THE ENERGY TRANSITION IN CALIFORNIA AND GLOBALLY: A DIALOGUE BY ENERGY LEADERS

HOSTED AT STANFORD UNIVERSITY
BY THE NATURAL GAS INITIATIVE

Final report prepared by

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May 2019

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"San Francisco Energy Dialogues: Executive Summary"

This executive summary was prepared from audio recordings of the event hosted at Stanford University on January 24, 2019.

Introduction

The Stanford Natural Gas Initiative (NGI) and Energy Dialogues LLC convened a symposium on January 24, 2019 to discuss the role of natural gas, and the changing energy landscape, in California and globally.

The Stanford NGI and Energy Dialogues LLC are grateful to our partners on this event: Boston Consulting Group, Schlumberger and Baker Botts, who provided support and participated on the steering committee to engage energy leaders from across the globe.

The event convened the university's experts and external leaders to explore ways that natural gas and liquefied petroleum gas (LPG) can most effectively be used to address energy poverty around the world.

It welcomed nearly 60 participants, representing Stanford, industry, and non-governmental organizations. The event was comprised of one keynote presentation and four panel discussions, in addition to three roundtable working sessions designed to facilitate dialogue among small subsets of the participants. The full program is provided in the appendix.

The final product from the event is this report that summarizes the main takeaways and recommendations for further efforts. Three themes of interest emerged from the symposium, which are important to understanding the potential role of natural gas in a decarbonizing world.

Decarbonization in California

The initial discussion centered on California's pathways toward a low-carbon, renewable energy future. Participants discussed the recent SB100 bill with requirements for California to get to 60% renewable energy by 2030 and 100% carbon free energy by 2045. California currently has ~34% of its electricity generated from natural gas and ~32% from renewables.

Participants agreed that the 60% renewables goal was well within reach given the huge amount of solar energy in California and the ability to import wind power from Wyoming. It is considered unlikely that the offshore wind resource will be mature enough to be incorporated into the energy system by 2030. Cost of electricity will continue to be a major driver with Californians already paying a premium for electricity at an average rate of 18 cents per kWh, compared to the national U.S. average of 12 cents per kWh.

Experts described dispatch models that indicate utilizing natural gas with CCS to attain carbon free energy will be half the cost of trying to meet the 100% clean energy goal with renewables alone. However, the continued use of natural gas in California will require carbon sequestration at the rate of about 30 million tonnes of CO_2 per year to achieve

100% zero carbon. Storage sites do exist, but economics have so far discouraged investors. However, the cost associated with CCS is significantly lower than the cost of battery storage solutions associated with renewables, so participants emphasized the need to look at lifecycle economics on a portfolio basis. Innovations in utilizing the CO_2 in a product or converting it to a fuel are currently not at a large enough scale to make a significant impact but remain the holy grail for decarbonization.

There was general consensus that battery storage presents a major challenge for coping with the huge ramping requirements of up to 3 GWh/hr, the daily variation in solar power, and the seasonal variation that can be as much as 50% greater in the summer compared to winter. Battery costs are still high, but participants envision those costs reducing as the technology is scaled up. However, the storage capacity of batteries is not sufficient to address the seasonal variations in renewable power output. In California there are periods of up to 10 days when the sun doesn't shine and therefore no solar power is generated. Participants emphasized the use of natural gas to provide reliability in the power supply. Other downsides of using batteries include reduced energy efficiency and the environmental impact of manufacturing that mostly occurs in China utilizing a carbon-intensive grid.

Due to high electricity demand, California imports more electricity than any other state; In 2017, 90% of natural gas was imported from out-of-state (and then 91% of natural gas power was generated in-state), compared to 28% of renewable power being imported. Most notably, ~53% of wind power is imported, mostly from the Northwest region. For a high penetration of renewables, there is a fundamental need to increase the area over which energy is generated to negate the impact of wind and solar resources being correlated in time. Therefore, the 100% carbon-free goal will require a regional approach to energy governance. Critical issues regarding the formation of a regional electricity market include state vs federal pricing authority, use of prices to correct for environmental policy. Participants generally agreed that the west grid is on its way to becoming a lot greener, which will increase the likelihood of a regional electricity market, lowering transaction costs associated with moving solar/wind power across state borders, and ultimately lowering the unit cost to the consumer.

Participants discussed the economic and social value of California conducting what is essentially a large-scale pilot project for what will hopefully become full global decarbonization. Economically, it was noted that it would actually be cheaper to reduce carbon emissions by investing in other parts of the world. However, California is well positioned socially, politically and technically to create a working decarbonization model that could be replicated in other locations. Many consumers are willing to pay a premium for clean energy. Politically there is a motivation as the decarbonization process will create jobs in the local economy and many of the technical leaders have headquarters in California.

