II for EOR and UIC Class VI for Storage only. Or for credits under mandatory systems like the EU-ECX and recently under California's CARB cap and trade program.
- ***CO₂ for EOR-Storage done to qualify for the 45Q Tax Credit. Protecting drinking water and against air emissions -- this is where there is debate as to what reporting standard (s) to be used.***

EPA Underground Injection Control (UIC) Regulations and Safe Drinking Water Act Provisions

- Congress passed the SDWA in 1974. In part, the SDWA requires EPA to develop minimum federal requirements for UIC programs and other safeguards to protect public health by preventing injection wells from contaminating underground sources of drinking water (USDWs)

Class I Industrial and Municipal Waste Disposal Wells

Class II Oil and Gas Related Injection Wells

Class III Injection Wells for Solution Mining

Class IV Shallow Hazardous and Radioactive Injection Wells

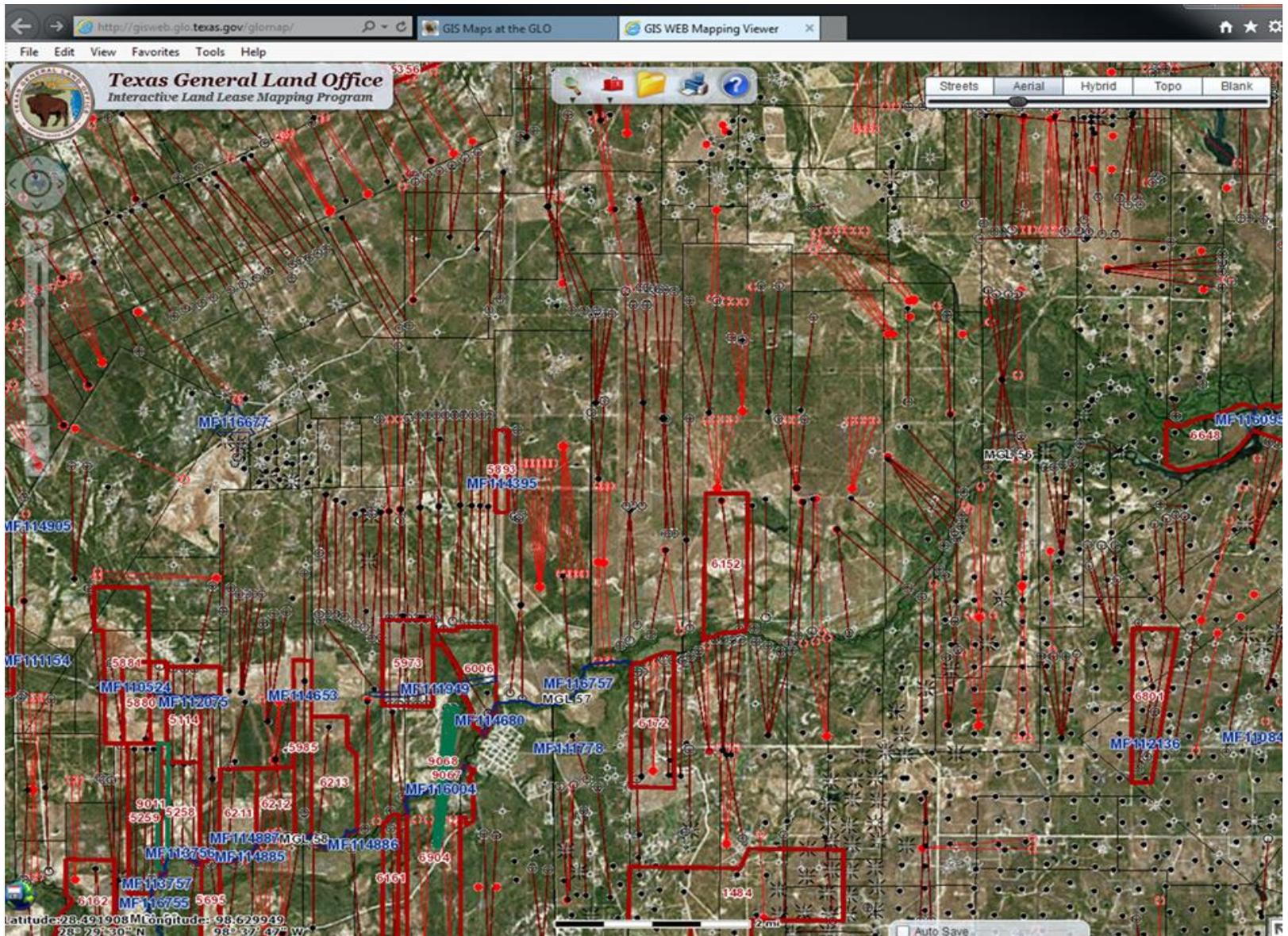
Class V Wells for Injection of Non-Hazardous Fluids into or Above Underground Sources of Drinking Water

