KAPSARC

مركز الملك عبدالله للدراسات والبحوث البترولية

King Abdullah Petroleum Studies and Research Center

حوار الطاقة ٢٠١٦

Energy Dialogue 2016

Energy Dialogue 2016 Summary

March 2017 / KS-2017--WB04

About KAPSARC

The King Abdullah Petroleum Studies and Research Center (KAPSARC) is a non-profit, global institution dedicated to independent research into energy economics, policy, technology and the environment, across all types of energy. KAPSARC's mandate is to advance the understanding of energy challenges and opportunities facing the world today and tomorrow, through unbiased, independent and high-caliber research for the benefit of society. KAPSARC is located in Riyadh, Saudi Arabia.

Legal Notice

Table of Contents

Introduction

From Open Discussion to Practical Action

The following is an introduction by **Samer Al Ashgar,** former President, King Abdullah Petroleum Studies and Research Center (KAPSARC).

With more than 300 participants — high-level officials, leading researchers, policy strategists, and industry players — representing diverse branches of the energy sector from the Kingdom and the rest of the world, KAPSARC's Energy Dialogue 2016 delivered rich insights and thoughtful discussion about the rapid transitions underway in an area of national and global importance.

This Summary Report follows the format of the Energy Dialogue, comprising five Plenary Sessions and 12 extended Roundtable Discussions. I believe this event created opportunity for all participants to hear about strategic activities underway and also contribute to focused discussion on key areas, with the aim of identifying solutions that can be taken up in the near term and adapted to local contexts as necessary. It also gave space to probe the larger, longer term challenges still ahead that will require collective action, including the need to reduce the impacts of energy production and consumption to meet the agreed targets of the COP21 Paris Agreement.

As part of the network of centers of knowledge and innovation recently established in Saudi Arabia, KAPSARC was honored to host an event that showcased to international participants the commitment all Gulf countries are making to be leaders in a clean energy future, diversify their economies and engage more openly in collective, strategic action.

The summaries in this report reflect several trends of critical importance to all energy stakeholders, such as:

Technology advances and market innovations that fundamentally alter how energy is produced, distributed and used, as well as strategies to decarbonize electricity and transportation.

The need for new policy frameworks and business models that ensure a fundamentally altered sector remains viable and continues to provide energy security, which in some contexts will require specific action to boost energy productivity.

Geographic shifts in future demand and supply, including rapid demand growth projected in China and India, and the vision of these countries to accelerate their transition to renewable energy sources.

How international agreements, including the COP21 Paris Agreement, set new standards for a low-carbon future.

Importantly, I believe the Energy Dialogue achieved its aim of going beyond discussion to stimulate practical action. KAPSARC takes seriously the message from the Chairman of the Board of Trustees and others that we need to "think more unconventionally and to set even higher targets … to identify ways to balance economic development needs with environmental stewardship by increasing the economic value generated from energy — for the benefit of our nation, our region and the entire world."

KAPSARC looks forward to continuing the Energy Dialogue. We are also examining ways to keep discussion alive between events through the KAPSARC Energy Workshop Series. For now,

we offer these summaries of key insights from the discussions, held under the Chatham House Rule. They set the agenda for future engagement between KAPSARC and our stakeholders in the Kingdom, the wider GCC and the global community.

We have set a solid foundation for international and multi-disciplinary engagement on the substantial challenges facing the energy sector, and we look forward to building on this foundation with you in 2017 and beyond.

Keynote Addresses/ Plenary Sessions

A Forum to Share Ideas and Insights

The following is the text of the speech by **H.E. Khalid Al-Falih,** Minister of Energy, Industry and Mineral Resources for the Kingdom of Saudi Arabia.

Salutations and introduction

Distinguished guests, ladies and gentlemen, as-salaam alaykum. It is a pleasure to welcome you all to KAPSARC's first Energy Dialogue in the Center's new campus. The Energy Dialogue provides a forum to discuss issues of local, regional and global significance, to share ideas and insights, and to create energy solutions that benefit people around the world. It's rewarding to see such a wide range of participants this morning and to hear their varied perspectives.

I will focus today on three topics: first, the evolution of the global energy system and the move from debate to action following the entry into force of last year's historic Paris Agreement at COP21. This is particularly timely in the run-up to COP22 in Marrakech later this month. My second topic is the multidimensional wave of change sweeping across the world, which is remaking and reorienting our economies, societies and way of life. Finally, I will look at the exciting transformation of the Kingdom's economy in line with Saudi Vision 2030.

Climate change and the energy transition

Let me begin with the Paris Agreement, which recognizes various paths to the agreed goal of keeping global warming to well below two degrees Celsius. These paths combine different policy options, energy growth rates, energy mixes and time frames, among other variables. Foremost among these are the pursuit of technologies to reduce greenhouse gas emissions, efficiency improvements, greater use of cleaner gas, expanding deployment of renewables, and steady growth in the use of alternative technologies as they overcome the technical, economic and infrastructure hurdles facing them.

Of course, the attractiveness to different nations of each of these different options varies with the large gaps in their development stages — developed, developing and underdeveloped–as well as the readiness of alternatives and the time needed to transform our enormous global energy system.

All nations must contribute to climate goals, but clearly developed nations can move more aggressively on the alternative path, since their highly diversified and high-tech economies, populated with value generating industries, can better accommodate higher-cost energy. On the other hand, developing economies must strike a balance by adopting development paths that will lead them to become wealthy enough to afford the emissions mitigation and abatement measures that are ultimately required.

China and India are prime examples of this reality, and each will play a vital role in achieving global climate change targets. After three decades of sustained rapid economic expansion, China is moving from a manufacturing and export-led growth model to one driven by domestic consumption and higher quality growth. Much of China's development to date was fueled by coal and oil — and in fact, the People's Republic has become the world's largest importer of oil, with the Kingdom its largest source of supply. Now, though China's oil consumption growth is moderating while the driver of incremental demand is also shifting from manufacturing to consumption by the ever-expanding middle class. Further west, India is also on a high economic growth trajectory and is

becoming the fastest-growing major oil consumer in the world.

Both nations have ambitious plans to supplement their conventional energy supplies with renewable energy. However, while the proportion of conventional fuels in these nations may fall, the absolute overall quantities of oil and gas will continue to increase over the next several decades.

Since experience tells us and caution warns us that the transition to a new global energy mix will take time, we see a long future ahead in which both conventional and unconventional fuels will be part of the global fuel mix, with the contribution of alternatives steadily growing.

The Kingdom is committed to meeting the energy needs of China, India and other developing economies throughout the decades-long transition toward a more environmentally sustainable future — keeping in mind that the path of the transition itself must continue to meet the tests of accessibility, availability, affordability and acceptability. As such, greater investment in reducing the environmental impact of fossil fuel production and consumption is essential to meeting agreed-upon climate targets, and Saudi Arabia is investing in groundbreaking technologies to achieve this objective.

At the same time, the Kingdom is committed and will remain committed, to doing its part to address the issue of climate change and I will take this opportunity to reaffirm the Kingdom's intent to translate our commitments made at COP21 into action.

New energy systems

Of course, the world's continued reliance on fossil fuels is driven in part by the fact that the breakthroughs in technology and the reductions in the cost of renewable sources (including alternative technologies) have to date been insufficient to enable alternatives to shoulder a greater burden of the world's energy needs. Without significant advancements in energy technologies, new energy systems will take longer to reach their potential, because ultimately market competitiveness will determine how significantly these new technologies penetrate the global energy mix.

In my view, the enormous financing needed to meet future global energy demand — drawing upon all sources — will not be forthcoming unless we get these new policy frameworks and market structures right, including energy efficiency enhancements and well-to-wheel environmental assessments of alternative vehicles and the energy that powers them. At the same time, the world cannot afford to subsidize large-scale deployment of alternatives on a sustained basis.

Notwithstanding these cautions, we believe renewables can and should play a greater role in meeting the world's energy needs, and Saudi Arabia keeps an open mind as to the best route to achieve global climate objectives. The Kingdom is investing heavily in renewables and we have set aggressive targets for the growth of these sources, such as introducing 9.5 gigawatts of power generation through renewables by 2023 — mainly solar and wind. In addition, the King Abdullah City for Atomic and Renewable Energy continues its multidimensional efforts to develop a more sustainable long-term energy mix for our nation.

A world being transformed

Of course, the drivers of this massive energy transformation are rooted in the broader megatrends shaping our world, and we must remember the intimate and intricate linkages among energy,

economic development, societal shifts and ecological sustainability. Let me elaborate.

Groundbreaking technologies will have profound implications for the way energy is produced and consumed in our homes; for mobility; for emergence of new industries and the different skills they will demand; and for how urban centers are managed. Open trade leading to wage equalization among different markets will continue to stress societies in developed nations, while the boom in social media is leading to more populist expression and increased public pressure on governments. The center of gravity of the global economy is also shifting as developing countries — notably China, India and developing Asia, Africa and Latin America — emerge as new economic powers.

Structural demographic shifts will also have a major impact on energy, most notably the effects of a growing global population characterized by younger populations in developing countries and aging populations living longer in the developed world. Greater automation and digitization also promise to reduce the need for labor and create less energy-intensive economies. In addition, changing social norms, greater urbanization, more mobile lifestyles, more affluent living standards and the repercussions of climate change are going to shape a 'new' world with major implications for energy and the Kingdom.

Some of these developments are bullish for oil and gas demand growth, while others imply increased electrification and substitution. The path of energy demand and the fuel and technology mix that will result from these changes will not only pose major challenges for the world and its industries but also create tremendous opportunities. Saudi Arabia's ability to move beyond an economy based on its role as an energy provider therefore depends on staying ahead of these trends and remaining competitive in the global marketplace. So, how will the Kingdom respond to this changing environment?

Economic transformation in Saudi Arabia

Saudi Arabia's plentiful endowment of oil and gas and the lower cost of energy has powered economic growth and encouraged the growth of energy-intensive industries such as petrochemicals and aluminum. In fact, the historical trajectory of our nation and its position on the world stage would have been unimaginably different were it not for the petroleum industry. However, this energy-intensive development came at the expense of the efficient use of resources, and hindered the formation and development of businesses that were not so heavily reliant on energy inputs. This in turn has undermined the quest for greater economic diversification.

But in and of themselves, the pillar industries of oil and gas, chemicals, and mining cannot meet the rising economic aspirations of a Saudi population that now exceeds 20 million people. In addition, these sectors are more capital and less labor intensive, so they will not generate enough jobs for a large and rapidly expanding young population. Add in a world that will be increasingly technology-intensive rather than energy-intensive, as well as more integrated and more competitive, and we can see the significant challenges Saudi Arabia and the region are already facing.

The Kingdom's Vision 2030 is a proactive response to those challenges.

As most of you are aware, the Vision calls for economic diversification, privatization of major state-owned enterprises, an economy led by the private sector, greater localization, international investments to help diversify revenue sources, and turning Saudi Arabia into a global logistical hub connecting Asia, Africa and Europe.

Saudi Arabia will also fully leverage the next industrial revolution to drive future economic growth, seizing opportunities in new industries such as digitization, artificial intelligence, robotics, big data, cloud computing, the Internet of Things, genomics and biotechnology. Saudi Arabia's recent agreement with Softbank to participate together in a $100 billion investment fund is an indication of this determination.

To prepare for the technologically intensive future, though, we must bridge gaps in high-quality education and sharpen our focus on STEM disciplines, training, research, innovation and entrepreneurship. Only with an emphasis on national capacity building will we be able to successfully participate in the knowledge industries of the future.

However, let me caution that this does not mean reducing the contributions of oil and gas, chemicals, or mining, but rather enhancing the development of other sectors to rebalance and accelerate the growth of the overall economy. Such restructuring and diversification will also help us to maximize our nation's potential, as well as minimize the volatility that comes with commodity businesses.

KAPSARC's role in the global dialogue

Ladies and gentlemen, navigating a path to a better and brighter economic and energy future requires thoughtful analysis, a holistic approach to problem solving and opportunity identification, wise decisions, and enabling policy frameworks. We will also need breakthrough innovations and step-change developments that transform our global energy system, not merely incremental improvements that enhance existing structures, markets and technologies.

This is why the King Abdullah Petroleum Studies and Research Center Board of Trustees and I are challenging KAPSARC to think more unconventionally and to set even higher targets when it comes to identifying pathways for transforming global energy, mitigating climate change, managing the lengthy and complex transition ahead, and better understanding and planning for a changing world. To meet all of these imperatives, we must balance economic development needs with environmental stewardship by increasing the economic value generated from energy — for the benefit of our nation, our region and the entire world.

Addressing these global energy challenges, exploring our options and identifying optimal solutions is why KAPSARC was created in the first place — and I will say today that our expectations for KAPSARC are for a trail-blazing future.

In closing, I'm delighted to see that this year's Energy Dialogue has brought together such a distinguished gathering of eminent experts, analysts and policymakers to explore the constantly changing elements of the local, regional and global energy economy. It is our honor to host you and it is my sincere hope that your discussions will help to develop multidisciplinary and multi-perspective options enabling mankind to meet its most difficult energy challenges, and help create a sustainable energy future for the world.

Transformation to a More Competitive Saudi Economy

This following is a summary of a plenary session. The speakers were:

H.H. Prince Dr. Turki Al-Saud, President, King Abdulaziz City for Science and Technology (KACST).

Dr. Aabed Al-Saadoun, Deputy Minister for Company Affairs, Ministry of Energy, Industry and Mineral Resources.

H.E. Dr. Nabeel Al-Amudi, President, Saudi Ports Authority.

Eng. Ziyad Al-Shiha, President and CEO, Saudi Electricity Company (SEC).

Saudi Arabia has achieved a great deal of economic success over the past several decades through holding large endowments of natural resources, particularly oil and gas, that benefited from the commodity super-cycle. In a rapidly changing context, it is now clear that this narrow foundation of the Saudi economy is not adequate, particularly as the population grows and domestic energy demand increases.

The recently released Vision 2030 sets out a clear mission to transform the economy to make it more diverse, innovative and competitive. With clarity on national goals, now is the time to take policy actions that will bring the strategies and vision to life. Four key areas have been identified as being springboards for a transformation that is at once cross-cutting and sharply targeted on mutual goals: energy (including energy efficiency), innovation, privatization and local content. This briefing highlights progress to date, areas of potential collaboration, challenges ahead and lessons learned that can smooth the way.

Reforming energy production and consumption

Energy has underpinned economic and social development of the Kingdom for several decades. Indeed, strategic decisions were made to build wealth on the Kingdom's large resource endowment and to distribute the revenues by providing low-cost energy to both individuals and industry. Such welfare distribution is normal — every country seeks to both stimulate growth and help the poor through policy instruments such as incentives, grants, taxes, subsidies, etc.

With global energy markets evolving rapidly in ways that have huge implications for the Kingdom, it is timely to take stock of past experience and plan for what is sure to be a dramatically different future. A recent report on the Saudi energy economy confirms that providing extensive support to industry has led to market distortions. Policymakers recognize the need to transform the economy — starting with how energy is used.

The question then is how to rebalance this resource utilization? It is clear that some of the industries have become self-sustaining, raising a need to re-examine what is given and to whom. One approach is to start transferring some of the incentives along the value chain, for example into manufacturing of finished goods rather than intermediate bulk products.

While economic diversification is vital, it is critical to not overlook or abandon the energy-intensive industries that have been staples of the economy. There is inefficiency in how big industrial companies are run; the lesson learned is to avoid incentives that distort markets. Saudi Arabia is better prepared now

to take measures to reform these industries, but care should be taken not to 'shock' the system.

Electricity generation and consumption warrant special attention in this transformation. Recognizing it also holds vast resources in solar energy, Saudi Arabia is aiming to install 9.5 gigawatts (GW) in the next seven years. While small in relation to the 10 GW of solar China aims to install annually, the Kingdom is at the start of the process and may well adjust targets upward as costs decline and skills and learning are built up.

Boosting efficiency across the energy system

For as long as Saudi Arabia's abundant resources delivered high revenues, there was little incentive to think about using those resources efficiently in the domestic context. Rather, providing low-cost energy was perceived as a way to make industry competitive on global markets and to allow individuals to enjoy high levels of comfort in their homes. But this created distortions in the domestic energy market, as well as in industry. For example, in some industrial sectors that rely on carbon or on carbon-based power, the energy component of goods manufactured is as high as 70 percent to 80 percent of production, whereas similar goods produced in other countries have an energy component as low as 15 percent to 20 percent.

This culture of inefficiency is starting to change. New regulations and initial price reforms are beginning to replace the long-standing practice of keeping energy prices low (reflecting the low cost of domestic production) as a means of distributing natural resource wealth, but which has led to inefficiency and waste. While more efficient technologies and practices are available (and indeed have become the norm in other contexts), Saudi Arabia faces an overarching challenge of needing to change social norms, which will require both policy action and public awareness.

The challenge now to the energy sector is how to encourage customers to change their behaviors and adopt efficient practices. One approach is to lead by example: Saudi Electric Company (SEC) is currently analyzing the transmission network to reduce energy losses and also the mix of fuels and technologies in its generation fleet to maximize efficiency. Additionally, the government is investing SAR 120 billion in efficiency initiatives, with the aim of reducing domestic consumption by 600,000 barrels per day (bbl/d). There is a strong focus on the residential sector, which accounts for 60 percent of electricity consumption. The building code is becoming more stringent; now it needs to be implemented and enforced. The Saudi Energy Efficiency Commission (SEEC) is launching several initiatives for efficient appliances, etc. Additionally, more than 40 organizations are investing in public awareness campaigns (including through social media) so that people become more 'energy literate'.

One overarching strategy is to couple industry and power generation, in part by pursuing research and development (R&D) on renewables and on technologies such as smart meters and smart grids. There is also a role for price reform, which is necessary regardless, in stimulating change.

The younger generation of Saudis is already behaving in ways that have the collateral result of different energy consumption patterns, in that they are marrying later and having fewer children, leading to lower consumption per household. In fact, they are generally more environmentally and ecologically conscious, and are showing interest in climate change. This shifting mindset creates a window of opportunity to incentivize stopping old, wasteful behavior and encourage commitment to energy efficiency.

Creating an innovation ecosystem

Following the approval (in 2012) of policy for science and technology that would shift Saudi Arabia to a knowledge economy by 2020, multiple players within government and in the private sector have been collaborating to develop strategies and plans to achieve this goal. Clear targets have been established across all sectors, along with mechanisms for accountability. Now it is time to forge ahead and act.

As the Kingdom has not reached maturity in terms of an R&D framework, it is vitally important to establish an innovation ecosystem that supports the full innovation cycle from research to production and even export, pursuing technology innovation, capacity development and local content. To this end, the government is committed to providing funding in key areas, such as for universities and industry (particularly technology start-ups), while also taking steps to establish mechanisms for greater engagement by venture capitalists and the private sector more broadly. The King Abdulaziz City for Science and Technology (KACST) is playing a lead role in this initiative.

Similarly, SEC is spearheading a private-public partnership, working closely with Saudi Aramco to develop a national energy strategy with clear targets for both innovation and efficiency. The shared vision is to maintain domestic energy demand at the current level of 4 million bbl/d, even as the economy grows and population expands. The scale of this challenge should not be underestimated: under a business-as-usual projection, future demand would grow to 8 million bbl/d by 2050. Improving energy efficiency across all levels of the system is a top priority. Targets have been set for energy efficiency at the power plant level and electricity connections will be improved at the system level. In buildings, including residential, new codes require builders or owners to demonstrate that insulation has been installed in walls and ceilings, and all windows are double-glazed before an electricity connection is approved. Additionally, new policy is shaping the market for energy efficient appliances: for example, all inefficient air-conditioning units have been taken off the market and other home appliances are subject to energy star ratings.

Privatization to boost competitiveness

Opportunity for private players is key to a vibrant, diverse knowledge economy. While large-scale effort to open up privatization represents unprecedented reform in the Kingdom, it is not without examples of success.

The Saudi Ports Authority has been progressively privatizing over a period of almost two decades, and now manages nine ports that handle 90 percent of the country's imports and exports, reflecting annual values of SAR 30 to 40 billion. Over this time, the Authority has been building experience that will be valuable to others now starting out on the privatization process, including strategies for revenue-sharing between private and public entities.

Even so, the Authority still faces challenges that are perhaps specific to the Kingdom context. With 13 government agencies involved in port activity, governance of the sector remains complex. A more effective authority structure is needed to enable strategic management of a rapidly changing industry.

As with other sectors, the Port Authority is also now tasked with improving energy use and overall efficiency.

To a large degree, the hard infrastructure to support efficient operations is in place. However, there is still a need to further implement 'multi-modal' approaches to create efficiencies across transport modes and across the value chain (the United Arab Emirates [UAE], for example, has a direct link between its major port and the airport). Another route for improving efficiency and reducing emissions in shipping is to transfer to liquefied natural gas (LNG) as a low-sulfur fuel that can be used as a bunker fuel. Many ships now being manufactured have LNG-ready engines. Investment by shipping companies to improve the industry overall is significant; but shipping itself is in turmoil, with many companies near bankruptcy.

The more pressing need in the Saudi port and shipping industry is to make efficient the soft infrastructure by introducing digitization to better integrate procedures and processes. This would also help to create a platform that supports commerce and enables local companies and industries to compete in the supply chains in which they participate, including at international and global levels. Globally, the shipping industry may be able to draw lessons from Uber to manage more efficiently the match-up of goods to be shipped and vessels available. It is also worth noting that Saudi Arabia is now included on the map for China's Belt and Road Initiative, which could boost activity and efficiency in transport, and also support economic diversification.

In the coming years, the Saudi power sector will also be privatized, reflecting the vision to create an environment for sustainable market dynamics. Debate is still ongoing on how the privatization process will be achieved, and indeed which parts of the system will be liberalized and to what degree. Certainly, generation — including from renewable energy sources — will be opened to the private sector. A substantial change is that the role of regulator will become that of ensuring sustainable and efficient system operation.

Boosting local content across the economy

Over the long term, boosting local content across all sectors will be vital to sustaining a dynamic knowledge economy in Saudi Arabia. To that end, it is important to begin both building and mining intellectual capacity now. Here again, the energy sector is taking the lead, with Saudi Aramco aiming to boost local content in its workforce from 30 percent to 70 percent by 2021 and SEC forging ahead on several fronts.

To both improve the efficiency of electricity services and boost local content, SEC is undertaking to have 8.5 million smart meters installed in Saudi homes. The project was tendered to private sector suppliers and received bids from 50 consortiums representing 120 companies — strong demonstration that a more competitive market is emerging. Additionally, electricity cables and equipment are now being manufactured in the Kingdom and the first locally installed gas turbine recently began operations. The next challenge is to build local capacity in R&D of distributed energy resources, including solar and wind, including both scaling up and also ensuring the grid is smart enough to integrate such resources. At present, KAPSARC has the largest ground-mounted (5 megawatt [MW]) solar farm in Saudi Arabia.

Reflecting its role at the center of the innovation ecosystem, KACST takes the view that local content is not only about manufacturing or 'made in the Kingdom'; it also needs to be about generating

domestic intellectual property (IP) and ensuring it can be exported and compete in the international marketplace. The huge expansion of universities in the early part of this century set a solid foundation for an innovation ecosystem and for building a skilled labor force capable of generating IP. To date, the Kingdom has not yet learned to use this human capacity to its full potential. Additionally, private Saudi domestic industry is not yet doing its own R&D.

KACST and the King Abdullah University of Science and Technology (KAUST) have taken important steps to partner with other innovation centers such as Frankfurt University for the Green Super Computer (which is second in the world in terms of efficiency) and with University of Santa Barbara to set a world record in the efficiency of light-emitting diodes (LEDs).

What is now needed is to create a Saudi Silicon Valley so that universities, start-ups and large companies can collaborate to innovate and scale up. To this end, the government is investing SAR 1 billion annually to help start-ups survive the 'valley of death'. The plan seeks to create clusters of companies that help the start-ups establish close relations with knowledge hubs (universities or research centers). Then, as solutions are developed, the ministry will fund production and will encourage large companies to buy from or acquire the start-ups. The plan aims to launch 600 high-tech companies in the next five years.

As is the case with ports, the soft infrastructure for innovation and local content is needed, particularly in terms of legislation to support (financially and otherwise) R&D, technology transfer and start-ups, including protecting IP and preparing it for export.

The time is right for reform

Several factors contribute to this being the right time for Saudi Arabia to turn policy into action that delivers the reforms discussed above, including that key strategies have been set and supporting policies developed and/or deployed. The social changes already underway, particularly among the young generation, bode well for creating a culture of innovation and entrepreneurship with greater social and environmental awareness. Additionally, KACST and companies like Saudi Aramco are building their reputations as competitive innovation centers, both domestically and internationally, thereby building confidence among other stakeholders, including investors.

Making these visions a reality requires additional progress on three fronts. First, legislation is needed to ensure that new policies can be enforced and achieve the objectives they are designed to support. As many of the activities are cross-cutting, a central entity is needed that can not only implement programs, but also has the authority to monitor and evaluate progress, and to penalize those not upholding new policies and legislation. Finally, beyond the practicalities established by government institutions, it is necessary to stimulate a mindset for reform and innovation within the private sector.

R&D in Renewables and Energy Efficiency

The following is a summary of, the presentation by **H.H. Prince Dr. Turki Al-Saud,** President, King Abdulaziz City for Science and Technology (KACST).

An overview of recent achievements, ongoing initiatives and future plans at the King Abdulaziz City for Science and Technology (KACST) highlighted the importance of strategic innovation to the future of Saudi Arabia, both domestically and to secure its place in global activities.

KACST is identified as having a key role in the Vision 2030, as is evident from its stated mission — i.e., to be a world-class organization in science and technology, fostering innovation and promoting a knowledge-based society within the Kingdom of Saudi Arabia (KSA). Tied to this vision is a role for KACST in serving sustainable development through activities such as formulating policies and national plans, and coordinating action for their implementation. In conducting scientific research and technology development, KACST also seeks to develop and strengthen local, regional and international partnerships for technology transfer and invests in commercial processing of such technology. Sponsoring, promoting and investing in intellectual property (IP) are some of the ways the City will help build a knowledge-based society, along with providing advice and innovative solutions.

In support of the National Transformation Program 2020 (NTP), KACST initiatives are designed to enhance the high-tech local content contribution in key sectors (e.g., water, electricity and energy, petrochemicals, health, transport, and telecommunications) to increase the value retained in such sectors. Together, these sectors have an estimated value of SAR 400 billion that could be captured in the next five years.

To realize this value, KACST devised strategic activities to evolve the economy and enhance local content, thereby progressing to overcome three challenges:

Low levels of technological local content contribution: The current shortfall of local content in KSA is widespread. While progress is evident in terms of locally providing basic materials (e.g., cement and rebar), a larger gap in local content of high-tech, higher value technologies (e.g., telecommunication, electronics and engines) means these products and services are being imported. Actions to be undertaken include localizing and developing technology in sectors with large domestic spending and providing technical consulting for governmental agencies.

Lack of a research and development (R&D) framework to enhance local content: At present, the R&D framework lacks key components including a well-trained Saudi workforce, infrastructure, supplies and equipment, funding, and resources. Additionally, collaboration is lacking among universities, research centers and industry. Three key actions are identified in this area: increasing national capabilities qualified to support development of local content; providing sustainable support for R&D that will boost local content; and upgrading the necessary infrastructure and equipment.

Lack of an innovation framework: To enhance contribution to local content, KACST will promote the capabilities of existing small and medium enterprises (SMEs) and establish added-value high tech start-ups.

The resulting strategy for KACST comprises three main programs: enhancing local technological content in key sectors; supporting R&D; and supporting innovation and manufacturing. This approach ensures that research delivers innovation, and innovation moves from the laboratory into industry across ten sectors: agriculture; building and construction; oil and gas; energy; water; environment; transportation; health and medicine; advanced materials; and information and communication technologies (ICT).

