The background of the cover is a photograph of a stone building with arches and columns. The stone is a warm, golden-brown color. The architecture features classical columns with decorative capitals. The scene is brightly lit, suggesting a sunny day. A red rectangular box is overlaid on the top half of the image, containing the title and authors' names in white text.

**The Stanford Natural Gas Initiative
Reducing Energy Poverty with
Natural Gas: Symposium
Action Paper**

Usua U. Amanam and Tisha Schuller

Symposium

**Reducing Energy Poverty with
Natural Gas: Changing
Political, Business, and
Technology Paradigms**

**May 9 & 10, 2017
Stanford University, CA**

Stanford Natural Gas Initiative

Reducing Energy Poverty with Natural Gas: Changing Political, Business and Technology Paradigms

Symposium Action Paper

Usua U. Amanam and Tisha Schuller

August 2017

1 Background

The Stanford Natural Gas Initiative (NGI) convened a symposium on May 9 and 10, 2017 entitled *Reducing Energy Poverty with Natural Gas: Changing Political, Business and Technology Paradigms*. The event was the second Stanford Natural Gas Initiative Symposium; it followed the successful 2015 one, *Natural Gas and the Energy Bridge*.

The Stanford NGI collaborated with the Stanford Global Development and Poverty Initiative, the World Bank, the Cynthia and George Mitchell Foundation, the Breakthrough Institute, and the Observer Research Foundation (ORF) to hold the symposium. The event had a steering committee composed of Stanford researchers and students, Stanford NGI members, and external partners. The committee collaborated for 11 months to prepare the agenda.

The symposium 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 130 participants from 13 countries, representing Stanford, industry, foundations, and both government and non-governmental organizations. The first day included two welcome keynotes and two introductory panel discussions, while the second included two regionally-focused panels. Additionally, three series of breakout sessions (14 in total) were held to facilitate dialogue among the participants. The full symposium program is provided in the appendix.

The final product from the symposium is this action plan that summarizes the main takeaways and recommendations for further efforts. Six themes of interest emerged from the symposium, which are presented in section 4. Each focused on one fundamental aspect important to understanding the challenges of addressing energy poverty and the potential role of natural gas and LPG.

2 Literature Reviews

Four literature reviews were prepared in advance of the symposium to provide a baseline of shared information for symposium participants. They were released between January and May 2017. The first, titled *Energy Poverty: What You Measure Matters*, was authored by Lauren C. Culver to provide a survey of energy poverty metrics. Culver authored an additional report, *Framework for Understanding the Role for Natural Gas*

in Reducing Energy Poverty, to assess the prospects for natural gas to contribute to addressing global energy needs. Two geographic areas were identified as good examples for what solutions might look like for new and emerging gas markets, thus introductory papers were prepared for each. *Natural Gas in India: Markets and Influencers*, by Usua U. Amanam, reviewed two of India's gas markets in detail: the power sector and the natural gas vehicle fleet. In the final paper, *Natural Gas in East Africa: Domestic and Regional Use*, Amanam discussed the use of the natural gas resource in East Africa and provided an overview of the energy markets in both Mozambique and Tanzania.

3 Agenda

The two-day symposium commenced with keynotes by Samir Saran of ORF in India and Maarten Wetselaar of Shell in the Netherlands to set the stage for discussions on the beneficial role that gas can play in addressing energy poverty around the world. The first panel, titled *Natural Gas and the Multi-faceted Energy Poverty Challenge*, moderated by Todd Moss from the Center for Global Development, was designed to create a common understanding of the topic of energy poverty. This was followed by a second panel *Sustaining Success: Requirements for Natural Gas to Deliver Its Energy Promise*, and was moderated by Stanford University's Mark Thurber. Topics related to the long-term sustainability of natural gas projects were discussed, including investment, socio-political practice, and market development. Over lunch, NGI Director Mark Zoback interviewed Shell Nigeria's (Shell Petroleum Development Company of Nigeria Limited) Philip Mshelbila to put the symposium's work in the context of actual challenges grounded in the human experience.

The second day began with an overview of natural gas activity around the globe by Peter Hughes of Global Gas Partners. The focus then shifted to two geographic areas: India and East Africa. Jeremy Carl of Stanford University moderated the panel on India, and Stanford's Christine Jojarth served in the same capacity during the East Africa panel. Each day concluded with a series of concurrent breakout sessions on topics that ranged from the opportunities for and barriers to the adoption of LPG, to how geopolitical decisions affect energy access and the adoption of useful technology. The following section includes themes from these sessions, as well as those from panel discussions.

4 Key Takeaways

Several themes emerged from the symposium that are different from the prevailing narratives on both poverty alleviation and climate change. Symposium participants addressed the topic of energy access in the context of human development, prosperity building, and socioeconomic development at scale, rather than the less ambitious goals often defined around isolated access to minimal lighting or individual cook stoves.

Sustainable energy access is often discussed in a context that implicitly or explicitly rejects a future role for any fossil fuels. Natural gas and LPG were identified as important fuels with the potential to change energy development paradigms when given the chance. Because the pros and cons of fossil fuels are not created equally, symposium speakers identified the unique health, environmental, scaling, and climate-benefits of gas. The key takeaways that resulted from these discussions are explored further in the following sections and are summarized as follows.

- Energy access is critical to alleviating poverty.
- Energy poverty reduction requires more than low-level electricity.
- Natural gas and LPG meet important energy needs.
- Economic development, health, and environmental goals must be pursued simultaneously.
- Natural gas development requires a viable value chain.
- Companies can participate in developing their future markets.

4.1 Energy access is critical to alleviating poverty.

A significant portion of the world’s population still lacks meaningful access to modern energy services. There are currently 1 billion people without electricity, up to 2 billion whose electricity is inadequate and unreliable, and a total of 3 billion that use traditional low-grade fuels like firewood, dung, and charcoal for cooking [1]. Although it is unclear if limited energy access is a cause of or the result of poverty, it is certain that sustainable socioeconomic development requires access to energy. The absence of legitimate energy services limits the prospects for individuals, families, communities, and, indeed, entire economies.

There are many measures that help define energy poverty, but Culver shows that there is no one metric that adequately encompasses the scope of the issue [2], making the drafting of solutions difficult. As a result, the symposium participants ultimately articulated the objective as such: *modernizing economies through continual, sustainable improvements in energy services*. Jadavpur University’s Professor of Economics, Joyashree Roy, discussed the unproductive nature of defining a minimum energy requirement in terms of demand and wattage. Many attendees held similar sentiments, articulating that the focus instead should be to encourage efforts that equip societies with the tools to continually move up the energy ladder.

The building blocks of economic development, whether they are goods or services, require energy. Water sanitation, medical care, and education, for example, all serve as gauges for a nation’s developmental progress, and each requires affordable and reliable energy systems. The relationship between societal development and energy consumption is well established, with the human development index (HDI), a composite metric that quantifies a country’s level of human development, showing a strong correlation with energy use.

