



THE BOSTON CONSULTING GROUP



INTERNATIONAL ENERGY FORUM

Energies' New Value Propositions for Industrial Growth in Asia

2nd IEF Industry Advisory Committee Workshop

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How Can Asia Take the Lead in Oil & Gas Innovation?

Right now, the energy industry is going through the largest transformation it has seen in decades. For the first time ever, the industry is becoming more dependent on new technologies and cutting-edge innovation than on the extraction of oil and gas.

This profound shift offers Asia a compelling opportunity to take the lead on developing efficient and sustainable new ways of producing energy and promote the growth of its many energy-intensive industries. Properly positioned, the region could become a hub for research and development in the energy sector, and the generation of technology-enabled hydrocarbon and renewable energy. The result: reduced dependence on energy imports and more competitive energy-intensive industries.

China alone now produces more steel, aluminum, glass and cement than the rest of the world combined. If China, and the Asian region overall, is to meet its goals for increased urbanization and a healthier environment, these highly energy-intensive industries will need to become more productive, more efficient, and more environmentally friendly. Only through the development of advanced energy technologies can these goals be met.

Digital innovation in O&G

Historically, high levels of technology investment have been driven by high prices for oil and gas. Between 1976 and 1985, the motivating force was offshore drilling in the North Sea. Between 1999 and 2007, investments in deepwater drilling flourished thanks to a five-fold increase in oil prices. More recently, producers turned their attention to shale as oil prices hovered at around \$100 a barrel for four consecutive years. In this atmosphere, many independents also took risks, pushing the learning curve and reducing development costs significantly. In the past 10 years, 150,000 shale wells have been drilled; today, 500 operators are focused on shale.

These price cycles have also changed the type of innovation the industry is pursuing. In the decade before 2014, innovation was about “pushing the extremes” to deeper, more remote and higher-pressure environments while reducing the high cost of these efforts.

The sheer size of these investments is huge. Major exploration and production (E&P) players are currently investing between \$500 million and \$2 billion a year on R&D. IOCs like Exxon, Total and Shell each spend around \$1 billion annually on R&D, filing an average of more than 2,500 patents between 2013 and 2017. China’s Sinopec and Petrochina filed more than 15,000 patents combined in the past five years, while Saudi Aramco now maintains 11 research centers around the world, including one in South Korea, focused on carbon management, and one in Beijing, focused on oil recovery and seismic technologies. We believe these high levels of technology investment will continue going forward.

Since 2014, companies have refocused their innovation efforts on the need to drive efficiency and productivity, often through new digital technologies. Many companies are increasing the funds available to corporate venture capital for investment into energy efficiency and renewable energy. Chevron launched its Technology Ventures arm in 2009; in June, the company announced an additional \$100 million commitment with the launch of its Future Energy Fund. Norway’s Statoil, now called Equinor, first set up its Statoil Technology Invest in 2000; in 2016, it launched Statoil Energy Ventures with the goal of investing \$200 million over the next four to seven years.

The majors have also made more than 20 acquisitions in renewable energy in the past three years. Equinor and Total led the way in 2016, Shell went on a spree between 2017 and 2018, while BP is also back to renewables. This year the company announced its commitment to invest \$500 million a year in clean technologies and recently acquired the UK's largest electric vehicle charging company as part of its commitment.

The majors are also working together to develop new technologies. In 2014, 10 IOCs came together to launch the Oil and Gas Climate Initiative with four areas of focus: Carbon capture, utilization, and storage; reduction of methane emissions; reduction of transport emissions; and improvements in energy efficiency in industry.

The consortium also set up a \$1 billion investment vehicle that has already made several promising investments: Solidia Technologies is developing a novel cement and concrete manufacturing process with the potential to reduce CO₂ emissions by 70 percent and water consumption by 80 percent; The Clean Gas Project aims to capture and store CO₂ from gas-powered plants and local industrial emitters with the potential to reduce CO₂ emissions by 90 percent; Achates Power is working on highly fuel-efficient engines with the potential to reduce CO₂ emissions by 20 percent; and Inventys that is a Canadian carbon-tech company with a vision to become a CO₂ marketplace.

Going forward, the industry's technology investment will continue to expand to include big data, advanced analytics and artificial intelligence. Already, fiber optics are being used in completion, intervention and production operations. Eni's supercomputer can run 100,000 high-resolution reservoir simulations in 15 hours, compared to the hours it takes a reservoir engineer to run a single simulation using old software.