Technology, Innovation and the Changing Narrative

The paradigm is shifting within the energy industry, with the formal acceptance of global warming by the major oil and gas companies. However, the oil and gas industry still evokes a negative reaction, particularly from millennials who would prefer the emphasis be on renewable and clean energy. Indeed, within the bay area and Silicon Valley there are over 1400 energy companies, many focusing on developing or investing in new clean energy technologies.

The role of the established energy companies in solving the climate issue has not been well communicated to the younger generation. Participants agreed that Millennials generally lack education and understanding on what the key energy issues are and what the practical considerations are for transitioning to renewable energy. Millennials bring a new set of skills to the energy space, most notably in their use of data science and technology.

Traditionally, employees of energy companies have enjoyed a multi-decade career. This is in stark contrast to the Millennial philosophy of experiencing a new company every few years. Furthermore, Millennials are impatient and want to succeed quickly, but the energy industry is not in tune with that. Participants agreed that there is a resistance to change within the oil and gas industry, but dialogue and connection is important. Millennials also have a strong sense of social justice and equality that the energy industry could tap into.

One key topic that is getting attention in both the traditional and the start-up energy communities is detecting and preventing fugitive oil and gas methane emissions. A recent study suggests that a couple of percent of produced natural gas is emitted at some point along the value chain. These emissions effectively double of the greenhouse gas impact from natural gas and eroding much of the environmental benefit over coal. The global methane emissions leakage is about 75 million metric tons, with approximately 20 million metric tons in the US. To put this in perspective, in the US we have about a million oil and gas wells and in each well there are about a thousand components that might leak.

Detection technologies that may have a significant impact and result in a reduction in methane emissions include both mobile and fixed monitoring sensors. Partnerships between technology startups and large energy companies is critical for pilot projects and field tests that establish technology credibility.

A serious challenge for a young company in the energy sector is the requirements of financing. Oil and gas technology is by definition capital intensive just because of the scale and hardware required. The venture capital industry in California provides a mechanism for funding small technology proof-of-concept projects in a way that the traditional private equity industry does not.

Global Energy Access

Currently, there are around a billion people without access to any energy, and a further 1.5 billion people with intermittent, unreliable energy. Since 2010 the number of people who are gaining access to energy each year is accelerating, currently at approximately 118 million people per year. However, this is more than offset by the concurrent huge population growth.

There is consensus that the amount of oil and coal is going to remain fairly constant over the next few decades, with the increase in energy demand being met by an increase in natural gas and renewables. There is an understanding that energy system solutions will need to be designed with regional constraints in mind (e.g., hours of sun/wind), in addition to technology, regulatory and commercial factors.

Participants agreed that it was necessary to tackle the issue of energy access and climate mitigation concurrently. Decarbonization of the global electric power sector is critical, and the abundance of natural gas in conjunction with carbon capture and storage technologies offers a pathway to achieve the objectives laid out in the Paris accords. The oil and gas industry produces approximately 30 billion barrels of oil a year, which is coincidentally the approximate volume of CO2 that would need to be sequestered annually to prevent an increase in global temperatures.

The focus should be on urban population centers where 90% of the energy poverty exists. This will increase as climate change increases migration from rural communities toward cities. Countries such as India and Pakistan currently need more than 5 times the power they have now, However, solar and wind do not offer the reliability necessary for industrial applications and without natural gas, coal becomes the only economic option. Indeed, there are 300 Gigawatts of coal-burning capacity under construction in Asia.

Renewable energy markets, particularly wind and solar, continue to develop in a geographically distributed manner. The cost of solar in particular is steeply declining associated with the implementations occurring at scale. Wind energy continues to be commercialized on-shore, and the off-shore sector is starting to pick up in Europe and the US east coast. Reliability continues to be the thorn in the side of renewables, and until storage options are economic, fossil fuels will remain important. Participants discussed the concept of “leap-frogging” in developing countries, but the availability of cheap fuels like coal in conjunction with the reliability issue make this unlikely.

Investment has occurred at a variety of scales, from small sustainable finance initiatives through the World Bank to international oil companies investing billions of dollars in LNG plants, like the one in Mozambique that will double the country GDP. Participants also discussed the recent uptick in venture capital units within energy companies intended to spark innovation. Energy poverty solutions need to focus on being affordable, scalable and cleaner and developed through partnerships between private sector, universities, NGO’s and governments. Examples discussed included private companies partnering with utilities

in Bangladesh, resulting in an increase in electricity access from 30% of the population to 50%.

