



## 2019 CONFERENCE REPORT: USAEE 37<sup>th</sup> North American Conference in Denver

Welcome to the 2019 Conference Report for the 37<sup>th</sup> USAEE North American Conference held in Denver, November 3<sup>rd</sup>-6<sup>th</sup>, 2019. The theme of this year's conference was "Energy Transitions in the 21<sup>st</sup> Century." Conference speakers focused on the rapidly accelerating changes taking place across global energy as stakeholders balance decarbonization goals with energy demand requirements. Speakers provided insight on current and potential future implications of the transition for energy markets, policy, technology deployment, geopolitics, and much more. Included in the following pages are short summaries of conference keynotes, plenary sessions, tours, and other activities. Please note that the conference session write-ups do not aim to be comprehensive, but rather to capture some of the speakers' key points and serve as a resource on where to look for additional information on specific energy themes. Each conference section includes an [embedded video link](#) for a deeper dive on that content. Please also note that the write-ups include both paraphrasing and direct quotes of the conference speakers. Direct quotes may appear without quotation marks because the content was typically drawn from volunteers' conference notes, and that may not be specified. In every case, the intellectual content belongs to the speakers, regardless of the format. We encourage readers not to rely solely on the report, but to utilize the embedded video links and check primary sources for themselves on topics of interest.

Thank you to all the contributors to the conference report including communications committee members Robert Kleinberg, Eric Hittinger, Mark McCarthy and Seth Blumsack and volunteers Omar Cabrales, Carol Dahl, and Tina Vital. And a special thank you to all the speakers and USAEE members for their contributions in advancing the energy transition. We hope membership finds the report useful and hope to see everyone at the 2020 North American Conference in Austin, Texas, November 1<sup>st</sup> - 4<sup>th</sup>. Mark your calendars now.

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## Opening Keynote Bill Ritter: States Are Filling Policy Vacuum on Decarbonization

In his keynote address, Former Colorado Governor Ritter addressed how U.S. states are filling the policy vacuum created by federal inaction on climate. State responses have been encouraging. 31 states have renewable portfolio standards. Of the 34 states electing governors in 2018, nine have candidates calling for 100% clean energy standards. Ritter runs a “state legislator clean energy academy” that develops model legislation that the states can adapt and adopt. One model example is regional agreements along the lines of the Obama-era Clean Power Plan. Ritter estimates. More than 4500 pieces of legislation will be introduced this year at the state level that would impact clean energy and climate. Ritter estimates about 600 to 650 of those bills would become law. Ritter added there are some “laggard states” on decarbonization to include Alabama and Mississippi. In addition, Ohio has repealed decarbonization initiatives. However, states may not be “allowed to lag for long.” Shareholders for utilities and other corporations may force the transition. Power generators like the Southern Company and Xcel have decarbonization plans. Xcel has pledged 80% CO2 reduction by 2030.

Regarding federal climate policy, Ritter stated there was still some “hope. There are 10 Republican Senators discussing climate policy centered on a carbon pricing with dividend framework. The outcome would depend on future presidential election results, but these Senators are helping lay groundwork for the future.

Ritter added that while policy is important, markets can be transformative. Federal pro-coal efforts have “failed miserably” due to market trends including falling costs for renewables and natural gas. Ultimately, greenhouse gases will need to be taxed. The price on carbon will drive innovation. Investment capital is waiting on the sidelines for that economic signal on decarbonization investments.



Bill Ritter discusses decarbonization and state policy with NREL's Douglas Arent

[LINK: FULL VIDEO](#)

## Energy Transitions: Learning through History: Oil Entering a Twilight?

Is oil entering a twilight? Or not? FreightWaves' John Kingston raised these questions on oil's future and prospects of an energy transition. The smaller, nimble oil companies responsible for the shale revolution are struggling to create free cash flow, profits, and dividends. Their financial situation raises questions about the sustainability of the shale business model. At the same time, oil majors have strong free cash flows and oil production is booming in a number of countries. A glut of cheap abundant oil could continue well into the future and make the world “even more tied to it” (oil).

Rocky Mountain Institute's Amory Lovins' key point was there is too little attention being paid to “efficiency as resource.” He stated that since 1975, the cumulative energy saved from reduced primary energy intensity is thirty times the cumulative increase from renewable energy. His second key point was that “integrated design” is a low hanging fruit for additional efficiency gains because it does not require technological change. Rather, it is based on a different conceptual approach to design that emphasizes multipurpose use, not singular benefits. For example more efficient auto lights also create the opportunity to reduce battery size. For more information, Lovins encouraged participants to read his paper, “How Big Is the Energy Efficiency Resource,” which is available for download on the internet. Lovins encouraged the USAAEE audience to conduct more research on the demand side. He said, there are “a lot of supply side papers” and many are insightful, but “on the demand side, not so much.”