BP, meanwhile, is using drones and crawler robots to look for microscopic cracks inside a hydrocracker at its Cherry Point refinery in the U.S. Previously, it took a team of engineers 23 man-hours to inspect the unit. Today, there might be 25 people in a drilling crew, but five years from now there could be fewer than five.

At the same time we have plenty of evidence to indicate that E&P companies are getting serious about digitization. Equinor has recently established its Digital Centre of Excellence; as part of this effort, the company expects to invest \$250 million to \$500 million by 2020. Chevron has announced a multi-year partnership with Microsoft to accelerate the digitization of its oilfields. Total is building the first autonomous surface robot for the oil & gas industry, with a total budget of up to \$3.5 million. And Chevron's Tengiz oilfield expansion in Kazakhstan, scheduled to start production in 2022, will include about 1 million sensors. It has become a cliché to say "data is the new oil."

The Asian advantage

What does all this activity mean for Asia? A great opportunity for the region to take a lead role in the future of E&P technology. While previous E&P technology developments focused on gaining access to new resource types and geographies, future efforts will expand to include big data, advanced analytics and artificial intelligence. Historically, O&G companies were differentiated by their innovation assets, such as R&D centers, manufacturing facilities and intellectual property portfolios. In an era of faster moving digital technology, barriers to entry are failing and competitive advantage now centers on people and talent. Companies best able to attract, organize and retain innovation talent and capabilities will likely be the winners.

Over the past 20 years the region, led by China, has become a global technology leader. China, is now the No. 2 global leader in artificial intelligence, after the U.S., with the goal to become the world leader by 2030—aided by planned investments of \$150 billion. China has several distinct advantages in its determination to reach this goal: its sheer scale, "unlimited" access to data, early moves online, and its single market.

The Asian region is already a center for investment in renewable energy. In 2017 China led the world in investment in clean energy with \$130 billion, followed by the U.S., with \$60 billion. Together, 10 countries in the region invested a total of \$500 billion in renewable energy in 2017.

The opportunity for Asia extends well beyond the energy sector. Investment in new technologies can enable the region to become a hub for the research, development and manufacturing of technology-intensive and renewable technologies, to improve the return on capital and efficiency in O&G, to promote the development of autonomous vehicles, and of drones and robots that will make wind and solar energy more cost competitive.

The demand for energy is growing rapidly in Asia, and especially in China. If the region can transform itself into a world leader in energy technology and innovation, it can both meet that demand and gain a tremendous advantage for all of its industrial sectors.

Dr Ivan Marten
Vice Chairman Energy
Senior Partner and Managing Director
The Boston Consulting Group

Energy sector is dependent on technology and innovation



□ Become a hub for the research, development and manufacturing of technology-intensive and renewable technologies



□ Reduce import dependence, changing the national-level energy economics



□ Increase competitiveness of energy-intensive industries in the region

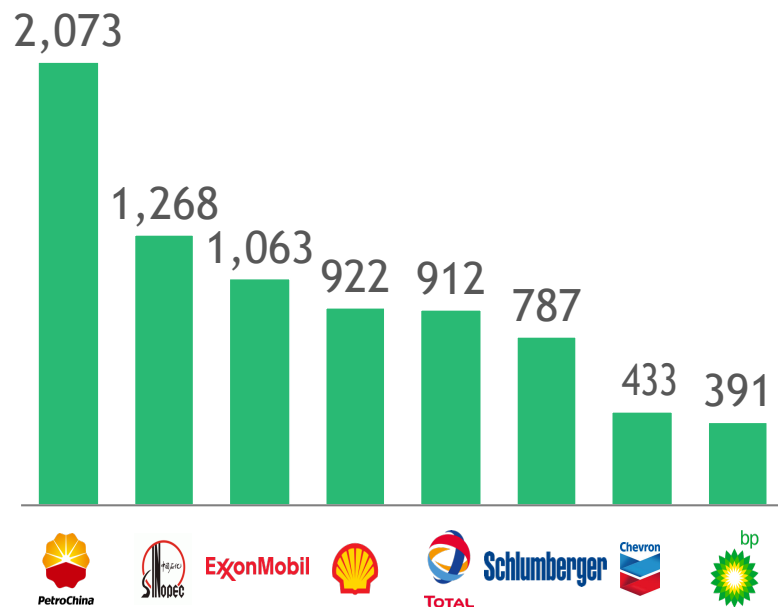
Energy transition poses new value propositions for industrial growth in Asia