Activities in the energy sector focus on four areas — renewable energy, energy storage, energy efficiency, and modeling and simulation — with substantial projects already underway or delivered (Figure 1). In many cases, KACST is partnering with leading research centers and technology companies from around the world. These collaborations not only help build capacity in the Kingdom but also ensure that IP developed by Saudi agencies has greater opportunity for rapid deployment in the region and beyond.

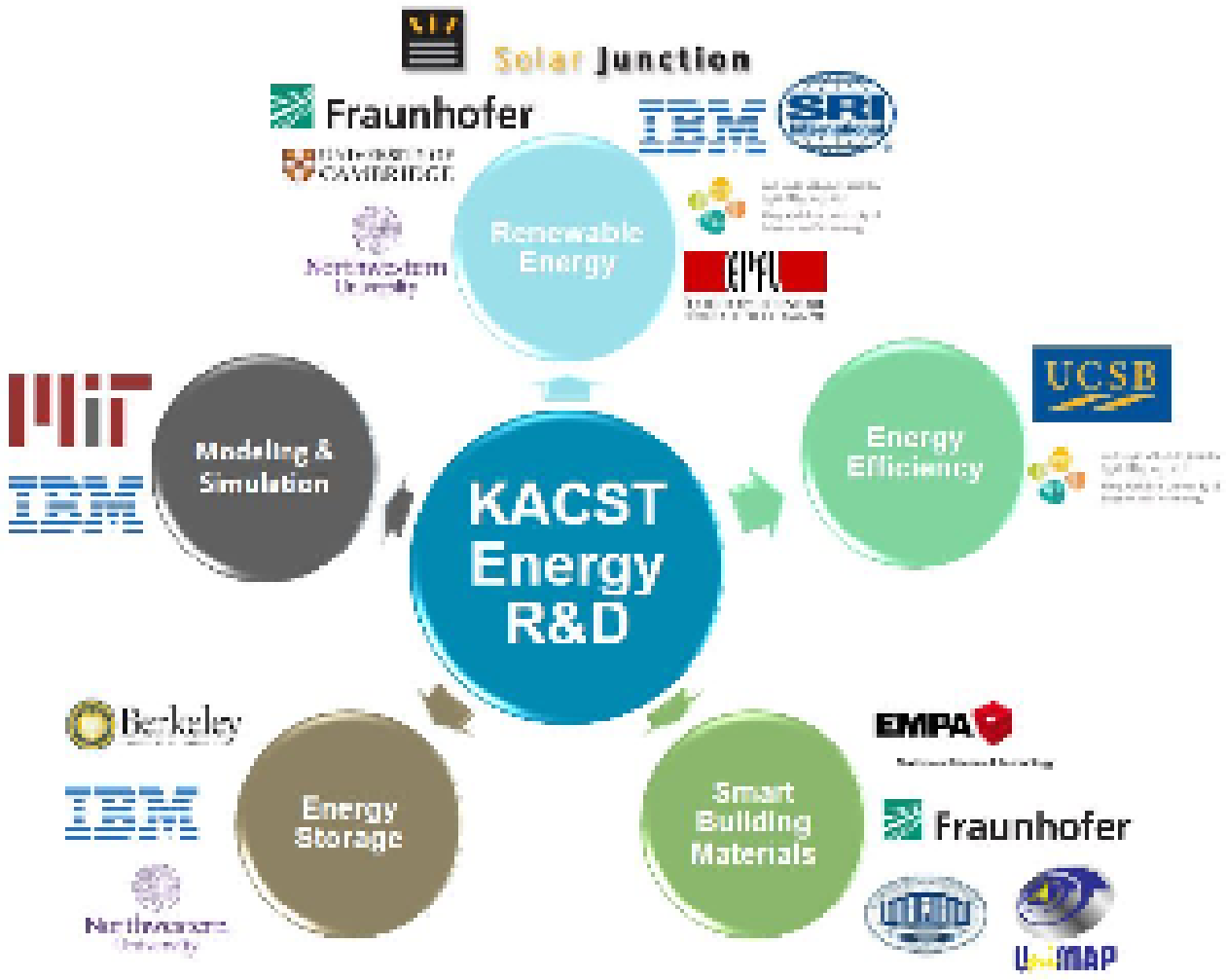

Figure 1. KACST research areas and strategic partners.

Source: KACST.

Renewable energy

The renewable energy program places strong focus on applications for solar power in the Kingdom, with two large-scale activities having high priority. The Solar Saline Water Reverse Osmosis (SWRO) is a 60,000-cubic meter/day desalination plant that relies on solar power to support reverse osmosis and electro-chlorination while also seeking to boost plant efficiency. The 50 MW Layla Solar Plant, the first independent solar power plant in the Kingdom, is being developed in two phases. It is constructed using locally sourced PV modules from KACST and is projected to save 4 billion barrels of high-cost diesel fuel while reducing carbon dioxide (CO_2) emissions by 1.7 million tons (MT).

The R&D component of the renewables program has a strong focus on developing conventional and flexible silicon solar cells that are cost-effective. A partnership with SRI International, for example, seeks to transfer processes so that high purity silicon can be manufactured in the Kingdom to support the design, construction and operation of a pilot project. The Nanotechnology Center for Excellence, jointly established with IBM, aims to develop efficient solar cells using low-cost processes to enable grid parity and achieve world records in solar efficiency.

In other examples of progress, KACST has helped to establish a 100 MW PV cell manufacturing line (with double printing capacity) and a PV module assembly line facility, both of which are fully automated. Together with Northwestern University, KACST launched the Joint Center for Integrated Nanosystems, which is carrying out R&D on organic PV devices to manufacture highly efficient nano-structured solar cells using low-cost materials that can be easily printed as thin films on flexible substrates. With the University of Cambridge, KACST is developing novel hybrid LED and PV technologies based on 'inorganic host/organic guest (IHOG)' materials made with high photoluminescence efficiencies.

Carbon capture and flexible energy storage

Saudi Arabia will continue to be a major producer of oil and gas, but it is exploring ways to make its consumption more environmentally sustainable. A key element of this is to develop low-cost carbon capture and to reduce the parasitic loads that result from conventional amine processes. The KACST-UC Berkeley Center of Nanomaterials for Clean Energy has demonstrated that metal organic frameworks (MOFs) can selectively seek and separate CO_2 in a process that saves 90 percent of the energy required with traditional amine solutions.

Optimizing the large solar resource in Saudi of course requires advances in energy storage. Here again, KACST is pushing ahead on multiple fronts. The possibility of storing electric energy in the form of chemical energy — i.e., hydrogen gas — is being investigated through a process that converts the low-value carbon (CO_2) into a high-value form (syngas). Use of Sodium-Metal Halide (SMH) batteries is another energy storage mechanism that is particularly well-suited to desert environments.

Another initiative is localizing manufacturing techniques and production of high capacity supercapacitors based on carbon nanotubes for storage.

Energy efficiency

In the area of energy efficiency, one of the most important projects is the KACST Solar Village — a worldwide pioneer project for adsorption

desalination and cooling that uses waste heat, can operate on 100 percent thermal solar energy, and has switch on/off friendly technology to enable night runs. The facility is an excellent example of Saudi localization, as KACST engineers were trained in modeling, design, manufacturing, installation and maintenance services. Local content was also significant in technology design and manufacturing.

A joint lighting program, established in 2013 by KACST, the King Abdullah University of Science and Technology (KAUST) and the University of California, Santa Barbara (UCSB), quickly went on to develop (in 2014) the first single-chip blue laser bulb in the world and to achieve (in 2015) the world record for efficiency of green LED (achieved by Saudi student).

Energy efficient lighting research may also be changing the future of food supply, as the KACST-KAUST Technology Innovation Center (TIC) investigates the potential for laser-based, indoor multi-tier horticulture. Knowing that most leaves absorb only red and blue light, this facility uses solid-state lighting to give plants exactly what they need. The vertical design saves water, energy and space. In 2013, this project won first place in the Dow Sustainability Innovation Student Challenge Award.

Establishment (in 2010) of the Saudi Energy Efficiency Center (SEEC), which has a mission to coordinate energy efficiency activities among governmental and non-governmental stakeholders, has been vital to institutionalizing and creating governance mechanisms to support the mission of reducing energy intensity to the lowest possible level. In addition to developing a clear plan and monitoring its implementation, SEEC helps to promote awareness, build capacity and promote an industry around energy efficiency. SEEC has specific targets in three end-use areas.

Buildings in Saudi Arabia account for 80 percent of total electricity demand, with air conditioning (AC) consuming 70 percent of this volume. Efforts to reduce electricity consumption for cooling span improving the efficiency of AC units, updating thermal insulation for buildings, and updating efficiency standards for lighting (residential, commercial, and street lighting) and appliances (such as washing machines and refrigerators). The aim is to reduce building demand by 50 percent.

Transport, which accounts for about 23 percent of total energy demand, is also a target sector. SEEC has introduced fuel economy standards for light-duty vehicles, adopted fuel economy labels, strengthened tire standards and provided incentives to retire old vehicles. It is now assessing options for heavy-duty vehicles.

Industry, with a 42 percent share of total energy demand (of which 80 percent is attributed to petrochemical, cement and steel industries) is ripe for efficiency measures. A two-tiered approach for selected industries has established baseline energy intensity targets for a total of 120+ plants as well as for 25 specific processes. Additionally, new standards stipulate that new plants must be designed with a maximum energy intensity level and efficiency standards for electric motors have been updated.

Modeling and simulation

To support energy planning and reform, Saudi Arabia developed the Integrated Energy Decision Support System (IEDSS), an agent-based simulator that explores the complex interactions between social, energy and logistical systems. The system provides insights into supply-demand equilibrium conditions under fuel price uncertainties. It also enables evaluation of the trade-offs between different system equilibria using key performance indicators (KPIs).

A complementary optimization tool, SUPER (Sizing, Ultimate Placement, Expansion and Reinforcement) simulates long-term planning and short-term operation of the Saudi power system. It aims to help planners find the optimal sizing, placement and timing of renewable and conventional technologies.

Specifically for Saudi's growing cities, the Urban Energy Modeling (UEM) tool seeks to better understand energy use and opportunities to improve sustainability at the household level. It enables analysis of building type, building materials and occupant behavior, then offers recommendations for supply optimization, energy efficiency measures and demand-side management.

Moving forward

Together, these initiatives show Saudi Arabia has been steadily building an innovation system for the energy sector. The government is committed to providing support — including substantial funding — for each system component. The critical first element is to ensure that innovative R&D work can be carried out to build intellectual capacity and intellectual property. The KACST model of clustering start-up companies around research centers facilitates the application of solutions in the Saudi context, further boosting local content. Strategic partnerships ensure ongoing knowledge exchange among world experts, and ultimately facilitate the export of Saudi-led solutions to other parts of the world.

Opportunities and Challenges for Energy in the KSA

The following is the text of the speech by **Amin H. Nasser,** President and CEO, Saudi Aramco

The role of energy in global economic development remains undeniable. But since KAPSARC was established six years ago, the environment in which we are working has become more challenging and more dynamic than ever before. And the environmental sustainability of our planet has become one of the defining issues of our time.

This prompts me to discuss these issues and the leading role that Saudi Aramco is playing in addressing them. I also want to explain why I believe these challenges present some huge opportunities to KAPSARC.

Energy and climate change: today and tomorrow

Energy is the lifeblood of modern civilization and also a barometer of living standards. One look at annual per-capita energy consumption, and you will see a direct link with prosperity and affluence. Today, the averages are vastly different: about five barrels of oil equivalent per person for India, 17 barrels for China and 50 barrels for the United States. The global average is less than 14 barrels.

Perhaps surprisingly, 25 years from now the global average of energy consumption per capita is expected to remain largely unchanged from current levels. This is the effect of rising living standards being offset by increasing efficiency.

By then, however, there will be another two billion people on the planet. As a result, global energy consumption, in absolute terms, will actually rise by more than one-quarter. Fortunately, under this scenario, carbon dioxide (CO_2) emissions are projected to grow by less than 14 percent, or roughly half of the rise in energy consumption.

Nevertheless, the question remains: how do we meet the world's growing energy needs while managing greenhouse gas (GHG) emissions?

Certainly, climate change is driving the transformation of the global energy system, which is commendable. But a successful transformation requires alternatives that are ready to reliably and economically shoulder the burden of growing world energy demand. At the same time, the massive global energy infrastructure needs to be transformed and prepared for alternatives, which is an enormous undertaking.

History tells us that such transformations take a long time. And this transition must be managed effectively. The share of oil and gas combined in the world energy mix is expected to fall by only a few percentage points, remaining at roughly half over the next quarter-century. Under one recent worst-case scenario by the World Energy Council, the share of oil in the transport sector — which is the largest and highest growth area for oil — is still 60 percent in 2060, compared with over 90 percent today.

So, pragmatism demands that sufficient investments must continue to be made in oil and gas during the long transition. At the same time, strong emphasis needs to be placed on minimizing the carbon footprint of these fuels.

The Global Methane Initiative, Mission Innovation, and the Carbon Sequestration Leadership Forum (CSLF) are just a few examples that show the Kingdom's commitment to the goal of clean energy and the top priority it places on addressing climate change.

Saudi Aramco's efforts and focus

At the company level, we at Saudi Aramco have a comprehensive carbon management strategy, based on four pillars.

First, we are making concerted efforts to shrink the Kingdom's own carbon footprint, such as working closely with the Saudi Energy Efficiency Program, which focuses on all end-user sectors. We are aggressively expanding our gas supplies and have a long-term ambition of doubling them to 24 billion standard cubic feet per day (bcsf/d). This will increase the share of clean gas in power generation to almost 70 percent, making it among the highest in the world. In renewables, we have a key role to play in helping the Kingdom become a solar powerhouse.

Second, I strongly believe that research and technology are critical if the world is to successfully transition to alternatives and renewables over the long term. In fact, the 11 research and technology centers and offices that Saudi Aramco has established in the Kingdom, North America, Europe and Asia powerfully demonstrate our belief in that long-term mission.

Take transport. Without game-changing advances in legacy fuels and new transport technologies, we will neither manage the transition period successfully nor be ready for full-scale deployment of alternatives and renewables. That is why, instead of focusing on engines alone, Saudi Aramco is working with auto manufacturers on the advanced integrated engine-fuel systems of the future.

Third, turning carbon into beneficial products, instead of discharging it into the atmosphere, would clearly be a win-win. Investments in technologies in this area are critical for solutions to bear fruit. For our part, we recently acquired a U.S. company, Novomer, which specializes in converting CO_2 into valuable chemicals.

Fourth, collaboration is one of the most important levers the industry has available. For example, we have joined forces with nine other companies to establish the Oil and Gas Climate Initiative, or OGCI. Members of OGCI, who represent 20 percent of the world's oil and gas production, are part of a wider industry-led response to climate change.

The role of KAPSARC

What does all this mean for KAPSARC's role and mission? Certainly, KAPSARC should be a master of the climate change debate — from climate change economics, policy and sustainable development to clean energy, conservation and economic growth pathways.

More broadly, KAPSARC should be one of the leading think tanks of the East while also serving as a link to the West. Besides independent research, I think the low-hanging fruit for KAPSARC is creating greater value for our policymakers through research in a range of areas. These include monetization and value maximization of the Kingdom's resources, and studies on the economy, energy, climate change, social issues and trade, as well as new economic sectors.

For example, in terms of petrochemical feedstocks, the Middle East carries nearly half of the world's proven oil reserves (roughly 800 billion barrels), and over 40 percent of the gas reserves (more than 2,800 trillion cubic feet). Yet our region's petrochemicals revenues are less than $100 billion, or 2.5 percent of the world total of $4 trillion.

The proportion is even less favorable when it comes to jobs, with the Middle East employing around 150,000 people, or less than 1 percent of the 20

million people employed in the global chemicals and related industries. Similarly, the region's share of the global market for speciality chemicals does not exceed 2 percent.

How do we bridge the massive gap between today's underperforming reality and our full potential — not just in chemicals but in a range of areas? This is a debate that I think KAPSARC should be adding real value to, because addressing a glaring local and regional weakness (and in the process helping to make Vision 2030 a reality) will really bolster KAPSARC's reputation here in the Kingdom and across the region. It will also hasten the day when governments, businesses and potential investors around the world turn to KAPSARC instinctively for answers to pressing questions like these.

In brief, the Kingdom places the highest priority on addressing climate change and is determined to support the objectives of the Paris Agreement. Saudi Aramco is playing its part by centering its investments on reliable oil supplies and creating cutting-edge technologies to reduce their carbon footprint. Finally, for KAPSARC to establish itself as the go-to think tank for the Kingdom, it must prioritize the opportunities offered by Vision 2030.

You have incredible resources; now it is time to deliver.

Energy Transitions in India and China

With the COP21 Paris Agreement having been quickly ratified, virtually every country in the world is now faced with the daunting challenge of keeping pace with energy demand in the context of a carbon-constrained world. With projected energy demand growth shifting from the western world to Asia, KAPSARC was keen to invite leaders from China and India in particular to the Energy Dialogue 2016.

After a period of aggressive economic growth underpinned by conventional energy sources, China has now recognized the need to mitigate the health and environmental costs of this approach. It has become the world leader in deployment of renewables, yet still faces substantial hurdles if it is to achieve its ambitions to reduce dependence on fossil fuels. India has the added challenges that some 20 percent of its population still lacks access to electricity, while its lowest cost major domestic energy resource is coal. As both countries have traditionally had strong state control over their energy sectors, they are also transitioning to more liberalized approaches, which requires new policy frameworks and engagement with the private sector.

Countries in the GCC are also in the midst of energy reform domestically, layered with rapid change in global markets that dramatically affect demand for their primary resource, and thus their primary source of revenue. With conventional foundations of energy demand and supply being shaken, open dialogue about future options is valuable to all three parties.

There follows a brief summary of the key points from the session,which was divided into two parts, one focusing on India and the other on China.

India: Striving for Universal Access That is Affordable and Sustainable

The following is a summary of discussion by four distinguished speakers:

Dr. Ajay Mathur, Director-General, The Energy and Resource Institute (TERI)

Dr. Kirit Parikh, Chairman, Integrated Research and Action for Development (IRADe)

Dr. Sunita Narain, Director General, Center for Science and Environment (CSE)

Sanjeev S. Ahluwalia, Advisor, Observer Research Foundation (ORF)

Four transitions are underway in India's energy sector. Overall demand growth in outpacing supply, but this creates opportunities to rethink the best way to meet the basic needs of people. Modernization of the buildings sector, including greater use of air-conditioning, is pushing up peak demand, yet baseload power plants are being used less than in the past. Two kinds of growth are evident in transport: personal road transport is increasing in urban areas and road transport (rather than rail) is growing for freight between cities. With economic development, growth in energy demand for industry is inevitable, but continued reliance on coal and oil would undermine air quality improvement and emissions reduction goals; more effort is needed to promote electrification and renewable energy.

An overarching challenge is that India remains at a serious energy deficit: annual per-capita

consumption is 0.6 tons of oil equivalent (TOE) compared with 2.5 TOE in most industrialized countries. Additionally, 20 percent of the population (240 million people) have no electricity at home and 40 percent (700 million) still rely on biomass or kerosene for cooking. In rural areas, the rate skyrockets to 80 percent. The World Health Organization identifies biomass cooking as one of the world's biggest killers. Similarly, in urban centers like Delhi, pollution is the major public health problem.

This cannot be separated from the reality that India also has a large human development deficit. Average per-capita income (based on purchasing power parity or PPP) is $5,000 versus $50,000 in United States, and 20 percent of Indians live in extreme poverty, with income of less than $160 annually.

One of the current ironies for India is that it has energy, but its people do not have access to energy. Indeed, large numbers of electricity plants are ramping down because there are not enough buyers, yet large numbers of homes have no electricity. In addition, a large volume of generation capacity is stranded because distribution utilities are bankrupt: they do not have the money to buy energy that people want and generators are willing to supply. Having better access to energy is vital to having education, work, mobility, industry, improved home life and 'connectedness' to the world.

The underlying problem is that the government does not allow market-based pricing for energy: because prices are fixed too low, the system is not functioning at capacity. Additionally, because the energy sector remains dominated by public sector enterprises, stifling bureaucracy constrains progressive energy policy. Prime Minister Modi is trying to make the public sector more efficient; abolition of the planning commission is one example of his will to change the mindset about the government's role in society. What is really needed is deep and extensive privatization of the whole economy, including energy.

The pressing challenge is to improve energy access, which means increasing supply within a shrinking carbon space. In the Indian context, the task is made more difficult by the fact that coal is the only major domestic resource. Coal accounts for 85 percent of electricity generation today, which could be brought down to 20 to 25 percent by 2050. Yet if electricity demand growth stays at 5 percent annually, accessible coal reserves will be depleted in 30 to 40 years.

India, in fact, is under pressure to move away from of coal quickly, particularly because of the COP21 Paris Agreement targets. Yet it bears asking what is India's responsibility to the global climate change threat? Between 1990 and 2012, India's contribution to global emissions was less than 5 percent: considering the population grew to over 1.3 billion in this period, total cumulative emissions on a per-capita basis have been negligible. Still, India is taking a strong stance on climate change, including making coal more uncompetitive against renewables, for example by strengthening emissions standards.

Two big issues confront India's energy sector, namely:

> How to get affordable energy to the poorest segments of society (who are too poor even to afford the cheapest energy, which is coal).

> How to do it so that India does NOT pollute and then clean up afterward (as industrialized countries are now doing). Can India have a model in which the poorest get the cleanest energy, at affordable rates?

India is being aggressive on energy access: it has doubled the capacity of infrastructure in some areas over the past 10 years and has put in place ambitious plans for renewables.

Expanding solar to achieve 100 gigawatts (GW) by 2022 is a stated national target, as is having renewables reach a 35 percent share of the fuel mix by 2050. But there are costs associated: replacing 1 megawatt (MW) of coal requires installation of 4 MW of solar considering that coal plants run 75 percent of the time while solar generates only about 20 percent. Also, solar's capacity and capital cost is about 1.5 times that of a coal plant, meaning the upfront investment is about 6 times higher. In a country with so many deficits and already-stretched resources, it will be clear to the government that greater investment in solar means less money available for education, health, other sectors and infrastructure.

Often, the question is raised whether aggressive grid ex on often say that DER is a popular buzzword and less straightforward than most people think. When investing in solar capacity, it is also necessary to invest in storage and/or back-up for the solar, as well as extra back-up in case the solar system fails completely. People in the grid extension 'camp' believe it is much simpler to build out a grid that reaches everyone. They cite the example of Prime Minister Modi, while still chief minister of Gujarat, connecting every village to the grid in just 2.5 years. If each state could build out its grid in this way, it would do more than deliver access to all: it would create the potential to interconnect grids among states to support more efficient use and distribution of resources.

The DER advocates see an unprecedented opportunity to do things differently. Instead of devising a capital-heavy, top-down approach to energy as the rest of the world has done, India could rewrite energy futures with DERs playing a major role. They also see positive gains to be made by "cutting the pipeline and putting energy in the hands of the people." Giving people the ability to generate power locally, means it is also possible to manage billing and payments locally, which is a massive problem for large centralized agencies. DER advocates posit that if people control their own energy, they will be aware of the price and perhaps avoid doing what the rest of the world does — e.g., buying more appliances and devices that need more energy. DERs are a way to make the connection between people and demand. The key is to find scalable solutions that meet the aspirations of people.

The great thing about solar, say DER advocates, is that it is modular. In rural areas, people can start small and add onto their systems as their needs change and they can finance the next element. Yet there is an inherent social challenge: to meet renewable targets, it will be important to overcome the current perception that solar is a solution for the poor by demonstrating that it can also be used effectively for the rich. Some positive examples are already in place. In Delhi, in one such example, all occupants of a large commercial building agreed to install rooftop solar. As the upfront cost was more than they could bear, they engaged with a third party to finance the project. That entity now sells the electricity generated to the shareholders for less than what it costs to buy from the grid. While such megacities cover vast areas, not all rooftops are suitable: the nature of urban landscapes means many buildings do not have the unobstructed exposure necessary to make solar economically feasible.

A second important social change is already evident, particularly considering India's long history of subsidizing energy costs. Studies show that individual households are willing to pay for energy and, in many cases, are already paying excessively high prices to people who set up informal mini-grids though diesel generator sets, inverters, batteries, etc. Often, this electricity is sold at three times the price of grid-supplied power. Greater regulation of off-grid solutions would help ensure energy access is affordable to low-income populations.

What is exciting is that technology innovation and societal change create an opportunity to re-think and rework the energy question. Ultimately, the integration of DERs and grid extensions makes sense: over time, installation of DERs in a given area can create sufficient load aggregation to support grid extension, while ongoing local generation ensures the grid does not become strained.

India can also benefit from what is known as the 'latecomer advantage', particularly in the area of energy efficiency by advancing directly to the best available technologies. In lighting, for example, India can make the transition from incandescent bulbs directly to light-emitting diodes (LEDs), completely skipping compact fluorescent lighting (CFL) which was a transition technology in many countries. As of March 27, 2017, India has already distributed 221 million LEDs to households, with a goal of 700 million. The replacements to date reduce annual electricity demand by about 28 terrawatt hours (TWh) and save about 23 million tons of carbon dioxide (tCO2) emissions. The reductions and savings will continue to grow, and have the benefit of being cumulative over time. India is now moving forward with super-efficient fans and appliances and energy demand for households is declining. One area that warrants strategic action is agriculture, particularly in small-scale farming, which is a huge part of the Indian economy but still very inefficient.

Given anticipated demand growth, planned expansion of renewables and reduction of coal to meet climate change commitments, it is inevitable that India will need to bring more natural gas into its economy to serve a balancing role. But gas products can also serve niche markets. When Delhi pollution was particularly high in the late 1990s, some actors pushed for the adoption of compressed natural gas (CNG) for vehicles (especially auto-rickshaws and buses). Initial resistance was overcome and now more than 100,000 CNG vehicles are on the streets of the city and transportation pollution levels are now significantly lower than they would have been without the fuel switching. Liquefied petroleum gas (LPG) can provide a cleaner alternative to using biomass for cooking. Per unit of delivered cooking heat, burning wood results in about seven times the lifecycle carbon of LPG; thus, even though it involves using a fossil fuel to replace a renewable energy source, LPG reduces greenhouse gas
(GHG) emissions.

The hard reality is that gas in India is not competitive with coal or with renewables. There is tremendous potential for gas to be the main bridging fuel during the clean energy transition, with demand increasing four to five times. But its current price leads to market distortions that influence how priorities are determined. One way to address these distortions is to liberalize the energy market, which would imply reducing public sector involvement. Against coal, it is important to raise awareness of gas as a 'cleaner' fuel that reduces the negative impacts of local pollution and therefore provides higher value relative to its price.

One cannot talk about India's energy future without touching on transportation, which is projected to grow exponentially. Continued reliance on conventional fossil fuels would dramatically increase transport emissions, overriding the recent gains made through the switch to CNG and leading to additional health impacts. Again, the question arises of how to seize the opportunity for radically different approaches. In urban areas, with Delhi as an example, only 20 percent of people own private vehicles at present, yet traffic is already congested and pollution is high. Thus, the real challenge is to provide effective, flexible public transport alternatives that will avert the problems that would come with more people buying more cars. In the Indian context, to curb the growth of transport emissions, it may be necessary to shift the

priority of vehicle electrification away from individual cars towards buses and to 2- and 3-wheelers (the latter of which will be the biggest segment of personal transport). As was seen in China, advances in low-weight battery technology may be the key to rapid evolution of the 2- and 3-wheeler stock.

While India faces substantial challenges in its energy transition, one thing is clear. In its bid to meet growing domestic energy demand in a carbon-constrained world, India may need to cast a new model for economic development and work with its citizens to reshape prevailing concepts of prosperity, which Western societies have shown may not be sustainable. On a practical side, key drivers of whether India can achieve universal access to energy while shifting to cleaner sources are access to low-interest, long-term financing and/or higher efficiency technology at lower cost.