Class VI Wells Used for Geologic Sequestration of CO₂

Conventional CO₂-EOR Permian Basin



Eagleford Shale - Laterals

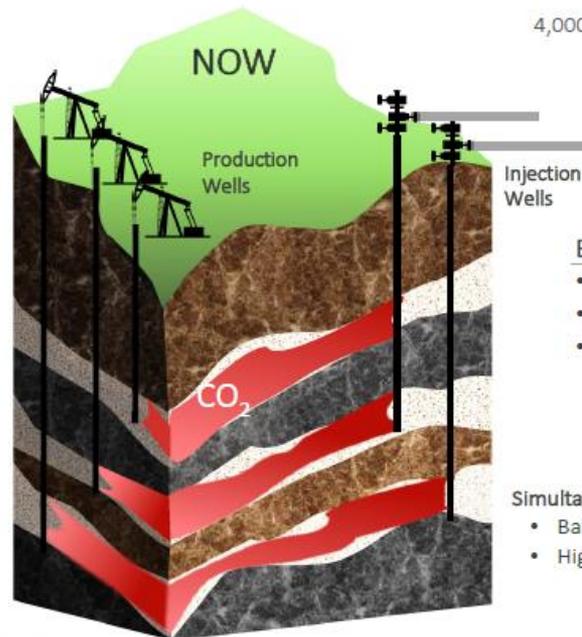
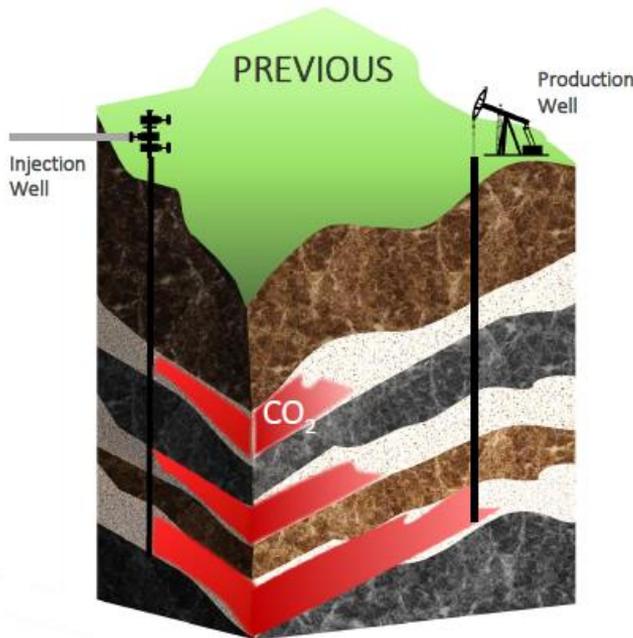
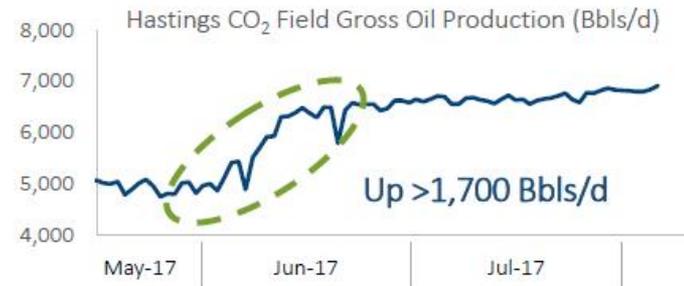


Denbury Reconfigures Hastings for Optimal Production

Hastings Redevelopment Project



Production has increased by >1,700 Bbbls/d (gross) on capital spend of \$26 MM



Benefits

- Top-down injection results in better sweep efficiency
- Dedicated producers allow for higher overall rates
- CO₂ is used more efficiently

Simultaneous series – dedicated producer and injector per reservoir

- Balanced injection and withdrawal
- Higher processing rates and greater flood control

Tall Cotton “Greenfield” ROZ CO₂ EOR

“Our portfolio is very robust in lower prices, primarily because we are utilizing existing infrastructure,” Arenivas said. “When you’re looking at a [CO₂ pilot study] project like Tall Cotton, you have to have high prices to make them work. But Yates and SACROC are very infrastructure-rich, so we are able to continue to drill wells utilizing those existing facilities.”

Tall Cotton, located in the Permian Basin northwest of Seminole, is a greenfield residual oil zone CO₂ project. Tall Cotton is the first field without a main pay zone to be specifically developed for CO₂ technology, according to Kinder Morgan. The project began in 2014 and has added 1.5 Mbbbl/d to Kinder Morgan’s production.

- The first commercial test of the greenfield residual oil zone opportunity in the Permian Basin.
- Historically no production from this region with conventional approach.
- Only after looking at similarities to mature MPZ going on to CO₂-EOR after water flooding did the idea that CO₂ would (and has) work on ROZ.



Harts August 2017 E&P Magazine story

Interested Parties

- State Oil & Gas agencies
- State environmental agencies
- US EPA Underground Injection Control program to protect drinking water (UIC)
- US EPA Air Emissions programs (Office of Air & Radiation)
- PHMSA (CO₂ pipelines)
- Landowners and mineral/pore space owners
- NGO's
- Institutional investors