Major E&P players invest actively in R&D

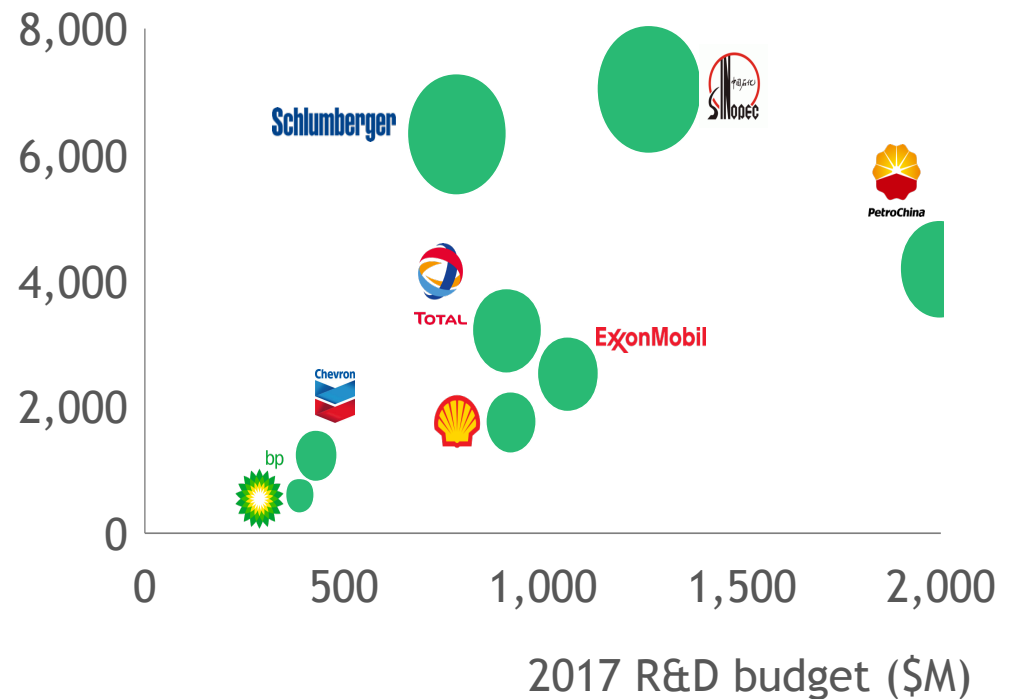
They spend ~\$1B on average annually...