China: Strategies to Deliver a Diversified Fuel Mix

The following is a summary of discussion by three distinguished speakers:

Guo Wei, Deputy Director, Department of Electric Power, NEA**.**

Han Wenke, Former Director General, Energy Research Institute, NDRC.

Jiang Xuefeng, Vice President, Economics & Technology Research Institute, CNPC.

Energy development in China over the past 20 years has been impressive in terms of speed and magnitude. In 1994, China was an oil exporter; today it is the world's largest oil importer. Since that time, electricity installed capacity has grown from 300 GW to five times that amount. Much of this growth was driven by aggressive economic development aims.

More recently, China has demonstrated a concerted effort to better balance economic goals with the growing concerns of local environment and global climate change. For the past 15 years, every five-year plan (FYP) incorporated substantive changes for energy development, including pursuing energy efficiency and diversifying the energy mix. The former has helped to temper energy demand growth: in the 2000-2005 period, primary energy demand grew by 8.6 percent; subsequent periods saw slower growth of 5 percent (2006-2010) and 3 percent (2011-2015). The latter has quickly brought China to the point of having the largest installed capacity of wind, solar and hydro. Aggressive plans will soon put China in the lead position for nuclear capacity as well.

China is now adapting to a 'new normal' status and looking ahead to create a roadmap for energy development over the next five years, including the upcoming release of the 2020 Plan for China's Electricity Development. This plan is expected to call for the greatest possible development of renewable, nuclear and non-fossil fuel power, as well as improved grid capacity to support increased shares of renewables and greater flexibility for peak load adjustment. It will also take account of growing demand as the use of electricity increases for heat supply, electric vehicles (EVs), etc. With a stronger focus on providing cleaner and more efficient electricity for China, future electricity development may not be at the same rapid speed as seen in the recent past, but stable growth is expected.

The roadmap for China's energy future will no longer support rapid growth and high consumption at all costs, as the negative impacts such an approach has on the environment are clear. The need to balance economic development and a clean energy transition has been discussed for a long time; now, decision–makers are ready to take serious action.

While progress is clear, a gap remains between government aims for low-carbon development and reality. China has the largest electricity system in the world, and accounts for 50 percent of global coal production and consumption. Coal-fired power plants are still the foundation of China's electricity infrastructure and the biggest source for electricity. Investment in and construction of coal-fired plants is still significant.

The 13th FYP (2016-2020) aims to limit the increase of coal-fired generation. Additionally, steps have been taken to retire outdated coal capacity, including closing small-sized plants that tend to have low efficiency and higher emission levels. Today, there is greater focus on updating existing plants to incorporate cleaner technologies and improve efficiency. The government has put in place stricter environment standards, backed by enforcement mechanisms, and is providing incentives to industrial enterprises.

In parallel, the 13th FYP sets out strategies to steadily increase the share of renewable and low-carbon energy in the fuel mix while reducing reliance on fossil fuels.

Many recent near-term measures seek to close the gap between installed renewable capacity and actual power generation and distribution. This is to rectify the problem that much of China's initial spurt of wind and solar installations was not well connected to the grid, and thus underutilized while conventional power plants continued to be called upon to meet demand.

China's energy revolution also puts a strong emphasis on boosting energy productivity and energy efficiency: a stated goal is to cap the growth of energy consumption by 2030. Using renewable resources and/or waste industrial heat to generate electricity for district heat supply in northern China is one example.

In the time frame to 2030, nuclear power development plays an important role. Ensuring the safety of nuclear operation is a top priority, including the ongoing systematic review of existing plants, new measures to check safety and enhancing the expertise of plant operators.

In mid- to long-term energy development, China aims for a more balanced mix overall, with one objective being to ensure a stable supply of oil while significantly increasing use of natural gas. In 2015, oil consumption in China was 11 million barrel per day; a projected annual growth rate of 2 percent will see oil maintain a share of 66 to 67 percent of imports by 2020. In parallel, the share of gas will increase to 10 percent of the overall energy mix (up from about 8 percent currently).

Over time, natural gas is projected to have a more important role in China's energy future, but this shift carries inherent challenges. Domestic production of gas is constrained for two reasons: limited availability of low-cost resources in China and even those reserves that can be tapped are far-removed from demand centers, thus adding the cost of long-distance transport. As a result, competitiveness of gas is weak: at current prices, acquiring the same heat value with natural gas costs three times that of coal.

Finding ways to make natural gas economically attractive is key to China's energy transition. Experience to date shows this is no small feat. Many point to how the United States rapidly achieved low-cost domestic gas through the shale gas revolution. In this case, much higher prices a few years ago drove the market to pursue technology innovation, which ultimately led to more reserves becoming accessible. But a liberal market was not the only factor: policy was in place to support access to resources and technology.

China does not have the same framework to support this type of market action. To facilitate expansion of the gas market, new fiscal and tax policies are needed. Also, investments in pipeline construction and operation are a precondition for opening up opportunities for gas in urban residential use. At present, state-owned enterprises SOEs, many of which are already in poor financial traits, dominate the gas network business. Some experts question why SOEs are holding the market so tightly rather than allowing others in, as investors and operators, to create a market-based system.

To expand the role of gas, China will have to rely on imports, which raises the question of energy security and how China defines it: looking only at what share is from imports is no longer reasonable. Perhaps opportunity exists to learn from Japan, which relies completely on energy imports but still has a high level of energy security.

Environmental concerns are also driving China's transition. While growing transport demand (including upgrading vehicles in cities and new use of road transport in rural areas) will continue to drive growth in oil demand, China is taking steps to provide clean, efficient public transport as a means of curbing use of personal vehicles overall and of petrol (gasoline) vehicles specifically. Through various policy actions, China aims to quickly become the world's largest EV market.

China is still in transition in regards to balancing the role of the government and a more liberalized energy market. There is much discussion about market reform, yet government administration seems to become stronger.

In the past, the Chinese government was in a strong position to finance investments to expand energy supply to keep pace with demand. It is now clear that state investment alone may no longer be sufficient to absorb the high levels of funding implied by the historical model of energy development. Going forward, officials have a stronger focus on accelerating the energy transition through a new model with a stronger 'business development' approach, including engagement of private companies and private investors.

In effect, the government is seeking to ensure fair competitive conditions in order to effectively use the power of the market. The central government is pushing SOEs to reform the natural gas network and market, but local governments still lag behind these ambitious objectives. Also, there is greater recognition that the government should focus on market supervision, including taking steps to intervene when a market failure becomes evident.

Moving forward

Saudi Arabia, India and China are vastly diverse countries, yet all are advancing through challenging energy and economic transitions. One way to navigate the uncharted territory more quickly may be to learn from each other's experiences in areas such as finding ways to tap into gas as a bridging fuel, advancing research and development to support wide deployment of renewables, and developing grid technologies that support long-distance transmission over interconnected systems.

Similarly, they will benefit from sharing knowledge and experience in areas such as policy development, capacity building and market reform, including balancing the roles of government and the private sector. As all three countries navigate the dual challenge of energy and economic transitions, there is opportunity to cooperate and KAPSARC stands ready to partner with its peers in India and China.

Roundtable Discussion Summaries

Future Focus in Oil-Rich Countries Economical, Efficient Resource Use

Moderator: Dr. Adnan Shihab-Eldin,

Director General, Kuwait Foundation for the Advancement of Sciences (KFAS)

Efficient use of current resources at the disposal of oil-rich countries (i.e., net exporters) is largely about finding ways to maximize the societal benefits of these economies as they move into a future that is rapidly changing on many fronts. Often, there is a narrow focus on natural resource endowment, leaving other elements — such as financial might — beyond frame.

Oil importers and exporters are bound in an energy trade nexus that impacts both economies. A move toward making the energy fuel mix more efficient by reducing the share of high-cost energy sources tips the scales toward low-cost inputs. Recognizing that changing the fuel mix carries risks for both exporters and importers, this session explored a range of topics relevant to reconciliation of current market trends, ultimately reaching four main conclusions:

Anticipated changes in the future fuel mix will affect different sectors in different ways. The greatest impact will be on the power sector. Transportation will be less affected, as emerging technologies (e.g., battery-powered vehicles) for road transport are not yet mature enough to significantly displace incumbent technologies, and other modes (e.g., maritime and aviation) still depend heavily on fossil fuels. In comparison, the power sector relies on various fuel types for power generation, as well as being more responsive to technological advancements in non-fossil fuels.

Co-investments between oil-exporting and -importing economies are key to minimize the risks associated with changing the future fuel mix and can, in fact, lead to mutual benefit. Trading excess power generated for natural resources is one example of such opportunity. For example, co-investments by oil exporters and oil importers in renewables has the mutual benefit of reducing local consumption of oil by exporters, thereby allowing additional supply to importers at a lower price.

In the power sector, establishing interconnected or cross-border grids is a necessary backdrop to facilitate efficient allocation of the future fuel mix. Initiatives undertaken to date demonstrate that the benefits of this approach also create new challenges.

Specific to the Kingdom of Saudi Arabia (KSA), given its overall economic state and ongoing economic reforms (such as the introduction of value-added tax or VAT), incentives are needed to spur private investment to support the future changes and developments of the fuel mix. Boosting private investment is particularly important in the KSA, as government spending to support economic development will no longer be sustained (or will continue, but at lower levels).

Overview: Oil-rich economies face new energy and economic challenges

Diversifying fuel resources has become a priority for many economies around the globe, particularly in light of efforts to decarbonize the global energy system. As the feasibility of alternative energy sources increases, the transition raises questions about potentially game-changing implications. This makes it valid to examine how changes to the global energy fuel mix might affect both net oil exporters and importers.

From an economy-wide perspective, diversifying fuel resources can eradicate some of the volatility in energy consumption patterns. With a diverse mix, an economy is less vulnerable to the risks associated with a single source of energy and is able to offset risks by using substitutes or alternatives. It is also likely to increase efficiency. These potentials are particularly valuable for economies with energy-intensive industries, as they can mitigate risks associated with specific fuel types and stabilize output prices.

For oil-producing countries that depend heavily on exports for revenue generation, transforming the fuel mix creates new risks. If trading partners adjust their traditional energy mix, both exports and revenues may decline for the producing economy.

In the past, high oil prices played a primary role in prompting the development and adoption of alternative sources of energy. More recently, other factors have come to the fore to varying degrees, including accessibility and security of supply, efficiency of resource extraction and use, terms of trade, and concerns regarding climate change and the environment.

Determining an appropriate energy mix for any economy is ultimately about the bottom line. This raises some overarching — and potentially diametrically opposed — questions. If oil prices continue within or near the band of $40 to $50 per barrel, does it cool the motivation for and reduce the viability of policies and plans to boost shares of alternative energy in the future fuel mix?

Or is an alternative challenge emerging? While technological development, declining costs and other factors have driven down the price of some renewables and alternative energy sources — and may continue to do so in the future — the sharp decline in oil prices over the past couple of years may have outpaced that of these substitutes. In this case, perhaps a more intriguing question arises: if alternative energy resources, or some renewables, stay or become costlier than oil, can we expect a turnaround toward more crude in the future fuel mix? Several scenarios could play out that would bring this question to the fore sooner rather than later.

Yet the reverse question is also important: i.e., what would be the future role of crude oil — and how could it be safeguarded — in the future energy mix if the rate of cost and price reductions continues and expand to other alternative energy sources under development?

A changing fuel mix and economic sector impact

Given the available technologies in the power sector, altering the future fuel mix will significantly impact the underlying cost structure and power generation of electricity providers and producers. Specifically, alternative energy sources are relatively easier to embed in the infrastructure of power generation when compared with the transportation sector. It is not a question of whether the power sector will be impacted; rather, it is an inquiry to assess the magnitude of the impact. Rapid adoption

of renewables, even on a consumer level, can contribute to changes in consumption behavior. Thus, the combination of the available infrastructure and available and/or emerging technologies — characterized by a declining cost framework in developing these technologies — allows for faster adoption of energy fuel mix changes in the power sector.

In contrast, the transportation sector has yet to develop technologies that will substantially change the fuel mix. Automotive, maritime and aviation transportation modes still depend heavily on fossil fuels, which seems likely to remain the status quo for the next two to three decades. Thus, in the near to medium term, the transportation sector as a whole will more likely be impacted through indirect effects of changing the future fuel mix, such as those related to input costs of production and manufacturing. However, unlike for the power sector, such impacts would not be significant enough to change current trends.

New approaches to resource trading and lessons learned to date

Countries belonging to the Gulf Cooperation Council (GCC) have great potential to reap the benefits of solar energy in the bid to diversify their fuel mix. At present, however, they may lack the competitive edge to make it a reality. Asian economies, which currently make up a significant portion of the GCC trade partners, have already taken aggressive steps to develop and deploy solar (and other renewables), and thus have the technological edge and industry know-how.

This suggests an opportunity to expand the scope of a traditional energy trading partner relationship between the two regions. Indeed, co-investments among Asian and GCC countries could facilitate trading oil for solar in such a way that excess fossil fuel capacity is matched with excess capacity of renewable know-how and technology. The recent tender from Abu Dhabi's solar project, for example, was awarded to a Japanese-Chinese consortium with a bid of $0.29 per kilowatt hour (/kWh).

With the establishment of the interconnected electricity grid in 2010, the power trade has become a hot topic among the six countries that make up the GCC region (Saudi Arabia, the United Arab Emirates [UAE], Qatar, Bahrain, Kuwait and Oman). If renewables come to make up a larger portion of the power sector fuel mix (which is largely based on associated gas at present), an integrated electricity system and market may become more necessary and more attractive. Additionally, Saudi Arabia's plan to privatize the electricity sector means that, to avoid surplus supply, businesses likely need to consider the possibility of cross-border energy trading. Consideration of consumer behavior changes is also well within the scope of cross-border energy trading impact.

To understand what might be expected for the GCC region, the German experience may offer lessons and point out pitfalls to avoid. Germany's experience demonstrates the importance of supply planning, ensuring reliability, enabling cross-border power trade and promoting efficient consumer behavior. With aggressive renewable targets, Germany found itself with excess supply, which prompted an effort to 'dump' it across borders. This move ultimately drove prices down, having the spillover effect of undercutting prices and rendering invalid the business models of industry players in other parts of Europe. It is worth noting that Germany was the largest solar photovoltaic (PV) producer in the world — 50 percent of total output — in 2011, despite its restrictive geographic characteristics relative to GCC countries with regards to solar exposure.

A primary difference between the German and Saudi Arabia contexts is consumer behavior, which is related to pricing policies and reliability of supply. Consumers in the Kingdom are used to below-market energy prices; in turn, they do not engage in efficient consumption practices. By comparison, Germany's consumer behavior is quite the opposite: as an importer exposed to the mercy of market prices, the country makes it a priority to encourage efficient energy consumption.

Two basic conditions will be necessary for renewable energy to have a substantial impact in the GCC region. First, ensuring reliable power from renewables will require substantial investment in mechanisms to integrate flexible resources. Second, governments will need to tailor pricing policies in such a way that they alter consumption behavior. Seasonal consumption, especially for air conditioning in the summer, may demonstrate that rooftop PV is not an efficient solution for GCC countries. Household PV systems may generate as little as 15 percent of daily consumption.

Given the very different contexts and consumer behavior patterns, there is no guarantee that what may have worked for Germany (i.e., feed-in tariffs) will be applicable in the GCC region.

Economic reform in the GCC region

Saudi Arabia is emerging as one of the regional leaders of transformative economic policies. Considering its economic status as the largest oil exporter and one of the largest producers, its economic health during the transition (and after) will be closely watched and carefully considered as other importers consider their own future fuel mix. Saudi decisions to increase or reduce production due to economic needs are likely to influence the future path of other exporters. While climate and environment issues are also a factor in the decision-making process, from a pure market perspective, the costs of alternative energy are the primary determinant in fuel mix models. In fact, if oil prices remain low relative to alternative energy, then fossil fuels will likely continue to make up a large portion of the energy mix.

With large endowments and low production costs, GCC countries are in the unique position that it has historically been economic to burn crude oil for power generation. However, this situation is closely linked to the global price of oil, which has been increasingly volatile in recent years. When planning their future fuel mix for the power sector, GCC countries need to take this potentially volatile link into account. High oil prices will mean that using crude to generate power will have a higher opportunity cost. Conversely, if the global oil price drops to a point that using crude to generate power is less costly than switching to alternative energy sources, it may prompt higher domestic consumption of fossil fuels.

Moving forward

In the GCC region, the future energy fuel mix and efficient allocation of resources will depend on pricing trends, costs of input, consumer behavior and overall economic health. The German experience indicates that governments seeking to transform their future fuel mix — and their power systems in particular — will need to strive for lower costs but also for higher efficiency, reliability and flexibility, as well as reduced emissions. The transition from fossil-fuel dependency to renewables and alternative energy sources will be less difficult if actions on these fronts are coupled with initiatives to change consumer behavior.

Whether such a transition is pursued within the next decade or over a longer time frame, it is clear that GCC economies would benefit from a shift

toward using alternative energy options, specifically solar power. This stems from the reality that, with economic reforms focused on diversifying revenue generation, use of domestic oil in the power sector is likely to have a higher opportunity cost in relation to exporting. The target of having oil activities achieve about 45 percent of economic output in Saudi Arabia is carefully balanced to generate a minimum revenue stream into government consumption. Yet it creates additional pressure to generate power from alternative sources, including natural gas, solar and even nuclear.

At the system level, the efficient and reliable supply of energy is a function of the reliability of the generators, the electric grid and other supply chain elements. On the demand side, with high per-capita consumption and low efficiency, it will also be important to alter the behavior of GCC consumers through end-user pricing. Policies, including those to eliminate subsidies, will need to align incentives to adopt efficient energy use at both industry and household levels.

Finally, the energy challenge will need to be tackled from both sides of the equation: importers and exporters can benefit from aligning their interests through strategic investments that are mutually beneficial.

Leveraging Resources for Economic Development: Local Content in KSA

Moderator: H.E. Dr. Muhammad Al-Jasser,

Adviser to the Royal Court

Efforts to boost local content in the Kingdom of Saudi Arabia (KSA) have been underway since the 1950s, but have taken on much greater importance in recent years with the downward trend in oil prices and subsequent decrease in revenues. In this environment, local content is seen as a method of generating additional employment and revenue from the economy's primary industry, while also diversifying into a range of other sectors.

A growing, youthful and increasingly educated population creates the need to boost employment in the Kingdom and also the opportunity to fill posts with skilled Saudis. Programs such as Vision 2030, Saudi Aramco's In-Kingdom Total Value Add (IKTVA) and *Nitaqat* Saudization regulations indicate that the push towards local content, diversification and job creation will drive important changes for the foreseeable future. Government and industry leaders have identified a few key challenges in the near term:

> Local content initiatives are in place in many companies, industries, and ministries across the KSA. Coordinating and streamlining these efforts (whether through regulation or more informally) will require a central champion within the government, endowed with appropriate implementing authority.

> In manufacturing, the Kingdom has an abundance of capacity with strong firms capable of supplying many industries. The cross-sector infrastructure required to foster linkages that could increase local content is very weak at present, with major gaps in standards, procurement mechanisms, and systems to announce and manage opportunities for tenders.

> The goal of local content in the KSA should be to increase Saudi participation in the labor force without sacrificing efficiency or quality. Implemented properly, this can create a competitive advantage for Saudi firms and build a quality infrastructure for manufacturing and services that can contribute to economic development.

> Ultimately, local content in Saudi Arabia should be able to compete internationally, eventually making Saudi human capital an export in and of itself.

> If, as anticipated, local content in Saudi Arabia will be driven from the energy sector, then Saudi Aramco's efforts will have a strong influence. As it controls a large share of the national economy, the company's plans to increase local content to 70 percent by 2020 (from 30 percent currently) through the IKTVA program is set to energize diversification efforts across the economy.

Overview: The value of local content in Saudi Arabia

The purpose of local content policies is to increase the value generated by exploiting resources that remain in the domestic economy. In oil-producing countries, they also seek to develop linkages between the oil sector and the rest of the economy. In fact, the activity beyond the oil sector is of greater importance, as it is the 'new' element in the economy (where oil and gas activity is anticipated to continue).

Local content initiatives abound in the Kingdom, from telecommunications to financial services to energy to the defense industry. In each case, these

initiatives are being driven by a ministry office and/or led by a large Saudi industrial company.

In fact, the state of domestic industry in Saudi Arabia is strong, with a significant and growing industrial base in energy, petrochemicals and defense industries. Within each sector there is an abundance of capacity to meet manufacturing needs, but firms are largely siloed and do not supply other industrial sectors. The cross-sector infrastructure required to foster such linkages is very weak, with major gaps in standards, procurement mechanisms and systems to announce and manage opportunities for tenders that can increase local content.

Lacking any central coordination, existing local content initiatives can be at best duplicative and at worst contradictory. Taking the example of car batteries, two large consumers might each develop their own suppliers for the same component, rather than working with one large supplier (duplicative), or two consumers may define a component's specifications differently enough that it is impossible for a single supplier to serve both consumers (contradictory). If nationalization and diversification goals are to be achieved — and local content is to be one policy lever to drive this change — then a central champion within the government is needed. Properly empowered, this single champion should be able to coordinate the various local content initiatives and build the necessary cross-sector infrastructure.

Without a doubt, the energy sector, and Saudi Aramco in particular, will strongly influence the Kingdom's local content policies and implementation plans. They have set a company target of 70 percent local content by 2020, which would be a significant increase over the current situation. The IKTVA program developed by the company is procurement-driven with the express aim of making suppliers substantiate their value-added in the Kingdom and report their progress towards increasing local content in manpower and supply for the oil and gas sectors.

Changing times spur need for new approaches

A global oil price boom from 2003 to 2013 fueled rising prosperity across the countries in the Gulf Cooperation Council (GCC). The KSA became the world's 19th-largest economy, as gross domestic product (GDP) doubled, household income rose by 75 percent and 1.7 million jobs were created for Saudis, including for a growing number of Saudi women. The government invested heavily in education, health and infrastructure, and built up reserves amounting to almost 100 percent of GDP in 2014.

The subsequent drop in oil prices in 2014-2015 dramatically changed projections for the future. But the altered context also provided policymakers in GCC countries with an opportunity to finally take on economic reforms, particularly in the areas of reducing energy subsidies and pushing economic diversification. These reforms aim to allow resource-rich countries in the region to capture a larger portion of the foreign direct investment (FDI) flows for their domestic firms across the entire oil and gas value chain. In the case of the KSA, the motivation for these reforms was spelled out clearly in the McKinsey Global Institute's report Saudi Arabia Beyond Oil and in the Kingdom's own Vision 2030 strategy, both published in 2016.

The concept of local content received heavy emphasis in both reports, in relation to all GCC countries and to KSA in particular. Essentially an extension of prior labor market reforms that date back to the 1950s, current efforts seek to increase

national participation in the workforce. With an urgent need to diversify the economy driving a new national vision for economic transformation, there is great pressure on the energy sector to prioritize domestic firms, retain value in-kingdom, and employ more Saudis. This raises the question of what issues energy policymakers in KSA need to consider as they embark on setting local content policies to meet these goals.

Economic diversification as a political imperative in KSA

In the current and expected economic context, it is clear the Kingdom can no longer sustain growth based on oil revenue and public spending. In addition to the changing global energy market, the KSA faces a demographic transition that will lead to a bulge in the number of working-age Saudis by 2030. Current labor participation is 41 percent, and productivity growth of 0.8 percent from 2003 to 2013 lagged behind that of many emerging economies. Foreign workers on temporary contracts, who are paid considerably less than Saudi nationals, constitute more than half of the labor force.

A productivity-led transformation of the economy could, however, enable Saudi Arabia to again double its GDP and create as many as six million new Saudi jobs by 2030, as referenced in the McKinsey report. Eight sectors — mining and metals, petrochemicals, manufacturing, retail and wholesale trade, tourism and hospitality, health care, finance, and construction — have the potential to generate more than 60 percent of this growth opportunity. Existing estimates suggest that such an initiative would require about $4 trillion in investment.

The newly formed Ministry of Energy, Industry and Mineral Resources oversees more than 70 percent of the economy of Saudi Arabia. Ergo, it is no surprise that these sectors will be a primary focus in this transformation to meet future demand for employment.

'Nationalization' of industry in KSA

Various studies demonstrate that the KSA has grappled with the issue of how to increase national participation in the labor market for decades. This history was summarized well by Professor Jennifer Peck, from the Massachusetts Institute of Technology, in her comprehensive study of labor market reforms in Saudi Arabia. Key points are as follows:

> From 1995 to 2010, Saudi Arabia's nationalization (referred to as Saudization) efforts were similar to others in the region, with extremely ambitious targets. Laws implemented during these periods required companies in nine sectors to achieve 30 percent nationalization targets, while construction companies were assigned a 10 percent target. These laws were not enforced, however, and companies in most sectors fell well short of these quotas. Some success was achieved in the oil and gas industry, and in financial services.

> In 2011, the Saudi Ministry of Labor began enforcing an updated version of the old, non-binding nationalization program. This new program, called Nitaqat or 'bands', gave firms more attainable targets and introduced incentives to achieve mandates. The program developed targets based on firm size and industry, and imposed visa restrictions reflecting how well firms performed relative to these targets.

> These incentives were strictly enforced and non-compliers faced restrictions on work visas for foreign workers. By contrast, firms that performed well were given expedited access to ministry services such as recruiting assistance and visa approvals. Even today, this employment quota program is unprecedented regionally in the breadth of its scope as well as its rigorous enforcement and close monitoring.

The *Nitaqat* program succeeded in increasing native employment but had significant negative effects on firms. Program compliance rates were high, with firms increasing their Saudization by almost 3 percent on average. Quota compliance was primarily accomplished by hiring Saudis, and Nitaqat was responsible for adding an estimated 96,000 Saudi workers to the private sector workforce over a 16-month period. Ultimately, however, the program carried significant costs, causing approximately 11,000 firms to shut down and decreasing total employment among surviving firms. It also led to overall private sector employment decreasing by 418,000 workers and an increase of 50 percent in the exit rate for expatriates.

Background on local content

The pressure on Saudi Arabia's energy sector to drive national economic transformation and produce jobs is significant, but clearly Saudization targets such as those used in the *Nitaqat* program ought to be considered carefully. One alternative means to achieve these goals, which has become quite commonplace in the oil and gas industry in other countries, is so-called 'local content' policies. Assessing how they can be applied in the KSA context is a valid exercise.

Cross-sector linkages are a critical element of building local content, and can encompass forward, lateral and backward linkages. Examples from the oil and gas industry may provide insights for other sectors. These linkages are especially important to local content policies that are a part of a country's wider industrial policy aimed at economic diversification and transformation.

Backward linkages are those created by commercial relations among oil operators and their supply chains, which include the transfer of technology and know-how, employment of nationals, and sourcing local goods and services. Lateral linkages utilize demand within the sector to develop skills, services and infrastructure that can positively impact other economic sectors while allowing locals to participate in the petroleum supply chain. Forward linkages involve the construction and operation of facilities that process and export oil and gas resources, such as refineries and petrochemical facilities.

If local content policies are implemented successfully, these economic linkages can create significant spillovers in the economy. Local content objectives in KSA could contribute to the economic transformation sought by Vision 2030, but this is not guaranteed. In fact, much commentary and analysis of local content policies in the energy sector shows that quite opposite outcomes can arise.

Summary of current thinking about local content

In a comprehensive World Bank study of local content in the energy sector, Silvana Tordo succinctly summarized the arguments for and against this approach. She concluded that governments most often pursue such policies for three reasons: 1) to increase in-country value-added by the energy sector; 2) to correct for a market failure; and 3) to support employment and other social objectives. Empirical evidence supports some of these arguments.