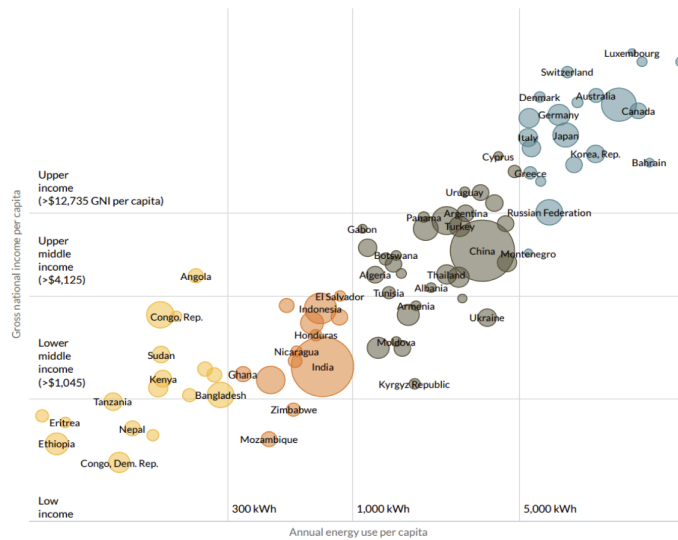


Figure 1: Annual energy use per capita vs gross national income per capita [3]

Samir Saran made a keen observation during his opening keynote, contrasting photos of women carrying energy (such as wood on their backs) and energy carrying women (in a car). This led to an ongoing discussion throughout the symposium of the disproportionate affect energy poverty has on women in many developing regions. This is a reality not often discussed despite the known association between the welfare of women and socioeconomic development [4]. In the end, prioritizing energy access for developing regions will facilitate development. Whether in cities or rural areas, in a residential setting or an industrial zone, improved energy access allows for the transformation of lives, communities, and economies. Providing this energy is a critical component to poverty alleviation and ultimately, human prosperity.

4.2 Energy poverty reduction requires more than low-level electricity.

Electrification usually dominates discussions on energy access in the developing world, with many conversations emphasizing one element, such as the importance of providing a single lightbulb to a rural home. While these efforts are important and commendable, symposium participants engaged in a significantly more ambitious conversation about creating the building blocks for serious economic development. In his opening remarks, Todd Moss contrasted the average electricity use in several emerging economies with that used in the United States for Christmas lighting alone.

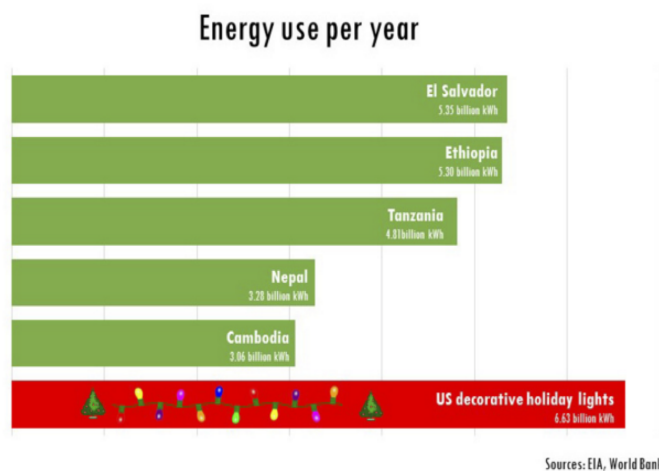


Figure 2: Energy use per year of emerging economies compared to U.S. decorative holiday lighting in 2007 [5, 6, 7]

Currently, the most commonly used definition of modern energy access is 100 kilowatt-hours per person per year for those living in urban environments [8]. This is equivalent to using one lightbulb for five hours per day, as well as a mobile phone charger [3]. In rural areas, the threshold is half of that [8]. As a result, participants were enthusiastic about raising the ambitions of energy access goals to meet higher targets that can offer access to labor-saving devices such as washing machines and economic building blocks such as refrigerators.

Throughout the symposium, an emphasis was placed on other important forms of energy: thermal, such as for heating and cooking, transportation fuels, and feedstock (energy resource) for fertilizers and petrochemicals. In developing economies, cooking alone represents 80 to 90 percent of household energy needs and therefore affords a significant opportunity to improve health outcomes (see sections 4.3 and 4.4) [9]. Additionally, transportation systems are critical for moving goods and people, creating the lifelines for economic development. The Breakthrough Institute’s Alex Trembath stressed that not enough attention is currently being paid to income-generating access like agriculture, industry, and commerce. Modernizing agriculture, for example, can play an important role in feeding a growing population in developing economies by boosting productivity levels and moving beyond subsistence farming. And although it is popular to talk about energy development in terms of individual solar panels and microgrids, understanding that meaningful access to energy in the developing world will require depth, breadth, and scale is critical. This means providing the appropriate energy needed to support commercial and industrial development. Natural gas and LPG can be uniquely versatile fuels with respect to these different applications, as is discussed in the following section.

4.3 Natural Gas and LPG meet important energy needs.

Both the first and second panels emphasized the different approaches required to address rural and urban energy needs. In their armchair discussion, Rachel Pritzker of the Pritzker Innovation Fund and Joyashree Roy articulated the disconnect between the perception of energy access needs and the reality. Pritzker relayed a disconcerting story of "solar access" that essentially amounted to holes in the roofs of homes and Roy discussed the absence of meaningful incentives to transition away from coal in India.

Much public discussion on energy access emphasizes "last mile" electrification in rural areas. Thus, most miss three important components. First, distributed last-mile generation often emphasizes inadequate energy quantity and quality required to raise communities out of sustenance living. Second, there is a great migration of people to urban areas [10]; as a result, urban electrification is more critical for meaningful impact [11]. ORF director Sunjoy Joshi and Philip Mshelbila discussed the importance of urban electricity in economies such as India and Nigeria. Third, urban electrification requires another order of magnitude in quality and scale because disruptions affect many economic components of society and inhibit socioeconomic development. This type of electricity production requires a scale not often discussed in the context of energy access, unexpectedly providing entry opportunities for coal.

Advances in technology for extracting gas have resulted in an abundance of affordable energy that can be used to address access at a variety of scales. Natural gas and LPG are clean-burning fuels, with lower greenhouse gas emissions than coal. They are also devoid of any significant amounts of mercury, particulate, and other toxic by-products. This, for example, has led to an increase in natural gas use for power generation in developed economies like the United States [12]. When used as a transportation fuel, natural gas reduces fuel costs and provides air quality benefits in cities. And though transportation-fueling networks require careful planning and investment, these have already been achieved, to a certain extent, in some developing economies, including those of India and Pakistan. Natural gas also contains important feedstock for many industrial processes including the development of steel, plastics, and electronics.

During the symposium, World LPG Association's CEO and managing director, James Rockall, detailed the multifaceted and vital role of LPG. First, LPG provides an affordable, transportable resource that can significantly reduce household air pollutants. By switching to a cleaner and more efficient cooking fuel, the number of individuals who die from household air pollution each year will decrease. Second, in relevant climates, it can be used for space heating, as it is in developed regions [13]. Third, LPG can serve as a modular precursor to natural gas while creating markets by establishing demand for gas in different communities, eventually being replaced once the appropriate infrastructure is in place. It is well known that natural gas is difficult to store and transport, requiring capital-intensive investments in infrastructure; LPG provides a viable approach to phased growth.

4.4 Economic development, health, and environmental goals must be pursued simultaneously.

Discussions about energy access can draw out possible tensions between economic development, human health, and environmental goals. Development goals are critically important, and numerous speakers emphasized that we should not allow them to be deprioritized because of climate concerns. Participants remarked on the limitations placed on project support by financial institutions' strict guidelines that enable a renewables-only approach. Speakers agreed that climate and other environmental risks pose real and serious concerns, and we must find ways to address them without stunting economic growth in poorer countries. Promoting economic development empowers countries to determine their own prioritization around health, environmental, and climate outcomes. Building infrastructure in education, medicine, and commercial development allows communities to move away from survival to thriving development.

The use of fossil fuels and the reduction of emissions are not mutually exclusive. For example, switching the 3 billion people in the world currently cooking with traditional biomass to LPG would have a negligible impact on global greenhouse gas emissions, but would have significant positive health outcomes. In his talk, Rockall asserted that more people die from exposure to smoke from cooking with traditional fuels than the total that dies from HIV/AIDS, malaria, and tuberculosis combined [14, 15, 16]. Roughly \$25 billion is invested annually in fighting these three diseases, while only \$400 million is spent on improving access to clean cooking [17, 18, 19]. According to the International Energy Agency, ten percent of what is currently being spent to fight those three diseases annually would be enough to achieve universal access to clean cooking [20, 21].