... & have amassed a formidable IP base

2017 R&D budget (\$M)



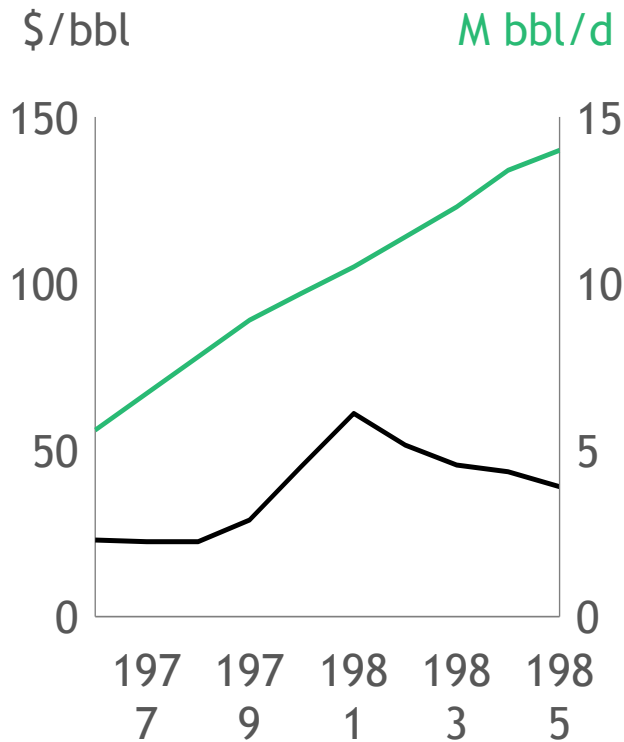
of patent families^{1,2} 2013-2017



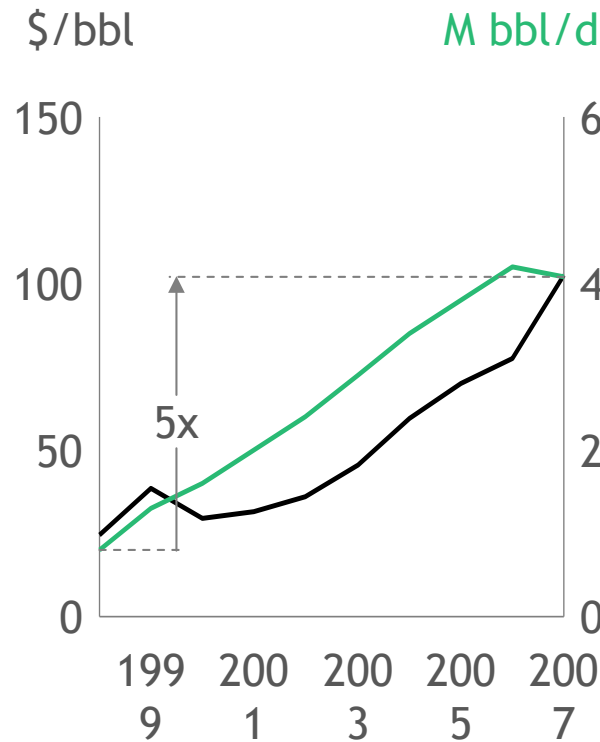
1. A collection of patent records that relate to the same innovation. For example, a patent describing a single innovation by the same group of inventors is filed in multiple jurisdictions and published at multiple stages. A patent family groups these records and selects one representative of the family; 2. For Saudi Aramco, only # of patent families shown
Source: Capital IQ, Derwent Innovation; BCG Analysis