Institutional Investors and Companies

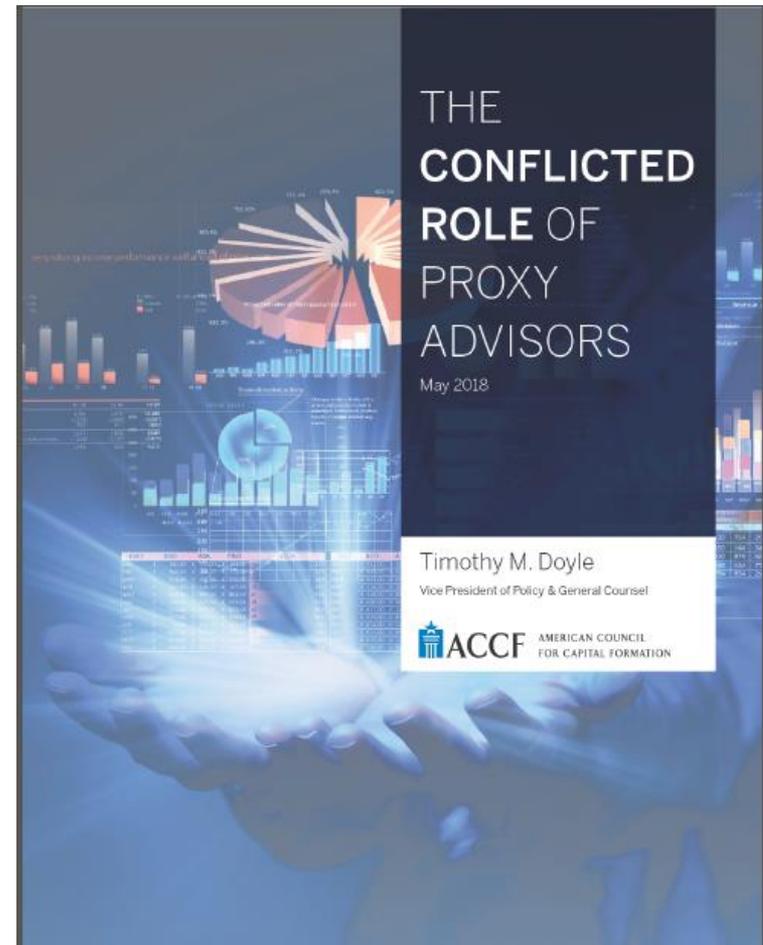


BlackRock

- [BlackRock](#), which had \$6.29 trillion in assets under management at the end of December, will be working throughout the year with the companies in which it holds shares, going beyond just proxy votes or engagement at annual meetings, Fink said in his letter, posted Tuesday on the firm's website. "The time has come for a new model of shareholder engagement — one that strengthens and deepens communication between shareholders and the companies that they own," he wrote.
- The letter is the latest move by an asset manager to focus more on shareholder activism and environmental, social and governance criteria in investments. For instance, BlackRock competitor Vanguard Group said in an August report that it is taking a more active approach to monitoring companies in its portfolio, while a McKinsey & Co. study published in October found that asset managers no longer consider ESG a niche strategy.
- <https://www.blackrock.com/corporate/en-us/investor-relations/larry-fink-ceo-letter>

Proxy Advisors and Climate Change

- “The SEC’s upcoming roundtable on the proxy process and the role of proxy advisory firms, coupled with the recent revocation of two staff guidance letters, demonstrates the importance of these issues to the Trump administration and its continued commitment to regulatory reform,” Doyle said. “This renewed attention is an excellent first step toward ensuring that the concerns of investors are appropriately represented in the shareholder proposal process.”
- “There is a growing body of evidence that a conflict of interest exists within proxy advisory firms, which often provide ratings and consulting services to the same client simultaneously. When coupled with the inability of corporate leaders to have input into the recommendations of proxy advisory firms, even in cases where the information is incorrect or misleading, and the lack of transparency in the analysis process, the role of proxy advisors and those who rely on them deserves a closer look to ensure that shareholders benefit from changes sought through the shareholder proposal process.”
- Tim Doyle is author of the ACCF report: “The Conflicted Role of Proxy Advisors” looking at the unchecked influence of proxy advisors and the need for greater oversight. Read his recent opinion piece in Real Clear Policy.