Resources for the Future's Richard Newell pointed out that previous energy transitions have been “additive.” New dominant fuels emerged, but demand for old energy sources still continued to increase. The world consumes three times the biomass it did in 1800 and 60% more coal today than in 2000. Newell highlighted some positive trends in the underlying data. The US and EU are reducing the carbon intensity of their economies and energy usage, and that could be a future model for emerging nations. However, while the trends are “in the right direction” in the advanced economies, these regions are still “way off” the magnitude of change needed to address climate change.

[FULL VIDEO PART I; PART II](#)



Energy Transition Panelists: Richard Newell, Resources for the Future (above); Amory Lovins, Rocky Mountain Institute; John Kingston, FreightWaves:

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### USAEE Student Activities: UC Berkeley's Susanna Berkouwer Wins Best Paper

Keeping with USAEE/IAEE tradition, there was a large slate of student-focused events during the conference. This started with the PhD Day on Sunday, sponsored by the Sloan Foundation. At this event, PhD students presented work-in-progress to each other, with plenty of time for discussion, critique, and networking. Later that day, the final round of the USAEE Case Competition took place, sponsored by the King Abdullah Petroleum Studies and Research Center (KAPSARC). During the summer, case competition teams had been issued packets describing a fictional customer worried about electrification of aviation. Student teams write consultant reports, with two selected to present at the conference. The winning team was Colin Sasthav and Dustin Gilmer, from the University of Tennessee Knoxville. A mentoring event capped off Sunday's student events, with five experienced energy professionals giving career advice to a rotating group of around 25 students.



Susanna Berkouwer of UC Berkeley accepts award for best student paper

On Monday, the Dennis J. O'Brien USAEE/IAEE Best Student Paper Award had its own concurrent session, with four great papers from current PhD students. The winner was Susanna Berkouwer from UC Berkeley for her paper entitled "Credit and attention in the adoption of profitable energy efficient technologies in Kenya". Monday also featured the student "work-in-progress" session, where students got feedback from academics on their research that is still underway. A student reception sponsored by the Center for Energy Studies at Rice University took place at the nearby Gordon Biersch Brewery on Monday night.

### Global Decarbonization of Road Transport: EV Uncertainty & Occupancy Trading

Columbia's Marianne Kah highlighted the wide range of electric vehicle (EV) forecasts. Columbia's survey of third-party forecasters shows a range of between 15% to 95% penetration for EVs in 2040, a gap "wide enough to drive a truck through." In addition, more survey participants lowered forecasts in 2019 than raised them due to skepticism about falling battery costs, lower future car sales, and potential relaxation of US vehicle regulations. The survey results highlight the uncertainty of future EV market share and decarbonization pathways in the road transport sector, a more challenging sector than the power for low carbon solutions.



Global Decarbonization of Road Transport Panelists: Lew Fulton, UC Davis; Marianne Kah, Columbia CGEP; Amitai Bin-Nun, SAFE; Paul Leiby, ORNL

UC Davis' Lew Fulton stated EVs currently account for about 1.5% of LDV sales, but must reach a much larger market share to address climate issues. There is uncertainty on how to achieve the needed growth. Fulton expressed hope that shared mobility and automation could speed up EV penetration. Currently, China is the key region for EV growth. Fulton suggested that Chinese auto companies could soon be producing EVs for export.

SAFE's (Securing America's Future Energy) Amitai Bin-Nun recited a long list of optimization opportunities from autonomous vehicles that could contribute to road transport decarbonization, enhance energy security, and improve road safety. The list included optimized route choice, powertrains, occupancy, vehicle size, materials, and more. Bin-Nun said SAFE is heavily engaged in outreach because a vision showing societal benefits has to be communicated before policymakers will take the risk on the new technology. SAFE forecasts a decade-plus process for autonomous vehicle deployment in the fleet, and adds the process has already begun.

Oak Ridge National Lab's (ORNL) Paul Leiby stated that shared-automated-mobility holds strong potential to reduce transportation costs. However, reduced costs could result in a demand response that increases miles traveled. Leiby states policy strategies and incentives would be needed to offset higher demand. He is researching "occupancy standards" where vehicles running high occupancy trips would receive tradable credits and low occupancy vehicles would be obliged to purchase credits. Fees are another policy lever. Research shows that a 10% increase in road use costs leads to roughly a 5-10% reduction in VMT. Leiby also stated that EV domination of future autonomous shared-mobility is questionable. DC fast charging costs equate to around 8-12¢/mile, which would be roughly equivalent to \$3.20 to \$4.80/gallon for a 40MPG hybrid. Liquid fuels could retain a cost advantage in mobility in future.