High prices have always driven technology development

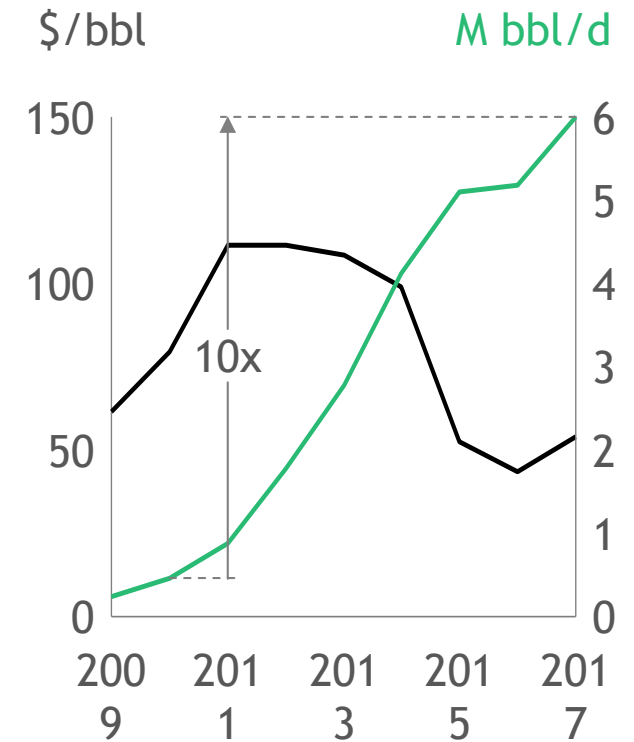
1976-1985: Offshore



1998-2007: Deepwater









2009-2017: Shale



— Oil prices
— Production

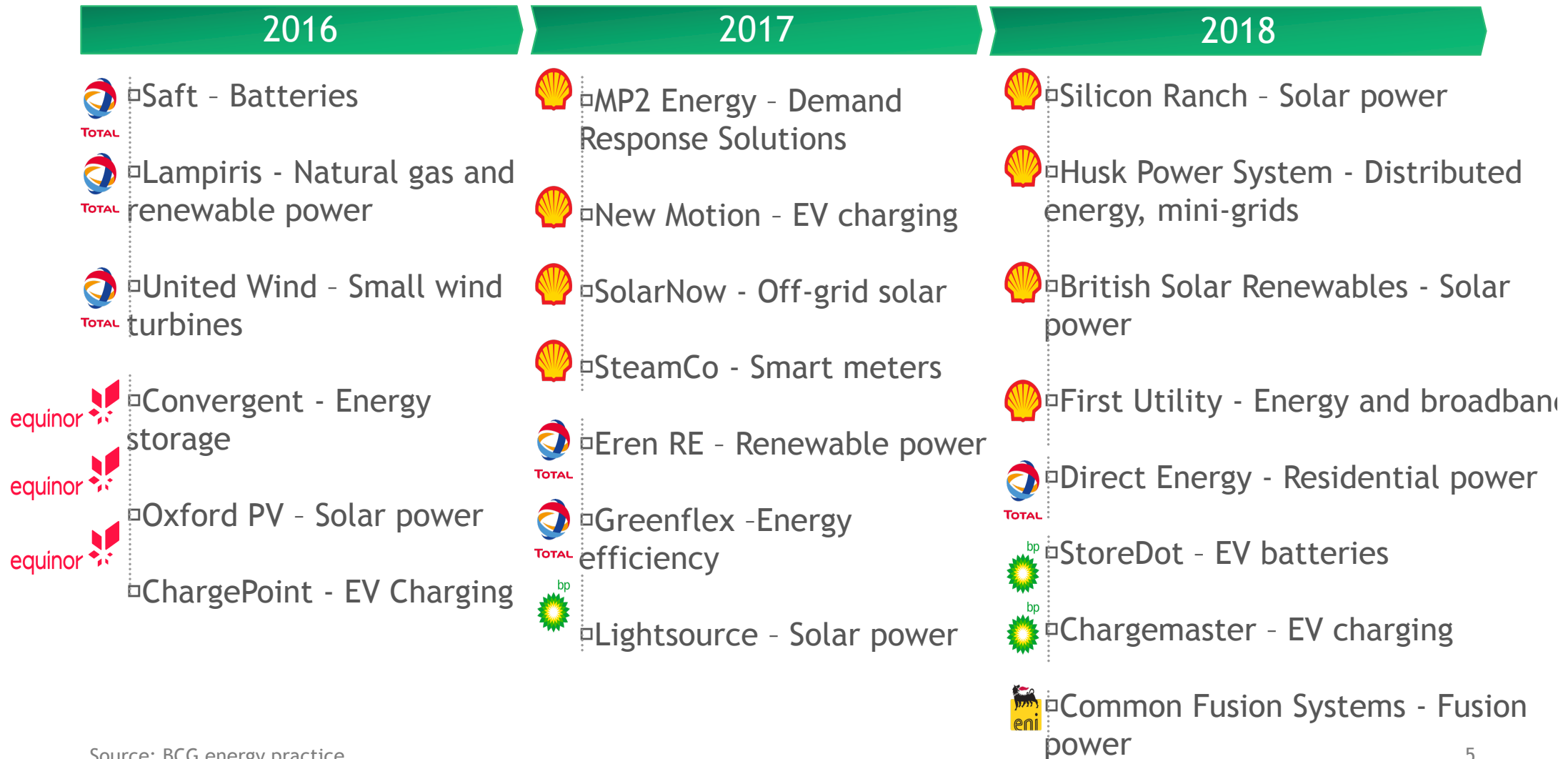
Majors have set up corporate venture capital funds to invest in Energy Efficiency and Renewable Energy

	Fund Name	Total Investment ¹	Year of Setup	Focus Technologies
 	AE Ventures	\$200M	2006	Biofuels, O&G and energy efficiency
	Chevron Technology Ventures	\$250M	1999	O&G, alternative energy, advanced materials, energy transition
	Future Energy Fund	\$100M	2018	Energy efficiency, alternative fuels, grid management
	Energy Technology Ventures	\$300M	2011	Renewables, smart grid, energy efficiency, fossil energy, nuclear, water
	Total Energy Ventures	\$175M	2016	Renewable energies, energy efficiency, waste management
	Equinor Technology Invest	\$135M	2000	Upstream O&G, renewable energy
	Equinor Energy Ventures	\$200M	2016	Renewable energy, energy storage, EV charging, solar, wind
	Saudi Aramco Energy Ventures	\$120M p.a.	2012	O&G, renewable energy, energy efficiency, water

1. Investment over the period: BP - 2006-13; Chevron - \$250M since 1999, \$100M since 2018; ConocoPhillips - since 2011; TOTAL - as of 2016; Equinor - \$135M 2000-16 and \$200M 2016 onwards for 4-7 years; Saudi Aramco - up to \$120M per year since 2012