At times, the global focus on reducing fossil fuel use and promoting renewables artificially restricts options for energy development and access in a way that hurts both development and environmental quality. For example, countries may feel pressure to focus their "green" efforts on renewables, even while continuing to increase their use of inexpensive coal. Participants emphasized that gas developments may offer better economic, environmental, and health outcomes overall, than other fuels. Properly balancing the pursuit of these three ambitions is critical to improving the quality of life for people in developing regions.

4.5 Natural gas development requires a viable value chain.

A significant complication associated with natural gas is the need to stitch together a value chain from gas field to transport infrastructure (pipelines or LNG) to final consumers in a sustainable manner. Philip Mshelbila showed how a well-planned gas-to-power value chain fractures at each segment without proactive governance and effective collaboration of different institutions along the way.

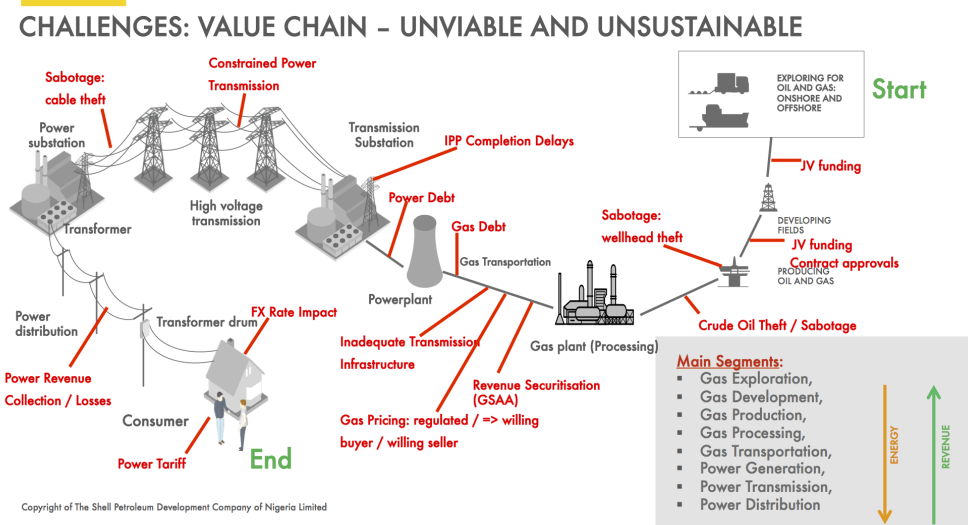


Figure 3: Competing unforeseen forces in gas value chain [22]

Many of the breaks in the chain shown above are directly related to costs and payments. Transport infrastructure is expensive for gas, and there is not a liquid global market for gas to the same degree there is for oil. Without assurances that the gas will be there, investors will not build gas-consuming facilities like power or petrochemical plants. Without assurances that there are customers who will pay prices over the long term to allow a return on gas infrastructure investments, upstream and midstream developers will not be willing to proceed. Strong governance institutions, defined markets, and appropriate gas pricing are critical to ensuring success. Peter Hughes noted that this dynamic has and will continue to hinder greater gas development. He also indicated that if a different approach is not utilized to make gas more economical that includes smaller-scale technology, for example, gas deployment is not guaranteed.

Symposium attendees cited the need for financially viable end-consumers of natural gas for success. Several countries represented at the conference struggle with the problem of how to build a viable gas value chain when state-owned power companies are unable to pay or to pay a high enough price, for the gas they consume. This is often a result of individual consumers' inability to pay for power, resulting in the power company's inability to recover costs. George Amoako-Adjei of the Ghana National Gas Company commented on the importance of investing in identifying credible demand to ensure favorable economics down to the end-consumers. In Ghana, companies make note of the appliances that are powered on the grid and by backup generators in order to gain clarity on what individual households can afford. Then when financing, the initial investment services those who can pay, and is later scaled up. Amoako-Adjei noted that, though an arduous effort, it is worthwhile.

The value chain challenges of natural gas highlight the possible complementary role of LPG in developing gas markets before natural gas is widely available. LPG is easier

and relatively cheaper to transport than natural gas, allowing distribution networks to be built out more readily. The generally fragmented character of the LPG industry is an illustration of the low barrier to entry. As a result, LPG can precede and serve as a model for natural gas, creating smaller scale access with modular expansion capacity. Small-scale efforts and distributed infrastructure can get off the ground more easily and allow scaling over time from smaller to larger grids. Scalable business models using LPG can be used to create initial demand for gas and allow the establishment of an appropriate regulatory environment, creating a pathway for increased natural gas use later.

Hamis Ussif, of the Ghana National Petroleum Corporation, commented on the benefit of using public funds to build gas infrastructure projects. Unsuccessful subsidy policies have shown this practice in a negative light, but this does not have to be the case. Careful, proactive planning may be taken to avoid misappropriation. Sound governance is a requirement for many aspects of natural gas development. Corruption, lack of physical security, bad credit (security of payments), conflicting subsidies and misaligned goals can all impede the best-planned projects.

Additionally, incumbent players may resist reform. For example, open access might hurt state-run enterprises by eliminating their monopolies. These entities have significant political power and often a direct say in how policies get drafted. As a result, state-owned entities might be understandably reluctant to give up their prerogatives, especially given their difficulties recovering costs from customers. Sunjoy Joshi asserted that in India, power generation plants are often not able to sign power purchase agreements because state utilities lack the funds to pay. The utilities end up saving more money by not providing power because of high levels of cross-subsidization, an unintended consequence of government regulation. On the other hand, effective government intervention can lead to successes. In India, more than 200 million people achieved access to modern LPG cook stoves within 5 years as a result of proactive, top-down government initiatives [23].

Stanford researcher Mark Thurber conveyed that in many developing countries, pricing gas has proven to be the most important factor in enabling effective gas utilization. Innovation and discipline around pricing policy are required. Socio-political concerns often negatively affect pricing plans; however, when gas prices are set too low, it disincentivizes production and distribution of natural gas. During the *Understanding the Developing Country Demand* breakout session, an attendee commented on the desire for universally, highly subsidized energy in Guatemala due to the lack of available funds by many impoverished citizens. But, highly subsidized gas has repeatedly led to unsustainable programs. Thurber noted that subsidies have to be carefully targeted and implemented, and adopted with appropriate exit strategies.

4.6 Companies can participate in developing their future markets.

In many instances, countries with a natural gas resource have only been able to effectively develop their export market because of the lack of a domestic consumer base. Tanzania's

acting chief technical advisor for the Oil and Gas Advisory Bureau, Dr. Emma Msaky, described her country’s development challenges, which included balancing exporting gas at a high price, with domestic use, often at a lower price. An important opportunity identified in the symposium for companies along the entire natural gas value chain is to participate in the creation of future domestic markets. Currently, companies largely observe developing economy advancement, timing their market entry with consumer prosperity. Providing energy access and the associated economic development could be a good business strategy if it helps create future customers.

