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King Abdullah Petroleum Studies and Research Center

Adaptive Strategies in the Low Carbon Energy Transition

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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

Key Points

As 'energy transition' enters the mainstream lexicon, a new narrative is emerging. The presumption that there is an urgent need to achieve full decarbonization via the elimination of fossil fuels is being tempered by calls to capitalize on the opportunities afforded by technology to reduce and even eliminate the greenhouse gas (GHG) footprint of existing energy sources. Across the energy value chain, players are reinventing and adapting their modus operandi to thrive in a low emissions world. Reports of the 'end of oil' may be overdone, but those whose economies depend on the revenues from or consumption of oil and gas are not ignoring the need to address environmental sustainability as much as questioning the affordability and reliability of the future energy system.

- The energy transition is not a zero-sum game. It is an ongoing process that requires all actors in the energy value chain to confront the risks of ignoring the driving forces of transition.
- The GHG footprint of some hydrocarbons is being reduced through the use of renewables in the production process as well as carbon capture, use and storage for enhanced oil recovery (EOR) at the well-head.
- Although the industry will incur costs adapting to changing demand patterns, it could well benefit from the growth in demand for petrochemicals and the opportunities of process integration of refineries and petrochemical plants.
- Emissions reduction policy is a key pillar of trust between politicians and citizens, and between corporations and consumers.

Executive Summary

Responding to the energy transition is becoming a major priority for incumbents in the energy sector throughout the entire value chain. Key actors, be they senior government policymakers in both resource-holding and consuming countries or senior company executives, are now focused on ensuring their ability to continue prospering in a fast-changing energy landscape.

Technology continues to be a key driver of the energy transition, providing solutions such as electric vehicles that may contribute to lower emission transportation solutions. However, technology is also providing a lifeline for some hydrocarbons, notably oil, through creating economic decarbonization strategies such as carbon capture and storage and enhanced oil recovery (CCS-EOR). Recognizing this, oil producers are focusing on developing defensive strategies to protect market share, and ensuring their customers have access to high-value energy without having to trade off environmental and economic development concerns.

Not all crude oil has the same environmental footprint, and this phenomenon is increasingly gaining traction in consuming regions through low carbon fuel standards. Some producers, including those in the Middle East, may enjoy a greater competitive advantage beyond low production costs. As energy consumers increasingly seek to reduce their net GHG emissions, legacy resource holders with low emissions in their production systems are set to benefit from the carbon-competitive nature of their crude oil. Furthermore, those willing to invest in capturing carbon dioxide at the wellhead and injecting it into oil reservoirs can effectively create a product that has a lower emissions footprint than arises from the combustion of the barrel of oil. Furthermore, if oil were to be used to produce hydrogen with CCS-EOR, truly zero-GHG emission vehicles would become a reality.

It requires more than simple ‘virtue signaling’ from governments and corporations to balance conflicting pressures from stakeholders. Many international oil companies (IOCs) are re-inventing themselves to retain shareholder value as well as to protect the trust that their end-consumers place in their brands. Likewise, governments are facing increasing pressure from citizens and civil society to take tougher measures to combat climate change and, perhaps more importantly, deteriorating air quality in metropolitan areas. The challenge is to find policies that harm neither energy security nor economic growth while meeting climate commitments.

The refining industry faces particular challenges. In addition to being under pressure to cut emissions like all large industrial undertakings, biggest challenge is to anticipate how the energy transition will transform the shape and geography of demand for their products over the coming years and decades. Increasingly complex refineries have long since moved beyond the physics of distillation into the chemistry of changing molecules into more valuable products. The distinction between refineries and petrochemical plants will likely blur further as deeper process integration becomes a necessary survival strategy. But this will require the wholesale reconfiguration of production plants and massive investments at a time when all capital investments in the sector are under intense scrutiny.

Crude oil to chemicals (COtC) configurations could become the new normal for refineries, but oil as a petrochemicals feedstock is facing competition from coal to chemicals (CtC) and from increasing use of natural gas liquids.

Technology remains a wildcard, offering multiple solutions that benefit competing pathways. Just as renewables, electric vehicles and battery technologies may combine to deliver a fossil-free future, solutions that address the GHG footprint of

fossil fuels may combine to throw oil a lifeline. For example, breakthroughs in the internal combustion engine, such as the recent efficiency gains announced by the Japanese, manufacturer Mazda, provide evidence that technological innovations can be harnessed in defense of the incumbents, raising the bar for new entrants even as other innovations bolster their ability to compete.