Source: BCG Energy Practice

Majors are increasingly investing in renewables technology



In 2016, Oil and Gas Climate Initiative OGCI was launched

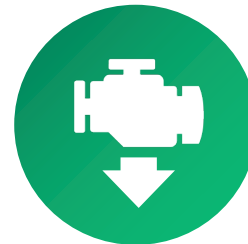
A \$1 billion investment vehicle



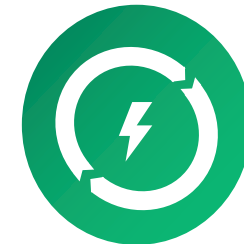
Carbon capture, utilization, and storage (CCUS)



Reducing methane emissions



Reducing transport emissions



Improving energy efficiency in industry



Investments will foster the expansion of new technologies



Big data & analytics



Cloud computing



Sensors



3D scanning



Mobile connectivity



Collaborative tech. platforms



Real-time comms & tracking



Additive manufacturing



Virtual reality



Unmanned aerial vehicles



Robots & automation



Cyber-security & blockchain

E&P companies are getting serious about Digitalization



Established
Digital Center
of Excellence



Looks to big data
to help weather
weak oil price



Partnership
with Microsoft to
fuel Digital
Transformation



Launching
second plant
4.0 start-up
incubator



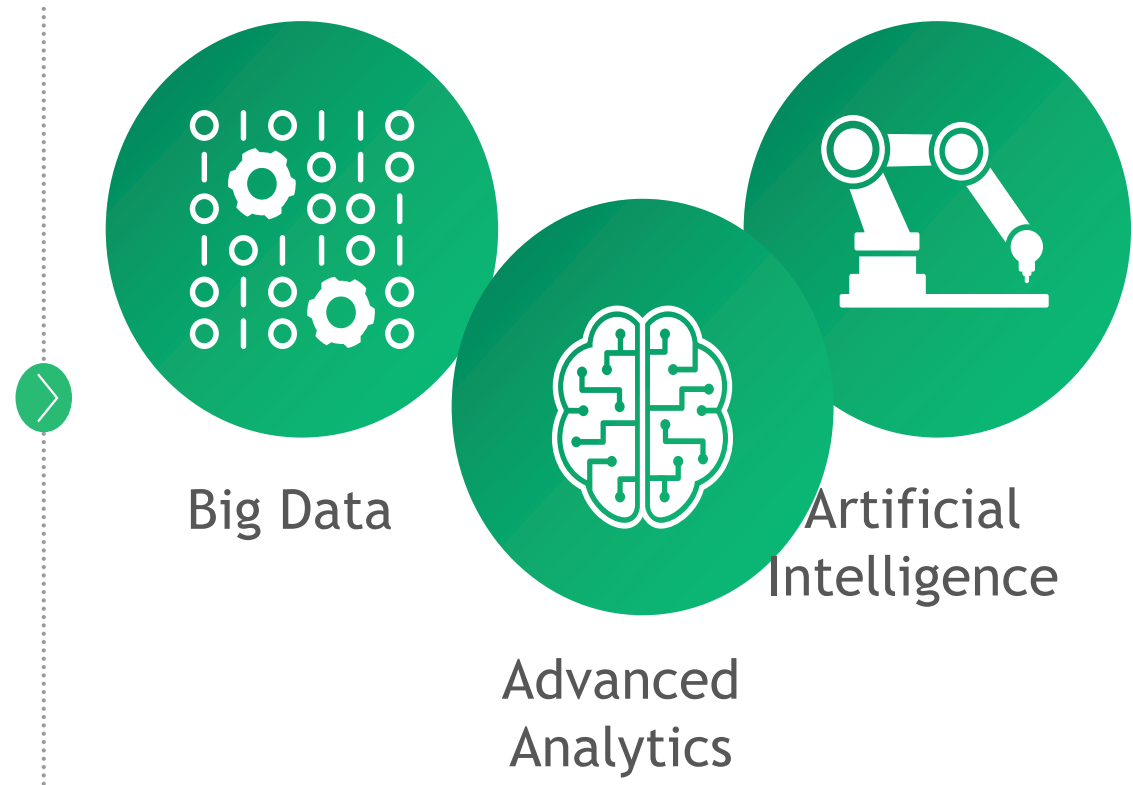
Created new
Digital Ventures

Asia is better suited for the future of E&P technology

The Past E&P Technology:
enabled access to new resource types

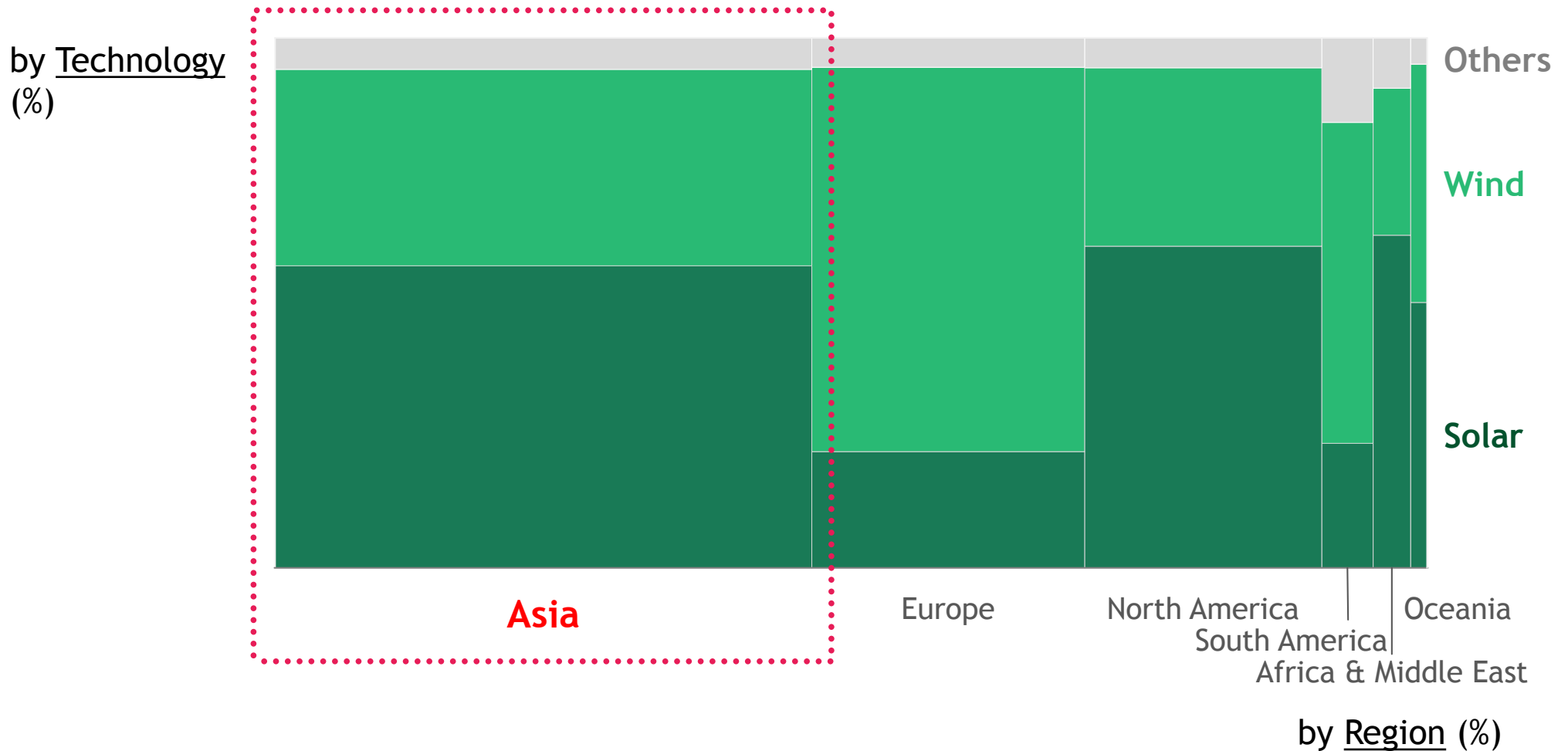


The Future E&P Technology



Asia is already a centre for Renewables growth

Renewable energy Investment by Region and Technology in 2016



1. Data for Biomass & Waste estimated from preliminary 2016 data

Note: Investment includes Asset Finance, Corporate R&D, Government R&D, Public Markets, Reinvested Equity, Venture Capital / Private Equity

Source: BNEF. BCG Analysis

Three opportunities for industrial growth in Asia



Become a hub for the research, development and manufacturing of technology-intensive and renewable technologies



Reduce import dependence, changing the national-level energy economics



Increase competitiveness of energy-intensive industries in the region



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