Increasing in-country value-added occurs when domestic firms are able to produce and export a 'new' product (i.e., one that was not previously produced in that setting). The challenge for domestic energy firms in Saudi Arabia is that steep barriers to market entry for foreign firms has led to the creation of mostly joint ventures, which disincentivizes domestic firms from competing independently. To the extent that this is a market failure, local content requirements have the potential to develop specific skills and capacities in the domestic workforce, thereby correcting the imbalance of knowledge between domestic and foreign workers. Experience with local content policies in Latin America shows that they can create productive externalities, such as when local firms begin interacting with foreign firms in technology transfer.

Such policies can, however, regularly lead to negative economic outcomes, especially in trade as has been shown by Gary Hufbauer and his colleagues at the Peterson Institute for International Economics. In a global study of 117 local content policies implemented between 2008 and 2013, across all types of economies and industries, the Institute estimated that such policies affected roughly 5 percent of all global trade. The net effect was a $93 billion reduction in trade. The study also points out that local content policies may enable domestic producers to capture economies of scale and enter global markets, but they may also insulate firms from competition and generate lags in new technology. The cost of implementing these policies is difficult to calculate downstream and, as they seldom contain 'sunset' provisions, resulting market distortions may last for a very long time.

To date, questions related to the macroeconomic impact of local content policies on energy sector productivity remain largely unanswered. The advent of these policies is relatively recent and most are tied to the boom in oil and gas prices between 2003 and 2013. Thus, research on this topic is still in its infancy.

For Saudi Arabia, the question is more than academic, though. The mandate for economic transformation driven by Saudi Arabia's energy sector makes decisions about local content policies critically important and urgent.

Moving forward

The goal of local content in Saudi Arabia is well-targeted on increasing Saudi participation in the labor force without sacrificing efficiency or quality. Those driving the initiatives, i.e., the Ministry of Energy, Industry and Mineral Resources and Saudi Aramco, would do well to draw lessons from prior labor market reforms that did not achieve the desired economic growth, and in some cases led to negative impacts. One such lesson is the need for a national champion to centrally facilitate the development of a quality infrastructure for manufacturing and services to help create a competitive advantage for Saudi firms. The strategy will be considered a success when Saudi firms can compete internationally, eventually making Saudi human capital an export in and of itself.

Gas, Power Cooperation in GCC: Scope for Integrated Markets

Moderator: H.E. Dr. Majid Al-Moneef,

Advisor to the Royal Court

The recent move to create a GCC Economic and Development Authority makes it timely for countries in the Gulf region to consider opportunities for trade — as well as obstacles — from economic, technical and political perspectives.

As energy is a crucial component of economic development, greater energy system integration holds potential to benefit individual countries and the region as a whole.

With the aim of finding ways to capture the dividend of cooperation among GCC states, the sessions focused on the economic and social benefits of collaboration in the gas and power sectors while also examining some of the known barriers.

> Development of the GCC interconnection grid is considered a successful model of regional energy cooperation. Optimizing its use beyond the current emergency function to facilitate trade among member states could lead to savings across all GCC states of $27 billion in capital expenditure (CAPEX) costs between 2014 and 2038.

> Large gas resources could also create opportunity for intraregional trade; however, at present, the future for gas remains uncertain. The opportunity to trade British thermal units (Btus) through power trading is acknowledged.

> Scope may exist to expand regional trade to include water, particularly as the resource is scarce in all countries and closely connected to power.

> Three elements are needed to move toward greater intraregional trade: transparency of price (which does not have to be monetary); equality of the exchange rate or value; and dependability of the shared capacity.

Overview: Cooperation to promote sustainable use of energy

Over the past several decades, Gulf countries have become a hub for energy development and trade, which has had profound effects in driving economic growth. The Gulf Cooperation Council (GCC), formed in 1981 to promote and facilitate multinational cooperation in the region, has enabled development of free-trade areas, financial cities and industrial zones.

In the current context, it is increasingly clear that sustainable use of energy is crucial to future development. However, the area exhibits high overall demand and high per-capita usage as well as low efficiency rates and substantial waste.

Addressing these energy challenges is on the agenda of each country. Some propose that an aggregate, regional approach could be more effective, leveraging synergies and delivering mutual benefits. Coordinated action could, for example, promote more efficient distribution of resources and eliminate some of the inefficiencies and waste. Several factors make cooperation a valid option, including that all Gulf countries face similar issues, such as:

> High dependence on energy exports — upwards of 60 percent to 80 percent — for government revenues means countries are vulnerable to global market demand and price volatility. All GCC countries are searching for ways to diversify their economies.

- Shared concerns on geopolitical issues such as security.
- Population growth is leading to rapid increased growth in energy demand.
- A young population (almost one-third of GCC is under the age of 25) generates pressure to create jobs for youth. Additionally, this generation is putting a lot of emphasis on sustainability.

More recently, the COP21 Paris Agreement has intensified global efforts to act to mitigate carbon dioxide (CO_2) emissions. The case for GCC countries is particularly challenging as they are not only major fossil fuel producers but also have some of the highest per-capita consumption in the world — and therefore very high per-capita emissions (International Renewable Energy Agency [IRENA], 2016).

In short, many factors could lead to a ripe environment for cooperation in the power and gas sectors, but there are also many concerns that could preclude joint effort. The fact that the GCC states share very similar cultures, one language and the same religion creates a strong foundation for cooperation.

Now that initial steps toward greater cooperation in the energy field have been taken, it is timely to ask if the region is getting the most out of these early efforts and whether other areas of cooperation might be explored.

Power cooperation through the GCC Interconnection Authority (GCCIA)

The interconnected grid is an example of a successful cooperative initiative in the energy sector for the GCC, reflecting its methodical joint development. A study conducted in 1986 by a committee from the GCC countries in cooperation with King Fahad University of Petroleum and Minerals (KFUPM) and Kuwait Research Institute demonstrated the technical benefits of the project. The GCC countries agreed to form the GCCIA to create an interconnected power system and, as per Royal Decree No. M/21, the Interconnection Authority was established in 2001.

The project was designed with three phases. The first phase to connect the northern systems of Bahrain, Kuwait, Qatar and Saudi Arabia was concluded in 2009. The second phase linked the southern systems of Oman and the United Arab Emirates (UAE). The third phase connected the northern and southern systems. As a result, the GCCIA managed to connect all six member states successfully by 2011 (www.gccia.com.sa).

The way in which the GCCIA was incorporated is noteworthy: the approach emphasized technical abilities, creating a form and structure of ownership that eliminated political concerns which could have hindered fulfilling its mission.

Additionally, the project initially built its business case around an identified shared need: providing security during threats of blackout. Since operation began, the interconnected grid's ability to provide emergency electricity supply has alleviated over 1,400 incidents within the member states. (Figure 1)

It is now clear that the grid could provide joint benefit well beyond emergency supply. Now that the infrastructure is in place, it opens up a great opportunity to facilitate electricity trade within the GCC. Over the longer term, the grid could connect beyond the GCC region with countries such as Egypt and Jordan, and eventually Europe.

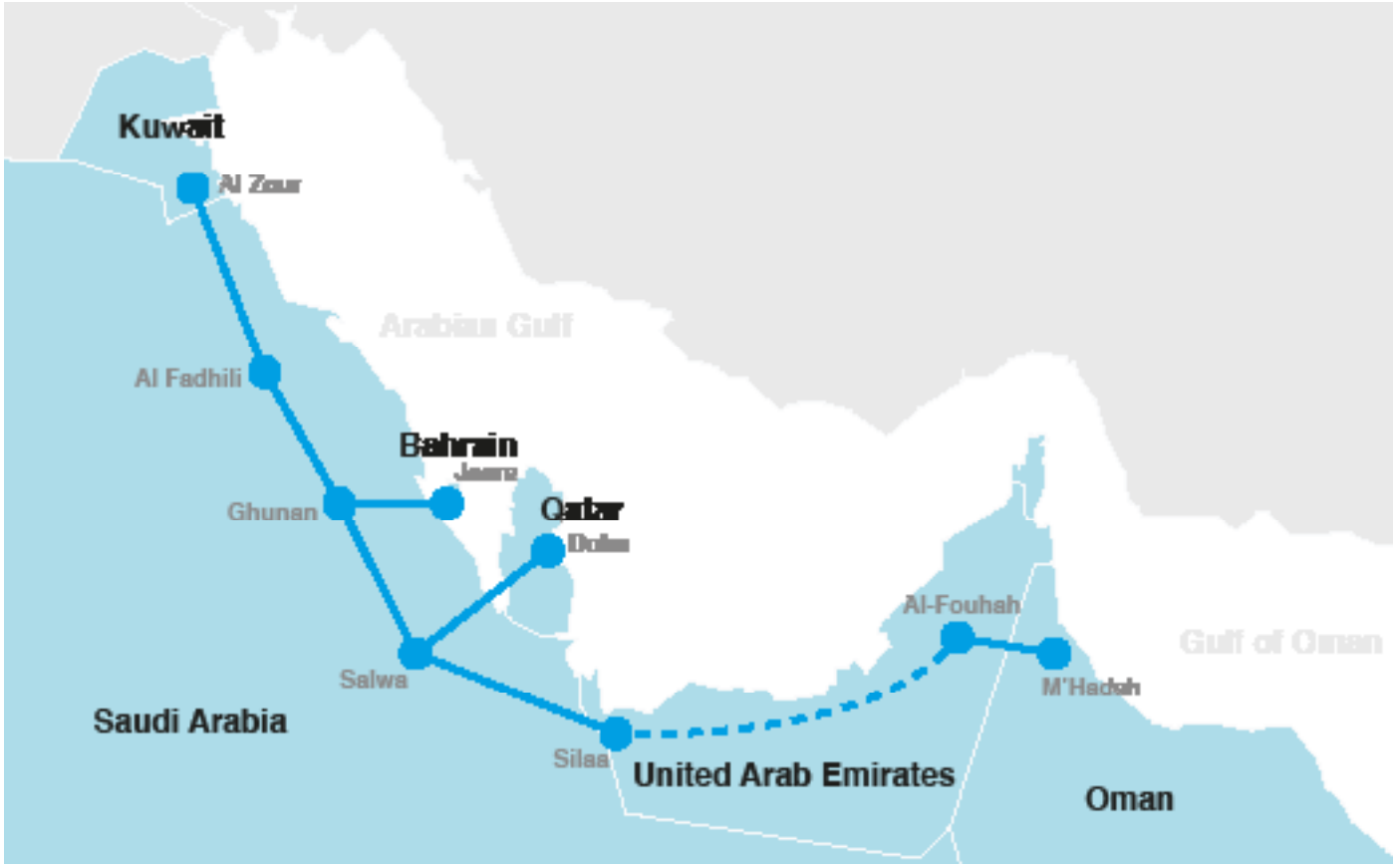

Figure 1. The GCCIA Interconnector.
The six countries have been connected through the GCCIA since 2011.

Source: KAPSARC analysis.

If the network were fully utilized, the interconnection authority could help GCC states save up to $27 billion in CAPEX costs over the period 2014 to 2038. One example of operational savings is that, for each degree increase above the average weather temperature, the Saudi Electricity Company (SEC) is required to increase electricity production by around 600 megawatts (MW) country-wide, at an estimated cost of around $6 million. Trade across the interconnected grid could reduce or eliminate this cost.

In cooperation with international organizations and through other projects, the GCCIA is now working on building a suitable platform to establish a power trading market in the GCC and eventually beyond the region.

Opportunities and obstacles to power trading

Various studies show that one of the highest yielding areas of cooperation for the GCC would be to establish a regional, liberalized power trading market. While some signs of movement toward this goal are evident, two overarching challenges continue to dominate the debate: retail energy prices and political will.

At present, retail electricity prices within each state reflect a few layers of incentives that are designed

to deliver value to citizens. This makes the prices unsuitable for export or trading in a liberalized market. Currently, the GCCIA benchmark price is based on global prices and the pricing mechanism is determined through negotiated bilateral contracts or in-kind trading (not necessarily watt for watt). There are no price subsidies. Participants in the GGC Integrated Grid need to agree on a mechanism to establish a trading price for power.

In July 2015, the UAE announced that it would adjust its fuel prices to a liberalized level. In reality, the increase in gasoline prices has been rather limited as they were already close to the international levels. Saudi Arabia announced in December 2015 various reforms applicable to water, electricity, natural gas and petroleum products, including raising the price of certain fuels such as low- and high-octane gasoline (by 67 percent and 50 percent, respectively). In contrast to the UAE, Saudi Arabia might consider implementing sharp increases to bring local prices closer to international levels, as suggested by some studies (www.apicorp-arabia.com/Research/EnergyReseach/2016/APICORP%20Energy%20Research%20-%20V01-N04-Jan-2016.pdf).

In terms of political will constraining the possibility of establishing a regional energy market, one underlying factor is the barrier initiated from consumer behaviors and attitudes. However, recent reforms have started to remove these barriers. Despite the increase in the price of hydrocarbons in Saudi Arabia, for example, the price reform process has been implemented as part of the new tariff system.

Across the GCC, varying degrees of sophistication are evident in each country's trading system. Indeed, much room exists for each country to reform its own power sector, both economically and politically, in order to create a level playing field at the regional scale. The establishment of an independent regulator for the GCC has helped tremendously in paving the way. Participants have expressed that the regional mindset is changing. With growing support for regional trade within the regulatory bodies, most GCC countries now generally favor moving toward a liberalized energy market.

Gas trade and cooperation

The GCC region is considered to have the world's largest natural gas reserves. The availability and accessibility of these reserves has prompted several past initiatives to create a gas market. Qatar, which has the highest share of GCC gas reserves, launched an attempt to establish an intraregional connected grid as a first step in creating a bridge that would connect the GCC to Europe. The plan, reflecting a model developed by the GCC Secretariat, also included connecting Egypt to the gas grid. The initiative proved difficult to launch: each country had developed its own gas programs and strategies, which swayed the decision away from investing in an interconnected gas grid. Eventually, Qatar also changed its strategy and pursued the liquefied natural gas (LNG) option for export.

At present, as it seems uncertain whether gas trading might expand any further, some interest has been expressed in the alternative of trading BTUs by trading power through the interconnection grid.

Water and water trade

Water scarcity is a growing concern for all countries in the GCC region: due to the lack of freshwater resources, the region depends on desalination. The interplay of power needed to desalinate water and

water needed for power production makes the two sectors strongly linked. Thus, any future discussions regarding the power trade would do well to consider the water-energy nexus, taking full consideration of the fact that the water trade goes hand in hand with power cooperation. Indeed, the GCC Secretariat is currently working on a unified law for water usage and treatment in the GCC.

Moving forward

In the power sector, having established the GCCIA infrastructure, the platform is effectively in place to facilitate future decision-making — including on how to utilize the integrated grid in a more efficient manner. Scaling up power trade and expanding GCC trade to other sectors requires agreement on three key areas:

Transparency of price, acknowledging that the price does not have to be monetary. Several examples exist in which in-kind trade facilitated transfer of different volumes of power at different times of day. Establishing a uniform exchange rate would help planners make decisions.

Equality of exchange, implying that a fair exchange rate or value should apply to any deal among member states, thereby resolving any perceived issue of member favoritism.

Dependability of capacity needs to be assured, so that planners can be confident it will be available as contracted and can plan accordingly.

With demonstrated success on the technical side of intraregional power trade in place, taking steps to achieve these economic and political elements will build confidence in expanding such trade to other sectors, including gas and water. Once member states can plan around a transparent, equitable and dependable system, opportunities for trade and arbitrage will arise organically — a first, small step toward a power market.

Energy Productivity as a New Growth Paradigm in the GCC

Moderator: Dr. Richard Newell,

President and CEO, Resources for the Future

The concept of energy productivity has recently emerged as a new way of framing energy planning and policymaking. The underlying aim — i.e., to optimize the economic and social value of each unit of energy consumed — is of interest to multiple stakeholders, which has given rise to different ideas on how to operationalize the concept.

General agreement places two broad actions at the core of an energy productivity approach: improving energy efficiency and pursuing economic diversification to better balance energy-intensive sectors with high value-added services sectors. Yet because application of the concept is somewhat new, relatively limited attention has been given to applying an energy productivity perspective to such issues.

The KAPSARC energy productivity project aims to investigate the application of this approach to countries belonging to the Gulf Cooperation Council (GCC). The work includes analysis of the policy levers that would be needed to stimulate productivity gains higher than a business-as-usual scenario, and the indicators needed to track progress against energy productivity goals. To date, five overarching points have emerged.

Establishing clear distinctions between different energy-related concepts is important to better understand energy productivity. Proponents of energy productivity stress that it has different impacts at the micro and macro levels of an economy, and that its application will need to be tailored appropriately to energy exporting and importing economies.

Setting clear energy productivity targets is a core action in any context. With energy playing a dominant role in GCC economies, a strong case exists for governments in the region to apply an energy productivity approach to amplify existing energy efficiency and economic diversification goals.

Significant investment may be required to achieve energy productivity goals. Globally, it is estimated that capital investment in energy efficiency alone is around $400 billion per year. To attract investment opportunities in the broader aims of energy productivity, policymakers need to stimulate the transition with strong capital spending and take steps to align the financial sector with a high energy productivity framework.

Continued energy price reform will be necessary to support energy productivity goals. Low energy prices can encourage wasteful use and inefficiency. Provided safeguards are in place to protect the socially vulnerable, shifting to an energy productivity approach creates an opportunity to positively recast energy price reform as a policy tool to deliver national economic and social benefit. This may be a more politically powerful tool for taking energy price reform forward than the idea of reducing unfair or inefficient subsidies.

Energy productivity requires a comprehensive policy approach. Because it prompts simultaneous action on different levels of cross-cutting issues, an energy productivity approach necessarily involves coordination among diverse entities (at both micro and macro levels) and carries important transaction costs. Engaging the actors involved early in the process is one way to secure buy-in.

Overview: A new paradigm, founded on key movements

Defining energy productivity as distinct from sustainability, energy efficiency, or green growth is an important first step. Energy-related concepts have evolved over time, as shown in the economic literature, reflecting different periods and contexts. Energy conservation emerged as a result of the oil crisis of the 1970s. Energy efficiency followed, with attention on ways to reduce the amount of energy needed to use equipment (e.g., cars, planes, industrial machinery). The emphasis was then on the amount of energy used per piece of equipment per unit use of output obtained. Broadening the scope to the whole economy, the concept of energy intensity emerged, shifting the focus to how much energy is used per unit of output (gross domestic product [GDP]).

More recently, energy productivity emerged as a concept. It is essentially the inverse form of energy intensity, or energy consumption divided by GDP. In other words, energy productivity describes how much value (usually measured in GDP) can be produced using an amount of energy (usually measured using total primary energy consumption). It can also be thought of as a measure of how much economic value is created from a barrel of oil or British thermal unit (BTU) of gas. The concept reflects what activities energy is used for in the economy (degree of structural diversification) as well as how well energy is used in specific activities (energy efficiency).

With the emergence of the concept of energy productivity, valid questions have arisen as to whether it is similar to policy approaches based on sustainable development, energy efficiency as 'the first fuel', or green growth. Given the substantial political capital already invested to organize the international community around the existing concepts, it is valid to question whether energy productivity is a case of dressing up an old concept (energy efficiency) in a new coat.

Those proposing energy productivity, including KAPSARC, assert the distinction that it places its emphasis more neutrally on how energy can be used to drive economic growth and increase government revenues, while also lowering overall energy consumption, reducing carbon dioxide (CO_2) emissions and resulting in less environmental impact from energy use. Under energy productivity, the latter three aspects are seen as co-benefits that can be realized through the primary drivers of economic diversification and increased energy efficiency. It can also be argued that concepts evolve to meet current anxieties and policy imperatives, and the emergence of new concepts does not need to incite competition with existing ones. Energy productivity is gaining traction around the world because governments are seeking to boost growth and create jobs as first priorities, while remaining committed to reducing emissions and environmental impacts as co-benefits.

Energy productivity can thus be viewed as a coherent framework that can be applied at the economy level to direct a wide range of policy domains — financial, industrial, urban, transport, innovation, etc. — toward the overarching goal of increased growth, productivity and competitiveness.

National targets and policy setting for energy goals

A growing number of countries, including the United States and Australia, currently advocate improving energy productivity as a way to achieve energy and climate goals, and are building productivity targets into their energy and economic planning. The concept is also spreading

through initiatives such as EP100 (https://www.theclimategroup.org/project/ep100) — a program that engages large corporations to commit to doubling energy productivity by 2030.

The transition to this new approach can draw valuable lessons from past experience with large-scale energy planning initiatives. While focused more narrowly on energy efficiency, China's national energy conservation scheme is a good example of how policy can be used to lower energy intensity. In 2011, a Top 10,000 program was introduced, which set efficiency targets for the country's highest energy-consuming enterprises. The approach included four steps:

1. **Set targets:** in this case, the targets were negotiated between the government and individual enterprises, which helped ensure buy-in at the company level.

2. **Develop a roadmap:** this document set out clear steps to achieve targets, providing comprehensive system design supported by guidelines, monitoring, appraisal and audits.

3. **Set an implementation and action plan:** this plan, established as a contract signed by the government and Chinese enterprises, was deemed vital to the success of the program.

4. **Establish support mechanisms:** government policies provided concrete assistance, for example by offering financial support to enterprises to overcome technological challenges and invest in efficient equipment and machinery.

A similar practice could be adopted to roll out energy productivity programs with specific goals.

What does an energy productivity approach mean in GCC countries?

Energy and the economy are strongly linked in GCC countries. As revenues from oil exports decline and domestic energy consumption increases, there is a strong case for governments to set energy productivity as an overarching framework that integrates and amplifies existing energy efficiency and economic diversification goals. The policy framework that KAPSARC has used to analyze the potential for improved energy productivity in GCC countries can provide a starting point for setting economy-wide energy productivity targets.

With specific energy productivity targets in mind, the framework first establishes a foundation for institutional reform across four areas: utilities, energy efficiency governance, energy efficiency finance, and industrial and infrastructure development policies. At this level, a variety of cross-sectoral institutional reforms can jointly contribute to improving energy productivity. For example, policies for utilities to upgrade technological standards in power generation and distribution are linked to energy efficiency governance and to financial incentives to encourage private investment in energy efficiency (which additionally helps to diversify the economy into different services). This thread can carry over into policies for industrial and infrastructure development, such as implementation plans for buildings retrofits (which can create opportunities for the small and medium enterprise [SME] sector). Within this foundation, setting targets at the micro level, such as for energy-intensive sectors to reduce CO_2 emissions, can spur economic growth and diversity (Figure 1).

To improve energy productivity at the major end-uses — buildings, transport and industry — a

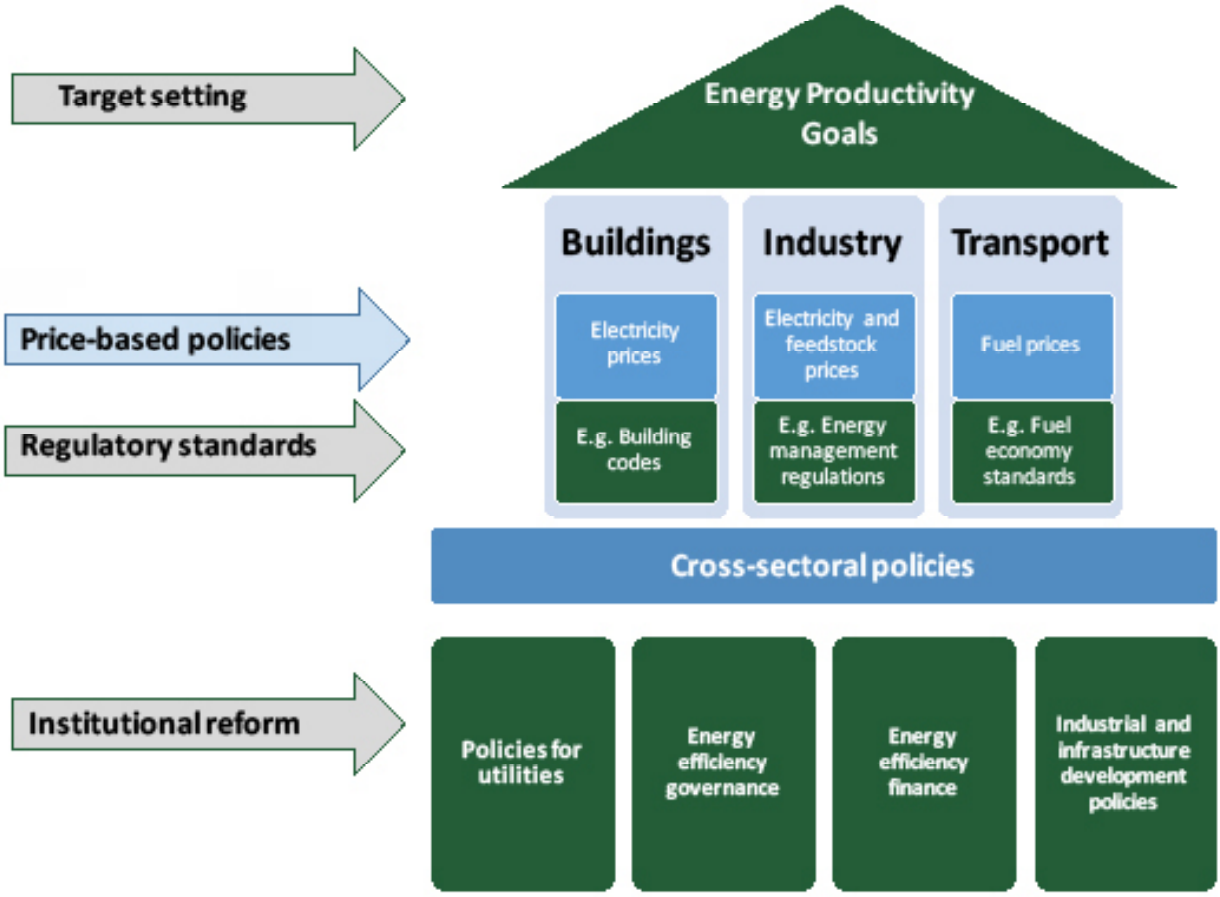

Figure 1. Options for energy productivity: price reform and beyond.

Sources: KAPSARC based on IEA (2014) Energy Efficiency Policy Recommendations for the Arab South Mediterranean Region and UNECE (2015) Best Policy Practices for Promoting Energy Efficiency.

combination of policies, institutional reforms and regulatory standards can reduce energy consumption and free for export volumes of oil that are currently consumed domestically for electricity generation. Mandatory building codes for insulation and appliances are one such example. In parallel, price reforms can encourage more energy efficient behavior, but may be more difficult to implement.

Saudi Arabia is, in one regard, well placed to adopt an energy productivity approach as plans to boost economic diversification are outlined in the Vision 2030 plan and efforts to improve energy efficiency are well underway.

Since its establishment in 2010, the Saudi Energy Efficiency Center (SEEC) has developed 84 initiatives focusing on these three end-use sectors, including providing support and financial mechanisms for stakeholders. The SEEC has also developed super energy service companies (super-ESCOs) and is currently testing a pilot project to retrofit government buildings, aiming to save up to 36 percent of annual electricity consumption, which delivers a five-year payback. In parallel, a human capital development program seeks to meet current and future market labor needs by working with universities and vocational or professional institutions to develop a skilled labor

force. The SEEC-led initiatives are already boosting the economy by creating local manufacturing opportunities, increasing employment and building up human resource capital, while also curbing wasteful energy consumption in the domestic market (thereby making more oil available for export).

Saudi Arabia's commitment to optimizing resource use within Vision 2030 is evident in efforts such as finding uses for the associated gas resulting from oil production (which was previously flared), reducing fuel subsidies in transport and electricity, and reducing austerity measures across the entire population to direct support toward the underprivileged. Saudi Arabia is not alone in pursuing economic diversification and growth in ways that ultimately contribute to energy productivity. Similar approaches and targets are found in the United Arab Emirates' (UAE) Vision 2021, and in plans for Kuwait and Bahrain (Vision 2030). (Figure 2)

Figure 2. Key Elements of the Saudi Energy Efficiency Program (SEEP).