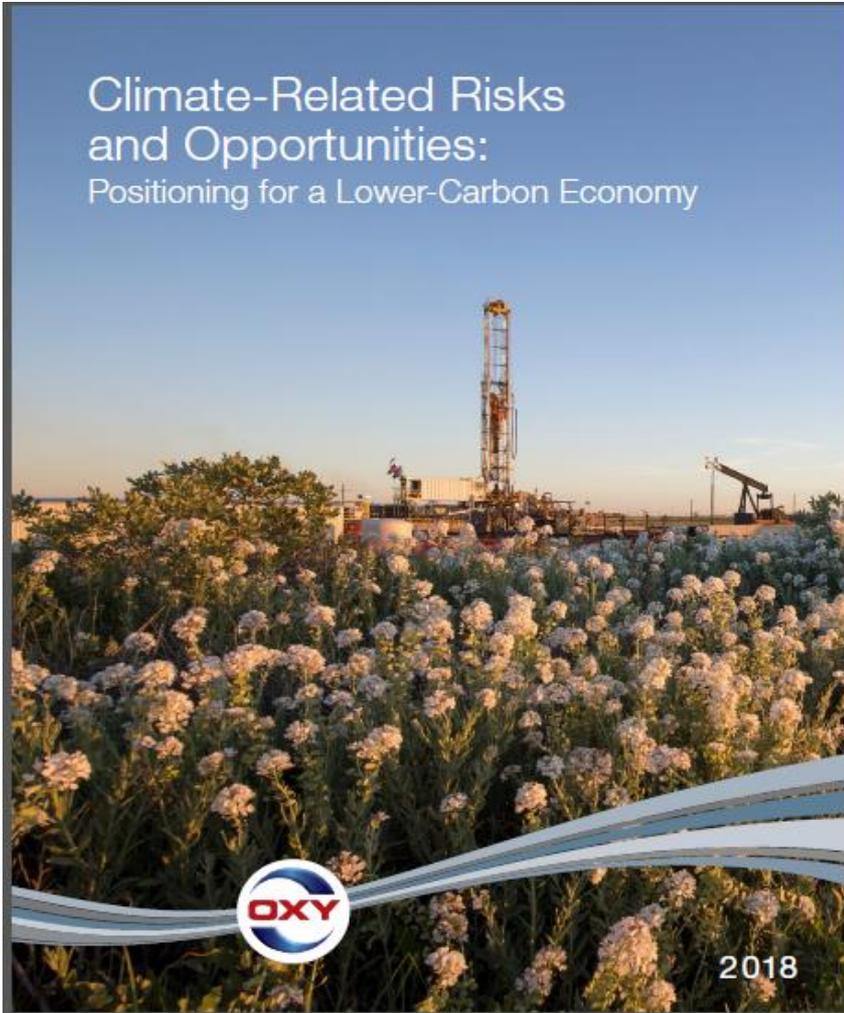


<http://accf.org/>

<http://accf.org/2018/09/28/accf-applauds-sec-call-for-roundtable-on-the-proxy-process/>

OXY

Climate-Related Risks and Opportunities: Positioning for a Lower-Carbon Economy



Carbon Capture and Enhanced Oil Recovery Technologies

The important role of carbon capture, utilization and sequestration (CCUS) technology to help reduce greenhouse gas (GHG) emissions on a global scale is recognized by respected energy and climate organizations and authorities. Occidental is a leader in the technology and its application in the oil and gas industry. In this section, we distill the terms and concepts of CCUS, detail our business approach and the significance of our effort, and provide context for its potential to reduce global GHG emissions while expanding Occidental's business opportunities.

Essential Concepts

What is CCUS?

CCUS is a process that captures anthropogenic (man-made) carbon dioxide (CO₂) emissions from sources such as coal-fired power plants, ethanol plants and cement production. The CO₂ is then used in a manner that prevents it from entering the atmosphere, usually by sequestering (permanently entrapping) the CO₂ deep underground. Carbon dioxide sequestration in geologic formations includes injection into oil and gas reservoirs, un-mineable coal seams and deep saline reservoirs — structures that have stored crude oil, natural gas, brine and CO₂ for millions of years. One of the most commercially viable forms of CCUS is carbon dioxide enhanced oil recovery (CO₂ EOR).

What is CO₂ EOR?

Primary oil and gas recovery is driven mostly by native pressures in the subsurface hydrocarbon formation. As hydrocarbons and other fluids are produced from the formation, the natural pressures are reduced. Once that pressure drops to a level that renders primary production methods uneconomic, various methods can be used to re-pressurize the formation and/or increase hydrocarbon mobility to enhance recovery of the remaining oil and gas. Enhanced oil recovery using CO₂ is a well-established EOR technique used in mature oil fields.

Using CO₂ EOR to produce more oil from mature fields can be less environmentally intrusive than exploration and development of new fields. CO₂ EOR avoids new habitat disturbance and leverages existing infrastructure, thereby reducing lifecycle environmental impacts of equivalent production volumes. Injection of CO₂ typically allows an additional 10-20 percent recovery of original oil in place in the fields where it is employed.

In the most common type of CO₂ EOR, carbon dioxide is injected into reservoirs at sufficient pressures to cause the CO₂ and oil to become a homogeneous mixture, similar to carbonated beverages. The resulting CO₂ and oil mixture has lower viscosity, enhanced mobility and lower interfacial tension than reservoir oil without dissolved CO₂. This facilitates the recovery of more oil from the reservoir.

http://www.oxy.com/SocialResponsibility/overview/SiteAssets/Pages/Social-Responsibility-at-Oxy/Assets/Occidental_Climate%20Report_2018.pdf

Carbon Markets and 45Q



Carbon Pricing

- US 45Q (Federal) \$36-50/ton
- California \$14.90-15.05/ton
- Proposed US Carbon Tax \$40/ton
- EU ECX (European) \$18-24.00/ton

- US Carbon Tax - Climate Leadership Council
<https://www.clcouncil.org/>
- California Cap and Trade
<https://www.arb.ca.gov/cc/capandtrade/auction/auction.htm>