Whatever the final configuration of the new energy system, each technological step forward is reducing the climate and other environmental impacts of energy consumption in value chains that are characterized by high capital intensity and long lead times. If the goal of policies that are driving the energy transition is to minimize potential volatility and dislocations, it will require a more pragmatic approach than seeking to eliminate fossil fuels from the energy mix before cost-effective alternatives are available at scale. This requires a degree of dialogue between producers and consumers that has not been sufficiently evident thus far.

Background to the Workshop

In 2017 KAPSARC launched a new research initiative - The Future of Oil in the Low Carbon Energy Transition - with a number of international partners. Its focus is on the long-term role of fossil fuels, particularly petroleum, as the world transitions to a low greenhouse gas (GHG) future, in line with the goals of the Paris Agreement. As part of the initiative KAPSARC and the Clingendael International Energy Program co-hosted a series of workshops in Riyadh and The Hague in 2017 and 2018. This Workshop Brief covers discussions held in Hus Clingendael in The Hague in April 2018. The workshop series will continue in 2019.

There is growing evidence that current climate policy trajectories are not sufficient to achieve the 2 °C target, creating pressure to strengthen policies aimed at reducing GHG emissions. There is a risk that this will be seen as a zero-sum game – investments in non-emitting technologies being the only alternative to the 80% of the global energy mix supplied by fossil fuels. Such policies, combined with technological advances in transportation and power generation, have so far achieved limited impact in absolute terms despite strong annual growth rates from a low base. However, as momentum builds, markets may respond in unanticipated ways with unintended consequences.

It has been commonly assumed that the only losers are the producers of fossil fuels, and that currently importing economies will gain by capturing the resource rents through consumption taxes in a market in which demand is scarcer than potential supply. The perception that the winners and losers can be so easily identified hinders progress toward a consensus on what the transition should look like.

The objective of the workshop series has been to understand whether there are strategies that could alter the calculus of winning and losing and so, armed with this understanding, parties might seek a path less prone to unexpected and unintended turns that reduces the economic costs of future volatility. Key topics covered included:

- As the energy transition evolves, what could the new global energy system look like?
- What strategies are available to resource-holders to maximize value if demand were to fall?
- Can hydrogen and carbon capture and storage associated with enhanced oil recovery provide a cost-effective path to climate mitigation?
- Is the inherent cost competitiveness and the energy density of oil (stripped of at least a part of its economic rent) sufficient to ensure that it can play a role in a low GHG emissions future?

Adaptive Strategies for the Energy Transition

As the energy transition increasingly becomes a reality, energy system actors are embarking on new strategies to ensure their survival and continued growth. In the space of a few years, the risk profile of a sector that was once the stalwart of stability has increased dramatically with all elements of the value chain under review. Existing energy scenarios limit themselves to asserting the certainty of the change. Future oil demand projections offered under multiple scenarios point to such a wide range of possible trajectories that they provide limited added value to corporate leaders and strategic planners. Increasingly, some international oil companies (IOCs) are prepared to accept lower profits, rather than taking higher risks, to protect long-term shareholder value. Overall, value is migrating to the downstream and, as balance sheets improve on the back of delayed investments, there could be a surge in capital spending in defensive measures as companies reposition and reinvent themselves. Balancing the demands of shareholders with those of consumers will be a key challenge for all corporations in the entire energy value chain.

Increasingly, civil society is driving the pace of the transition by calling for pathways to achieve zero emissions and putting pressure on both governments and corporations, particularly in cases where emissions adversely affect air quality. Air quality and climate policies, key drivers of decarbonization, are becoming pillars of trust between voters and politicians, and between consumers and corporations. A recent example of a government responding to public pressure is in the Indian capital New Delhi, where policymakers brought forward the introduction of Euro-VI fuel standards by two years, leap-frogging Euro-V standards. However, climate and pollution control policies enacted by governments are no longer the primary catalyst for emissions reduction. Increasingly industry – both on the energy supply and demand sides – is under pressure from end-consumers to reduce emissions and is responding accordingly in order to retain consumer trust. Consumer pressure initially focused on the transportation and energy sectors but now reaches all sectors of the economy. The emissions and energy consumption policies of individual entities, be they municipal authorities, large corporations or small enterprises, are increasingly being drafted to secure public trust.

Decarbonization Strategies Offer a Potential Lifeline for Oil

Over the last two decades, oil and gas production has become more energy intensive. This has resulted in ever higher carbon emissions at source and has highlighted the differential between high-carbon and low-carbon oilfields. The average energy intensity of oil and gas production has grown by 25% since 2000 due to an increasing proportion of oil, such as tar sands, shale, and oil extraction processes like enhanced oil recovery (EOR), requiring high energy input. Legacy oil producers such as those in the Middle East are beginning to identify the low carbon tag associated with their oil as a possible selling point.