Source: Saudi Energy Efficiency Program.

Private sector investment in energy productivity

Applying an energy productivity approach requires substantial investment in two main areas. At the economy-wide (structural) level, investment needs to be directed toward shifting the economy from energy-intensive industry to the services sector, i.e., economic diversification. Energy efficiency investments typically target the micro level, supporting activity in retrofits, refurbishments, technological changes to replace energy-intensive equipment with efficient alternatives, etc.

Achieving energy productivity targets on the macro level often requires a reorganization of capital investment. The trend to date in emerging economies and GCC countries has been to rely on public capital spending. More recently, industrialized economies have launched initiatives to attract private sector participation, although a lack of clarity still exists regarding investment mechanisms and financial support services available for private sector investments.

Opportunity for private investment in energy efficiency is more advanced and is, in fact, quite large. The World Bank estimates that investments of $400 billion per year are needed to develop energy efficiency markets globally, approximately 85 percent of which could be met by the private sector. Unlocking this potential remains a challenge, but not because of a lack of finance. Rather, mechanisms are needed to facilitate the better linking of projects and investors, as those seeking to undertake large-scale energy efficiency projects believe a lack of finance to be their major obstacle while investors perceive a shortage of suitable projects.

Initiatives across four areas could help to stimulate private sector investment in energy efficiency and productivity:

Institutional infrastructure to support energy investments: policy planning, regulations, codes and standards need to be developed at the institutional level to mandate energy efficiency targets. If the price of energy is rationalized at the utility level, and reflects cost at industrial and individual levels, the incentive for private sector investment increases (especially for GCC countries).

Information and communication: investors need to be aware of opportunities and need information on which to base their decisions. One major factor is a given country's readiness for investment. Two recent initiatives seek to address this aspect. The World Bank has released an initiative called Readiness for Investment in Sustainable Energy (RISE), which assesses laws, regulations, incentives, subsidies, sector planning and governance in 111 countries (including those in the GCC). In the United States, the American Council for an Energy-Efficient Economy (ACEEE) scorecard on energy efficiency describes the policy landscape for investment, reflecting investor criteria.

Standardization of contracts and technical capacities: in countries with limited public capital funding, an important technical capacity is that of standardizing templates and building manpower capacities to create a more attractive environment for private investment.

Capacity building in the financial sector: to attract large-scale investments, a strong financing and incentives framework is needed. Several industrialized economies have facilitated the establishment of large ESCOs.

> One successful example is the Municipality, Universities, Schools and Hospitals (MUSH) initiative in the United States, which standardized measures for retrofits of similar building types, thereby achieving greater savings from energy efficiency, reducing CO_2 emissions across these sectors and spurring job creation.

Given that GCC governments currently face a constrained fiscal environment while low energy prices for domestic consumers do not encourage energy efficiency, one policy option to stimulate energy productivity investment is a market-based 'nega-barrel' program. Under such a scheme, governments could provide financial incentives for organizations or households to invest in energy efficiency, and then commoditize the barrels of 'avoided consumption'. This would deliver economic value in three ways: increased income through exporting the saved unit of energy; reduced need for energy subsidy payments (where these are present); and reduced need for new electricity generation capacity investments (as GCC utilities are mainly publicly owned and operated).

A nega-barrel program on the scale of around $100 billion, implemented across the GCC over 10 years, could incentivize private sector investment, generate around 800,000 to 1.2 million new jobs and increase government revenue. Establishing a robust ESCO market would be key to capturing these benefits, which implies the need to develop implementation programs and build expertise in the areas of energy auditing, efficiency and management.

Energy price reforms in support of energy productivity

Energy prices that do not accurately reflect the cost of energy use tend to discourage implementation of energy efficiency measures at the system level and promote wasteful energy consumption behavior. Such pricing distortions at both macro and micro levels often curtail investment that could ultimately support energy productivity goals.

When governments control all resources in a resource-rich country, the case is often made that price reform can help to increase revenue, as it boosts economic output with less energy input. The increased revenue can be re-invested in the economy. In Saudi Arabia's Vision 2030, the government calls for development of a competitive energy sector through actions such as diversification of the energy mix and withdrawal of inefficient subsidies, both of which can support the third aim of attracting investment.

Setting energy productivity and energy efficiency targets at the micro level can set the stage to then initiate pricing reform that addresses inefficient practices that have been in place in GCC economies for a long time. Various policy and regulatory tools, such as performance standards, mandatory compliance codes, carbon taxes and fuel taxes, can be applied to gradually remove subsidies on electricity tariffs and transport fuel. In recent times, Saudi Arabia and the UAE have implemented such measures to move their economies toward becoming more energy efficient.

Additionally, a strong argument was made that recasting energy price reform as a means to increase energy productivity — rather than to reduce unfair or inefficient subsidies — could deliver economic benefits. This potential requires further investigation.

Moving forward

Energy productivity is viewed by its proponents as an effective framework for integrating economic,

energy and environmental policy. For instance, in an energy productivity framework, energy efficiency in the building and industrial sectors does not just lower customer consumption, it can reduce the need for new investment in electricity generation capacity. This is likely to be more economically efficient than simply investing in the latest, most efficient combined cycle gas turbine (CCGT) cogeneration power plants. The value generated can, in turn, be used for other purposes.

By its nature, energy productivity stimulates a whole-of-government approach that provides policymakers with a more comprehensive way to tackle simultaneously (rather than each in isolation) a range of cross-cutting issues involving energy and economic growth. Implementing such a comprehensive policy approach is obviously not without challenges. The different levels of energy productivity interventions necessarily involve coordination of different entities both at the micro and macro levels. This approach consequently carries important transaction costs. One way to meet this challenge is to better engage the actors involved.

To be effective, energy productivity strategies will need to be country-specific, with both macro- and micro-level targets tailored to account for national differences, economic implications and their effects, opportunities to improve competitiveness, and measures needed for climate mitigation.

By using an energy productivity framework, countries can increase the value they get from their energy resources. It can also become an important element of a much wider agenda focused on economic development, diversification and the environment.

Energy Relations Between Northeast Asia and the GCC

Moderator: Dr. Daniel Yergin,

Vice Chairman, IHS Markit

Countries in Northeast Asia (NEA) and the Gulf Cooperation Council (GCC) have been connected along the Silk Road, one of the world's oldest trade routes, for more than 2000 years. As the lead energy-producing region of the world, the GCC countries have a natural affinity with countries in the NEA, the world's biggest energy-consuming region. At present, nearly half (44%) of GCC exports flow to NEA — almost exclusively in the form of hydrocarbons.

China's Belt and Road Initiative (BRI), combined with growing international focus on actions and technology innovations needed to address climate change — including dramatic reduction of dependence on fossil fuels — could fundamentally alter the trade relationship between the two regions.

Since 2015, KAPSARC has collaborated with research organizations in the GCC and NEA to explore topics of joint interest, including trade and connectivity, domestic policies, energy security and the environment. The work led to a newly released book, Energy Relations and Policy Making in Asia, which focuses on the question of how NEA and GCC countries can establish more trust-based relationships. While many opportunities and challenges are identified, three emerge as critical in the early stages of establishing a mutually beneficial future.

> Strengthening energy relations between NEA and GCC can no longer be considered in isolation from global issues. Global political, economic and environmental issues will influence these bilateral and regional relations — which in turn will be influenced by the actions of other players. All of these factors must be evaluated simultaneously.

> Shifting the focus to opportunities for stronger trade relations, instead of obstacles that block progress, will require bold leadership and active participation by many players in both regions. Yet parties generally agree that some obstacles need to be addressed up front to unlock the opportunity.

> Changing views on climate change, associated with widespread acceptance of targets set out in the COP21 Paris Agreement, and the potential of new technologies, particularly renewable energy and rapid evolution of the transport sector, may prove to be driving forces in bringing the two regions together.

Overview: Reshaping a long history to better suit the future

Despite being separated by more than 12,000 km, the NEA and GCC regions trade nearly $500 billion worth of goods annually. This compares to GCC trade with Europe of $168 billion and with the United States of $134 billion.

In 2013, GCC countries exported $367 billion worth of goods to NEA, composed almost entirely of hydrocarbons and meeting a substantial proportion of NEA hydrocarbon demand (Figure 1). For context, the GDP per capita is indicated for each country in NEA and GCC in the figure using US dollars. This large volume of trade for a single commodity illustrates the nature of traditional relations between the two regions. Energy imports from the GCC are critical to helping the NEA build export-oriented economies while maintaining high levels of energy security, in turn making the NEA a critical hydrocarbon customer to the GCC.

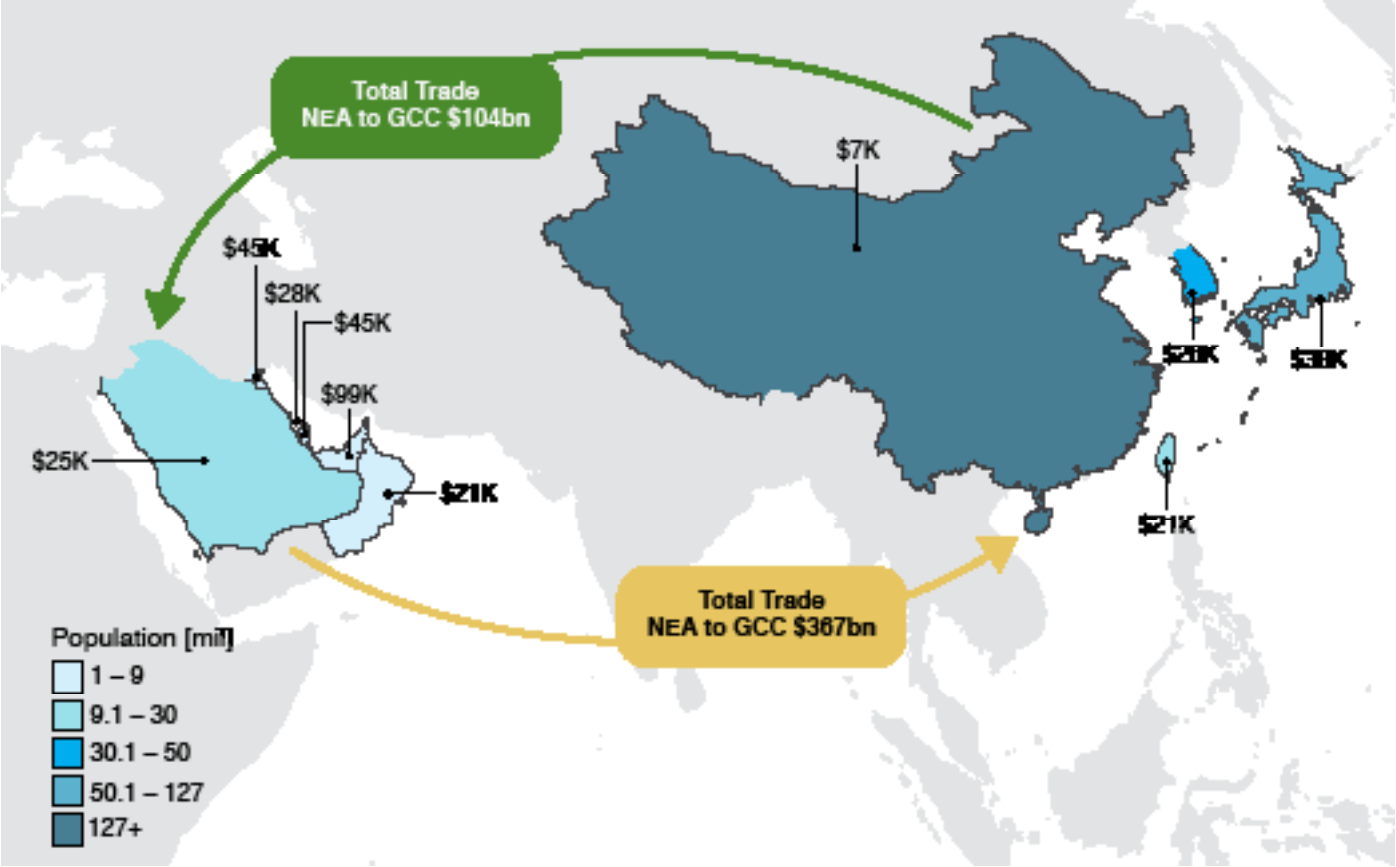

Figure 1. Total trade flows from NEA to GCC, and GCC to NEA, 2013.

Source: KAPSARC.

In the opposite direction, GCC imports from NEA totaled only $104 billion. GCC countries do not heavily rely on imports from NEA nor do they represent a large share of NEA's exports. In fact, while 44 percent of GCC exports flow to NEA, only 23 percent of GCC imports come from NEA. However, NEA exports to GCC comprise a more diverse portfolio of goods. Considering the GCC's young and fast-growing population, and relatively high per-capita income, the future may provide opportunities for trade growth.

The book mentioned above provided background research to support, in the context of the Energy Dialogue, discussion on energy security and trade in the region. With the BRI creating a framework to combine China's Silk Road Economic Belt and Maritime Silk Road Initiatives, substantial opportunity exists to broaden and deepen trade relationships across Central Asia to Europe and the Middle East. Yet all stakeholders recognize that obstacles exist and that the road to cooperation must be built not only in the physical sense through investment in infrastructure, but also metaphorically by reducing trade barriers and overcoming historical barriers that diminish trust.

China's Belt and Road Initiative in the era of COP 21

The BRI has been a key foundation for President Xi Jinping's foreign policy and a major strategic

objective over the past three years. The intent of the BRI is to expand development, trade and economic prosperity along the belt (which includes countries situated along the historic land route of the original Silk Road) and the road (which includes countries along a seaborne route for the Silk Road). Naturally, this includes both NEA and GCC.

The BRI has many lines of effort, with the overarching theme to create 'win-win' arrangements and mutual cooperation based on interdependence. A core aim is to stimulate a more holistic view on relations among countries along these two routes, thereby reducing risk in trade. In this regard, the BRI has a strong focus on market access, infrastructure investment and regional energy market integration. Additionally, its broadened view includes promoting diplomatic relations, focusing on sustainability concerns (including climate change and energy efficiency), enhancing technology's role in trade, and addressing social issues such as health and wellbeing.

Specific to the NEA-GCC relationship, the recent international focus on climate change and the COP21 Paris Agreement have added a layer of complexity (some would stress instead the opportunity) to a relationship once focused on energy trade. Both parties recognize that actions to mitigate climate change could impact trade, with the potential growth in electric and autonomous vehicles having a substantial impact on oil demand in NEA — and hence on imports from GCC countries. Thus, it is valid to investigate whether the two regions could come together to support the new focus on Nationally Determined Contributions (NDCs) to climate change mitigation, including the role of their hydrocarbon trade. One view is that leaders from the two regions could focus on enhancing trade beyond hydrocarbons and on promoting opportunities for renewable energy. In fact, the ability to match GCC resources and NEA technology to increase deployment of renewable energy could be a new lane in the Silk Road.

Trade and energy security

One area of mutual interest — that also has regional and international implications — is the current energy security paradigm in NEA countries, which places strong emphasis on political stability and keeping energy trade routes secure. Being on opposite sides of the supply and demand chain, energy security means different things to the two regions. NEA countries are focused on the potential cost of an interruption in supply, and have actively pursued supply diversification to enhance their energy security. This raises concerns for GCC countries: as energy consumers seek to meet their needs through multiple sources, suppliers become more concerned about security of demand.

One recent initiative sees Japan and South Korea establishing joint programs with GCC countries to stockpile crude oil in Asia, allowing more rapid response to disruptions in oil supply.

Transportation technology

At present, transport accounts for more than 75 percent of global oil consumption, but the associated climate change impacts are a key target for action. Changes in transportation technology, including ambitious plans to deploy electric vehicles (EVs) and autonomously driven vehicles (AVs) in the NEA, are thus also recognized as potentially affecting the long-term BRI objectives and NEA-GCC trade relations.

All stakeholders agree on the need for more research to assess how growing penetration of EVs and AVs in the NEA could affect oil demand

from the GCC. Wide adoption of AVs, even if they are not EVs and do not stimulate fuel switching, could reduce transportation energy demand by as much as 40 percent. KAPSARC is well positioned to lead joint investigation of the potential path for consumer adoption of EVs and AVs, and of how such a transition might impact the balance of trade between the two regions.

Investment with mutual benefit

A more diversified GCC trade relationship with NEA, i.e., moving beyond a hydrocarbon-dominant focus, would more closely align with the goals of COP21. Several joint investment opportunities are viewed as concrete, near-term options to expand the scope of trade relations, including in upstream oil and gas development, downstream oil refining and petrochemical production, power projects (including renewable energy), and joint hydrocarbon stockpiling. Current joint ventures by GCC oil companies based in the NEA region, and including local partners, provide benefits to both sides, including contract certainty, technology transfer and reduced barriers to entry in NEA markets.

As GCC countries seek to diversify their economies beyond hydrocarbons, substantial opportunities may include developing advanced manufacturing in the GCC, and promoting country-specific trade and growth sectors such as shipping, tourism, healthcare and financial services. These areas may open opportunities for foreign investment by China and other NEA countries (within the BRI framework or otherwise). Both capital and knowledge resources could be starting points for collaboration to achieve successful industrial development.

Overcoming barriers to greater cooperation

Finally, an overarching challenge is the need to overcome the restrictive trade, import and investment environment in the GCC, which has been a barrier to balancing trade from NEA. Current ownership and labor laws, coupled with heavy bureaucracy, are formidable obstacles to NEA trade with GCC counterparts. Such restrictions are unlikely to see quick reform, but careful evaluation of the legal and policy frameworks that cause the trade obstacles can help to identify what reforms would best serve the mutual interests of both NEA and GCC.

Additional effort will be required to build understanding between the two regions, which have diverse cultures, traditions, languages, histories, and strategic aims for social and economic development. In particular, greater understanding in NEA of the GCC countries' markets and trade goals could facilitate a deeper trade relationship.

Moving forward

A Chinese proverb says "If you want to be rich, build the road first." This aptly captures the aim of the BRI, which sees the road as having multiple lanes, all of which must be kept running smoothly to meet its objectives. With BRI and COP21 developing in parallel, opportunities exist to enhance trade between NEA and GCC countries. Both regions can benefit from collective effort, and particularly from strategies that ensure trade flows in both directions along the road so that opportunities along the route can be optimized.

Utilities of the Future: Finding a Sustainable Business Model

Moderator: David Hobbs,

Head of Research, KAPSARC

The electricity sector is set for a major disruption driven by technological advances, mainly in distributed energy resources (DERs) and their increasing market penetration, as well as by economic and political pressures, such as calls to decarbonize the industry. So far, there is neither consensus on how utilities can adapt their business models to deal with these changes, nor is there a clear regulatory framework to help utilities navigate the complexity of the emerging market.

A range of issues affecting the electric power sector warrants investigation: drawing from the experiences of countries in different parts of the world, it is possible to examine key challenges faced by utilities as they evolve and adapt their traditional business model. Analysis of four countries, at different levels of economic development and market liberalization, leads to six key points.

> The three key drivers for the new power sector paradigm include technological advancements, regulatory frameworks and business models.

> New players are entering different parts of the distribution market, including a new category of consumers that produce all or part of their electricity usage ('prosumers').

> Digitization and big data analytics, together with smart grids and smart meters, can enable utilities to achieve renewable and decarbonization goals.

> Utilities' response to the challenges so far has been to try to embrace smart technologies and diversify into renewable generation. Key threats to utilities as they evolve are cybersecurity and uncertainty about the future source of their profits (i.e., which value-added services they will provide).

> New regulatory rules will be needed to guide the transitions the electricity sector is undergoing and to ensure utilities still play a key role in a fundamentally different global energy system. But policies need to be tailored to the specificities of each country regarding the level of economic development and market maturity.

> Of the three key drivers for change, finding a viable business model is perhaps the most pressing challenge for utilities.

Overview: Rapid change in every possible area

A rather simple schematic (Figure 1) quickly demonstrates how almost everything about the electricity sector is changing in parallel. The underlying constant is that customers, whether industrial or residential, place high value on a secure, reliable and affordable supply of power — and increasingly show preferences for clean power sources. Traditional electricity markets were designed to run at the national level, usually with the national or federal government regulating and enforcing wholesale and national commerce and transmission. In the United States, for example, the Federal Power Act of 1935 established a 'bright line' between federal and state regulation of the power sector, assigning some regulatory functions to the federal government and delegating others to the states.

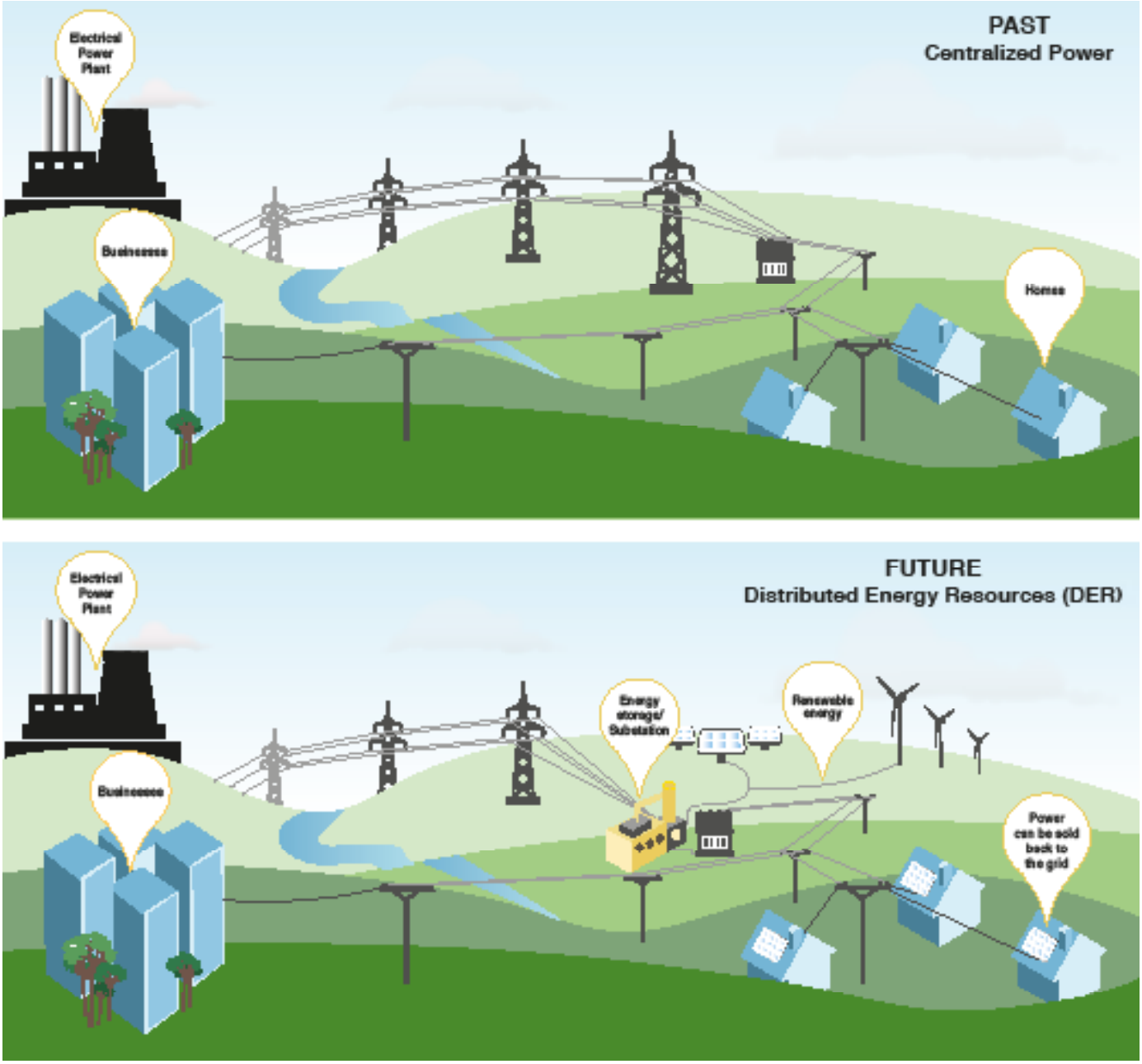

Figure 1. Transition of energy systems from centralized to distributed resources.

Source: KAPSARC.

Traditionally, the supply of electricity has been a natural monopoly characterized by vertically integrated companies that provide an end-to-end service, from generation to delivery to the end consumers. Since the mid-1990s, efforts have been made to liberalize the electricity sector to create more competitive markets. In the United States and Western Europe to some extent, the generation market has been largely liberalized while deregulation in the utility distribution sector is being pursued with varying degrees of maturity. Utilities in emerging economies are still largely vertically

integrated. Some operate under a 'rate of return' regulation in which regulators approve a reasonable return margin; others operate in heavily subsidized tariffs and a non-transparent cross-subsidy system.

The emergence of new technologies in the electricity sector occurs in a context of transition in generation mix, ageing infrastructure, low load growth and environmental concerns. The adoption of new technologies (including smart grids and smart meters), as well as the move towards digitalization, brings new opportunities but also exacerbates old problems and delivers new challenges. Growth of local DERs creates overlap (and potential conflict) among traditional federal and state jurisdictions, while digitization results in new cyber security issues.

In light of the disruptions already occurring across every part of the electricity value chain, finance models based primarily on calculating how to recover (over many years) fixed costs by charging customers for the units of power one predicts they will consume, seem outdated. To remain viable in the future, utilities need to evolve and adapt both how they operate and the way they do business. Depending on the level of development, the utilities of the future could be the traditional utility plus a smart grid, or a total decomposition and repackaging of services and prices that closely resemble customer preferences.

New players entering the energy market

As shown above, a comprehensive picture of the traditional electricity sector value chain would include fuel markets, large-scale generation, trading, transmission, distribution and retail. New players (i.e., new competitors) are engaging at every link in the chain, expanding it and making it more granular or fragmented. Companies like Panasonic and Volkswagen are entering the storage market. Others such as IBM, Cisco and Siemens are developing trading platforms and tools for grid optimization and utility systems integration. Additionally, Google and some mobile operators (such as T-Mobile) are examples of companies targeting the retail end of the value chain by developing online tools for utilities and home automation systems to help deliver electricity to customers more efficiently. Google has also entered the renewable generation market, investing more than $1 billion in solar and wind projects around the world.

As a result, the traditional utilities are facing multiple attacks on every part of their business, from a variety of players and industries. The objective of the utilities of the future would be to find new products beyond electricity supply. Utilities would do well to concentrate on delivering value to customers.

A new layer is emerging also at the end of the value chain, often referred to as the transition from electricity consumers to the 'prosumer' segment, reflecting new abilities to generate power or self-manage consumption. At the industrial level, this part of the new value chain may include after-final-consumption activities such as demand response, energy performance contracting and building efficiency. For residential customers, it typically includes all activities related to home-based solar photovoltaics (PV) and smart home management.

Different technologies

Similarly, technology innovations are occurring across the entire power sector value chain, including advances in DERs and storage, smart grids (information and communications technology [ICT]-enabled management of grids), and home energy management systems (enabled by smart meters and other ICT tools).

Smart grids and smart meters are changing how electricity is delivered and consumed. In the short term, smart grid technologies enable more efficient and reliable operations, including rapid recovery when an outage occurs, which deliver cost reductions to system operators. Smart meters also allow greater customer engagement through demand management and more granular time-of-use tariffs.

In the long term, smart grid and smart metering technologies have the potential to make a vast amount of data available to utilities, consumers and other market players, enabling them to manage and optimize energy usage on an unprecedented scale. The evolution of smart grids would range from focusing at an operational level to distribution automation and home energy management. In parallel, digitization could make previously unfeasible market concepts a realistic option in the new electricity market and create new business opportunities. One example is peer-to-peer platforms, which are distributed computer architectures that do not require central control and coordination, and allow users (such as prosumers) to deal directly with each other. This concept has emerged also in finance, with peer-to-peer lending platforms.