Shell Integrated Gas & New Energies Director, Maarten Wetselaar, articulated how a company’s enlightened self-interest could evolve this dynamic for mutual benefit. Energy developers have not traditionally played this kind of role in unlocking future markets. It requires innovative thinking, planning, financing, and execution. Smaller scale, modular implementation may be required. Based on his own experience, Paul Krishna of XTO Energy noted that it might be best for companies to choose to partner in a consortium so as to share development risk. There may be an opportunity to create a more integrated approach that can help connect the dots from exploration to production, mid-stream to distribution, and ultimately to final consumers. This may require new business models and other efforts involving previously unconnected stakeholders and commercial partners. Sunjoy Joshi and ExxonMobil’s Seth Levey noted that there are models that remove the utilization risk from the private company, such as U.S. utilities. This involves government participation and building a portfolio of projects that help spread the risk from an individual to multi-project level. The road hybrid-annuity model (HAM) in India is one that has been tested and shown to be successful.

5 Path Forward

The recommendations for a path forward consist of a combination of original research, follow-up meetings, and a policy briefing. These are presented as six recommendations to further the conversation begun at the symposium.

Recommendation 1: Role of Natural Gas in Alleviating Energy Poverty Materials

There was broad agreement that the potential role of natural gas and LPG are generally underappreciated and the key takeaways from the symposium should be easily accessible in a broadly appealing format. This could be achieved through two avenues: an attractive, easily digestible 3-page paper about the role of natural gas and LPG and a short video detailing the material. These materials would be a resource for philanthropists, policy makers, researchers, and future collaborators.

Recommendation 2: Washington, D.C. Policy Briefing

It would be useful to compose a briefing on the potential for natural gas and LPG to reduce energy poverty to articulate the policy opportunities and implications in the U.S. and abroad. This could be organized jointly with the Center for Global Development, and could include: a white paper, a general press release, and an event in Washington,

D.C. The purpose would be to lay out the potential role for natural gas and LPG, enhanced with data and opportunities to influence policy.

Recommendation 3: Schedule Next Global Meeting

The next meeting may be scheduled in the first quarter of 2018 in Delhi, India and be co-sponsored with ORF. It is important that ongoing efforts be based in countries, like India, with enormous potential to both contribute to and benefit from the potential of natural gas in alleviating energy poverty. The agenda would be focused on the key areas for additional research discussed in Recommendation 6.

Recommendation 4: Additional White Papers

In preparation for the 2018 meeting, additional white papers would be useful in laying the ground work for the discussions of meeting topics presented in Recommendation 6.

Recommendation 5: LPG-focused Meeting

Due to the important role LPG plays, a LPG-focused meeting sponsored by or co-hosted with the World LPG Association could be very productive. The meeting may be co-located with another event such as the World Gas Congress in Washington, D.C. in June 2018 or the World LPG Forum in Houston in October 2018.

Recommendation 6: Further Research on Priority Issues

The symposium created the opportunity to identify topics worthy of future research or exploration. These topics could be pursued for white papers, research projects, or convening topics:

- **Unlocking future markets.** As a follow-up to one of the most important symposium takeaways, it would be beneficial to understand what the industry's role may be in unlocking future natural gas markets in developing regions. This includes understanding how and what innovative business partnerships that can cover the natural gas value chain look like. An ideal area of interest would be how stakeholders plan to handle the emerging East African gas market and establish credible demand domestically.
- **Innovative LPG business models.** An in-depth analysis of new LPG business models and distribution methods, such as market-owned cylinders or the use of pay-as-you-go-valves, would be beneficial in helping LPG resources more effectively reach communities.
- **Policy and process mentorship.** Participants from emerging economies identified a desire for mechanisms for successful countries or companies to aid developing countries in their implementation of exploration, production, midstream development, market creation, and coal to gas switching in electricity generation. This may include assembling useful case studies on countries that have successfully addressed the barriers to improving energy access and best practices in government energy policy. For example, India and the growth of the LPG market is a good case study.

- **Facilitation of large-scale natural gas access for emerging economies.** Participants from countries seeking or developing natural gas resources prioritized future work that would enable their access, including projects covering financing, policy, and market development.
- **Small-scale innovation.** Enabling small-scale gas solutions (including microgrids, floating regasification storage units, LPG) was a recurring theme covering several areas: technology development, technology adoption, partnerships, financing, and business models.
- **Micro LNG and distributed independent systems.** Of the many small-scale innovations discussed, micro LNG has enough progress and interest to be explored in detail.
- **Case study comparisons.** There was much discussion about the different energy access needs, such as rural versus urban populations and first access versus reliable access. Quantifying and identifying viable approaches in each case would be beneficial.
- **Energy poverty analytics.** Appropriately ambitious analytics will be useful for project goal setting, financing, and evaluating outcomes.
- **Pricing policy studies.** Effective, sustainable subsidy/pricing policies that can expand energy access to the poor without limiting supply are critical. Identifying barriers to creating such policies and strategies on how they may be overcome will be useful.
- **Natural gas's optimal timeframe.** It would be interesting and relevant to articulate the timeframe in which natural gas has an opportunity to meaningfully contribute to energy access. Is it now, or when emerging economies have more robust market places?
- **Driving health outcomes.** How can policy considerations monetize health or quality of life improvements to incentivize private sector investment over and above existing greenhouse gas reduction incentives?
- **Prioritizing human health and prosperity.** Future research and collaborations may further explore how the UN's sustainable development goals may be balanced with the creation of human health and prosperity in the context of natural gas and LPG development.
- **Natural gas electricity infrastructure development.** Building upon the discussion of Nigeria's infrastructure challenges, how are electricity infrastructures being built out in practice in developing economies? What are the current barriers and opportunities to overcome? Are there any promising actions in one region that could be applied elsewhere?

6 Conclusion

The Stanford Natural Gas Initiative was proud to host the *Reducing Energy Poverty with Natural Gas: Changing Political, Business and Technology Paradigms* symposium. The quality of participation from a diverse group of countries and institutions confirmed the importance of the topic and allowed for insightful recommendations for further exploration. Alleviating global poverty will require meaningful, scalable access to significant new energy resources. Once the importance of balancing human prosperity with health and climate considerations is acknowledged, natural gas and LPG rise in prominence as potential solutions. These fuels meet many energy needs, provide valuable feedstock, and have significant benefits over other fossil fuels and less reliable energy resources. Natural gas will not be developed without appropriate planning, financing, security, and governance though. It is our hope that this symposium began the conversations that will contribute to the meaningful assessment of future development and inspire its implementation.

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Appendix



Stanford University Natural Gas Initiative Research Symposium 2017

Reducing Energy Poverty with Natural Gas:
Changing Political, Business and Technology Paradigms

May 9 and 10, 2017, 8:00 a.m. – 6:30 p.m.

Jen-Hsun Huang Engineering Center, Mackenzie Room, Third Floor
Stanford University

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*School of Earth, Energy & Environmental Sciences
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The symposium is being held by the Stanford Natural Gas Initiative
in collaboration with the following organizations:

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The Cynthia and George Mitchell Foundation
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The Observer Research Foundation
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Mark Zoback

Director of the Natural Gas Initiative

When we launched the Stanford Natural Gas Initiative in 2015, I could not have imagined the scope and reach of the initiative after only two short years. This is no better illustrated than by this symposium—Reducing Energy Poverty with Natural Gas: Changing Political, Business and Technology Paradigms. Bringing together a wide range of experts from more than eight countries, this symposium hopes to explore one of the world’s most pressing and challenging topics: how to create opportunities to bring energy and reduce poverty in some of the most challenging, yet critically important, areas of the world. I am very happy to welcome you to this conference and to thank you for the contributions you will be making to these important discussions.

Together, we will have two days to better understand the challenges and possible actions that have the potential to improve the lives of more than a billion people worldwide. Our hope is that together, these discussions will eventually launch projects, collaborations, and new approaches to seemingly intractable problems at a global scale—truly a result that could be much greater than what any of us, or our respective institutions, could accomplish alone.