[FULL VIDEO PART I; PART II; PART III](#)

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### Decarbonization of North American Power: Modern Grid Culture

California ISO CEO Steve Berberich stated the California case demonstrates the ability to run a modern grid with high renewables penetration. CA regularly runs the grid with over 50% renewables, and often hits 70% peaks. He notes this figure does not include hydro and nuclear, which could increase the system's total clean power an additional 15%. Berberich stated he engages system operators all over the world, and concludes that the single biggest obstacle to higher renewables penetration is culture. It wasn't long ago that managing 20% renewables was considered a major challenge. CA grid operators formerly planned around a thermal system with some renewables. Now it's a renewables system with some thermal. Operators need to embrace new thinking. Berberich also discussed the importance of forecasting and geographic diversity for renewables.



Decarbonization of North American Power Panelists: Steve Berberich, CA ISO; Debra Lew, Debra Lew LLC; Jesse Jenkins, Princeton; Doug Arent, NREL

Princeton's Jesse Jenkins identified political economy as both important and perhaps the most "under-studied" aspect of power decarbonization. Aligning benefits for the majors shifts in infrastructure needed is the key to realizing grid decarbonization. If the transition "goes the ox" for well-established entrenched interests, without ameliorating the effects of economic dislocation, then the transition is going to run into a "political brick wall" and won't succeed at the pace needed. Jenkins called for more research that combines the technical, economic, and political pieces.

Consultant Debra Lew stated the industry hasn't tapped the biggest lever for balancing load, which is demand. She encouraged research on rate design and market structures that link up demand with the needs of the system. Operators need to incentivize customers to offload at peak to optimize available resources. Lew warned that electrification of other sectors is a double-edged sword. The industry has to have flexibility with new electric loads (EVs, heat) through price signals, direct control, or aggregators. Failure to design that flexibility would make the problem worse. Lew also stated the industry has to start thinking of curtailment as a resource as more renewables come on the grid. She cited ancillary services such as regulation reserve and spinning reserve as near-term options. Power-to-X (synthetic fuels) could be an option in future.

[FULL VIDEO PART I; PART II](#)

### Geopolitics of the Energy Transition: Overcoming Zero Sum Approaches

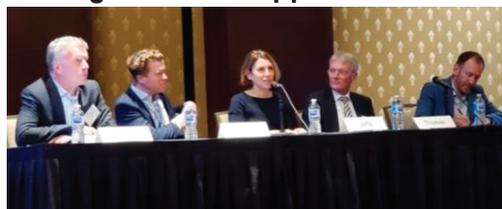
CFR's Amy Jaffe discussed scenarios related to the shift from an oil scarcity paradigm to oil abundance paradigm. Iran and Russia could be acting more aggressively to demonstrate they still have leverage and can't be ignored even if there is reduced need for their oil & gas supplies. Jaffe noted that if the politics of energy transition lead to decapitalization of oil companies, it could have the unintended consequence of increased oil dependence on National Oil Companies (NOC) and OPEC.

Equinor's Eirik Wareness identified geopolitics as a potential barrier to any energy transition. Today's geopolitical climate, characterized by low trust and zero sum thinking, make it difficult to meet sustainability goals. Long-term benefits, including reduced geopolitical tensions, may not be realized if the world can't overcome near-term challenges including higher costs, volatility, and changing interdependencies.

Shell's Wim Thomas commented that the US shale revolution has postponed a global energy transition by at least 10 years. The statement highlights the challenge of global climate coordination in an age of oil abundance. Thomas discussed Shell's "well below 2°" Sky energy transition scenario. The world has 50 years to go from 80% fossil to 20% fossil / 80% non-fossil. The transition requires overcoming the political problem of "who will pay?"

Andreas Goldthau of the Willie Brandt School outlined potential geopolitical implications of an energy transition through four scenarios. The first scenario includes a policy-driven "just transition" that includes a generous climate fund to soften the landing on dislocations. A second scenario is less cooperative with nations retaining cleantech breakthroughs for national advantage. The third "nationalist populist" scenario sees energy independence prioritized and reluctance to give up fossil fuels. The final scenario is a business as usual "muddling on" scenario.