Storage technologies will play a key role in the evolution of the transmission and distribution segments in the value chain, both allowing the integration of DERs into the grid and helping prosumers manage locally their supply and demand. Storage is likely to play a significant role in micro-grids (e.g., community solar PV projects) and in the integration of electric vehicles (EVs) into the grid.

As utilities incorporate more smart devices into their operational environment on a continuous basis, the need to deal with the massive amount of data generated by such instruments arises. Emerging digital transformation technologies such as social media, mobility, 'big data' and analytics, and cloud computing can be leveraged in this regard for data acquisition and management.

The emergence of secure, decentralized electronic payment systems, as with blockchain technologies, combined with smart meters, will enable the implementation of peer-to-peer platforms for managing community solar enterprises, for example. A question remains whether these systems can be scaled to wide-area networks of interconnecting micro- and mini-grids.

These technology innovations are influencing the future of utility regulatory frameworks and business models. Despite their emerging benefits, these technologies are immature; this creates resistance to their adoption, and many lack the funds needed to scale up deployment.

Threats — some old, some new — to manage

Threats can be broadly categorized into two groups. The first includes potential damage to the infrastructure caused by natural causes (earthquakes, floods, geomagnetic disturbances, etc.). The last mile in the system is particularly vulnerable to these kinds of risks. The second group includes hacker activity and coordinated cyber-attacks, the risk of which is significantly increased by digitization and networked smart meters.

The issue of cyber security is increasingly critical, given that the electricity system is a key component of any country's national security. Electricity is essential to maintain economic growth, to support

emergency response and to connect networks such as telecommunications, energy, financial services, water and transportation. Protecting the physical infrastructure has always been vital for continuity of government, economic prosperity, quality of life and even defense. With smart technologies, cyber security becomes critical.

New vulnerabilities in the grid, particularly in the form of cyber threats, are likely to be intractable as their frequency is low, but their potential impact could be very high. At present, these characteristics are not well captured by standard risk management frameworks due to a lack of data. This makes such threats difficult to forecast and to prevent. This area of research is currently underrepresented and warrants higher priority.

Utilities' response

Traditional utilities have responded to changes in the technological landscape by adopting a more granular business strategy that follows two main avenues:
1) applying a 'Utility 2.0' approach, in which information, data and ICT, decentralized services, and smart technologies take center stage; and
2) expanding their traditional operations — large fossil fuel and utility-scale renewables — in emerging markets.

The particular innovation strategy followed by a utility would determine how it can respond and adapt to the changing environment. In Western Europe, two main trends have emerged. Utilities such as RWE and EDF are investing heavily in research and development (R&D) in an attempt to develop proprietary technology protected by patents. By contrast, utilities such as Iberdrola and EDP are following a technology licensing strategy and partnering with third-party service providers to take advantage of the new developments in smart grids and energy generation. It remains to be seen which innovation strategy is likely to be more effective in the long term.

The need for new rules and regulations

The new power sector paradigm is based on higher levels of locally produced electricity from many small-scale installations, which are often customer or third-party owned. This shifts distribution to center stage in the markets of the future and highlights the need for more integrated transmission and distribution planning. It also likely creates a market environment in which local considerations would take precedence over national policies, potentially creating a need to realign the roles of federal and local jurisdictions.

Local jurisdictions will play a large role in the development of the electricity system of the future. In particular, local authorities could have more say on end-user adjusting of retail demand to price signals, aggregation of individual retail transactions, microgrids, storage, load controls for demand responses and commercial practices.

The regulatory challenge would be to find a framework that helps re-define the role of electricity and new structures that guide the transition. Regulation would also need to guarantee that utilities' profits are obtained by delivering value and not by squeezing their market power.

Demand response at the residential level is becoming more important, as it can contribute to the organization of wholesale markets that seek to mitigate the risk of volatile renewables. Although use of demand response would seem to be an 'easy decision' for any electric power sector, it should be taken up with caution. As it is potentially unreliable, it cannot be safely used as capacity. One problem is that there are no penalties if consumers fail to curtail demand in the promised amounts. More importantly, demand can backfire after the call period is completed, leading to a shadow peak. If not prepared for it, the 'snap-back' can distort distribution-level grid operations.

Case studies

With the growing trend toward localization, it is valuable to explore the evolution of utilities in diverse countries and/or contexts.

Saudi Arabia plans to unbundle the current vertically integrated monopoly of the electricity industry and transform it into a competitive market. Smart grids and smart meters are key to enable three major objectives: 1) enable renewable targets and deployment on the network; 2) improve network reliability, quality of service and efficiency; and 3) provide additional services to customers and enable energy efficiency.

In the United States, integration of renewables is advancing rapidly; the growing presence of micro-grids is forcing utilities to redefine their business models to cope with two-way flow of electricity.

In Germany, utilities have had to adapt and change at the fastest rate in the western world, as policy reform quickly led to a large share of DERs in parallel with the decommissioning of nuclear power plants.

Malaysia opted to implement large-scale solar (LSS) and net energy metering (NEM) instruments to accelerate development of renewable technologies. The government has also encouraged distributed generation, especially in rural areas.

Moving forward

Technological disruptions and targets to decarbonize the electric power sector are driving utilities and regulators to re-think the revenue model of electricity provision. In the future, it appears that distributed and centralized generation will need to co-exist, albeit with different roles and different regulations.

Perhaps the most challenging policy question is how countries that have vertically integrated utilities can leapfrog — and avoid the substantial transition costs of unbundling the electricity value chain — to a decentralized, distributed electricity sector. For some countries, utilities of the future may mean a reconfiguration of service packages, pricing systems and the overall understanding of the industry, with higher consumer engagement. For others, the utility of the future make take the form of a traditional utility plus the use of end-use technologies such as smart meters and smart grids. Ultimately, utility business models will need to focus on how to deliver the various desired characteristics of electricity provision along the value chain.

Utilities should expect residential consumers to participate more in the process, both by engaging in a two-way communication with the use of new technologies, and by revealing more closely their real preferences for each of the attributes of electricity.

In industrialized countries, the transformation of utilities is well underway, with a more or less well functioning liberalized electricity generation market and the adoption of smart technologies along the whole value chain advancing apace. However, the pathways taken to liberalize the distribution end vary considerably among countries, depending on regulatory regimes. For developing countries, in particular those belonging to the Gulf Cooperation Council (GCC), in which governments are rolling out smart technologies and setting ambitious renewable targets, the focus should be on developing policies that will enable a quicker, smoother transition to new business models. Furthermore, the emergence of DER technologies could potentially make a bigger impact in the developing world, and to some extent in underdeveloped economies, where legacy systems and regulatory frameworks are not deeply rooted.

Transitions to Decarbonized Electricity: Finding the Right Balance

Moderator: David Hobbs,

Head of Research, KAPSARC

A transition toward a decarbonized electricity mix is clearly taking place, marked by a substantial increase in renewable energy at a global scale and particularly evident in some advanced economies. Since 2010, solar installed capacity increased by 4,000 percent and wind capacity by 600 percent.

This is the most impactful trend in energy markets. However, experience to date shows that this transition is a process full of unexpected difficulties, which should serve as a warning for policymakers in other countries that are now starting down the decarbonization pathway. At present, four overarching challenges emerge:

> Currently, technology seems to be running ahead of regulations and costs seem to be misaligned with prices. This poses problems for policymakers and incumbent market participants during the transition.

> Policymakers need to first set a clear vision of why their country is doing the transition and how far the country wants to go, then define how the aim can be carried out.

> Market distortions are evident in the transition to date, but it is not always clear whether it is high penetration of renewables that causes the distortion, or problems with existing policies and market design. The overall energy system must be considered to determine cause and effect.

> Developing parallel markets for capacity, generation, energy and greenhouse gas (GHG) emissions could better accommodate renewable energy (rather than markets operating only in the generation of electricity) and reduce some of the cost inefficiencies.

Finally, renewable technologies are gaining competitiveness very rapidly; in fact, in many ways the technologies are far ahead of renewable policies. This fast pace of technological change can partially explain the decarbonization that is happening in some countries, but, more important, it is also a signal that the world of energy is going to change dramatically in the next 30 years.

Recent estimates emphasize that to meet internationally agreed climate mitigation targets, decarbonization of the electricity sector needs to accelerate: at the current pace, it would take 150 years to reach the goal.

Overview: Is the world on right path toward decarbonization?

In 2015, renewable energy sources (RES) represented more than half of the electricity generating capacity added worldwide, surpassing cumulative installed capacity of coal-fired generation. However, the global installed capacity remains very far from what is needed to reach global climate targets. In 2015 in Germany, for example, RES accounted for 30 percent of electricity generation; but carbon dioxide (CO_2) emissions still rose 1 percent.

Massive deployment of renewable energy underpins the transition towards a decarbonized electricity mix, driven by technological changes, climate change concerns and policies that favor cleaner

energies. Managing this transition requires strategic planning on two levels: first, designing liberalized electricity markets to weather the impacts of the decarbonization process; and second, implementing the right policy instruments to achieve energy targets in a cost-efficient manner.

In some advanced countries with high penetration of renewable technologies, experience demonstrates that massive deployment of RES can strongly distort the functioning of electricity-only markets. In this context, and given the ambitious targets to decarbonize the electricity system, the question emerges as to whether the current design of liberalized markets is compatible with a high penetration of RES. Additionally, it can be the case that poor policies are disrupting liberalized markets, in which case the problem is not existing market design but ineffective policy.

Periods of transition are characterized by the need for innovation, often involving trial and error. Timely analysis of new policies and policy instruments now 'in fashion' — including objective critique of their pros and cons — can distill useful recommendations and steer future actions of countries starting out on the decarbonization process.

Renewable energy sources: Bigger — but not big enough

Policymakers need to clarify why they want to boost deployment of RES. In general, three potential objectives drive the move: the aim (voluntary or imposed by international agreements) to cut CO_2 emissions; ambition to show technological leadership; and targets to boost domestic manufacturing jobs. In some cases, there is also a pure economic incentive to reduce power generation system costs. Policy targets and policy tools (how to achieve certain objectives) are not independent of the answer to the question: why do we want renewable energy?

After a first round of attempts to stimulate RES deployment through policy action, it is necessary to recognize that RES policy tools are currently being revised all around the world. In hindsight, Europe, China and the United States consider their RES policy tools as 'too generous' or even as 'fat subsidies'.

But is this a fair analysis or is it the result of current energy market conditions and the reality of periods of transition, which are full of uncertainty on many levels? Technological change, volatile energy prices and the long life of power generation assets make it challenging to strike the right balance. Moreover, most everything remains in a state of flux. The current lowest-cost option may not be lowest cost in the long term. There is a need for forward-looking and flexible policies, rather than polices focused on current costs and benefits.

Electricity markets favor competition, not integration of renewable energy

Current liberalized electricity markets were designed to accommodate fossil fuel technologies. Their main mechanisms are based on two assumptions: the energy produced will have positive marginal costs (the cost of producing an additional kilowatt-hour of electricity) and the power can be dispatched on demand.

It is now clear that neither of these assumptions is applicable to renewable technologies. As a result, the transition toward decarbonization in liberalized markets is having some unexpected impacts, particularly in those markets with high penetration of RES. The massive deployment of RES is impacting electricity prices, which are lower (even becoming negative) and more volatile. This change in the behavior of prices has a negative impact on the profits and asset valuation of incumbent utilities,

and on the effectiveness of energy policies to promote RES. What is not yet clear is whether electricity markets are in a transitory imbalance or if a permanent problem with integrating renewables is taking hold, unless low-cost storage becomes available.

RES represents a technological change that carries a pricing challenge. In addition to their generation being intermittent and non-programmable, these technologies have very low marginal costs. These characteristics do not support an easy integration of RES in current liberalized markets and are behind the change in electricity price behavior.

However, inadequate market design is not the only possible explanation for lower and more volatile prices. In parallel, some countries have been decarbonizing by decommissioning fossil fuel power plants — a slow and a costly process. If the RES push is too aggressive, incumbent utilities do not have time to adjust generation capacity, which can create a transitory capacity excess that leads to lower and more volatile electricity prices.

Under current market design, a 100 percent RES penetration is not achievable. The price would be close to zero, which creates a paradoxical situation: renewable energy needs fossil fuel generators to have positive and sufficient electricity pricing. In addition, the drop in electricity prices generates a divergence between the total cost of the electricity system (including capital expenses) and its revenues from the market.

Crucial issues for integrating renewables into electricity markets

Five crucial issues have emerged for RES integration in the electricity market: priority of dispatching, intermittency of availability, grid security, quantity volatility and price volatility.

These five issues are analyzed in conjunction with five different policy instruments that have been used worldwide: bilateral power purchase agreements (PPAs), green certificate markets, feed-in premiums, feed-in tariffs and investment tax credits.

There is no 'best' policy tool. Different policy instruments have different pros and cons, in terms of flexibility, inefficiencies and their effects on profitability and on long-term future investment decisions. They also have different capacities to support producer and consumer risk sheltering, and to create incentives to achieve deployment of the best available technologies.

In any case, all policy tools are facing difficulties to fit renewable technology progress with decreasing costs. Technology seems to be running ahead of regulation and policy, and costs seem to be running ahead of electricity prices.

New policy trends to foster electricity decarbonization

RES, particularly solar and wind, is the main driver of this decarbonization, largely as a result of wide-spread policy support. However, despite falling costs, the rapid increase in RES deployment has raised economic concerns, leading to policy curtailment or reform.

Policymakers need to broaden their scope of action. Traditionally, they have focused on the supply side of the energy sector. More attention is now needed to address the reality that new actors have entered the market and opportunity exists to promote decarbonization through policy action targeting the demand side as well.

For example, increased system flexibility, through demand response and the greater use of storage, will be essential in a decarbonized power system.

In this context, a 'regulatorily acceptable' demand response has the potential to smooth the electricity transition towards decarbonization. Additionally, a governance reform of the electricity system is necessary to enable new actors to enter the market while also ensuring that the system transformation does not negatively affect the quality of service to customers. Finally, consumers need to be at the center of electricity policies, not only to encourage energy efficiency, but to allow them to become producers of power and play a greater role in grid management.

Moving forward

The challenge of how to stimulate a faster decarbonization transition in a cost-effective manner took center stage during the session, particularly as many 'early mover' countries are now rethinking their policies to support renewable energy. The low and volatile prices now seen are not only a problem of inconsistent policy objectives and fat subsidies. They also reflect that policy tools are poorly designed for the new reality, and now interfere with the normal functioning of traditional electricity markets. There is a feeling of 'too much expenditure' or 'too little return' that is likely to have a transitory negative impact on RES deployment in the coming years.

As it is no longer clear if current liberalized markets can accommodate a high share of RES technologies, one option considered is the possibility of creating new, parallel markets for capacity and CO_2 emissions. But how to integrate these markets is still an open question.

In debate around regulated markets, some would argue that public companies are better equipped to deal with a scenario of constantly declining prices. Indeed, only a state-owned monopoly would be able to incorporate intermittent zero marginal cost output by distributing the costs within its overall rate structure. Yet, regulation itself is no panacea. Highly regulated markets are experiencing many of the same RES-related problems as liberalized ones.

In parallel, a very relevant question has emerged: are RES dealing with problem of inadequate market design or are poor policies generating the difficulties to integrate RES into existing markets? In particular, some of the cost inefficiencies could be reduced with the creation of new markets: capacity and GHG emission markets. These markets, in conjunction with generation and energy markets, working together could accommodate better renewable energy.

Experience to date shows different outcomes of different policies, making it possible to consider the pros and cons, for example, of a carbon tax versus renewable subsidies. In the United Kingdom, a carbon tax enabled gas to displace coal, but had a smaller effect on renewables. In other European countries (such as Italy and Spain), rather generous renewable energy subsidies had a larger effect on renewables and were able to displace gas in favor of coal (especially in the evening and night hours). These experiences can be relevant for other countries, including Saudi Arabia and other GCC countries, that are now starting the transition towards a decarbonized energy mix. Opportunity now exists to avoid repeating the trial-and-error process that identified which approaches proved ineffective in other developed countries.

Future Path of Energy for Transport: Modes, Fuels and Technologies

Moderator: Prof. Daniel Sperling,

Founding Director, Institute of Transportation Studies, University of California, Davis

Energy use in transportation is undergoing rapid change with new energy efficient transport technologies, greater use of non-petroleum fuels and new travel demand paradigms such as shared mobility. In parallel, a rapidly growing share of new demand for transport is occurring in urban populations in developing economies.

How to meet future transportation energy demand is one of the most highly debated challenges facing decision–makers with concerns about resulting impacts on both the economy and the environment. Many questions arise when investigating how public policy might influence transportation energy efficiency and reduce associated environmental impacts, including how policy can shape the role of technology. The future path of energy for transport is inherently uncertain and solutions will need to reflect differing regional contexts. Yet, there is general agreement on five broad areas.

> Transportation energy demand will continue to grow significantly in the near and medium term due almost entirely to surging growth in developing economies. Fossil fuels will remain the main source for meeting transportation energy demand, although new alternatives are emerging that show potential to expand depending on regional needs and opportunities.

> Technologies will increasingly influence transport energy consumption through improved energy efficiency, but can only partially offset the expected rise in greenhouse gas (GHG) emissions.

> A key role of public policy planning is to enable more sustainable transport by meeting demand with more energy efficient technologies, new fuel choices and alternative mobility options that shape societal behaviors.

> Better understanding of the structure of cities and mobility patterns is needed to create tailored transport policies, especially for passenger transportation.

> Improvements in logistic practices for freight transportation will also influence energy demand.

Overview: Reducing transport impacts, even as demand grows

Transport demand is a major consumer of energy and a dominant source of GHG emissions; it currently accounts for around 25 percent of the world's total in both areas, and the share is set to increase. Indeed, transport's share in final energy consumption has risen over the last three decades, with petroleum-based products dominating the market. In 2016, such fuels provided 92 percent of transportation energy needs.

Rapid increases in demand for personal mobility and freight transport (which follows from increased production of and demand for goods and services) have been closely linked over the past two decades with strong economic growth and rising living standards, particularly in non-OECD countries such as China and India. Today, four of the world's five largest transportation energy consumers are emerging markets, notably China (2nd), Russia (3rd), Brazil (4th) and India (5th) as the gap closes on the United States. Nearly all growth in transportation

energy demand in the near and medium term will take place in developing and emerging economies, while consumption in industrialized economies will remain flat or decline.

The size of these nations plays a significant role in the rise of transport energy demand, not only domestically but globally. China, which is home to around 20 percent of the world's population, accounted for 5 percent of world transportation energy demand in 2000; just 15 years later, its share has more than doubled to almost 12 percent. There are now 46 cities in China where car ownership is more than 1 million and 16 cities where it is more than 2 million. The number of plug-in electric vehicles (PEVs) is growing in the country. More recently, a second wave of increased transportation energy demand started in India, also home to around 20 percent of the world's population. Other developing nations of Asia, Latin America and Africa, each also home to vast populations, are expected to see rising transportation sector energy consumption.

Projections on the future of transport energy demand

At present, per-capita transport energy consumption in emerging economies is far lower than in industrialized economies. The historic link between economic development, rising incomes and increased transportation energy use seems likely to continue, albeit at a moderated pace. The impact of continued economic growth in developing economies will shift the geography of demand for transportation energy, and thus for petroleum products, away from the previously dominant areas of North America and Europe. Transportation energy demand is expected to keep growing, increasing by nearly 50 percent by 2040, particularly in countries not belonging to the Organisation for Economic Co-operation and Development (OECD), where share surges from just under 50 percent to over 60 percent. Petroleum-based fuels will continue to provide the vast majority, just under 90 percent, of transportation demand.

Technology innovation and incremental advances can play a key role in curbing these trends. At present, light-duty vehicles are the largest energy-consuming transportation mode, accounting for around half of total demand. Bringing non-petroleum fuels to this market is critical or, indeed, introducing new replacement technologies that meet transport needs.

Many currently available fuel-efficient technologies (e.g., improving the efficiency of internal combustion engines) are already significantly reducing consumption of petroleum-based transport fuels. Various engine, aerodynamic, transmission and other vehicle technologies are delivering 4 percent annual improvements in the fuel efficiency of new vehicles entering the fleet. Their impact will grow as they become more widely deployed (and thus make up a larger share of the vehicle fleet), and further reductions can be expected with future improvements of technologies already in use and with additional technology innovation.

PEVs can also increase transport energy efficiency, reduce petroleum-based fuel consumption and, depending on the means used to generate the electricity, reduce overall GHG and pollutant emissions. Yet, the future role of PEVs is hotly debated: much uncertainty remains on their rate of uptake and hence their impact on global oil demand. Technological progress — including reductions in battery cost and charging time, and increased synergies with distributed home

electricity storage — could stimulate wider use. An even stronger synergy may arise for PEVs and automated, connected vehicles within the framework of new shared ownership models. This would allow multiple users to share the costs, while also increasing utilization, thus accelerating vehicle stock turnover by shortening the replacement time for passenger transport vehicles.

The adoption of transport technologies will differ among countries and regions, reflecting price sensitivity, cultural factors and policy frameworks. Technological progress alone, however, will not be sufficient to meet GHG emission reduction targets for the transport sector. Parallel efforts will be needed for effective demand management of both passenger and freight transport, including economic incentives that are technology-specific. This requires careful consideration of how policy measures and regulations can support more efficient transport growth.

Public policy planning in the driver's seat?

Development and implementation of policy measures that promote uptake of new technologies and fuel options, or that encourage changing conceptions of mobility, have the potential to influence transportation energy demand.

For example, the penetration of PEVs is currently driven by policy measures to stimulate demand by helping potential buyers manage the high upfront cost. Policy support has also had important impacts on innovations by promoting sales that, in turn, generate cost reductions through economies of scale. For example, battery costs have dropped by around 80 percent in the last few years, with the resulting lower purchase cost having a further positive effect on PEV market penetration rates.

Yet the slow uptake of PEVs even with current policy measures and regulations begs the question of whether sales will continue in the absence of such strong policy measures. Particularly in developing country markets, where affordability is key, the role of PEVs in the short to medium term is even more uncertain. In some countries, especially in Asia, two-wheeled electric vehicles, rather than light-duty passenger cars, could play a key role in the development of sustainable passenger transportation, especially where travel distances are short.

Regulations and policy measures that improve fuel efficiency and/or address the cost of different fuels used with corresponding migration to different transport technologies, will be important. Other options include policies for travel demand management such as road tolls, vehicle taxation by distance, vehicle exclusion days and increased subsidies for public transportation. On the fuel side, policy could encourage greater use of natural gas in maritime shipping and the uptake of bio-fuel in the aviation sector (use of which is expected to increase by 2050).

Most green transport policy measures aim to render unattractive the high carbon footprint of transport, often through cost structure, modal speeds, infrastructure level of service, logistics, awareness campaigns, etc. The overarching goal is to modify individual or firm transport choices towards more energy efficient options, ultimately reshaping the overall transport system structure.

Energy demand of mobility is, in general, a local concern; additional research to understand the local nature of passenger and freight mobility will be key to developing policy that supports full access to transport services in the most energy efficient and environmentally friendly way possible.

Changing the structure of cities to alter mobility patterns

Several broader societal factors affect demand for transport, including demographics, income, economics and land-use patterns. The range of mode options available in a given context also plays a major role. Often, these factors are specific to a city, country, or region. Increasingly, policymakers are introducing or implementing measures that are customized to address challenges at the local scale. Where traffic pollution is causing major health issues, cities are incentivizing the use of cleaner technologies (such as PEVs) and fuels (such as compressed natural gas [CNG]). Where congestion is the major issue, public policy may prioritize mass-transit solutions. In fast-growing cities, accessibility of transportation for the population is of greater importance.

In general, there is a wide consensus that designing urban structures through public planning encourages greater mode sharing and/or a shift to more energy efficient modes, including public transport, cycling and walking. In cities with effective policy and urban design, including easy access across transportation modes, the number of transit commuters, cyclists and pedestrians is increasing.

While public policy measures play an important role in redefining how transportation activities are organized and carried out in cities and regions, the optimal solution or system will be different for each country, city and even transport network. Some policy measures in transportation will likely imply trade-offs that may be similar in most applied cases, while influenced by territorial and cultural realities in other cases, with impacts on the results achieved. Integrating societal factors into policy planning, implementation and analysis will be important to meeting transport demand growth more optimally.

The influence of changes in logistic practices on energy demand

In the case of freight transportation, many inefficiencies are linked to current logistical practices. To propose effective policy measures, more investigation is needed to better understand existing logistics systems. Current transport forecasting models do account for the expectation that improved logistical management will move freight more efficiently.

New types of mobility services based on asset sharing could deliver substantial efficiency gains and reduced GHG emissions, particularly when coupled with better practices in route optimization. The potential is perhaps greatest in countries that are extensively building out transport systems, i.e., in densely populated regions of Asia. The opportunity to pursue this approach to mitigate and avoid pollution from road transportation is likely strongest in economies that have not yet developed extensive rail transportation systems. Where rail is already a major transport mode, the policy approach might focus more on developing intermodal and multi-modal transport to encourage shifting to more energy efficient modes.

Coupling new automotive technologies with greater connectivity could disrupt current business models for freight transportation. Connectivity will provide new mechanisms to better meet customer demand and provide faster freight delivery. Use of drones and autonomous ground vehicles could also lower costs, particularly for small package delivery in dense urban environments, which is expected to see the greatest growth in demand and thus the greatest innovation.

One area that seems a good fit for public action is the potential to improve efficiency among transport

firms by developing and deploying open-access public information systems that operate in real time to support inter-modal freight transport.

Moving forward

Considering the projected transport demand growth, rising urbanization and current understanding of environmental impacts of existing modes of transport and transport fuels, it is certain that meeting future demand cannot follow the historical model of scaling current practices for passenger and freight.

Technology developments will continue to improve transport efficiencies, thereby offsetting rising transport energy demand driven by economic growth, and will help to reduce emissions associated with fuel sources (which remain mostly petroleum-based in the near to medium term).

Yet recent trends show that best available technologies are slow to be taken up. Policy planning is, thus, certain to play a central role in matching greener technologies and mass-transit solutions to transportation demand. Developing and deploying integrated solutions that are appropriate to local and regional realities is key to sustainable transport. The expected changes in transport usage patterns and congestion will have substantial impacts on pollution; thus, encouraging the roll-out of technology options will require effective policies to be more targeted, flexible and adaptive. By allowing frequent updating of underlying input data and assumptions, systems modeling and data analytics are supporting this progression.

To design effective policy, policymakers will need to better understand the structure of cities and mobility patterns; thus, future transportation scenarios need to better reflect the variability of consumer choice. Once this knowledge base is built up, integrating improved, real-time information into transport systems will allow connected mobility consumers — whether freight or passenger — to choose the best modal combination to suit their transport needs. This implies also the need to study personal and freight mobility at the greatest possible level of disaggregation. The possibility to combine big data and microeconomic study of mobility may deliver solutions that are practical and feasible.

With freight transportation energy demand (especially by truck) having grown sharply in the last decade, to now account for nearly 40 percent, a strong research focus on technologies and policies that can temper future increase is vital to reaching global climate change targets. Yet, relatively little study has been done of the underlying relationship between the economy, people and the energy consumed in the movement of goods. Given the direct link between freight movement and economic development, policymakers will need to overcome past hesitance to take action, turning their attention to finding ways to reduce energy consumption without undue detrimental impacts on national economies.

The two emerging energy giants of China and India also warrant focused research, including how their transportation trends will influence the major determinants of energy demand at the global scale. While solutions that account for the unique social, geographic, or economic circumstances of each country or region are needed, policies and technologies developed and matured in relatively wealthier, industrialized economies may prove valuable to curb future demand growth in developing and emerging economies.