It is our fervent belief that natural gas will effectively play a critical role in addressing energy poverty around the world. But its potential cannot be realized without addressing very real challenges. Providing meaningful energy access in developing countries will be no mean feat, nor will establishing governmental and regulatory systems that encourage development of economically viable and widely accessible enterprises utilizing abundant and clean natural gas in an environmentally responsible manner. It is our belief that successful efforts to implement new energy solutions are likely to require new partnerships among people living in different parts of the world, their governments and regulatory agencies, the non-governmental institutions working in those regions and private industry, both domestic and international.

Correspondingly, we have assembled experts from academia at Stanford and other universities, private industry, private foundations, and both non-governmental and governmental institutions to ask tough questions, make new contacts, and envision bold and world-changing ideas. In the end, we hope to have had an experience that can leave each of us more informed, better connected, and better positioned to make a real contribution to reducing energy poverty around the world.

I want to personally thank Tisha Schuller, Strategic Advisor to the Natural Gas Initiative and Symposium Chair, and Brad Ritts, Managing Director of NGI, for their hard work and incredible leadership in bringing us all together to address these critical issues.



Agenda

Tuesday, May 9, 2017

Jen-Hsun Huang Engineering Center, Mackenzie Room, 3rd Floor
475 Via Ortega, Stanford, CA 94305

MORNING

8:00 REGISTRATION, BREAKFAST, AND NETWORKING

8:30 WELCOME REMARKS

Mark Zoback, Director, Natural Gas Initiative, Stanford University
George P. Shultz, former Secretary of State, Stanford University

8:45 WELCOME KEYNOTES

MODERATOR: Tisha Schuller, Strategic Advisor, Natural Gas Initiative, Stanford University

What Does Meaningful Reduction of Energy Poverty Entail?

Samir Saran, Senior Fellow and Vice President, Observer Research Foundation

A Vision for Natural Gas in Transforming Energy Access

Maarten Wetselaar, Integrated Gas and New Energies Director, Royal Dutch Shell

10:15 BREAK

10:30 NATURAL GAS AND THE MULTI-FACETED ENERGY POVERTY CHALLENGE

MODERATOR: Todd Moss, Senior Fellow, Center for Global Development

PANELISTS:

James Rockall, CEO and Managing Director, World LPG Association

Catherine Wolfram, Professor of Business Administration, Haas School of Business, University of California, Berkeley

Rathin Roy, Director and CEO, National Institute of Public Finance and Policy; Secretary to the Government of India

12:00 LUNCH—ADDRESSING THE AMBITION GAP

MODERATOR: Mark Zoback, Director, Natural Gas Initiative, Stanford University

Philip Mshelbila, General Manager—Gas and Director, Shell Petroleum Development Company of Nigeria Ltd (SPDC)

1:00 BREAK

AFTERNOON

1:15 SUSTAINING SUCCESS: REQUIREMENTS FOR NATURAL GAS TO DELIVER ITS ENERGY PROMISE

MODERATOR: Mark Thurber, Associate Director, Program on Energy & Sustainable Development, Stanford University

PANELISTS:

George Amoako-Adjei, Commercial Director, Ghana National Gas Company

Patrice de Vivies, Senior Gas Advisor, Energy and Extractives, World Bank

Robin Dunnigan, Deputy Assistant Secretary for Energy Diplomacy, Bureau of Energy Resources, U.S. State Department

Ken Koyama, Managing Director and Chief Economist, Japan Institute of Energy Economics

2:45 BREAK

3:00 CONCURRENT BREAKOUT SESSIONS

Understanding Demand in the Developing World

LOCATION: Huang, Room 304

Global LNG Markets and the Developing World

LOCATION: Huang, Room 305

Liquefied Petroleum Gas (LPG)

LOCATION: Mackenzie Conference Center

Where Does Gas Fit in a Decarbonized Energy Strategy?

LOCATION: Y2E2, Room 382

Natural Gas Infrastructure and African Business Environments: Challenges and Opportunities

LOCATION: Huang, Room B016

Additional breakout session details on page 6.

4:00 BREAK

4:15 CLOSING KEYNOTE MEANINGFUL ENERGY ACCESS IN PRACTICE

MODERATOR: Rachel Pritzker, Founder and President, Pritzker Innovation Fund

Joyashree Roy, Professor of Economics, Jadavpur University in Kolkata

5:00 NETWORKING EVENT

LOCATION: Jen-Hsun Huang Engineering Building, Huang Amphitheater, Basement level

6:30 DAY 1 CLOSSES

Wednesday, May 10, 2017

Jen-Hsun Huang Engineering Center, Mackenzie Room, 3rd Floor
475 Via Ortega, Stanford, CA 94305

Agenda

MORNING

8:00 BREAKFAST AND NETWORKING

8:30 WELCOME KEYNOTE

The Global Natural Gas Business

Peter Hughes, Partner, Global Gas Partners GMBH

9:15 MEETING THE PROMISE OF INDIA

MODERATOR: Jeremy Carl, Research Fellow, Hoover Institution, Stanford University

PANELISTS:

Sunjoy Joshi, Director, Observer Research Foundation

Ajay Khandelwal, President of E&P Business, Reliance

BC Tripathi, Chairman and Managing Director, GAIL

10:30 BREAK

10:45 ENERGY AT STANFORD

Sally Benson, Co-Director, Precourt Institute for Energy; Director, Global Climate & Energy Project, Stanford University

10:55 BUILDING BLOCKS OF PROSPERITY: NATURAL GAS IN EAST AFRICA

MODERATOR: Christine Jojath, Lecturer, International Policy Studies, Stanford University

PANELISTS:

Morgan Bazilian, Lead Energy Specialist, World Bank

Emma Msaky, President's Office, Oil and Gas Advisory Bureau, United Republic of Tanzania

A. Scott Moore, Vice President of Worldwide Marketing, Anadarko Petroleum Corporation

12:15 NETWORKING LUNCH

Sponsored by Anadarko Petroleum Corporation

1:00 BREAK

AFTERNOON

1:15 CONCURRENT BREAKOUT SESSIONS

Community and the Social License to Operate

LOCATION: Y2E2, Room 382

Governance

LOCATION: Y2E2, Room 300

Technology and the Promise of Small Scale Natural Gas

LOCATION: Y2E2, Room 299

India: Domestic Regulation and Governance

LOCATION: HUANG, Room 305

Harnessing the African Gas-fired Power Opportunity: What is Needed from African Governments?

LOCATION: Huang, Room 304

Additional breakout session details on page 7.

2:30 TRANSITION

2:45 CONCURRENT BREAKOUT SESSIONS

Natural Gas Beyond Electricity

LOCATION: Y2E2, Room 299

Pricing

LOCATION: Y2E2, Room 300

Geopolitical Moves for Securing Energy Flows

LOCATION: Y2E2, Room 382

India: Midstream Infrastructure and Capacity

LOCATION: Huang, Room 305

Additional breakout session details on page 8.

4:00 TRANSITION

4:15 CLOSING REMARKS TAKING THE EFFORT FORWARD

Tisha Schuller, Strategic Advisor, Natural Gas Initiative, Stanford University

4:30 ADJOURN

Breakout Sessions

Tuesday, May 9, 2017

3:00 – 4:00 p.m.

UNDERSTANDING DEMAND IN THE DEVELOPING WORLD

There is still much that economists and development experts do not understand about how growth among the poor affects energy demand. Changes in energy demand are not linear. What are the priorities for research?