[LINK: FULL VIDEO PART I; PART II](#)



Geopolitics panelists: Eirik Wareness, Equinor; Andreas Goldthau, IASS; Amy Jaffe, CFR; Wim Thomas, Shell; Morgan Bazilian, CSM

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### USAEE NREL Tour: A Driverless Shuttle and an Eagle Computer

On November 6, 18 delegates to the USAEE Denver Conference toured the U.S. National Renewable Technology Labs Golden Colorado Campus. The tour started at the Golden Campus Education Center where NREL's James Bosch provided the group with an overview of the laboratory's mission, funding, and salient accomplishments. James explained that NREL, one of 19 Federal R&D sites, focuses on the science and engineering of energy efficiency, sustainable transportation, and renewable technologies. The lab partners



USAEE tour of National Renewable Energy Lab (NREL); The automated electric shuttle (above right) was the highlight for the USAEE tour group

with private companies, including many small and startup entities, and provides them with facilities and technical support as they conduct cutting edge research on technologies of the future. Of equal importance, when the research yields promising technologies, the lab provides companies with support and know how to help bridge the dreaded "valley of death", which is the point where companies look to move beyond R&D and into commercial viability.

After the overview, James led the tour to various laboratories where researchers are working on areas such as battery technology, advanced manufacturing of energy efficient materials, bioenergy, and transportation. A highlight of the lab tour was seeing some of the lab's high performance computers, including their Eagle computer which has a peak performance of 8 petaflops. The tour participants learned that NREL is home to the most energy efficient data center in the world.

Throughout the tour, participants saw ways in which some of the materials and designs born in the lab are used in building construction at NREL. These include glass that darkens under sunlight to reduce the need for air-conditioning during certain times of the year, and wall cladding that helps reflect heat. Another highlight was watching NREL's autonomous shuttle vehicle perform test runs on a road lined with electric vehicles being charged.

The tour was a great opportunity for USAEE delegates to learn about the work being done at NREL.

### North American Energy Infrastructure: Rise of the Fracking Zombie Movies?

GTI's Paula Gant introduced the panel highlighting how infrastructure projects have enhanced North America market integration and interdependence. However, new infrastructure projects are proving more challenging.

Canada Energy Regulator's Jean-Denis Chalebois stated Canada's oil & gas resources are globally competitive and the nation could increase oil production even with a price a carbon. However, "pipeline drama" has created bottlenecks. Crude oil production for export has increased faster than pipeline capacity. 5 major oil pipes have been proposed, but not yet built. This has led to steep discounts for Canadian crude. Canada has benefited from energy integration with the US, but needs more partners.



Infrastructure Panelists: Tisha Schuller, Adamantine Energy; Luis Serra Barragan, Tecnologico e Monterrey; Paula Gant, GTI; Jean-Denis Charlebois, Canada Energy Regulator

Adamantine's Tisha Shula discussed how shareholder resolutions are increasingly focused on environmental matters. The most popular issue is the 2 degree climate limit. In New York State, climate goals apply to all government actions. The oil and gas industry must ask what public is looking for. Consumers are not willing to pay for climate mitigation. Polls show that consumers value climate action at less than \$10/month. A community will ban fracking but will not ban the use of oil & gas. There are two new movies about zombie invasions caused by fracking.

Monterrey Tech's Luis Serra Barragan discussed Mexico's challenges including social conflicts, lack of energy policy clarity, lack of transparency, and lack of regulatory independence. Economic growth is not the priority. The priority is national sovereignty, despite fuel shortages. PEMEX is designated as the cornerstone of the economy, despite being \$100 billion in debt. Despite an overall lack of competitiveness, the cost of wind & solar energy is among the lowest in the world at about USD 20/MWh.

[LINK: FULL VIDEO PART I; PART II](#)

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### Adelman Frankel Award to BP Statistical Review

USAAEE annually bestows the Adelman-Frankel award to an individual or organization that makes unique and innovative contributions to the field of energy economics. BP's US Chief Economist Michael Cohen accepted on the award on behalf of the BP Statistical Review. Cohen discussed the history of the publication highlighting the important role it filled on energy information in the 1950s, 60s, and 70s before there was an EIA or IEA. The information has always been accessible, BP data is all in one place. There are no passwords to be remembered, and no special programs you need to use. In addition, the information continues to improve. BP still tracks oil & gas, but has added new data sets such as the "materials that go in to EV batteries and rare earth metals, which will play increasingly prominent roles in the energy system in the decades to come." The data has "no politics. There is no spin. You can't argue with the facts. Dan Yergin, one of the great energy historians of our time, said that he always keeps two things in his briefcase: his passport, and a copy BP's Statistical Review. He called it "a global go-to source for decision makers and analysts around the world."