Energy and Climate Change: Toward More Practical Climate Change Policies

Moderator: Masakazu Toyoda,

Chairman and CEO, Institute of Energy Economics, Japan

The 2015 COP21 Paris Agreement represents an important step forward in global climate change agreements. It combines national goal-setting within a global framework to drive collective action, recognizing that each nation has unique socio-economic, resource and development conditions. However, the sum of the Nationally Determined Contributions (NDCs) and Intended Nationally Determined Contributions (INDCs) proposed to date fall well short of the agreed upon goal of limiting global temperature rise to 2°C. Thus, a key collective challenge facing policymakers is how to respond to this challenge in a timely and cost-effective manner.

A range of issues must be examined to determine whether the bottom-up approach will ultimately deliver a substantial and cost-effective global outcome. To date, investigation has led to five key points arising.

> The bottom-up approach embodied in the Paris Agreement NDCs/INDCs is a positive step, but it needs to be made more efficient and accountable by ensuring that the full lifecycle costs of mitigation do not exceed the social cost of carbon (SCC).

> To be politically viable, it will be necessary to find ways to instill widespread belief that climate control policies strike an optimal balance among mitigation, adaptation and damage. This will require a sustainable balance to be struck between decarbonization and economic development.

> Concerns were raised about excessive deployment subsidies resulting in inefficient and premature investment at the expense of investment in research and development (R&D), which may yield more timely and cost-effective technological solutions.

> Simplicity and transparency are virtues from a policy perspective. Policies ought to focus on economy-wide measures and addressing market failures — for example, pricing carbon and correcting the problem of insufficient R&D.

> Climate policies need to reflect countries' unique and different starting points, resource endowments and growth rates. Particular note was taken of the very clear differences in issues and implementation strategies adopted by developed and developing economies, including the potential to deploy economy-wide and sectoral approaches in different situations, particularly in China and India.

Overview: Forging an effective path forward

While the COP21 Paris Agreement is generally a welcomed milestone, in the years ahead a key challenge will be to ensure that the sum of NDCs ultimately delivers an effective global outcome. The sum of NDCs and INDCs proposed to date would reduce carbon emissions by only around 3.8 percent by 2030, resulting in continued emissions growth and a carbon trajectory that is inconsistent with meeting the current global goals.

A global goal is only likely to be met in a bottom-up framework, where it is spontaneously adopted by most countries and reflected in their nationally determined policy responses. Spontaneous

adoption of the global goal will need to be driven by a shared imperative that achieves a 'tipping point' of national responses. At present, we are nowhere near that point.

However, it is important to avoid top-down approaches that attempt to unduly accelerate change. To date, such policies have served to discourage invention and innovation, while encouraging inefficient and expensive rent-seeking behavior. Given their poor track record to date — with many expensive and distortionary unintended consequences — policymakers need to be more realistic about what top-down policies can achieve. Previous COP processes have proven incapable of delivering substantial, practical and enforceable global agreements. This is unlikely to change.

The Paris Agreement marked a turning point: its rejection of top-down approaches in favor of a bottom-up framework breathed new life into the process. Governments accepted a very sensible process that reflects the reality of executive power resting with nation states, not international organizations.

The challenge going forward will be to ensure that the process delivers effective outcomes. A key component will be to make the five-year review process effective, in terms of assessing progress, encouraging performance and establishing practical intermediate goals. The process needs to keep nations honest, which requires the adoption of goals that appropriately balance the full lifecycle costs of mitigation actions against the social cost of carbon (SCC), which represents the quantified, monetized discounted value of future damage. This might be best achieved if one or more key nations were to demonstrate the leadership needed to drive effective accountability. An underlying challenge is that great uncertainty remains around how to calculate the social cost of carbon and that any calculation should also include potential social benefits (e.g., agriculture, forestry, land use).

Importantly, political reality dictates that mitigation costs must not consistently exceed the real or perceived social cost of carbon. At the moment, they do. In such circumstances, it is logical for governments and populations to prefer to live with the consequences of climate change: the costs of mitigation are perceived to be higher than the costs of living with the damage. As a result, there is no broad public support for generally expensive climate change policies — nor will there be until we solve this problem.

Global approaches need to balance mitigation, adaptation and damage

Many people perceive that, to date, action has been too narrowly focused on mitigation. Analysis shows that the current heavy reliance on mitigation is more expensive than a more balanced (optimal) path that incorporates mitigation, adaptation and damage (i.e., the likely impact of unmitigated climate change).

An optimal path scenario that incorporates a balance of mitigation, adaptation and damage, as well as potential technology cost reductions, could achieve zero emissions by 2150 — i.e., 75 years later compared with a scenario targeting a 50 percent carbon dioxide (CO_2) emission reduction by 2050 (consistent with a typical standard analysis) that achieves zero emissions by 2075. The analysis assumes the cost of advanced technologies falls at a compound rate of around 1.5 percent per annum. It results in a maximum atmospheric CO_2 concentration of around 520 parts per million (ppm) shortly after 2100, compared with maximum concentrations of 450 ppm around 2060 and around 400 ppm shortly after 2100 under the 50 percent reduction by 2050 scenario.

The optimal path scenario is also much less costly, showing a maximum annual cost of between 2.5 and 3 percent of global gross domestic product (GDP) around 2140 compared to a maximum annual cost of over 5 percent of GDP around 2075 under the 50 percent reduction by 2050 scenario. The uncertainties associated with climate science, especially in relation to climate sensitivity to CO_2 concentrations, have been noted and will have a significant bearing on the ultimate results. Given these uncertainties, it is important to take a longer-term perspective.

These insights suggest the need for a more balanced and practical policy approach. Aiming for a 50 percent reduction in global carbon emissions by 2050 may not be feasible or cost-effective. Policies might aim to minimize the total long-term cost of mitigation, adaptation and damage rather than focusing exclusively on mitigation over a shorter time horizon. New technologies will be needed to decrease the cost of reducing carbon emissions, and technological deployment will need to be supported with appropriate financial schemes and effective international collaboration. It is particularly important to ensure that technologies can be shared with developing nations in a timely and cost-effective manner.

Policy responses to climate change and decarbonization will be constrained by several factors that are outside the control of governments:

> Energy transitions occur over multi-generational time frames. What governments are currently aiming to achieve has never previously been done. New renewables raise the challenge of cost-effectively obtaining high energy density fuel from low energy density sources, an ambition that seeks to turn the industrial revolution on its head. Resolving these challenges will be difficult.

> Under capitalism, the natural trajectory of energy intensity reduction has changed little with each successive industrialization, showing a ratio of improvement of around 1 percent per annum. Great uncertainty remains regarding what might happen as governments try to force a more rapid rate of improving (i.e., decreasing) energy intensity.

> The rise and fall of global public interest in, and support for, climate action over the last decade or so illustrates an elementary rule of politics in democracies; unless there is evidence of strong support, public policies are not developed or implemented.

Subsidies would be better spent on R&D than deployment

Strong evidence suggests that governments are overinvesting in deployment subsidies and underinvesting in research and development (R&D) to encourage invention and innovation in less carbon-intensive energy technologies.

The economic literature indicates that the social returns from early-stage R&D are much higher than current levels of investment imply. Conversely, deployment subsidies are generally an expensive way to try to meet decarbonization goals. However, it is difficult to estimate the cost and extent of invention and innovation market failure.

The market failure case for deployment subsidies is very weak by comparison. Some 'learning-by-doing' spillovers may be associated with solar photovoltaic (PV) deployment, but it is very weak. For example, if one installer's actions lower the learning-by-doing costs for all other installers, but the innovator has no capacity to capture the economic benefits associated with that wider learning (i.e., there are innovation spillover benefits that the individual is

unable to appropriate), then it is arguable that a market failure exists. Some evidence suggests that this may be the case, but also indicates that the cost of this kind of market failure is far lower than implied by the typical level of feed-in tariffs, which suggests that such subsidies are currently too generous.

In response to questions about the most effective ways to stimulate invention and innovation, some suggest that governments need to pull back from the great sense of urgency and the belief that, if they push hard enough, they can use public resources to stimulate efficient and innovative private responses. Also, the 'valley of death' problem is aggravated by aggressive deployment of subsidy regimes, which produce premature deployment of immature technologies that then 'crowd out' efforts (in terms of resources and people) and money that could be more effectively applied to R&D. Other difficulties are associated with efficiently allocating R&D funding.

Eliminating deployment subsidies may well need to be made a priority, as they encourage misdirection of capital and are therefore compatible with an effective R&D policy. Investors can make very adequate returns from existing renewable technologies; however, they are not going to put their capital at risk in pursuing invention (very risky), or possibly even innovation. An alternative position is that deployment subsidies are incompatible with effective R&D policies. However, the combination is likely to prove much more expensive than an effectively targeted policy weighted towards R&D.

Some public good dimensions need to be taken into account, as do potential unintended consequences. For instance, problems arising from the subsidized deployment of certain technologies, such as the costs and operational challenges associated with market and grid integration of renewables, may not be properly addressed. Renewable integration costs tend to be socialized across all consumers or users. At present, the United Kingdom is experiencing significant system integration problems relating to wind and solar. But these problems are 'nobody's' problem; they are socialized and, as a result, have not attracted the attention of the various industries involved. The U.K. government may be considering applying the system costs caused by wind to wind owners and operators. Important lessons could be drawn from how such a change affects their approach and behavior on the system; it might be positive.

Some experts perceive that European governments are deploying renewable subsidies to achieve arbitrary targets and timetables, rather than to spur cost reductions, leading to very poor policies and implementation strategies. A good indication of the undesirable consequences of this approach is that investors are not focused on the technology they are deploying; rather, they are taking action simply to obtain a subsidy for a short period. Once they have obtained the subsidy, they typically sell the asset or, if they retain ownership, they will under-maintain it, knowing that the value is in the consent and the grid connection. This kind of rent-seeking behavior, which may be much more widespread than most suspect, was common where governments eager to meet a political timetable employed generous deployment subsidies.

Many politicians focus on renewables in an extremely simple-minded way; they look at the generating machine and think about the television opportunities. They simply have never thought about the system costs, let alone the integration challenges. Policy suffers accordingly — and the cost-reduction rationale for renewable energy subsidies is lost.

Interactions among different policy instruments can also have substantial unintended negative consequences. Additionally, the political environment may not permit effective evaluation of these issues. German experience with the interaction of feed-in tariffs and the E.U. level emissions trading scheme are cases in point. Reaction to political pressure is not a substitute for due diligence in policymaking. Particularly with carbon emission policies, careful consideration is indispensable yet very seldom done because of the strong element of emotion in the debate.

Similarly, nationally or regionally applied carbon policies can have unintended consequences for the operation of international energy markets, with the potential to undermine overall global environmental outcomes. For example, a reduction in relatively 'clean' coal consumption in industrialized countries can depress global coal prices, encouraging greater consumption of coal in developing countries where less efficient uses lead to more CO_2 being released. From a global perspective, the outcome may be worse. These wider trade-offs also ought to be considered in the context of developing decarbonization policies.

Key principles for developing effective climate policies

Several key principles ought to be applied to develop an economically 'ideal' approach to climate change policy. A lowest-cost policy approach to meet a climate objective, for example, should address market failures directly and adopt economy-wide measures. Above all, simplicity and transparency are virtues for the ideal policy approach.

The climate change externality would be best addressed by some form of carbon price or tax. Innovation-related market failures would be most effectively addressed through carefully targeted investment and/or subsidy programs focusing on R&D. As different innovation market failures for new technologies sometimes interact, this could provide motivation for additional public investment in the early stage of developing climate-friendly technologies.

Economy-wide measures would allow each sector to reduce emissions until the marginal cost of abatement is equalized. An efficient policy would also equalize the marginal adaptation costs and/or costs associated with climate-related damages — i.e., the social cost of carbon (the SCC). A climate policy based on an economy-wide carbon price set to the SCC and updated as new science develops and new SCC numbers are generated would provide an economically efficient outcome.

SCC estimates developed by the U.S. Interagency Working Group on Social Cost of Carbon are currently used by the U.S. and several other governments to inform the development of their climate change policies. These estimates suggest an average SCC of around $42 per ton of CO_2 (/tCO_2) (in 2020, assuming a 3 percent discount rate). However, SCC estimates are subject to considerable uncertainty. For instance, the 95th percentile result showed an SCC of around $129/$tCO_2$ (in 2020, assuming a 3 percent discount rate).

Effective climate policies reflect national circumstances

A variety of country-specific approaches to climate change policy will be needed. Several that are beginning to emerge better reflect national and regional socio-economic circumstances, resource endowments and trading opportunities.

Analysis of potential policy options for Saudi Arabia focuses on opportunities for industrial fuel price reforms, which have the potential to yield substantial economic and environmental benefits. The proposed reforms appropriately reflect Saudi Arabia's starting point as a major energy exporter with highly regulated domestic fuel prices.

By contrast, analysis of policy options for Japan focuses on achieving key goals of energy safety and security, economic growth, and environmental outcomes, reflecting Japan's status as a major industrialized country with high energy import dependency.

Federal climate policy in the United States incorporates a mix of initiatives including standards for vehicle efficiency, energy efficiency, methane and light-/heavy-duty vehicles, as well as land-use change provisions. Technological development and innovation are critical to achieving longer-term policy objectives.

In China, domestic economic restructuring as well as domestic and global economic growth figure prominently in determining the nature and scope of climate policy decisions. Low-carbon technologies, and more transparent and competitive markets, are expected to have a growing role in achieving policy outcomes.

The case studies illustrate the value of tailoring policy responses to reflect national circumstances. In general, industrialized countries are growing at a slow rate while emerging economies are showing rapid growth. Thus, even when improving energy intensity, emerging economies may not be able to reduce emissions in absolute terms. Even under an advanced technology scenario, developing countries with strong economic growth are unlikely to show a reduction in carbon emissions (with the possible exception of China). Clearly, different approaches are needed in industrialized, emerging and developing countries.

In the Japanese case, the energy mix is constrained for political reasons. This has led to the exploration of a range of alternatives to help achieve a balanced energy portfolio. Sectorally focused approaches, as in the EU 20-20-20 policy, are an alternative option. The United States does not have an explicit energy mix goal, although an implicit 20 percent target for nuclear is evident. The variety of approaches emerging at the country-specific level was noted with interest. Improved knowledge of Chinese and Indian approaches could help to build a more comprehensive understanding of the range of country-specific policy responses that are emerging. Indeed, better information exchange could inform more effective policy development in the future.

Moving forward

KAPSARC and the Institute for Energy Economics, Japan (IEEJ) will continue their research into more practical climate policy approaches, focusing on policy options for Saudi Arabia and Japan. Initial case studies for these two countries are expected to be published during the first half of 2017.

Subsequently, KAPSARC is planning to extend its analysis to examine practical climate change policy options for the Gulf Cooperation Council states, starting from the second half of 2017. The IEEJ is also planning to extend its analysis to consider practical climate change policy options for China and India.

Global Gas Markets: The Great Reconfiguration?

Moderator: Dr. Coby van der Linde,

Director, Clingendael International Energy Programme

Following the COP21 Paris Agreement, the role of natural gas in the global energy sector has become uncertain. Over the short term, the gas industry faces a 50 percent increase in liquefaction capacity. This raises questions about how market players will navigate through the upcoming glut and still be in a position to invest in new upstream assets and liquefied natural gas (LNG) export capacity beyond 2020. In the longer term, to gain market share in the future energy mix, gas has to be delivered to customers at the lowest possible cost so that it can outrun coal and oil, and establish its place as a competitor for renewables and energy efficiency.

> To secure its future, the gas industry needs to convince politicians that natural gas is the fuel of choice: it currently appears as the third preference, after renewables and energy efficiency. Without some strong political support, gas will not succeed for economic, political and regulatory reasons.

> Gas industry players cannot overlook that 'cost is king': gas needs not only to be competitive but also affordable to expand its use in developing markets.

> To some degree, gas is waiting for carbon capture and storage (CCS): the long-term future of gas is linked to the ability to develop CCS. If this technology takes decades to develop, it may prove too late: the window of opportunity for gas may disappear.

> Within the LNG market itself, buyers and sellers are currently at odds: while buyers are looking for increased flexibility and different price indexation, sellers seek stability and certainty based on long-term contracts.

> Market players will have to be innovative and collaborate: in order to adapt to changing market conditions, they need to reinvent the existing framework in terms of contracts and pricing mechanisms, while also fostering technological developments to reduce costs.

Overview: Can gas secure its place in uncertain energy markets?

The post-COP21 world, combined with price volatility and a looming boom-and-bust cycle on the LNG side, has created total uncertainty regarding the future appetite for gas. Initially thought of as a clean fossil fuel and a renewable energy enabler, gas remains a greenhouse gas (GHG) emitter and is perceived as an antagonist to the decarbonization cause. Even on a cost basis, natural gas is getting crowded out by coal and low-cost renewables in some regions.

This implies that to create a competitive market for itself, the natural gas industry needs strong political support and consistency in regulatory frameworks. Undeniably, the old debate remains that financing, economic development and securing implementation of initiatives during and after COP22 will still be a challenge, as the national decision of each country remains the catalyst for change. The likelihood of success in securing a longer-term role for natural gas will increase if strong policy helps to secure future demand at the pricing levels needed to stimulate necessary investment and to account

fully for the environmental and health impacts (or benefits relative to coal and oil) of gas, for example through carbon pricing.

Yet natural gas faces more immediate challenges: a rapid increase in LNG export capacity up to 2020 combined with weakened demand has put downward pressure on gas spot prices, while oil-linked gas prices have dropped in concert with oil prices. Bigger challenges may be felt from 2018 onward when all the Australian LNG plants and a few U.S. LNG plants have started to operate. If LNG demand does not pick up significantly by then, surplus LNG could be left stranded, and forced to aim at the residual European market, where it would face competition from pipeline Russian gas. Low prices and uncertainties about future LNG demand result in companies hesitating to take final investment decisions (FIDs). This is exacerbated by the fact that buyers, which currently have the upper hand in negotiations, hesitate to commit to long-term contracts or are more demanding in terms of pricing and flexibility conditions.

Stepping up environmental solutions

Scenarios from international institutions and companies paint a relatively optimistic picture for gas in the next 20 to 30 years as energy demand is growing nearly everywhere (except in Europe). But current market conditions challenge these optimistic considerations. In regions where natural gas consumption is expected to increase, the scale of incremental consumption is uncertain at this stage. Beyond 2030 or 2040, the outlook for gas depends on the degree of climate change awareness at a global level and on international cooperation. If awareness is high, gas market share in the primary energy mix will decline gradually; it will play out its transitory role and be replaced by renewable energy. If awareness is low, the gas market share will be significantly higher. In that case, however, the target for limiting carbon dioxide (CO_2) emissions will likely be missed.

The application of CCS may increase the longevity of gas demand. At present, however, CCS implementation is assumed to take place between 2050 and 2060, which may be far too late. Some analysts reason that a technological breakthrough in CCS is needed within the next five to ten years, as renewable energy technology costs are falling rapidly. The stalling of the CCS technology that has occurred to date is due to the inability of the technology to take off. Others argue that even if it were to take off, coal with CCS would be more competitive on a levelized cost of electricity (LCOE) basis since coal is cheaper than gas and the CCS cost would be the same for both fuels. The latter argument may not hold true if all externalities are taken into account. Coal is known for other air and water pollution impacts, such as sulfur, ash and mercury, having detrimental human health impacts. The gas industry would be wise to start investigating health data to prompt politicians to account for the health costs associated with using coal, which may prove to be costlier than straight LCOE comparisons.

The gas industry might also be more proactive in facing the climate stress tests that are heading its way. Recently published studies have drawn attention to the methane leakage issue throughout the natural gas value chain. This could be a setback for the gas industry, which has long argued to environmentalists that gas is cleaner than coal. Also, building long-term transnational or transcontinental pipeline infrastructure faces strong opposition from environmental groups, who see it as a hurdle to transitioning toward sustainable energy development solutions.

The role of carbon pricing

Ahead of the COP21 meeting in Paris, each country submitted its Intended Nationally Determined Contributions (INDC) as a starting point to achieve the 2ºC target — a realistic, bottom-up approach rather than trying to dictate ambitions from the top. Although many of the plans do not lower emissions as we move toward the 2025-2030 time period (rather, only slowing growth compared with a business-as-usual scenario), they would be subject to international review with the intention to ratchet up the level of ambition over time. Interestingly, 80 percent of the INDCs make reference to renewable energy, but only those submitted by gas-producing countries (Russia, the United States and countries from the Middle East) make reference to the fuel. This may suggest that unless they have the advantage of low-cost domestic gas resources, very few countries genuinely want to significantly increase the share of natural gas in their primary energy mix.

One year after the COP21 Paris Agreement was signed, it remains difficult to assess how it will affect future gas demand. Despite having lower CO_2 emissions compared with traditional fuels, its abundance and its flexibility, the fact that gas is a fossil fuel undermines its potential to fulfil an important role in energy access in power-hungry countries and to reduce emissions elsewhere, at least in the short term. Also overlooked is its capacity to address security of supply challenges, notably in Europe.

A main element put forth initially in the Kyoto Protocol and now reflected in the Paris Agreement is the role of carbon pricing to give an economic signal that could help spur the switch from coal to gas. About 100 of the INDCs actually refer to carbon pricing, whether through a carbon tax, an emissions trading scheme (ETS) or other mechanisms. This represents approximately 60 percent of global emissions. However, when examining progress to date, we see that in 2016 about 40 countries and more than 20 cities, states and provinces have put in place or implemented a carbon price option. This represents only 13 percent of global emissions. While a sign that efforts are progressing, it is certainly not fast enough to reach the intended target. If China upholds its initiative to implement its planned ETS program in 2017, then coverage would rise to almost 25 percent.

At present, however, there is a big discrepancy across regions on the price of carbon. In order to be in line with a 2ºC target, prices would need to be between $80/ton and $120/ton. In reality, carbon prices worldwide range between $1/ton and $130/ton, with 75 percent of these prices below $10/ton. In addition, carbon pricing could be a double-edged sword for the gas industry; if the price is too high, it may allow some renewable energy technology to be economical as compared with gas.

Advancement in electricity grids, yet another obstacle

Advancement in electricity infrastructure, beyond the actual generating unit, is playing a significant role in optimizing existing generation and may be hindering the future demand for natural gas. Development of the 'Internet of Things', artificial intelligence and other technologies is enabling the evolution of virtual power plants (or smart grids). Power system operators can now manage energy systems and integrate all the decentralized energy within a specific region or a city, optimizing it to help reduce substantially the required generating capacity.

For gas to remain part of the solution in light of these technological and environmental developments, it has to exert its place as a useful source of energy.

To gain market share in the future energy mix, gas does not have to win against all competitors: rather, the industry has to be imaginative about ways to bring gas to customers at the lowest possible cost. It has to be reliable, affordable and easy for consumers to accept. At the same time, with the advancement of renewables and electricity grids, the natural gas industry needs a technological breakthrough that will enable it to package itself as an integrated solution with renewable energy — and not a separate, unique solution on its own.

Other aspects of gas that have not been well marketed are its role downstream, its non-energy use (such as in petrochemicals), and its uses in remote areas to replace biomass and oil products for heating and cooking. Bringing more attention to the complete value chain of natural gas, not just the power sector element, could strongly promote the role of gas.

Avoiding the boom-and-bust cycle in LNG

Significant LNG supply is on its way, as more than 150 million tons per annum (mtpa) of liquefaction capacity — a 50 percent increase compared with 2015 levels — will come online over the 2015-20 period. These new LNG plants are arriving to the market at a time when Asian LNG demand shows signs of weakness, having dropped by 2 percent in 2015 alone. Not anticipating the recent demand weakness, the gas industry has continued to carry forth previous investments that were driven by high oil prices as well as by a large gap emerging between spot prices in the United States and oil-linked gas prices in Asia. Such investment was also supported by the belief that Asian natural gas (and LNG) demand would grow substantially, with buyers ready to pay high prices for LNG for security of supply reasons. This combination of new supply capacity and weakened demand has put downward pressure on both spot and term prices. LNG projects are now arriving online in a worse environment than what investors ever anticipated; many now struggle to recover their costs.

As of late 2016, we are still at the very beginning of the LNG supply surge with one-third of the planned capacity online, but not yet operating at full capacity. The bulk (coming mostly from Australia and the United States) is expected to reach global gas markets by 2018; it could send spot prices to lower levels than those witnessed in the early part of 2016.

Investment concerns are building for the post-2020 period in both the upstream sector and LNG export capacity. It is likely that new LNG capacity will be needed a few years from now when markets rebalance, but that outlook carries policy, demand and price risks. Demand uncertainties and lower prices together are likely to postpone these investments, as sponsors wait for better times and attempt to deal with high capital costs. If demand picks up earlier than anticipated, there is a high risk that gas prices will skyrocket again. Meanwhile, buyers and sellers are at odds regarding the pricing, duration and flexibility structure of contracts that would support new LNG projects. A disconnect has emerged between buyers' needs for flexibility and affordable gas, and sellers' needs for certainty.

The boom-and-bust cycle currently seen in the LNG market is familiar to many industries that have survived it — often more than once. This one is no different, except that consumers and policymakers are becoming wary of such volatility at a time when the overall benefits of gas in a decarbonized world are in question. To avoid a boom-and-bust cycle, companies will have to take a long-term view and take the risk to invest. In parallel, buyers and sellers will need to move from their initial negotiating positions and be creative to make these investments feasible.

The overarching challenge is how new projects can move ahead in a market context where traditional buyers are hesitant to commit for a long duration, while new buyers from developing countries have limited needs and low creditworthiness. This may call for smaller projects, possibly floating LNG (FLNG), if the ones starting over the coming years prove an effective way to reduce capital costs. Brownfield LNG, the presence of liquids and specific advantages given by the host country will help projects to move ahead. For example, two FIDs on LNG export capacity were taken in 2016 so far. The first was a brownfield project (the third train of Tangguh); the second was the small Woodfibre LNG project in Canada, which benefits from low electricity prices. Eventually, pressure on costs could drive the LNG industry back to a more regional business in which, due to squeezed margins, sellers seek to optimize shipping by targeting the closest destinations. On a global scale, such an optimization of shipping could generate $2 billion of annual savings.

Changing contractual patterns

In terms of gas pricing, Asian players have been calling for a move away from traditional oil linkage toward the establishment of a regional trading hub and more flexibility on the LNG market, notably with the removal of final destination clauses in long-term contracts. Singapore, China and Japan have taken the lead to create their own trading hub; realistically, three distinct hubs could co-exist given the scale of the Asian market. Japan is also keen to play “a leading role in developing a flexible and liquid LNG market”. But in the current absence of a trading hub in Asia, the National Balancing Point (NBP) and the Title Transfer Facility (TTF) spot prices will likely set the global marginal price as Europe will be the market of last resort. The current move from buyers is geared toward acquiring cargoes at spot prices. In markets where a spot price exists, end-users call for gas being priced at spot prices. There is a risk, however, of a decorrelation between oil-indexed gas and spot prices, which would put more pressure on buyers to move away from oil indexation. Given that the rationale for oil indexation was designed on the basis of the energy equivalent, such a delinkage could shift patterns in gas consumption.

Pricing is therefore likely to become hybrid and reflect different indexations including oil, Henry Hub (HH), NBP, or TTF; in the future, it may also include indexes such as U.S. free on board (FOB) or Asian hub. Ultimately, there could be a push toward a real commoditization in the LNG business, even though this may not be what sellers want. Given the evolution of the LNG industry from a cozy club with limited members to a multi-business industry, new players are appearing at all parts of the LNG value chain. Many have new ideas and needs, and are challenging the traditional business model of the 50-year-old LNG industry. They could propose other ways to manage prices. For example, many parts of the energy industry do not use bundle prices, but make a distinction between capacity and commodity prices. Such price structures could be more appropriate for downstream markets to underpin the competitiveness of gas. End-users would have guaranteed access to gas at short-run marginal costs.