A recent study by Stanford University looking at well-to-refinery emissions and the net energy of China's crude oil imports identified a range of the carbon intensity of these imports of between 1.5-46.9 grams per kilojoule of carbon dioxide (CO_2). Saudi Arabia was the supplier with the lowest carbon intensity.

It is possible that oil can become a decarbonized fuel through the application of new technologies. Until recently, the focus has been on reducing carbon emissions from fossil fuel consumption, but emissions could start to fall substantially during the production process due to technological innovation. This may, in some cases, result in fully decarbonized energy.

A nexus between oil and renewables is emerging involving the use of solar and wind power to achieve cost and emissions reductions along the hydrocarbon value chain. Solar thermal technology has already been successfully implemented in EOR projects in Oman. Wind could also be used to electrify offshore oil platforms in regions such as the North Sea.

With a growing body of scientific evidence showing that the 1.5 °C global warming target set by the Paris Agreement is unlikely to be achieved without carbon capture and storage (CCS), the oil industry is well placed to mitigate emissions by using carbon in EOR operations. Such technology, known as CO_2-EOR, involves injecting CO_2 into oil reservoirs to maximize oil recovery rates while sequestering the carbon underground. CO_2-EOR provides a straightforward route for scaling up CCS deployment and represents an opportunity that industry and policymakers may wish to capitalize upon. The United States and Brazil already have multiple CO_2-EOR projects. The International Energy Agency in its Sustainable Development Scenario suggests that the potential exists for as much as three billion tonnes of CO_2 to be captured, providing large quantities of CO_2 for CO_2-EOR.

Producing crude oil and processing it close to the wellhead while capturing the carbon emissions and re-injecting them into the field confers multiple benefits for resource holders. These include decarbonizing the oil, giving it added value, enhancing oil production and extending the life of the field. Already some producers, including Saudi Arabia, are eyeing the potential of producing hydrogen close to the wellhead allied to a CO_2-EOR project as a way to export fully decarbonized energy. Japan has developed hydrogen fuel cell technology for the electric vehicle (EV) industry and is keen to promote this concept. Helping to ensure the energy-input of its EVs is fully decarbonized would make EVs more attractive to end consumers.

In any event, the future of the Middle East as an oil-producing region appears to be secure. By 2050 the world will need annual capacity additions of less than 2 million barrels of oil per day (MMbbl/d), of which half will come from the region. Middle Eastern countries can mitigate any future risk posed by carbon taxes by decarbonizing their oil.

The Refining Industry Looks to Petrochemicals for a Secure Future

As the energy transition steadily advances, challenging long-standing business models, corporations and resource holders alike are increasingly looking at adaptive strategies to try to ensure their long-term survival. Nowhere is this truer than in the refining industry. The sector has become used to reconfiguration through decades of constantly changing product specifications, the emergence of new markets and volatile crack spreads. Now it needs to address the growing risk of a decline in petroleum products demand growth, particularly for transportation fuel, and changing demand patterns.

The European refining industry faces a particularly challenging future. Demand for oil is falling and set to fall further while the demand profile is changing, with the middle of the barrel taking the biggest hit. European refiners will have to choose between cutting capacity or increasing product exports. However, some refiners are continuing to invest in capacity, with two Dutch refineries alone spending an estimated 1.8 billion Euros on investments with a 15-year lifespan. European refiners might be well advised to invest in reconfiguring their refineries promptly to ensure their continued competitive advantage.

In addition to falling demand, European refineries – which form a significant proportion of the industrial base in some of the continent's countries – are facing the added challenge of needing to reduce direct carbon emissions from the refining process. Integrating a wide range of available technologies into the existing system will be key to refineries' survival while they look for new monetization models that build on existing trading systems. Europe's developed infrastructure can be adapted to new models through re-engineering and retrofitting.

Beyond Europe, a mixed picture is emerging. Investments in North America's refining industry continue at very low levels with little new capital expenditure (capex) expected for the foreseeable future. However, substantial growth in capex in Latin America, the Middle East and Asia is expected on the back of continued – if slower – demand growth in petroleum products.