ICE-ECX Carbon Markets



<https://www.bloomberg.com/quote/MO1:COM>

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

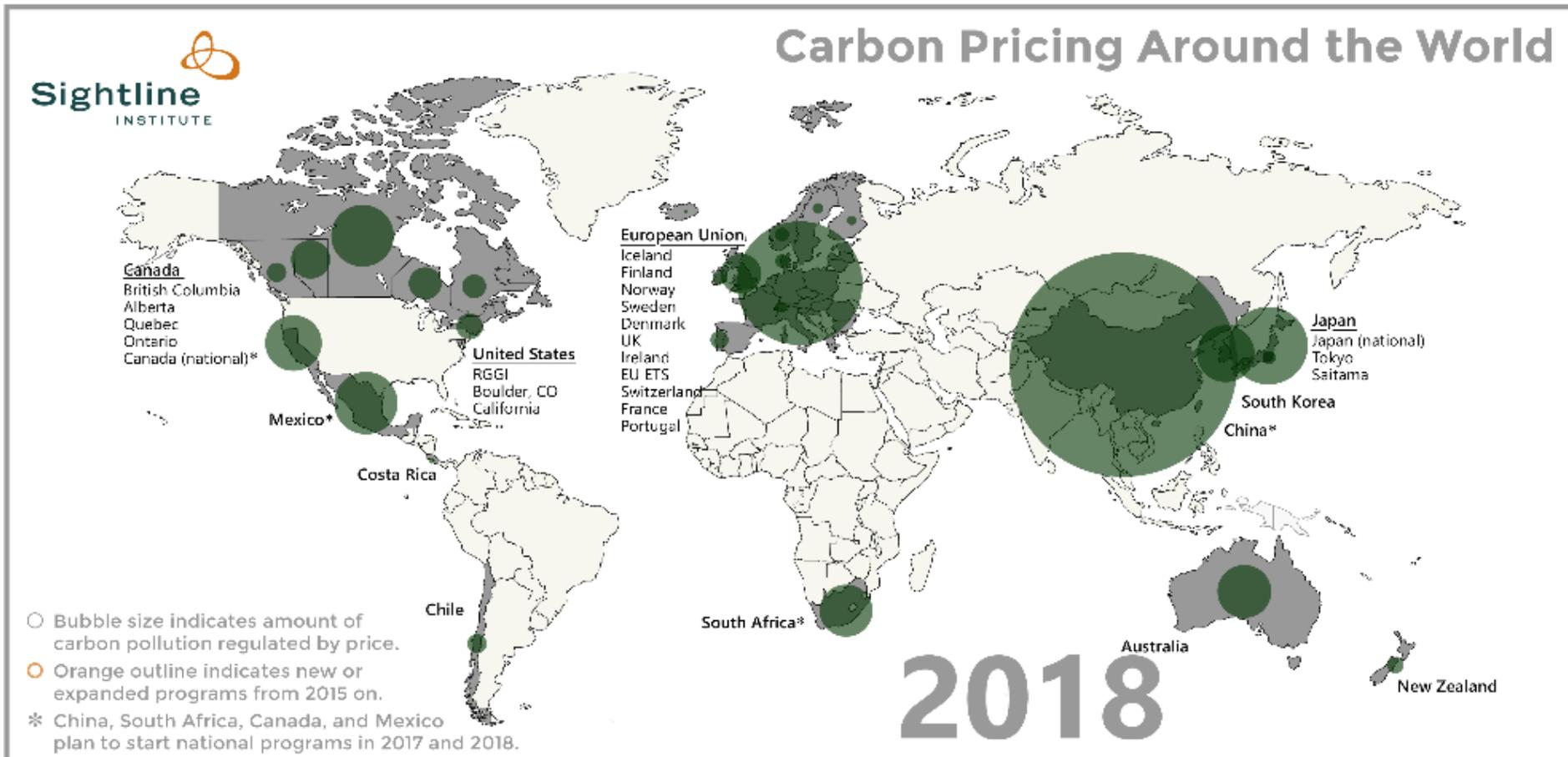
- Major oil and gas companies BG Group plc, BP plc, Eni S.p.A., Royal Dutch Shell plc, Statoil ASA and Total SA, today announced their call to governments around the world and to the United Nations Framework Convention on Climate Change (UNFCCC) to introduce carbon pricing systems and create clear, stable, 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

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.

Carbon Pricing – Energy Producers vs. Consumers...

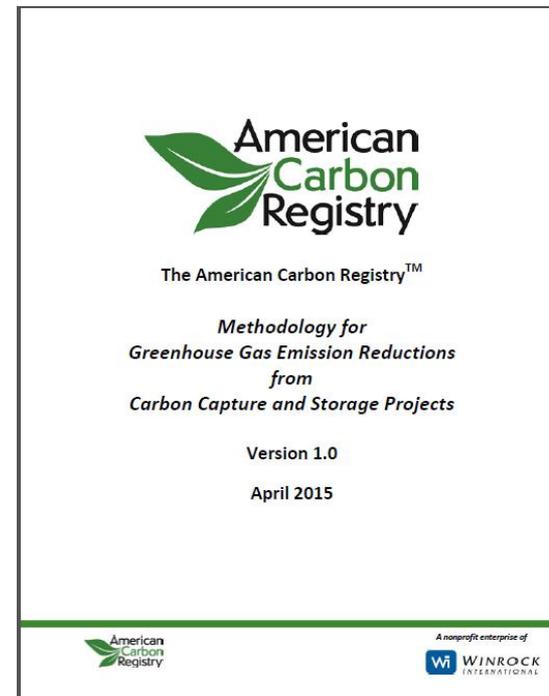
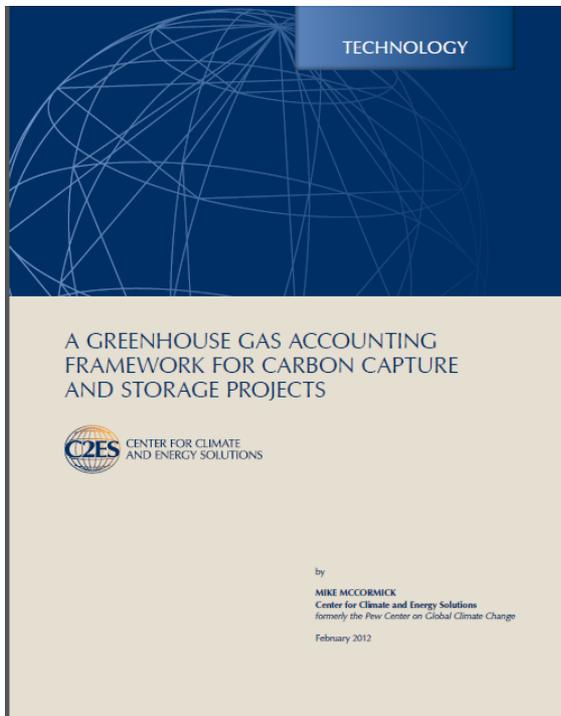