Sally Benson, Co-Director, Precourt Institute for Energy; Director, Global Climate & Energy Project, Stanford (moderator and champion)

Joyashree Roy, Professor of Economics, Jadavpur University in Kolkata

Alex Trembath, Communications Director, Breakthrough Institute

Hamis Ussif, Principal, Corporate Strategy and New Business, Ghana National Petroleum Corporation

LOCATION: Huang, Room 304

GLOBAL LNG MARKETS AND THE DEVELOPING WORLD

Global LNG markets are undergoing dramatic change. Can the market deliver gas reliably at prices that can benefit the world's poor? What are the risks and benefits of developing countries exposing themselves to this changing market? Are there technologies or business models that can mitigate the risks? How can the risks of gas development and the LNG market be balanced between producers and consumers?

Lauren Culver, student, Management Science & Engineering, Stanford University (moderator and champion)

Paul Doucette, Global Public Policy Leader, GE Oil & Gas (champion)

Anatol Feygin, Executive Vice President and Chief Commercial Officer, Cheniere

Neil Parsan, former Ambassador to Trinidad and Tobago

Oliver Simpson, Vice President of Commercial, Excelerate Energy

LOCATION: Huang, Room 305

LIQUEFIED PETROLEUM GAS (LPG)

LPG is far superior to traditional biomass when it comes to air quality. What policies can enhance the availability and affordability of a health- and climate-friendly cooking fuel? Current projects have identified opportunities and barriers to adoption of LPG on a massive scale.

Andrew Adu, Commercial Manager, Ghana National Gas Company

James Rockall, CEO and Managing Director, World LPG Association

Mark Thurber, Associate Director, Program on Energy & Sustainable Development, Stanford University (moderator and champion)

LOCATION: Mackenzie Conference Center

WHERE DOES GAS FIT IN A DECARBONIZED ENERGY STRATEGY?

The development community increasingly suggests that we don't need to develop gas because renewables will soon be cheaper anyway. This breakout will ask the question... can energy poverty be reduced without natural gas? Natural gas has roughly half the emissions of coal and is capable of supplying consistent base load power to balance renewable energy in the grid. How can global policies and conversations, particularly those around investments by multilateral development banks and the OECD move towards investments in natural gas infrastructure in developing countries? How can energy poverty and climate goals be addressed simultaneously?

Paula Gant, formerly U.S. Department of Energy (moderator)

George Minter, Regional Vice President, External Affairs and Environmental Strategies, Southern California Gas Co.

Todd Sostek, Manager, Environmental Research, Southern California Gas Co. (champion)

LOCATION: Y2E2, Room 382

NATURAL GAS INFRASTRUCTURE AND AFRICAN BUSINESS ENVIRONMENTS: CHALLENGES AND OPPORTUNITIES

The business environment in Sub-Saharan Africa (SSA) has long been a constraint on the growth of African gas. This session will explore SSA's business environment obstacles, characterizing their relative impact and country-level distribution and identifying strategies for navigating them. How can investors and project developers navigate the political and administrative barriers, regulatory and taxation challenges, local content requirements, logistics and supply chain constraints, labor availability issues, and social and cultural complexities facing Africa's most promising gas markets? Longer-term, what reforms should policy makers in these markets prioritize to de-risk investment and accelerate projects?

Mark Caine, Special Assistant for Energy and Economy, African Union

LOCATION: Huang, Room B016

Wednesday, May 10, 2017

1:15 – 2:30 p.m.

Breakout
Sessions

COMMUNITY AND THE SOCIAL LICENSE TO OPERATE

With new resource development, there is often a strong expectation among the local community for immediate improvements in employment, services, and infrastructure. What are best practices for managing expectations, finding the right community liaisons, and balancing in-country commitments with market considerations?

David Carroll, President and CEO, GTI; President, International Gas Union

Landon Derentz, Energy Policy Advisor, U.S. State Department (moderator and champion)

Philip Mshelbila, General Manager - Gas and Director, Shell Petroleum Development Company of Nigeria Ltd (SPDC) (speaker and champion)

George Mensah Okley, Ministry of Energy and Petroleum, Ghana
LOCATION: Y2E2, Room 382

GOVERNANCE

What are the best practices for sustainable development and distribution of wealth? What can be done to help governments develop their resources sustainably? What are the learnings from developed markets, and what are the constraints faced by energy poor countries in emulating these learnings?

Patrice de Vivies, Senior Gas Advisor, Energy and Extractives, World Bank

Christine Jojarth, Christine Jojarth, Lecturer, International Policy Studies, Stanford University (moderator and champion)

Emma Msaky, President's Office, Oil and Gas Advisory Bureau, United Republic of Tanzania

Kenyon Weaver, Attorney-Advisor, Commercial Law Development Program (CLDP), Office of the General Counsel of the U.S. Department of Commerce

LOCATION: Y2E2, Room 300

TECHNOLOGY AND THE PROMISE OF SMALL SCALE NATURAL GAS

Small scale distribution of natural gas could open up many new markets and may be critical to serving low income countries where initial demand may be very modest. What technology, policy, and business models are currently being considered? What innovation is still needed? What is the synergy with the ongoing revolution in mobile banking? How relevant are new Silicon Valley driven efforts to collect data to understand customer behavior and de-risk investment?

Ricky Buch, Senior Strategy Leader, GE Power

Paul Doucette, Global Public Policy Leader, GE Oil & Gas (moderator and champion)

Alex Trembath, Communications Director, Breakthrough Institute

Hamis Ussif, Principal, Corporate Strategy and New Business, Ghana National Petroleum Corporation

Alicia Trent, Product Leader, Gas Processing at GE Oil & Gas

LOCATION: Y2E2, Room 299

INDIA: DOMESTIC REGULATION AND GOVERNANCE

India currently does not have an open gas market. Gas prices are set by the government which discourages foreign investments. Low gas prices have failed to spur a domestic gas market. The political will to allow for the development of an integrated gas market is needed. The difficult decision to remove direct and quasi control over pricing and end-use will create conditions where benefits and costs are accrued through market operations and will help attract interest from investors, producers and distributors. What pricing structures can enable domestic use without crippling domestic development? How can price structures that incentivize both supply and demand be created?

Sunjoy Joshi, Director, Observer Research Foundation

Ajay Khandelwal, President of E&P Business, Reliance

Rathin Roy, Director, National Institute of Public Finance and Policy, India (speaker and champion)

Pallassana (Venkat) Venkataraman, Global Business Development Lead, ExxonMobil (moderator and champion)

LOCATION: Huang, Room 305

HARNESSING THE AFRICAN GAS-FIRED POWER OPPORTUNITY: WHAT IS NEEDED FROM AFRICAN GOVERNMENTS?

Africa's gas-fired power opportunity is substantial, but so too are the barriers to its realization. Many of these emerge directly from the policies and practices (or lack thereof) of African governments, which often control not only mineral rights and land but also some or all of their domestic electricity markets. This working session will draw on participants' research and experience to produce a set of actionable recommendations for African governments seeking to increase the role of natural gas in their electricity supply.

George Amoako-Adjei, Commercial Director, Ghana National Gas Company

Mark Caine, Special Assistant for Energy and Economy, African Union (moderator and champion)

Todd Moss, Senior Fellow, Center for Global Development

Mark Thurber, Associate Director, Program on Energy & Sustainable Development, Stanford University

LOCATION: Huang, Room 304

Breakout Sessions

Wednesday, May 10, 2017

2:45 – 4:00 p.m.

NATURAL GAS BEYOND ELECTRICITY

Natural gas is an important feedstock for chemicals, an alternative transportation fuel, and source of energy for industry. Can gas consumers that are not in the power generation business anchor upstream gas development or initiate investment in natural gas distribution, or must power generation or gas exports lead the way?