BP's Michael Cohen accepts award on behalf of the BP Statistical Review

### Government Policies and Low Carbon Transition: Multi-Trillion Dollar Gaps

Moderator Susan Tierney noted that the panel was taking place one day after the Trump administration officially started the process to leave the Paris Agreement. Tierney stated there is still terrific momentum on climate issues in the US despite the administration's position. Panelists discussed where the momentum is and future implications.



Government Policies Promoting Low Carbon Panelists: Susan Tierney, Analysis Group; Kelly Sims-Gallagher, Tufts; Carrie Jenks, M.J. Bradley & Associates; Sarah Ladislav, CSIS

CSIS' Sarah Ladislav discussed the challenges of optimizing policy in a suboptimal political environment.

Ladislav sees potential for pursuing climate policy through non-controversial, "familiar" policies that people understand. She identified Clean Energy Standards (CES) as having the advantage of political convenience. A Clean Energy Standard could be enacted by "adding dimensions" to the existing state Renewable Portfolio Standards (RPS). The CES policy could include support for nuclear, CCS, and potentially methane emissions. Congress isn't ready for a federal CES yet, but it's a policy option that could become more visible in future.

Carrie Jenks of MJ Bradley & Associates provided an overview of US subnational action on climate. 21 states have GHG reduction targets, 29 have an RPS/CES (covering 56% of US power), and 8 states have 100% zero emission goals. In addition, several states are pursuing transportation programs. She cited the Transportation Climate Initiative (US Northeast/Mid-Atlantic) as an example. Congress won't be ready to act in a significant way for another 2-3 years or longer. In the meantime, states are being forced to increase stringency in absence of federal leadership. The federal government could leverage these policy models when it is finally ready to take action, which could occur through overlapping policy or pre-emption.

Tufts' Kelly Sims-Gallagher discussed her research on climate policy effectiveness and highlighted four metrics for evaluation including 1. Mobilization of finance 2. Economic efficiency 3. Environmental integrity 4. Equality of access. Early results show that different policies have their pros and cons. The US loan guarantee program is effective at mobilizing money and inexpensive to taxpayers. However, it is perceived as unequal (recipients are bigger, wealthier firms) and is politically vulnerable. China's green bonds program is effective at mobilizing capital, but there are big questions about environmental integrity. The US tax credit program is transparent with equal access, mobilizes capital, but is expensive for taxpayers. Sims-Gallagher concluded that there is no silver bullet policy, but rather these policies need to be "nested" in a broader policy portfolio. Sims-Gallagher placed particular emphasis on mobilization of climate finance. She estimated there is currently about \$460 billion per annum spent on climate related investments. However, the climate finance gap is still a staggering \$3 to \$6 trillion/year. Climate finance differs from other sectors. For example, it is more of a national process. 80% of existing finance is raised in the same country where it is spent.

**[FULL VIDEO PART I; PART II](#)**



### Keynote Speech: Canadian Consul-General Stephane Lessard

In his keynote speech, Canadian Consul-General Stephane Lessard highlighted the strong energy links between Canada and the United States. The bilateral trade in energy between the two countries amounts to \$116 billion a year. 74 oil and gas pipelines cross the border, and 46% of gas produced in Canada is exported to the US. Recently, crude-by-rail shipments to the US have tripled; this mode of transportation is inferior to pipelines, and the Keystone XL pipeline should be completed to solve this problem. Canada is looking forward to the confirmation of the US-Mexico-Canada (USMCA) trade agreement to restore a firm political footing.



Consul-General Stephane Lessard speaking at the USAAEE North American Conference in Denver.

Lessard also discussed the importance of energy to the Canadian economy and decarbonization plans. Energy is a major component of the Canadian economy, and Canada is a principal supplier to energy to the world. 11% of Canadian GDP is in the energy sector. Canada is the world's fourth largest producer of oil, the fourth largest producer of natural gas, the second largest producer of uranium, and the third largest producer of hydroelectricity. 17% of Canada's domestically consumed energy is renewable. Canada has a low carbon energy plan to meet its Paris commitments. Canadian provinces are taking different approaches to carbon pricing. Carbon taxes, cap-and-trade and regulation are all instruments being used. Technical innovation is also playing a role in decarbonization. Carbon dioxide emission from oil sands production is declining in intensity. Canada is home to a direct air capture pilot plant, which takes carbon dioxide out of the air.

### Energy Trade: "The Nexus of the Interesting and Important"

API's Dean Foreman introduced the energy trade theme as the "the nexus of what's both interesting and important." Foreman proceeded to tie trade issues to every important trend from the macroeconomy, industry, and climate. Foreman highlighted the importance of trade to the US energy industry and asserted the current trade frictions poses serious challenges to growth going forward. The trade war with China has already affected products important to the US oil industry from lithium batteries to turbines, valves, meters, and motors. LNG production is ramping up rapidly with 5.4 bcf/d of capacity online, 8.3 bcf/d under construction, and 13.1 bcf/d approved. Growth depends on trade partners.