ISO-CCS Standards for Geologic Storage under Development

- International Standards Organization - 31000, 17024, 14064, 14065
- International Performance Assessment Centre for Geologic Storage of CO₂ – 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 CO₂-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/CO₂-EOR Protocol Framework and Storage Protocols

- PEW/C2ES CCS Protocols- released 2012
- ACR CCS CO₂-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>

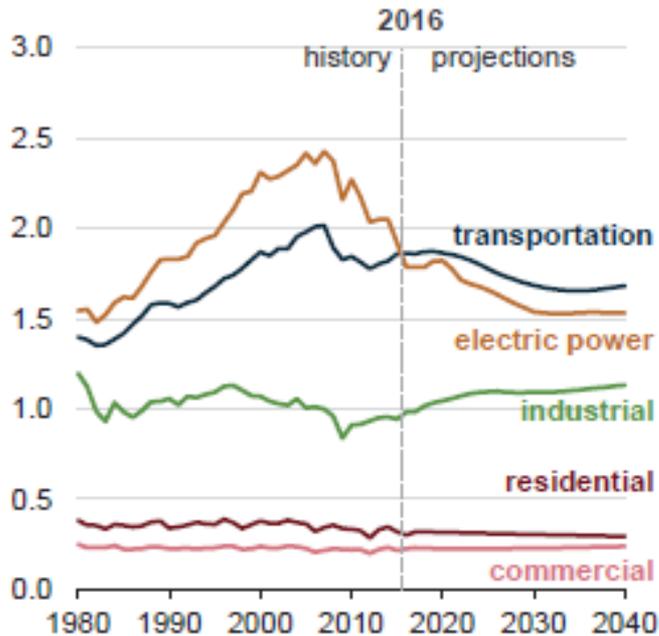
www.c2es.org/docUploads/CCS-framework.pdf

NGO's

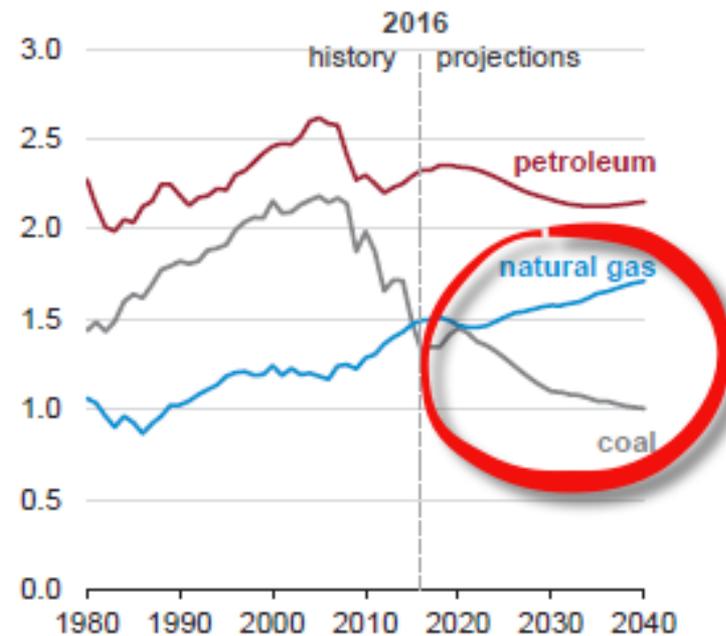


Change in CO₂ Sources

U.S. energy-related carbon dioxide emissions (Reference case)
billion metric tons of carbon dioxide



billion metric tons of carbon dioxide



Over the horizon natgas will have CO₂ emissions issues beginning about 10 yrs. out coinciding with shortening of long term LNG contracts to 10 yrs. or less