Morgan Bazilian, Lead Energy Specialist, World Bank

David Carroll, President and CEO, GTI; President, International Gas Union (moderator and champion)

Philip Mshelbila, General Manager–Gas and Director, Shell Petroleum Development Company of Nigeria Ltd (SPDC)

Simon Zhang, CEO, NW Innovation Works

LOCATION: Y2E2, Room 299

PRICING

Price is everything. Price too high and gas is unaffordable for poor or strained power companies. Price too low and investment in infrastructure is stifled. Subsidies encourage over consumption. Domestic obligations discourage upstream development. Is there a way to cross-subsidize domestic use to protect the most vulnerable, create sustainable markets, and encourage production and distribution? What does a coherent pricing structure look like? How does it inform the balance between domestic use and export?

George Amoako-Adjei, Commercial Director, Ghana National Gas Company

Peter Hughes, Partner, Global Gas Partners, GMBH

Rathin Roy, Director, National Institute of Public Finance and Policy, India

Mark Thurber, Associate Director, Program on Energy & Sustainable Development, Stanford University (moderator and champion)

LOCATION: Y2E2, Room 300

GEOPOLITICAL MOVES FOR SECURING ENERGY FLOWS

Sanctions on energy rich countries might be effective in pressurizing the countries in question to change their domestic policies on energy. However, this also has the knock on effect of driving up energy prices and reducing supply in the market, both of which impact developing countries and their ambitions to extend energy access. Furthermore, in the case of gas, reductions in supply inevitably lead consumers to switch to coal, compromising climate goals and setting us back in the transition away from coal powered plants. How can geopolitical decisions shift away from blocking energy access and stop passing the cost of sanctions to the energy poor in developing nations?

Tom Campbell, student, Stanford Graduate School of Business (moderator and champion)

Robin Dunnigan, Deputy Assistant Secretary for Energy Diplomacy, Bureau of Energy Resources, U.S. Department of State

Samir Saran, Senior Fellow and Vice President, Observer Research Foundation

Megan Welch, student, Stanford Graduate School of Business (moderator and champion)

LOCATION: Y2E2, Room 382

INDIA: MIDSTREAM INFRASTRUCTURE AND CAPACITY

India faces a capacity deficit in midstream infrastructure for handling natural gas, particularly in receiving LNG, regasification terminals, and pipelines within the country for transporting natural gas and last mile delivery to customers. Creating a midstream regasification and distribution network is critical to supporting downstream and upstream policy changes for scaling up natural gas capacity in India. India needs to develop its domestic infrastructure for ramping up handling of imported natural gas in the country considering its prospective agreements with Iran, Oman and Turkmenistan. Floating Storage and Regasification Units (FSRU) and micro LNG may help in the short to medium term. Considering developing this infrastructure will be expensive, how does India leverage foreign and domestic capital for such investments and allow for cost recovery?

Sunjoy Joshi, Director, Observer Research Foundation (moderator and champion)

Ajay Khandelwal, President of E&P Business, Reliance

BC Tripathi, Chairman and Managing Director, GAIL

LOCATION: Huang, Room 305



Thank
you

OUR STEERING COMMITTEE

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Andrew Adu

is a commercial manager at Ghana National Gas Company, with responsibility for the planning and economics of

gas commodity, and the service commercialization of offshore gas. Prior to joining Ghana Gas, Adu worked as a senior commercial analyst at Centrica/British Gas. He was also a project accountant for Verizon Business and RWE/Thames Water in the UK. Adu received a master's in international business management from Surrey Business School at the University of Surrey (UK).



George Amoako-Adjei

is director of commercial operations of the Ghana National Gas Company, with responsibility for the commercialization of gas

from the Jubilee/Tano basin offshore and LNG. He is also a fellow of the Royal Statistical Society (UK). Amoako-Adjei was former general manager for commercial & business development of the West African Gas Pipeline Company, and senior manager of corporate finance of the Volta River Authority in Ghana. He received an MBA in finance & operations research from the University of Edinburgh Business School (Scotland), and graduated in statistics/economics from the University of Ghana-Legon.



Morgan Bazilian

is lead energy specialist at the World Bank. His academic affiliations include Columbia University, Cambridge University and

the Royal Institute of Technology of Sweden. A member of the World Economic Forum's Global Advisory Council on Energy, Bazilian wrote the book, *Analytical Methods for Energy Diversity and Security*, and articles for *Foreign Affairs*, *Nature Energy* and other journals. He served as a deputy director of the U.S. National Renewable Energy Laboratory and as the European Union's lead negotiator on low-carbon technology at the U.N. climate negotiations. He received a PhD in areas related to energy systems and markets from UNSW (Australia).



Sally M. Benson

joined Stanford University in 2007. She holds three appointments at Stanford: professor of energy resources engineering in

the School of Earth, Energy & Environmental Sciences; co-director of the Precourt Institute for Energy, the campus-wide hub of energy research and education; and director of the Global Climate and Energy Project. An internationally recognized scientist, Benson is responsible for fostering cross-campus collaborations on energy and guiding the growth and development of a diverse research portfolio. Formerly, Benson was at Lawrence Berkeley National Laboratory, where she held a variety of key positions, including Associate Director for Energy Sciences and director of the Earth Sciences Division. A groundwater hydrologist and reservoir engineer, Benson is regarded as a leading authority on carbon capture and storage. She also uses energy systems analysis to help guide decisions about the most promising pathways for clean energy development.



Ricky Buch

is a senior strategy leader at GE Power, where he identifies and validates new business opportunities for GE. He also leads efforts

to develop new products and services for emerging markets, with a primary focus on off-grid electrification. Buch co-founded GE Current, a startup within GE that helps businesses manage energy use more efficiently. He has also worked at Cisco Systems and Microsoft. Buch received an MBA from the University of Michigan's Ross School of Business.



Mark Caine

is special assistant for energy and economy at the African Union Commission. He develops and implements strategies to

accelerate Africa's transition to flexible, low-carbon energy systems and productive, inclusive economies. From 2014-2016, he was a policy advisor at the U.K. Foreign Ministry office in San Francisco, where he managed the British government's energy and climate engagements across the western U.S. Caine also worked at the London School of Economics, the British Royal Academy of Engineering and the Breakthrough Institute. He received a master of philosophy degree from the University of Cambridge.



Tom Campbell

is a first-year MBA student at the Stanford University Graduate School of Business. From 2014-2016, he was director for global

midstream at Stratas Advisors, where he oversaw the firm's research and consulting activities in areas such as LNG, international natural gas pipelines, gas conversion/syngas, and natural gas as a transportation fuel. Prior to Stratas, Campbell was head of analysis at Zeus Development, an energy research and consulting firm. He received a BA in history from Rice University.



Jeremy Carl

is a research fellow at the Hoover Institution at Stanford University, where he focuses on energy policy and U.S. politics. He is the

author or editor of several books, including *Conversations about Energy: How the Experts See America's Energy*, and has written for the *New York Times*, *Wall Street Journal*, *National Review* and other publications. Carl has also been a policy advisor to several national political figures on issues ranging from energy to electoral strategy. He received an MPA from the Kennedy School of Government at Harvard University and did doctoral work at Stanford University.



David Carroll

is president and CEO of the Gas Technology Institute (GTI) in Des Plaines, Illinois. He joined GTI in 2001 after holding various technical

and management positions with Praxair Inc., Liquid Carbonic Industries and Air Products and Chemicals Inc. Carroll is president of the International Gas Union, which will hold its 2018 World Gas Conference in Washington, D.C. He also serves on the board of the National Fuel Gas Company and the Stanford Natural Gas Initiative. He received an MBA from Lehigh University and completed the executive program at Stanford University Graduate School of Business.