Energy Trade panelists: Horace Hobbs, Phillips 66; Kevin Book, ClearView Energy; R Dean Foreman, API; Oliver Tuckerman, Cheniere

Oliver Tuckerman reviewed LNG markets. He expects the US to become the largest LNG exporter by 2022. Tuckerman commented on the prospects for LNG from western Canada and US. Canadian LNG can be shipped to northern Asia in ten days, versus thirty days from the US Gulf Coast, an advantage for Canada of about \$1/MMBtu. However, construction in northern British Columbia is much more expensive, primarily due to skilled labor constraints.

Horace Hobbs discussed international hydrocarbon trade flows with a focus on the US. The US is both the world's largest exporter and largest importer of gasoline. NAFTA renegotiation put half of US gasoline exports at risk, but the situation seems to be settled. The US is world's largest producer and largest exporter (by far) of natural gas liquids. Tariffs have pushed US LPG to third countries, which then re-export to China. World trade is balanced, but at reduced efficiency. Hobbs noted that long-term US sustainable oil production could be as much as 17 Mb/d, which would imply an export capacity of around 9 MMB/d.

Kevin Book discussed US energy politics. A major theme is that the age of energy scarcity is over. The situation has led to presidential candidates taking the industry for granted. In that context, they are making proposals such as banning oil and gas drilling on federal land, or banning fracking altogether. In general, tariffs and sanctions have proved to be relatively low cost instruments of national power, and are likely to be harder to reverse than many think. There is a possibility that the US and China economies will become much less integrated. On the other hand, an emerging pressure point is strategic minerals, a challenge that will need to be faced by future administrations. Another emerging challenge is the prospect of a European border adjustment tax affecting fossil fuels.

**[FULL VIDEO PART I; PART II](#)**

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37<sup>th</sup> USAEE/IAEE NORTH AMERICAN CONFERENCE  
NOVEMBER 3-6, 2019 / DENVER COLORADO

## ENERGY TRANSITIONS IN THE 21<sup>ST</sup> CENTURY



### Night at the Geology Museum

The well lit M up on the mountain signaled that our buses were getting close to our reception venue at the Geology Museum at the Colorado School of Mines. Delegates could greet old friends and meet new ones over good food and drink while wandering amongst cases containing the most extensive public collection of Colorado minerals. Gold glittered and crystals sparkled from the cases. It was too dark to see the dinosaur tracks on the nearby geological trail. Come to think of it, they are hard to see even in the light.

The wall murals with mining scenes looked down on the happy crowd comparing their favorite events of the days, discussing the latest trajectory of market prices, pondering profits and other topics near and dear to the heart of those interested in energy economics. With the departure nearing a trip to the dessert bar in the lower level allowed a walk by not one, but two moon rocks. So not all the rocks were home grown. A walk through the cave to minerals that glow in the dark was a perfect end to a convivial evening that seemed to be enjoyed by one and all. If you can't visit the museum in person, check out some great pictures at the link: [VIRTUAL TOUR: CSM GEOLOGY MUSEUM](#)



### Paths to a Sustainable Future: Sequestered Breath?

Carol Dahl of Colorado School of Mines introduced the "Paths to Sustainable Future" panel by highlighting that there are different ways to get to a sustainable future. The panel featured one speaker each on potential future roles for nuclear energy, natural gas, and CCUS (Carbon Capture, Utilization, and Sequestration).

Idaho National Lab's Shannon Bragg-Sitton raised the following question. Given the importance of nuclear energy for achieving 2050 climate goals, why isn't nuclear energy thriving? She cited three key reasons including cost, public concern, and policy. Bragg-Sitton sees promise on the cost challenge through a shift to standardized design and manufacturing. The industry could address public concern with new designs that reduce the probability of accidents and mitigate the consequences if they occur. Regarding policy, she called on technology neutral frameworks that reward outcomes including emissions, reliability, and efficiency. If policy forecloses the role of nuclear, then society can't expect to see investment, and this could significantly delay progress towards climate mitigation while raising costs of deep decarbonization. Bragg-Sitton outlined a new vision of distributed small modular and micro-reactors providing power for industry, process heat, clean hydrogen, water, and possibly even syngas from captured CO<sub>2</sub>.