Clean cooking fuels remain a focus with over 4 million people dying annually due to indoor air pollution associated with burning solid fuels such as biomass and wood on open fires or traditional stoves. Participants discussed the innovation in business models necessary for commercial-scale solutions.

The long value chain associated with natural gas, particularly LNG, means the transportation of gas is much more difficult than oil. For example, in India there is a resistance to building expensive gas power plants and petrochemical plants without a guarantee of supply. However, the subsidies currently in place across the nation make it uneconomic for large oil and gas companies to participate in that market. LNG also offers a solution for islands with limited energy supply but has been met with policies that target the elimination of natural gas.

Understanding the customer view will be increasingly important when designing energy systems for the future. Oil and gas companies are considering how to migrate down the value chain toward the customer. Examples of customer-focused solutions include modular LNG, pay-as-you-go solar and LPG.

With regard to the global development of unconventional oil and gas resources, participants noted that the North America shale revolution is difficult to replicate elsewhere. The US regulatory framework and favorable commercial terms made investment attractive. Subsidized pricing in other countries is also an obstacle.

Participants also discussed the role of nuclear power as a carbon-free energy source. In general, the social license to operate is the primary barrier, although in the US especially it is also a low value proposition.

Finally, in contrast to energy poverty is the issue of energy gluttony. Participants discussed the need for energy efficiency and regulating energy consumption. Digital technology has a lot of potential for providing customers with detailed information on their energy usage. Technology companies also need to be mindful that the products they bring to market, such as pad chargers, do not diminish energy efficiency.

SAN FRANCISCO ENERGY DIALOGUES

JANUARY 24, 2019 | STANFORD, CA

CITY SERIES
BY ENERGY DIALOGUES

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9:00am – 9:30am Coffee and Registration

9:30am – 9:40am: Welcome Remarks
Monika Simoes**, Managing Director, **Energy Dialogues LLC

9:40am – 9:50am: Stanford NGI Welcome Remarks
Naomi Boness**, Managing Director, **Stanford Natural Gas Initiative

9:50am – 10:30am: CALIFORNIA'S PATHWAY TOWARDS A LOW-CARBON, RENEWABLE ENERGY FUTURE
"Fireside Chat" On California's race towards net zero carbon

- *California's energy scenarios, overall plans to transition to a low-carbon economy and what they will mean for the state and the region - examining targets and aspirations*
- *Challenges and risk mitigation in the wake of California's wildfires - how can all stakeholders collaborate in building solutions going forward?*
- *A closer look at regulatory and policy frameworks; how will they influence businesses overall, as well as supply and demand for various resources?*
- *What do California initiatives look like for emissions reduction in transportation and a decarbonized power grid?*
- *What are the realities, opportunities and challenges of SB 100 and achieving 100 percent carbon free electricity by 2045?*
- *How will existing energy sources integrate with new sources? Will new energy be increasingly renewable?*
- *What will California's changing energy landscape mean for consumers?*
- *What will be the role of natural gas in achieving California's goals?*
- *Building a sustainable ecosystem around energy and win-win value chains; what are the prospects for a sustainable way forward?*

Moderated by: Chris Carr**, Partner, **Baker Botts
Panelists: Thomas Baker**, Partner & Managing Director, **Boston Consulting Group
Sally Benson**, Co-Director, **Precourt Institute for Energy
Michael Wara**, Director, Climate and Energy Policy Program, Senior Research Scholar, **Woods Institute for the Environment, Stanford University

Q&A

10:30 – 10:45am: Gamechanger: What's New in an Old Industry: Oil & Gas in the Era of Decarbonization
Mark Zoback**, Benjamin M. Page Professor of Geophysics and Director, **Stanford Natural Gas Initiative

10:45am – 11:30am TECHNOLOGY LIGHTNING ROUND
How will innovation, new technologies, AI, Blockchain, and digitalization revolutionize how business is done in energy? What will be the catalysts for change? - Looking at startups in Silicon Valley and beyond and their work in the energy sector

- *Grid reliability, storage and battery technology*
- *Monitoring, capturing and solving methane leakage*
- *Renewable natural gas*

- *Digitized operations, cloud platforms and blockchain*
- *Transportation - What will it take to electrify the sector?*

Moderated by: Abhi Ravishankar**, Principal, **Boston Consulting Group
Panelists: Drew Pomerantz,** Principal Research Scientist, **Schlumberger
Meade Lewis**, Founder & CEO, **mIQroTech
Cully Cavness**, Co-Founder, **Crusoe Energy
Brian Jones**, Chief Operating Officer & Co-Founder, **Kairos Aerospace