The future of petrochemicals and their role as a lifeline for refineries and, consequently, oil is uncertain. As things stand, petrochemical demand is unlikely to alleviate some of the pressures facing oil in North America and Europe or to make a major contribution to its future in Asia. Petrochemicals producers in North America are turning to feedstock from shale gas, while in China the emergence of a coal to chemicals industry is limiting the ability of refineries – and therefore oil – to benefit in full from any increase in petrochemical production.

Historically, petrochemicals have grown at a faster rate than gross domestic product (GDP), with a multiplier effect of 1.2 or more for most value chains; this is likely to continue. Packaging is set to be the principal growth driver in emerging markets, resulting in greater consumption of olefins and their derivatives. However, there is a growing risk of regulatory action following a worldwide public backlash against pollution caused by plastics waste. A further boost for petrochemicals will come from EVs, even as they contribute to a fall in demand for gasoline and diesel as EV manufacturers look to maximize the use of lightweight plastics to offset heavy batteries.

Refineries will need to reexamine their operations if they are to benefit from growing petrochemical demand. Integrating refining with petrochemical production could help increase the value of hydrocarbons and maximize overall margins. Increasing the complexity of refinery configurations

would help increase product production flexibility and product range, and enable the optimization of site synergies for the production of heat, steam and hydrogen. Refineries might wish to become fully integrated with both aromatics and olefins production capacity in order to aid their survival through the energy transition.

Reinventing refineries as petrochemical plants through crude oil, to chemicals (COtC) engineering solutions could offer a new future for refineries. COtC technology involves reconfiguring a refinery to maximize chemicals production instead of fuels, merging refinery and petrochemical plants. A COtC facility is typically configured to convert more than 40% of oil feedstock into chemicals and goes beyond state-of-the-art refinery petrochemical integration. Due to their large scale, COtC units have the potential to be a threat both to existing petrochemical plants and to refineries. COtC solutions could thus have profound strategic implications for the global petrochemical and refining industries.

For oil resource holders with access to capital faced with the future threat of peaking oil demand, COtC offers an opportunity for diversification. Saudi Aramco has already partnered with chemicals company Saudi Basic Industries, a company Aramco is now in the process of acquiring, to develop a COtC complex expected to process 400,000 bbl/d of crude oil and to produce approximately nine million tonnes of chemicals and base oils annually. It is predicted that, by 2030, the complex will be a significant contributor to Saudi Arabia's GDP and will play a key role in helping its economic diversification, as set out in Saudi Vision 2030, by shifting away from crude exports to higher-value industrial products.

Petrochemicals ventures should be well placed to benefit from the new demand that technological advances could help unlock. For example, the application of new materials and innovative uses of existing material, as in three-dimensional printing, could account for some 2 MMbbl/d of incremental demand for oil by 2040.

About the Workshop

In 2017 and 2018 KAPSARC convened a series of workshops titled "The Role of Oil in the Low Carbon Energy Transition." The fifth event, the outcome of which is articulated in this brief, was held in The Hague in association with the Clingendael International Energy Program (CIEP). It adopted a modified version of the Chatham House Rule under which participants consented to be listed below, having joined on one or both days. However, none of the content in this briefing can be attributed to any individual attendee.

List of Participants

Majid Al-Moneef – Secretary-General, Kingdom of Saudi Arabia Supreme Economic Council

Sverre Alvik – Program Director, Energy Transition, DNV GL – Group Technology and Research

Atul Arya – Senior Vice President, IHS Markit

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Weidong Chen – President, Mind Institute

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Joel Couse – Trading and Shipping Vice President Market Analysis, Total

Bassam Fattouh – Director, Oxford Institute for Energy Studies (OIES)

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Florian Merz – Senior Vice President - Strategic Planning and Key Performance Indicator Delivery, Mubadala Petroleum and Petrochemicals

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Sunita Narain – Director General, Centre for Science and Environment (CSE)

Richard Newell – President, Resources for the Future

Meaghan Parker – Senior Writer/Editor, Woodrow Wilson Center

About the Workshop

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About the Author

Paul Mollet

Paul is a research fellow in the Policy and Decision Science program. He is a former journalist and energy market analyst with almost 30 years of experience in international energy markets. Previously, Paul was Middle East Bureau Chief for Platts and Petroleum Argus as well as senior advisor to the Secretary-General at the World Energy Council (WEC).

About the Project

This project addresses the role of hydrocarbons, and oil in particular, in a world in which the Paris Agreement has successfully led to a 2°C (or less) planet. The role of international oil companies (IOCs) and national oil companies (NOCs) is explored, in terms of adaptive strategies, value retention through adjustment in business models, and an examination of whether there would still be a future for oil in a post Paris Agreement world.

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