Natural gas has an important role in the future energy mix, even in low carbon scenarios, according to Exxon's Sara Banaszak. The IEA's 2018 two degree C° "Sustainable Development Scenario" (SDS) shows a significant role for natural gas even with a roughly 50% emissions reduction compared to the NPS base case. A range of other scenarios tracked by the Stanford Energy Modeling Forum also show a role for gas. The recent 2019 Bloomberg New Energy Finance outlook shows strong annual capacity growth for natural gas in power to 2050. The gas is primarily used for renewable energy backup and flexibility, but capacity still doubles by 2050. Banaszak added that the key point is that all sources are needed to meet energy needs in 2050, even in low carbon scenarios.

BP's Cindy Yeilding provided a preview of the upcoming National Petroleum Council (NPC) CCUS study, which will be publicly released in mid-December. The study is a roadmap to "scale up" CCUS as a viable low carbon option. The study draws on the expertise of 110 organizations including oil & gas firms, financial institutions, and NGOs among others. The technology section of the report focuses on "capture" because it accounts for 80% of CCUS costs. The tech overview includes both "tried and true" options and promising new technologies. CO<sub>2</sub> would need to be transported because capture directly over sequestration and utilization sites would be rare. Yeilding expects pipelines to be the main transportation option, though trucks and trains would also see usage. Storage would occur in oil & gas and saline reservoirs or products. Yeilding cited a number of potential products for captured carbon including potential exotic options such as "diamonds made from a beloved's breath." A centerpiece of the study is a cost curve developed from modeling almost 2000 actual US emissions sources. The study concludes with a series of policy recommendations to catalyze growth of CCUS.



Paths to a Sustainable Future Panelists: Cindy Yeilding, Shannon Bragg-Sitton, INL; Carol Dahl, CSM; Sara Banaszak, ExxonMobil

[FULL VIDEO PART I; PART II](#)

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## Energy Entrepreneurship and Finance: Innovative Finance Supports Innovation

Ambassador Robert Perry of the Stevenson Group discussed the roles of the Trade and Development Agency (USTDA), the US International Development Finance Corp. (USIDFC), and US import-export Bank (EXIM). USTDA promotes exports, connects US firms with foreign project sponsors, coordinates with foreign delegations, manages grants, and more. USIDFC stimulates US investment in emerging markets. EXIM finances transactions that commercial lenders decline due to political or commercial risk.

Sequoia Investment's Greg Taylor discussed innovative energy infrastructure financing. Energy debt is typically private and higher yield than corporate bonds or leverage loans and is backed by energy assets or projects. Energy equity investors typically provide about 35% of the capital of the project company. Infrastructure bonds are typically resilient in a recession and are about 33% as volatile as corporate bonds.

Robert Fenwick-Smith discussed early-stage technology investment. Early stage is high risk with potential high returns—typically equity investments with no collateral. VC Funds typically take a portfolio approach—making 10-20 investments with an expected failure rate of 75%. Nearly all returns are generated by 10% of the investments. Fenwick-Smith stated that you have to take those odds and play those numbers. These types of investments are needed to support emerging technology and address climate change.

[FULL VIDEO PART I; PART II](#)



Energy Entrepreneurship and Finance Panel: Greg Taylor, Sequoia; Ambassador Robert Perry, Stevenson Group; Tina Vital, Castle Placement; Robert Fenwick-Smith, Aravaipa Ventures.

## Changing Oil & Gas Company Investment

Oil investment panelists highlighted the need for robust capex spending despite the rise of electrified vehicles and the climate challenge. Rice University's Mark Finley highlighted the point in his introduction, stating the energy industry needs to invest trillions of dollars just to maintain energy supplies even during the transition to low carbon energy.

ExxonMobil's Chris Birdsall explained that Exxon continues to invest in its core business. Exxon has major oil investments in Guyana, Brazil, and the Permian Basin, and natural gas projects in Papua New Guinea, Mozambique and elsewhere. Birdsall said that the world does not yet have the technologies needed to achieve its climate goals. There are opportunities for technological breakthroughs in grid storage and in biofuels, both algae-based & cellulosic. In the meantime, fossil fuels would remain important in the industrial and power sectors.

Rystad's Per Magnus Nysveen presented an industry overview. Global average depletion of oil reservoirs is 12%/year, with infill drilling giving back about 6%. Global average breakeven is \$26/bbl, tight oil breakeven cost is \$45/bbl (of which operating expenses are typically \$7/bbl to \$9/bbl), and oil sands is the highest cost oil on the market at \$83/bbl. All price figures are referenced to Brent. Globally, investments (OPEX+CAPEX) come to \$500 billion/year, with a typical cost of developing production at \$100,000/barrel/day. Tight oil has not been squeezed out by OPEC, but has been squeezed down by the supply curve. Tight oil production is flat at \$40/bbl, and grows at \$50/bbl. US production could reach 20 million bbl/d by 2030, but perhaps flattening by 2035.