11:30am – 11:50am: Coffee Break

11:50am – 12:30pm: FUTURE ENERGY SYSTEMS IN AN ERA OF DECARBONIZATION
1st Roundtable Working Sessions

- What do California's targets and unfolding of action tell us about future energy systems?
- What does an ideal regulatory framework look like to enable these systems to develop?
- How will technology and innovation transform the value chain and impact individual organizations?
- What are notable advancements in energy from renewable natural gas, which areas of demand may RNG fulfill and what is needed to get there?
- What could "certified green" natural gas look like?
- What will infrastructure development look like to support advancement of future energy systems and energy transition goals?
- How do lifecycle emissions and carbon intensity play into defining future energy systems?
- What will the energy demand curve look like in an era of energy transition?
- What may future energy systems look like in the US, regionally and globally? What are engineering, economic, political, and geopolitical concern? What are uncertainties and opportunities?

12:30pm – 1:30pm: Lunch Reception

1:30pm – 2:10pm: GLOBAL ENERGY ACCESS AND ENERGY POVERTY SOLUTIONS
Panel Discussion on what it will take, how it can be achieved and what trade-offs will be to bring energy to the world

- *What are different perspectives on energy transitions when considered on a global scale?*
- *Where do natural gas and other energy resources come into play when addressing economic development and energy poverty? How can the conversation be broadened on a global scale?*
- *Where is investment best focused? What are areas across the value chain that will make the biggest difference? What partnerships and initiatives are needed to solve the energy poverty conundrum?*
- *What is the responsibility of developed nations to provide safe and affordable energy access to the world?*

Moderated by: Rob Jackson**, Professor of Earth System Science, Senior Fellow, **Stanford Woods Institute for the Environment and the Precourt Institute for Energy
Panelists: Naomi Boness**, Managing Director, **Stanford Natural Gas Initiative
Robert Schwiers**, Deputy Chief Economist, **Chevron

Q&A

2:10pm – 2:50pm: CORPORATE SOCIAL RESPONSIBILITY INITIATIVES AND SUSTAINABILITY GOALS
2nd Roundtable Working Sessions

- Government versus private sector's role in addressing health challenges, climate change, air quality concerns and more?

- Silicon Valley and the energy industry - a complicated or symbiotic relationship?
- Zero carbon strategies - what do those look like across the globe?
- What may the best areas be to focus on achieving societal benefits and financial returns?
- How can "Total Societal Impact" become a new strategic lens for companies?
- How are companies measured for their sustainability performance? What do investors look at?

2:50pm – 3:10pm: Coffee Break

3:10pm – 3:50pm: CHANGING THE NARRATIVE OF THE ENERGY INDUSTRY
Panel Discussion on the image of the energy industry, Millennials and how to attract a new generation to the sector

- *How can we jointly change the narrative and reach a new generation of leaders?*
- *How do we educate stakeholders outside of the industry? What is the role of conveners and "dialogue sparkers"? What is needed to take conversation and action to the next level? How can we strengthen fact based, practical conversation and dialogue?*
- *Are there important lessons to be learnt from other industries?*
- *In an era of information and surveillance democratization, how can we avoid fake news and focus on data and industry image? Is there a better way to build trust, grow coalitions and truly join forces in the build-out of an efficient, clean future energy system?*

Moderated by: Naomi Boness**, Managing Director, **Stanford Natural Gas Initiative
Panelists: Shandell Szabo**, Vice President U.S. Exploration, **Anadarko
Cassie Bowe**, Associate Vice President, **Energy Impact Partners
Jef Caers**, Director, **Stanford Center for Earth Resources Forecasting
Monika Simoes**, Managing Director, **Energy Dialogues LLC

Q&A

3:50pm – 4:30pm: TAKING ACTION, BUILDING COALITIONS AND MAKING A CASE FOR OPEN DIALOGUE IN A TIME OF ENERGY TRANSITION
3rd Roundtable Working Sessions

- How can we create a wave of initiative, a "rational middle" and a better education about energy?
- What are ripple effects around public perception on natural gas and the wider energy sector?
- What will it take to change the energy narrative? What is industry's role in doing so? Where do other stakeholders come in?
- What will shifting demand scenarios look like in the light of a push away from fossil fuels?
- What will it take to engage the next generation of leaders in the dialogue?
- How can better dialogue be shaped and collaboration be achieved on local issues?

4:30pm – 4:50pm: SUMMARY AND CONCLUSIONS
Table Leader Panel - Summary and Conclusion of Roundtable Talks
Informal panel of working session facilitators

5:00pm – 6:00pm: Closing Cocktail Reception at Stanford's Natural Gas Initiative