Beyond Coal, Oil and Natgas

- April 19th, 2016 Mark Hand SNL S&P Global Market Intelligence spoke with Lena Moffitt of Sierra Club
<https://www.snl.com/InteractiveX/articleabstract.aspx?id=36149158&KPLT=8>
- *The Sierra Club's top priority in recent years has been shutting down coal-fired power plants across the U.S. The group's Beyond Coal effort has been described as "the most extensive, expensive and effective campaign in the environmental group's 123-year history."*
- *Hoping to build on the success of its Beyond Coal campaign, the Sierra Club launched initiatives targeting both oil and natural gas. In late 2014, the Sierra Club decided to merge its Beyond Natural Gas and Beyond Oil efforts into a campaign called Beyond Dirty Fuels.*
- *We are doing everything we can to bring the same expertise that we brought to taking down the coal industry and coal-fired power in this country to taking on gas in the same way. I look forward to seeing the same success brought to taking down gas plants to ensure that we're actually moving to a 100% clean energy future. That is the one Sierra Club policy that we are all working toward: getting us to 100% clean energy, which, of course, would include no new gas.*

Market Drivers



Crude Oil Volatility

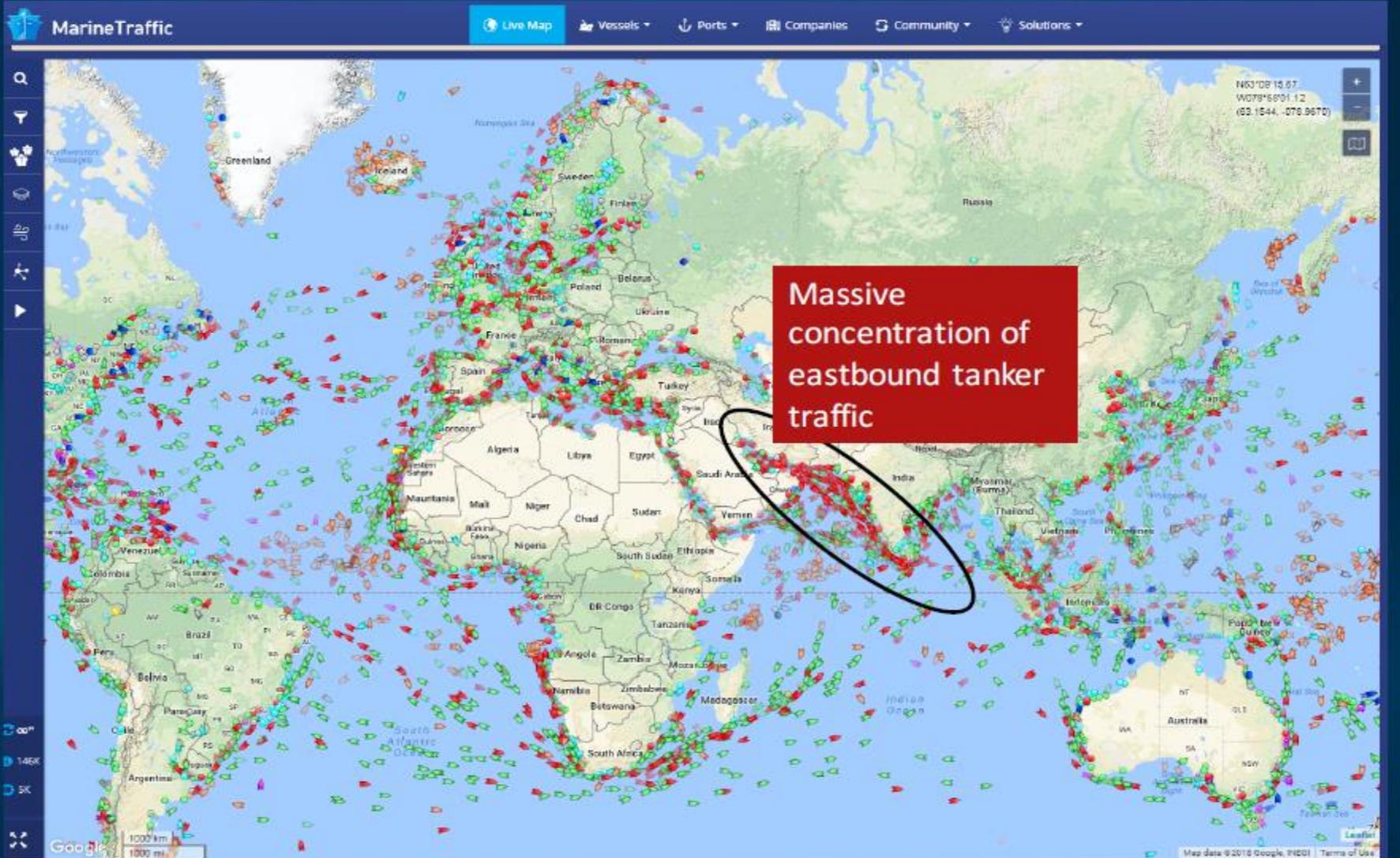


<https://tradingeconomics.com/commodity/crude-oil>

IEA report: Global Oil Supply-Record Production of 100MMbpd

- **9-13-18 IEA report: Global oil supply hit a record high in August despite Iran, Venezuela fallout**
- Global oil supply hit a record high in August at 100 million barrels per day (bpd) - demand just below that.
- Higher output from OPEC managed to more than offset seasonal declines from non-OPEC members, which nonetheless increased year-on-year, led by the U.S.
- August saw OPEC's crude supply hit a nine-month high of 32.63 million bpd, despite falls in production from major players Venezuela and Iran.