Pioneer's Mark Berg focused on the Permian Basin. Permian oil production is now more than 4 million barrels per day, which is comparable to Ghawar, Saudi Arabia's largest oil field. Pioneer's operations are now in "manufacturing mode." Investors now insist on cash flow, and the growth rate is slowing due to capital discipline and depletion of resource. In fact, initial production rates are declining across all US tight oil plays. Pioneer uses a well spacing of 850-950 ft, having found that the 600 ft well spacing used by others is too close. Well productivity is improving each year, though the rate of improvement is now slowing. The breakeven cost of production is \$26-\$30/bbl, which has been achieved by driving down service costs and reducing cycle times. There is still room for equipment design improvement. Berg concluded by asking what world energy prices would be without tight oil and shale gas.

[LINK: FULL VIDEO PART I; PART II](#)



Oil & Gas Investment panel: Chris Birdsall, ExxonMobil; Mark Papa, Pioneer; Mark Finley, Rice University; Per Magnus Nysveen, Rystad



**USAAEE Tour: Noble Energy’s Oil & Gas Production Facilities, Denver Julesburg Basin**

We left the warmth of the conference hotel early to catch the minibus and head N.W. to Wells County, Colorado. An occasional pump jack (also called nodding donkeys) signaled we were in oil country. The Noble Energy Operations in Colorado are in Wells County producing from the Denver Julesburg Basin, which extends into Wyoming and Nebraska. Our first stop was Noble’s Operations Control Center. The light is low in this area full of computer screens telling those in the know what is happening out in the field 24x7x365.

Temperatures, pressures, and fluid flows can all be monitored for problems at the Control Center. When something suspicious arises control room operators can call the lease operator for a consult or even shut down operations within minutes. Geological, leaseholder, and well maps along with real time drilling data allow one operator to control drilling on two wells at a time. From 8 – 24 wells can be drilled from a pad with the most usually being 6-8. Care must be taken not to drill into any other wells past or present. With improvements in directional drilling, operators have more ability to maneuver the drilling to hit the best hydrocarbon payload possible.

From the control room, we were taken to their training center. After the safety briefing, we donned hard hats and safety glasses and continued our lessons outside amongst simulator equipment for training on oil field operations. We learned more about artificial lift, blowout preventers, equipment to separate sand and natural gas out of the oil, the intricacies of metering.

Armed with heads full of information, we set off to the lease for more on compressors, measuring, and fluid flow. Near the shadow of the drilling rig, we learned more about drilling versus

production casing, drilling mud, drill bits and smart pigs (not the type that produce ham, but the type that can clean pipelines between batches and check for corrosion). With low oil prices, they have learned to economize. Wells that used to take 17 days to drill can now be drilled in 4-5 days because of better bits, better motors, and more skilled rough necks. Longer laterals and more wells per drilling pad have reduced cost for drilling and fracking as well.

Noble not only focuses on cost and efficiency but also prizes being a good employer, a good neighbor and pays close attention to environmental issues. They have a policy of never flaring natural gas, have moved towards reduced use of combustion engines, switched pneumatic valves from natural gas to compressed air, and have infrared camera’s to detect fugitive methane and VOCs in compliance with a 2014 Colorado law, the first in the country.

Within their leases most wells drilled are horizontal. Although vertical at first, at some point they make a turn. This horizontal or lateral portion is typically around two miles long. Once the well is drilled with the casing installed and cemented, the fracking operation can begin. It is done in stages starting at the far end of the well. A portion of the pipe is perforated. Then water, sand and other chemical are injected under high pressure into the wells to create cracks in the tight formation to release oil and gas that was formerly unavailable. The sand will help keep the cracks open so the hydrocarbons can keep flowing. When completed the first stage is sealed off, and another portion of pipe is perforated and fracked. Up to eighty such stages may be completed before seals are drilled out and the well starts to produce. Much of the first few days of production is water, which is recycled or else disposed of. But soon the hydrocarbons start to flow out and the cash can start to flow in. Although there is some disagreement on its spelling (hydraulic fracturing, fracking, fracing), there is no dispute it has recently returned the US to the status of number one oil producer for the first time decades. Good news for the economy, but more worrisome for OPEC and the climate.

The group would like to thank Noble Energy for the time and energy spent informing us about the technology and showing us their operations. We appreciate their warm hospitality and for not giving us a test at the end of the day.



USAAEE tour of Noble Energy’s Oil & Gas production facilities in Denver Julesburg Basin, 7 Nov 2019.



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