Patrice de Vivies

as been senior gas adviser at the World Bank since 2015. His career at Total spanned more than 30 years and included key

leadership positions, such as senior vice president for exploration production-Europe, and president of global gas, power and renewables. From 2002-2005, de Vivies served as gas director of the French Energy Regulatory Commission. He is a graduate of Ecole Nationale Supérieure de Chimie, Ecole Supérieure des Sciences Economiques et Commerciales, and Institut de Hautes Etudes de Défense Nationale. He also received an MBA from the Stanford University Graduate School of Business.



Paul Doucette

is a global public policy leader for GE Oil & Gas. He is responsible for the development and execution of growth

strategies relating to government policy, and for establishing collaborative research relationships with governments, universities and customers. He serves as the operating agent for the IEA Gas & Oil Technologies Collaboration Program, and as chairman of the board of the Research Partnership to Secure Energy for America. Prior to joining GE, Doucette was an executive at Cornell Companies Inc., Star Enterprise and Texaco. He also served with Strategic Air Command. Doucette received an MBA from Nicholls State University and is a graduate of the Advanced Executive Development Program at Northwestern University's Kellogg School of Business.



Lauren Culver

is a graduate student and Benchmark Fellow in Stanford University's Department of Management Science &

Engineering. Her research focuses on global gas markets and the role of natural gas in alleviating energy poverty, applying engineering techniques, such as probabilistic system modeling, to improve energy-policy design. From 2012-2014, Culver was an advisor to the U.S. State Department on energy markets and technologies. From 2009-2012, she was a Presidential Management Fellow at the U.S. Department of Energy, where she counseled the under secretary for energy on innovation and manufacturing. She received two MS degrees from MIT in technology & policy and in civil & environmental engineering.



Landon Derentz

is an energy policy advisor at the U.S. State Department's Bureau of Energy Resources.

His portfolio addresses integrating the impact of global energy markets in U.S. foreign policy, including a focus on the growing role of liquefied natural gas. Prior to joining the State Department, Derentz worked at the Department of Energy's Office of Energy Efficiency & Renewable Energy and at the U.S. Air Force. He received a JD from Pepperdine University School of Law and an MPP from the Trachtenberg School of Public Policy & Public Administration at George Washington University.



Robin Dunnigan

has been deputy assistant secretary for energy diplomacy in the Department of State's Bureau of Energy

Resources since August 2014. She oversees U.S. energy diplomacy to ensure that energy resources are used to promote global economic growth and stability, and to advance global integration of renewable and cleaner energy sources in support of U.S. climate change goals. Since joining the State Department in 1992, Dunnigan has served in the U.S. and overseas. She received master of science degrees from the National War College and Georgetown University.



Anatol Feygin

is executive vice president and chief commercial officer of Cheniere Energy, and a director of Cheniere Energy Partners LP

Holdings. Prior to joining Cheniere, he worked with Loews Corporation developing forecasts for Loews' three energy platforms (upstream, midstream and services), identifying risks and making capital allocation decisions. Feygin has also worked as a senior analyst covering natural gas pipelines at Bank of America and at J.P. Morgan Securities. He received an MBA in finance from New York University's Stern School of Business.



Paula Gant

recently served as principal deputy assistant secretary in the Department of Energy's Office of International Affairs.

Her work focused on enhancing U.S. energy security and accelerating global adoption of clean-energy technologies. From 2013 to 2015, she was DOE deputy assistant secretary for oil and natural gas, administering R&D programs and natural gas import/export regulation. Before joining the DOE, Gant was an executive with the American Gas Association and Duke Energy, and taught at Louisiana State University and the University of Louisville. She received a PhD in economics from Auburn University.



Peter Hughes

is an independent adviser to major international energy companies and has been involved in international arbitration

relating to long-term gas contracts. He has held numerous senior-level positions during his career, including executive vice president-group strategy at BG Group; vice president-strategy & portfolio for BP Gas, Power & Renewables; and senior director/head of the PanEurAsia Division of Cambridge Energy Research Associates (CERA). Hughes received a BA degree from the University of Wales in Cardiff, and a MSc degree (Sloan Fellowship) from the London Business School.



Christine Jojarth

is an affiliate of Stanford University's Center on Democracy, Development & the Rule of Law and the Program of Energy and

Sustainable Development. She advises governments and non-governmental organizations on international policy issues related to energy and development. Her datasets and models have been used by industry and leading financial institutions, including the International Monetary Fund and the Federal Reserve. Jojarth also wrote the award-winning book, *Crime, War and Global Trafficking*. She received a PhD in international political economy from the London School of Economics and Political Science.



Sunjoy Joshi

is director of the Observer Research Foundation in India. As a member of the Indian Administrative Service for 25 years, he

acquired a broad range of experience in various energy sectors, including oil and gas exploration and renewables. He continues to write and conduct research on India's energy needs and its interplay with development challenges and climate change. Joshi received a master's in English literature from Allahabad University (India) and a master's in development studies from the University of East Anglia (UK). He also studied upstream economics and risk analysis at the Petroleum Economist.



Ajay Khandelwal

is president of E&P business at Reliance Industries in India. Prior to joining Reliance in 2013, he was CEO of Jubilant Group and an investment adviser at Shell.

Khandelwal has broad experience in multinational corporations in areas such as business development, finance, private-equity investment in oil and gas, and the energy and infrastructure sectors. Khandelwal received an MBA from Cranfield School of Management (UK).



Ken Koyama

is chief economist and managing director at the Japan Institute of Energy Economics and a lecturer at the Shibaura Institute of

Technology. His fields of expertise include economic and political analysis of global oil and natural markets, and energy security and the geopolitics of energy. Koyama has served on several energy-policy advisory councils and committees of the Japanese government. In 2016, he received the BrandLaureate's Brand Personality Award. He received a PhD from the University of Dundee (Scotland).



Seth Levey

is a member of the public policy and stakeholder relations teams at ExxonMobil Corporation. Prior to joining Exxon in

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Rachel Pritzker

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Mark Zoback, director of the Stanford Natural Gas Initiative, is the Benjamin M. Page Professor in the Department of Geophysics in Stanford University's

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THE NATURAL GAS INITIATIVE AT STANFORD

Major advances in natural gas production and growth of natural gas resources and infrastructure globally have fundamentally changed the energy outlook in the United States and much of the world. These changes have impacted U.S. and global energy markets, and influenced decisions about energy systems and the use of natural gas, coal, and other fuels. This natural gas revolution has led to beneficial outcomes, like falling U.S. carbon dioxide emissions as a result of coal to gas fuel switching in electrical generation, opportunities for lower-cost energy, rejuvenated manufacturing, and environmental benefits worldwide, but has also raised concerns about global energy, the world economy, and the environment.

The Natural Gas Initiative (NGI) at Stanford brings together the university's scientists, engineers, and social scientists to advance research, discussion, and understanding of natural gas. The initiative spans from the development of natural gas resources to the ultimate uses of natural gas, and includes focus on the environmental, climate, and social impacts of natural gas use and development, as well as work on energy markets, commercial structures, and policies that influence choices about natural gas.

The objective of the Stanford Natural Gas Initiative is to ensure that natural gas is developed and used in ways that are economically, environmentally, and socially optimal. In the context of Stanford University's innovative and entrepreneurial culture, the initiative supports, improves, and extends the university's ongoing efforts related to energy and the environment.



Join NGI

The Stanford Natural Gas Initiative develops relationships with other organizations to ensure that the work of the university's researchers is focused on important problems and has immediate impact. Organizations that are interested in supporting the initiative and cooperating with Stanford University in this area are invited to join the corporate affiliates program of the Natural Gas Initiative or contact us to discuss other ways to become involved. More information about NGI is available at ngi.stanford.edu or by contacting the managing director of the initiative, Bradley Ritts, at ritt@stanford.edu.

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