The Maritime Energy Transport Domain: A “100,000 foot view”



Source: Marine Traffic.com, 28 February 2018

<https://www.bakerinstitute.org/media/files/files/f5ff0213/collins-global-energy-shifts-what-naval-security-practitioners-should-know.pdf>

CCUS on Natgas Generation

- Primary multinationals expect CCUS on natgas within 10 years
- NGO's
- Institutional investors
- Pressures from “leave it in the ground” interests
- Social license to operate in some countries

Long Term LNG vs. Coal in a Carbon Constrained World

- LNG suppliers having trouble securing long term off-take agreements up to ten years - now making financing for new projects very hard
- Transition point 10 yrs. out coincides with multinational expectation of CCUS on natgas generation etc.
- From a national energy security standpoint:
- Rounds of sanctions and tariffs changing view of energy source security
- LNG/natgas, all laid in costs (shipping, ports, infrastructure and CCUS)
- Coal, all laid in costs (shipping, ports, infrastructure and CCUS)
Coal is looking cheaper more secure if coal is already produced in country
- Additionally driven by growing GHG controls and climate change management desires of institutional investors and some governments

Questions & Thank You!

Michael E. Moore



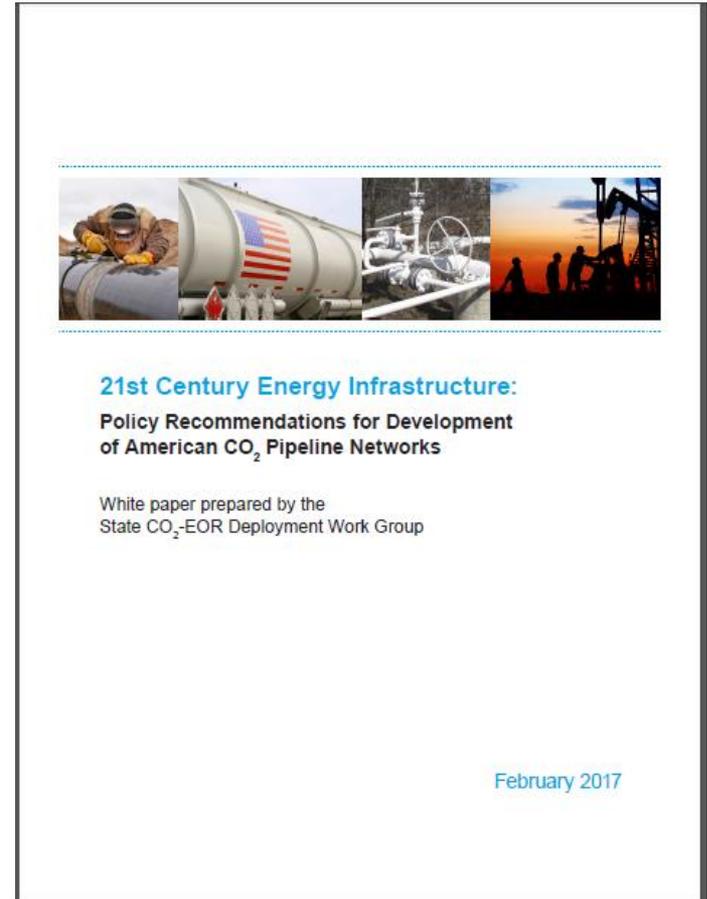
- **Managing Partner East West Strategic Advisors Washington DC**
- **mmoore@ewsa-global.com**



CO₂ Shipping and CO₂ Pipelines



http://www.ieaghg.org/exco_docs/2017-TR1.pdf



http://www.betterenergy.org/sites/default/files/White_Paper_21st_Century_Infrastructure_CO2_Pipelines_0.pdf

IEA and KAPSARC co-host Workshop on Decarbonisation Potential of advanced CO₂-EOR

31 January 2018

- Doug Cooke, KAPSARC's Program Director Energy Transitions and Environment, noted that advanced CO₂-based oil recovery in combination with geological storage has the potential to offer a 'win-win' for oil producing and consuming countries by contributing to decarbonising the transport sector while ensuring the longevity of national hydrocarbon assets in oil-producing countries.
- However, both Mr. Varro and Mr. Cooke recognized that there are a number of legal, regulatory and economic challenges to realise the potential of advanced CO₂-EOR combined with verifiable CO₂ storage.
- "Establishing appropriate policy frameworks to enable investment will key to the development of EOR+," said Mr. Varro. Mr. Cooke added that "the benefits of advanced CO₂-EOR need to be proven if it is to become a credible part of the global response to combatting carbon emissions. International collaboration between all key stakeholders will be critical for success."
- "Advanced CO₂-EOR can also provide market pull for the deployment of CCS technology by supporting crucial early CCS investment in some jurisdictions" noted Juho Lipponen, IEA head of CCS, "because CCS accounts for one sixth of the required emissions reductions worldwide by 2060."
- Advanced CO₂-EOR is not yet a mainstream practice and will require changes in how projects are planned and operated. This in turn will require changes in the legal, regulatory and commercial framework to support its deployment. Effective public policies will be required to harness this potential.
- <https://www.iea.org/newsroom/news/2018/january/iea-and-kapsarc-co-host-workshop-on-decarbonisation-potential-of-advanced-co2-eor.html>