The attractiveness of indexing U.S. LNG against HH spot prices is likely to be challenged by low oil prices. Under current market conditions, U.S. LNG now appears more expensive than oil-indexed LNG. This forces off-takers to consider the liquefaction fee as a sunk cost, prompting two questions: to what extent will U.S. LNG plants operate at capacity and will we see some off-takers defaulting? While having downward pressure on gas demand growth in the short term, low oil prices could eventually also threaten the next generation of projects.

Elements other than price indexation in long-term contracts are facing pressure. Due to increasing demand uncertainties, buyers need more flexibility, either by having reduced take-or-pay obligations in their long-term contracts, or by holding a mix of long-term, short-term and spot LNG in their portfolios. This affects even countries such as Japan, which traditionally put high emphasis on security of supply. Flexibility will most certainly increase as more LNG is traded on a spot and short-term basis, driven by increasing quantities of uncommitted LNG, portfolio LNG, flexible U.S. LNG and limited extensions of expiring contracts.

These anticipated modifications in contractual practices could yield tremendous changes. It is uncertain at this stage how far buyers' requests could go. Facing all these rapid changes, sellers are concerned that contract sanctity may be at risk and also that banks would not support the evolution toward shorter-term, spot-indexed contracts when it comes to project financing.

Moving forward

To secure a more certain future, the natural gas industry will have to find ways to address the two issues of costs and swaying public and political opinion. Both issues are very much interlinked: an expensive and highly cyclical commodity is less appealing for consumers, policymakers and financiers.

As domestic production is usually insufficient to cover increasing demand, most countries are importing or will have to import increasing quantities of natural gas. In some cases, such as India or Argentina, domestic prices have been maintained at low levels, resulting in a need to import more expensive LNG. An increase in domestic prices is very politically sensitive, but could trigger additional exploration and production activity, and thereby reinforce the role of natural gas in the longer term.

Politically, gas is often seen as the third-best option, behind renewables and energy efficiency — a reflection of the COP21 Paris Agreement commitments to reduce energy-related emissions. But the bid to achieve universal access to energy can provide growth opportunities for gas in developing countries lacking access to electricity and modern cooking. Gas can also provide cleaner energy to some developing countries than they currently use, but it has to be at affordable costs. Policy can play an important role in capturing the relative benefits of natural gas. Pragmatic policy would reflect the externalities related to respective fuel sources and allow the market to decide what is most cost-effective.

Reform of China's Energy Economy: Industrial Transformation

Moderator: Dr. Jin-Yong Cai,

Partner, TPG Capital

China faces several new challenges as economic growth slows and public concern for the environment and climate change grows. Policymakers are strongly focused on how to drive industrial and energy transformation when the financial system is still under intense pressure. They also seek to expand deployment of China-made, low-carbon solutions on international markets, particularly through the Belt and Road Initiative (BRI), which is strategically designed to boost development of China's energy economy.

These transformations in China also have implications for Saudi Arabia, first because China has been a major importer of Saudi oil and gas. As China pursues lower demand growth, imports will show slower than anticipated growth. But another element comes into play: Saudi Arabia is seeking to transform its own energy and industry economies, and to boost energy productivity. Thus, there may be opportunity to explore an evolving relationship, based on four high-level actions that are advancing in parallel:

> Supply-side structural reform, as an innovative move in China, is slowly restoring confidence in China's economy.

> Efforts to decarbonize energy development and improve energy productivity are driving China's energy transformation.

> China's strategic aim to boost energy productivity may help shape a similar vision in Saudi Arabia, although different paths to energy productivity in each context will determine the future direction of investment and industrial development.

> Collaboration on energy efficiency, renewables and new industries could bring mutual benefits to China and Saudi Arabia. The industries that Saudi Arabia has identified as top priority in its National Transformation Plan are also targeted by the Green Industry Development Plan of China. Working together can substantially increase the chance of success for both countries.

Overview: Committed to new approaches for future growth

The rise of China as an economic and trading superpower can be largely attributed to reforming the domestic market economy to better align with globalization, but it is also strongly linked to the strength of industrial competitiveness. The recent growth pattern — based on energy- and resource-intensive investment, manufacturing, and exports — has led to economic, environmental and social imbalances over time. Recognizing that unrestrained growth has led to some negative impacts, China is now exploring an industrial transformation away from traditional industry. Two main mechanisms are supply-side structural reform and an energy transformation through rapid deployment of renewables and low-carbon energy.

China and Saudi Arabia have had a long relationship founded on energy trade. As both countries are now aggressively seeking to reform their energy systems, industrial infrastructures and, indeed, economies, opportunity may exist to share knowledge and experience. Saudi Arabia currently faces a set of policy challenges very similar to those that China has been navigating. The downturn of global oil prices and the low share of non-oil sectors in the Saudi economy is slowing down

economic development and pushing the government to diversify the economy and improve industry productivity. Given the need for economic transition in Saudi Arabia and ambitious targets in its Vision 2030, it is valid to explore whether the policy path and experience of China could provide insights for Saudi Arabia's industrial economy development.

Additionally, it is worthwhile to examine areas in which collaboration may bring mutual benefit for both China and Saudi Arabia. It could be related to the design and implementation of policy in support of energy efficiency, renewables and new industry development, or in new ways of cooperating to improve energy security. More study is needed to move forward in these areas.

Structural reform to restore confidence in China's economy

China enjoyed rapid economic growth for around three decades, fueled by capital investment, exports and consumption — all of which are associated with the demand side. More recently, these growth drivers have been losing steam as global demand shrinks, Chinese private investment drops alarmingly, and the debts of local governments and corporations climb to high levels. A more severe challenge is that ambitious build-up of industrial production has led to excess capacity in sectors that extend beyond traditional heavy industry (e.g., steel, cement, electrolyzed aluminum and flat glass) to include emerging industries (e.g., solar photovoltaics [PV], wind turbines and new materials).

To remedy its economic ills, China rolled out supply-side structural reform in 2015, stipulating five major tasks, namely: reducing overcapacity, destocking, deleveraging, reducing costs and shoring up weak growth areas. Such measures are expected to increase the supply of high-quality goods and services, lower prices, and boost consumption to stimulate China's economic development in the long term.

Data from the first three quarters of 2016 suggest that the economy is slowly stabilizing. The ratio of consumption to gross domestic product (GDP) has increased slightly while the household saving rate has declined. The services sector share in the economy has risen to over 50 percent. In parallel, China's steel and coal industries have perked up as capacity cuts and production curbs boost prices and profits, while the infrastructure spree and housing boom have spurred demand for building materials from iron beams to cement. The information technology and automotive industries have maintained competitiveness and show a growing market share.

But on the other side, increasing reliance on government spending and growing investment by state-owned enterprises have barely improved the imbalance between public and private investment. Reforms of the real economy have not kept pace with financial liberalization. More concrete measures are needed to achieve the green industry ambition of the 13th Five-Year Plan (FYP; 2016-2020) and to reduce uncertainties around the Made in China 2025 plan, which is still under development. These elements raise concerns about the future momentum of the economy, when the property market will be on a downward cycle and new industry will be too young to drive the economy.

Yet everyone recognizes that it takes time to rebalance the supply and demand sides of an economy, particularly one as large as China's. The proactive decisions and innovative actions now driving the supply-side structural reform will continue to reshape China's future and no doubt attract global attention.

China takes concrete action on energy transformation

As China's economy settles into a 'new normal' status, energy demand growth is slowing down. For example, electricity demand growth dropped significantly from 12 percent in 2011 to 0.96 percent in 2015. On the demand side, comprehensive policies and actions to improve energy efficiency, phase out outdated industrial capacity, and increase the share of tertiary industry in the national economy have significantly decreased energy consumption per GDP unit. On the supply side, as clearly stated in the Energy Development Strategic Action Plan 2014-2020 and the 13th FYP on National Economic and Social Development, it is the right time to drive the energy transformation by limiting the use of coal, encouraging the uptake of natural gas and accelerating the deployment of renewables.

All in all, it is critical for China to decarbonize energy development and improve energy productivity to fulfill its commitment to the COP21 Paris Agreement on climate change, but substantial challenges lie ahead.

Coal will continue to play the major role in China's energy supply but its prioritization is much downgraded. Policymakers are more determined to squeeze coal's share in the energy mix, setting an ambitious target to reduce coal-fired generation from 64 percent in 2015 to 55 percent by 2020 and to cap the total installed capacity of coal-fired plants at 1.1 terawatts (TW) by 2020. They also aim to reach peak use of coal during the 13th FYP period. But achieving these targets is not easy. Just adding up coal-fired projects under construction and those in the pipeline for approval leads to total capacity of 1.25 TW.

Natural gas is expected to grow steadily in the near term. The greatest areas for its use are to replace coal in the industry sector for cleaner production, to meet growing residential needs in the urbanization process and to generate power for peak-load adjusting. The price reform and market expansion of natural gas in China is moving ahead with more challenges than expected, and is particularly affected by the shale gas revolution in the United States and liquefied natural gas (LNG) projects in Australia, North America and East Africa. But policymakers remain committed to use natural gas as a strategic choice to address air pollution and carbon dioxide (CO_2) emissions. The 13th FYP sets a target to secure market growth of natural gas from 6 percent in 2014 to 10 percent by 2020.

The declining cost of renewable energy has paved the way for its rapid development and deployment in China. During the 12th FYP period, the cost of wind power fell 30 percent and that of solar PV dropped by 80 percent. This builds confidence for renewables' future competitiveness against conventional fossil fuel. According to the 13th FYP, by 2020 when total installed capacity of solar PV reaches 150 gigawatts (GW), it is expected that the cost will be equal to the grid selling price. Moreover, when total installed capacity of wind power reaches 250 GW, its cost will be approximately the same as that of a coal-fired power plant.

To date, a combination of transmission bottlenecks and the need to establish a market framework have blocked large volumes of renewable electricity from reaching the grid. In 2015, 15 percent of China's wind energy was wasted, a historical high. It is noteworthy that Chinese policymakers have recognized the importance of improving grid flexibility and reliability to curb the waste rate of renewables to within 5 percent during the 13th FYP period. This would require decentralized renewable development, smart grid construction with improved peak-load shifting capacity and enhanced prediction of renewable power generation.

Pathways to achieve Vision 2030 in Saudi Arabia

Saudi Arabia, where 45 percent of GDP and 80 percent of government revenues have previously come from oil, is now facing an economic downturn caused by the significant drop in global oil prices and the small share of non-oil sectors in its overall economy. Under the National Transformation Plan designed to achieve the Vision 2030, the government has developed ambitious targets to diversify the economy and improve industry productivity. This includes increasing the contribution of industry to GDP from 12.1 percent to 20 percent, increasing industrial exports' share from 18 percent to 35 percent, increasing technology-based exports from 30 percent to 60 percent, and increasing the Saudi industrial labor force from 15 percent to 30 percent, among other activities.

Saudi Arabia has various options to consider. The industries of petrochemicals, refining, metals and building materials would lead to higher investment and intensive energy consumption than other sectors, while the services sector would generate the highest growth of value-added. Based on the understanding of this, two potential development pathways could be pursued to achieve the goals in Vision 2030:

> **High energy productivity path**: increases fossil fuel exports, using revenues to invest domestically in energy efficiency, renewables and development of high-value service industry.

> **Low energy productivity path**: reduces fossil fuel exports, directing more energy toward domestic use to accelerate the development of energy-intensive industry.

Compared with the low energy productivity path, the high energy productivity path could avoid 1 million barrels per day (bbl/d) of oil equivalent and reduce emissions by up to 114 million tons of CO_2 equivalent ($MtCO_2$-eq). Additionally, the high energy productivity path could almost meet the target stated in Saudi Arabia's Intended Nationally Determined Contributions (INDC) to the COP21 Paris Agreement of achieving a reduction of 130 $MtCO_2$ by 2030.

As global oil prices and production capacity are still highly uncertain, it is valid to ask how Saudi Arabia can secure the revenue increase from oil and gas export to invest in energy efficiency and renewables. Other prerequisites for industrial economic development include developing human resources and industrial skill systems to ensure the availability of a technically and scientifically qualified and well-trained workforce. In reality, it is likely more practical to have a moderate energy productivity pathway, which could benefit from establishing a system of benchmarks and targets to improve energy productivity in the industrial sector, create an environment for advanced technology development, and set up a policy package to encourage foreign investment.

Moving forward

Exploring other possibilities for collaboration between China and Saudi Arabia, as a means of moving toward parallel objectives or shared goals, is a valid undertaking. One opportunity is through the Belt and Road Initiative (BRI), which China launched in 2013 to promote efficient resource-sharing and regional integration of infrastructure to benefit countries along the original Silk Road and along a maritime route. The connection between China's BRI and Saudi Arabia's Vision 2030 provides the best opportunity for collaboration between these two countries. Interaction among high-level government officials and industrial leaders is progressing well, while more concrete cooperation at a project level is

still under exploration. New ways to cooperate in the context of the global energy system transformation will also impact energy relations between these two countries.

The systematic and comprehensive measures that China has taken to improve industrial energy productivity could be used as a reference case for Saudi Arabia, offering insights on how to set appropriate targets, build the necessary data system, evaluate progress and link evaluation results with performance appraisals for local governors and industrial CEOs. China also has experience in how to use government funding, capacity building, information sharing and technology renovation as support measures.

Renewables are playing a growing role in China's energy transformation. The policy experience to accommodate their deployment in the past decade, the cost-effective and advanced technologies China has developed, and the investment capacity that Chinese industries have accumulated could bring benefit to renewable energy development in Saudi Arabia, particularly given its resource advantage and political will for change.

In accordance with the energy productivity pathway and the nature of current circumstances, further investigation is needed to identify the best way to move forward with industrial development for both countries. For Saudi Arabia, effort is needed to improve the investment environment, increase the qualified labor force and extend the market in neighboring countries. There is also a learning process for Chinese enterprises to enter new markets under the current policy regimes and business practices. The industries that Saudi Arabia has identified as top priority in its National Transformation Plan are also targeted by the Green Industry Development Plan of China: working together can substantially increase the chance of success for both countries.

Energy Infrastructure in India: Financing the Growth

Moderator: Dr. Sunita Narain,

Director General, Center for Science and Environment (CSE)

The Indian energy sector is in the midst of a transition driven by two overarching goals: enhancing energy access and increasing the share of renewables in the fuel mix (from the current 45 gigawatts [GW] to 175 GW by 2022). That India has a vast resource of low-cost coal, which has traditionally played the major role in power generation (186.5 GW, more than 60 percent of India's installed capacity), creates additional challenges as the country strives to achieve both universal access to energy and meet its COP21 Paris Agreement commitments to reduce carbon dioxide (CO_2) emissions.

While political will is evident and strategic decisions are being taken, India faces a massive challenge: an estimated $400 billion would be required — over the next ten years alone — to expand and improve just the existing energy transportation infrastructure (India Brand Equity Foundation 2016). This level of funding will require a mix of public and private financing, which in the case of India adds another layer of unconventional challenges. At present, various financing options are available, but due to perceived market risks, far fewer private investors than warranted are attracted to the opportunities inherent in such a large-scale build-out of energy infrastructure.

To address these challenges, and indeed build interest in the opportunities, Indian policymakers need to act strategically across four key areas:

Managing market risks: Given the scale of investments required to develop Indian energy infrastructure, energy policy needs to evolve in a manner that builds confidence that energy market risks can be managed and effectively priced into business models. Policy focused on market creation needs to take a long-term view and ensure that necessary subsidies will not unduly influence market behavior.

Subsidy design and leakages: Distortion in pricing of energy commodities has not only affected the business models of the industry but also widened the scope for rent-seeking behavior. Rationalizing price structures and capturing subsidy leakages will help lower the subsidy/cross-subsidy burden on the government and utilities. Efficient targeting of subsidies will help to ensure fair pricing of energy and provide better information about the actual size of the market.

Technology, transparency and behavioral change: Technology can also help develop and promote tools that provide transparency in terms of actual consumption patterns and help reduce pilferage. This information can help to target subsidies to the needy. Promoting technologies and services that help consumers understand and control their energy usage will deliver savings to them and lower energy needs overall. Appropriate price signals and increased transparency in energy accounting will also drive change in consumer behavior.

Resource management and provisioning: Building appropriate levels of demand-side management into infrastructure development, to ensure better resource optimization, could significantly curb the level of investment required.

> Incorporation of technology measures to promote energy efficiency, for example, will help India to better balance investment in both supply and demand sides.

Overview: Significant investment needed for energy access goals

India is likely to emerge as one of the largest energy-consuming countries in the world by 2030. Its stated aims of improving both living standards and access to clean, affordable energy will be key factors in the bid to keep pace with rapidly rising energy demand. At present, more than 300 million people in India (~23 percent of the population) do not have access to electricity. As economic growth is inextricably linked to energy provisioning, achieving a desired level of prosperity will require significant expansion and improvement of existing energy infrastructure, as well as an adjustment of the energy mix.

Assertive policy has recently played a strong role in boosting capacity growth of renewable energy technologies, reducing the impacts of coal by spurring the move to super-critical and cleaner coal-fired power plants, and aggressively targeting energy efficiency. This push reflects the need to ensure that energy access is increased by expanding the reach of the electricity grid and developing off-grid solutions to supply remote and inaccessible areas. Beyond building up clean, efficient generation capacity and transmission grids for electricity, India needs to enhance gas pipelines, ports and railway networks.

All of this will carry a substantial cost. An estimated $400 billion would be required over the next ten years to expand and improve the existing energy transport infrastructure of India, according to the India Brand Equity Foundation. For instance, interregional transmission capacities need to be significantly increased to bring surplus power from other regions to high demand areas in northern and southern regions. Effective use of an increasing share of renewables will also require robust electricity grids with better connectivity. Similarly, large-scale capacity augmentation of railway networks and additions to wagon capacity will be needed to improve the transport of coal from mines (located in the central and eastern region) to power plants in the northern, western and southern regions.

Given the scale of investments required to improve India's energy infrastructure, it is unlikely the internal resources of public sector enterprises will be sufficient. Hence, policymakers need to foster the active participation of the private sector. This will require fine-tuning existing policy and regulatory frameworks in some areas while also putting in place new, innovative approaches in others. Critically, policy reform will need to provide a level playing field for both private and public investors. As a starting point, procedures need to be streamlined for land acquisition, right of way, environmental approvals procedures, etc. Strategic action in these areas provides Indian policymakers an opportunity to influence energy choices and technologies.

Policy focus on coal enhances its appeal as a cheap energy source

India's energy mix is evolving, albeit rather slowly. Coal continues to hold the largest share (almost 47 percent) of primary energy, and dominates (60 percent share of capacity) the electricity generation mix, according to a study by Niti Aayog. With abundant availability of domestic reserves and economics in its favor, coal is expected to remain the preferred fuel for electricity generation for the

foreseeable future. Given the poor thermal efficiency of widely used sub-critical technology and growing environmental considerations, policymakers acknowledge the need to promote more efficient and cleaner coal technologies.

In 2005, a policy initiative was launched to develop the Ultra Mega Power Projects (UMPP). The plan would see plants installed at both coastal and pithead locations, each having a capacity of 4 GW or more and using super-critical technology. The policy aimed to deliver power at competitive cost by achieving massive economies of scale.

At present, the distribution side policy remains mired in fuel price pass-through and related commercial issues, even though the policies of the UMPP and the Mega Power Plant facilitated development of a market in which super-critical technology was able to make inroads. In fact, the UMPP policy contained a technical requirement allowing only super-critical technology, which effectively enabled multiple vendors to develop domestic manufacturing capability for these boilers and turbines. From 2017 onwards, India anticipates installing only super-critical plants. Subsequent policies in pushing washery developments and controlling emissions by strengthening regulations helped to drive momentum toward cleaner technology for coal usage in power plants.

As India's coal has a high ash content, additional effort will need to focus on upgrading washery capacity to meet the coal quality requirements of super-critical boilers and achieve revised emission regulations that aim to minimize pollution at the plant level. Implementation of super-critical technology is in a nascent phase in India; additional policy mechanisms need to be developed to ensure that the environmental gains of cleaner burning technology are not lost because of a severe lack of quality coal supply.

Addressing market risks to support the energy transition

Investments in the energy infrastructure are exposed to a variety of market risks. In India, the risk level is exacerbated by factors such as unfair pricing of energy commodities and operational inefficiencies, creating substantial cost recovery concern for private investors. For instance, a long-standing policy of subsidizing electricity rates for certain consumer categories and under-recovery of dues have eroded the financial health of electricity utilities, in turn raising the market risks for generators.

Gas for power has been a high priority for Indian energy planners because of its potential to meet growing demand in a more environmentally sustainable manner. But interest in building a gas pipeline network is characterized by similar challenges. In this case, the 'chicken-and-egg' dilemma dominates: mid-stream players are wary of investing without an assured market and anchor customers don't want to commit to long-term supply contracts, particularly under the current volatile market conditions with economics clearly not in their favor.

Policymakers calling for a transition to a gas-based economy will likely need also to take steps to create an ecosystem that supports a viable gas market. With domestic coal setting stiff competition in terms of both price and supply, a gas market is generally not considered feasible. Yet India has nearly 80 cities with a population of over 1 million, some of which have large industrial areas. One mechanism to establish the necessary ecosystem would be to connect these industrial clusters by building gas distribution networks that would provide supply on site for various industrial applications (e.g., power generation,

heating and cooling). Encouraging composite use of gas would achieve several aims: increase overall efficiency, help create a market for gas, and avoid transmission and distribution losses in the electricity grid. Policy support to promote such an ecosystem and gas supply arrangement will be necessary to address some of the perceived market risks of gas suppliers, transporters, customers and, critically, investors.

Energy subsidy reforms to improve targetting and disbursement

The detrimental effects of energy subsidies on the energy economy are well understood. In India, underpricing of electricity for residential and agriculture customers has significantly affected the balance sheets of utilities and also constrained their ability to provide adequate supply to meet growing demand. In addition to inciting consumer malpractices, electricity subsidies have widened the scope for rent-seeking behavior, thus generating vested interests who are greatly interested in maintaining the status quo of the current political economy.

As subsidies discourage efficiency improvements (on both supply and demand sides) and encourage wasteful consumption of energy resources, policy action to provide proper price signals is considered necessary for balancing social and economic interests. Reliability and quality of power supply need to be properly considered in the process of designing rates for different consumer categories. For instance, agricultural consumers often get poor quality, unreliable supply at odd hours; yet their underpriced tariff structure is cited as one major cause of financial distress in the sector. Persistent power shortages in the past decade have driven up demand for alternative/backup power sources (power inverters, generator sets, batteries, etc.), resulting in high consumer spending on energy needs in relation to income levels.

Rationalizing price signals will help lower the subsidy/cross-subsidy burden for the government and utilities. However, designing and disbursing well-targeted subsidies will remain the biggest challenge in removing market imperfections.

Smarter energy infrastructure to encourage behavioral change

Human behavior can be an important factor in achieving sustained reduction in energy consumption, but low awareness about the potential benefits of energy efficiency and energy conservation has long been cited as a major barrier. Smart innovations that provide information on energy consumption and incorporate demand-control features (an integral part of smart grid solutions), together with the right price signals, can greatly influence how electricity is consumed. For example, the use of a dynamic electricity pricing structure (i.e., retail rates that vary with the time of electricity consumption in relation to system demand) can improve efficiency, reduce supply requirements and deliver savings to consumers.

Bringing intelligence into energy infrastructure will deliver efficiency improvements on both supply and demand sides while also helping to reduce growing energy needs. Implementing smart incentives, such as the recent government initiative to establish an energy service company (ESCO) to facilitate the massive roll-out of light-emitting diode (LED) bulbs and pass the economies of scale on to consumers, can prompt more consumers to adopt energy efficiency and demand-side measures.

Energy planning requires shift to demand-side approaches

Energy infrastructure planning has traditionally focused on supply-side approaches with the aim of meeting the energy needs of consumers. Recently, the concept of integrated resource planning is getting more attention, yet greater and collective efforts are needed to integrate and promote demand-side (consumer end) approaches into both planning and strategy formulation. Such measures will help to reduce energy infrastructure needs while also curbing the CO_2 footprint stemming from energy production and consumption. Decarbonization and energy efficiency have to be pursued in parallel.

Moving forward

Finding an optimal policy solution between ensuring energy access to all and providing quality, reliable and sustainable energy in India is proving to be a bigger challenge than just increasing energy supply. Policy frameworks will need to incentivize investors to develop innovative business models, put in place supply chains, encourage entrepreneurs and generate business volumes that adequately consider both supply- and demand-side approaches. Given the federal setup of India, allocating each incremental dollar of investment to optimize its use for supply- and/or demand-side interventions may be a challenge.

Substantial effort, particularly through policy reform, has been undertaken over the past decade to rapidly transform the Indian energy sector. Unfortunately, the Indian consumer mindset has not changed at the same pace. Political discourse has continued to focus on providing low-cost energy for consumers, resulting in a situation in which consumers have cheap energy that is unfortunately not reliable. Consumers willing to pay for quality and reliable energy supply and infrastructure are a growing constituency, but still a small one.

Policy mechanisms to initiate change in consumer behavior and create targeted mechanisms to ensure delivery of subsidies to the needy without leakage will contribute substantially to the development of energy markets.

One way forward would be to push for digitization in the energy sector to boost transparency in its accounting while at the same time empowering end-users to control their consumption behavior. The build-out of smart grids, together with targeted delivery of subsidies, development of energy efficiency measures, and action to stop leakages, will enhance the attractiveness of the Indian energy sector, thus pulling in greater investments from the private and public sectors.

Appendices

List of Abbreviations, Acronyms and Measurements

Abbreviations and Acronyms

ACEE	American Council for an Energy-Efficient Economy
BRI	Belt and Road Initiative
CAPEX	capital expenditure
CCGT	combined cycle gas turbine
CCS	carbon capture and storage
CNG	compressed natural gas
CO_2	carbon dioxide
COP21	21st Conference of the Parties
CSLF	Carbon Sequestration Leadership Forum
DER	distributed energy resources
ESCO	energy service company
ETS	emissions trading scheme
EV	electric vehicle
FDI	foreign direct investment
FYP	five-year plan
FLNG	floating LNG
FOB	free on board
GCC	Gulf Cooperation Council
GCCIA	GCC Interconnection Authority
GDP	gross domestic product
GHG	greenhouse gas
HH	Henry Hub
ICT	information and communication technology
IEEJ	Institute for Energy Economics, Japan
INDC	Intended Nationally Determined Contributions
INTVA	In-Kingdom Total Value Add
IP	intellectual property
IRENA	International Renewable Energy Agency
KACST	King Abdulaziz City for Science and Technology
KAUST	King Abdullah University of Science and Technology
KFUPM	King Fahad University of Petroleum and Minerals
KSA	Kingdom of Saudi Arabia
LCOE	levelized cost of electricity
LED	light-emitting diode
LNG	liquefied natural gas
LSS	large-scale solar
MUSH	Municipality, Universities, Schools and Hospitals
NBP	National Balancing Point
NDC	Nationally Determined Contribution
NEM	net energy metering

OECD	Organisation for Economic Cooperation and Development
PEV	plug-in electric vehicle
PPA	power purchase agreement
PV	photovoltaic
R&D	research and development
RES	renewable energy sources
RISE	Readiness for Investment in Sustainable Energy
SCC	social cost of carbon
SEC	Saudi Electricity Company
SEEC	Saudi Energy Efficiency Commission
SEEP	Saudi Energy Efficiency Program
Super-ESCO	super energy service company
TTF	Title Transfer Facility
UAE	United Arab Emirates
UMPP	Ultra Mega Power Project
VAT	value-added tax

Measurements

bbl/d	barrels per day
GW	gigawatt
kWh	kilowatt hour
M bbl/d	million barrels per day
$MtCO_2$	million tons of CO_2 equivalent
Mtpa	million tons per annum
MW	megawatt
ppm	parts per million
tCO_2	ton of CO_2
TW	terawatt

KAPSARC

مركز الملك عبدالله للدراسات والبحوث البترولية

King Abdullah Petroleum Studies and Research Center

حوار الطاقة ٢٠١٦

Energy Dialogue 2016